AN INVESTIGATION OF THE EFFECTS OF LARGE HOUSES ON OCCUPANT BEHAVIOUR AND RESOURCE-USE IN NEW ZEALAND

By

Iman Khajehzadeh

A thesis

submitted to Victoria University of Wellington

in fulfilment of the requirements for the degree of Doctor of Philosophy

in Architecture

Victoria University of Wellington

2017

To my mother Zohre and my father Hamid

whose prayers always support me

Acknowledgements

I would like to give my special thanks to Professor Brenda Vale for all her support over the course of my PhD study as without this my research could not have achieved this quality on time. I cannot express how lucky I feel for having her as my primary supervisor. I have learned much from her and I wish I hope to be lucky enough to learn more from her in following years. My thesis idea was inspired by the book *Time to Eat the Dog?* written by Professors Brenda and Robert Vale. I wish success and health for both of them. I should also thank my second supervisor, Doctor Nigel Isaacs, who has supported me and my wife however he could. I extend grateful thanks to my PhD examiners Emeritus Professor George Baird from Victoria University of Wellington (New Zealand), Professor Kajsa Ellegard from Linkoping University (Sweden) and Associate Professor Nalanie Mithraratne from National University of Singapore for their careful reading and constructive feedback.

I could do my PhD with a free and relaxed mind only because my wife Faeze supported me over this period and I want to thank her for all days I left her alone with life's problems. I should also thank my lovely children Avin and Aydin who lost some of the best days of their childhood for me to do my PhD. I hope they forgive me for those lovely sunny days when they could play outside but stayed at home to give some more time to a busy dad.

I was lucky enough to study in beautiful New Zealand with its lovely people who are always ready to help. This study could not happen without the patience and kindly support of the 7 anonymous households of study 1 and their family members who patiently filled out the time-use diaries for 14 days. I would also like to thank those kind people from various parts of New Zealand who took part in the online survey and devoted their time to filling out the quite time-consuming questionnaire. I hope this piece of work can be considered my thank you to lovely New Zealand people.

Over the course of my study I have always been technically supported by Victoria University of Wellington School of Architecture staff and thank them for all their efforts on my behalf. In particular, I would like to thank Stewart Milne, Selena Shaw and Eric Camplin who helped me whenever I was in trouble. I should also thank my friends and colleagues in the research room who have always been kind and supportive to me and who have made the PhD journey easy for me.

Abstract

According to Statistics New Zealand the average size of new New Zealand houses almost doubled from 1974-2011 at the same time that occupancy reduced, meaning fewer people live in larger houses. Features of large houses are extra bedrooms, specialised rooms (e.g. study, media room), more than one living space, several bathrooms (including en-suites), and double/triple garages. This contrasts with what is defined in this thesis as the "core house", which is a house (or part of a house) consisting of a living room, a dining room, a kitchen, and a bedroom for each occupant (assuming couples share a bedroom). Based on this, houses with more space than the appropriate core house for each household are considered as living in some level of large housing.

Living in larger houses than necessary means use of more natural resources in terms of construction materials, operating energy and the additional furniture and appliances needed. This study, therefore, aimed to measure resource-use efficiency in different sized houses and rooms found in NZ houses to show the significance of human decisions on housing energy use. To do this, it used a life-cycle energy approach to measure resource-use and reveal the long term environmental impact of house size decision. A 100 year cycle was used to cover typical human lifespan.

Using grounded theory, the research developed into four studies:

1- An observation of the features of New Zealand houses: Houses advertised for sale in TradeMe website were studied to show the features of New Zealand houses and types of furniture and appliances people keep in their houses.

2- Study 1: Based on the observation study, a questionnaire was prepared for a pilot study of 7 households living in small and large houses asking about occupants, type/number of rooms and types/number/location of furniture/appliances in their house. Each occupant also reported where he/she spend his/her time at home indoor for 14 consecutive days. This study revealed any problems with the preliminary questionnaire and also set strategy for the large time-use survey.

3- Study 2: Based on the results of study 1, an online questionnaire based survey was undertaken by families with 4 or fewer members living in NZ owner-occupied houses. The questionnaire asked for information about family members, type/number of spaces in their home, furniture and its location and the time spent in each room of the house, outdoors, and out of home by each occupant over one day. This survey provided a reliable data set about the features of New Zealand owner-occupied houses and their occupants, the type an number of furniture items, appliances and tools in them and where/for how long each household member spent his/her daily time in the house.

4- Floor plan study: To get a better understanding of the size of rooms in NZ houses, a floor plan study of 287 houses was performed. Floor plans were redrawn in AutoCAD and the floor area of each room and the whole house were extracted for mapping with house size in SPSS.

Results of the time-use study indicate New Zealanders on average spend 15.94 hours/day at home indoor and house size does not affect this. On average 54.7% of this is spent in usual bedrooms, 29.9% in the usual living room, dining room and kitchen, and use of other rooms including bathrooms accounts for 15.4% of time at home indoors.

Using a life cycle analysis approach, selecting to live in a house with 3 extra rooms, a single person, couple, couple with one child and couple with two children will use 66%, 66%, 75% and 66% more energy for housing over 100 years. By combining time-use and energy use results, a sample person living in a house with no extra rooms for their whole life will have a housing energy of 1.59GJ/hour which increases to 2.68GJ/hour by living in a house with 3 extra rooms. Based on resources for construction, refurbishment and heating and the time occupants spend in each room over the life the

house, for each hour of using a master bedroom New Zealanders use 0.9MJ, and this increases to 9.3MJ for an hour of using a study and 5.1MJ for a play room.

This research suggests more public awareness is needed regarding the role of human behaviour in achieving a sustainable architecture and perhaps it is time for governments to control use of natural resources by restricting house sizes where applicable.

Contents

List of Figures ..... **ix**

List of Tables ..... **xii**

1. Introduction **1**

1.1. Introduction 1

1.2. Aim of the study 2

1.2.1. House size and resource use 2

1.2.2. How efficiently are housing resources used? 2

1.2.3. Public awareness and policy making 3

1.3. Organisation of the thesis 3

1.4. Average house size 4

1.4.1. A comparison of house size in different countries 4

1.4.2. New Zealand house size 4

1.5. Features of large houses 9

1.5.1. Number of bedrooms 9

1.5.2. Garages 13

1.5.3. New spaces and bathrooms 14

1.6. Demographic features and New Zealand house size 16

1.7. Affordability and New Zealand house size 19

1.8. Summary 21

2. Literature review **22**

2.1. Introduction 22

2.2. Overcrowding 22

2.3. Regulations 28

2.3.1. International housing regulations 28

2.3.2. Housing Regulations in New Zealand 30

2.4. Occupant behaviour and energy consumption 35

2.5. Psychological investigations 39

2.6. Sustainability 45

2.6.1. Use of natural resources 45

2.6.2. “Lifetime” houses 47

2.7. Life Cycle Assessment 48

2.7.1. Life cycle assessment studies 48

2.7.2. Life cycle assessment studies in New Zealand 50

2.8. Time-use studies 53

2.8.1. International time-use studies and their methodological approach 53

2.8.2. Time-use studies in New Zealand 58
2.9. A gap in knowledge 60
3. Study design and methodology 63
3.1. Introduction 63
3.2. Possible methods 64
3.2.1. Time-use studies and tracking people 64
3.2.2. Resource accounting 68
3.3. Research question and aims 70
3.4. Research framework and approach 71
3.5. Study design 73
3.5.1. Data Collection 74
3.5.2. Data Analysis 76
3.6. Ethical issues 77
4. An observation of the features of New Zealand houses and their contents 78
4.1. Introduction 78
4.2. Methodology 78
4.3. Results 80
4.3.1. Rooms of the house 80
4.3.2. Garages, carports and parking spaces 83
4.3.3. Average floor/land area 84
4.3.4. Furniture and appliances 85
4.4. Discussion 87
5. Study 1 89
5.1. Introduction 89
5.2. Aims and objectives 89
5.3. Development of the questionnaire 90
5.4. Method and sample selection 92
5.5. Sample characteristics and data collection times 95
5.6. Definitions and categorisation of house spaces 99
5.7. Results 101
5.7.1. Problems with the “Day 1” questionnaire 101
5.7.2. Problems detected with the “Day 2” questionnaire 104
5.7.3. Problems detected with the time-use diaries 106
5.8. Analysis of time-use diaries 108
5.8.1. Time-use differences between weeks 1 and 2 108
5.8.2. Time-use at home outdoor and weather parameters 109

5.8.3. Time-use at home on different days of a week 112
5.8.4. Time-use in different spaces on weekdays and at weekends 115
5.8.5. Average daily time spent in rooms by each household 117
5.9. Discussion 121
5.9.1. Choosing days to represent a week 121
5.9.2. Day spaces and night spaces 126
6. Study 2 131
6.1. Introduction 131
6.2. Method 131
6.3. The questionnaire and completion 133
6.4. Respondents and recruitment method 135
6.5. Analysis of sample houses and their features 136
6.6. Further data analysis 140
7. A floor plan study of New Zealand houses 142
7.1. Introduction 142
7.2. Methodology 142
7.2.1. Data sources 142
7.2.2. How house and room floor areas are calculated 143
7.2.3. Number of house plans 147
7.2.4. Spread sheet and statistical analyses 148
7.3. Results 148
7.3.1. Sample 148
7.3.2. Average room floor areas 149
7.3.3. Presence of different room types 150
7.3.4. Number of room types 154
7.3.5. Size of rooms 156
7.3.6. House size and number of garages 161
7.3.7. Effect of number of storeys on circulation floor area 162
7.4. Discussion 163
7.4.1. Average floor area of New Zealand houses 163
7.4.2. House size and number of rooms 165
7.4.3. House size and size of rooms 167
7.4.4. Plan layout and construction age 168
7.4.5. A tool to estimate the floor area of houses 170
8. Time-use analysis 174
8.1. Introduction 174

8.2. Methodology 175
8.3. Results 178
8.3.1. Time-use at home indoors/outdoors 178
8.3.2. Time-use at home indoors/outdoors and influential parameters 181
8.3.3. Time-use in different rooms of a house 188
8.4. Implications 201
8.4.1. Effects of large housing on occupant behaviour 201
8.4.2. How "time-use at home indoors" can predict time-use in rooms of a house 204
8.4.3. The effect of internal plan layout on time-use 205
8.4.4. Exposure-time effect of living in houses with two different plan layouts 209
8.4.5. Use of large houses 211
9. Embodied and life cycle energy of selected houses 213
9.1. Introduction 213
9.2. A definition for small, suitable-size, and large housing 216
9.3. Method 217
9.3.1. Embodied energy per square metre of different sized houses 217
9.3.2. Embodied and life cycle energy of kitchen and sanitary fittings 219
9.4. Results: 224
9.5. Discussion 226
9.5.1. Initial embodied energy of different house sizes 226
9.5.2. Life cycle energy of different sizes of house 228
9.5.3. Embodied and life cycle energy per person of different sized houses 229
9.6. Conclusion 231
10. Furniture and appliances 232
10.1. Introduction 232
10.2. Methodology 234
10.3. Results 237
10.3.1. Average number of furniture items and appliances 237
10.3.2. Do larger houses have more furniture, appliances and tools? 240
10.4. Embodied and life cycle energy of furniture, appliances and tools 242
10.4.1. Initial embodied energy of furniture, appliances and tools 242
10.4.2. Life cycle energy of furniture, appliances and tools 245
10.4.3. Second hand furniture/appliances 249
10.5. Discussion 254
10.6. Conclusion 256
11. Time-use and resource-use 259

11.1. Introduction 259
11.2. Methodology 260
11.3. Analysis 262
11.3.1. Sample households, sample occupants, sample houses and related life cycle energy 262
11.3.2. Time-use analysis for sample occupant over 100 years 263
11.3.3. A tool to combine time-use and resource-use (life cycle energy) 264
11.3.4. Resource-use efficiency of the rooms of a house 265
11.4. Discussion 272
12. Conclusion 275
12.1. Introduction 275
12.2. Why do people have large houses? 276
12.3. How much are houses used? 277
12.4. Answers to research questions 277
12.5. Further research: 282
12.6. Study limits 284
12.7. What is next? 285
13. Bibliography 286
Appendices 307
Appendix 4.1: Proforma for TradeMe observations 307
Appendix 5.1: Questionnaire for Study 1 310
Appendix 5.2: Human Ethics approval for Studies 1 and 2 330
Appendix 5.3: The weather data taken from Kelburn station for the Study 1 period 331
Appendix 6.1: Questionnaire for Study 2 332
Appendix 6.2: Human Ethics approvals for amendments of questionnaire for Study 2 368
Appendix 6.3: Results of the post-hoc test to examine house size by household/house size 370
Appendix 7.1: Results of the post-hoc tests for floor plan study 373
Appendix 7.2: Full list of references for floor plan study 388
Appendix 10.1: Price of furniture items, appliances and tools in New Zealand 394
Appendix 10.2: The average number of various furniture, appliance and tool items per household and per person 397
Appendix 10.3: Post-hoc test results for Chapter 10 400

List of Figures

Figure 1.1 Average floor area of new houses in New Zealand 1974-2013 (December based). (Source: Statistics New Zealand (2014i)) 7
Figure 1.2 Average area of new houses in New Zealand (blue line) and Wellington (red line) 1991-2013 (December based). (Source: Statistics New Zealand (2014i)) 8
Figure 1.3 Houses with 1 and 2 or more bedrooms spare in Wellington and New Zealand 1991-2006 (Source: Statistics New Zealand (2014n)) 11
Figure 1.4 Relationship between number of bedrooms and number of usual residents (Source: Based on data from Statistics New Zealand (2014d)) 12
Figure 1.5 Number of motor vehicles for households in private occupied dwellings 1986-2013 (Source: (Statistics New Zealand, 2002a, 2013c, 2014j) 14
Figure 1.6 Tenure type by number of bedrooms, 2006 (Source: Statistics New Zealand (2011a)) 16
Figure 1.7 Households with 2 or more bedrooms spare for different ethnicities in Wellington and New Zealand-2006 (Source: Statistics New Zealand (2014m)) 17
Figure 1.8 Average household size in New Zealand from 1951 and its projection until 2031 (Sources: Bates and Kane (2005) and Statistics New Zealand (2008)) 18
Figure 2.1 Sample time-diary used in the 1985 National Study of American's Use of Time project (Robinson, 1988) 55
Figure 2.2 Diary form used by Dörre (1996) 55
Figure 2.3 Calendar–style diary used in a web-based method (Wu et al., 2012) 56
Figure 2.4 Dialogue-style diary used in a web-based method (Wu et al., 2012) 57
Figure 3.1 A diagram showing different parts of the research and how each study will feed other parts 77
Figure 4.1 Changes in number of main spaces for 1-6 bedroom houses 81
Figure 4.2 Number of available bedrooms and number of bedrooms used as a bedroom 81
Figure 4.3 Total number of available bathrooms and en-suite bathrooms for 1-6 bedroom houses 83
Figure 4.4 Total available garage, carport, and parking spaces for 1-6 bedroom houses 84
Figure 4.5 Average floor and land area for 1-6 bedroom houses 85
Figure 5.1 Proforma for recording use of each space by each occupant 94
Figure 5.2 The Average time per day spent indoors by all family members in weeks 1 and 2 109
Figure 5.3 Average time per day spent at home outdoors by all family members in weeks 1 and 2 109
Figure 5.4 Time spent at home (indoors and outdoors) by whole sample (per person) in weeks 1 and 2 113
Figure 5.5 Average times spent in different space categories for weekdays, weekends and whole week for all households 116
Figure 5.6 Time spent in different spaces in a typical 24 hour day by households living in small houses 120
Figure 5.7 Time spent in different spaces in a typical 24 hour day by households living in large houses 120
Figure 5.8 Time spent in usual bedrooms for all households over four time frames as a percentage of the total time spent in usual bedrooms 126
Figure 5.9 Time per person spent in usual bedrooms for all households over four time frames 127
Figure 5.10 Time spent in usual bedrooms for all households over four scaled time frames as a percentage of the total time spent in usual bedrooms 127
Figure 5.11 Average time spent in 12 space categories over four scaled time frames as a percentage of the total time spent in each category 129

Figure 6.1 Distribution of various house sizes as occupied by four different household types 137
Figure 6.2 Average number of bedrooms and other rooms in different sized houses of this sample 139
Figure 6.3 House size (based on number of rooms) with age of the oldest occupant of the house .. 140
Figure 7.1 Selected floor plan as it appeared in the source (Design 301 Wood (1993:8)) 144
Figure 7.2 Redrawing of Design 301 (Wood, 1993:8) in AutoCAD 2016 and how floor area of each room type is calculated 145
Figure 7.3 Percentage of houses with at least one of each room type categorised by house size 153
Figure 7.4 Average number of various room types by house size 155
Figure 7.5 Average floor area (m^2) of different room categories in various house sizes 158
Figure 7.6 Average floor area (m^2) of selected rooms in different sized houses 160
Figure 7.7 Average floor area by house size (based on number of rooms) 163
Figure 7.8 Average number of rooms and bedrooms in different sized houses and trends 165
Figure 7.9 Total rooms in different sized houses and split between bedrooms and other rooms 165
Figure 7.10 Average number of all bathrooms in different sized houses and en-suites as part of this 166
Figure 7.11 Share of five different room categories in the total floor area of different sized houses (storage excluded) 168
Figure 7.12 Percentage of houses with cellular and open plans in different decades 169
Figure 8.1 Time-use distribution at home indoors and home outdoors by frequency in sample 182
Figure 8.2 A comparison of time spent at home by different age groups in Canada-CHAPS 2 (Matz et al., 2014) and New Zealand 184
Figure 8.3 Average time spent at home indoors and number of rooms 187
Figure 8.4 Time-use distribution in different room categories 191
Figure 8.5 Time spent in the core part of the house and extra rooms as a percentage of time spent at home indoors for different sized houses 204
Figure 8.6 Average times spent in different rooms by occupants of open-plan houses 209
Figure 8.7 Average times spent in different rooms by occupants of non-open-plan houses 209
Figure 8.8 Time spent in separate kitchen for different age groups for different living space plan forms 211
Figure 9.1 Estimated initial embodied energy and life cycle energy per square metre based on Mithraratne et al. (2007) 219
Figure 9.2 Floor area of typical small ($12m^2$) and large ($15.7m^2$) kitchen and quantities of fittings .. 223
Figure 9.3 Initial embodied of houses and fittings based on number of extra rooms for four household types 226
Figure 9.4 Embodied energy of building materials and sanitary/kitchen fittings for various sizes of house for a single person (or couple) 227
Figure 9.5 Distribution of embodied energy between various rooms in different sized houses for single persons and couples 228
Figure 9.6 Embodied energy per person (year 0) of houses and fittings per person living as a single person household, couple, couple with one child and couple with two children 229
Figure 9.7 Life cycle energy per person (after 50 years) per person living in a single person household, couple, couple with one child and couple with two children 230
Figure 9.8 Life cycle energy per person (after 100 years) per person living in a single person household, couple, couple with one child and couple with two children 230
Figure 10.1 Average number of furniture/appliance/tool items of each category by household type 239
Figure 10.2 Average number of furniture/appliance/tool items for each category by house size 241

Figure 10.3 Initial embodied energy of furniture, appliances and tool categories (GJ) and the share of each category in the total for each house size 243
Figure 10.4 Initial embodied energy (GJ) of seven furniture, appliances and tool categories by house size 244
Figure 10.5 Breakdown of initial embodied energy of categories of furniture, appliances and tools (GJ) for each household type 245
Figure 10.6 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size 248
Figure 10.7 Break down of the embodied energy of furniture, appliances and tools at various life stages of a house 249
Figure 10.8 Initial embodied energy of furniture, appliances and tools with and without considering second hand items 251
Figure 10.9 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size and considering the effect of second hand items 253
Figure 10.10 Breakdown of the embodied energy of furniture, appliances and tools at various house life stages considering the effect of second hand items 253
Figure 10.11 Share of furniture/appliance/tools and building materials, fittings, maintenance, and heating energy in total embodied and life cycle energy of different sized houses at different life stages (all furniture/appliance/tools bought new) 256
Figure 10.12 Share of furniture/appliance/tools and building materials, fittings and maintenance and heating energy in total embodied and life cycle energy of different sized houses at different life stages (considering the effect of second hand furniture/appliance/tools) 256
Figure 11.1 Life cycle energy per total-hour and use-hour for the sample occupant living in 6 different sized houses 265
Figure 11.2 Life cycle energy/total-hour and use-hour (MJ/hour) for selected rooms 270
Figure 12.1 Rating the eight reasons for having a large house 276

List of Tables

Table 1.1 Average dwelling area and population density for selected developed countries (Sources: Dol and Haffner (2010), United States Census Bureau (n.d.-a), Wilson (2012), Statistics Japan (2013), QV (2011a), Statistics New Zealand (2014i) and United States Central Intelligence Agency (2009)) 5
Table 1.2 Average new house floor area by decade (Source: (QV, 2011a)) 6
Table 1.3 Average area of new houses in New Zealand 1974-2013 (December based). (Source: Statistics New Zealand (2014i)) 6
Table 1.4 Top and bottom 10 cities/districts with highest and lowest avearge house floor areas 2011. (Source: QV (2011b)) 7
Table 1.5 Top 10 suburbs with highest avearge house floor areas 2011. (Source: QV (2011b)) 8
Table 1.6 Average floor area of new houses in Wellington city and suburbs 1991-2013 (December based) (Source: Statistics New Zealand (2014i)) 9
Table 1.7 Crowding rates for major cities based on Territorial Authorities 2006 (Source: Statistics New Zealand (2014l)) 11
Table 1.8 Household composition and number of usual residents by number of bedrooms, 2006 (Source: Based on data from Statistics New Zealand (2014d)) 12
Table 1.9 Number of bedrooms in private occupied dwellings 1986-2013 (Source: Based on data from (Statistics New Zealand, 2002b, 2011b, 2014e) 13
Table 1.10 Tenure type by number of bedrooms, 2006 (Source: Statistics New Zealand (2011a)) 16
Table 1.11 Crowded and not crowded households by tenure type 2013 (Source: Statistics New Zealand (2014f)) 17
Table 2.1 Comparison of 3 crowding indices (based on data from Goodyear et al. (2011)) 23
Table 2.2 Minimum dimensions of regulated house spaces according to Housing Improvement Regulations 1947 (New Zealand Government, 2013) 31
Table 2.3 Maximum number of people sleeping in a bedroom based on room area 32
Table 2.4 Minimum space dimensions and floor area for old people's homes based on NZBC (DBH, (2011)) 33
Table 2.5 Minimum floor area for different types of apartments in Auckland central (Auckland Council, 2011) 33
Table 2.6 Factors influencing occupant space heating behaviour (based on data from Wei et al. (2013)) 38
Table 3.1 Different methods for tracking people and pros and cons of each 68
Table 4.1 Average number of kitchens, dining rooms and living rooms in 1-6 bedroom houses 80
Table 4.2 Number of bathrooms and their features 82
Table 4.3 Average number of garages/carports/parking spaces for 1-6 bedroom houses 84
Table 4.4 Average floor/ land area for 1-6 bedroom houses 84
Table 5.1 Participant household characteristics (household 1.E was removed from the study as the information was incomplete) 95
Table 5.2 Start date and end date for filling out timetables in the pilot study 97
Table 5.3 Time spent for each questionnaire/timetable by each household 98
Table 5.4 Ten categories of spaces and those found in each participant household 100
Table 5.5 Furniture/Large appliances located in a space not among offered choices 105
Table 5.6 Categorisation of a typical 24 hour day time 108
Table 5.7 Average Minimum temperature, Maximum temperature, Rain fall and Wind speed for outdoor usage for all households. 110
Table 5.8 Average time-use at home on different days of the week for each sample household 112

Table 5.9 Paired samples t test 114
Table 5.10 Differences between times spent in space categories on working days and at weekends 116
Table 5.11 Time spent in different space categories as a percentage of 24 hours and in hours and minutes (average of 7 households) 119
Table 5.12 Differences between “Modelled time” and “Real time” for different days over 2 weeks for Household 1.A 123
Table 5.13 Differences between “Modelled time” and “Real time” using Sunday with another weekday to represent a week for Household 1.A over 2 weeks 123
Table 5.14 Differences between “Modelled time” and “Real time” using 1 working and 1 weekend day to represent a week for Household 1.A 124
Table 5.15 Average of differences/Minimum of differences/Maximum of differences if 1 random day represents a week 125
Table 5.16 Average of differences/Minimum of differences/Maximum of differences if Sunday and another random weekday represent a week 125
Table 5.17 Average of differences/Minimum of differences/Maximum of differences if 1 random working and 1 random weekend day represent a week 125
Table 6.1 Number of participants that started and those that successfully finished various parts of the survey 136
Table 6.2 Average number of occupants and selected room types and sanitary spaces by house size 137
Table 6.3 Average number of occupants and selected room types and sanitary spaces by household type/size 138
Table 6.4 Results of an ANOVA one-way test to see the effect of house and household size on the average number of selected room types 138
Table 7.1 Floor area of the house and each room type and house characteristics extracted from the AutoCAD drawing file 146
Table 7.2 Number of plans needed to reach a consistent average floor area within ±1% or ±2% 148
Table 7.3 Number of plans used and mean, minimum, maximum, median and standard deviation of the floor area for each house size 149
Table 7.4 Number of integral garage spaces and storeys in the sample plans 149
Table 7.5 The average room floor area for various house sizes in this sample 150
Table 7.6 Results of the post-hoc test for comparing average room area in various house sizes 150
Table 7.7 Percentage and frequency of houses with at least one of each room type by different sized houses 151
Table 7.8 ANOVA one-way test results for significance of presence/absence of various room types with house size 152
Table 7.9 Average number of various room types by house size 155
Table 7.10 Results of ANOVA one-way test to see if number of various room types is significantly different by house size 155
Table 7.11 The average floor area of all room types investigated and number of sample for various sized houses 156
Table 7.12 ANOVA one-way test results to see if average floor area of 5 room categories is significantly different by house size 157
Table 7.13 ANOVA one-way test results to see how average floor area of selected rooms changes with house size 159
Table 7.14 Mean, number of cases and standard deviation for the average number of available garage spaces in different sized houses 162

Table 7.15 Average floor area of circulation spaces based on number storeys in different sized houses 163
Table 7.16 Percentage of various dwelling sizes (based on number of rooms) in New Zealand housing stock based on census 2013 and the average floor area of various house sizes based on this study 164
Table 7.17 Percentage of houses with cellular and open plans in different decades 169
Table 7.18 Assumed floor area for various room types in different sized houses based on this study 172
Table 7.19 Floor area of circulation spaces as a percentage of the floor area of all rooms in different sized houses 173
Table 8.1 Frequency and percentage of participants in different age groups compared to census 2013 (Statistics New Zealand, 2015) data for owner-occupied households 178
Table 8.2 Frequency and percentage of successful participants and days concerned 178
Table 8.3 Time spent at home indoors/outdoors for New Zealand compared to other developed countries 180
Table 8.4 Mean and Standard deviation of time spent at home indoors and outdoors for influential parameters 181
Table 8.5 Mean, Median, Minimum/Maximum, Standard Deviation and number of cases considered in time-use of each room type 190
Table 8.6 Results of an independent sample t test for time-use in different room categories by gender and day type 193
Table 8.7 Results of an ANOVA one-way test for time-use in different room categories by age, job type, family role and house size type 193
Table 8.8 Results of post-hoc multiple comparisons using Tukey's HSD test showing details of significant differences according to age, job type, family role and house size for time-use of room types of a house which were significant in Table 8.7 194
Table 8.9 Results of an independent sample t test to see the effect of presence/absence of extra rooms on time-use at home indoors 202
Table 8.10 Results of an independent sample t test to see the effect of presence/absence of extra rooms on time-use in usual bedrooms 202
Table 8.11 Results of an independent sample t test to see the effect of presence/absence of extra rooms on time-use in usual living areas 203
Table 8.12 Results of the Linear Regression test to see if time spent in room categories of a house can be predicted by time spent at home indoors 205
Table 8.13 Mean average time spent in living areas, number of houses and standard deviation in each option 206
Table 8.14 Mean, number and standard deviation for time-use in living areas in options 1 and 2 by day type, job type, age group, gender, family role and house size 208
Table 8.15 Average time spent in all space categories of a house for houses with open and non-open plan layouts 208
Table 9.1 Total embodied energy and embodied energy per square metre based on three New Zealand house LCA studies 215
Table 9.2 A basic house for 4 different household types and the minimum number of rooms 216
Table 9.3 Number of rooms needed in small, suitable-size or large houses for 4 household types 216
Table 9.4 Number of rooms and average floor area for each level of large housing for 4 different household types 217
Table 9.5 Useful life of different building elements/parts according to Mithraratne et al. (2007) 218
Table 9.6 Average number of sanitary spaces in different sized houses 220

Table 9.7 Embodied and life cycle energy of bathroom fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132)) 221
Table 9.8 Embodied and life cycle energy of toilet fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132)) 221
Table 9.9 Embodied and life cycle energy of combined bathroom/toilet and en-suite fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132)) 221
Table 9.10 Embodied and life cycle energy of combined toilet/laundry fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132)) 222
Table 9.11 Embodied and life cycle energy of laundry fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132)) 222
Table 9.12 Embodied and life cycle energy of bathroom/toilet/laundry fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132)) 222
Table 9.13 Embodied and life cycle energy of kitchen fittings of 4-6 room houses (based on Vale and Vale (2009:188)) 223
Table 9.14 Embodied and life cycle energy of kitchen fittings of 7-7+ room houses fittings (based on Vale and Vale (2009:188)) 223
Table 9.15 Average floor area, embodied and life cycle energy per square metre and total embodied and life cycle energy of 6 housing options for single person households and couples 224
Table 9.16 Average floor area, embodied and life cycle energy per square metre and total embodied and life cycle energy of 6 housing options for couples with one child 224
Table 9.17 Average floor area, embodied and life cycle energy per square metre and total embodied and life cycle energy of 6 housing options for couples with two children 224
Table 9.18 Embodied and life cycle energy of sanitary spaces and kitchen fittings for different house sizes for single person households and couples 225
Table 9.19 Embodied and life cycle energy of sanitary spaces and kitchen fittings for different house sizes for couples with one child 225
Table 9.20 Embodied and life cycle energy of sanitary spaces and kitchen fittings for different house sizes for couples with two children 225
Table 9.21 Total embodied and life cycle energy of different houses for single person households and couples 225
Table 9.22 Total embodied and life cycle energy of different houses for couples with one child 225
Table 9.23 Total embodied and life cycle energy of different houses for couples with two children 226
Table 9.24 Increase in energy use by selecting to live in larger houses for a single person household (or couple) 229
Table 10.1 Furniture, appliances and tools investigated in this study classified into 8 categories 235
Table 10.2 Average number of popular furniture items and appliances and percentage of houses with at least one item 237
Table 10.3 Mean, Standard Deviation, minimum and maximum number of all furniture, appliance and tool items by household type 238
Table 10.4 Results of the ANOVA one-way test for dependency between average number of furniture, appliances and tool items (in 8 categories) and household size 240
Table 10.5 Mean, Standard Deviation, minimum and maximum numbers of all furniture, appliance and tool items by house size 240
Table 10.6 Results of the ANOVA one-way test showing dependency between average number of furniture, appliances and tool items (in 8 categories) and house size 241
Table 10.7 Average, standard deviation, minimum and maximum initial embodied energy of furniture, appliances and tools in different sized houses 242

Table 10.8 Average, standard deviation, minimum and maximum initial embodied energy used by different sized households for furniture, appliances and tool 245
Table 10.9 Useful life of some furniture/appliance items from other studies compared with values from New Zealand Inland Revenue (2015) and the useful life assumed in this study 247
Table 10.10 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size 248
Table 10.11 Percentage of furniture items/appliances bought new in different sized houses..... 250
Table 10.12 Average, standard deviation, minimum and maximum initial embodied energy in different sized houses for furniture, appliances and tools considering the effect of second hand items 251
Table 10.13 Average, standard deviation, minimum and maximum initial embodied energy (Year 0) used by different household sizes for furniture, appliances and tools 252
Table 10.14 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size and considering the effect of second hand items..... 252
Table 10.15 Total embodied and life cycle energy of different furnished houses for single person and couple households 254
Table 10.16 Total embodied and life cycle energy of different furnished houses for couples with one child 254
Table 10.17 Total embodied and life cycle energy of different furnished houses for couples with two children 255
Table 11.1 Floor area of houses A0-A5 and life cycle energy per household and per person at different life stages 262
Table 11.2 Floor area of houses B0-B5 and life cycle energy per household and per person at different life stages 262
Table 11.3 Share of housing life cycle energy over 100 years for the sample occupant in 6 different sized houses 263
Table 11.4 Number of days with weekday and weekend time-use patterns for different age groups 264
Table 11.5 Different rooms in sample house A3 with the number of use years and number of persons using each room..... 266
Table 11.6 Average floor area of different rooms and life cycle energy of the house and components at relevant life stage of each room 268
Table 11.7 Total person-hours each room has been occupied over its whole life 270
Table 11.8 Difference between LCE/use-hour and LCE/total-hour and resource-use efficiency ranking for rooms of the sample house for the sample household 271
Table 11.9 Critical furniture and appliance items and their share in the subtotal life cycle energy of the room 273
Table A.5.3.1 Weather data for investigation period (Source: (National Institute of Water and Atmospheric Research, 2014))..... 331
Table A.6.3.1 Results of the post-hoc test to examine the details of differences of the average number of selected rooms by household type 370
Table A.6.3.2 Results of the post-hoc test to examine the details of differences of the average number of selected rooms by house size 372
Table A.7.1.1 The results of the post-hoc test for comparing the average room size in various house sizes 373
Table A.7.1.2 results of the post-hoc test to see the details of significant differences of presence/absence of non-master bedroom by house size..... 373

Table A.7.1.3 results of the post-hoc test to see the details of significant differences of presence/absence of study room by house size 373
Table A.7.1.4 results of the post-hoc test to see the details of significant differences of presence/absence of games room by house size 374
Table A.7.1.5 results of the post-hoc test to see the details of significant differences of presence/absence of studio by house size 374
Table A.7.1.6 results of the post-hoc test to see the details of significant differences of presence/absence of separate kitchen by house size 374
Table A.7.1.7 results of the post-hoc test to see the details of significant differences of presence/absence of separate living room by house size 375
Table A.7.1.8 results of the post-hoc test to see the details of significant differences of presence/absence of separate dining room by house size 375
Table A.7.1.9 results of the post-hoc test to see the details of significant differences of presence/absence of combined living room/kitchen by house size 375
Table A.7.1.10 results of the post-hoc test to see the details of significant differences of presence/absence of combined living room/dining room by house size 376
Table A.7.1.11 results of the post-hoc test to see the details of significant differences of presence/absence of combined living room/dining room/kitchen by house size 376
Table A.7.1.12 results of the post-hoc test to see the details of significant differences of presence/absence of separate bathroom by house size 376
Table A.7.1.13 results of the post-hoc test to see the details of significant differences of presence/absence of en-suite by house size 377
Table A.7.1.14 results of the post-hoc test to see the details of significant differences of presence/absence of separate toilet by house size 377
Table A.7.1.15 results of the post-hoc test to see the details of significant differences of presence/absence of bathroom/toilet/laundry by house size 377
Table A.7.1.16 results of the post-hoc test to see the details of significant differences of presence/absence of separate laundry by house size 378
Table A.7.1.17 results of the post-hoc test to see the details of significant differences of presence/absence of storage by house size 378
Table A.7.1.18 results of the post-hoc test to see the details of significant differences of presence/absence of circulation space by house size 378
Table A.7.1.19 Results of the post-hoc test to see the significant differences in the average number of bedrooms by house size 379
Table A.7.1.20 Results of the post-hoc test to see the significant differences in the average number of living rooms by house size 379
Table A.7.1.21 Results of the post-hoc test to see the significant differences in the average number of dining rooms by house size 379
Table A.7.1.22 Results of the post-hoc test to see the significant differences in the average number of specialised rooms by house size 380
Table A.7.1.23 Results of the post-hoc test to see the significant differences in the average number of bathrooms by house size 380
Table A.7.1.24 Results of the post-hoc test to see the significant differences in the average number of en-suites by house size 380
Table A.7.1.25 Results of the Post-hoc test to see the significant differences in the average number of toilets by house size 381
Table A.7.1.26 Results of the post-hoc test to see the significant differences in the average number of laundries by house size 381

Table A.7.1.27 Results of the post-hoc test to see the significant differences in the average floor area of all bedrooms by house size 381
Table A.7.1.28 Results of the post-hoc test to see the significant differences in the average floor area of all specialised rooms by house size 382
Table A.7.1.29 Results of the post-hoc test to see the significant differences in the average floor area of all living room, dining room, kitchens by house size 382
Table A.7.1.30 Results of the post-hoc test to see the significant differences in the average floor area of all sanitary spaces by house size 382
Table A.7.1.31 Results of the post-hoc test to see the significant differences in the average floor area of all circulation spaces by house size 383
Table A.7.1.32 Results of the post-hoc test to see how the average floor area of master bedrooms is different by house size 383
Table A.7.1.33 Results of the post-hoc test to see how the average floor area of second bedrooms is different by house size 383
Table A.7.1.34 Results of the post-hoc test to see how the average floor area of third bedrooms is different by house size 384
Table A.7.1.35 Results of the post-hoc test to see how the average floor area of fourth bedrooms is different by house size 384
Table A.7.1.36 Results of the post-hoc test to see how the average floor area of kitchens is different by house size 384
Table A.7.1.37 Results of the post-hoc test to see how the average floor area of separate living rooms is different by house size (for all houses with at least one separate living room) 384
Table A.7.1.38 Results of the post-hoc test to see how the average floor area of separate living rooms is different by house size (for all houses with only one separate living room) 385
Table A.7.1.39 Results of the post-hoc test to see how the average floor area of combined living room/dining room/kitchen is different by house size 385
Table A.7.1.40 Results of the post-hoc test to see how the average floor area of bathroom is different by house size 385
Table A.7.1.41 Results of the post-hoc test to see how the average floor area of combined bathroom/toilet is different by house size 386
Table A.7.1.42 Results of the post-hoc test to see how the average floor area of en-suite is different by house size 386
Table A.7.1.43 Results of the post-hoc test to see how the average floor area of toilet is different by house size 386
Table A.7.1.44 Results of the post-hoc test to see how the average floor area of garages is different by house size 387
Table A.7.1.45 Results of the post-hoc test to see the difference between the average number of open plan and cellular houses in different decades 387
Table A.7.2.1 References for 3 room houses 388
Table A.7.2.2 References for 4 room houses 388
Table A.7.2.3 References for 5 room houses 389
Table A.7.2.4 References for 6 room houses 390
Table A.7.2.5 References for 7 room houses 391
Table A.7.2.6 References for 8 room houses 392
Table A.7.2.7 References for 9-9+ room houses 393
Table A.10.1.1 Estimated NZ median market price, minimum/maximum price and useful life (years) for investigated furniture, appliance and tool items 396

Table A.10.2.1 Average number per person and per household for all investigated furniture, appliances and tools and percentage of houses with at least 1 item of each 399
Table A.10.3.1 The post-hoc test results for the correlation between the average number of furniture, appliances and tools in 8 categories and household size 400
Table A.10.3.2 The post-hoc test results for the correlation between the average number of furniture, appliances and tools and house size 401
Table A.10.3.3 The post-hoc test results for the correlation between the average number of furniture, appliances and tools in 8 categories and house size 402
Table A.10.3.4 Results of the post-hoc test comparing the average initial embodied energy of furniture, appliances and tools with house size 402

1. Introduction

1.1. Introduction

In the past having a big house has been a dream for many people, Currently, buying a bigger house, in an “attractive location” with “better-quality fixtures and fittings” has become a popular trend as incomes rise (Kiernan, 2012), while poorer people have to live in smaller houses, and may not even be able to afford these. Building larger houses equates with using more resources than are really necessary to house people and there are insufficient natural resources available for large numbers of people to build houses as large as they can afford (Mithraratne, 2013). These trends have appeared at the same time as many people have neither enough space to live in nor enough fuel to heat their often low quality houses. This has initiated the global problem of “Bad or Poor housing” (Harker (2006) and Friedman (2010)), which affects all countries although at different rates.

While the problem of “poor housing” exists in many countries a different, new phenomenon here called “large housing”, seems to have been created in some wealthy developed countries like the United States, Canada, Australia, and New Zealand. Large housing in this study is defined as an inappropriate relationship between house and household size (see section 9.2). High incomes and available land in these countries (Kiernan, 2012) have produced a good situation for people to fulfil their dreams of having huge houses, often pejoratively called “McMansions” (Ross, 2014:196). The great number of single person households living in houses with 2 or more spare bedrooms (see section 1.5.1) and a yearly increase in the area of new houses (see section 1.4.2) are parts of this problem, as decreasing annual occupancy rates (see section 1.6) means having bigger houses with fewer residents. This needs to be viewed in a situation where humanity is already living beyond the means that the planet can supply on a sustainable basis (Global Footprint Network, 2016) and when in 2013 in a wealthy country like the USA 14.5% of people live below the poverty line (United States Census Bureau, 2014).

Many studies have addressed the problem of crowded houses but there is almost no research on the outcomes of large housing (see Fuller et al. (2009) discussed in section 2.7.1). All crowding indices define minimums for housing but with no thought to what maximum levels might be. On the other hand, crowding indices seem to be based on western life styles, while for many ethnicities people like and are used to sharing spaces and make flexible use of the same space for living, eating, and sleeping, but the crowding indices ignore such aspects.

1.2. Aim of the study

1.2.1. House size and resource use

The first question that comes to mind is "What is wrong with large houses?" Such houses probably provide more flexibility and comfort for their occupants and buying or not buying a large house is just a matter of affordability. It is quite obvious that larger houses need more building materials for their construction and maintenance and, if all their rooms are heated (which may be necessary for to a healthy house) more energy for their heating. Living in a large houses will probably also mean having more furniture and appliances. As a consequence, this research aims to investigate how living in different sized houses might impact on the energy used for building materials, furniture, appliances and tools and heating the house.

1.2.2. How efficiently are housing resources used?

People who can afford and opt to live in a larger house may do this for many reasons including have space to work from home and put up guests. In other words, the resources that go into large houses are not necessarily 'wasted'. That said, it is also important to find out whether large houses are used more and how long people spend in their various rooms. This study, therefore, also aims to compare the resources needed to build, furnish and operate houses over their life with the number of people living in each house and the average time spent in each room by each member of the household. This will give an indication of how efficiently resources are used in different sized houses in New Zealand.

1.2.3. Public awareness and policy making

The results of this study could be used to raise public awareness about the environmental impact of living in large houses. They could also give designers and policy makers a better understanding of the impact of house size on energy consumption in the residential sector and thus help in constructing policies for reducing housing resource-use.

1.3. Organisation of the thesis

The thesis starts by looking at house size in different countries including New Zealand (see section 1.4). House size trends in New Zealand and the features of New Zealand houses will be investigated using data from various sources including Statistics New Zealand. Chapter 2 continues the literature review by considering how various branches of knowledge have discussed the subject of house size and time spent at home. Chapter 3 explains possible methods, research questions and how the overall study is designed and how the different parts work together. Chapter 4 describes the first study which is an observation of the features of New Zealand houses and their contents. Based on the results of Chapter 4, a questionnaire based pilot survey (Study 1) was developed and is described in Chapter 5, together with analysis of the data.

Using the results of study 1, the questionnaire was further developed for an online survey on a larger sample in New Zealand. This study (Study 2) investigated the house and household features, furniture, appliances and tools in the house and how much time people spent at home in the different rooms of the house. Chapter 6 describes this study together with some initial analysis results. Chapter 7 discusses the floor plan study of 287 New Zealand houses, which was undertaken to show how changes in house size influence the size and combination of rooms within the house.

Chapter 8 returns to the on-line survey data and presents the analysis of the time-use data from Study 2, aiming to show how much time people spend in different sized houses and in the various rooms of their house. Using analysis of the house size aspect of Study 2 and the floor plan study results, Chapter 9 presents a life cycle energy analysis of different sized houses for different household types. Chapter

10 uses the data from the survey on furniture and appliances to undertake a life cycle energy analysis of contents of the house.

Chapter 11 combines resource-use and time-use in New Zealand houses to see how efficiently energy is used in different sized houses and rooms within them. Chapter 12 concludes the research and addresses the research questions and future research areas. The thesis concludes with a Bibliography and a set of Appendices relating to the survey documents, floor plan study references, and results of statistical tests.

1.4. Average house size

1.4.1. A comparison of house size in different countries

Table 1.1 shows the average floor area for all and new dwellings in European countries, the United States, Canada, Australia, Japan, and New Zealand. Data for some countries are old but most are from 2008 and 2009. It seems Australia, the United States, Cyprus, New Zealand, and Canada have the largest new dwellings by area respectively, while most European countries have small average floor areas. A comparison between the average floor area of new dwellings and all dwellings shows that except for the UK and Italy, the average floor area of new dwellings is higher meaning the trend in these developed countries is towards bigger houses. Additionally, population density shows that Canada, Australia, New Zealand, and the United States are among the countries with the lowest population densities in the world, which is linked to availability of land. Apart from Cyprus, these four countries are newly developed with lots of available land and a part of their populations have high incomes.

1.4.2. New Zealand house size

As shown in Table 1.1, New Zealand has one of the highest average house floor areas in the world. Statistics New Zealand does not collect data on house area but does have data on the floor area of newly built houses from 1974 for the whole of New Zealand, and from 1991 for all major cities which

can be accessed through building consents. On the other hand, private companies working in the property sector like QV (2014) and RP (Rpdata, 2014), which are powered by Property IQ (2014), have good information on New Zealand properties, including the area of dwellings. Their data is not free but can be accessed by postal address though information on each individual property has to be paid for separately. Based on QV (2011a), the average house floor area in New Zealand was 149m^2 in 2011. Table 1.2 shows the average house areas by decade for 1900-2010, indicating that the trend for increasing house size started in the 1940s although most growth happened between 1980 and 2010.

Country	All dwellings		New dwellings		Occupied dwelling stock		Population density 2009
	Average floor area (m^2)	Year	Average floor area (m^2)	Year	(m^2/person)	Year	(Persons/km^2)
Austria	98.5	2009	101.0	2002	42.9	2009	99.6
Belgium	81.3	2001	105.0	2005	NA	NA	344.0
Bulgaria	63.9	2008	88.2	2008	25.2	2008	65.2
Cyprus	NA	NA	197.6	2002	NA	NA	86.2
Czech Republic	76.3	2001	107.0	2008	28.7	2001	132.2
Denmark	114.4	2009	131.5	2008	51.4	2009	129.8
Estonia	61.2	2009	100.8	2009	29.7	2009	30.1
Finland	79.4	2009	101.7	2008	38.9	2009	17.2
France	91.0	2006	99.0	2006	39.9	2006	100.1
Germany	89.9	2006	113.6	2008	42.9	2006	235.8
Greece	81.3	2001	124.6	2001	30.6	2001	82.1
Hungary	77.7	2005	88.8	2009	31.2	2005	107.3
Ireland	104.0	2002	105.0	2003	35.0	2002	61.0
Italy	96.0	2001	73.5	2007	36.5	2001	197.7
Latvia	58.5	2008	142.7	2008	27.0	2008	35.1
Lithuania	62.9	2008	106.2	2003	24.9	2008	NA
Luxembourg	133.5	2008	180.4	2007	66.3	2008	190.2
Malta	106.4	2002	NA	NA	34.3	2002	1282.2
Netherlands	98.0	2000	115.5	2000	41.0	2000	493.3
Poland	70.2	2008	104.0	2008	24.2	2008	126.4
Portugal	83.0	2001	96.2	2008	NA	NA	116.5
Romania	38.7	2008	70.0	2008	15.0	2008	96.5
Slovak Republic	56.1	2001	116.2	2009	26.0	2001	112.0
Slovenia	75.6	2004	108.7	2004	30.9	2004	99.5
Spain	99.1	2008	116.0	2008	33.0	2008	81.1
Sweden	92.8	2008	99.1	2009	45.2	2008	22.1
United Kingdom	86.9	2001	82.7	1981-2001	44.0	2001	253.0
United States	NA	NA	205.8	2008	77.0	2009	33.5
Australia	NA	NA	214.0	2009	89.0	2009	2.8
New Zealand	149.0	2010	196.8	2008	56.2	2010	15.7
Canada	NA	NA	181.0	2009	72.0	2009	3.7
Japan	NA	NA	94.1	2008	35.0	2009	339.1
Hong Kong	NA	NA	45.0	2009	15.0	2009	6770.7

Table 1.1 Average dwelling area and population density for selected developed countries (Sources: Dol and Haffner (2010), United States Census Bureau (n.d.-a), Wilson (2012), Statistics Japan (2013), QV (2011a), Statistics New Zealand (2014i) and United States Central Intelligence Agency (2009))

Decade	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Average house area (m^2)	131.7	135.3	136.7	129.8	112.7	117.5	128.2	140.2	142.4	166.4	194.2	205.3

Table 1.2 Average new house floor area by decade (Source: (QV, 2011a))

However, building consent figures from Statistics New Zealand (2014i) indicate the average house floor area has fluctuated with it approximately doubling for new dwellings from 1974 to 2012 (Table 1.3). In other words, older dwellings in New Zealand have lower average floor areas than new ones. A study by BRANZ (Page, 2007) states 27% of existing houses in New Zealand have an average floor area of more than 200m^2, and that the average floor area of new houses is more than 127% that of existing houses. According to Figure 1.1, the highest rates of increase happened respectively in 2004-2005 (+5.93% per year), 1998-2000 (+5.41% per year), and 1991-1996 (+4.72% per year) while the highest rate of decrease was in 1996-1998 (-4.3% per year). The figures also show that 2010 was a peak for building large houses and from then on the figures fluctuate, though this does not necessarily mean the peak has been passed, as the historic pattern shows. Kiernan (2012) states this recent decrease might be related to disappointing outcomes for New Zealanders overinvesting in property, recent tighter credit conditions for the housing sector, changes in tax treatment for property investment, and Canterbury earthquake rebuilding work.

Year	Average area (m^2)	Year	Average area (m^2)	Year	Average area (m^2)	Year	Average area (m^2)
1974	108.7	1984	123.4	1994	164.2	2004	180.3
1975	106.9	1985	123.4	1995	170.7	2005	191.0
1976	111.9	1986	125.6	1996	171.7	2006	191.4
1977	113.0	1987	126.6	1997	161.8	2007	196.2
1978	115.0	1988	125.7	1998	157.0	2008	196.8
1979	122.7	1989	129.9	1999	163.1	2009	195.4
1980	125.7	1990	135.6	2000	174.0	2010	199.5
1981	131.7	1991	138.9	2001	178.3	2011	191.6
1982	127.6	1992	150.9	2002	176.3	2012	197.2
1983	124.7	1993	158.7	2003	184.7	2013	191.9

Table 1.3 Average area of new houses in New Zealand 1974-2013 (December based). (Source: Statistics New Zealand (2014i))

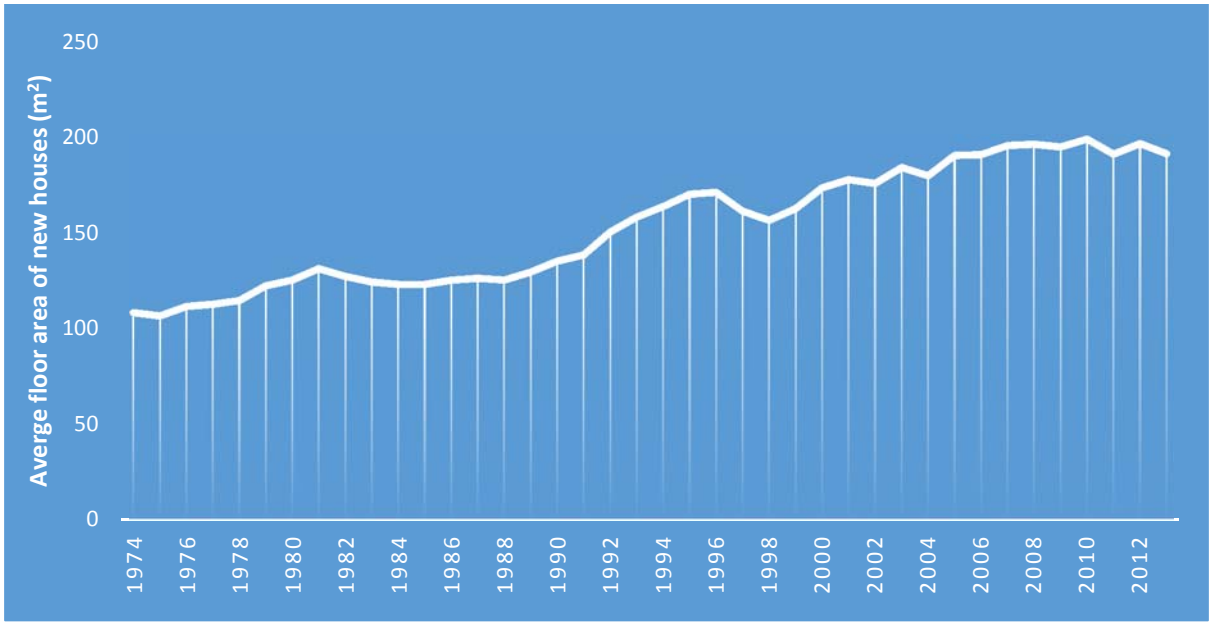


Figure 1.1 Average floor area of new houses in New Zealand 1974-2013 (December based). (Source: Statistics New Zealand (2014i))

Based on figures published by QV (2011b), the average house size differs between districts in New Zealand. The largest houses seem to be located in the main centres, in areas with more space, and in areas with more new houses (QV, 2011b). According to Table 1.4 the biggest houses within New Zealand are in the main cities that have experienced recent housing development, while small ones are usually located in rural areas (QV, 2011b), which paradoxically would have more land available. This suggests the trend for larger houses is driven by available income.

The top 10 cities/districts with the largest average house floor area (m^2)									
Selwyn District	Queenstown Lakes District	Auckland-North Shore	Auckland-Rodney	Tauranga District	Wellington City	Auckland City	Hamilton City	Kapiti Coast District	Waimakariri District
181	181	176	164	162	159	158	158	158	156
The bottom 10 cities/districts with the smallest average house floor area (m^2)									
Chatham Islands	Wairoa	Kawerau District	Waikato District	MacKenzie District	South Waikato District	Waitomo District	Ruapehu District	Hauraki District	Buller District
110	112	113	114	116	117	118	118	120	120

Table 1.4 Top and bottom 10 cities/districts with highest and lowest avearge house floor areas 2011. (Source: QV (2011b))

Similarly, consent figures from Statistics New Zealand (2014i) indicate that different cities within New Zealand have different house size patterns. For instance, Wellington has a completely different pattern compared to New Zealand as a whole (Figure 1.2).

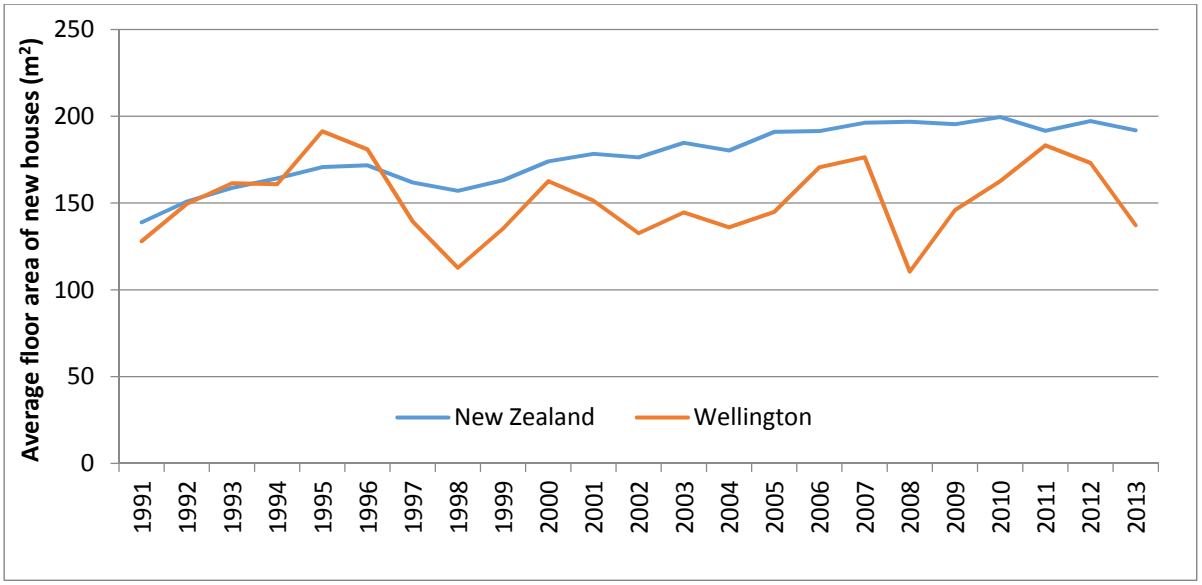


Figure 1.2 Average area of new houses in New Zealand (blue line) and Wellington (red line) 1991-2013 (December based). (Source: Statistics New Zealand (2014i))

Suburbs are more likely to have newer and bigger houses than city centres. According to QV (2011b) the 10 top suburbs with the highest floor areas are all near major cities, with 5 being Auckland suburbs (see Table 1.5). The average floor area of Shamrock Park, a suburb of Auckland which is top of the 10 largest suburbs, is nearly twice that of Auckland city centre (see Table 1.5).

The top 10 cities/suburban areas with the highest average house floor area (m^2)									
Auckland	Christchurch	Queenstown Lakes	Hamilton	Auckland	Christchurch	Auckland	Auckland	Auckland	Hutt City
Shamrock Park	Kennedys Bush	Lake Hayes	Harrowfield	Schnapper Rock	Westmorland	Albany Heights	Eastern Beach	Fairview Heights	Lowry bay
306	279	274	262	259	256	255	249	244	243

Table 1.5 Top 10 suburbs with highest avearge house floor areas 2011. (Source: QV (2011b))

Similarly, consent figures from Statistics New Zealand (2014i) show the same pattern for Wellington and its adjacent districts. The average floor areas of new houses built each year from 1991 to 2013 in Wellington and seven adjacent districts indicate that the former is lower than for all districts, with Porirua City being the highest (see Table 1.6). A study by Nathaniel Lichfield & Partners Ltd (2010) in the UK found that it was the suburbs in the Nottingham city area that mostly had the high quality large houses.

It thus seems that larger houses in New Zealand are more likely to be located in the main cities and especially in their suburbs or adjacent districts. Additionally, bigger and more populated areas are more likely to have larger houses in comparison to rural areas.

	Kapiti Coast District	Porirua City	Upper Hutt City	Lower Hutt City	Wellington City	Masterton District	Carterton District	South Wairarapa District
1991	146.5	161.8	130.3	125.7	128.0	139.0	112.6	116.3
1992	158.6	165.6	135.0	130.0	149.5	134.1	142.0	146.2
1993	158.5	203.0	149.3	169.6	161.4	154.7	137.7	173.6
1994	172.0	205.0	175.6	181.5	160.8	155.5	205.4	133.3
1995	169.5	211.1	217.1	190.6	191.3	154.3	181.1	146.2
1996	169.8	196.2	183.8	180.8	180.9	174.2	153.4	138.4
1997	164.2	225.9	142.6	189.5	139.3	158.7	170.0	176.1
1998	153.7	204.2	188.7	201.1	112.7	162.8	146.2	181.7
1999	160.9	202.8	177.1	195.8	135.3	178.4	168.7	199.6
2000	175.4	213.0	189.6	202.8	162.6	190.7	180.6	197.0
2001	183.9	236.4	189.9	196.0	151.3	197.5	210.8	185.3
2002	188.8	230.0	192.5	202.9	132.6	172.7	211.4	196.6
2003	190.8	209.3	219.5	184.9	144.6	192.1	201.6	182.7
2004	197.1	236.4	202.1	189.8	136.0	195.2	177.7	197.7
2005	191.7	269.4	222.5	172.7	144.9	189.6	154.0	217.7
2006	205.7	235.6	196.7	160.5	170.6	163.6	138.5	187.4
2007	198.6	238.7	187.8	186.0	176.4	171.6	168.4	193.4
2008	202.6	224.4	151.2	172.4	110.5	175.3	143.4	209.8
2009	220.4	214.1	196.0	167.8	145.9	201.1	166.2	183.9
2010	237.9	205.2	204.2	162.5	162.6	198.0	189.1	204.9
2011	203.6	232.7	168.4	173.0	183.2	151.5	176.2	196.9
2012	180.1	237.9	189.6	153.3	173.1	173.2	194.3	232.6
2013	178.6	231.7	164.6	145.3	137.2	188.6	183.3	221.8
Average 1991-2013	179.4	217.9	185.1	172.5	147.4	171.9	169.9	188.2

Table 1.6 Average floor area of new houses in Wellington city and suburbs 1991-2013 (December based) (Source: Statistics New Zealand (2014i))

1.5. Features of large houses

1.5.1. Number of bedrooms

Having more bedrooms usually equates to a larger house floor area. Normally, couples share a bedroom while for other family members sharing bedrooms is related to cultural background, financial situation, sex and age. A situation where there are insufficient rooms/bedrooms for the number of people living in a house is known as overcrowding. However, definitions of overcrowding differ in the six existing international crowding indices and are generally based on use of rooms or bedrooms (see section 2.2). Research by Goodyear et al. (2011) indicates that the Canadian National Occupancy Standard (CNOS) "works best for New Zealand". According to CNOS definitions:

- A bedroom can only be shared by a maximum of 2 people

- Couples, children under 5 (of same or opposite sex), and children under 18 (same sex) can share a bedroom
- Shared bedrooms for a child aged 5 to 17 and a child under 5 of opposite sex are not allowed
- Single adults over 18 and any other remaining unpaired children need a separate bedroom

Based on CNOS definitions, households that need 1 and 2 or more extra bedrooms are categorized as 'Crowded' and households with no spare bedrooms are 'Not crowded' (Goodyear et al., 2011). While having more households living in 'Not crowded' situations is the goal of all governments in the world (Building and Social Housing Foundation (BSHF) and Morten (2013)), it should be noted that living in houses with 1 or more spare bedrooms is over the standard. Having a look at NZ occupancy rates 1991-2006 (2.8 persons per dwelling in 1991, 2.8 in 1996, 2.7 in 2001, and 2.7 in 2006) and knowing the permitted bedroom sharing regulations in CNOS two things emerge. First it is only children who are likely to share bedrooms, and second that most households with one or more spare bedrooms have a room(s) that might have no usual user or have another usage.

Data for New Zealand from 1991-2006 (Statistics New Zealand, 2014n) indicate that more than 50%of all households live in houses with spare bedrooms and nearly 25% live in houses with two or more spare bedrooms. Interestingly numbers of houses with one spare bedroom are slowly decreasing while those with 2 or more spare bedrooms are rapidly increasing. The pattern for Wellington is very similar to New Zealand but with different rates (see Figure 1.3).

Additionally, crowding rates for major cities indicate the central Otago district (80.2%) has the highest and Auckland city (65.7%) the lowest percentage of houses with at least one spare bedroom (Table 1.7)(Statistics New Zealand, 2014l). The 2006 rates for crowded households show that Hamilton city (5.5%) has the highest and central Otago district (2.4%) the lowest in New Zealand. Table 1.7 shows the percentages of crowding in the six major cities of New Zealand in 2006 with the yellow row representing the size of the poor housing problem in New Zealand (crowded and severely crowded households). The pink row represents households with 1 or more spare bedrooms, and could be

thought of as revealing the problem of rich housing in New Zealand. As seen, the large housing problem is more than fifteen times that of crowded housing in terms of the numbers of persons involved.

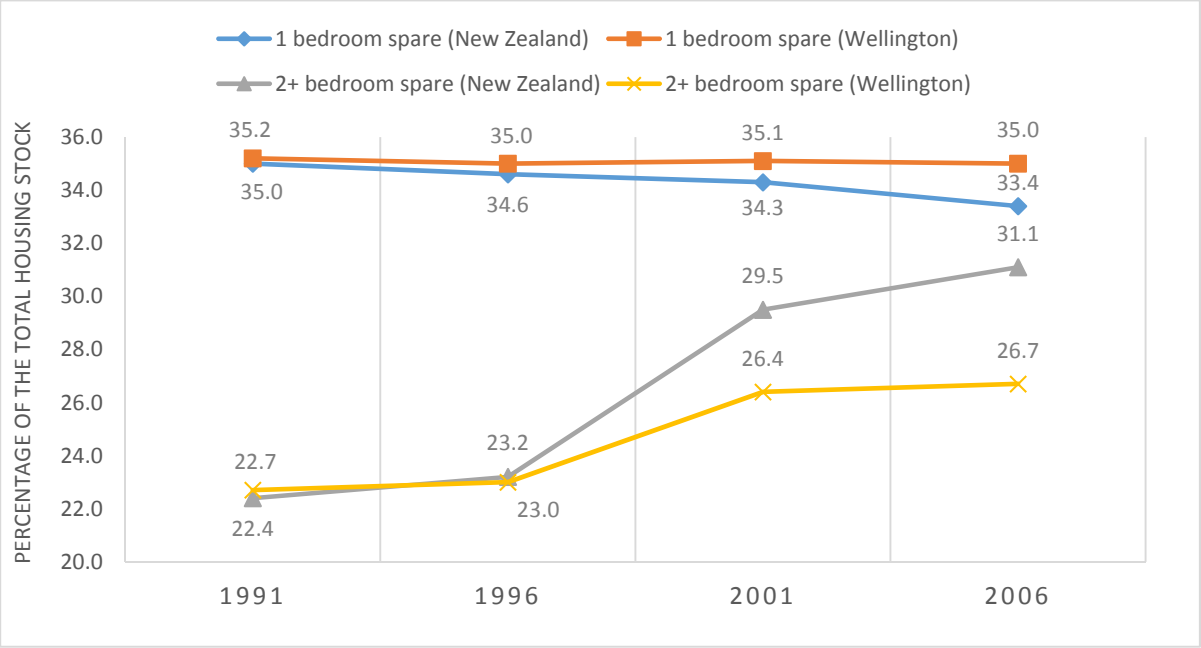


Figure 1.3 Houses with 1 and 2 or more bedrooms spare in Wellington and New Zealand 1991-2006 (Source: Statistics New Zealand (2014n))

Households with		Cities						
		Auckland city	**Hamilton city**	**Wellington city**	**Christchurch**	**Central Otago district**	**Dunedin city**	**New Zealand**
Crowded	1 bedroom needed	4.2%	4.3%	3.4%	3.7%	2.1%	3.3%	3.7%
	2+ bedrooms needed	1.1%	1.2%	0.5%	0.8%	0.3%	0.5%	0.9%
Total crowded		5.3%	5.5%	3.9%	4.5%	2.4%	3.8%	4.6%
Not crowded	No extra bedrooms required	29.1%	25.2%	29.1%	25.5%	17.5%	27.7%	23.3%
	1 bedroom spare	36.8%	36.6%	37.6%	38.0%	32.7%	37.8%	36.4%
	2+ bedrooms spare	28.9%	32.8%	29.4%	32.1%	47.5%	30.8%	35.6%
Households with at least 1 bedroom spare		65.7%	69.4%	67.0%	70.1%	80.2%	68.6%	72.0%

Table 1.7 Crowding rates for major cities based on Territorial Authorities 2006 (Source: Statistics New Zealand (2014l))

According to Table 1.8, which is based on the 2013 census (Statistics New Zealand, 2014d), the average number of bedrooms increases with the number of usual residents of the house but the increase rate does not seem to be proportional to this. For instance households with 1 usual resident on average live in houses with 2.4 bedrooms while the relevant figures for households with 2, 3, 4, 5, 6, 7 and 8 usual residents are 3.0, 3.3, 3.5, 3.8, 4.0, 4.1 and 4.1 bedrooms. Allowing 1 bedroom per occupant in an ideal situation, households with 1, 2, 3, 4, 5, 6, 7 and 8 usual members will respectively need 1, 2,

3, 4, 5, 6, 7 and 8 bedroom houses (blue line in Figure 1.4). According to Figure 1.4, households with 1, 2 and 3 usual members live in houses with more bedrooms than ideal while households with 4 and 4+ usual members live in houses with fewer bedrooms than they need. However, if the assumption is made that all 2 person and above households contain a couple and couples share a bedroom (orange line in Figure 1.4), on average families with 1, 2, 3 and 4 usual members live in houses with more bedrooms than needed while larger families (5 and 5+ usual residents) live in houses with fewer bedrooms than necessary. This means that statistically finding large families living in houses with extra bedrooms is less probable. Additionally, the difference between the available number of bedrooms and the ideal increases as the number of usual residents increases. In other words, living in houses larger than the core house is a pattern usually seen in small households and rarely in large households.

Number of usual residents in the house	Number of bedrooms in the house								
	1	2	3	4	5	6	7	8+	Average (bedrooms)
One person	17.3%	35.6%	36.8%	8.5%	1.3%	0.3%	0.1%	0.1%	2.41
Two persons	4.1%	21.7%	48.9%	21.0%	3.5%	0.5%	0.1%	0.2%	3.00
Three persons	1.0%	13.6%	52.2%	24.6%	5.7%	0.9%	0.2%	0.2%	3.25
Four persons	0.3%	6.4%	46.2%	37.0%	8.5%	1.2%	0.2%	0.2%	3.51
Five persons	0.2%	3.8%	35.7%	40.9%	15.9%	2.8%	0.5%	0.3%	3.78
Six persons	0.2%	3.1%	32.5%	35.4%	20.6%	6.7%	1.1%	0.5%	3.96
Seven persons	0.2%	2.1%	30.7%	34.2%	20.4%	8.3%	2.8%	1.1%	4.05
Eight persons	0.2%	1.8%	25.8%	31.8%	22.3%	10.6%	4.3%	3.1%	4.14

Table 1.8 Household composition and number of usual residents by number of bedrooms, 2006 (Source: Based on data from Statistics New Zealand (2014d))

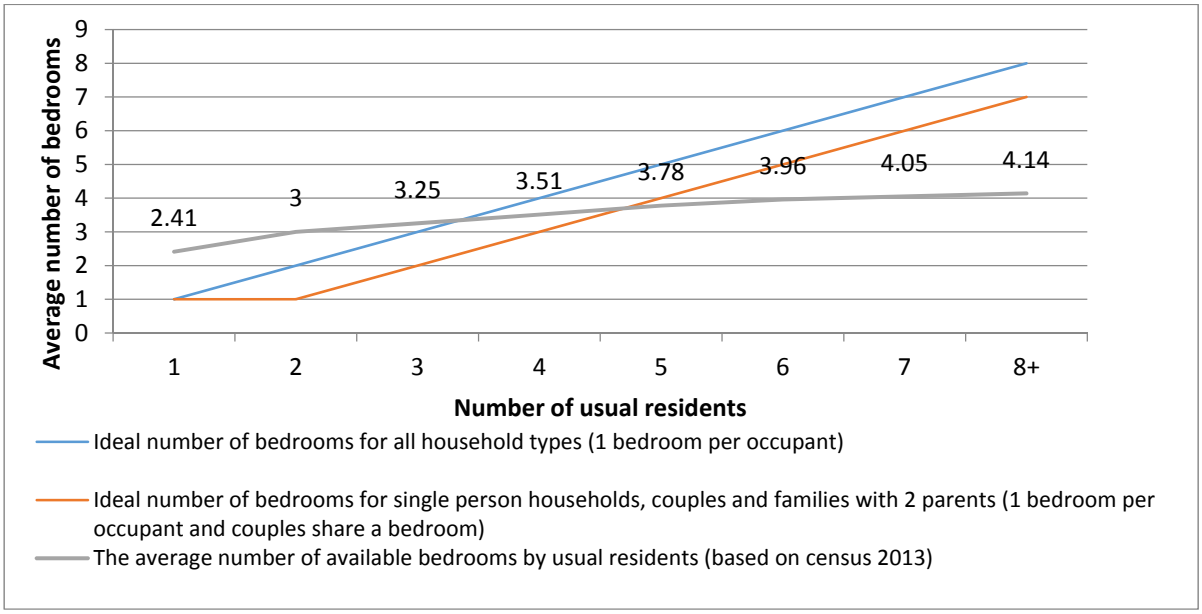


Figure 1.4 Relationship between number of bedrooms and number of usual residents (Source: Based on data from Statistics New Zealand (2014d))

Over the last few decades the New Zealand house has moved towards having more bedrooms. Table 1.9 shows the change in number of bedrooms in New Zealand houses from 1986 to 2013, revealing houses with 1, 2, and 3 bedrooms had a respective decrease as a proportion of the total housing stock of 6.6%, 19.0%, and 14.3%. On the other hand, houses with 4, 5, 6, 7, and more than 8 bedrooms had a respective increase of 51.0%, 123.1%, 175.0%, 100%, and 200% in the same period. The average number of bedrooms in New Zealand houses shows a small increase each year from 2.86 bedrooms in 1986 to 3.09 bedrooms in 2013, an 8% increase. So it can be concluded that small houses (with 3 or fewer bedrooms) are decreasing and big houses (with 4 or more bedrooms) are increasing each year although it should be noted this trend slowed from 2006 to 2013. A study by the United States Census Bureau by Sarkar (2011) on changes in American houses over recent decades shows the percentage of houses with 4 and more bedrooms increased from 16.8% in the 1960s and earlier to 33.6% in 2005-2009. Comparing 3.09 bedrooms per house and the occupancy rate of 2.65 in 2013 (Statistics New Zealand, 2014c), it is obvious that the average New Zealand house has more bedrooms than needed for the average New Zealand household.

Year	Number of bedrooms								
	1	2	3	4	5	6	7	8-8^{+}	Average
1986	6.1	23.6	51.6	15.5	2.6	0.4	0.1	0.0	2.86
1991	6.0	23.3	51.3	16.0	2.8	0.5	0.1	0.1	2.89
1996	6.1	22.7	47.9	17.9	3.7	0.7	0.4	0.6	2.97
2001	5.5	20.5	47.5	20.4	4.5	0.9	0.3	0.4	3.03
2006	5.8	19.8	46.3	21.6	5.0	1.0	0.2	0.3	3.05
2013	5.7	19.1	44.2	23.4	5.8	1.1	0.2	0.2	3.09

Table 1.9 Number of bedrooms in private occupied dwellings 1986-2013 (Source: Based on data from (Statistics New Zealand, 2002b, 2011b, 2014e)

1.5.2. Garages

As houses have grown in New Zealand so have the number of associated garages, which again take resources to build. Based on the New Zealand censuses of 1996, 2000, 2006, and 2013 the percentage of households with 0 and 1 motor vehicle decreased each year from 1986 to 2013, while households with 2 and 3 motor vehicles increased in the same period (Statistics New Zealand, 2002a, 2013c, 2014j). Figure 1.5 shows the number of households without a motor vehicle decreased by 39% from 1986 to 2013 while the number of households with 3 or more motor vehicles increased by 83%. Figure

1.5 also indicates the highest changes happened in households with 1 and 2 motor vehicles. Additionally, Figure 1.5 shows that trends in all four categories have become steady from 2006.

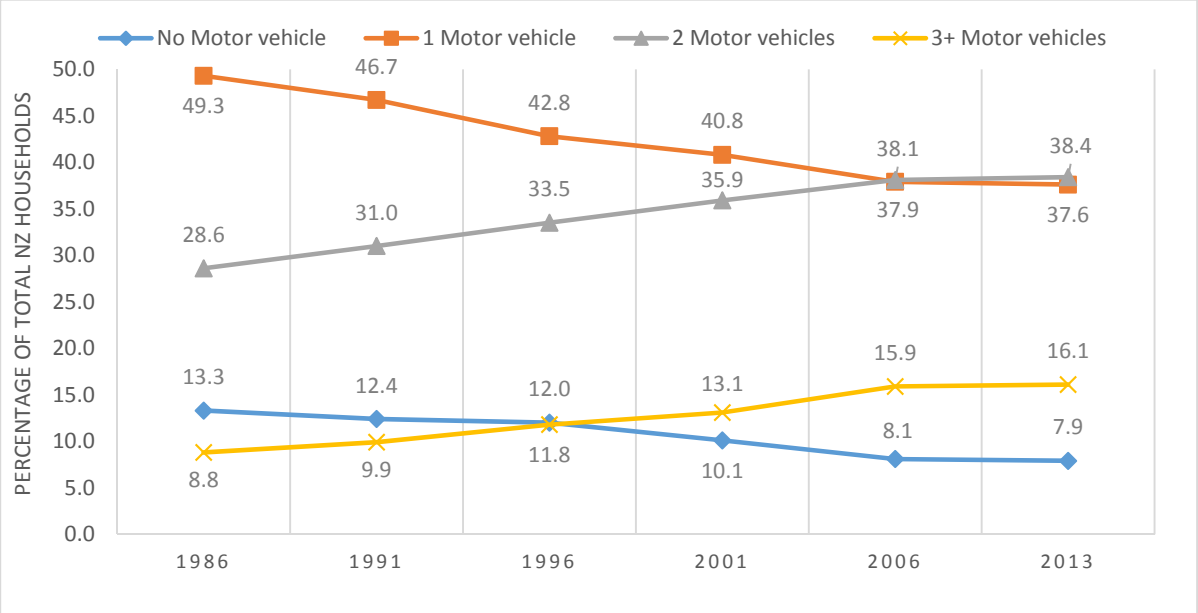


Figure 1.5 Number of motor vehicles for households in private occupied dwellings 1986-2013 (Source: (Statistics New Zealand, 2002a, 2013c, 2014j)

The NZ Transport Agency (2013) states there were 2,843,625 cars and 119,307 motorcycles in New Zealand in 2012, meaning that approximately 96% of motor vehicles were cars and 4% motorcycles. Adding these figures to Figure 1.5 reveals that in 2013 more than 52.3% of households have at least 2 cars as against 35.9% in 1986, meaning the number of families with at least two cars has increased by approximately 45% in 27 years. Having double the cars means double the garages or parking space which also leads to bigger houses. A study by BRANZ (Page, 2007) indicates double garaging is the most important design feature when people come to buy a new house in New Zealand.

1.5.3. New spaces and bathrooms

Changing life styles and the presence of new specialised spaces in houses is another reason for them being bigger. A study by BRANZ (Page, 2007) indicates a 'study' is an important feature for people buying a new or existing house or renting a house and interestingly this feature is more important for people buying new houses than existing ones, showing the raised expectations around the former.

The BRANZ study also indicates people want a 'games room', which again is more important for buyers of new houses than existing ones or renters.

Another study by the Commission for Architecture and the Built Environment (CABE) (2005) indicates people in the UK prefer bigger bedrooms while specialized rooms for computers and utilities were also desired. Another study by the Centre for Housing Research Aotearoa New Zealand (CHRANZ) (Bates & Kane, 2005) projecting "the future of housing in New Zealand" describes how a young person in a scenario uses a spare bedroom as a work space, reflecting both the future and what may now be happening in New Zealand houses. Nathaniel Lichfield & Partners Ltd (2010) found that employed and self-employed people in the UK often need a room for working at home and this might be a reason for households seeking extra bedrooms. The London Housing Design Guide (Mayor of London, 2010) also recommends more space for new homes to give occupants the capability of working from home. Another study by the United States Census Bureau (Sarkar, 2011) shows the percentage of houses with 2 or more living rooms increased from 3.1% in the 1960s and earlier to 6.1% in 2005-2009. The same study also shows that the percentage of houses with a respective laundry/utility room, family/great room, den/library/TV room and recreation room has increased from 17.5%, 12.7%, 8.9% and 2.9% in the 1960s and earlier to 38.2%, 21.6%, 14.7% and 6.2% in 2005-2009 (Sarkar, 2011).

Vale and Vale (2009) state that the single living room of the early 20th century house in the UK had an area of 12m^2 and had multiple uses for cooking, eating and relaxing but that each of these activities can happen in a separate room in new houses. They also mention the presence of separate formal and family living rooms in modern houses which are used respectively for everyday living and special occasions. It seems the single multi-use space in older houses has become several specialized spaces in modern houses.

The presence of multiple and en-suite bathrooms is another feature of larger houses (Vale & Vale, 2009). They discuss large houses of 231m^2 offered to self-builders in UK with four bedrooms and four bathrooms among which three were en-suite. They also report another case in Rangiora Eco Village in

New Zealand with 2 bathrooms with the en-suite having a floor area of 9m^2, which equates to a double bedroom in many countries such as the UK. The previously mentioned study by Sarkar (2011) in the US shows that percentage of houses with 2 or more bathrooms has increased from 10.1% in the 1960s and earlier to 47.9% in 2005-2009.

1.6. Demographic features and New Zealand house size

Accepting the number of bedrooms as an indicator of house size then according to Table 1.10 and Figure 1.6 houses with 1 and 2 bedrooms (small houses) are mostly rental houses while those with 3 or more bedrooms (medium and large houses) are mostly owner occupied. Additionally the rate of ownership increases with the increase in the number of bedrooms peaking for 4 bedrooms houses (medium houses) and from this point the rate of ownership starts decreasing and becomes nearly equal to renting for houses with 8 and more bedrooms (very large houses). The pattern for Family trust housing is very similar to owner occupied housing.

House size (based on number of bedrooms)	Percentage by tenure type			
	Owned	Rental	Family trust	Other
1	19.7%	72.1%	3.0%	5.2%
2	41.5%	47.6%	7.0%	3.8%
3	57.5%	29.0%	11.1%	2.4%
4	61.9%	18.4%	18.1%	1.6%
5	59.0%	17.8%	21.6%	1.6%
6	53.7%	23.4%	20.8%	2.0%
7	49.6%	27.8%	19.8%	2.8%
8$^+$	43.1%	38.2%	14.2%	4.5%

Table 1.10 Tenure type by number of bedrooms, 2006 (Source: Statistics New Zealand (2011a))

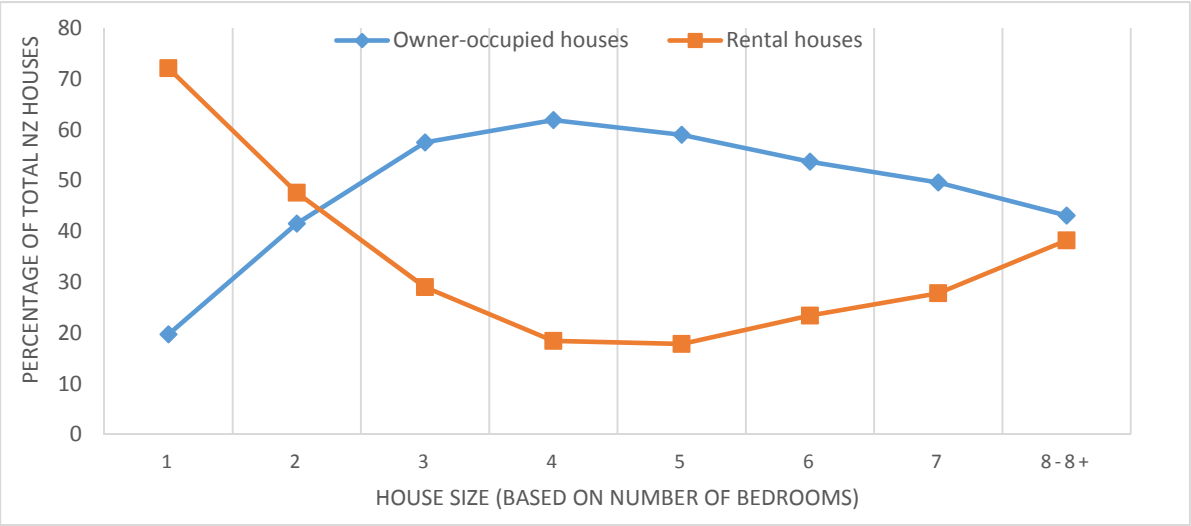


Figure 1.6 Tenure type by number of bedrooms, 2006 (Source: Statistics New Zealand (2011a))

Crowding rate is another parameter related to tenure. According to the 2013 census (Statistics New Zealand, 2014f) and based on the Canadian crowding index, crowded households are twice as likely to live in rental dwellings, which supports the findings about the relationship between tenure type and house size (see Table 1.11). It should be noted that in Table 1.10 "owned" covers all types of owned or partly owned dwellings, "rental" covers all types of rental dwellings whether any payment is made, not made, or not defined, and "family trust" covers all dwellings held by a family trust whether mortgage payments are made, not made or not defined. To conclude it seems larger housing is more probably owner occupied than rented or family trust housing, especially for houses with 3 and more bedrooms.

Crowding condition	Percentage of households by tenure type		
	owned	rental	family trust
Crowded households	30.6%	63.7%	5.7%
Not crowded households	52.8%	32.7%	14.6%

Table 1.11 Crowded and not crowded households by tenure type 2013 (Source: Statistics New Zealand (2014f))

The distribution of house size in New Zealand is also different between different ethnic groups. According to Statistics New Zealand (2014m) and based on the 2006 census, European and Asian ethnicities have the highest respective percentages of living in houses with spare rooms, while Pacific, Middle Eastern, Latin American, and African (MELAA), and Maori ethnicities have the lowest respective percentages of such households (Figure 1.7).

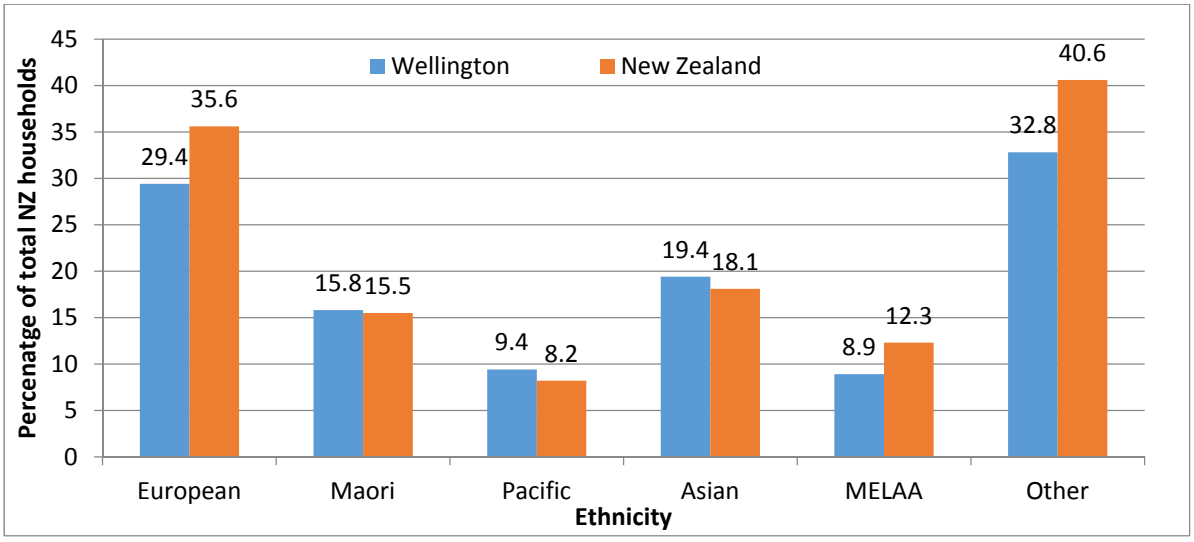


Figure 1.7 Households with 2 or more bedrooms spare for different ethnicities in Wellington and New Zealand-2006 (Source: Statistics New Zealand (2014m))

In Figure 1.7 'Other' refers to people identifying themselves as New Zealanders (Statistics New Zealand, 2014m). The pattern for Wellington is completely different from New Zealand which might be related to the aggregation of some ethnicities in some parts of the country (Statistics New Zealand, 2014m).

As mentioned before, from 1974 to 2012 in New Zealand the average area of new houses nearly doubled (see Table 1.3). Since larger families usually need larger house, are these larger houses a result of an increase in household size? The average household size was 3.7 people in 1951 and this decreased to 3.0 by 1981 (Statistics New Zealand, 2008). According to the 2006 census, the average household size was then 2.6 people (Statistics New Zealand, 2008). Based on series 5B projections average household size is projected to decrease to 2.4 people by 2031 (Statistics New Zealand, 2008) (Figure 1.8), although a report by the Department of Building and Housing (2010) state the fact children are living in their parental homes for longer times (up to 29 years) has increased the average household size in recent years. Series 5B is one of the nine projection series created by Statistics New Zealand and is based on medium levels of mortality and migration (Statistics New Zealand, 2008). Statistics New Zealand (2008) state it is the most suitable projection for assessing future changes in families and households.

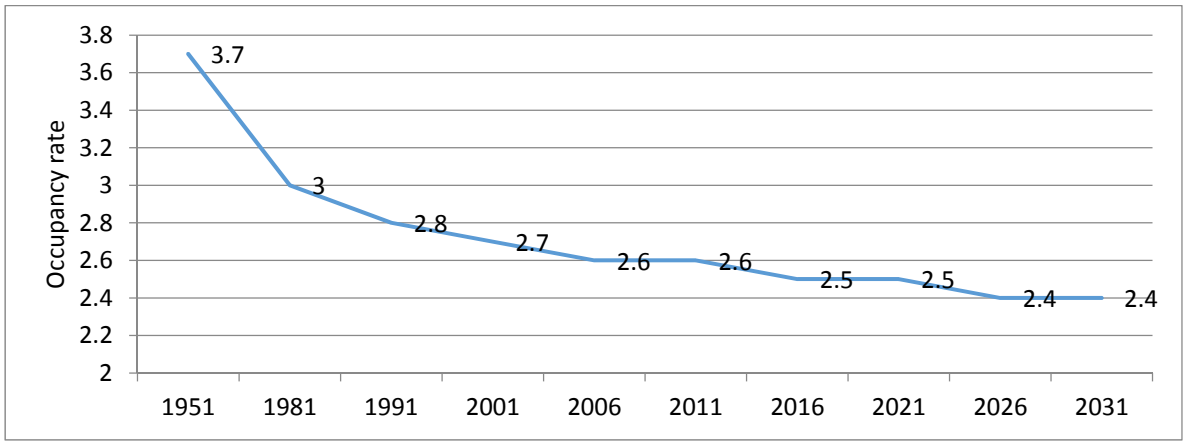


Figure 1.8 Average household size in New Zealand from 1951 and its projection until 2031 (Sources: Bates and Kane (2005) and Statistics New Zealand (2008))

Dwelling occupancy rate is the average number of people per dwelling. According to the Department of Building and Housing (2010) and based on series 5 national population projections, dwelling

occupancy rate has continued to decline from 2.8 persons per dwelling in 1991 to 2.7 in 2006, and is projected to fall to 2.6 in 2015, 2.5 in 2026, 2.4 in 2034, 2.3 in 2046, and less than 2.3 by 2061. These figures combined with the data on house sizes above indicate that while houses are increasing in size, the number of occupants is projected to decrease meaning there will be big houses with few residents or as Marriage (2010:1) says: "we are now housing less people, in larger houses".

1.7. Affordability and New Zealand house size

One of the problems raised by large housing is that inevitably such houses are more expensive, which affects housing affordability. Statistics New Zealand (2014h:10) state that "affordable housing exists where no more than 25 to 30 percent of household income is spent on mandatory housing costs (i.e. rent/mortgage payments as a proportion of income)". Based on a survey by Demographia (2016) of housing affordability in 9 metropolitan markets (Australia, Canada, China, Ireland, Japan, New Zealand, Singapore, United Kingdom and United states) and using data for the 3rd quarter 2015, after China (Hong Kong) and Australia, New Zealand has the most unaffordable housing market among the surveyed countries. In terms of unaffordable housing Auckland ranks 362th internationally with the median house price of $748,700 compared to the median household income of $77,500. Demographia (2016) assesses housing affordability by dividing the median price of a house by the median household income. In 2015 the result for Auckland was 9.7 meaning that a typical household in Auckland would have to pay 10 years of income to buy a house.

In addition, Demographia (2016) categorised national housing markets into affordable, moderately affordable, seriously unaffordable and severely unaffordable and New Zealand is in the last category. A report by Department of the Prime Minister and Cabinet (2008) indicates the "real house price" increased by 80% from 2002 to 2008 and the rate of home ownership has also decreased by 4.5% from 1981 to 2006. Demographia (2014:5) also reports that none of the surveyed countries with a severely unaffordable housing market have a "liberal land policy" and "the central government of New Zealand has recognized the problem and is pursuing strategies to open up land supply and reduce housing

costs." However, neither of these reports discusses the issue of large housing. The latest Demographia survey (2016) ranks Auckland as having the fourth-equal most unaffordable housing market in the world (behind Honk Kong, Sydney and Vancouver).

On the other hand, in most parts of the world the house is the most important capital asset for families. The same report from the Department of the Prime Minister and Cabinet (DPMC) (2008:3,13) stated, "Housing makes up just over 70% of household net wealth…net wealth per capita doubled between 1980 and 2001 and doubled again from 2001 to 2006 as a result of house price boom". While this situation seems good for wealthy families, it has led to difficulties for renters and people who want to buy their first home. Though new construction is meeting part of the housing demand, as the report notes, this new supply is in the form of large and expensive houses and has not met the demands of lower income people. These larger houses indicate "larger returns to builders" as well as "declining affordability for people on lower incomes" (DPMC (2008:41)).

The DPMC (2008) relates high house prices to the high increase in land price and cost of materials and labour, with land having the highest rate of increase of 115.4% from 2001 to 2007. Reference is made to a study by the Department of Building and Housing, comparing the costs of building 145m^2 and 202m^2 houses, which indicates building cost has increased more for the former from 2001 to 2007, with the "higher concentration of service areas" in small houses given as the main reason for this.

Although house prices can be reduced in different ways, the DPMC (2008:5) states "lower costs of sections and construction are the most likely way of achieving a long-term reduction in housing costs". While house size can play an important role in house price decrease it is usually ignored, and as Easton and Saville Smith (2008:7) state, "where affordability is a consideration, the default response appears to be to deliver cheap low quality housing, rather than to design to high quality, but smaller dwelling sizes".

What may be happening in New Zealand is that builders will build larger houses but decrease the overall price by moving the location of new houses to outer suburbs where land is cheaper. This brings

its own problems for the overall sustainability of society, as often this means households have no other option than to drive to access everyday needs.

1.8. Summary

This Introduction has set out the background behind this research into the resource implications of large housing in New Zealand. The aim has been to show that new houses are increasing in size at the same time that average household size is decreasing. The new, larger houses have more bedrooms, bathrooms, specialised rooms and garage and parking spaces but as yet there has been very little international research into the resource implications of these, and none in New Zealand. Chapter 2 reviews relevant literature for further confirming the gap in knowledge and the possible ways of setting up this investigation.

2. Literature review

2.1. Introduction

As discussed in chapter 1, living in large houses has become common in many developed countries including New Zealand. This phenomenon can be examined from many different viewpoints but this research is focussed on resource-use and occupant behaviour. Before designing the research, it is important to know what other researchers have investigated and where the potential knowledge gap lies. As a result, this review of the literature in this field has been organised into seven categories (overcrowding, regulations, occupant behaviour and energy consumption, psychological investigations, sustainability, life-cycle assessment, and time-use). In addition to the literature reviewed in this chapter some is discussed in the relevant chapters as needed.

2.2. Overcrowding

It may seem strange to start research into large housing by looking at overcrowding, but the relationship between the number of people living in a house (household size) and house size has been studied in order to determine when a house becomes overcrowded, and potentially an unhealthy place for its occupants. According to Statistics New Zealand (2014g):

> *"Household crowding is a theoretical concept about the acceptable number of people per household. Crowding in households relates to situations where the number of people residing in a household exceeds the ability of the dwelling to provide adequate shelter and services to its members."*

Crowding indices are tools used to measure the level of crowding in the household. Internationally, there are six common indices: The American Crowding Index (ACI) or People Per Room (PPR), Equivalised Crowding Index (ECI), Canadian National Occupancy Standard (CNOS), British Bedroom Standard (BBS), Occupancy Rating Standard, and People per Floor Area Index (Goodyear et al., 2011). The ACI is the most popular index while a version of CNOS is used by Statistics New Zealand and in Australia and seems to be the best fit for the New Zealand situation (Goodyear et al., 2011). Crowding indices are usually

calculated according to the number of residents, number of rooms, type of room, sex of residents, and age of residents (Goodyear et al., 2011).

Apart from the People per Floor Area Index, the other crowding indices consider the number of rooms or bedrooms when measuring house size and also different age/gender conditions for sharing bedrooms. Table 2.1 compares three popular crowding indices, showing the number of rooms/bedrooms is a key parameter in all, which suggests an inaccurate count of these could lead to misleading crowding rates. Crowding indices are mainly used for measuring overcrowding although they can also help in measuring under-use of houses, which in turn could link to under-use of the resources and energy that go into housing. However, while crowding indices are designed for measuring overcrowded houses, they are not focussed on measuring the level of under-utilization in large houses.

Crowding index	**House size basis**	**Which pairs should share a bedroom?**			**Age which needs separate bedroom**	**Crowding condition**				
		Couples	**Young children of any gender if**	**Children of same gender if**		**Crowded**		**Not crowded**		
ACI	Rooms	NA	NA	NA	NA	Severely crowded	Crowded	Not crowded		Underutilized
						1.5<PPR	1<PPR<=1.5	0.5<PPR<=1		PPR<=0.5
BBS	Bedrooms	Yes	Age<10	Age<21	Age>21	Overcrowded		Equal to standard	1 above standard	Under-occupied
						1+ extra bedrooms		0 extra bedrooms	1 extra bedrooms	2+ extra bedrooms
CNOS	Bedrooms	Yes	Age<5	Age<18	Age>18	2+ extra bedroom needed	1 extra bedroom needed	No extra bedroom needed, none spare	1 bedroom spare	2+ bedrooms spare
						Crowded		0 extra bedrooms	1 extra bedrooms	2+ extra bedrooms

Table 2.1 Comparison of 3 crowding indices (based on data from Goodyear et al. (2011))

As seen in Table 2.1, the three crowding indices are dependent on the number of rooms or bedrooms as a measure house size, hence knowing what is defined as a “room” and “bedroom” is important. It is common for scientific studies and national statistics centres, including Statistics New Zealand (n.d.), the United States Census Bureau (n.d.-b) and Australian Bureau of Statistics (n.d.), to use the number of rooms in a house as an indicator of house size. Statistics New Zealand (2014k) defines a room as a habitable space if it is enclosed by walls, has a floor and ceiling and is covered by a roof, and has a minimum height of 2m and floor area of 4m^2. Service areas including pantries, toilets, bathrooms,

laundries, spa-rooms, walk-in wardrobes, hallways, corridors, verandas, and garages are excluded even if they meet all other criteria. The kitchen, living room and dining room are counted separately even where these are combined in an open plan layout (i.e. a combined living room/dining room/kitchen is counted as 3 rooms).

Statistics New Zealand (2014k) defines a room as bedroom if it is used, or intended for sleeping. A room is considered to be a bedroom if it is furnished as such, even if it is not being used at the time of the data collection. A furnished bedroom should include sleeping facilities such as a bed or mattress, and could include items such as a dresser and chest of drawers (Statistics New Zealand, 2014k). A room such as a living room that is used as a bedroom at night, either short–term or long–term, should not be counted as a bedroom unless it forms the only bedroom facilities in the dwelling. The definition of bedroom by the United States Census Bureau is quite different as "a room built as a bedroom, although not used for that purpose, such as a room meant to be a bedroom but used as a sewing room, is counted as a bedroom" (Eggers & Moumen, 2013:3). Unlike the US, the definition of a bedroom in New Zealand is highly dependent on how it is furnished.

When considering large houses, three concerns regarding the accuracy of room and bedroom standards as tools for measuring house size in crowding indices emerge. The first problem is that specialized rooms such as a study/office/library, games room/rumpus room/gym, play room and studio/workshop are counted as a room in the room standard but not considered as bedroom(s) in the bedroom standard. For instance a house with 3 bedrooms, 1 study and 1 games room will be counted as a 3 bedroom house as will a house with only 3 bedrooms and no specialized rooms although the size and floor area of the two houses could be quite different. The second problem is the presence of multiple bathrooms (including en-suites) and walk-in wardrobes in new NZ houses. Service areas are not counted either as rooms or bedrooms in room and bedroom standards. Investigations show some new NZ houses have en-suites as large as 14m^2 (Navigation homes, 2015), walk-in wardrobes as large as 9m^2 (House plans, 2016a) and laundries as large as 17m^2 (William Pearson & Associates, 1979b), meaning some of these

service rooms are bigger than a bedroom, but are never considered in room and bedroom standards. The third problem is inconsistency between different countries when discussing house size and crowding. According to the Housing Statistics for European Union 2010 (Dol & Haffner, 2010) the average floor area of UK houses is 82.7m^2 compared to 196.8m^2 for New Zealand in 2008 (Statistics New Zealand, 2014i) while on average a New Zealand house has 6.3 and the UK house has 4.7 rooms. A comparison of figures for both countries reveals that while the average number of rooms in NZ houses is 34% more than the UK, the average floor area of NZ houses is 71% more than the UK, indicating the number of rooms is perhaps not a good tool for comparing house size between countries.

Crowding is important because there is clear evidence of relationships between overcrowding and physical/mental health (Gray (2001), Shelter (2007), Harker (2006), Reynolds et al. (2004), Reynolds and Robinson (2005), Friedman (2010), and Office of Deputy Prime Minister (2004)) and educational achievement and childhood development (Office of Deputy Prime Minister (2004), Morris and Easton (2008), Bennett et al. (1992), Harker (2006), Reynolds et al. (2004), Reynolds and Robinson (2005), Murray (1974), and Friedman (2010)). Studies also show that living in crowded houses can lead to negative social outcomes including crime, unsustainable family relationships, and delinquency (Reynolds and Robinson (2005), Murray (1974), and Friedman (2010)). Finally, the literature in this field shows that children and minority groups (e.g. African ethnicities in the UK) are those more affected by crowded houses (Murray (1974), Statistics New Zealand (2012), Friedman (2010), Reynolds et al. (2004), Reynolds and Robinson (2005), Harker (2006), and Office of Deputy Prime Minister (2004)).

Cultural differences are not seen in any of the crowding indices. A complementary document for Clause G5 of the New Zealand Building Code (NZBC) (Department of Building and Housing (DBH), (2011)) also states that the Canadian Crowding Index “does not account for social and cultural expectations”. Goodyear et al. (2011) state that for many households crowding is a consequence of “cultural preferences” and the case of New Zealand shows that European ethnicities are living in the

lowest and Pacific ethnicities in the highest levels of crowding. In England, Reynolds et al. (2004) found the overcrowding rate is different for different ethnicities as black and minority ethnics (BME) are over six times more likely to live in an overcrowded situation. Reynolds and Robinson (2005) also found that the percentages of overcrowded Black/Black British, Asian/British Asian, and Other/Mixed families are twice those of White British families. They also asked families about the causes of their overcrowding. As predicted, affordability was the most important parameter but interestingly "Need to live together" and "Need to live in this area" were the second and third important factors respectively, meaning that sometimes people live in crowded situations because they choose to do this.

Researchers have also investigated the impact of architectural features on crowding definitions. Mainly originating for small UK houses, these usually criticise the very tight limitations considered in various crowing indices, particularly those which are bedroom based. Robert-Hughes et al. (2011) investigated the size of UK homes and found that the available space in a dwelling impacts on the residents' privacy level, ways of preparing and eating food and dealing with waste and recycling, types of furniture and activities supported by that furniture, level of socializing with guests and family members, and storage space. All these issues relate to the design of the dwelling. The London Housing Design Guide (Mayor of London, 2010) also found that more space is needed in English houses for socializing, 'storage', 'personal activities', and better circulation, together with allowing for private study in bedrooms and working from home, space in the kitchen for children to play under parental supervision, for waste and recycling bins, improved daylight, and better ventilation. A joint study by CABE and Royal Institute of British Architects (RIBA) (2009) on the opinion of residents of the spaces in new UK homes found that additional space could allow families to eat and relax together, create stronger interactions between children and adults, and create better opportunities for privacy.

A study by Carmona et al. (2010) on the benefits of space standards, based on a literature review, concludes that living in homes with adequate space is linked with health and wellbeing and makes

family life better and provides better situations for children to study, which in turn is linked to their future productivity. Bigger houses can potentially provide space to work from home to "address the life-work balance" and also be more adaptable to different life stages and changing life styles. Bigger houses can reduce anti-social behaviours through reduced overcrowding and potentially make a "more stable housing market". The review by Carmona et al. (2010) thus argues for rather than against big houses, but fails to consider the resources bound up in them.

Other studies argue that existing crowding indices are not efficient and are therefore outdated (BSHF and Moreton (2013) and Harker (2006)). The BSHF and Moreton (2013:4) found that overcrowded definitions "…appear arbitrary and do not reflect differences in the way people use their homes". They also focused on finding the appropriate size, number of rooms and equipment for different groups of people based on people's perceptions. They found that perceptions of the size of internal spaces and total area of houses and sharing are very different from standards, regulations, and the BBS. According to their findings, crowding rates in the UK would be doubled if people's perceptions were taken to account. In addition, while most crowding indices use the number of bedrooms for defining house size, Robert-Hughes et al. (2011) found that the number was less important than their size, which is ignored in all crowding indices.

As discussed above overcrowding studies look at the impacts of living in houses smaller than needed by households. While most crowding indices are capable of measuring the underutilized and under occupied side of housing, they are seldom used for such and if so used may not be very precise at measuring underuse. In addition, there are many studies investigating the problem of small houses or houses with insufficient internal spaces. Most conclude that more space is needed for new homes and this extra space could improve life quality, mental and physical health, child education, and family relationships, but none say how big is big enough and there is no study on big houses or houses with more internal space than needed. In addition, the presence or absence of private outdoor spaces is

ignored in all crowding indices. Reynolds and Robinson (2005) found that access to a private outdoor space had a great influence on the effects of overcrowding for households in such houses.

2.3. Regulations

The second category of literature concerns regulations or studies on regulation and its effect on house design, and by implication its size. This part will look at international examples as well as those relevant to New Zealand.

2.3.1. International housing regulations

Based on findings of investigations into overcrowding many governments have regulations to prevent this. Carmona et al. (2010) state that while housing regulations in the 19th century were focused on morality and basic health, in the 20th century they are mostly focused on the well-being of families. Almost all regulations talk about minimums related to the number of occupants or bedrooms while affordability and the market are supposed to set maximums. According to the UK Housing Association Training and Consultancy (HATC) (2006) space standards differ between countries. For example, Belgium has a minimum gross habitable area per occupant, Denmark and Sweden have a minimum gross dwelling area, France has a net habitable area per occupant, Germany and Norway have minimum areas for rooms, the Netherlands has minimum habitable area for dwelling plus functional space standards for individual rooms, and Scotland has functional criteria and minimum space standards for some rooms.

The UK has one of the oldest housing standards, originally published by the United Kingdom Ministry of Housing and Local Government (1961) as *Homes for today & tomorrow*, and also known as the Parker Morris space standards. These were to reflect “New patterns of living” for that time, mainly based on family needs, activities, and types of appliances used in 1960s. This standard recommended minimum overall floor areas based on number of occupants for all house types with the recommendation to use minimum overall size instead of minimum room sizes based on functional requirements (Great Britain Department of the Environment, 1975). Unlike the original intentions, as

Carmona et al. (2010) and HATC (2006) have reported, these minimum Parker Morris space standards very soon became a maximum for housing. These standards were widely used in the UK up to 1980 when they were scrapped as mandatory by the government which "argued that the market would provide the right type and size of homes" (Robert-Hughes et al., 2011:12). Marriage (2010) believes that Parker Morris space standards are no longer very useful and sustains his claim by referring to Carmona et al. (2010:8) who say "the 'modern family' of the 1950s lives a very different lifestyle from the modern family of the 21st century".

The London Housing Design Guide (Mayor of London, 2010) is the most recent housing regulation in the UK. Like previous ones it is based on human activities and furniture but is also based on the needs of modern life, and considers the meta-physical needs of humankind. This design guide defines a minimum gross internal area based on the typology of the dwelling, number of bedrooms, and number of people living in it.

In contrast with studies trying to improve the minimum standards for residential buildings, there are recent efforts towards restricting certain groups of people when it comes to selection of size of house. The National Housing Federation (2013b) reported the UK government introduction of the "bedroom tax", "under-occupation penalty", or "removal of the spare room subsidy" for the social rented sector. According to this from 1 April 2013 working age households living in houses with spare bedrooms lose part of their housing benefit (National Housing Federation, 2013b). Spare bedrooms are counted on the basis of BBS, but carers, foster carers, disabled children, and parents of armed forces personnel who continue to live at home are allowed to have 1 spare bedroom in their houses (National Housing Federation, 2013b). Based on the Bedroom Tax criteria, households with one spare bedroom will lose 14% and those with two or more spare bedrooms 25% of their housing benefit-eligible rent. Based on government predictions the yearly clawback from this act will be about £480 million in 2014 increasing to more than £550 million by 2020 (National Housing Federation, 2013b).

Because of the mismatch between the available small houses in the social sector and number of small households, "the DWP [Department for Work and Pensions] has suggested that people could respond to the new size criteria by taking in a lodger to fill a 'spare' bedroom" (National Housing Federation, 2013b). Another report by the National Housing Federation (2013a) provides evidence that the bedroom tax does not work in Merseyside with its traditionally large houses and very few small ones, as it pushes poor people in England into more debt, separates families, makes problem for disabled people, and moves people far from their work places. The report estimates it would take nearly 6 years for all people in Merseyside to downsize. This study points out the danger of too many large houses in the housing stock especially at a time when populations in the developed world are aging (World Atlas, 2016), leading to more small one and two person households.

2.3.2. Housing Regulations in New Zealand

The *Housing Improvement Regulations 1947*, prepared by New Zealand Government (2013), is currently the only regulation on houses and housing in New Zealand. It was reprinted in 1950, 1975 (twice), 1979, 1985, 1989, 2009, 2011 and 2013 (New Zealand Government, 2013) and states that each house needs various essential spaces as well as sufficient windows and must also follow minimum dimensions and areas. There is also a limitation on the maximum residents in both the house and its bedrooms.

Based on this regulation (New Zealand Government, 2013) each house should have a living room, kitchen (or kitchenette), bedroom, bathroom and toilet (water closet). The presence of a place for washing clothes is mandatory for houses that can accommodate more than two persons. Each bathroom and toilet set can be used by a maximum of 7 persons and all members of a family can use one such set. If a house is not for a family there should be a separate toilet and bathroom for each sex. Based on certain conditions spaces might be multi-use:

- Spaces with an area not less than 14m^2 in new houses (and not less than 9m^2 in old houses) can be used as a combined living room and kitchen.

- A house used by a maximum of two persons can have a combined living room and bedroom if the combined space area is not less than 11m^2 for 1 person and 14m^2 for 2 persons but there should be a separate kitchen or kitchenette available.
- Usage of cooking appliances in bedrooms is not permitted (i.e. kitchen and bedroom cannot be combined)

There are also regulations for the minimum size and area of house spaces as listed in Table 2.2:

House space	Defined minimums for various parts of a house space				
	Width (m)	Length (m)	Height (m)		Floor area (m^2)
			For existing houses	For new houses	
Kitchen	1.5	NA	2.1	2.4	4.0 (for any number of residents) 3.0 (for maximum of two residents)
Bedroom	1.8	NA	2.1	2.4	6.0 (for new houses) 4.5 (for existing houses)
Living room	NA	NA	2.1	2.4	NA
Bathroom	NA	NA	2.1	2.4	NA
Water closet	NA	NA	2.1	2.4	NA

Table 2.2 Minimum dimensions of regulated house spaces according to Housing Improvement Regulations 1947 (New Zealand Government, 2013)

Housing Improvement Regulations 1947 (New Zealand Government, 2013) also have definitions for the number of people using a bedroom to avoid overcrowding (Table 2.3). A house of 2 or more dwelling units will be overcrowded if any unit fails to comply with the following standards and Table 2.2.

- If any two or more persons older than 10 years of opposite sexes who are not couples sleep in one bedroom.
- If the number of persons who sleep in a room exceeds the maximum number of residents in Table 2.3.
- In counting the number of persons in a room, children less than 1 year are not counted, children between 1 and 10 years are ½ person and more than 10 years old are 1 person.
- If the number of persons who sleep in a room exceeds the maximum number of residents permitted by the local authority law in some districts.

Floor area range (m^2)	Number of people allowed to sleep in the bedroom
0.0-4.5	0.0
4.5-6.0	0.5 for existing houses and 0.0 for new houses
6.0-8.0	1.0
8.0-10.0	1.5
10.0-12.0	2.0
12.0-14.0	2.5
14.0-17.0	3.0
17.0-20.0	3.5
20.0+	4.0 and 1 additional person for each additional $5m^2$

Table 2.3 Maximum number of people sleeping in a bedroom based on room area

The present housing standard regulation is very old and so most needs of modern life are ignored. For instance many facilities used in existing houses such as a microwave, fridge, freezer, washing machine, television, computers and desks are ignored. In addition, there is no regulation for parking spaces and no minimum dimensions for some rooms. While bedroom area would be a useful way of defining crowding rates, unfortunately, at present Statistics New Zealand does not collect data on the bedroom area of New Zealand houses and so there is no way of working out the rate of overcrowding in New Zealand houses according to the Housing Improvements Regulations 1947. On the other hand, the latter, like most similar regulations, only gives limits to prevent overcrowding and there is no limitation on "underutilization" or "spare bedrooms", meaning that people are free to live in houses as big as possible. The same thing occurs for room size.

According to the DBH (2011) the NZBC does not have regulations for total house area, although clause G5 of Interior Environment pays attention to the importance of adequate internal floor area for some rooms. Clause G5 (b) aims to "safeguard people from injury or loss of amenity caused by inadequate activity space" and under the functional requirements of clause G.5.2.1 (b) indicates that a "building shall be constructed to provide adequate activity space for intended use", but this is only for use for old people's homes. In addition clause G5.3.3 indicates "habitable spaces shall have sufficient space for activity, furniture, and sanitary and mobility aids" but again linked to the design of old people's homes. In the acceptable solutions of Clause G5 (DBH, (2011)) homes for old people shall have "spaces for living, dining, and sleeping" and a minimum acceptable dimensions as seen in Table 2.4.

Room type	Width (m)	Minimum floor area (m^2)
Living room	2.75	$10.0m^2$ + $1.0m^2$ for each resident over 3 in number
Dining room	2.75	$8.0m^2$ + $1.0m^2$ for each resident over 3 in number
Bedroom	2.20	$6.0m^2$ for each resident over 3 in number (excluding wardrobes)

Table 2.4 Minimum space dimensions and floor area for old people's homes based on NZBC (DBH, (2011))

In contrast, Auckland City Council does have space standards for apartments. Based on reports of new (2004) studio flats as small as $12m^2$ in central Auckland, the city council defined a minimum standard for flats in this area (Marriage, 2010). The practice notes (Auckland Council, 2011) refer to clauses G5.1 (b) and G5.2.1 (b) of the building code which state the importance of adequate space for occupant safety and the usability of space for intended activities. Marriage (2010) states this Auckland regulation is the only minimum standard in New Zealand. According to the City of Auckland district plan (Auckland Council, 2011) a minimum total floor area is defined for each type of flat and studio as well as for internal spaces like living rooms, kitchens, bedrooms, bathrooms, laundries, and balconies (Table 2.5). As seen in Table 2.5, total areas of studios and 1 bedroom apartments are respectively 50% of 2 bedroom apartments and 3+ bedroom apartments with the aim being to "promote flexibility in the mix of apartment types".

Room types	Flat type with minimum floor area (m^2) for each room			
	Studio	1 bedroom flat	2 bedroom flat	3-3+ bedroom flat
Living room	11.00	15.00	24.00	28.00
Kitchen	5.10	10.80	13.20	16.20
Bedroom 1	9.00	9.00	9.00	9.00
Bedroom 2	0.00	0.00	9.00	9.00
Bedroom 3	0.00	0.00	0.00	9.00
Bathroom 1	3.00	3.00	3.00	3.00
Bathroom 2	0.00	0.00	0.00	3.00
Laundry	0.84	0.84	1.26	1.26
Wardrobe (per bedroom)	0.36	0.36	0.36	0.36
Entry	0.72	1.08	2.16	3.24
Balcony	5.00	5.00	8.00	8.00
Total (rounded)	35.00	45.00	70.00	90.00

Table 2.5 Minimum floor area for different types of apartments in Auckland central (Auckland Council, 2011)

Housing New Zealand has published a series of design guides for new houses in New Zealand based on Housing New Zealand Corporation (HNZC) housing specifications, the NZBC (NZBC), and relevant NZ Standards. The design guides are a combination of recommendations and regulations for architects and contractors who want to design and build new houses or refurbish existing ones. These guides are

The Architecture Design Guide, The Pacific Housing Design Guide, and *The Maori Housing Design Guide*.

The Architecture Design Guide (HNZC (2002a)) has guidance on the size and number of spaces for new houses, stating that "New Zealand houses are getting bigger" and "designs need to respond to this trend". It also adds that New Zealand houses need adequate internal and external storages for "lawnmowers, bicycles, and sports equipment". This guide also recommends self-contained bathrooms and toilet facilities for extended families and an additional space for studying for families with children. It also acknowledges the importance of a private outdoor space that gets sun as "outdoor cooking is a part of New Zealand life".

The Pacific Housing Design Guide (HNZC (2002c)) aims to improve the understanding of architects, designers, and property developers regarding the major housing needs of Pacific people. It states that Pacific people live as extended families and their home spaces should be flexible, multi-purpose and large enough for several persons. A Pacific house consists of a formal space which is used for visitors and informal spaces which are used for family members, and they must be separate. Garages may be used for ceremonies and entertainment and so must be taken into consideration. Pacific houses need large kitchens as well as outdoor cooking spaces. Pacific people have special sleeping arrangements based on the age and sex of family members, as elderly and female members sleep inside and "sleep-outs" are used by male teenaged family members. There are also regulations for internal layouts mostly concerning the unacceptability of connecting the main entry and formal space with other informal spaces.

The Maori Housing Design Guide (HNZC (2002b)) states Maori people prefer living in low density residential developments with lots of open spaces for playing, gathering, and outdoor living. This guide recommends flexible design with more indoor/outdoor flow to reduce pressure on internal areas in Maori housing, and large bedrooms for more occupants. Connections between laundry, toilet, and bathroom with all food related spaces like kitchen, dining room, and living room as well as connections

between the main entry and private spaces (like bedroom, bathroom, toilet, and laundry) are not acceptable. The whanau or living room is a multi-use space for meeting, welcoming, and sleeping guests and should be large enough to accommodate as many as 20 people. Making bedrooms large enough to accommodate two or more children, or two adults is recommended. A large kitchen connected to a dining room and an outdoor kitchen are also important features of Maori houses. A double garage is a "cultural icon" and can serve as a sleeping place when needed.

According to these three design guides, while open plan living and cooking in outdoors are common features of all New Zealand houses there are big differences in the houses of different ethnic groups. Based on these three design guides, living in large groups and more privacy with an access hierarchy are the main features of Maori and Pacific houses. Unfortunately, while living in large groups seems to be a cultural feature of some ethnic groups, crowding indices lack cultural interpretation and may see these households as living in overcrowded situations. It seems more investigation is needed to find out how these different ethnic groups live in small and large houses and whether their cultural inclinations for sharing spaces have been influenced by house size or not.

Most countries in the world have regulations for housing but these only define minimums for house size on the basis of type and number of bedrooms, with the UK the only country to start controlling house size by introducing a bedroom tax, but only for social housing. The main housing regulation in New Zealand (Housing Improvement Regulations 1947) is very old and does not cover the needs of modern living and as Marriage (2010) states it is "a very low standard" and fails to define any minimums or maximums for housing. The only available minimum housing definition belongs to Auckland City Council for residential apartments although apartments do not represent a large group in the New Zealand housing stock.

2.4. Occupant behaviour and energy consumption

A large body of studies have investigated the role of occupant behaviour in domestic energy consumption. Several compare the role of occupant decisions with technological improvement in

energy or resource-use in the residential sector, with discussion about which is more important. For example, Guerra-santin and Itard (2012) found that occupant behaviour was the main reason for variations in the energy consumption of energy efficient houses, leading to the 'rebound effect' where people either take more comfort because they can afford it or spend the money saved on other energy consuming appliances, such as having more televisions. O'Callaghan et al. (2012) investigated the role of occupant attitudes toward the environment as an indicator of occupant behaviour towards resource-usage (and hence the environment) and compared this with technological factors in sustainable design (including solar water heaters, insulated walls, double glazed windows) and found that technological parameters were associated with an approximate double reduction in energy consumption compared to "pro-environmental attitudes" in a detached house, concluding technological parameters were more important than behavioural ones. Galvin (2013) investigated the role of behaviour regarding energy consumption in low energy dwellings and found big differences in energy consumption in the same apartments related to the different heating behaviours of the occupants. This study concluded that controlling energy consumption through the behaviour of heavy energy users is more useful than controlling general energy consumption behaviours.

A group of studies in this field refer to the uniqueness of occupant behaviour which makes it difficult to generalise solutions. Weihl and Gladhart (1990) investigated the role of behaviour in energy conservation at home through a series of continuous monitoring of thermostat setting, ventilation and hot water use using microprocessor technology and a separate interview with occupants. They found that though occupant behaviour regarding energy consumption is highly patterned and constant over time for a typical household, the pattern is widely different between different families. Based on this finding they doubt using the average behaviour of a population in energy conservation studies is meaningful. Their findings indicate that such occupant behaviour often appears "irrational or unexpected" and is highly influenced by "family schedules, occupancy patterns and comfort preferences" (Weihl & Gladhart, 1990:171), concluding that conservation programs aimed at making existing behaviours more efficient seem more successful than those aimed at changing behavioural

patterns. As their study used both occupant self-reported and monitored behaviour, it provides a good framework by which to compare both methods. They state that “occupants usually describe their family habits, schedules, and preferences very well but could not report details of actual behaviours with precision” (Weihl & Gladhart, 1990:178). By details of “actual behaviour” they mean things like thermostat settings. They also state that occupants know why and how they had set the thermostat better than the degree and time set points, although the latter will affect energy consumption.

One of the main issues reported in behaviour-based surveys is the potential for mistakes to occur in remembering a previous behaviour. To remove this, in a study of the role of occupant behaviour on the control of the indoor environment (lighting and heating) in Danish dwellings, Andersen et al. (2009) asked the participants to report the situation of the windows, heating, shading and lighting of the room they were sitting in at an exact time. For instance they asked questions like “Right now, is the heating on?” as well as other questions regarding the same behaviour during the previous 2 weeks (Andersen et al., 2009:12).

Guerin et al. (2000) reviewed the literature on occupant behaviour and energy consumption from 1975 to 1998 to identify the predictors of energy consumption and relate them to a theoretical basis. They categorised all influential parameters (such as age, income, physical size of house, comfort, motivations, weatherization) into natural (NE), social (SE) and design (DE) related indicators. They then used “human ecosystem theory” to examine the relationships between NE, SE and DE and human organism (HO) (Guerin et al. (2000) from Guerin (1992)). Guerin et al. (2000) state the interaction between the human organism and each element of these three indicators affects energy consumption at home. To find out the relevant importance of each, the predictors of energy consumption were categorised into two groups: energy-consumption behaviours, and energy-consumption change based on the available studies indicating a relationship between natural, social and designed environments. In trying to find the reasons behind existing relationships they stated:

"Human ecosystem theory suggests that we should look to other environments (DE and NE), the HO, and other variables within the SE to try to explain why this relationship exists. The model is there to direct our attention to the other investigative directions we should take… people make decisions that relate their attitudes to their actions, such as desiring to be comfortable and turning up their thermostat or installing a flow restrictor in the shower and then taking longer showers" (Guerin et al., 2000:71-72).

A group of other studies in this field refer to the significant role of occupant behaviour in energy-use simulation tools. Wei et al. (2013:37) investigated literature reviewing the role of "existing behaviour and factors that cause this behaviour" regarding space heating in residential buildings. They classified factors which influence occupant space heating behaviour into four groups (Table 2.6). Wei et al. (2013) also investigated the way data is given in space-heating modelling and found that though there are many influential factors (27) regarding this, only 5 are used in building performance simulation, which might lead to inaccurate outputs.

Environmental factors	Building and system related factors	Occupant related factors	Other factors
Outdoor climate (7S)	Dwelling type (7S)	Occupant age (14S/2N)	Time of day (9S)
Relative humidity (1S)	Dwelling age (3S/1N)	Occupant gender (2S)	Time of week (1S/1N)
	Dwelling size (1N)	Occupant culture/race (2S)	Occupancy (8S)
	Room type (8S)	Previous dwelling type (1S)	Heating price (2S/1N)
	House insolation (5S)	Occupant social grade (1S)	Energy use awareness (3S/1N)
	Type of heating system (3S)	Household size (4S/2N)	
	Type of heating fuel (1S/1N)	Family income (5S/4N)	
	Type of temperature control (9S)	Occupant educational level (1S/1N)	
		House ownership (3S/1N)	
		Thermal sensation (2S/1N)	
		Health (1S)	
		Perceived indoor air quality and noise (1S)	

Table 2.6 Factors influencing occupant space heating behaviour (based on data from Wei et al. (2013))

Note- **S** means supported and **N** means not supported. The number following S or N indicates number of supporting/not supporting studies. Highlighted items indicate significant factors supported by several studies.

Studies by Martinaitis et al. (2015), Blight and Coley (2013), and Motuziene and Vilutiene (2013) have also found evidence indicating the characteristics of occupants (including age, behaviour, number of times and length of time at home) have significant effects on house energy simulations. Martinaitis et

al. (2015) believe these tools suffer from less than accurate input information regarding occupancy patterns and Motuziene and Vilutiene (2013) and Wei et al. (2013) agree behaviour and occupant preferences can lead to a difference between predicted and measured energy use in buildings. It seems that little is known about where people spend their time in terms of the different rooms of their dwellings and many assumptions have to be made.

2.5. Psychological investigations

A number of studies have investigated the internal spaces of the home from the psychological point of view. Probably the most outstanding were gathered and edited by Canter and Lee (1974b) and those most relevant to this research are summarised below.

The first group investigated the possible relationships between furniture, the built environment and its function, and occupant behaviour. In a non-reactive study of room usage in modern Japanese apartments, Canter and Lee (1974a:48) found that furniture and its arrangement are among the decisions that enable people to "modify" and "contribute" to their "physical environment". In addition, people's decisions regarding furnishing provide "non-reactive psychological data" indicating "what people want, or expect, to happen in particular spaces" or in other words furnishings tend to define activities in spaces. By mapping the location of 43 furniture categories according to the frequency/similarity of the selected location pattern in 137 modern Japanese apartments, Canter and Lee (1974a) found two major groupings of spaces in these. The first grouping mostly indicates kitchen/dining rooms and the second "sleeping accommodation". They also investigated activities happening in different spaces within different types of apartment and found that dwellings with more rooms are "more functionally differentiated in each of those rooms" (Canter & Lee, 1974a:53). Of relevance to this study, Canter and Lee (1974a) suggested that domestic furniture arrangements can reveal room usage and that the physical environment can affect the "structure of behaviour setting".

In another study, Canter et al. (1974) investigated the effects of a focal point (assumed to be either the fireplace, TV or external view) and furniture arrangement on different types of activities in a living

room. The aim was to see the significance of focal points relative to furniture arrangement and certain activities. “Reading a book” and doing “physical activities” were respectively chosen to represent “passive” and “active” individual activities and “chatting to a friend” and “having a lively party” were respectively chosen to represent “passive” and “active” group activities. Rather than real environments, Canter et al. (1974:32) used “photographs of model rooms” and “scale plans of the same rooms” for their investigation. The plans and photos represented different furniture arrangements (different spacing of sitting positions) and different focal points (TV, fireplace and external view). Participants were asked to score each situation for each type of activity both from the furnished plan and the modelled photos. The analysis indicated that furniture arrangement and the presence, absence and type of focal point all have an effect on the different types of activity in the living room. They found that passive activities were scored low in rooms with a TV focal point while the situation was different for active ones, and the presence of a fireplace was not important for active activities like parties. In addition, an external focus seemed to be more suitable for passive activities, meaning that reading and chatting might happen better in the absence of a TV and fireplace (Canter et al., 1974). They also found that closer furniture arrangements were preferred more for passive activities while the reverse was true for active activities.

In another study, Edwards (1974) investigated differences between what architects anticipate regarding “activities and furniture” in a living room and how people really furnish their houses. The study was done on a frequently found local authority house-type, which had two separate spaces for living room and dining/kitchen, and which “enabled the families to use the accommodation in a variety of ways” (Edwards, 1974:39). A survey was made of 232 tenants living in these houses to discover how they had furnished their living rooms. The same survey was done by 50 “architects who specialised in local authority housing” and 28 out of these were also interviewed. Data analysis indicated that there was a big difference between the furniture layouts predicted by architects and how people used their houses. The interviews with participant architects about the reasons behind these big differences indicated that “architects are likely to rely on their own life experience” and designed their customers’

furnishing plans on the basis of their own lives, seldom using references indicating how people use or like to use their home spaces (Edwards, 1974:42).

Another study by (Canter & Tagg, 1980) examined the relationship between activities and physical features. They asked students to furnish 16 different spaces with 22 different types of furniture (Canter & Tagg, 1980). Spaces were different in size (small/large), roof form (flat/pitched), window (with/without window) and floor (with Japanese tatami mat/bare floorboards) and furniture was both Japanese and Western styles (Canter & Tagg, 1980). Analysis was done to show the most frequently occurring furniture in each space. The results indicated that Japanese furniture was mostly selected for spaces with tatami floor covering, and there were difference between small and large space, while "no systematic" difference was seen based on the presence of windows and roof form. Additionally small rooms were related to Western furniture while large rooms were related to Japanese furniture. Small rooms were also more related to furniture for sleeping while large rooms were more likely to be dining rooms, allowing them to conclude that "the furniture has specific implications for activities" (Canter & Tagg, 1980:16).

The second group of these studies investigated users' perceptions of built environment and architectural layouts. Canter (1972) investigated the behaviour of people in a ward that consisted of several distinct spaces within a children's hospital, through asking about the users' feelings. By analysing the participants' ideas about each space, descriptions and spaces were sorted into a diagram showing the rate of relationship between each space and each description. The diagram showed three distinguishable categories of spaces based on participants' feelings (Canter, 1972:554). When these three categories were aligned to the floor plan this revealed that these were very similar to the space categories in the floor plan. In other words, architectural boundaries are well described by people's feelings about spaces (Canter, 1977). (Canter, 1977:41) concluded the differences in people's feelings about two spaces can "help to explain the differences in behaviour which may be found in the two places".

In another study, Tagg (1974) investigated the subjective meaning of rooms in different types of buildings in an attempt to find out how the meaning of a room could be helpful for predicting people's responses to it and as a measure of "people's impressions of differences between rooms" (Tagg, 1974:65). First the meaning of different spaces in a home through the activities which normally occurred there was investigated to show the relationships between room names and activities. The analysis indicated that bedrooms had a "large activity range" while "specialised rooms" like bathroom, dining room and library had "small activity ranges".

Tagg (1974) then investigated the influence of building type on the meanings of the rooms within them, looking at 7 rooms in 7 types of buildings (hospital, church centre, town hall, night club, home, school and airport) making 49 spaces. A group of architecture students were asked to rate room types and building types on the basis of the three given scales of spaciousness, activity range, and pleasantness. The analysis indicated that pleasantness and spaciousness were more related to building type while activity range was more related to room type. (Tagg, 1974:70) concluded that the meanings of rooms were highly related to the "particular range of activities expected to occur in them" while the size of the activity range "indicates how undefined a particular situation appears", which is more dependent on room type than building type.

In another study, Canter and Tagg (1980) investigated classification of building aspects using empirical methods on the basis that something like the periodic table in chemistry is needed in architecture to help architects predict the outcomes of their drawings (Canter & Tagg, 1980). They asked respondents to score 20 pictures of plans and state their feeling about each space. Analysis then sorted the responses into three categories based on adjectives. The first category consisted of adjectives like characterful, interesting, impressive, fine, uplifting, common place good, active, lively, pleasant, beautiful, happy, bright, unexpected, sophisticated strong, status-ful and dignified. The second consisted of adjectives like tidy, harmonious, coherent, clear and stable, and the third adjectives like soft, feminine, welcoming and friendly (Canter & Tagg, 1980). In another part of this study they tried

to find the relationship between users' evaluation of spaces and physical attributes by asking teachers of a series of schools in Scotland to score five predefined feelings based on the physical aspects of a space. The results indicated that higher scores were mostly given to size and space between furniture while the answers to the question directly related to their work were completely different from others, meaning that people's feelings about different aspects of a space are highly related to their activity in that space. They also tried to find out the activities that could be classified in the space. In this part of the study, a group of students were asked to identify different activities they do in the different spaces of a home, resulting in 30 activities (Canter & Tagg, 1980). The analysis showed that living rooms and bedrooms covered a wide range of activities, with the latter having the greater range. They concluded that the activities happening in a space could be used for "predictions about the nature of life-styles and reactions to original house designs" (Canter & Tagg, 1980:12).

In a more recent study of this type, Ishikawa et al. (2011) investigated differences in the perceptions of people of house floor plans. They asked 94 males and females from different household sizes and different working situations in Tokyo to classify 48 house floor plans into as many groups as they thought appropriate (Ishikawa et al., 2011). The floor plans differed in terms of the number of bedrooms, overall shape, balcony area, access to bedrooms, and number of major directions for natural light.

The analysis indicated that participants could be classified into "the bedroom group, the shape group, and the access group", these being the groups who had respectively classified the plans based on number of bedrooms, external shape of the plan, and the access to the bedroom (Ishikawa et al., 2011). Further analysis indicated that "the percentage of housewives or part-time workers, all being female, was smaller in the shape group and larger in the access group" (Ishikawa et al., 2011:248). They relate this finding to the fact that connection of rooms is more important for people who spend more time at home and conclude that "how people spend their time in the house (or lifestyle at home)

might be a factor that influences the way in which people comprehend and evaluate floor plans" (Ishikawa et al., 2011:248).

The third group of psychological studies of relevance to this research are those discussing the effect of individual differences in the use of built environment. Brauer (1974) investigated the importance of individual differences in buildings from three different aspects. In a first step an open ended questionnaire was sent to occupants of family housing quarters in the US Army, asking for their "ideas or comments" about military family housing. Analysis indicated "wide differences in individual responses to similar housing conditions" (Brauer, 1974:105).

The second part of this study tried to find different behaviours and use of space among soldiers living in the same spaces, based on their individual differences. The survey was done on 2000 soldiers through a questionnaire asking them to report the time they spend in different facilities and buildings and again the same questions were asked about different parts of the barracks. The analysis indicated big differences between the time spent in each space on working days and weekends. In addition standard deviations were quite large when compared to means for the time spent in each space, indicating large differences between individual patterns of space use. Further analysis showed that the reasons behind these differences were mostly "demographic and background factors" (Brauer, 1974:107).

In the third part, he tried to investigate the matter as "as a function of personality" and asked participants to fill out a personality research form. Analysis of these, showed some correlations between aspects of individual personality and their preferences, noting some preferences had "design implications" (Brauer, 1974:107). In other words some aspects of personality lead to individual differences and different "responses to the built environment" (Brauer, 1974:107) based on which the recommendation was that individual differences should not be neglected and building designers should use "flexible design solutions that will satisfy a range of individuals".

2.6. Sustainability

Living in houses bigger than needed can be examined from four different sustainability viewpoints.

2.6.1. Use of natural resources

Living in large houses equates to using more natural resources. A useful tool for measuring resource-use is the Ecological Footprint (EF). According to Mithraratne et al. (2007:93) "the ecological footprint represents the area of biologically productive land and water required exclusively to produce the resources consumed, and to absorb the wastes generated, by a defined population, using the prevailing technology".

Rees and Moore (2013) report that currently the global human ecological footprint is 50% more than the total available productive land and water on the earth, meaning that humanity is using more natural resources than it should. The situation is even worse in developed countries and high-income cities, and these, as Rees and Moore (2013) state, are increasingly being scattered all over the planet. As an example, the total ecological footprint of Vancouver is 200-350 times larger than the physical footprint of the city and a similar pattern is also found in New Zealand, putting it among countries which need the resources of 3+ planets to sustain current lifestyles (Rees & Moore, 2013). They found rich people seem to be using resources as much as they can, as over-consumption of resources is the primary cause of "global degradation" and "the richest 20 percent alone have effectively appropriated the entire bio-capacity of earth and contribute most to its degradation" (Rees & Moore, 2013:4). They further state that extension of "global civilization" in the world needs wealthy countries to "reduce their per capita ecological footprints by up to 80 percent".

Dresner (2008:2) believes that "concern about sustainability must be based on moral obligations towards future generations - not just personal self-interest". This raises the question of whether rich people and rich countries should be allowed to use as much as they can afford of the available natural resources. Additionally, is there any balance between available natural resources and current human population growth, and what will happen if this "irreplaceable capital", as Schumacher (1973:13)

states, is exhausted? The answers are negative because as Rees and Moore (2013:12) state "while human populations and incomes are generally increasing, the earth's area of productive ecosystems is constant or even declining" and "the more people, the less we can each have".

Looking at these ideas, it can be concluded that the current large, new houses in most developed countries are very far from the concept of "fair earth-share" raised by Rees and Moore (2013), because more than 50% of the world's population is living below this level This situation is also very far from the Brundtland Commission's concept of "equity between generations" and "equity within generations" mentioned by Dresner (2008:2). Housing is one aspect of this trend because while many people in developed countries are living in houses larger than needed there are many people in underdeveloped countries and even in developed countries living in crowded situations.

Vale and Vale (2009) state that choices regarding buildings influence the consumption of energy and resources. They argue that size is one of these important choices as "smaller buildings need fewer resources to go into them, not only at the start but over their lifetime" (Vale & Vale, 2009:189). They refer to examples of large office buildings and office workers' houses which are not being used for a notable amount of time. They also compare the available floor area in the modern Melbourne Eco Home ($12m^2$/person) with an old house of the last century ($3m^2$/person) and state "this is all space that will need some form of energy to make it comfortable, and it is all space that requires energy and resources to make it" (Vale & Vale, 2009:131). They also argue that this trend in a "world where big is equated with good" will impact on energy and resources consumption which will lead to impacts on the environment (Vale & Vale, 2009:132).

The share of the total ecological footprint attributable to dwellings in wealthy nations is estimated to be 15-20% (Mithraratne, 2013), which is considered significant. Mithraratne (2013) states that construction, maintenance, demolition and use of the dwelling are important parameters in the dwelling footprint, although the latter is the most important phase of a dwelling's life and is estimated to make up to 89% of a dwelling's foot print (Mithraratne (2013) from WWF Cymru, 2005; WWF

Scotland, 2007). This suggests living in large houses is not sustainable and as Vale and Vale (2009:143) say "if sustainability is our goal…we should be aiming for the house with the smallest footprint, not the one with the largest number of bathrooms".

How the site of a houses is used in a sustainable way is also discussed by Vale and Vale (2009) as they compared a two-storey 100m^2 house within a 300m^2 plot area with a one-storey house with the same floor and plot areas, suggesting the available area of gardening in the former would supply the fruit and vegetables for a family. Mithraratne (2013:94) also believes that "having a smaller house could also be beneficial in increasing the area of the site available for growing food and generating energy on-site, which could further reduce the dwelling footprint".

2.6.2. "Lifetime" houses

Apart from house size, the frequent changes that occur several times over the life of a house to adjust it to its occupants' ever-changing needs is a potential waste of resources which is an unsustainable trend. Efforts in the field of sustainability are being made to persuade authorities and developers to design and build houses which can be used for longer times and which will accommodate groups of people from different age ranges and abilities. This concept is aimed at making houses more usable as their occupants age or even become disabled. This can also be seen as an extension of the idea of making better use of the resources that go into housing to avoid changing and updating dwellings.

Universal design is a term used in the United States and refers to the type of "design of products and environments to be useable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Mace (1998) in The Center for Universal Design (2006:2)). The universal design concept is aimed at all people from any age range and set of abilities as well as at all types of buildings. It also aims to cut the need for special designs for special people as they believe that special means expensive. Universal design in housing is trying to create spaces, sizes, doors and even house facilities that are usable by handicapped people, the elderly and children as well as normal adults (The Center for Universal Design, 2006).

Lifetime Homes is a very similar concept in the UK that sets regulations for space arrangement and space size and characteristics to make all houses usable for older and handicapped people, so that one house can be used for the whole period of a person's life (Habinteg, 2010). The concept was first developed by the Joseph Rowntree Foundation Lifetime Homes Group in 1991 but it is not obligatory in England (Davey et al., 2004). Davey et al. (2004) state that the Joseph Rowntree Foundation estimates "Lifetime Homes" standards save £5.5 billion over sixty years.

Lifemark housing is the same concept in New Zealand and was initiated by Lifetime Design Limited, a registered charity established by CCS (Crippled Children's Society) Disability Action. Lifemark has defined standards for New Zealand houses to make them usable for most people during their life time without needing to be adapted (Lifetime Design Ltd., 2012). Though Lifemark is mainly aimed at making houses more appropriate for older people its five principles of usability, adaptability, accessibility, safety, and lifetime value benefits people of all ages (Lifetime Design Ltd., 2012). Existing and new homes in New Zealand can apply for a Lifemark star rating which starts with three stars and ends with a five star Lifemark, which is a "fully accessible" home, based on points earned by achieving certain minimum required standards (Lifetime Design Ltd., 2012).

2.7. Life Cycle Assessment

2.7.1. Life cycle assessment studies

"Life Cycle Assessment (LCA) is a science-based, comparative analysis and assessment of the environmental impacts of product systems" (Klöpffer, 2014:2). Alcorn (2010) believes that efforts towards LCA studies started with the environmental awareness and energy shocks of the 1960s and 1970s. Life cycle assessment is useful tool for assessing the environmental impacts of the built environment in its many parts, resulting in a complex process (Crawford, 2011). LCA is useful for identifying which building phase is responsible for the highest energy use so it can be targeted in any strategy for reducing energy use (Ramesh et al., 2010).

Most life cycle assessment studies in the built environment have focussed on the technical aspects of the house and compared these for limited numbers of sample houses. Fay (1999) compared the life cycle energy of typical Australian dwellings including two attached, three semi-detached and three detached houses varying in overall floor area (82-146m^2). His study considered the embodied energy of the building materials (along with their maintenance and replacements over the life of the house), operation energy (including heating and cooling), and sanitary fittings, along with energy embodied in some selected appliance and furniture items. The results showed the embodied energy of these houses varied between 10.1-14.1GJ/m^2. Further analysis showed that variations between different houses were mainly rooted in thermal mass, insulation and dwelling type. Calculating the life cycle energy of these houses after 100 years found that insulation, thermal settings and dwelling type ranked the most important parameters responsible for variations between houses. Similar studies have been conducted in other countries including Sweden ((Adalberth, 1997, 1999) and (Adalberth et al., 2001)), Scotland (Asif et al., 2007), Switzerland (Citherlet & Defaux, 2007), US (Van Geem & Marceau, 2006), France (Peuportier, 2001) and Indonesia (Utama & Gheewala, 2008).

While some studies, including that of Fay (1999), have considered case study houses of differing sizes, because of the many influential parameters affecting LCA the real impact of house size has been less investigated. For instance, Fuller and Crawford (2011) in a LCA study of the impact of past and future Australian residential development patterns on energy demand (and other related emissions) compared typical Australian house types from 1950, 1960, 1970, 1980, 1990, 2000 and 2008 along with 3 possible housing options (high-rise inner-city apartment, outer-suburban detached housing and inner-suburban medium-density apartment) for Melbourne 2030. Variations in energy consumption, building materials, insulation level and average size of each houses in each period was considered in their analysis. The results showed that the inner-suburban residents could decrease their total annual energy consumption by 40-50% through using public transport, which was a greater reduction than from altering the dwelling. Again because many parameters (including transportation) were considered, the real impact of house size was hidden in this study.

In another study with a focus on the impact of house size, Fuller et al. (2009) compared a typical Australian house of the 1950s (floor area 95.0m^2) with a typical 2009 Australian house (floor area 233.5m^2) to see the impact of house size on embodied energy and water-use and discover "what is wrong with the big house?". They assumed similar building materials for both houses apart from replacing the weather boards of the 1950s by softwood cladding in the 2009 house. The results showed that the embodied energy and water of the 2009 house had increased by 113% and 161% respectively. By considering the reduction in occupancy rates between the 1950s and 2009, the embodied energy and water per capita of the 2009 house had increased by 215% and 287% respectively. This study concluded that while due to technological improvements, the operation energy of the 2009 house was less than that of the 1950s house, because of the increased size the overall embodied energy of the 2009 house was much bigger. Fuller et al. (2009) go on to say that their results are an underestimation because many modern Australian houses are larger than the selected sample, and require more energy for maintenance, and appliances and furniture (which are estimated to be more in larger houses). Appliances and furniture were not included in the LCA.

2.7.2. Life cycle assessment studies in New Zealand

Alcorn (Alcorn, 1996, 1998, 2003) investigated the embodied energy of New Zealand building materials and has published updated data in 1996, 1998 and 2003. He developed an input-output method (Baird & Chan, 1983) into a process analysis method (Alcorn, 1996) and finally a hybrid analysis (Alcorn, 2003). The results culminated in his PhD thesis (Alcorn, 2010) in which he aimed to develop a method for measuring the sustainability of samples of New Zealand houses from the 1970s, 2000s, 2010s, and 2020s, using the embodied energy of construction and operating energy for each house type, and where lower levels of overall energy and associated CO_2 emissions were considered to be more sustainable (Alcorn, 2010). Alcorn's analysis did not include plumbing and electrical works, or furniture (Alcorn, 2010).

Based on Alcorn's embodied energy data two more studies have looked at the embodied energy of New Zealand houses. Mithraratne et al. (2007) calculated the embodied energy of a typical 94m^2 New Zealand house for three different types of construction: light, heavy, and super-insulated, using the data set provided by Alcorn and Wood (1998). Unlike Alcorn (2010) this study includes plumbing and electrical works based on the similar study in Australia by Fay (1999). Mithraratne et al. (2007) also considered the embodied energy of selected furniture and appliance items for two different sized houses (146m^2 and 194m^2) and compared the results. This showed the embodied energy of the building materials per square metre decreased for larger houses because there were fewer interior walls. Mithraratne et al. (2007) also considered the useful life of building components and operating energy and compared the life-cycle energy consumption of each house for 0, 25, 50, 75 and 100 years.

The second study by Vale and Vale (2009) compared the embodied energy of materials in typical 100m^2 and 200m^2 New Zealand houses with walls of timber frame with brick veneer, straw bale, and straw stabilized adobe block. They also considered maintenance and operating energies to give the life cycle energy over 50 years. Like Mithraratne et al. (2007), Vale and Vale (2009) considered the embodied energy of plumbing, electrical works, and kitchen fittings and large appliances. They state that larger houses need more land and construction materials, resulting in more natural resources use. These natural resources could be materials such as wood, which is grown, harvested and processed, or manufactured materials like ceramics which need more energy for their production. Vale and Vale (2009:134) refer to "energy embodied in materials, including all the energy needed for their extraction, processing, transport, use and (ideally) disposal" while the land covered by a large house could also be used in "more productive ways". They conclude that living in smaller houses is the quickest and simplest way to reduce the embodied energy of housing.

A comparison between existing UK 100m^2 houses with energy efficient houses of the same area by Vale and Vale (2009) indicates that embodied energy as a percentage of total for the latter is nearly twice that of the former, meaning that eco houses use more embodied energy, which is related to the

additional materials, such as insulation, used in such houses and again shows the priority of reducing house size over technical solutions.

Furniture and appliances are inseparable parts of housing although only a few studies have considered the impact of these. Vale and Vale (2009) state that larger houses need more resources to fit them out with furniture. They compared a 200m^2 and 100m^2 houses with the same embodied energy of 5.5 GJ/m^2 and found that the latter has 137GJ embodied energy saving in furniture and appliances from having a smaller size (Vale & Vale, 2009). "Larger houses also tend to use more lighting, appliances, and so on, leading to further increases in lifetime energy" (Mithraratne, 2013:94). Mithraratne et al. (2007) state that the problem with furniture in modern lives is that it has become "fashion" item rather than a "valuable" item so is not built to last for years but rather to be replaced by new furniture based on new fashions.

Operating energy could also vary between small and large houses. Vale and Vale (2009:132) referring to New Zealand houses state "larger houses use more energy per m^2 than smaller ones". Mithraratne (2013) also refers to house size based on previous studies in New Zealand and states that "with 55 per cent and 100 per cent increase in floor area, the lifetime energy increased by 37 per cent and 79 per cent, respectively" (Mithraratne (2013:93) from Mithraratne et al. (2007)).

Some spaces in the house (e.g. bathrooms) have high embodied and life cycle energies due to the types of material used in their construction, or fittings need to support their function. Vale and Vale (2009) state that larger houses have larger (and usually more than one) bathroom and need a larger or even more than one hot water storage cylinder (where these are used) leading to more energy consumption. They also state that larger bedrooms have more embodied and operating energy over 50 years and the presence of more than one bathroom leads to even more embodied operating energy over 50 years and more environmental impact as they would be less shared.

In addition, maintenance of existing houses also needs energy and in the use phase larger houses need more lighting, heating and appliances. "Energy use is the main contributor to the use phase footprint

of dwellings" (Mithraratne, 2013:85). Mithraratne (2013) mentions many ways to decrease energy consumption in the home, such as switching off unneeded appliances, using more energy efficient appliances, and insulating the building envelope. Mithraratne (2013:92) states that while "new constructions represent less than 2 percent of the total stock" most global efforts are focussed on making new constructions more efficient".

Rees and Moore (2013) state that a 62% reduction in the operating energy of buildings in Vancouver would reduce the ecological footprint of building components by 50%. Studies by BRANZ (Isaacs et al., 2010) indicate that typical estimated monthly winter energy costs of dwellings increase with an increase in the dwelling's floor area. The same study indicates that for households of the same size typical energy costs also increase with increasing floor area (Isaacs et al., 2010), meaning that from an energy cost view point living in a small or large house really matters. An investigation in the Netherlands by Guerra-santin and Itard (2012) also indicates a positive relationship between energy consumption and number of bedrooms in dwellings built after 1996. Collectively these studies show the usefulness of LCA as a tool for investigating the impact of houses, and that size is important when it comes to environmental impact.

2.8. Time-use studies

2.8.1. International time-use studies and their methodological approach

Many different aspects of human behaviour have been studied in the social sciences although "the use of time as a basis for studying social behaviour is a relatively recent development in the social sciences" (Chapin, 1974:3). Niemi (1995) believes studies of family budget to be the origin of time use surveys. "The accounting method used for research on living conditions among working class families in England and France at the end of the nineteenth century developed into a time budget or time use research tradition in which people's behaviour is measured in terms of their use of time in hours and minutes" (Niemi, 1995:2). According to Fleming and Spellerberg (1999) the countries of Australia, Canada, Finland, France, Germany, Italy, New Zealand, Norway, Sweden, Japan, Austria, Bulgaria,

Denmark, Finland, Hungary, the Netherlands, Norway, France, Poland, Hungary have all undertaken some sort of time-use survey. Time-use surveys have also been traditionally used for "studies of population trend", "studies of living patterns within and between countries", "studies of quality of life", "distribution of paid work and household activities", "people who provide care", "voluntary work", "labour market participation", "activity patterns of specific population groups", "urban planning", "leisure activities" and "national development issues" (Fleming & Spellerberg, 1999:11-16). The same authors believe that in modern life, these surveys can also benefit "the policy context", "measuring non-market production" and "studies of the distribution of household work" (Fleming & Spellerberg, 1999:17-23). Data from time-use surveys can be used in many research areas including "labour market research", "aging studies", "carers and volunteers", "children and young people", "leisure studies", "psycho-social studies", "housing and town planning" and "sustainable consumption within households" (Fleming & Spellerberg, 1999:27-32).

Time-use studies collect data about where and for how long people spend their time. These studies can also say with whom this time has been spent. Most time-use studies rely on a time-use diary for data collection. Robinson (1988:2085) defined this as a "technique for collecting individual level data on human behaviour in an open-ended fashion on an activity-by-activity basis". Robinson also introduced multi-facet time-use diaries which collect additional data on the place of activity, accompanying persons, and the psychological state of the person doing the activity, as well as the time spent (Figure 2.1). Robinson (1988) believed that open ended diary surveys could provide generalizable aggregate data on a wide range of daily behaviour and would help to predict when and where particular activities were more likely to happen.

Time-use studies have had different aims including measuring occupant exposure to indoor/outdoor pollutants (Dörre (1996), Briggs et al. (2003), Denman et al. (2000), Steinle et al. (2013), Broich et al. (2012), Schwab et al. (1990), Yoon et al. (2012) and Wu et al. (2011)) or for public policy, human wellbeing or welfare (Committee on National Statistics, 2000). Depending on the target of the study,

they are either location or activity based although as mentioned before data can be collected on both. For instance, the time-use diary of Robinson (1988) (See Figure 2.1) is an activity based one and is generally known as time-use activity study. In contrast, studies that measure occupant exposure are location-based and are called time-use microenvironment studies. An example of the diary used for such studies is shown in Figure 2.2 which is an occupant exposure to pollutant materials study by Dörre (1996).

What you did from midnight until 9 in the morning

Time	What did you do?	Time Began	Time Ended	Where	List Other People With You	Doing Anything Else?	Enjoyment On a Scale of 1-Dislike -1, Like -
midnight		12:00					
1 AM							
2 AM							
3 AM							
4 AM							
5 AM							
6 AM							
7 AM							
8 AM							

Figure 2.1 Sample time-diary used in the 1985 National Study of American's Use of Time project (Robinson, 1988)

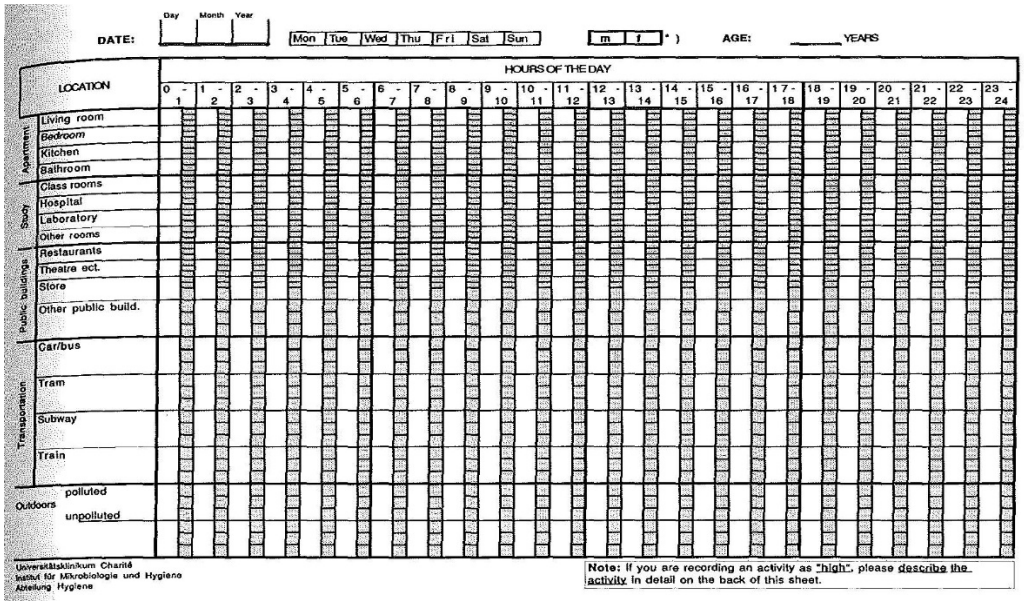


Figure 2.2 Diary form used by Dörre (1996)

While most time-use studies are either paper or telephone-based surveys, new technology including online surveys have also been developed and used by some researchers. In a study by Wu et al. (2012)

participants were asked to take part in a web-based survey which covered weekdays and weekends as well as different seasons. For both surveys parents were responsible for completing on behalf of their children. Two different types of web-based survey were designed. The first was a "calendar-style" (Figure 2.3) asking people to select an activity among offered options for each of the 24 hour cells (Wu et al., 2012). This method gave participants a chance to review their daily report and edit it if needed.

Participants claimed that the "calendar-style" method was confusing and so Wu et al. (2012) designed a "dialogue-style" way of reporting (Figure 2.4) and changed their method as the survey progressed. In the "dialogue-style", which was similar to the telephone-based survey, participants were asked to recall their very first activity at midnight and then the survey asked them for the location and details of that activity as well as its end time. This continued for the next activity and so on until the end of the day (midnight) was reached again. Though this method did not give participants the option to review and edit their daily report, they were more satisfied with it.

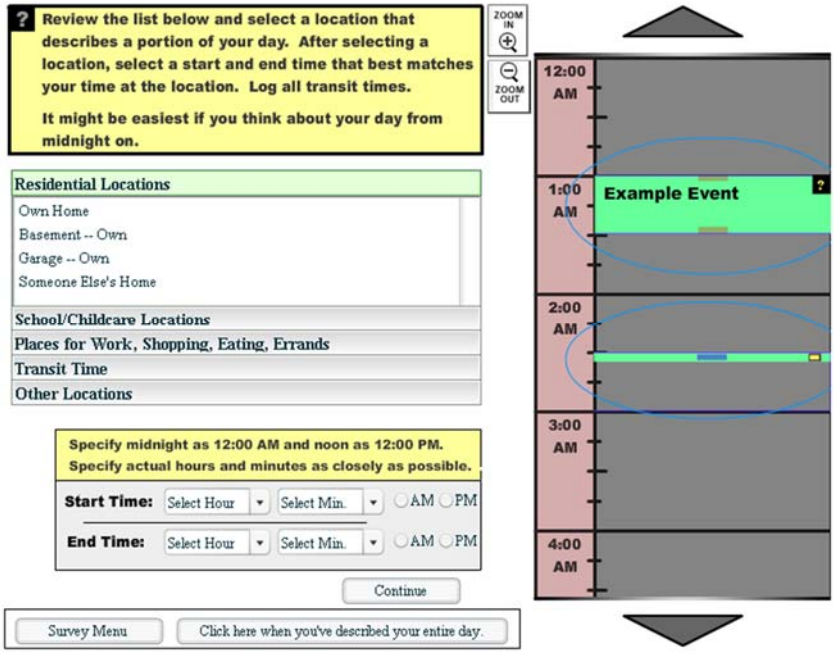


Figure 2.3 Calendar–style diary used in a web-based method (Wu et al., 2012)

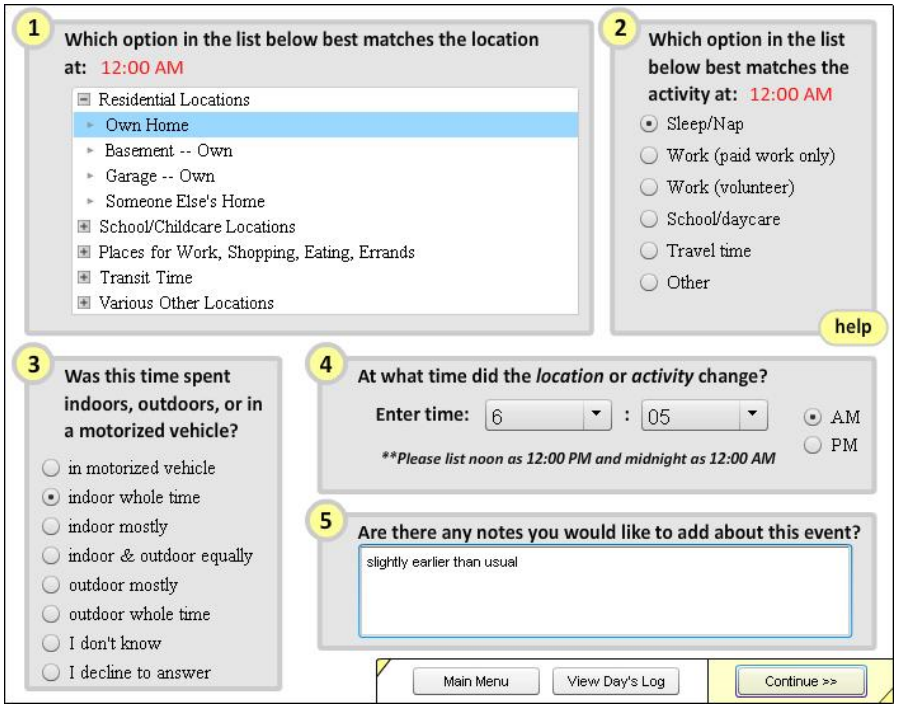


Figure 2.4 Dialogue-style diary used in a web-based method (Wu et al., 2012)

There are always discussions in time-use studies about the number of days needed for reliable results. EUROSTAT recommends a two-day diary including one weekday and one weekend day in their guidelines (Glorieux & Minnen, 2009). Some researchers believe short-term time-use surveys do not provide valuable data while a group of researchers have found indications that long-term surveys do not necessarily lead to more precise data because the quality of data decreases as the survey goes on (Glorieux & Minnen, 2009). Other researchers believe short-term surveys can also provide reliable and useful data and are easier and cheaper to do (Glorieux & Minnen, 2009).

Glorieux and Minnen (2009) tried to compare these two different viewpoints by comparing results of two days of a 7-day time-use survey with the original results of the 7-day one, using data from two 7-day time-use surveys in Flanders, Belgium in 1999 (1474 respondents) and 2004 (1780 respondents). They selected one random weekday and one random weekend day out of 7 investigated days to compare the results of these with those of the main 7-day survey for the same respondents. Analysis showed that the 7-day survey provided lower levels of measurement errors and more stable estimates, although with differences according to the nature of the activities. For instance, for daily and personal activities (i.e. sleeping, education) the results of both types of survey were comparable

while big differences were seen in social activities (i.e. shopping, sports, and recreational activities). Glorieux and Minnen (2009) relate these to the cycle of activities and state that short-time surveys can easily capture daily-cycle activities but not weekly-cycle activities. To compare the quality of the data from each method they selected three parameters as indicators of data quality. These were the number of activities reported each day (more activity equates with more precise data), the amount of unspecified time each day (more unspecified time equates with less precise data) and the number of activities that started and ended at rounded times of half hour or an hour i.e. XX:00 or XX:30 (more rounded start/ending times equates to less precise data). Analysis showed that for most parameters, longer surveys do not necessarily lead to more precise data as the change rate was very small for the first and third parameter. Overall, Glorieux and Minnen (2009) conclude that surveys with longer observation periods provide better and more accurate estimations although there is no indication that short surveys provide lower quality data. They finally recommended using 7-day surveys for capturing better estimations of relevant social activities on a weekly-cycle.

2.8.2. Time-use studies in New Zealand

Like other developed countries, the New Zealand government also conducts time-use studies which are organised and managed by Statistics New Zealand. By 2016, Statistics New Zealand had conducted two national time-use surveys in 1998-1999 and 2009-2010.

The most recent New Zealand time-use survey is 2009-2010 (Statistics New Zealand, 2011d) which was conducted from September 2009 to August 2010 with 9159 individual respondents aged 12+, each of whom filled out a time-use diary for 2 consecutive days (Statistics New Zealand, 2011e). This survey used a combination of face-to-face computer-assisted interviewing and self-administered questionnaires. According to Statistics New Zealand (2011e) the time-use diary asked questions about:

- The activity the respondent was doing
- The start and finish time of each activity
- The physical location of each activity

- The person accompanying the respondents during the activity
- If an activity was for an unpaid work then who that was done for

According to the user guide of the 2009-2010 time-use survey published by Statistics New Zealand (2011e), the following objectives were considered:

- *"Work-life balance: how do people divide their time between paid work, unpaid work, family, and leisure?*
- *How do people schedule their paid work, and where do they do it?*
- *How socially connected are people with family and friends, from inside and outside their own households?*
- *How much does unpaid work contribute to the New Zealand economy?*
- *How do people spend their leisure time?*
- *Who's caring for whom, for how much time, and where?"*

Statistics New Zealand has published three reports based on the results of 2009-2010 time-use survey:

- *Caring for children: Findings from the 2009/10 Time Use Survey* (Statistics New Zealand, 2013e)
- *The effect of geographical location on New Zealanders' use of time: Facts from the New Zealand Time Use Survey: 2009/10* (Statistics New Zealand, 2011c)
- *Who are Kiwis spending their time with? – Findings from the 2009/10 Time Use Survey* (Statistics New Zealand, 2011f)

The Statistics New Zealand time-use survey can be categorised as a time-use activity survey which has also collected data about the location of each activity. However, there are limitations in using the results for this research. For instance, location of activities has categorisations which are not necessarily useful for certain studies. In particular, it is useful for telling the overall time spent at home indoors but not about time in each room. In addition, this survey has not collected information about

respondents' dwellings, which makes mapping results with house features challenging. Finally, the age limit of the respondents could represent a loss of data for some types of research.

2.9. A gap in knowledge

Living in large houses is clearly against the idea of sustainability. As discussed in the review of the LCA studies, large houses use more resources for their construction and need more energy for maintenance and operation over the life cycle of the house. In addition, furniture and appliance items in the house also add energy to the overall house life cycle. To date, there is no comprehensive study considering all furniture and appliance items in the LCA of a house and existing literature has either not considered or only considered selected numbers of each. In addition, there is no study comparing the types and quantity of furniture and appliances for different household and house sizes.

As mentioned in section 1.4, the current trend in New Zealand is for new houses to be large and the same trend is reported in other developed countries. Some of the existing literature has considered the impact of house size on the life cycle energy of a house although results are usually affected by other parameters such as materials and technological improvements. Perhaps the most important lack in all of these studies is that none have been able to give a big picture of this as a general trend happening in several countries. A systematic study of the LCA differences of various sizes of house occupied by various sizes of household to enable a better understanding of this trend is absent from the existing literature. Considering the environmental impacts of using more resources, public awareness regarding the features and size of the problem seems necessary.

Accepting the very important role of technological improvements in reducing housing energy-use, the significant role of human behaviour when it comes to the selection of a place to live, is usually neglected in LCA studies. As described in section 2.4, human behaviour has a significant role in housing energy-use although as seen, the existing literature has mainly focussed on limited aspects of this (such as window opening behaviour) rather than fundamental decisions about size of house.

Apart from dated studies from the 1970s and early 1980s, the existing literature does not have sufficient information on how people use their houses. This information is important for knowing if the recent trends in house size selection have led to more use of the house and its rooms or not. In other words, it is important to know whether the existing trend in housing in New Zealand is an outcome of a need or just a fashion. The existing New Zealand time-use studies have not collected information to enable researchers to map occupant activities (or time-use) with house features (including house size).

A look at the existing literature regarding international and local regulations and policies in terms of house size standards shows almost all has been focussed on minimums rather than maximums. While the former is crucially important to avoid overcrowding and its negative impacts, the latter is also becoming important because of the potential environmental impacts. The extra bedroom tax in the UK is currently the only existing policy restricting house size and there are signs of unsuccessful initial results mainly because of the mismatch between the number of needed and available small houses there. The existing New Zealand regulations for housing, in line with international ones, only define minimums while some guidelines, such as the *Architectural Design Guide* (section 2.3.2) encourage designers to design larger houses because they are more liked by clients.

This trend for large housing might be a result of unlimited economic growth which, as Schumacher (1973:28) states, should be questioned on the "availability of basic resources and "the capacity of the environment to cope with the degree of interference implied", a concept that has implications for sustainable development. Sustainable development, as defined in the Brundtland report (1987:43) "meets the needs of present without compromising the ability of future generations to meet their own needs". Though this concept was again supported by the world's political leaders in the 1992 United Nations Conference on Environment and Development (UNCED), as Dresner (2008:2) states, "different people use the term in different ways, some emphasizing development through economic growth, and others sustainability through environmental protection". The first group believes that

economic growth would decrease if humanity concentrates on sustainable development concerns and the overuse of natural resources, while Herman Daly, a green economist, believes that this is treating the world "as if it were a business in liquidation" (Dresner (2008:3) from Daly (1992)).

"The liberal objection to limiting each individual's material consumption only applies if you accept the 17th century philosopher John Locke's justification for private property rights – that my expropriation of natural resources does you no harm as there is enough for you. If we believe in a world with environmental limits, then that argument does not hold. Resources have to be shared so that there is enough for everybody, both now and in the future." (Dresner, 2008:4).

This quote suggests that in a more sustainable future the resources that go into housing need to be shared more equitably. A first step, therefore, is to discover the importance of the environmental impact of living in large houses in a developed country (New Zealand). How this topic is addressed in this research is described in Chapter 3.

3. Study design and methodology

3.1. Introduction

This chapter outlines how and why the research has been conducted in a particular way and the reasons for choosing the methods used, noting that appropriate parts of the discussion of methods occur at the start of the relevant chapters. It also sets out the research questions. This chapter also explains how the various parts of the data collection and analysis work together to answer the research questions.

If comparing two different sized houses and assuming building technology, materials, thermal efficiency and occupants are the same, it is obvious that a large house needs more resources for its construction, maintenance and operation. This gives rise to two questions:

- What is the difference between the initial resources of different house size options and how does this difference change over the life of the house?
- How do people use various rooms of their houses and is there any difference between the use of spaces in a large and small house?

To answer these questions certain data has to be collected. It is necessary to know the physical differences between small and large houses (room configurations and sizes). In addition, the differences between the components of large and small houses (the number and type of furniture, appliance and tool items) is required. Whatever the reason, having more rooms in a house means more resources are used for housing. Having such information, a tool to compare the energy impact of living in different house size options is also needed. Life cycle analysis provides a suitable and reliable tool for measuring this. LCA can also show the resource-use in different sized houses in terms of energy and provide information of how energy-use patterns might change over the life cycle of the house.

Studies by Canter and Lee (1974a), Canter et al. (1974) and Canter and Tagg (1980), although not recent, linked the presence of specific furniture in rooms with the type of activity happening in them.

Again, asking people what they call a room and what furniture it contains will bring this knowledge up to date. There is also no study on how what could be considered 'spare' rooms in New Zealand houses are furnished.

Regardless of the energy related resource impacts, do people living in large houses really use all the rooms? To find an answer to this, time-use microenvironment studies reveal where and for how long people spend their time and what type of activity is done over this time. Time-use studies have been performed in many parts of the world, including New Zealand, although the focus of many of these studies is on time spent on activities rather than activity location. The time-use studies that have focussed on the latter usually group all the rooms in a house under the umbrella of home indoors. Additionally, mapping time-use together with the number of furniture items, appliances, and rooms, and types of rooms has never been investigated. The intention in this study is to find out how much time is spent in different sized houses, the share of different rooms in this, and if time-use patterns between small and large houses vary.

Finding the energy impact and the time-use in all rooms, it could also be possible to see how much energy might be bound up in rooms that are not used much, such as spare bedrooms, over the life cycle of the house and its occupants. This information could give a better understanding of what house size decision really means and what its impacts are.

3.2. Possible methods

3.2.1. Time-use studies and tracking people

Time-use studies can tell where, when and for how long people spend their time. These studies can also give information on the type of activity and the people who accompany a person doing a particular activity at a specific time. Time-use data is important for "understanding well-being" and making "public policy" including "augmented national economic accounts", "work and retirement", "child and family care" and "welfare reform" (Committee on National Statistics, 2000:5-14). Another important reason behind many time-use studies is environmental exposure assessment (Leech et al.,

2002), which is achieved by looking at the level of human exposure to pollutants in different microenvironments (Briggs et al. (2003), Denman et al. (2000), Steinle et al. (2013), Broich et al. (2012), Schwab et al. (1990), Yoon et al. (2012) and Wu et al. (2011)).

Prior studies in the field of occupant behaviour and energy consumption are mostly based on self-reported behaviour through use of a questionnaire (Guerra-santin and Itard (2012); O'Callaghan et al. (2012); Galvin (2013); Weihl and Gladhart (1990); Andersen et al. (2009)). Most time-use studies are also based on self-reported data in a time-use diary (TD) as part of a paper-based (Schwab et al., 1990) or telephone-based survey (Leech et al., 2002). More recent studies have started using online time-use diaries. For instance, Wu et al. (2012) compared telephone-based and online time-use activity recall diaries results, showing online to be as precise as telephone-based surveys. Although the accuracy of self-reported data has always been a concern for behavioural researchers, recent improvements in technology have provided the opportunity for more direct behaviour observation as reviewed below and summarised in Table 3.1. The most important problem with these new technologies is that it is difficult to use them for long term (24 hours) and for big samples.

1- Studies (Broich et al. (2012) and Yoon et al. (2012)) have used GPS kits which are available in different sizes and capabilities. They work with a satellite and people can easily be tracked from anywhere using Google map and appropriate software and, as a result, an observer at the place is unnecessary. These kits are very good for outdoor research and where long distances are involved. The big disadvantages are that they do not work well indoors and their accuracy is not more than 10 metres, so they cannot show the accurate place of the occupants within a house. Also, occupants have to carry the kit with them for the whole investigation and if they forget to attach the kits to themselves data will be missing. Guests are difficult to control with this system because each person coming into the house as a guest should be given a kit, which may be unacceptable. In this system only movements and the presence of occupants can be seen and it is not possible to distinguish the type of behaviour.

2- Intelligent cameras are small cameras which are sensitive to movements and body temperature. They start recording when the sensor feels a human presence in the place. The most important problem with this system is people not allowing photos or movies of behaviour in private spaces and the fact that the presence of a camera in the space may influence behaviour. The battery life and memory capacity are also problems. Movies in this system can be analysed manually or by software. One of the most important features of this method is seeing the occupants and distinguishing their behaviour at any time. This method has been used by Elias et al. (2007) in a study of the impact of user behaviour on domestic energy saving.

3- Bluetooth kits are small kits or even smart cards which can be distinguished by Bluetooth. This system works on the basis of Bluetooth waves and a receiver. In this system, the receiver can analyse the strength of the wave and find out the location of the kit which is connected to a person or piece of furniture, or can even track person from his/her mobile phone blue tooth. The data in this system is collected by a central computer for further analysis. This system can distinguish the movements and presence of people or objects in all spaces but not the type of activity. Yoshimura et al. (2012) used a Bluetooth system to track visitors to the Louvre museum by their mobile phones to find the parts they accessed and duration of each part visited.

4- New methods have also been invented by scientists. For instance, Crandall and Cook (2013) designed a new system for smart houses on the basis of motion and temperature sensors. These sensors are put in different parts of the space on the ceiling so that they can cover all the area. The combination of these with an algorithm can show the movements and presence of the occupants in the space but not the type of behaviour (Crandall & Cook, 2013). The most

important feature of this system is that it does not need kits to be connected to occupants and no cameras are used in their private spaces, so residents accept this system easily (Crandall & Cook, 2013). On the other hand, a great number of sensors are needed which could be difficult to retrofit to existing houses.

In another study Foroughi et al. (2008) designed an algorithm for smart houses for the elderly which could analyse the pictures taken by smart cameras and detect different human postures on the basis of person movement, body temperature and head position. The aim was to detect potential problems for the elderly who live alone (Foroughi et al., 2008). A similar system was produced by Nait-Charif and McKenna (2004) to support the elderly through detecting abnormal behaviour at home.

Tracking subjects using Wi-Fi signals has also become a popular in indoor positioning studies. Mobile phones are the most popular devices with Wi-Fi and most people have one. However, this method has good and bad points. For instance, all people using a building do not necessarily have mobile phones or if they do, do not necessarily carry them whenever they move within the building. Having Wi-Fi on at all times adds to this problem. One of the best methods for validating data using Wi-Fi is 'Fingerprinting' which is consisted of "a pair of an indoor location and a set of signal strengths of the Wi-Fi access points seen at the location" (Radaelli et al., 2014:167). Fingerprinting is usually done manually by surveyors or using a report from participants. Radaelli et al. (2014) developed a method called 'automatic fingerprinting', integrating Wi-Fi with fixed video cameras. In their proposed method, data captured by fixed camera(s) uses an algorithm to distinguish the entrance and time spent in individual spaces. At the same time Wi-Fi receivers in each individual space collect data based on the frequency of waves they receive from the mobile phones of individuals. A combination of these two sets of data can help researchers validate collected data via Wi-Fi. The results showed that 'automatic finger-prints' are comparable with those manually collected.

Parameter	GPS kits	Intelligent cameras	Bluetooth kits	New methods
Distinguish occupant presence	Yes	Yes	Yes	Yes
Distinguish occupant movement	Yes	Yes	Yes	Yes
Distinguish type of behaviour	No	Yes	No	No
Indoor/outdoor	Outdoor	Both	Both	Indoor
Suitable for private/public spaces	Both	Both	Both	Both
Accuracy at small scale	Weak	Good	Very Good	Very Good
Saving data	Computer	Manual/Computer	Computer	Computer
Acceptability	High	Low	High	High
The ability to control guests	Weak	Very good	Weak	Very good
Need presence of researcher	No	No	No	No
Battery life limitation	No	Yes	No	No
Memory limitation	No	Yes	No	No
Weather limitation	No	No	No	No
Time limitation	No	No	No	No
Number of the cases to be examined	Unlimited	Unlimited	Unlimited	Unlimited

Table 3.1 Different methods for tracking people and pros and cons of each

For this research the aim is to find a time-use method that can be used by a large sample of New Zealand households, so the methods in Table 3.1, although of interest may not be appropriate. In this instance the more traditional methods of the time-use diary that allow people to record what they have done and where may be more useful.

3.2.2. Resource accounting

Having discovered how long people spend at home and in the various rooms of their house, it is also important to analyse the environmental impact of the house over its life-cycle. This means finding out the size of houses people live in and how much furniture and appliances these houses contain, and a tool for analysing the environmental impact of having the house and its contents. The history of using LCA goes back to 1970-1990 when it first started in North America and Europe (Klöpffer (2014) from Fava et al. (1991)). One type of life cycle assessment is “cradle-to-grave” analysis which considers the impact of every stage of a product’s life on the environment, including on soil, water and air (Crawford, 2011).

Crawford (2011:40-42) considers the three types of LCA to be “Baseline”, “Comparative”, and ”Streamlined”. Comparative life cycle assessment is a reliable method for comparing the environmental impacts of two or more materials or products and would seem to be the appropriate tool for assessing the different impacts of having large and small houses.

LCA studies are usually based on three methods as described by Alcorn (2010):

- Input-Output analysis: This analysis is based on national economic input-output tables which are then combined with the known energy used by various industries for each $ value of their products.
- Process analysis: This analysis is based on energy and material data taken from a manufacturer for the products' processes plus other upstream data which have an effect on the overall process.
- Hybrid analysis: This analysis is a combination of Input-Output and Process analyses. Hybrid analysis is based on either Input-Output or Process analysis and each is supplemented by the other.

Energy is an important input into a life cycle analysis and a mixture of direct and indirect energy is required for processing various types of materials (Alcorn, 2010). The level of energy embodied in a material, including a building material, depends on the type of material and the process of its production (Crawford, 2011).

LCA can be used to quantify the impact of buildings on the environment (Crawford, 2011). According to the International Energy Outlook 2016 report (U.S. Energy Information Administration (EIA), 2016), residential and commercial buildings account for 20% of the total delivered energy consumed worldwide, with a projected 2.1% increase by 2040. However, this figure only reports the direct energy consumed by households and excludes the energy involved in industry to make things like the furniture and appliances that go into households. This study attempts to find out the importance of the latter for New Zealand.

Various stages of the life of a building including raw material extraction, material manufacture, construction, operation and maintenance and demolition need energy, water and other services while each of these stages also produce some wastes which should be recycled (Crawford, 2011). LCA

studies of the built environment are complicated (Mithraratne et al. (2007) and Crawford (2011)) for many reasons including:

- Buildings usually have a long life meaning that many changes might occur over the life of a building and predicting the replacement times is a difficult and not necessarily accurate (Mithraratne et al., 2007).
- Energy needed for stocking and moving building materials could vary with building type, site conditions and the quantity of materials wastes in each building type/site (Mithraratne et al., 2007).
- The service life of building materials varies with climate, type of user and change of use which in turn can affect the replacement times (Mithraratne et al., 2007).
- With technological advances, new materials might be more durable which will affect the maintenance schedule (Mithraratne et al., 2007).
- Technological advances also means the embodied energy of building materials is constantly changing, which affects the life cycle energy of the house (Mithraratne et al., 2007).
- Improvements in the energy efficiency of residential building can affect the overall life cycle energy of a house (Crawford, 2011).

Life cycle analysis of a residential building can give a better image of the energy impact of the building compared to just its embodied energy (Crawford, 2011). For this reason this research will compare the LCAs of different sizes of house including the contents to gain a clearer picture of the environmental impact of housing decisions in New Zealand.

3.3. Research question and aims

Following the discussion in the literature review, there is a limited understanding of the environmental impacts of occupant behaviour in terms of the choice of size of house. Based on this, this study poses the main research question:

What is the impact of house size selection on the embodied and life cycle energy of owner occupied New Zealand houses occupied by small households?

This question leads to a number of sub-questions:

- *Do small households live in large houses?*
- *How is the recent increase in New Zealand house size reflected in the type and number of rooms?*
- *How does house size selection impact on the number of furniture, appliance and tool items?*
- *Do people living in large houses with access to a number of rooms use these, and if yes for how long are they used?*
- *How efficiently are resources in different sized houses used at the house and room scale?*

3.4. Research framework and approach

This research aims to find out the impacts of living in different sized houses through a comparative study of the embodied and life cycle energy of these. Comparative analysis is a strategic method for generating theory "to establish the generality of a fact" (Glaser & Strauss, 1967). This research will use an inductive approach as each stage of the study creates the information and context from which to develop the next stage.

Current knowledge about potential resource-use differences based on the size houses is limited and it is impossible to design a full "linear research path" because it is not possible to predict what will happen in each phase of the research. So theories and hypotheses have to be established on the basis of findings through data collection. This research method, known as "grounded theory", was first proposed by Glaser and Strauss (1967). They called grounded theory "theory as process" which reflects its "ever-developing" nature which is not a "perfect product" and needs to be developed. Creswell (2014) (from Charmaz (2006) and Corbin & Strauss (2007)) states that grounded theory is a theory created in a process based on participants' views: "Grounded theory is a design of enquiry from

sociology in which the researcher derives a general, abstract theory of a process, action, or interaction grounded in the views of participants."

What is investigated is highly related to the findings in each step or as Charmaz (2008:208) states "What we know shapes, but does not necessarily determine, what we find." In addition, it might be necessary to change the direction of the study at any stage and this needs a flexible method. "Grounded theory adds flexibility and allows the data and theory to interact" and "[it can] help us remain open to the unexpected" and can change the direction of the research or even the research question based on findings in any phase of the research (Neuman, 2011). Charmaz (2008) also mentions the flexibility and "openness" of grounded theory in generating new theories and states that "Grounded theory methods are a set of flexible analytic guidelines that enable researchers to focus their data collection and to build inductive middle-range theories through successive levels of data analysis and conceptual development" (Charmaz, 2008:204). In addition, "The grounded theory openness to empirical leads spurs the researcher to pursue emergent questions and thus shifts the direction of inquiry." (Charmaz, 2008:209).

Grounded theory provides a situation through which to improve research steps, as each step can affect and improve the other. Charmaz (2008) refers to the effects of data collection and analysis on each other and states "grounded theory methods consist of simultaneous data collection and analysis, with each informing and focusing the other throughout the research process" (Charmaz, 2008:204). Glaser and Strauss (1967) refer to the effects of deductions on sampling and state that "Deductions from grounded theory, as it develops, are the method by which the researcher directs his theoretical sampling" (Glaser & Strauss, 1967). Grounded theory also provides a good method with which to focus deeper onto a potential problem (Charmaz, 2008).

This study will mainly rely on quantitative data collected through a questionnaire-based survey and an analysis of floor plans of New Zealand houses. Quantitative studies rely on "the principle of replication, adhere to standardized procedures, measure with numbers, and analyse the data with

statistics" (Neuman, 2011). Numbers indicating size and duration of stay in spaces are "hard data" which dictate quantitative research strategies (Neuman, 2011). Each single method has weaknesses and strengths and the combination of methods, known as "triangulation", can use the strengths of each single method and cover its weaknesses (Jick (1979) from Webb et al. (1966)). Jick (1979) reports several opportunities that "triangulation" provides for researchers. Triangulation "allows researchers to be more confident of their results" and "[can] stimulate new ways of capturing a problem" and "help to uncover the deviant or off-quadrant dimension of a phenomenon" and finally "serve as the critical test, by virtue of its comprehensiveness, for competing theories" (Jick, 1979:608-609).

This research consists of several quantitative studies (see sections 5.8, 6.5, 7.3, 8.3 and 10.3.1) and some of these will have an impact on the quality of housing. The main study (Study 2) in this investigation is quantitative research. However, where this study talks about behaviour (which is a qualitative aspect), this is translated to a quantitative and measurable aspect of human behaviour (time-use). So this part of the research is based on a quantitative research approach because the data collected are quantitative (like size, time, and duration) although they are used to measure selected qualitative aspects of life (like behaviour and occupant decisions). The study will be based on "close-ended questions" through a questionnaire based survey and questions are aimed at collecting both qualitative (behaviours, family relationships) and quantitative (size, duration and time of space use) data from participants and their houses through a quantitative approach. The LCA analysis is quantitative research, but based on the data emerging from the main study (Study 2).

3.5. Study design

As mentioned before, this study has an inductive approach based on "grounded theory", with each study (listed in section 3.5.1) creating information for conducting a further study. By overlapping the findings of various studies, an understanding of different aspects of the research question will be achieved. This research needs information on many different aspects of New Zealand housing including:

- What are the types and number of rooms and other spaces?
- What are the types and number of furniture, appliance and tool items?
- Who are the usual (and unusual) occupants of a house and what are their characteristics?
- How long are the various rooms, sanitary spaces and private open spaces of the house used by different household members?
- Calculation of the embodied and life cycle energy of different sized houses.
- Calculation of the embodied and life cycle energy of furniture, appliance and tool items.

3.5.1. Data Collection

Overall four studies emerged for collecting the information needed for this study. These are described briefly below with the relevant chapter numbers noted.

Observation of New Zealand houses (Chapter 4):

TradeMe (2014) is local website which provides a platform for local dealing of items ranging from personal effects to furniture and properties. Houses advertised in this website have a written description and photos to introduce various aspects and features of the house. Through a comparative study of different sized houses advertised in this website, it is possible to get a preliminary understanding of the types of rooms in New Zealand houses and how these might relate to house size. In addition, looking at the domestic furniture and appliances advertised for sale in TradeMe, it is possible to discover the types of these found in New Zealand houses and how they might change with house size.

Study 1 (pilot study) (Chapter 5):

Using the results of the observation study of the TradeMe website, a questionnaire will be designed and used for a small sample of households living in New Zealand owner-occupied houses. This survey, which will be partly interview based, will ask about types and number rooms, types and number of furniture/appliances and time-use in various rooms of the house by each family member for a suitable time-frame. The overall aim is to uncover potential problems in the questionnaire using the feedback

received from the respondents. The aim of the time-use part is to investigate the minimum number of days needed for time-use data collection to capture reasonable data about how much time people spend in the various rooms, sanitary spaces and outdoors of New Zealand houses. This study will also help in finding the best strategy for data collection on house/household features, furniture/appliances and time-use in the different rooms for the main survey.

Study 2 (main survey) (Chapter 6):

Using the results of Study 1, the questionnaire will be revised and finalised to be conducted on a large sample (the aim is 200+ households). The scope of the survey in terms of household types will also be set at this point. However, only houses will be investigated as prior international studies indicate people living in apartments spent less time at home (Yang et al., 2011). The survey will ask about the type/number of rooms and furniture/appliance/tool items in the house and time-use in different rooms by each household member. It is intended the results of this study will give reliable information about:

- The types and number of rooms and other spaces in New Zealand houses
- The types and number of furniture, appliance and tool items in New Zealand houses
- Usual/unusual occupants of each house
- Duration of the use of each room type in the house by day type (weekday or weekend), age, gender, job type and the role each person has in the family (i.e. single person, parent/adult carer, child, husband/wife)

Such information will then be fed into the life cycle analysis of the house, it furniture/appliance/tool items.

Floor plan study of New Zealand houses (Chapter 7):

This study was only included after it was realised the information gained from Study 2 was insufficient when it came to describing house and room floor areas. For this study, floor plans of New Zealand houses of a range of dates of construction published in journal archives, catalogues, books and

designers' website were selected and redrawn in AutoCAD 2015-16 so the floor area of each house and room could be calculated and analysed in an Excel spreadsheet. Data created in this part feeds into the life cycle analysis of houses in Chapter 9.

3.5.2. Data Analysis

It is intended the data will be analysed in the four steps below.

Time-use (Chapter 8):

The first step is to find out how long houses are used and how the various parameters of age, job type, gender, and family role affect time-use at home in the sample of New Zealand households.

Calculating the embodied and life cycle energy of the houses (Chapter 9):

Various assumptions will have to be made for the LCA calculations based on the information collected in Study 2. The aim in this section is to compare the LCAs of different sizes of house, all calculated on the same basis.

Calculating the embodied and life cycle energy of furniture, appliance and tool items (Chapter 10):

This analysis uses the price of furniture, appliances and tools as a means of assessing the energy that they contain, and then compares the results.

A tool to combine time-use and resource-use (Chapter 11):

The final step in the analysis is to find a way to combine time and resource-use to show how efficiently resources are used in different sized houses and in different room types. A scenario approach will be used but the data will come from the time-use study, LCA investigations, and the floor plan study.

Figure 3.1 shows the different parts of this study, the study process, and how each part feeds into the others. The green lines show how aspects of the literature review feed into data collection and analysis. In addition, black lines show how each study feeds into the other studies and the parts of the analysis. Finally, the red lines show how the results have contributed to the various fields of knowledge in the literature review.

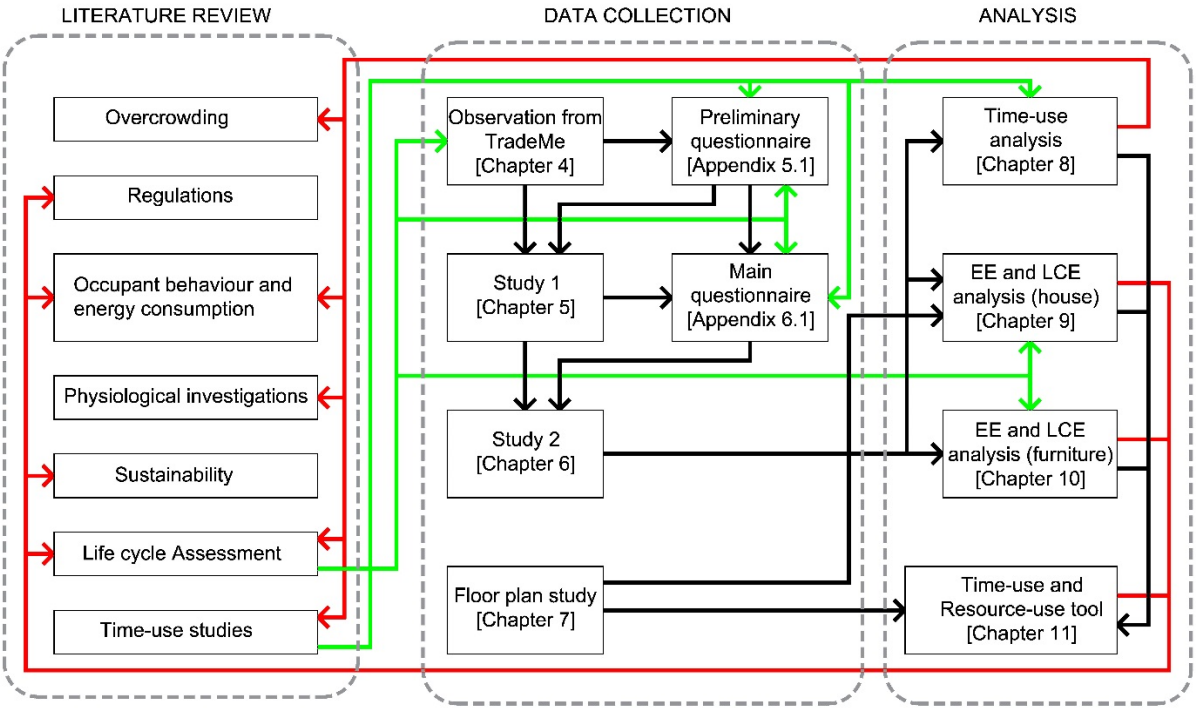


Figure 3.1 A diagram showing different parts of the research and how each study will feed other parts

3.6. Ethical issues

This research "involves collecting data from people, about people" (Creswell, 2014) and this raises the need to protect research participants and "develop a trust with them" (Creswell, 2014). Data collected and published in this research will be related to personal privacy and should be considered confidential. For both Studies 1 and 2, approval was obtained from the Human Ethics Committee of Victoria University of Wellington as discussed in sections 5.4 and 6.3.

4. An observation of the features of New Zealand houses and their contents

4.1. Introduction

While various sources (see section 1.4.2) indicate the size of New Zealand houses has increased in recent years, there is no study describing the features of these large houses. As a start, therefore, it might be helpful to discover the most popular rooms and furniture/appliances in existing New Zealand houses. To do this, observations were made of the TradeMe website. TradeMe is a local website established by Sam Morgan in 1999 as "the place where Kiwis buy and sell online" (TradeMe, 2014). Currently it is "the leading online marketplace and classified advertising platform in New Zealand" (TradeMe, 2014). 'TradeMe property', launched in 2005 aims to help New Zealanders sell and rent their properties easily (TradeMe, 2014).

By looking at houses advertised for sale on this website the aim was to find out more about the types of rooms in New Zealand houses, the size of plots, along with overall house size and types of furniture and appliances, the types and capacity of parking facilities, and how both the latter and number of rooms change with house size. The information gathered from this observation study was to be used as the basis of the questionnaire for the pilot study (study 1). Asking, for example "do you have a study; how many chest of drawers do you have; how many hair driers do you have" in the questionnaire was thought to gain more reliable answers than just asking people to list the rooms in their house and their contents.

4.2. Methodology

Houses advertised for sale on 'TradeMe property' were selected as case studies. The number of bedrooms was used as an indicator of house size and this created six groups of different sized houses (1-6 bedrooms) that were the first found in each the category to contain all the information required. These groups are respectively representative of very small to very large houses in New Zealand. Overall 60 houses were selected (10 each of 1-6 bedrooms houses) as samples on the basis of having sufficient photos and written description. The number of occupants and house prices were not

considered and no distinction was made between regions, districts and suburb in terms of house locations.

A pre-designed proforma (see Appendix 4.1) was filled out for each house based on what could be learned from the house photos and written descriptions. The more pictures the website offers, the more accurate the data extracted, which influenced the choice. On average small houses (1, 2 and 3 bedrooms) had 15 photos while large houses (4, 5 and 6 bedrooms) had 19 photos.

This method has limitations as well as positive points. The first is that each category of house by number of bedrooms is limited to 10 houses, so any results can only be indicative. As mentioned before, data is gathered on the basis of house photos. Though houses with more photos are selected, normally photos do not cover all aspects of each room, so some furniture may be missed, meaning the average number of furniture and appliance items observed could be an under estimate. In addition, some spaces (like laundries, storage and garages) are not often covered by photos, although garages are usually described, so the number of parking spaces is known. Generally photos of kitchens, living rooms, dining rooms, bedrooms and open spaces are sufficient. So, while this observation study collected the number of furniture and appliance items, because some might have been not visible, any discussion regarding the numbers of these is not reliable and is omitted here. However, type and location of furniture and appliances proved useful in setting up the questionnaire for study 1 (see Chapter 5).

This method cannot accurately assess the number of small appliances within the houses (like hair dryers or blenders) as these items are normally stored in cupboards. This is also true of gardening equipment so names and types of such items for the questionnaire were taken from items advertised for sale in the “Home & Living” part of TradeMe website (TradeMe, 2014).

TradeMe offers land area and floor area for most and building age for some houses. Missing floor and land areas were obtained by emailing the relevant agent. The QV website data base (QV, 2014) was also used as a source of missing land area and building age for some cases.

4.3. Results

4.3.1. Rooms of the house

This observation study showed the main living areas in New Zealand houses are a separate living room (also known as lounge, family room, formal living room, sun room, snack room, and TV room), separate dining room, separate kitchen (including scullery and utility room), combined living room/dining room, combined living room/kitchen, combined dining room/kitchen and combined living room/dining room/kitchen. All houses have bedrooms while some houses (especially large houses) have an en-suite bathroom and a walk-in dressing room in some bedrooms. Some houses had mezzanine sleeping areas.

One thing that emerged is that all houses have a kitchen, living room and dining room whether these are separate or combined with other spaces. Though most houses have only one kitchen, some large houses have a second kitchen which is only used for cooking and washing-up (Table 4.1). While a number of 1 bedroom houses do not have a separate dining room, some large houses have more than one dining area whether separated or combined with other spaces. Analysis indicates the number of dining rooms in 6 bedroom houses is almost double that of 1 bedroom houses (Table 4.1). Table 4.1 also shows that, apart from size, most New Zealand houses have more than 1 living area whether separate or combined with other spaces and the number of living rooms increases with house size.

House size (Based on number of bedrooms)	Average number of kitchens	Average number of dining rooms	Average number of living rooms
1 Bedroom houses	1.0	0.6	1.2
2 Bedroom houses	1.0	1.0	1.1
3 Bedroom houses	1.0	1.0	1.1
4 Bedroom houses	1.1	1.1	1.9
5 Bedroom houses	1.1	1.2	1.8
6 Bedroom houses	1.1	1.2	2.3

Table 4.1 Average number of kitchens, dining rooms and living rooms in 1-6 bedroom houses

Figure 4.1 shows how the number of some room types increases with house size indicating that in larger houses having more living rooms and bathrooms/toilets is more likely than more kitchens and dining rooms. Figure 4.1 also shows that the change in number of living rooms starts in 4 bedroom houses.

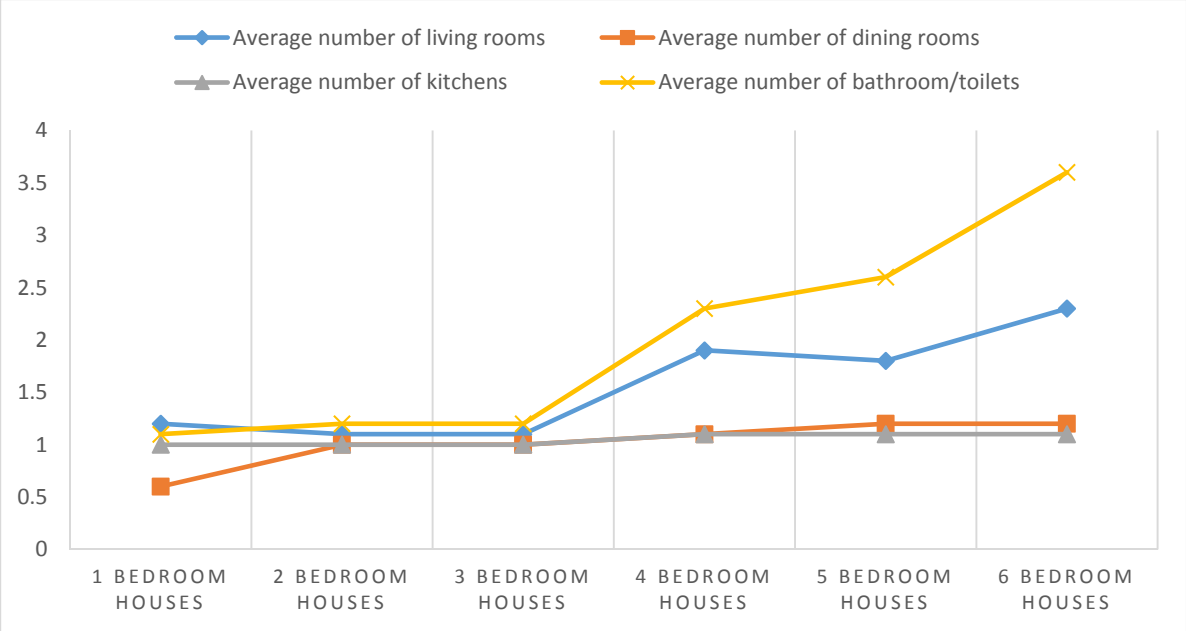


Figure 4.1 Changes in number of main spaces for 1-6 bedroom houses

This observation study found large houses have specialized spaces which do not exist in small houses. Sometimes these rooms, like a study or games room are named, but in other cases bedrooms in the photos do not have bedroom furniture and are obviously used as a play room, games room (also known as hobby room or rumpus room), gym, study (or office), library or media room. Figure 4.2 shows that the number of rooms labelled as bedrooms but without visible bedroom furniture increases as house size increases.

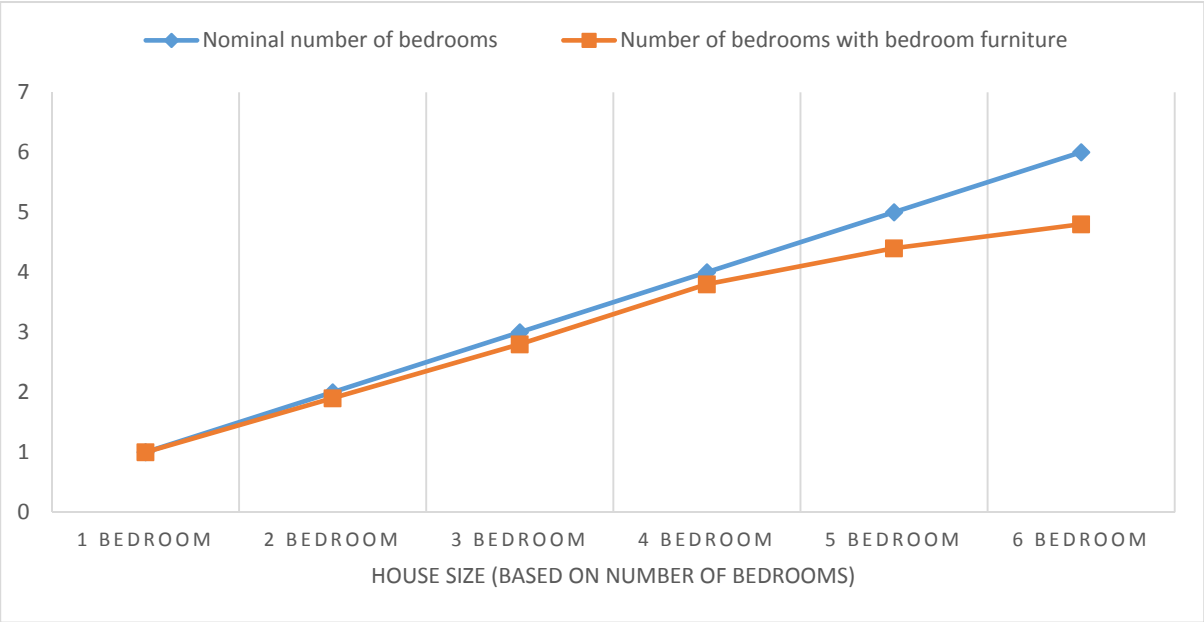


Figure 4.2 Number of available bedrooms and number of bedrooms used as a bedroom

Sanitary spaces observed in this sample of 60 New Zealand houses are separate laundry, separate bathroom, combined bathroom/toilet and combined bathroom/toilet/laundry. In some houses, the laundry is located in the garage or positioned in a built-in cupboard as part of the living room, dining room or kitchen. It is also clear that larger houses normally have more bathrooms. Analysis indicates the average number of bathrooms in 6 bedroom houses is more than three times that of 1 bedroom houses and en-suite bathrooms are, as would be expected, generally found more in large houses than small ones (Table 4.2). For instance, 80% of 6 bedroom houses have at least 1 en-suite bathroom while this is 0, 10 and 30% for 1, 2 and 3 bedroom houses. The percentage of en-suite to total bathrooms also indicates that more bathrooms in large houses are en-suite (Table 4.2). In other words, bathrooms in larger houses have private users rather than being a shared space.

House size (Based on number of bedrooms)	Average number of bathrooms	Average number of en-suite bathrooms	Percentages of bedrooms with en-suite bathroom	Percentages of houses with at least one en-suite bathroom	Percentages of en-suite bathrooms to total bathrooms
1 bedroom houses	1.1	0.0	0.0%	0.0%	0.0%
2 bedroom houses	1.2	0.1	5.0%	10.0%	9.1%
3 bedroom houses	1.2	0.3	10.0%	30.0%	25.0%
4 bedroom houses	2.3	1.0	25.0%	70.0%	43.5%
5 bedroom houses	2.6	1.1	25.0%	90.0%	44.0%
6 bedroom houses	3.6	1.8	34.6%	80.0%	50.0%

Table 4.2 Number of bathrooms and their features

More analysis indicates that big changes happen in 4 bedroom houses. For instance, the average number of bathrooms almost doubles and average number of en-suites triple between 3 and 4 bedroom houses. In addition, the percentage of bedrooms with en-suite bathrooms in 4 bedroom houses is 2.5 times that of 3 bedroom ones (Table 4.2 and Figure 4.3). This means that the decision to buy a 3 or 4 bedroom house could have a very different effect on the environment in terms of resource-use.

Some New Zealand houses also have storage space, but the nature of this could be quite different from house to house. In some houses, storage means an extra room (e.g. a bedroom) which is used for storing extra items but it can also mean a walk-in wardrobe, an attic, or an under-stair space. Storage in some houses is located in outdoor units (e.g. storage cage or caravan).

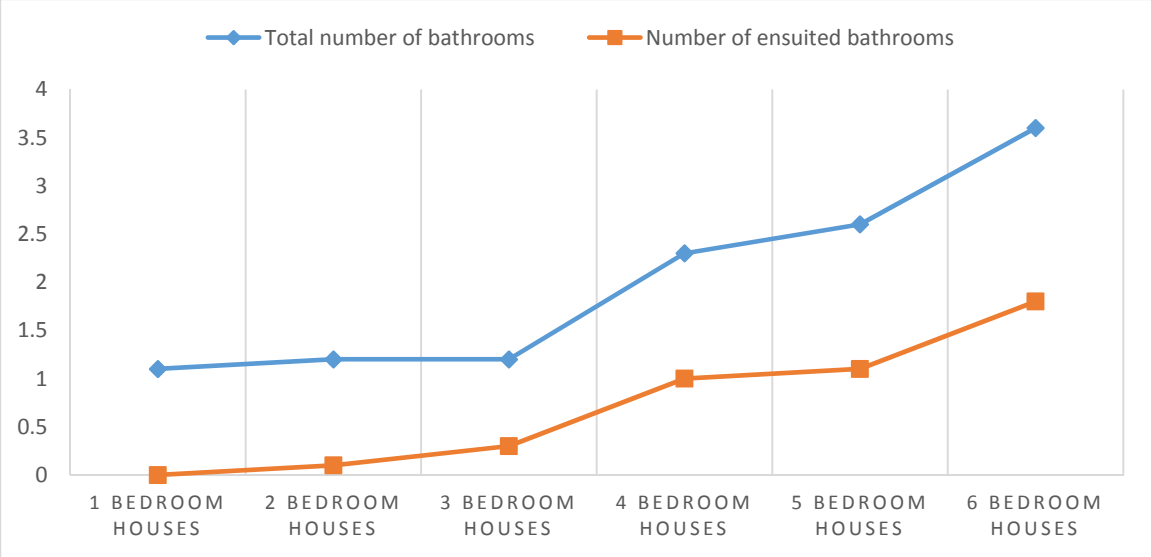


Figure 4.3 Total number of available bathrooms and en-suite bathrooms for 1-6 bedroom houses

Private open space in New Zealand houses usually includes a front and a back garden while many houses connect to the garden through a semi-open roofed space called a veranda. Many houses have one or more (covered or uncovered) decks as part of this private open space. Apart from these, some houses have habitable space in the garden (sleep outs) and greenhouses for plants.

4.3.2. Garages, carports and parking spaces

The two main built parking facilities in New Zealand houses are garages and carports. In older houses the garage is usually a small, separate building although in most new houses it is integral to the house and with an internal access. Some houses have an outdoor, un-roofed parking space, either a hard surface of concrete or timber on sloping sites, while some houses just reported parking their cars off street. As might be expected, the number of garages and parking spaces increases with house size while carports do not seem to follow this pattern. Based on Table 4.3, apart from house size, almost all houses in New Zealand have more than 1 available parking space with garages constituting a greater proportion of total parking spaces in larger houses. Table 4.3 shows the number of garages in 6 bedroom houses is almost 4 times that of 1 bedroom houses. In addition, Figure 4.4 indicates the biggest change in number of garages and total available parking space happens for 4 bedroom houses, forming a peak. From this point, figures do not change much and the trend for 5 and 6 bedroom houses is steady.

House size (Based on number of bedrooms)	Average number of garage spaces	Average number of carport spaces	Average number of parking spaces	Total available space
1 BR houses	0.5	0.2	0.9	1.6
2 BR houses	1.0	0.2	0.9	2.1
3 BR houses	1.1	0.5	1.2	2.8
4 BR houses	2.4	0.1	1.3	3.8
5 BR houses	2.1	0.2	1.5	3.8
6 BR houses	1.9	0.2	1.6	3.7

Table 4.3 Average number of garages/carports/parking spaces for 1-6 bedroom houses

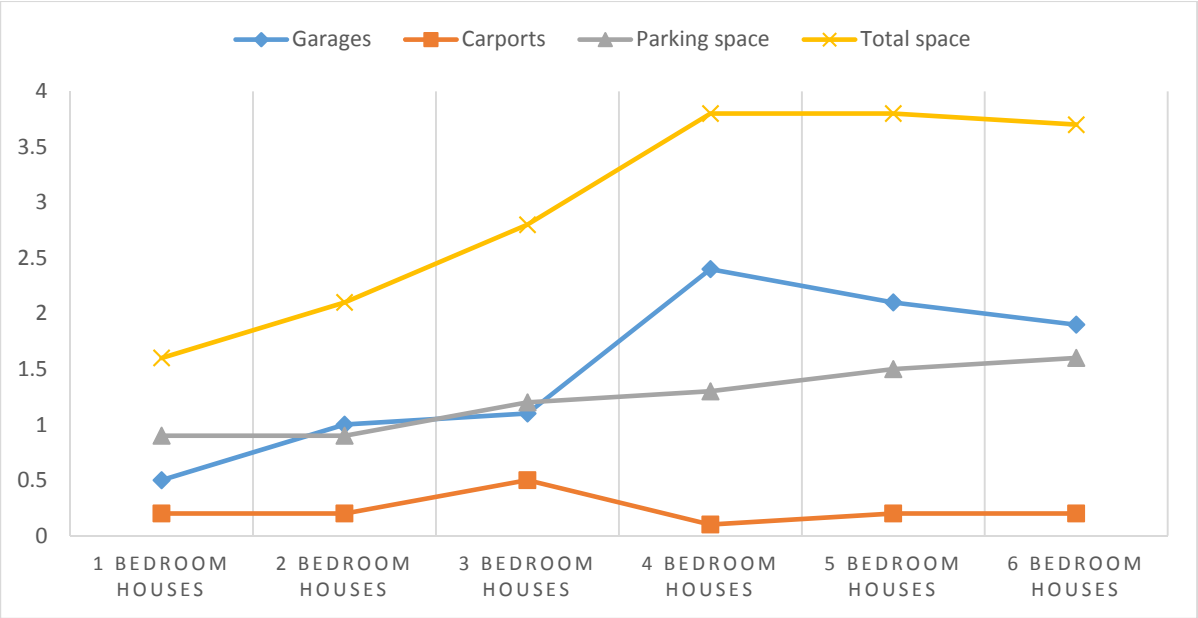


Figure 4.4 Total available garage, carport, and parking spaces for 1-6 bedroom houses

4.3.3. Average floor/land area

Analysis of written descriptions shows that the average floor area increases with house size while average land area does not necessarily follow the pattern (Table 4.4). For instance, a 1 bedroom house might be located on a larger plot than a 6 bedroom house, but overall in this limited observation study larger houses are usually built on larger plots (Table 4.4).

House size (Based on number of bedrooms)	Average floor area (m^2)	Average land area (m^2)
1 bedroom houses	74.5	428.9
2 bedroom houses	106.3	728.5
3 bedroom houses	130.9	627.1
4 bedroom houses	237.2	906.5
5 bedroom houses	324.9	1128.8
6 bedroom houses	350.4	905.7

Table 4.4 Average floor/ land area for 1-6 bedroom houses

However, Figure 4.5 indicates that 3 bedroom houses do not follow this overall trend in floor and land area. Census 2013 reveals that 3 bedroom houses are the most frequently occurring house size in New

Zealand (Statistics New Zealand, 2013b). The New Zealand Initiative (Bassett & Malpass, 2013) reports that by 2011 land price as a share of total house price had increased to 50%. So building more affordable 3 bedroom houses might be the reason behind building on these smaller, and hence cheaper, parcels of lands. As mentioned before, the average number of living rooms, kitchens, bathrooms/toilets, dining rooms and garages also support this finding. In other words, it seems that developers try to build 3 bedroom houses with the minimum acceptable number of extra garages, living rooms and bathrooms/toilets.

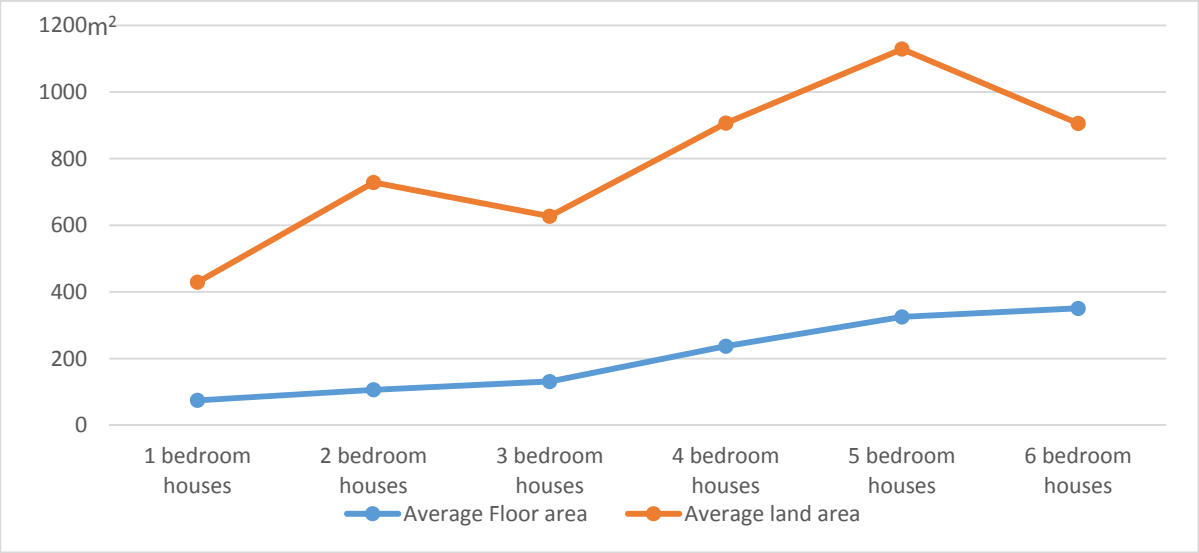


Figure 4.5 Average floor and land area for 1-6 bedroom houses

In addition, a comparison between average floor areas in Table 4.4 with proposed floor areas in the London Housing Design Guide shows that New Zealand houses are much bigger than English houses. The London Housing Design Guide (Robert-Hughes et al., 2011) proposes 74m^2 for a 3 bedroom house for four people. They also state that the proposed floor areas for a 2 bedroom house for three people in the Dublin City Development plan and Germany are 65m^2 and 70m^2 respectively.

4.3.4. Furniture and appliances

When it comes to bedroom furniture in New Zealand houses, most contain a double or single bed(s), together with numbers of bedside tables, wardrobes, chests of drawers, book cases, desks, desk chairs, desktop/PC, and large mirrors. In addition, bunk beds and clothes racks are seen in some

houses, especially small ones. The number of some furniture items (double beds, bedside tables, desks, desk chairs and large mirrors) increases with house size, while the number of other furniture items (single beds, bunk beds, wardrobes, book cases, desktops/PCs and chests of drawers) seems to be related to factors other than house size.

In most observed houses, the living and dining rooms contained at least one couch/sofa, side table, coffee table, TV, TV cabinet, entertainment unit, dining suite/table and chairs, buffet/side board, chest, display cabinet, ottoman/foot stool, floor lamps, rugs, and wall clock. Other furniture like pianos and large sculptures/vases are more likely to be seen in large houses. Generally, the number of some furniture items seems to increase with house size although because of the reasons mentioned before, this is not yet a reliable finding. The presence of other furniture items like entertainment unit, display cabinet, ottoman/foot stool and wall clock does not seem to depend on house size. Investigations indicate that most large houses have more than 2 TVs and more than 1 dining suite and couch set. In addition dining suites in large houses tend to be able to seat more people.

It seems the main kitchen appliances like a fridge, freezer, cooktop/oven, stove/ range and microwave are not dependent on house size and can be seen in any house. Photos show that the number of stools is more in large houses, suggesting larger houses are more likely to have a permanent place to eat in the kitchen as well as having a dining room, noting also that larger houses also have larger dining suites. At mentioned before, photos could not help in identifying the type (and number) of small appliances in different sized houses. However, looking at the “Home & Living” part of the TradeMe website suggests the most popular small appliances in the New Zealand domestic market are an iron, hair dryer, vacuum cleaner, ice cream maker, juicer, electric jug, food processor, coffee maker, toaster, electric frying pan, electric deep fryer, blender/mixer, sandwich maker, slow cooker, rice cooker, water cooler, games console, laptop, desktop computer, scanner, printer, DVD/Blu-ray play, fan, dehumidifier, electric blanket, electric bar heater, gas heater, heat pump, convector heater and electric oil filled radiator.

Sanitary spaces in New Zealand houses include some furniture and appliance items, amounting to an ironing board, clothes drying rack, washing machine, dryer, heated towel rail, and storage cupboard.

Private outdoor spaces contain a number of furniture items, tools and appliances including a BBQ, spa pool, outdoor chair, outdoor umbrella, gazebo, bench, outdoor table, swing seat, hammock, trampoline, climbing frame, slides, swing, sand box, paddling pool and play house. It also seems most NZ houses whatever their size have a BBQ, outdoor chairs or benches, an outdoor table and an umbrella/gazebo. Some outdoor items, as expected, seem to come with large houses, such as a spa pool, and outdoor equipment for children, although the lack of photographs makes this part of the observation incomplete. At the same time, New Zealand houses probably have many gardening tools and pieces of equipment although these do not appear in photos. The "Home & Living" part of TradeMe website revealed that these probably include a lawn mower, leaf blower, hedge trimmer, water blaster, work bench, drop saw and drill.

The furniture and appliances found in specialised rooms vary with room type. While the content of a studio/workshop was very varied, games rooms and gyms contained exercise equipment, table tennis tables, billiard tables and pool tables.

4.4. Discussion

This observation study was set up to discover the types and some features of various room and sanitary spaces in New Zealand houses. Depending on the owner and his/her needs, it seems some rooms are used differently from what was initially defined by the designer (e.g. a bedroom used as a playroom or study). Based on this, only looking at published drawings of New Zealand houses does not give a full understanding of the functions of the rooms and how people use them. Such changes could also happen with house renovation where the plan layout could be changed or a cellular plan house converted to an open plan one. Based on this, getting information on how the various rooms of a house are used directly from its occupants through a structured interview or questionnaire based survey would seem the next step.

However, preliminary results from this observation show signs that larger houses have more living rooms, dining rooms, specialised rooms, bathroom/toilets, en-suites and greater capacity for parking cars. However, because of the limitations of this observation study, these results are only indicative and need be tested through use of a more reliable method.

This observation study also produced a list of the most popular furniture and appliance items and where these are usually found in New Zealand houses. There are again indicative signs that larger houses tend to have more items of some furniture and appliances while other items (like spa pools) only exist in very large houses. This observation study also shows that even in very large houses all rooms are furnished with different types of furniture and appliances, though whether these are used regularly and by how many people remains to be discovered.

Based on the findings of this observation study a questionnaire was prepared for a pilot study (study 1) where occupants of a number for New Zealand houses were asked for the type and number rooms and furniture and appliances in their houses.

5. Study 1

5.1. Introduction

The observation of 60 New Zealand houses advertised for sale on the TradeMe website gave a basic insight of the types of rooms and their furniture in various sized New Zealand houses, as a means of preparing for the main survey. Using this information, a preliminary questionnaire was prepared for a pilot study. Because of the considerable data that was anticipated from the large number of participants needed for robust results, a pilot study with fewer participants was felt necessary to reveal any potential problems with the data collection and analysis. The pilot study used a preliminary version of the questionnaire and a small group of volunteer participants (families with up to 4 members). The questions were open ended leaving places for respondents to add additional rooms and furniture and appliance items. Previous observation of TradeMe website houses indicated that larger houses tend to have more furniture and appliance items and that certain items are only found in large houses, so it was important that the pilot study looked at large as well as small houses.

Because asking people to record their furniture and time-use could be a time-consuming process, one aim behind the pilot study was to see how willing people were to take part, and how long the various parts of this study took to complete. As the time-use part was anticipated to be most time-consuming aspect, another aim of the pilot study was to find out the minimum number of days needed for time-use data collection that will be sufficient for a reliable analysis.

5.2. Aims and objectives

As mentioned before, the main aim behind this study was developing the questionnaire towards a final version for the main survey (Study 2) so that the latter would be not too onerous for a large sample size. To reach this aim the following objectives were established:

- Finding the gaps and non-understandable parts of the questionnaire including any missing room types, furniture and appliance items

- Developing a simple method of categorising existing spaces in New Zealand houses so these can be counted
- Developing a simple method for discovering the number and location of furniture and appliance items in a house
- Improving knowledge about how occupants live in large and small houses in New Zealand and whether there are noticeable differences
- Developing a simple method for collecting data about time-use in different rooms of a house.
- Investigating possible difference between time-use patterns over the days of a week and between weeks
- Discovering the minimum days needed for data collection for reliable data on time-use at home and in the different rooms of a house

5.3. Development of the questionnaire

Large housing can be investigated from two viewpoints and the questionnaire needed to address both. The first is the user and the second the house and its attached open spaces. In this study both permanent users and temporary users (guests) were investigated. The time spent by each user in any space of the house gives an understanding of occupant behaviour. For the second viewpoint, the house and its physical characteristics, and the furniture and appliances within it were investigated. As a result, the questionnaire for study 1 was in 9 parts (see appendix 5.1) as described below:

Parts 1- Contact information: In this part participants were asked for their contact details, including the postal address. The latter was thought to be needed in order to find out house floor area and age, and land area via the QV website data base (QV, 2014) and Wellington City Archives, if necessary.

Parts 2- Occupants: Information was sought on the usual number of permanent occupants, their gender, age and occupation. As this study only covered up to four person families, this part only had room for answers from four occupants.

Part 3- Spaces in the house: Here, participants were asked about the type and number of spaces (including parking facilities and their capacity) in their house. A list of possible spaces was prepared based on observation of the TradeMe website (see section 4.3.1). Participants could add any unnamed spaces in free cells provided. Apart from the number, because the characteristics and components of bathrooms could be different between large and small houses a table was prepared to ask more about these. Similarly, given the number of normal occupants of a bedrooms could also affect the amount of furniture in the room, another table was prepared asking about the characteristics of bedrooms in the surveyed houses, including the presence of en-suite bathrooms, built-in wardrobes and the number of usual occupants.

Part 4- Furniture and appliances: In this part, participants were asked to report all the furniture and appliance items in their houses, based on a list prepared from the TradeMe website observations (see section 4.3.4), and again participants could add unnamed items.

Part 5- Number and location of furniture items: Based on the responses to part 4, participants were asked to select a number and location for all furniture items and large appliances from a list of potential locations.

Part 6- Guest users: Participants were asked about guests and parties at their house, including the typical number of people in a party, the frequency of such gatherings and where these happen.

Part 7- Satisfaction with the house: To understand whether people who live in larger houses are more satisfied with them, a question was included aimed at discovering what motivates people to buy large houses.

Part 8- Time spent in each space: The time each occupant spends in each space of the house was recorded.

Part 9- Additional information: This part was filled out by the researcher to provide information about the physical characteristics of the house that the occupants might not be aware of, such as site area,

total floor area and building age. The weather situation for the days on which the questionnaires were filled out was also noted.

5.4. Method and sample selection

The questionnaire as described in part 5.3 was developed in three parts to be completed on different days, being called "Questionnaire for Day 1" (parts 1-4), "Questionnaire for Day 2" (part 5-7) and "Time-use diaries for 14 days" (part 8) (see Appendix 5.1). At this point Ethics approval was obtained for the project in principle and the pilot study (approval no 21012 see Appendix 5.2). As described in section 1.5.1 (see Figure 1.4), large houses are mainly occupied by small families so this study was limited to family households of 1-4 members. At the same time, because furniture and appliances in rental houses do not necessarily belong to the occupants, the survey was limited to owner occupied households. The initial aim was to find at least 2 single person households, 1 childless couple and 1 couple with one (or two) child(ren), where one of each pair lives in a small and the other one lives in a large house. The intention was the researcher would meet with participants to introduce the questionnaire, how it should be filled out and discuss any potential problem seen in each part of the questionnaire.

The information sheet asking for volunteers was distributed among friends and contacts. For convenience, the pilot study area was limited to Wellington and its suburbs. Respondents were contacted, and each was sent an information sheet and consent form via email. Despite initial agreement, some respondents then declined to take part in the survey, mostly because they were not happy to fill out a Time-use diary for 14 consecutive days. Others were not happy to give private information about their life to a person who they knew. Prior study by Yoon et al. (2012) in Korea also showed that participants found it difficult to fill out a time-activity diary for a 24 hours over 7 days. Couples were the easiest to find and single households the most difficult, especially when came to small houses. Over two and half months, 8 participants were found who agreed to take part. One, who was a single parent, only completed the first day questionnaire.

All participants were then emailed for an appointment for the first day survey (see “Questionnaire for Day 1” in Appendix 5.1), which was estimated to take about 15 minutes. Where this happened was left to the participants. For some it was at their work place, while for others it happened in a café or their house. The latter meetings were the most useful as it was possible to discover more problems over selecting type of spaces and furniture as the Questionnaire for Day 1 asked about house layout, occupants, furniture and appliances. The researcher undertook the interview so was able to discuss any problems arising from the questionnaire, as well as recording how long it took to complete. In addition, as Wu et al. (2011) believe, the presence of interviewers can encourage participants to recall more details. At the end, another appointment was made for the second day questionnaire which was also estimated to take about 15 minutes.

The Questionnaire for Day 1 was transferred to a digital format and the Questionnaire for Day 2 and Time-use diaries for 14 days were adjusted based on the answers to the Questionnaire for Day 1. For instance, non-existing furniture and appliance items were removed from the “Questionnaire for Day 2” and non-existing spaces were excluded from the time-use diaries.

As before, the researcher was present when filling out the Questionnaire for Day 2. At the end the time-use diaries were introduced with instructions on how to complete them. Providing participants had no plans to be away in the next 2 weeks they were asked to start filling these out on the first Monday, otherwise the filling out was delayed until they were at home for two consecutive weeks. Two weeks was determined as the minimum period required for seeing differences in time-use patterns. A time-use microenvironment study by Dörre (1996) also asked participants to start filling out their time-use diaries on a Monday and end the Sunday of the same week (for 7 consecutive days). In this survey, if necessary one day before the start participants were sent a reminder email and a second was sent to ask about potential problems 2 or 3 days later. A final email was sent on the fifteenth day to make an appointment to collect the time-use diaries. Participants were also asked for

feedback on the time spent on each form each day, who had filled them out (for families), the time of day forms were usually filled out and on any problems or unclear parts of the timetables.

The intention was this part would be filled out by one adult member of the household on behalf of all family members. For this reason, a table for each day was created for each occupant (14 time-use diaries for each family member). The aim was to make daily completion easier and hence increase the accuracy of the information. In this method participants were to draw a line under the times they used each space up to the nearest 15 minutes on a pre-prepared form (Figure 5.1). For usages less than 15 minutes (like going to the bathroom), they were asked to put a line through one cell (15 minutes). To make this procedure clear, two examples were shown to them. The aim was to create an understanding of when, where and for how long each individual participant spent his/her time in the various rooms/spaces of his/her house.

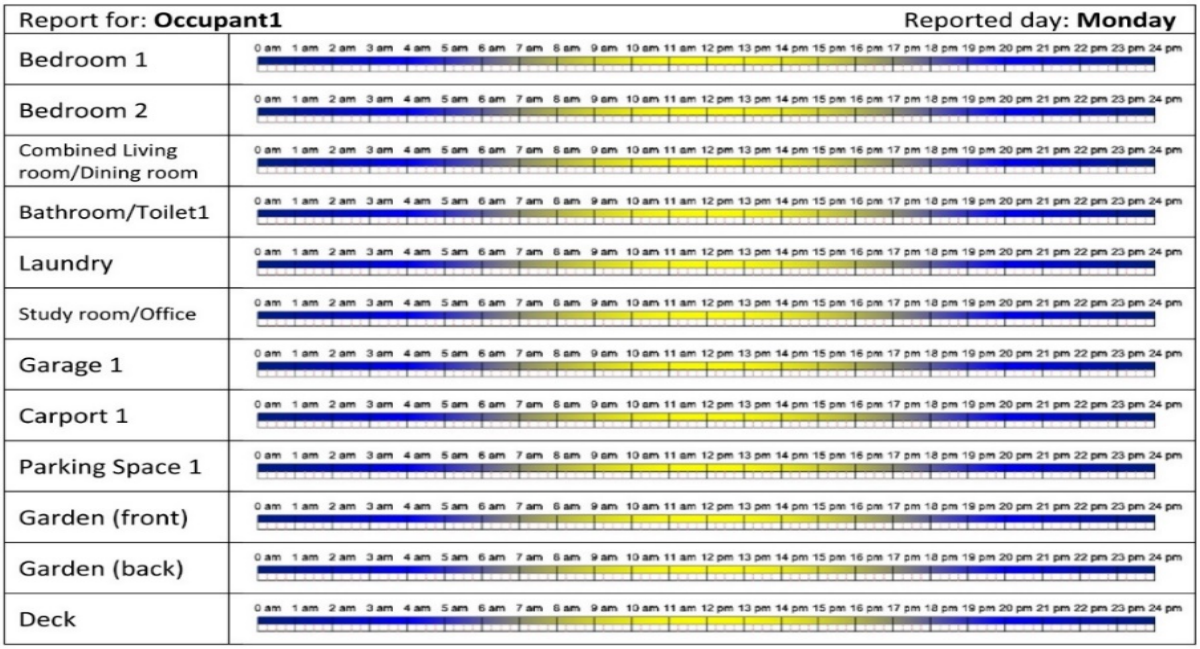


Figure 5.1 Proforma for recording use of each space by each occupant

Previous time-use studies show that season (Matz et al. (2014), Wu et al. (2012), Schweizer et al. (2007), Hussein et al. (2012), Echols et al. (1998), Leech et al. (2002), Conrad et al. (2013), Freeman et al. (1998), McCurdy and Graham (2003)) is a predictor of outdoors time-use. The pilot study was conducted during the heating season. The other predictor is day type (Hussein et al. (2012), Dörre

(1996), Schweizer et al. (2007), Schwab et al. (1990), Yoon et al. (2012), Wu et al. (2012), Glorieux and Minnen (2009), Echols et al. (1998), Conrad et al. (2013), Yang et al. (2011), McCurdy and Graham (2003)) but this was covered by asking for time-use over 14 days.

5.5. Sample characteristics and data collection times

Overall, 8 participant households took part in this study each representing one of the intended groups for investigation, with all groups covered (Table 5.1). All houses were owner occupied, with open spaces, and were located in Wellington city and adjacent suburbs, as previous studies have shown location of house can affect time-use at home indoors (Brasche and Bischof (2005) and Schweizer et al. (2007)) and outdoors (Matz et al., 2014). There was at least one large and small house for each household type. Overall, 14 individuals took part in the survey, with a good distribution of gender (8 females and 6 males) as prior studies indicate gender is another significant predictor of daily time-use in different environments, especially at home indoors (Matz et al. (2014), Briggs et al. (2003), Schwab et al. (1990), Schweizer et al. (2007), Brasche and Bischof (2005), Hussein et al. (2012), Yang et al. (2011)). The individuals had a wide age range (3-70 years) as age is also a significant predictor of daily time-use at home (Matz et al. (2014), Wu et al. (2012), Schwab et al. (1990), Schweizer et al. (2007), Brasche and Bischof (2005), Hussein et al. (2012), Conrad et al. (2013), Yang et al. (2011), Freeman et al. (1998)).

	Single person households		Couples with no children		Couples with 1 child	
	Number of cases	Key	Number of cases	Key	Number of cases	Key
Large house	1	1.G	1	1.C	1	1.B
Small house	1	1.H	2	1.A & 1.F	1	1.D

Table 5.1 Participant household characteristics (household 1.E was removed from the study as the information was incomplete)

Households A-G represent a range of house layout, house size, age group and job type as described below:

Household 1.A: This consists of a couple in their 50s who both work in education. They live in a small house with 1 bedroom, a combined living room/dining room/kitchen, bathroom/toilet, laundry and

study. The house has no garage or carport but has 2 parking spaces for their single car. Their house has a front and a back garden with a conservatory/shed.

Household 1.B: This household consists of a working couple in their 30s with a child under school age. The husband has a young daughter from his previous marriage who stays for one day every two weeks. They live in a very large converted church. The resultant house has 5 bedrooms, a combined living room/kitchen, combined living room/dining room, 3 bathroom/toilets (2 en-suites), 1 laundry and a storage room. The house has no garage or carport but has 6 parking spaces. They have 1 private and 1 business car. They also have a shipping container parked in one of the parking spaces to store stuff. Their house has front and back gardens with two decks.

Household 1.C: This household consists of an academic couple in the 65+ age group. They live in a large house with some unusual spaces. The house has 1 bedroom, a combined living room/dining room, 1kitchen, 1 bathroom/toilet, 1 toilet/laundry, 1 study/office, 1 music room, 1 sewing room, and 1 conservatory. The house has a garage which is being used to store the goods of a family member. They have 1 car which is usually parked outside the garage. Their house sits in the middle of a large garden with a deck outside the conservatory and which has three sheds (a train room, garden shed/workshop, and studio).

Household 1.D: This household consists of a couple in their 40s with a child at primary school, who work in research. They live in a small house with 3 bedrooms, a combined living room/dining room/kitchen, 1 bathroom/toilet and 1 study which is also used as a laundry. The house has 1 garage and 1 parking space and they have 2 cars. Their house also has a private back garden with a garden shed and a deck which is shared with another house.

Household 1.F: This household consists of a professional couple in their 50s. They live in a new house which has 2 bedrooms, a combined living room/dining room/kitchen, a separate living room, 2 bathroom/toilets and 1 study, which is a part of combined living room/dining room/kitchen but has a sliding door so it can be separated. The house has a garage for one car and parking space for 3 cars.

They have 1 car which is usually parked in the parking space. Their garage is used as music room. Their house also has front and back gardens with a patio.

Household 1.G: This household is a single professional in his 50s. He lives in a very large house which potentially has 6 bedrooms but at the time of the pilot study only 3 were used as such, with the others used as storage and for a study. The house thus has 3 bedrooms, 2 living rooms, 1 dining room, 1 kitchen, 2 bathroom/toilets, 1 laundry, 1 study/office and 2 storage rooms (which are potential bedrooms). The house has a garage and a carport each having space for one car. The participant has 4 cars and 2 boats. The house also has front and back gardens with 4 decks.

Household 1.H: This household is a single woman in her 70s who owns a business. She lives in a semi-detached town house. Her house has 2 bedrooms, 1 combined living room/kitchen, 1 bathroom/toilet, 1 toilet and 1 study/office. The house has a garage and a parking space each with space for one car. She has 1 car which is usually parked in the garage. The garage is also used as a laundry. The house has side and back gardens with 1 deck.

As noted, data collection happened in the heating months. According to the HEEP study report (Isaacs et al., 2010), June, July and August are the months accruing the highest percentages of total annual energy used for heating. These were thus the months selected for the survey to represent winter. The initial aim was to repeat the time-use diaries for a week in summer but only 5 out of the initial 7 households agreed to do this, and one of these had changed significantly in household composition. Based on this, it was decided to drop this idea, noting that the international literature (Leech et al. (2002) and Matz et al. (2014)) shows the difference between summer and winter time-use is around 4%. Table 5.2 shows the dates when each household started and ended the time-use diaries.

Households	1.A	1.B	1.C	1.D	1.F	1.G	1.H
Start date	16 June 2014	14 July 2014	30 June 2014	7 July 2014	21 July 2014	28 July 2014	4 August 2014
End date	29 June 2014	27 July 2014	13 July 2014	20 July 2014	3 August 2014	10 August 2014	17 August 2014

Table 5.2 Start date and end date for filling out timetables in the pilot study

Based on the recorded time for days 1 and 2 of administering the questionnaire and the times reported for filling out the time-use diaries, the overall time spent by each participant for the whole process is

shown in Table 5.3. This shows the time spent on the day 1 questionnaire is less than the estimated 15 minutes and this did not vary with the size of house. On the other hand, the time spent on the day 2 questionnaire was more than the estimated 15 minutes and although less time was spent for smaller houses, longer times did not necessarily correlate with larger houses. In addition, the times spent filling out individual timetables were very similar for all participants although the household time naturally depended on family size. Overall, it seems that variation in times for the day 1 questionnaire was personal while house size could be important for the day 2 questionnaire. Time spent on the time-use diaries depended on house size, participant speed and family size. It should be noted that surveys of this type are usually time consuming. For instance, McKenna et al. (2007) investigated time-use of older Australian using time activity diaries filled out during interviews, which took about 1 hour for each participant.

		Time spent on each part by each sample household (minutes)								
Household		**1.A**	**1.B**	**1.C**	**1.D**	**1.E**	**1.F**	**1.G**	**1.H**	**Average**
House size category		**Small**	**Large**	**Large**	**Small**	**Small**	**Large**	**Large**	**Small**	
Day 1 questionnaire		16	17	16	14	5	20	12	11	14
Day 2 questionnaire		14	24	20	20	NA	32	30	13	22
Time-use diaries	Each form/Person	5	5	5	5	NA	5	5	5	5
	Each day/Household	10	15	10	15	NA	10	5	10	10
	Two week subtotal	140	210	140	210	NA	140	70	140	140
Total		185	271	191	264	NA	207	122	104	192

Table 5.3 Time spent for each questionnaire/timetable by each household

Participating households differed over when they filled out their time-uses diaries. Some filled them out at the end of the day or early the following day, although most filled out their forms over the day because they thought they might forget the exact times spent in each room. A similar study by Yoon et al. (2012) in Korea also showed that participants filled out their time-activity diaries over a day although sometimes they forgot and completed these later or the next morning when they were reminded by a text message. All adult participants filled out their forms individually as they believed they would not know the exact times spent by their partner in different spaces of their house over a day. This could be a problem for families in which all participants are out of home at work or school. All time-use diaries for children were filled out by the parent who had spent more time with the child that day, normally mothers. Dörre (1996) also asked parents and nurses to fill out daily diaries on

behalf of toddlers. Wu et al. (2011) and Conrad et al. (2013) asked parents to complete time-use surveys on behalf of their children, while Leech et al. (2002) asked parents of participants aged 10- to report their child's time activities.

5.6. Definitions and categorisation of house spaces

All time-uses reported in this study follow a metric value e.g. 4 hours and 15 minutes (4:15) is shown as 4.25 hours. As each house has a different combination of rooms, the spaces within a house were put into 12 categories as listed in Table 5.4 and defined below. In this categorisation garages are not considered unless they have a different function from housing cars. It should be noted that for spaces with combined functions i.e. study/laundry, the function that happens for the majority of time will be considered. Table 5.4 also shows how the sub-spaces of each investigated house are categorised according to these definitions:

Usual bedrooms: Bedrooms used daily, or almost daily by at least one usual occupant over the days investigated

Extra bedrooms: Bedrooms not normally used by any usual occupant over the days investigated

Usual living area: The most used living room, dining room and kitchen or a combination of these (combined living room/dining room/kitchen, combined living room/dining room, combined dining room/kitchen, combined living room/kitchen, separate living room, separate dining room, separate kitchen).

Extra living areas: Any additional living room, dining room and kitchen or a combination of these as listed above.

Study/office: Any room or combination of rooms which is reported to be used as a study/office.

Specialised rooms: Any indoor space which is not used as a bedroom, living room, dining room, kitchen, storage, bathroom/toilet or study/office but that has a reported function These include workshops, games rooms, playrooms etc.

Usual bathroom/toilet(s): The bathroom/toilet(s) usually used at least by one of the usual occupants over the days investigated.

Space category	Participant household spaces						
	1.A	1.B	1.C	1.D	1.F	1.G	1.H
Usual bedrooms	Bedroom	Bedroom 1 Bedroom 2	Bedroom	Bedroom 1 Bedroom 2 Bedroom 2	Bedroom 1	Bedroom 1	Bedroom 1
Extra bedroom	NA	Bedroom 3 Bedroom 4 Bedroom 5	NA	NA	Bedroom 2	Bedroom 2 Bedroom 3	Bedroom 2
Usual Living areas	Combined living room/Dining room/Kitchen	Combined living room/Kitchen	Combined living room/Dining room Kitchen	Combined living room/Dining room/Kitchen	Combined living room/Dining room/Kitchen	Living room 1 Dining room Kitchen	Combined living room/Kitchen
Extra Living areas	NA	Combined living room/Dining room	NA	NA	Separate living room	Living room 2	NA
Study/Office	Study/Office	NA	Study /Office	Laundry/Study	Study/Office	Study/Office	Study/Office
Specialised rooms	NA	NA	Music room Sewing room	NA	Garage	NA	NA
Usual Bathroom/Toilet(s)	Bathroom/Toilet	Bathroom/ Toilet 1 Bathroom/ Toilet 2	Bathroom/ Toilet	Bathroom/ Toilet	Bathroom/ Toilet 1	Bathroom/ Toilet 1	Bathroom/ Toilet
Extra Bathroom/Toilets	NA	Bathroom/ Toilet 3	NA	NA	Bathroom/ Toilet 2	Bathroom/ Toilet 2	Toilet
Laundries	Laundry	Laundry	Toilet/Laundry	NA	NA	Laundry	Garage
Sheds and sleep outs	Conservatory /Shed	NA	Conservatory Train room Studio Garden shed/workshop	Garden shed	NA	NA	NA
Storage	NA	Storage	Garage	NA	NA	Storage 1 Storage 2	NA
Open spaces	Front garden Back garden	Front garden Back garden Deck 1 Deck 2	Front garden Back garden Deck	Back garden Deck	Patio Front garden Back garden	Front garden Back garden Deck 1 Deck 2 Deck 3 Deck 4	Side garden Back garden Deck

Table 5.4 Ten categories of spaces and those found in each participant household

Extra bathroom/toilets: Bathroom/toilets not usually used by any usual occupant over the days investigated.

Laundry: Rooms that have some kind(s) of washing machine (and used only for this purpose) regardless of whether or not they are called a laundry.

Sheds and sleep outs: Non-habitable rooms located outdoors including garden sheds, sleep outs and conservatories.

Storage: Any habitable indoor room used for storing extra items and that has no other reported function.

Open spaces: Spaces outdoors or that have at least one face open to outdoors. These include gardens, decks, verandas, patios and balconies.

5.7. Results

5.7.1. Problems with the "Day 1" questionnaire

As mentioned before, the Day 1 and 2 questionnaires were filled out in the presence of the researcher and feedback was collected. The feedback useful in the development of the questionnaire for study 2 are summarised below:

General information: One participant had a problem with writing an exact age and suggested an age range should be offered. One participant had written "none" for her student son's job, so this will need to be clarified so students do not appear in the results as unemployed or retired.

Spaces: Participants had spaces in their houses and outdoor space not listed in the questionnaire (conservatory, garden shed, music room, sewing room, train room, studio, separate toilet, toilet/laundry and patio). In addition, the order of presenting choices seems to be very important. For instance, there were more combined living room/dining room/kitchens than combined living room/kitchens, combined living room/dining rooms and combined dining room/kitchens, but because the latter were presented before the combined living room/dining room/kitchen, most participants selected the first or second option and then changed their minds. Additionally, some houses have side

gardens instead of front or back gardens, which were not an option, and for some participants front, side and back gardens were combined.

Another problem in this part was understanding the differences between combined and separate spaces. For instance many participants did not know whether their living room, dining room and kitchen were separate spaces or combined. For this reason, a unique definition was given verbally that will need to be incorporated into the final questionnaire: "a room can be called separated only if it has a door or door-size opening leading into the next space."

The number of garages, car ports and parking spaces was also confusing for some participants. The questionnaire asked "[Number of] Garages (Suitable for how many cars?)". This could have two different answers, one for the number of garages and the other for the capacity of the garage (i.e. 1 garage suitable for 2 cars). This provided more problems for the day 2 questionnaire on the location of furniture. For instance assuming a participant had a garage suitable for 4 cars, in part 5 the garage appears as 4 options (Garage 1, Garage 2, Garage 3 and Garage 4) but without defining the garage capacity. So one garage could house four cars, and this might not be accounted for in the results. The same problem exists for parking spaces and carports.

Furniture/Appliances: Most participants were confused with the headings in this part. The question asked them to tick furniture items available in **any spaces** of their house (e.g. A-Bedroom furniture). However, many participants thought they could only tick furniture available in the room in this heading. Built-in furniture was completely missed in the questionnaire. Participants added built-in wardrobes, chest of drawers, shelves, book cases, display cabinets, TV cabinets, storage cupboards, chaise longue, and benches to the listed bedroom/living room furniture. Other furniture items and appliances were added by participants; chipper, weed eater, chain saw and building electrical tools were added to part G (gardening equipment/tools); scooters (for adults) were added to part H (vehicles); and bread maker, curling iron, hair straighter, popcorn maker, waffle, sewing machine, scanner, fax, combined printer/scanner/fax, combined printer/scanner and stereo were added to part

I (small appliances). In addition, central radiators (gas), central heating, underfloor heating and DVS system were added to type of heating system used in the house.

There were also problems in each sub section as set out below:

Part A (Bedroom furniture): Some participants wondered whether a bunk bed was 1 furniture item or 2. Desktop/PC appeared both in this part and part I and as this is an appliance it needs to be deleted in this part. Some participants did not know what was meant by a clothes rack as many thought it was a clothes drying rack, which appeared in part D (bathroom/toilet/laundry furniture). Large mirrors were also confusing as some participants did not know what size was intended, so a size definition guide is needed.

Part B (Living room/Dining room/ Lounge furniture): Most participants did not know what type their television was (LCD/LED/plasma/cathode-ray). There was also confusion over the difference between a TV cabinet and an entertainment unit. One participant doubted if animal skins were rugs. One participant wondered if a bedside cabinet could be counted as a bedside table as they have very similar usages. Large sculptures/vases were another size definition problem.

Part C (Kitchen furniture/Large appliances): The order of choices seems to be important in this part. For instance, almost all participants selected fridge first but they changed to fridge/freezer when they saw this was another option. It seems that always the most popular items need to appear first to avoid mistakes. Most participants believed cook top and oven were two separate kitchen appliances, whereas the questionnaire presented them as a joint appliance. One participant also suggested that cooktop is usually known as “hob” in New Zealand and recommended changing this. Storage cupboards were an issue for most participants as they did not know what type of storage cupboards to report, and especially whether fixed or built-in storage cupboards in the kitchen and bathroom/toilet should be reported here or not.

Part D (Bathroom/Toilet/Laundry furniture): Heated towel rail was a repeated fixture as it appeared in part 3 (Bathroom features).

Part E (Outdoor furniture): Some participants added an outdoor table combined with a two benches (a picnic set) to the list.

Part F (Games furniture/equipment): Some participants wanted to write the exact types of exercise equipment used in their house (treadmill, weights, cycle etc.) but the question was only asked in a general way.

Part I (Small appliances): Unlike previous parts, this part asked participants to write a number for each appliance owned. Almost all participants ignored these instructions and continued ticking available appliances as previously.

5.7.2. Problems detected with the "Day 2" questionnaire

The following problems were detected in the "Day 2" questionnaire relevant to developing the main questionnaire for Study 2:

Number/place of furniture: While filling out the Day 2 questionnaire some participants found they had not reported or chosen wrong furniture items and needed to correct these mistakes. Overall, questions in this part were clear but time consuming for participants with many items of furniture/large appliances listed. For some people in very large houses it was difficult to remember the true number of some furniture items (e.g. chairs). One participant had both a private and a business car and did not know whether to report 1 or 2 cars as available for the household. The other problem in this part was that some furniture items were located in rooms which were not among the offered options. These and their location(s) are listed in Table 5.5.

On the other hand, some furniture items such as clothes drying rack, child's scooter, umbrella/gazebo or hammock did not have a specific location in the house. It seems that a guide is needed in this part to tell participants which location is more important for this study.

How a furniture item is used was also an issue. For instance, some participants doubted whether shelves without books or shelves containing something other than books (i.e. toys) could be counted as a book case. The questionnaire allowed for some furniture and appliance choices up to an estimated maximum and mostly the reported number was less than the estimated maximum. Storage cupboards and electrical building tools were the only items where the estimated maximum (3 and 5 respectively) was less than the reality (4 and 12 respectively).

Furniture/Large appliances	Location
Storage cupboard	Hallway
Scooters (for children)	Living room, Laundry
Book shelf	Kitchen
Dining table/suite	Conservatory
Chair (for dining table/suite)	Conservatory, Bedroom
Chair (other than desk chair/dining table chair)	Bedroom
Ironing board	Sewing room
Workbench	Workshop
Drills	Workshop
Cars	On road, Drive way
Hammocks	Wardrobe of bedroom
Double King/Queen bed	Living room
Clothes rack	Living room
Single seater Couch/Sofa (i.e. armchair)	Garage
Piano	Garage
Rug	Garage, Hallway
Floor lamp	Garage
Bench	Bedroom, Laundry
Book case	Foyer
Wall clock	Kitchen, Bathroom/Toilet
Chest of drawers	Garage

Table 5.5 Furniture/Large appliances located in a space not among offered choices

Gatherings and parties: This part was not clear for most participants and they wanted to select more than one option in answering the questions as they believed their parties and guests could vary from time to time. For instance, some participants selected up to 4 options to show the frequency of the different gatherings and parties in their house over a year. This also happened when selecting the location, number of people attending and time of the gathering/party. The same applies to the third and fourth questions about guests. In addition, some new statements (e.g. “every 2 years”, “half of a year” and “every two weeks”) were also added as options for the frequency of having a guest options by participants. Another participant added “kitchen” as the location of his gatherings/parties.

Satisfaction with the house: Questions 1 and 2 of this part seemed clear but the problem was that the answers were very dependent on who filled out the questionnaire. For instance, a couple filling out the questionnaire together had different ideas about the first question. The man believed their house was large house while the woman believed it was small. It therefore seems necessary to know who fills out the questionnaire. Some participants believed the sequence of importance in the third question (Not important, Somewhat important, Neutral, Important and Very important) was not logical as they thought "Somewhat important" is more important than "Neutral". This needs further consideration. This question also asked participants to add parameters when it comes house selection and number of spare bedrooms. The meaning of "Location" was not clear for most participants. [Presence] of "bush", [less] "noise", "hospitality", "guests" (space for entertaining) were other phrases added by participants as important parameters for selecting houses with spare bedrooms.

5.7.3. Problems detected with the time-use diaries

All participants were able to fill out the time-use diaries based on written and oral instructions although almost all had a problem with the very small cells, and some asked for larger versions. Using 15 minutes as the shortest unit of time gave acceptable results for spaces which were much used over a day (i.e. living rooms, bedrooms) but did not give true results for spaces with very short usages. For instance, a bathroom/toilet might be used several times a day for less than 5 minutes but based on the instructions each must be shown as 15 minutes. So a toilet used 10 times a day by a couple with each usage taking 5 minutes would be an overall time use of 50 minutes, but based on the instructions this would be 150 minutes or triple the real time. The same problem could happen for laundries, gardens, decks, specialised rooms and other spaces which are used rarely. It seems that shortest time for spaces with few usages needs to be different from other spaces in the final questionnaire. Elgethun et al. (2007) compared the results of a time-activity diary with 15 minutes steps with a GPS system and found that participants overestimated outdoor usages. They believed that the main reason for this was participants had to report 5 minutes being in a car as 15 minutes in diary. Schweizer et al.

(2007) also used 15 minutes steps in their time diaries and found this method gave more accurate data for long-use spaces than short-use ones.

For some spaces, the time people spend in them is not very important. For instance, for garages, parking spaces and car ports, the time the car is parked is more important than human use of the space. This was not clarified in the timetables although all participants were informed of the issue. However, this produced a second problem. Some participants used their garages for things other than car parking or used their garages both for parking and something else, and did know how to reflect these usages in the time-use diaries. Another problem for garages, parking spaces and carports as mentioned earlier is that though a garage might have capacity for 4 cars it is still one space whereas the time-use diaries asked for time spent in garages (or parking spaces/carports) as 4 separate spaces (i.e. asks how much time have you spent in garage 1, garage 2 etc.).

The method used in this part could also produce another problem as a person cannot be in 2 different spaces at the same time. Out of the seven participant households in the pilot study participant G logged more than 24 hours of space usage over a day. When asked about the reason, he was trying to account for spending short times in several rooms during each 15 minutes interval (For instance he was in the living room from 10:00am to 10:07am, dining room from 10:08am to 10:11am and kitchen from 10:12am to 10:15am). Rather than underline the room in which most time was spent, as others had done, he underlined all three spaces for the same interval.

Diaries used by Schweizer et al. (2007) were designed to record where participants were every 15 minutes and participants were able to select a 15 minute cell for several microenvironments but this would be divided evenly between those microenvironments. The same method was used by Echols et al. (1998). Elgethun et al. (2007) mention getting to a subtotal of 24 hours as an acceptable validity method used in many studies. Based on this, a smart timetable which can automatically check the validity of entered data, which must add up to 24 hours, could be useful.

5.8. Analysis of time-use diaries

5.8.1. Time-use differences between weeks 1 and 2

For a first analysis the typical 24 hour day was categorized into 5 parts as shown in Table 5.6. Figures for each participant/day/space were extracted from the original time-use diaries and put into the Table 5.6 format. Given the large amount of data for most participants (up to 4500 entries) a platform file was produced in SPSS for each participant and figures were transferred to SPSS for further analysis. Overall, for the participant households (7) and individual participants (14) this survey gathered data for 98 household/days and 196 person/days. This number of participants is more than the study of Yoon et al. (2012) in Korea who asked 6 participants to fill out time-activity diaries for 7 days (42 person/days).

Early morning	Working/School time	Evening/Early night	Sleep time	Overall time used
6:00am-9:00am	9:00am-4:00pm	4:00pm-21:00pm	21:00pm-6:00am	0:00am-24:00pm

Table 5.6 Categorisation of a typical 24 hour day time

For each household the average time per day spent at home indoors each week was produced by dividing overall time spent in all indoor spaces of the house by all household members by 7 and then by the number of household members. Analysis indicates times spent indoors and outdoors follow different patterns over the two weeks, but as seen in Figure 5.2, the average times spent indoors by all participants were very similar in both weeks with an average change of 0.6% (6.5 minutes) between the two weeks for the whole sample.

The same method was used to find the average time per day spent at home outdoors each week. This shows that the average time spent at home outdoors in weeks 1 and 2 are different (Figure 5.3) and on average, time spent outdoors in weeks 1 and 2 has changed by 13.5% (2.3 minutes). It is probable that the weather has had an effect and this discussed more in section 5.8.2.

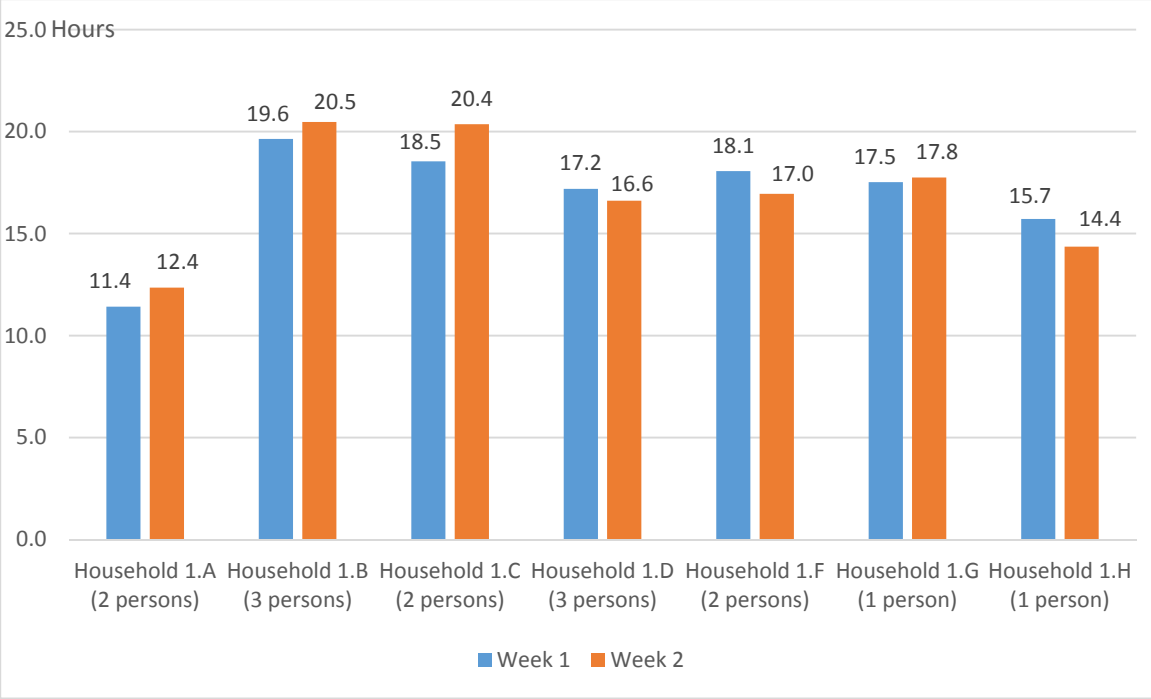


Figure 5.2 The Average time per day spent indoors by all family members in weeks 1 and 2

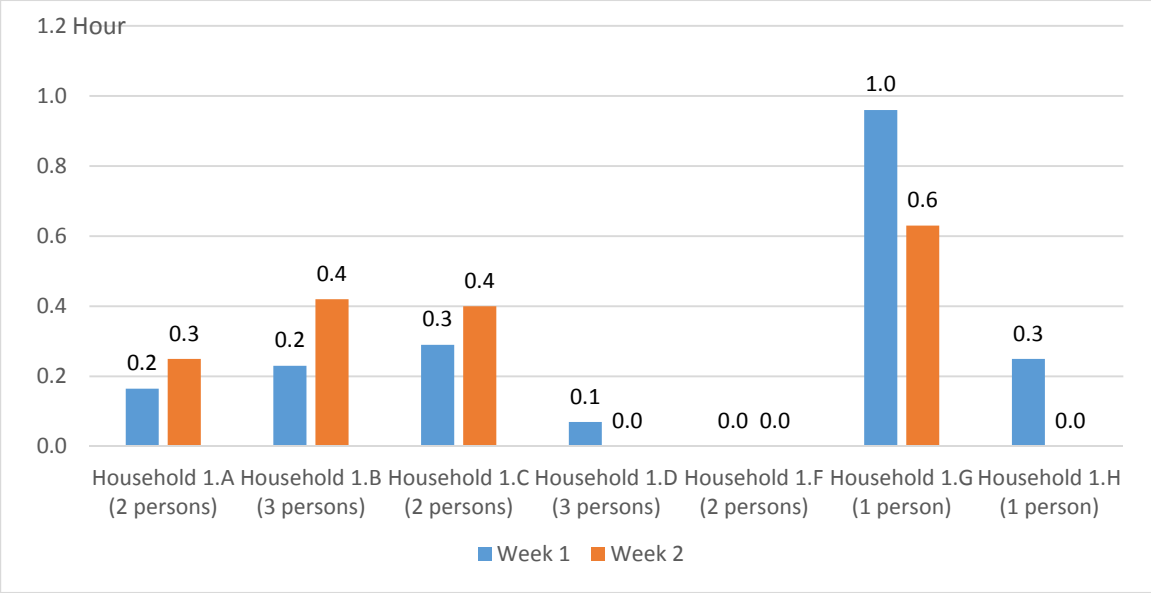


Figure 5.3 Average time per day spent at home outdoors by all family members in weeks 1 and 2

5.8.2. Time-use at home outdoor and weather parameters

As mentioned in section 5.8.1, for most households the average times spent at home outdoors is different (in terms of percentage) between weeks 1 and 2. Prior studies by McCurdy and Graham (2003) have shown a relationship between times spent outdoors and weather parameters. Table 5.2 shows the dates for which time-use diaries were completed. In their longitudinal time-activity study, McCurdy and Graham (2003) asked their single participant to report rain/snow fall and maximum

temperature for each of 369 investigated days in the time-activity diary of the relevant day. In this study, relevant weather data including maximum and minimum temperatures, rain fall, and wind speed were sourced from the "National Climate Data Base" official website (National Institute of Water and Atmospheric Research, 2014) for the period 16 June to 17 August 2014 (see Appendix 5.3). The average time-use at home outdoors for each household each day is the subtotal of the time spent in any outdoor spaces including decks and gardens by all occupants of that household divided by number of family members. The average time-use at home outdoors for each household was compared with weather data for that particular day. Averages were calculated for minimum and maximum temperatures, rain fall and wind speed for the days when the outdoors was and was not used (Table 5.7). Table 5.7 suggests using house outdoor space is correlated with higher minimum/maximum temperatures, less rain fall and lower wind speed.

Weather parameter	Value for days when outdoor spaces were used	Value for days when outdoor spaces were not used
Average minimum temperature (°C)	+7.16	+6.97
Average maximum temperature (°C)	+12.48	+11.76
Average rain fall (mm)	+2.02	+4.30
Average wind speed (Km/h)	+19.30	+21.25

Table 5.7 Average Minimum temperature, Maximum temperature, Rain fall and Wind speed for outdoor usage for all households.

Prior studies by Hussein et al. (2012) showed the importance of daily mean ambient temperature in daily time activity patterns in Finland as people tended to stay less at home and more outdoors in warmer days, although their study could not find any relationship between daily precipitation and wind speed with time/activity patterns, which they believe could be related to limited variation in those parameters on the investigated days. Studies by McCurdy and Graham (2003) and Leech et al. (2002) also show the influence of weather related parameters on human time-activity patterns in the USA and Canada. McCurdy and Graham (2003) compared time activity patterns from four different studies in the USA and found that temperature, precipitation and day-type were the origin of outdoor usage differences. The recent Human activity pattern in Canada (CHAPS 2) (Matz et al., 2014) found season to be an important predictor of time spent at home indoors and outdoors, with time spent in the latter in summer double that of winter, when people spent much more time at home indoors.

Studies by Echols et al. (1998) in Maryland also support this as participants spent up to 1 hour less at home indoors and 0.7 hours more at home outdoors in warmer seasons. Conrad et al. (2013) found the same finding for German children. In contrast, in another study of microenvironment time-activity patterns in 7 European cities, Schweizer et al. (2007) found no clear seasonal effects on the overall time spent "home indoors" although they believed this could be the result of categorizing all days together in summer or winter and ignoring the weather on the days investigated. A study by Schwab et al. (1990) in Los Angeles using time-activity diaries also showed participants spent 23 minutes less outdoors in winter months in comparison to non-winter months. Studies by Wu et al. (2012) in California also suggest season is an important influential parameter affecting time-location/activity patterns. Their study showed that young children were more likely to stay the whole day at home (indoors) in cold seasons than warm ones while adults spent more time outdoors and did more outdoor activities in warmer seasons (Wu et al., 2012). The results of a time-use study by Montoliu et al. (2013) also show 2% more time-use at home indoors in comparison to similar studies. The authors believe that the fact that study was conducted in winter is one of the main reasons behind this difference.

Acknowledging that this is a pilot study with a very small sample, it seems outdoor space usage, not unexpectedly, is more probable on warmer, less rainy and less windy days. However, this is not necessarily the case for everyone. It seems there are priorities in the influential parameters. For instance, using outdoors at weekends is more important than temperature. Prior study by Yoon et al. (2012) in Korea, Conrad et al. (2013) in Germany, McCurdy and Graham (2003) in USA and Echols et al. (1998) in Maryland also showed more time was spent outdoors at weekends than on working days. Studies by McCurdy and Graham (2003) showed that weather parameters were significantly important for time spent outdoors although when day types were included in the analysis this significance disappeared. Their study also indicated that time spent outdoors at weekends would be more than on other days if there was no heavy rain that weekend (McCurdy & Graham, 2003). In the pilot study it also seems the situation for wind and rain is different. People do not use the outdoors on days with

heavy rain but light rain is not a problem. What the study cannot tell is whether they are avoiding the rain events in the intermittent light rain (4 millimetres in 24 hours) when they choose to use outdoor spaces. The situation for windy days is similar. Apart from avoiding high winds, wind is not an important parameter. In this study, overall people use outdoors in their free time (mostly weekends) if it is not rainy and windy, with greater usage in fine weather.

5.8.3. Time-use at home on different days of a week

Timetable analysis gives the overall time spent in the house by each household member. Table 5.8 presents this over 2 weeks, by adding times spent in all indoor and outdoor spaces (excluding garages, carports and parking spaces) by all family members. Numbers in Table 5.8 account for 2 users for couples, 3 for couples with one child, and 1 for single person households. The last row gives an average time-use for the whole sample for each day in weeks 1 and 2 and this is graphed in Figure 5.4. As seen in Table 5.8, times spent at home by households are different for all investigated days. At the same time some days in both weeks appear more similar in terms of time spent at home. Highlighted cells in Table 5.8 represent unusual days as these have a difference of more than a standard deviation from the relevant weekly average. According to Table 5.8, 23% of weekdays and 39% of weekend days have unusual time-use patterns.

Respondent household	Reference Week	The average time-use at home on different days of a week (Hour)								Standard deviation (Hour)
		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Week average	
Household 1.A	Week 1	24.25	24.00	23.25	17.25	25.75	27.00	33.25	24.96	4.78
	Week 2	24.00	28.75	28.00	21.75	21.00	35.75	41.25	28.64	7.50
Household 1.B	Week 1	68.00	51.75	57.00	46.25	55.00	71.50	67.75	59.61	9.54
	Week 2	64.75	60.25	58.00	59.25	60.00	67.50	68.75	62.64	4.30
Household 1.C	Week 1	38.25	44.50	30.75	37.25	34.75	37.25	40.75	37.64	4.34
	Week 2	43.75	43.00	29.50	46.25	44.75	38.25	45.75	41.61	5.96
Household 1.D	Week 1	50.75	48.25	45.25	57.00	54.50	55.00	55.00	52.25	4.28
	Week 2	46.50	42.75	43.00	47.50	50.50	55.75	62.75	49.82	7.25
Household 1.F	Week 1	40.50	30.00	35.00	45.50	29.50	30.75	41.50	36.11	6.42
	Week 2	35.25	31.75	33.50	42.75	33.50	24.25	36.25	33.89	5.53
Household 1.G	Week 1	19.46	21.37	14.76	19.77	17.32	16.65	20.00	18.48	2.30
	Week 2	17.47	18.00	18.18	12.76	14.51	23.97	23.79	18.38	4.24
Household 1.H	Week 1	15.50	11.75	14.25	14.25	17.50	18.75	19.75	15.96	2.84
	Week 2	14.00	10.75	16.50	12.25	11.25	13.25	22.50	14.36	4.07
Total average (per person)	Week 1	18.34	16.54	15.73	16.95	16.74	18.35	19.86	17.50	NA
	Week 2	17.55	16.80	16.19	17.32	16.82	18.48	21.50	17.81	NA

Table 5.8 Average time-use at home on different days of the week for each sample household

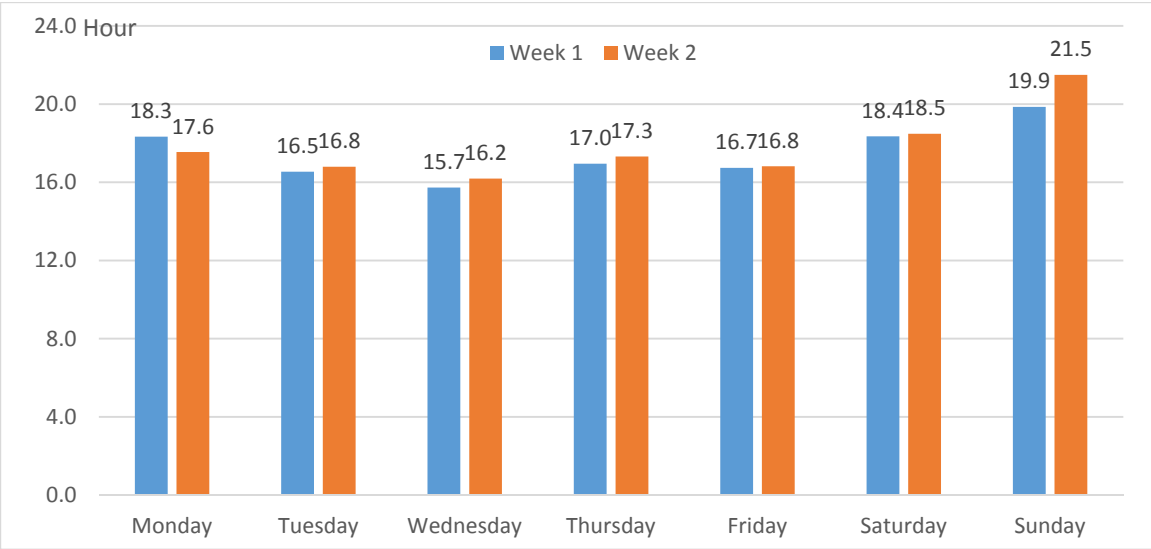


Figure 5.4 Time spent at home (indoors and outdoors) by whole sample (per person) in weeks 1 and 2

As seen in Table 5.8, for each participant some days in each week could be different for time spent at home. Consequently a Paired samples *t* test was undertaken using SPSS, yielding 21 different pairs of days for each week. Table 5.9 presents the results of the test with pairs with significant differences at 0.05 level highlighted. It shows that Sunday is the only day which is different from all other days of the week (even Saturdays). The same test was used by McCurdy and Graham (2003) to see differences between days regarding time spent indoors and outdoors for their single participant who filled out time-activity diaries for 369 days. They found some significant differences for time spent outdoors between different pairs of days specially Saturday/Sunday but no significant difference was found for indoors which they relate to the analysis being performed on data for one person.

In similar findings, Glorieux and Minnen (2009) believe that Saturdays and Sundays have very different characteristics although this difference is much smaller than the difference between weekends and working days. Echols et al. (1998) also found differences in time-use at home indoors/outdoors between Saturdays and Sundays.

Studies by Wu et al. (2012) in California indicated day-type (weekday vs. weekend) as the primary influential parameter for time-location/activity patterns. Studies by Hussein et al. (2012) in Finland also showed big differences in space usages between weekdays and weekends as people spent more time at home at weekends although they believe that this could change according to job type. They

found similar trends for holidays and days located between holidays and weekends as many people take them off to have longer holidays. Schwab et al. (1990) also found differences in time spent at home for school days and non-school days. Studies by McCurdy and Graham (2003) and Yang et al. (2011) show noticeable differences in time-activity patterns between weekdays and weekends. Wu et al. (2011) also found differences in the mean time spent on different activities by different groups on weekdays and at weekends based on both on web-based and a telephone-based survey. Dörre (1996) found differences in the mean averages for time spent in different microenvironments on Mon-Sun and Mon-Fri for German toddlers. So it seems that differences between weekdays and weekends are rooted in the job/study schedules of individuals and weekends are different because these are holidays for the majority of people. Schwab et al. (1990) also found people spend more time at home at weekends in comparison to working days, and a similar study by Yoon et al. (2012) in Korea of 6 participants showed clear time differences at home on weekdays and weekends, although this difference varied for housewives, graduate students and office workers. For instance, time spent at home increased at weekends for graduate students and office workers but decreased for housewives (Yoon et al., 2012).

Pair number	Pair days	Paired Differences					
		Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	Monday - Tuesday	2.54	5.74	1.53	1.66	13	0.121
Pair 2	Monday - Wednesday	3.96	5.03	1.34	2.95	13	0.011
Pair 3	Monday - Thursday	1.62	7.21	1.93	0.84	13	0.416
Pair 4	Monday - Friday	2.33	4.96	1.32	1.76	13	0.102
Pair 5	Monday - Saturday	-0.93	6.60	1.76	-0.53	13	0.605
Pair 6	Monday - Sunday	-5.47	5.55	1.48	-3.69	13	0.003
Pair 7	Tuesday - Wednesday	1.42	6.18	1.65	0.86	13	0.405
Pair 8	Tuesday - Thursday	-0.92	7.21	1.93	-0.48	13	0.640
Pair 9	Tuesday - Friday	-0.21	5.08	1.36	-0.16	13	0.879
Pair 10	Tuesday - Saturday	-3.47	7.81	2.09	-1.67	13	0.120
Pair 11	Tuesday - Sunday	-8.01	6.38	1.70	-4.70	13	0.000
Pair 12	Wednesday - Thursday	-2.35	8.16	2.18	-1.08	13	0.301
Pair 13	Wednesday - Friday	-1.64	6.23	1.67	-0.98	13	0.344
Pair 14	Wednesday - Saturday	-4.90	6.72	1.79	-2.73	13	0.017
Pair 15	Wednesday - Sunday	-9.44	4.68	1.25	-7.55	13	0.000
Pair 16	Thursday - Friday	0.71	6.38	1.70	0.42	13	0.684
Pair 17	Thursday - Saturday	-2.55	11.63	3.11	-0.82	13	0.426
Pair 18	Thursday - Sunday	-7.09	8.98	2.40	-2.95	13	0.011
Pair 19	Friday - Saturday	-3.26	7.11	1.90	-1.72	13	0.110
Pair 20	Friday - Sunday	-7.80	5.67	1.51	-5.15	13	0.000
Pair 21	Saturday - Sunday	-4.54	4.58	1.22	-3.71	13	0.003

Table 5.9 Paired samples t test

5.8.4. Time-use in different spaces on weekdays and at weekends

As mentioned, on average, times spent at home by households on weekdays and at weekends (especially Sundays) are different. This section investigates whether these differences happen in all spaces or only in some. For this reason, the average time spent in each space of the house on weekdays, at weekends and over the whole week was counted separately for each household. Garages, carports and parking spaces were excluded when used only for parking cars. For each household, weekdays, weekends and whole week averages were calculated using the following methods:

Weekday average for room X = (Subtotal of time spent in room X from Monday to Friday of weeks 1 and 2 by household) ÷ 10

Weekend average for room X = (Subtotal of time spent in room X on Saturdays and Sundays of weeks 1 and 2 by household) ÷ 4

Whole week average for room X = (Subtotal of time spent in room X on all days of weeks 1 and 2 by household) ÷ 14

Types of rooms in the sample houses are different and this makes the comparison difficult. To compare all participant households, all spaces were put into the 12 categories defined in section 5.6. The average time-use in each category for weekdays, weekends, and the whole week was calculated (Figure 5.5). In addition, Table 5.10 shows the differences between time-use in the different space categories in percentages and minutes on weekdays and at weekends.

As seen in Figure 5.5 and Table 5.10, the highest differences (in percentage terms) in space usage between weekdays and weekends is for storage rooms, extra bedrooms, garden and decks, extra living areas, specialised rooms, extra bathroom/toilets and laundries, with usual bedrooms usual living areas, study/office and usual bathroom/toilets having very similar time patterns on weekdays and at weekends. However, because time-use in some of these rooms is very small, the largest differences in terms of minutes appear in extra living areas and extra bedrooms. Glorieux and Minnen (2009) also found that activities with little day-to-day variations like sleeping and eating lead to lower day-to-day time-use variations. On the other hand, Freeman et al. (1998:425) found some activities follow a

periodic pattern (workshop use, house cleaning and vigorous exercise) and concluded these "episodic behaviours" need a full week time-activity diary to be captured.

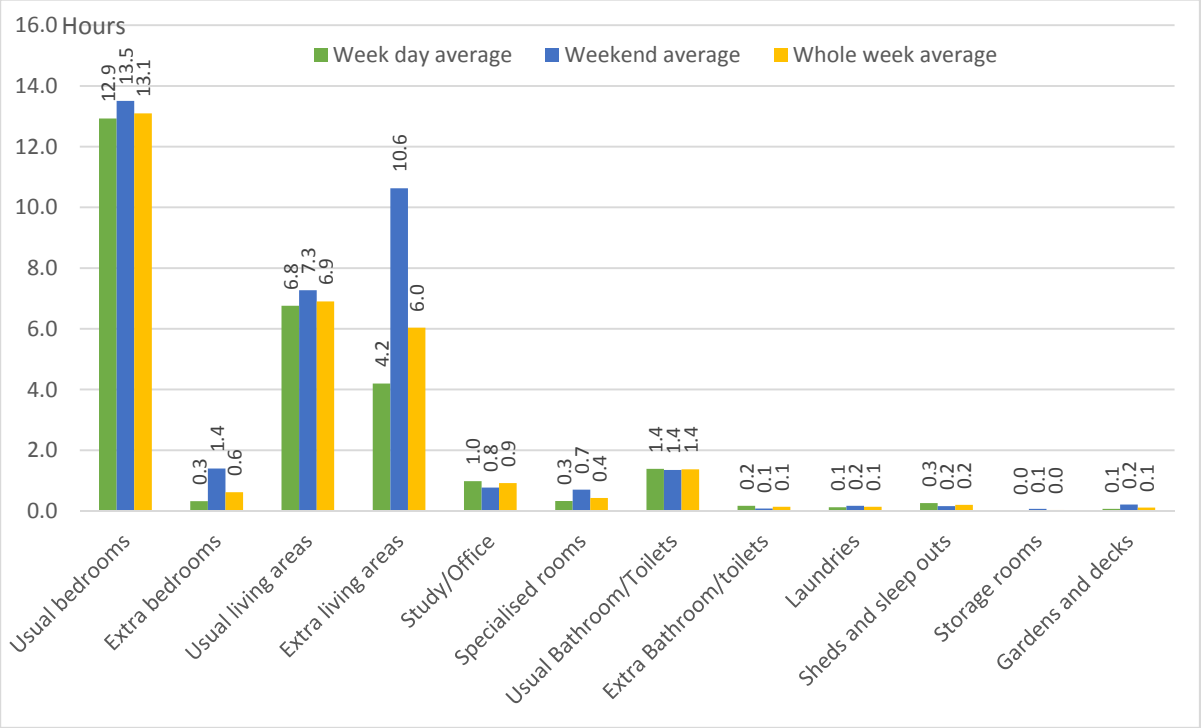


Figure 5.5 Average times spent in different space categories for weekdays, weekends and whole week for all households

Space categories	Difference between working days and weekends	
	in percentage	in minutes
Usual bedrooms	4.5%	35
Extra bedrooms	337.5%	65
Usual living areas	7.5%	31
Extra living areas	153.1%	386
Study/Office	21.4%	13
Specialized rooms	112.1%	22
Usual Bath/Toilets	2.9%	2
Extra bathroom/toilets	52.9%	5
Laundries	41.7%	3
Sheds and sleep outs	38.5%	6
Storage rooms	600.0%	4
Gardens and decks	200.0%	8

Table 5.10 Differences between times spent in space categories on working days and at weekends

On the other hand, considering the time spent in each space category shows most differences (in minutes) are for extra living areas and extra bedrooms. In other words, people spent more time at home at the weekends and this extra time is mostly spent in extra spaces. This difference might be rooted in the type of social activities happening in these, because as Glorieux and Minnen (2009) state, social activities usually have a weekly cycle and repeat on particular days of the week (usually

weekends). Prior study by Dörre (1996) of German toddlers showed noticeable differences in time usage of different spaces on weekdays and at weekends, with the biggest seen in their living room/bedroom category. In addition household type could also be important as a study by Wu et al. (2012) indicated that children and their parents are more likely to stay the whole day at home at weekends than on working days.

5.8.5. Average daily time spent in rooms by each household

This part of the study aims to find out how much time participant households spent in the sub-space categories of their houses. The time-use diaries give the estimated time spent in each room by each household member for each day. In this part, individuals are not important but the overall time spent in each space is. For this reason, the average time spent in each space category (as defined in section 5.6) by the household in a day was calculated as follows:

Average time spent in space category X = (Subtotal of times spent in rooms in category X by household in 2 weeks) ÷ 14

In addition, each household spent part of a day outside the home and this was calculated as follows:

Average time spent out of the home by each household = (Number of usual household members × 24) – (Subtotal of average times spent in all outdoor and indoor spaces)

The average time-use in each space category was calculated for all households. A comparison of these showed that the time spent in each is different and this could be affected by house size and the availability of extra spaces. On the other hand, the time spent in different space categories is affected by the time spent out of home, which will be related to jobs/education. For instance, people who have full time jobs spend more time out of home, while those working part-time or who have young children seem to spend more time at home. This is in line with studies by Schweizer et al. (2007) and Yang et al. (2011) who found that families with children tend to spend more time at home although it should be noted that children in those studies might not be of school age because a study by Denman et al. (2000) in the UK showed school children spent less time at home than adults (60% vs 72%). The recent Canadian human activity pattern survey 2 (CHAPS 2) shows time spent at home by infants (89.2%) and young children (74.0%) is much more than the average for all age groups (69.9%) (Matz

et al., 2014). Studies by Conrad et al. (2013) on German children also showed that time spent at home decreased with age. Old people also tend to spent longer times at home (Matz et al. (2014), Echols et al. (1998) and McKenna et al. (2007)). For instance, McKenna et al. (2007) in a study on elderly time-use patterns found that Australians aged 65+, on average, spend 85% of day time at home, compared with 77.7% for Canadians aged 60+ (Matz et al., 2014) and 81.3% for the 64+ age group of Maryland, USA (Echols et al., 1998).

Analysis of these 7 households shows that regardless of house size, on average, households spend 84.5% of the time they are at home in their usual living area (29.9%) and bedroom(s) (54.6%). Depending on household size, these spaces represent a small proportion of the house floor area in large houses. In addition, the time spent in bedrooms (9.28 hours) shows their importance. Prior study by Wu et al. (2012) in California also showed people spend almost half their time at home sleeping, and children sleep longer than adults. Matz et al. (2014) also found that Canadians spent slightly more than half (8.62) of time at home sleeping and about 8 hours awake at home. Time Use Survey 2009/2010 by (Statistics New Zealand, 2011d) indicates New Zealanders aged 12+ spend 8.8 sleeping per day, compared with 9.28 hours spent in usual bedrooms in this study where 2 out of 14 participants were children aged 12 or less.

Considering this is a winter time-use study, analysis of these 7 households indicates on average they spent 70.71% of day time in house indoor spaces and 1.11% in outdoor spaces. The subtotal of these two figures (71.82%) is very near the estimated figure by Baker et al. (2007) based on the NZ Time Use Survey and NZ Travel Survey. Baker et al. (2007) split this figure into 69.7% for indoors and 2.4% for outdoors based on a number of international studies, although they doubt the reliability of their method. It should be noted, however, that Baker et al. (2007) compared their results with old international studies. For instance, the percentage of time spent indoors at home for a Canadian is 66% according to Baker et al. (2007) while the recent CHAPS 2 study (Matz et al., 2014) found this had reached 69.9%, which is very near the findings of this study. Usage of outdoors also seems to differ by

ethnic group as a study by Echols et al. (1998) in Maryland showed that time usages of African-American and Caucasian participants were significantly different, although the difference was as small as 0.2 hour/day. A study by Leech et al. (2002:427) comparing time-activity patterns in the USA and Canada found seasonal differences as "Canadians spent less time outdoors in winter and less time indoors in summer than their U.S. counterparts". Considering the different climate and cultural backgrounds of New Zealanders, it is not clear that these results follow those of international studies, although it should be noted that the pilot study figures only reflect winter usages in a small sample.

To understand how much time households spend in the different spaces in their houses an average was created for each space category, using data from households with at least one space in that category. Table 5.11 shows the results as a percentage of 24 hours and also in hours. As might be expected, the largest part of a 24 hour day is spent in the usual bedroom(s) for all households, while extra bedrooms are only used 18 minutes during an average day by households who have these. All households spend 5.2 hours in usual living areas while households with extra living areas spend 2.02 hours in these. Study/offices were used less than 0.5 hours on average. It is also worth noticing that specialized rooms, extra bathroom/toilets, sheds and sleep outs, and storage rooms are used very little on an average day. In addition, open spaces have been used for an average 16 minutes a day in winter.

	Households in average	**Average time as percentage of 24 hours**	**Average time (hours)**
Usual bedroom	1.A, 1.B, 1.C, 1.D, 1.F, 1.G, 1.H	38.68%	9.28
Extra bedrooms	1.B, 1.F, 1.G, 1.H	1.24%	0.30
Usual living areas	1.A, 1.B, 1.C, 1.D, 1.F, 1.G, 1.H	21.64%	5.20
Extra living areas	1.B, 1.F, 1.G	8.42%	2.02
Study/Office	1.A, 1.C, 1.D, 1.F, 1.G, 1.H	1.84%	0.43
Specialized rooms	1.C, 1.F	1.34%	0.32
Usual Bathroom/Toilets	1.A, 1.B, 1.C, 1.D, 1.F, 1.G, 1.H	3.05%	0.73
Extra Bathroom/Toilets	1.B, 1.F, 1.G, 1.H	0.60%	0.15
Laundry	1.A, 1.B, 1.C, 1.G, 1.H	0.47%	0.12
Sheds and sleep outs	1.A, 1.C, 1.D	0.72%	0.17
Storage rooms	1.B, 1.G	0.19%	0.05
Open spaces	1.A, 1.B, 1.C, 1.D, 1.F, 1.G, 1.H	1.10%	0.27
Out of home	1.A, 1.B, 1.C, 1.D, 1.F, 1.G, 1.H	28.21%	6.77

Table 5.11 Time spent in different space categories as a percentage of 24 hours and in hours and minutes (average of 7 households)

To compare time usage in different space categories in small and large houses, Figures 5.6 and 5.7 were created to represent an average for all small and large houses. Figure 5.6 gives the time usage for the small (1.A, 1.D and 1.H) and Figure 5.7 for the large houses (1.B, 1.C, 1.F and 1.G).

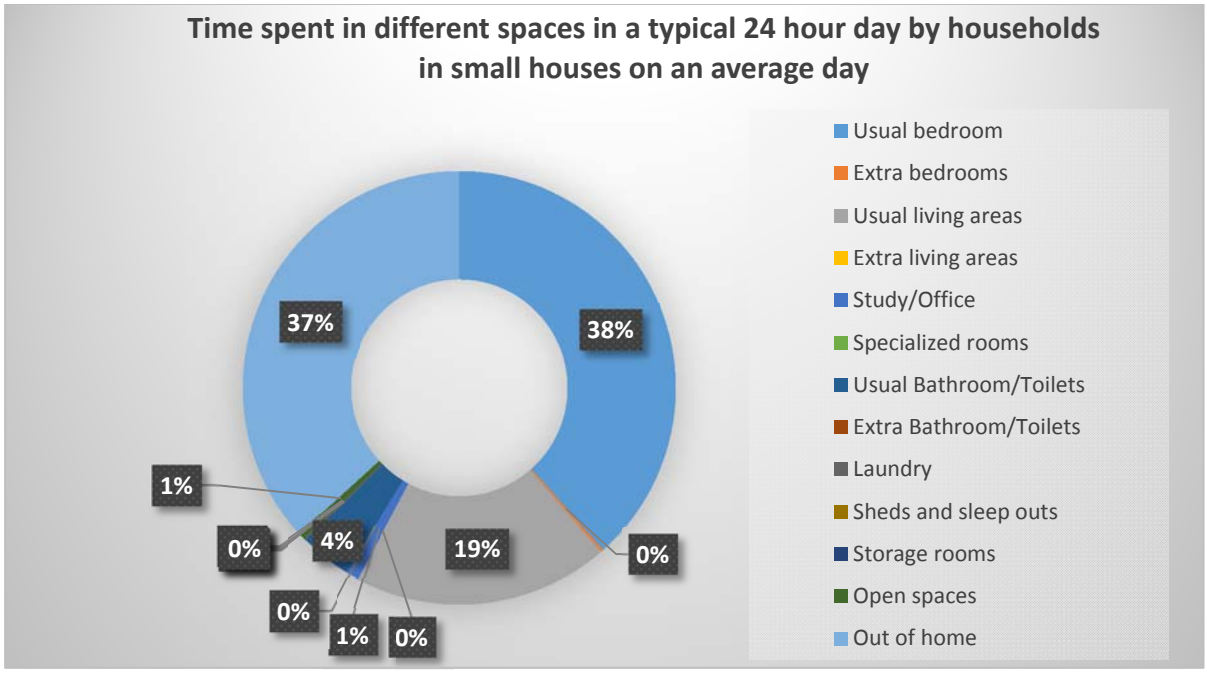


Figure 5.6 Time spent in different spaces in a typical 24 hour day by households living in small houses

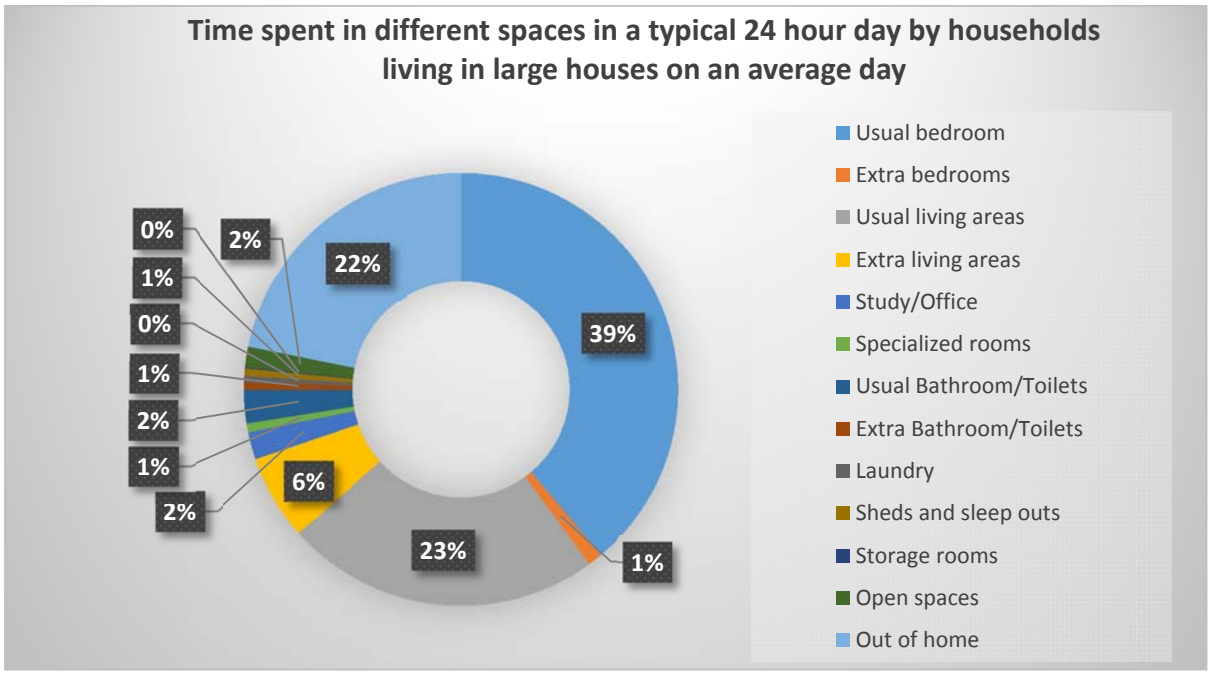


Figure 5.7 Time spent in different spaces in a typical 24 hour day by households living in large houses

Considering the limited number of participant households, Figures 5.6 and 5.7 show that house size is correlated with overall time spent at home. In other words, households living in larger houses spend

more time at home in comparison to those who live in small houses. This extra time is allocated to using usual living areas and using extra spaces. It seems these houses can house more activities and occupants are able to do more at home. However, it could also be related to demographic factors, as older people might have larger houses as a result of having bought them when house prices were cheaper relative to income. This will be something to investigate further in the larger study. Time spent in usual bedrooms is very similar in both size categories. In addition, households who have extra bathroom/toilets divide their use, with the main bathroom/toilet being used for 81% of all uses and the extra one(s) only for 19%. Time spent in the open spaces of large houses is three times that of small houses, which could be related to spending more time at home, or to having a larger outside space with a larger house.

5.9. Discussion

5.9.1. Choosing days to represent a week

As described in section 5.7.3, asking people to fill out a diary for each day was a very time consuming process, limiting the number of willing participants. Prior study by Yoon et al. (2012) in also found it a difficult to ask participants fill out a time-activity diary for 7 days. While some researchers believe that only long-term surveys can provide reliable and helpful results for research into time-activity patterns others have reasons for proposing short-term surveys (Glorieux & Minnen, 2009). Glorieux and Minnen (2009) mention a group of researchers (Gershuny and Robinson (1988), Hedges (1986), Rydenstam (1995), Bagatta (1995) and Shon (1999)) who believe that using long-term surveys will decrease the number of willing participants and increase the rate of leaving the survey before the end. In addition, they note some researchers (Neimi (1983), Vaisanen (2009), Golob and Meurs (1986)) who believe that long-term surveys highly affect the quality of data (Glorieux & Minnen, 2009). Glorieux and Minnen (2009) concluded that long-term surveys provide better and more accurate estimations (section 2.8.2) and that personal activities with daily-cycles can be easily captured by short-term surveys while social activities need a long-term survey. Freeman et al. (1998) compared the results of a 7-day time activity diary with the single-day diaries of the same study and found most activities

repeat on consecutive days for individuals. Consequently, they concluded “gathering information on only one or two days would be sufficient to characterize both daily activities and personal behaviour patterns”. While activities happening at home seem to be more of a personal nature and there are clear use differences between weekdays and Sundays, as Wu et al. (2012) and Echols et al. (1998) say, it is not clear to what extent short-term studies can represent long-term behaviours.

What is clear is that short-term surveys can make the survey cheaper and easier and this may be the main reason that EUROSTAT recommends using a two-day diary including one weekday and one weekend day for time-use surveys. The next section aims to find out how accurate choosing one or two days to represent the week would be in time spent in house based on the pilot study data.

According to the literature, it is possible to choose 1 or 2 days to represent the weekly time-use for each person although depending on the number and type of the selected day(s) the representative figure might have a level of error compared to capturing the time time-use for all days of the week. To examine this level of error, 3 different scenarios are constructed:

Scenario 1-Choosing one random weekday to represent a week:

For each household, the overall time spent at home each day, each week is available. This is called “Real time” and is counted by adding times spent in all spaces of a house by all family members for all days of a week. “Modelled time” is created by multiplying the total time spent at home on a random day by 7 to represent a week. For each household, this is calculated for each day over 2 weeks and the results compared with the Real time of the relevant week. The difference between Modelled time and Real time is given as percentage. This percentage indicates the degree of error between Modelled and Real time and the average of the 14 percentages gives an average degree of error. Considering the 7 participant households and 14 figures, the overall average is produced from 98 investigated days, giving an average percentage of being wrong based on one random day. Table 5.12 shows the results of this study for household 1.A. The same table was created for all other households but these are not presented here.

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	Modelled time	169.75	168.00	162.75	120.75	180.25	189.00	232.75
	Real time	174.75	174.75	174.75	174.75	174.75	174.75	174.75
	Difference in percentage	2.93%	4.00%	7.35%	44.70%	3.07%	7.56%	24.93%
Week 2	Modelled time	168.00	201.25	196.00	152.25	147.00	250.25	288.75
	Real time	200.50	200.50	200.50	200.50	200.50	200.50	200.50
	Difference in percentage	19.33%	0.38%	2.29%	31.68%	36.38%	19.89%	30.57%
Average of differences						For week 1		13.51%
						For week 2		20.07%
						For both weeks		16.79%

Table 5.12 Differences between "Modelled time" and "Real time" for different days over 2 weeks for Household 1.A

Scenario 2-Choosing Sunday and one other random weekday to represent a week:

As discussed in section 5.8.3, the Sunday average is different from the other days of the week, so it might be possible to use Sunday and one other random weekday (including Saturday) to represent a week. The method developed in scenario 1 is used again. Sunday and the other days of the week produce 6 different combinations. In this part "Modelled time" is calculated using the following formula:

Modelled time = Time spent at home by each household on Sunday + Time spent at home on another weekday by each household × 6

For each household, this has been calculated for each combination of two days over 2 weeks and the results compared with the Real time of the relevant week. The differences between Modelled time and Real time are shown as percentages. Each percentage can show the degree of error and the average of the 12 percentages an average degree of error for each participant household. From 7 households and 12 percentages, the overall average is produced from 84 investigated days and gives an average percentage of being wrong when using one random day plus Sunday to represent a week. Table 5.13 shows the results for household 1.A. Again this was done for all households but the results are not presented.

		Mon & Sun	Tue & Sun	Wed & Sun	Thu & Sun	Fri & Sun	Sat & Sun
Week 1	Modelled time based on 2 days	178.75	177.25	172.75	136.75	187.75	195.25
	Real time	174.75	174.75	174.75	174.75	174.75	174.75
	Difference in percentage	2.24%	1.41%	1.16%	27.79%	6.92%	10.50%
Week 2	Modelled time based on 2 days	185.25	213.75	209.25	171.75	167.25	255.75
	Real time	200.5	200.5	200.5	200.5	200.5	200.5
	Difference in percentage	8.23%	6.20%	4.18%	16.74%	19.88%	21.60%
Average of differences					For week 1		8.34%
					For week 2		12.81%
					For both weeks		10.57%

Table 5.13 Differences between "Modelled time" and "Real time" using Sunday with another weekday to represent a week for Household 1.A over 2 weeks

Scenario 3-Choosing one working and one weekend day at random to represent a week:

As discussed, there are big differences between time spent at home on weekdays and weekends. In another exercise a series of calculations were done on the timetables related to the 7 participating households to find out the degree of error from selecting 1 random working day to represent Monday to Friday and 1 weekend day to represent Saturday or Sunday. This gives 10 possible combinations (see Table 5.14). For each household, "Modelled time" based on a set of 2 days is calculated using:

Modelled Time for each week = (Time at home by household in a working day) × 5 + (Time at home by household in a weekend day) × 2

Calculations for each household are then compared with the "Real time" of the relevant week. The difference between Modelled time and Real time is given in percentages to show the degree of error and the average of the 20 percentages the average value of this. With 7 households and 20 percentages, the overall average produced from 140 investigated days gives the average percentage of error from using one random weekday and weekend day to represent a week. Table 5.14 shows the results for household 1.A. Again this was done for all households.

		Mon & Sat	**Mon & Sun**	**Tue & Sat**	**Tue & Sun**	**Wed & Sat**	**Wed & Sun**	**Thu & Sat**	**Thu & Sun**	**Fri & Sat**	**Fri & Sun**
Week 1	Modelled time based on 2 days	175.25	187.75	174.00	186.50	170.25	182.75	140.25	152.75	182.75	195.25
	Real time	174.75	174.75	174.75	174.75	174.75	174.75	174.75	174.75	174.75	174.75
	Difference in percentage	0.29%	6.92%	0.43%	6.30%	2.64%	4.38%	25.60%	14.40%	4.38%	10.50%
Week 2	Modelled time based on 2 days	191.50	202.50	215.25	226.25	211.50	222.50	180.25	191.25	176.50	187.50
	Real time	200.50	200.50	200.50	200.50	200.50	200.50	200.50	200.50	200.50	200.50
	Difference in percentage	4.70%	0.99%	6.85%	11.38%	5.20%	9.89%	11.23%	4.84%	13.60%	6.93%
Average of differences								For week 1			7.58%
								For week 2			7.56%
								For both weeks			7.57%

Table 5.14 Differences between "Modelled time" and "Real time" using 1 working and 1 weekend day to represent a week for Household 1.A

Tables 5.15-5.17 show results of the three scenarios for all households. Table 5.15 reveals using one random weekday to represent a week could be 12.95% wrong, with an error range of 1.33% to 36.61%.

Table 5.16 shows using Sunday in combination with another random weekday would be more precise. In this case, average results could be 9.23% wrong and the range of error runs from 0.64% to 24.00%. Compared with scenario 1, the minimum error is near zero and maximum error is less than in the previous case. Finally Table 5.17 shows by using 1 random weekday and weekend day to represent a week, the results could be 7.28% wrong, with an error range of 0.48% to 20.73%, both figures being smaller than in the previous cases.

	Households							Average for 7 households
	1.A	1.B	1.C	1.D	1.F	1.G	1.H	
Average of differences	16.79%	9.72%	9.82%	9.02%	13.48%	14.35%	17.44%	12.95%
Min difference	0.38%	0.65%	1.05%	1.34%	1.16%	2.13%	2.57%	1.33%
Max difference	44.70%	28.89%	41.05%	20.61%	40.75%	44.07%	36.18%	36.61%

Table 5.15 Average of differences/Minimum of differences/Maximum of differences if 1 random day represents a week

	Households							Average for 7 households
	1.A	1.B	1.C	1.D	1.F	1.G	1.H	
Average of differences	10.57%	7.54%	8.63%	6.19%	10.95%	10.78%	9.94%	9.23%
Min difference	1.16%	1.83%	0.28%	0.29%	0.00%	0.05%	0.89%	0.64%
Max difference	21.60%	20.85%	30.75%	12.21%	30.54%	28.23%	23.82%	24.00%

Table 5.16 Average of differences/Minimum of differences/Maximum of differences if Sunday and another random weekday represent a week

	Households							Average for 7 households
	1.A	1.B	1.C	1.D	1.F	1.G	1.H	
Average of differences	7.57%	4.27%	7.92%	4.48%	9.51%	8.08%	9.10%	7.28%
Min difference	0.29%	0.06%	0.09%	0.07%	1.15%	0.97%	0.74%	0.48%
Max difference	25.60%	13.77%	30.02%	8.77%	20.93%	20.76%	25.23%	20.73%

Table 5.17 Average of differences/Minimum of differences/Maximum of differences if 1 random working and 1 random weekend day represent a week

It seems that using 1 or 2 random days to represent a week is useable, leading to results which on average would be very near to the real time usages, although in some cases the results could be very different. However, using two days to represent a week could lead to more precise results and shorten the range of maximum differences. In this case, using one weekday and weekend day at random to represent a week is the more precise situation. This finding is in line with studies by Glorieux and Minnen (2009) and EUROSTAT (2004) guidelines which recommended using a combination of 1 weekday and 1 working day for the most precise results from time-activity surveys. Finally, these potential error analyses would only be valid if participants in the big survey are well distributed over all weekdays. For instance, if 1 random day represents a week but most participants report Sundays

then the results would be more likely to be near the maximum difference (36.61%). Matz et al. (2014) in the Canadian Human Activity Pattern Survey (CHAPS 2) collected data for both weekdays and weekends and targeted reaching ratios of 71.4%/28.6% (or 5/2) weekdays/weekends so this is considered in the main survey.

5.9.2. Day spaces and night spaces

The method used in the pilot study for time-use diaries not only provides information about the total time spent in each space but also gives the time of day a space was used. The time categories developed in Table 5.6 in section 5.8.1 were used and analysed according to the space categories developed in section 5.6.

Time spent in each sub space for each time frame is calculated as follows:

Time spent in space category X in a particular time frame (e.g. 6-9am for early morning) = [(Subtotal of time spent in space category X by household for particular timeframe over two weeks) ÷ 14] ÷ (Household population)

Figure 5.8 shows this time usage for usual bedrooms as a percentage of the total time in these, while Figure 5.9 gives the real time spent in usual bedrooms. As seen each of the four time frames cover different amounts of time (i.e. early morning time frame covers 3 hours, working/school time 7 hours, evening/early night 5 hours and sleep time 9 hours).

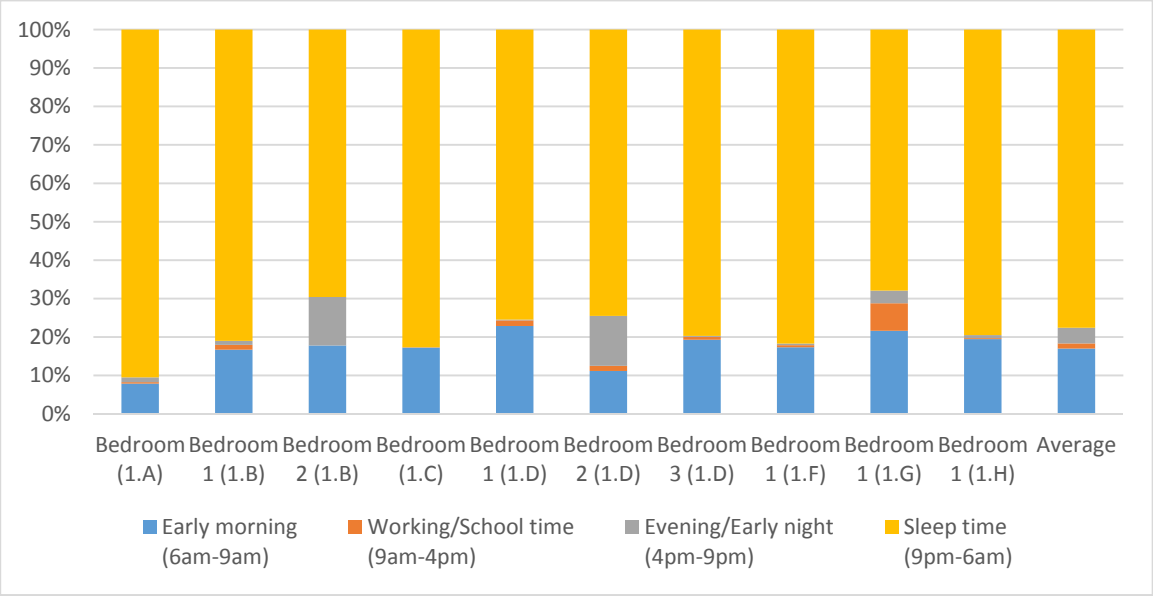


Figure 5.8 Time spent in usual bedrooms for all households over four time frames as a percentage of the total time spent in usual bedrooms

To make these four time frames comparable, the figures for each in Figure 5.9 are divided by the hours in each time frame, and the results shown in Figure 5.10.

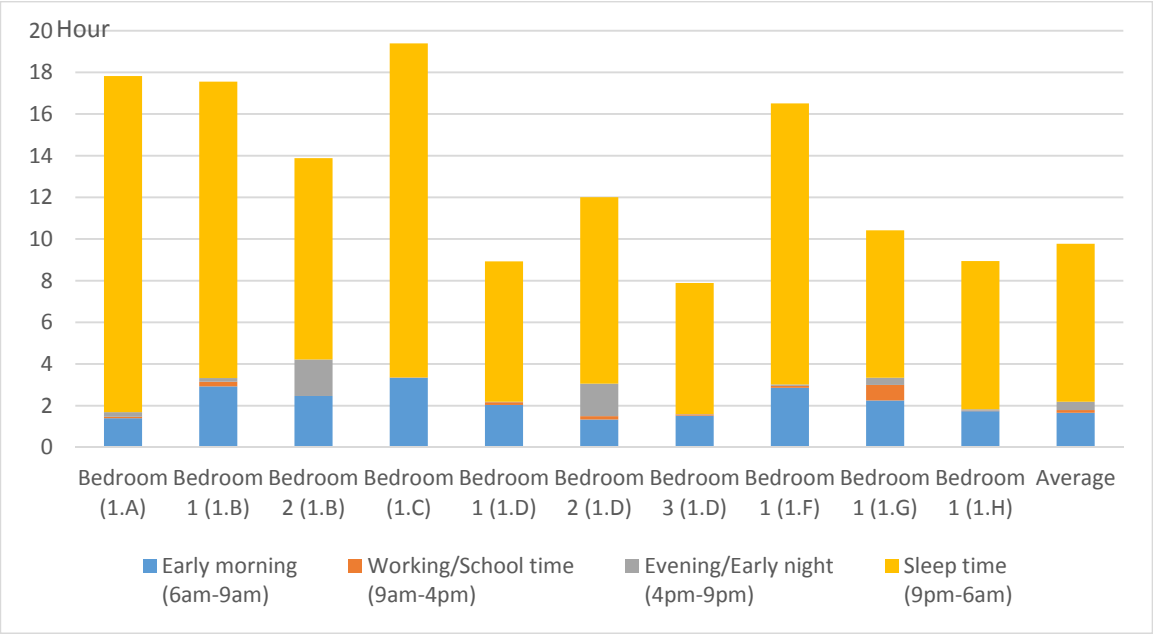


Figure 5.9 Time per person spent in usual bedrooms for all households over four time frames

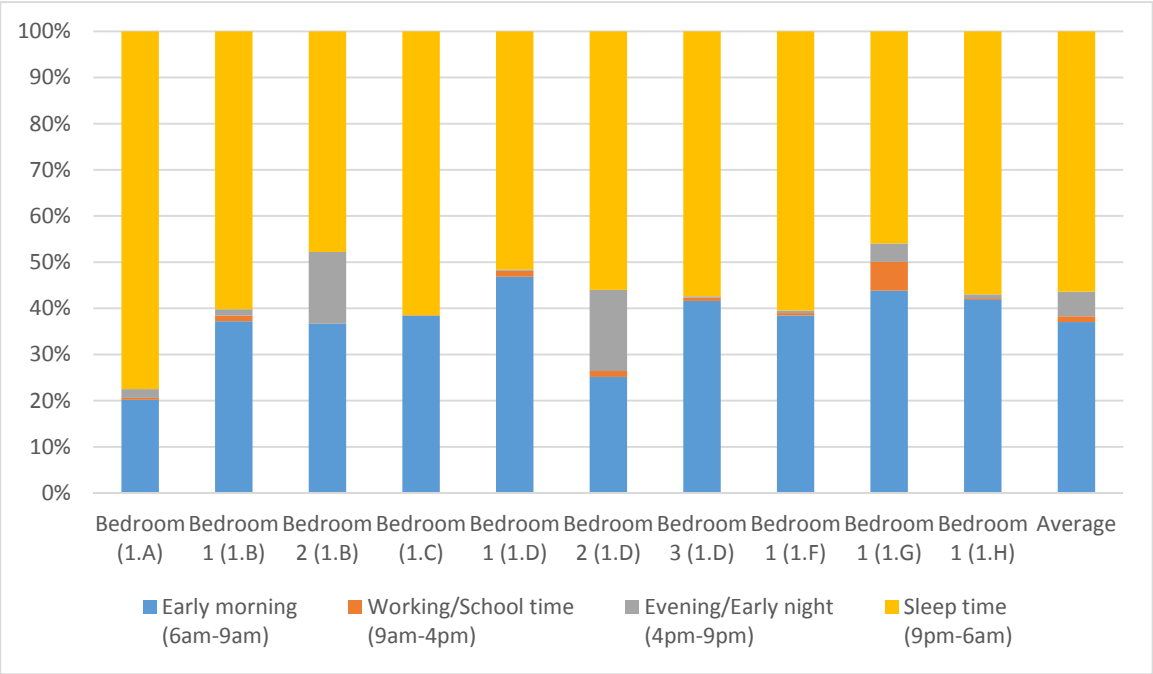


Figure 5.10 Time spent in usual bedrooms for all households over four scaled time frames as a percentage of the total time spent in usual bedrooms

As seen in Figure 5.8, on average about 78% of the time households spend in usual bedrooms is in the sleep time frame and another 18% in that of the early morning, with times in each of these from Figure 5.9 being 7.58 and 1.67 hours respectively. As might be expected usual bedrooms are used very little

during working/school time. Figure 5.10 compares weighted time frames and shows that on average usual bedrooms are mostly used in the sleep and early morning time frames. A more detailed look at the chart for each user shows that despite general similarities there are some differences between individuals which could be related to age and job type.

As scaled figures are the most comparable ones, this method was used for all other space categories. A chart similar to Figure 5.10 was created for all space categories (12 including usual bedrooms) although only the average of the whole sample for each category is presented in Figure 5.11. Because the number in the sample for some space categories such as specialised room, extra bathroom/toilet, shed/sleep out and storage room were very small, results would be unreliable and are not presented. For other space categories, Figure 5.11 shows that:

- Extra bedrooms are used in all time frames and are least used during sleep time. This clearly shows these bedrooms have usages other than for sleeping.
- Usual living areas are used in all time frames with evening/early night having the highest usage. Small usages in the early morning and sleep time frames refer to using kitchen and dining rooms for meals while usages in the other two time frames are for the living room.
- Use of extra living areas over the day is similar to that of usual living areas with a noticeable difference of less use in the early morning and more use in sleep time frames. In this study, all extra living areas are living rooms and there are no extra kitchens. It seems that extra living areas are supplementary to usual living areas over a day and are more used at nights.
- A study/office is mostly a day space. However, a detailed look at the time-use of this particular space category varied between households, possibly related to education level, job type and even demographic parameters. For instance household 1.D is a couple, both researchers, with a child. They might welcome a separate room for work, while in households with no children other rooms (e.g. living rooms) can be used for undisturbed work.

- Usual bathroom/toilets are used in all time frames over the day although on average, they are used more in the early morning, probably related to the getting up and ready for the day.
- On average, laundries are mostly used in working/school and early morning time frames and rarely during sleep times, though there are differences between households, perhaps related to when people are at home and free to deal with the chores.
- As seen in Figure 5.11, on average open spaces including gardens and decks are mostly used in working/school time, or what are probably the warmest parts of the day. This supports the earlier findings that usage of open spaces is highly dependent on the weather (see section 5.8.2). In addition, because this overlaps with the time people must go to work/school it is clear why people use open spaces mostly at the weekends when they have free time between 9am to 4 pm. It should also be noted that this time pattern changes for some households, possibly because of personal work schedules.

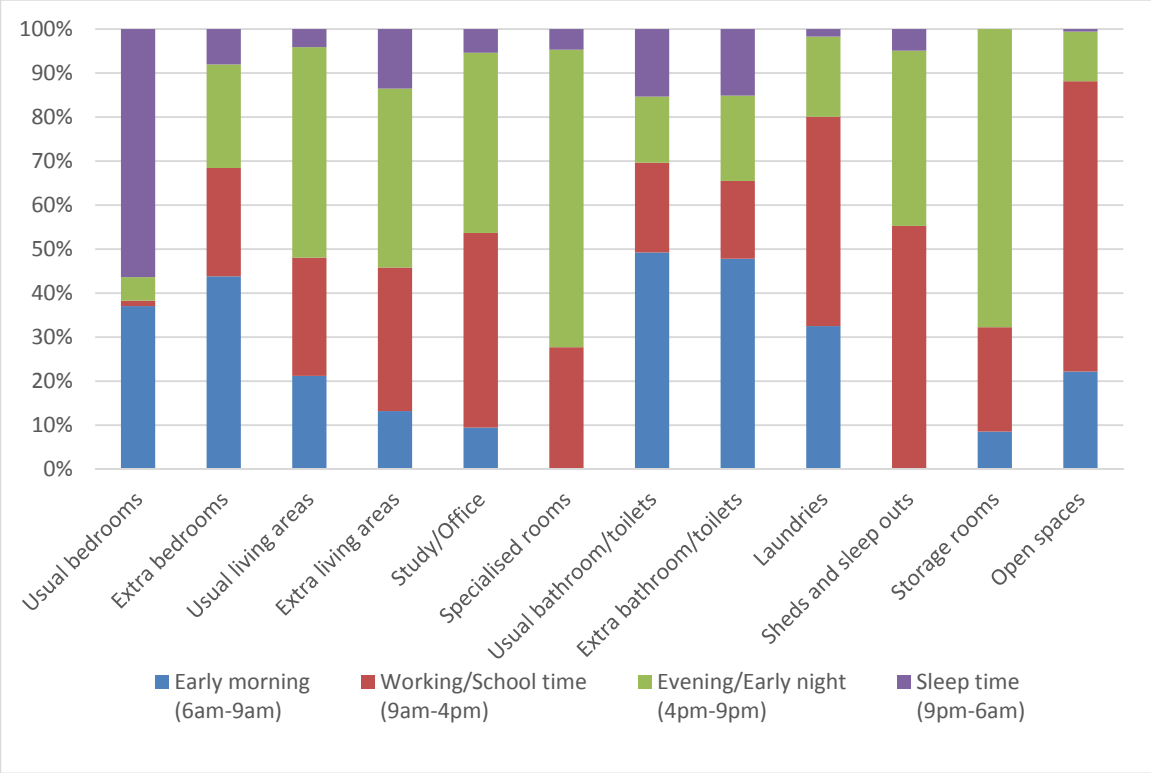


Figure 5.11 Average time spent in 12 space categories over four scaled time frames as a percentage of the total time spent in each category

This part of the study shows that occupants use the different spaces of their houses at different times of the day. The majority of sleep time is spent in usual bedrooms, a pattern common to all households. Usual and extra living areas are also used during sleep time but this usage is very small and occurs between 9 pm to midnight. Usage of open spaces is highly weather related and mostly happens over the working/school time period for households not at work during these times. Other spaces, including living areas, are day spaces, with many different usage patterns based on job type, age and family composition. This analysis shows that a great proportion of time spent at home is spent over night in the usual bedrooms, while other spaces are mostly used in the day time. This finding could help designers to make better decisions about the internal layout of a house for good natural light. It can also affect decisions regarding heating devices, especially the programmable ones used in smart houses so these work more efficiently. It is also important for those designing passive solar houses. However, more detailed conclusions will be left to the analysis of the main survey. The purpose of the pilot study was to test the questionnaire, which will be revised as a result, and the potential analysis methods.

6. Study 2

6.1. Introduction

The pilot study (Study 1), discussed in Chapter 5, revealed that a somewhat different approach to the questionnaire was required to examine different aspects of large housing in a big sample. In particular, because the questionnaire was long and time-consuming, it was decided to conduct an online questionnaire-based survey instead of a paper-based one. This would make the whole process easier, faster and could make the overall questionnaire look smaller in most cases. Based on the analysis findings of Study 1, it was decided to conduct a one-day time-use survey rather than a long term one as this would save time, give reasonably precise data, and hopefully would lead to a greater number of participant households. This chapter discusses the features of Study 2 and some general findings. Because the data set is large and complicated and also because the questionnaire addresses 3 different aspects of large housing, it was decided to split the presentation of the results into this and four further chapters (see section 3.5.2.).

6.2. Method

The questionnaire for the on-line survey was mainly based on the Study 1 questionnaire although using the participant feedback (see sections 5.7.1-3), this was revised and developed. Some of the reasons for switching from a paper-based to a digital format are summarised below:

- In the main survey the aim was to collect data from a big sample.
- The number of questions asked was quite high.
- Using an on-line method made it easier to delete inappropriate questions, and thus each questionnaire could be tailored to fit the circumstances of the participant household. For instance, if a respondent states he/she does not have treadmill, then a question about the location of this will not appear.

- Some questions in the survey need data from other household members and it was thought an on-line questionnaire that could be saved and is flexible in terms of when it could be filled out would enable data to be discussed and then entered.
- Having many questions and many respondents means a lot of data to enter into data analysing soft-ware such as SPSS, with an increasing risk of mistakes occurring, a process that is avoided in an online survey.
- The intention was to collect data from households throughout New Zealand and finding distant respondents through an online survey is easier.

Because of these issues, the questionnaire was rewritten for the web-based service Qualtrics (Qualtrics, 2015) under the licence of Victoria University of Wellington. The survey was conducted from mid-February to mid-April 2015 in New Zealand. This time frame is summer in New Zealand which is important for the time-use results because a number of time-use studies in countries with similar housing stock and climatic variations have found seasonal differences in time-use patterns (Leech et al. (2002), Wu et al. (2012), Conrad et al. (2013), Hussein et al. (2012), Echols et al. (1998), Matz et al. (2014), Freeman et al. (1998) and McCurdy and Graham (2003)). Despite the importance of seasonal time-use differences it was decided to conduct the study in single season. The first reason for this was the 4% time-use difference between summer and winter (Leech et al. (2002) and Matz et al. (2014), which was felt accurate enough for a study of this type that relied on reported information. The second reason was the time limits for a PhD, which made it impractical to wait to conduct the survey during the winter and still have time for the analysis.

As revealed in section 1.5.1 (see Figure 1.4), large houses are mainly occupied by small households. Statistics New Zealand (2013a) indicates that in 2013, 23.5% of all households are one-person while one-family households are 68.3% of total. In addition, couples with children made up 41.3%, couples without children 40.9% and one-parent-with-children 17.8% of families in 2013. Based on this, the survey was limited to small households with 4 or fewer members making the four selected household

types single person households, childless couples, couples with 1 child and couples with 2 children. It was also hoped that filling out the questionnaire for four family members would not be too onerous, something that might not be true of very large households. Because all furniture and appliances in rental houses do not necessarily belong to the tenants, the survey was also limited to owner-occupied houses. New Zealand was the geographical territory for this survey and any New Zealand household, whether from an urban or rural area, was welcome to take part in. The focus of the research was the size of the house and its contents, not its location.

The survey was anonymous and a snowball sampling technique was used for recruitment. Individuals and community groups from various urban/rural parts of New Zealand were contacted using social media, and email and printed invitations were delivered locally to community groups and one primary school in Wellington.

6.3. The questionnaire and completion

The questionnaire (see Appendix 6.1) was designed in 7 parts with 145 questions in total as described below. In Qualtrics, it was possible to define logics for questions and choices of what questions appeared according to the answers given by participants. This meant that each questionnaire was specific in what it asked the householder based on the answers at each stage, so only a proportion of the 145 questions were asked of each respondent. At this point two amendments were requested and approved by the Victoria University of Wellington Human Ethics Committee (see Appendix 6.2):

Part 1- General information: The questionnaire starts by asking general questions about household type and number, gender, age, and job type of occupants of the house. Participants were also asked to send a floor plan of their house if they had one, either electronically, or via a prepaid envelope which would be sent on request.

Part 2- Spaces: The questionnaire continues by asking respondents to select the number of various types of rooms in their house and then the features of bedrooms and bathrooms within it. To reduce

the number of questions, the questionnaire automatically removed non-existing bedrooms and bathrooms from these questions.

Part 3- Furniture/appliances: The questionnaire next asks about the number of furniture items, appliances and tools in the house.

Part 4- Place of furniture/large appliances: According to the responses to *part 3*, the location of all recorded furniture and appliance items will be asked for, noting that those the household does not have are automatically removed from the list. In addition, non-existing rooms do not appear in the list of location choices.

Part 5- Gatherings and parties: The questionnaire then asks about the number of attendees, location and frequency of gatherings and parties, along with the frequency and number of guests who might sleep in the house. The answers will provide information about non-permanent users of the house.

Part 6- General questions about satisfaction with the house: This part probes the reasons and motivations behind having a large house and contents. Also in this section, respondents were asked to estimate the percentage of their furniture and appliances they bought new and what percentage they obtained second hand. The latter information will be used in the life cycle analysis of furniture and appliances.

Part 7- Time spent in each space: The questionnaire ends with a time-use survey. A table of available rooms (based on answers to part 2) was created for each family member (according to the number disclosed in part 1) and respondents were asked to drag the slider alongside each room to estimate the time spent there from midnight to midnight the previous day. A row in the table was allocated to each room with one row for garden, one for deck and one for the “time spent out of home”. Where participants had more than one of a room type (i.e. two living rooms), these were numbered as “Living room 1” and “Living room 2” and appeared in 2 separate rows. For each person, the total time spent in all rooms of the house, garden/deck and out of home needed to total 24 hours. This was used to

check the validity of the data entered, following Elgethun et al. (2007). If incorrect, an error message appeared asking the respondent to review and correct their answers. The time-use table appeared for each household member with the age and gender of that person appearing at the top of the time-use table. The same time-use table also appeared for each car owned by the household and asked how much time each car owned was parked in the various available parking facilities and the time each car was in use. While acknowledging the significant role of the resources used in private parking facilities, analysis of these was excluded from this thesis because of the word limit.

6.4. Respondents and recruitment method

Because the questionnaire was long, some people did not finish the whole survey and left it mid-way. Fortunately, the questionnaire appeared in various sections and each of these can feed data into the parts of the analysis. Using "Households/Houses", "Furniture/Appliances/Tools" and "Time-use" as the three main types of data collected, even partial questionnaires were valid for the data analysis of each part.

The snowball sampling method began with making contact with several community centres and social groups in various parts of New Zealand. These were asked to distribute the survey link and information sheet to their email lists. To cover families with children, the survey flyer was also distributed to the parents of children in a primary school in Wellington. To cover the 65+ age group the survey link was further distributed through the University of the Third Age email list. All receivers of the link were also encouraged to pass it on to other suitable households.

The questionnaire survey started on 10 February 2014 and was closed on 12 April 2014. Analysis showed that over 62 days of data collection, 445 households took part in the survey, of which 286 finished the "Household/house" part, 260 the "Furniture/Appliances/Tools" part and 214 the whole questionnaire. This meant that as the "Time-use" part was the last part of the questionnaire, 214 households provided full data on time-use. At the same time, some respondents finished the "Time-use" part for some family members but not all, so by breaking the household time-use into individual

time-use, more successful respondents were added to the data set. Table 6.1 summarises the number of respondents who started and successfully finished various parts of the survey.

	Households/Houses	Furniture/Appliances/Tools	Time-use part	
			Households	Individuals
Number who started the survey	445	445	445	1026
Number who finished the survey	286	260	214	538
Percentage who finished the survey	64.3%	58.4%	48.1%	52.4%

Table 6.1 Number of participants that started and those that successfully finished various parts of the survey

Analysis shows that out of 214 respondent households who finished the whole survey 41 (19.2%) were single person with 81 (37.9%) childless couples, 49 (22.9%) couples with 1 child and 43 (20.1%) couples with 2 children. The questionnaire was set up to let participants spend as much time as they needed on it, as they could leave the survey and continue from where they left off up to 7 days from their last try. This potentially provided an opportunity for other family members to produce a timetable over a day that could be entered into the survey later, although the results show 95.2% of participants started and finished the survey the same day with 3.4% spending two days and 1.4% spending more than two days filling it out. The survey took 15-60 minutes to complete according to house and household size although, on average, successful participants took 33 minutes.

Most completed surveys came from households in Wellington and adjacent suburbs (67.5%) with Auckland (13.7%) and Dunedin (7.1%) respectively having the next highest completions. Though there are clear climatic variations between cities located in the North and South islands, as the study was performed in summer when temperatures are similar throughout the country, the influence of seasonal differences on occupational patterns should be less significant.

6.5. Analysis of sample houses and their features

Accepting the Statistics New Zealand room standard (see section 2.2) as an indicator of house size, of the 286 sample households who successfully finished the household/house part, 42 (14.7%) lived in ≤5 room houses with 75 (26.2%) in 6 room houses, 65 (22.7%) in 7 room houses, 41 (14.3%) in 8 room houses and 63 (22.0%) in 9-9+ room houses. The size of house the households in this study selected to live in, is presented in Figure 6.1.

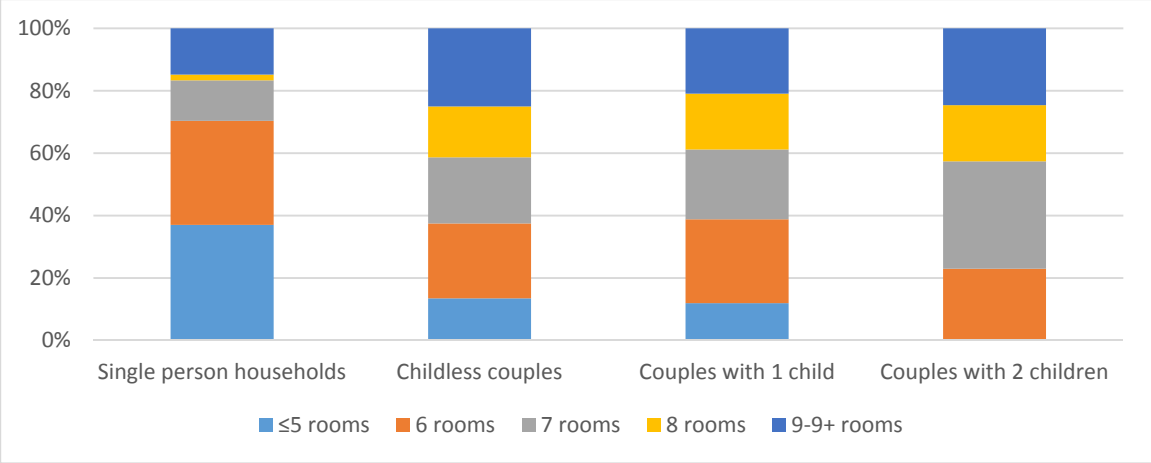


Figure 6.1 Distribution of various house sizes as occupied by four different household types

This shows 25.0% of childless couples live in very large houses (9-9+ room) and a similar 24.6% of couples with 2 children live in such houses. Figure 6.1 also shows that more than 70% of the sample single person households live in houses with 6 or fewer rooms. On average sample households in this study live in houses with 7.3 rooms and this breaks down into 6.6 for single person households, 6.9 for childless couples, 7.5 for couples with 1 child and 8.2 rooms for couples with two children.

Considering 1, 2, 3 and 4 persons in single person households, childless couples, couples with 1 and couples with 2 children respectively, the occupancy rate of the 286 households sample is 2.47 person per household. Table 6.2 presents the average number of people living in each house size category, with the average number of selected room types and sanitary spaces by house size. Table 6.2 shows that for all house sizes in this sample there are extra bedrooms above those needed for 2.47 occupants. Table 6.2 also shows that the number of living rooms and bathrooms in all house sizes (apart from ≤5 for number of living rooms) is more than 1 and this number increases with house size. Finally, Table 6.2 indicates the number of specialised rooms and en-suites increases with house size.

	House size (based on number of rooms)					Total sample
	≤5	6	7	8	9-9+	
Average number of occupants	1.71	2.37	2.77	2.80	2.57	2.47
Average number of bedrooms	1.76	2.51	2.83	3.17	3.71	2.83
Average number of living rooms	1.00	1.03	1.06	1.37	1.79	1.25
Average number of dining rooms	0.81	0.99	1.00	1.02	1.38	1.06
Average number of specialised rooms	0.17	0.47	1.03	1.39	1.60	0.93
Average number of bathrooms	1.05	1.25	1.48	1.93	2.29	1.60
Average number of en-suites	0.05	0.23	0.37	0.63	0.75	0.41

Table 6.2 Average number of occupants and selected room types and sanitary spaces by house size

A similar table (Table 6.3) was created for household size to see if the number of various room types changes with the number of people living in the house. Table 6.3 shows the number of bedrooms gradually increases with household size, but the number of some room types like living rooms and dining rooms does not vary. The number of bathrooms and en-suites is near one (1.24) for single person households but this rises to 1.62-1.79 for all other household types. Interestingly, the number of specialised rooms is highest for couples (1.19).

	Household types				Total sample
	Single person households	Childless couples	Couples with 1 child	Couples with 2 children	
Average number of occupants	1	2	3	4	2.47
Average number of rooms	6.27	7.30	7.34	7.62	7.19
Average number of bedrooms	2.20	2.71	3.00	3.41	2.83
Average number of living rooms	1.19	1.28	1.25	1.25	1.25
Average number of dining rooms	1.07	1.04	1.06	1.07	1.06
Average number of specialised rooms	0.67	1.19	0.93	0.74	0.93
Average number of bathrooms	1.24	1.66	1.62	1.79	1.60
Average number of en-suites	0.17	0.49	0.46	0.41	0.41

Table 6.3 Average number of occupants and selected room types and sanitary spaces by household type/size

The question arises as to whether it is house or household size which defines the number of various rooms and sanitary spaces in the house. To answer this, an ANOVA one-way test was performed for each room type and each influential factor (house size and household size) and the results are presented in Table 6.4.

Dependent variable	Factor					
	House size			Household type		
	F (4, 281)	Sig.	Result	F (3, 282)	Sig.	Result
Average number of rooms	809.46	0.000	✓	6.54	0.000	✓
Average number of bedrooms	57.48	0.000	✓	21.31	0.000	✓
Average number of living rooms	58.34	0.000	✓	0.48	0.694	×
Average number of dining rooms	27.24	0.000	✓	0.15	0.929	×
Average number of specialised rooms	32.56	0.000	✓	5.27	0.001	✓
Average number of bathrooms	35.95	0.000	✓	5.70	0.001	✓
Average number of en-suites	14.20	0.000	✓	3.85	0.010	×

Table 6.4 Results of an ANOVA one-way test to see the effect of house and household size on the average number of selected room types

As seen in Table 6.4, the average number of all room types is significantly different by house size at 0.05 level although it remains significant only for all rooms, bedrooms, specialised rooms and bathrooms when considering household size. A further post-hoc test was also performed to see the details of these differences (see Tables A.6.3.1 and A.6.3.2 in Appendix 6.3). The results of these tests

indicate that the number of rooms, bedrooms and bathrooms is only significantly different between single person households and other household types while the average is statistically similar for other household types. In addition, the average number of specialised rooms is only significantly different between couples and other household types. The post-hoc test results for house size also show that generally larger houses have higher numbers of all room types and the difference usually remains significant between all pairs of rooms (apart from some consecutively sized houses for some room types). This clearly shows that apart from single person households who usually have fewer rooms of some types, generally household size is not a good predictor of overall house size (based on the number of rooms) or the average number of various room types. In contrast house size is a good predictor of the average number of various room types.

Figure 6.2 presents the average number of bedrooms and other rooms in the different sized houses found in this sample. As seen, by upsizing from a 6 to an 8 room house, on average 1.34 "other rooms" and 0.66 "bedrooms" will be added to the house.

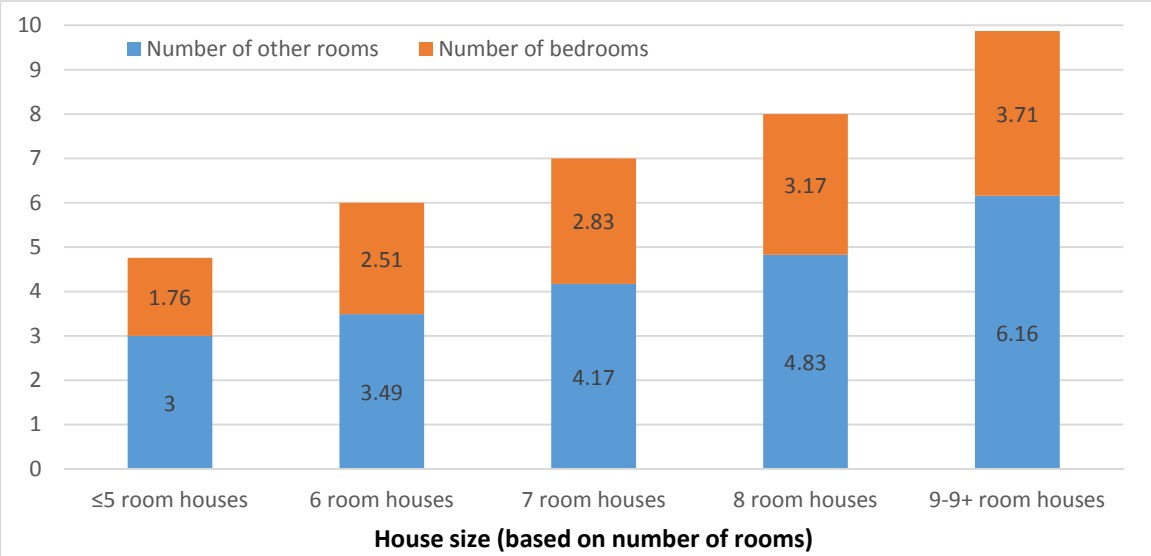


Figure 6.2 Average number of bedrooms and other rooms in different sized houses of this sample

Using the samples in this study, and accepting the number of rooms as an indicator of house size, a graph was created (Figure 6.3) showing the average number of rooms by age of the oldest occupant of the house. As seen in Figure 6.3, the average size of the house increases with an increase in the age

of the oldest occupant, meaning that older people usually have larger houses. This is very important because there are studies (Davey et al., 2004) showing that people in such age groups have problem with house maintenance and heating expenses.

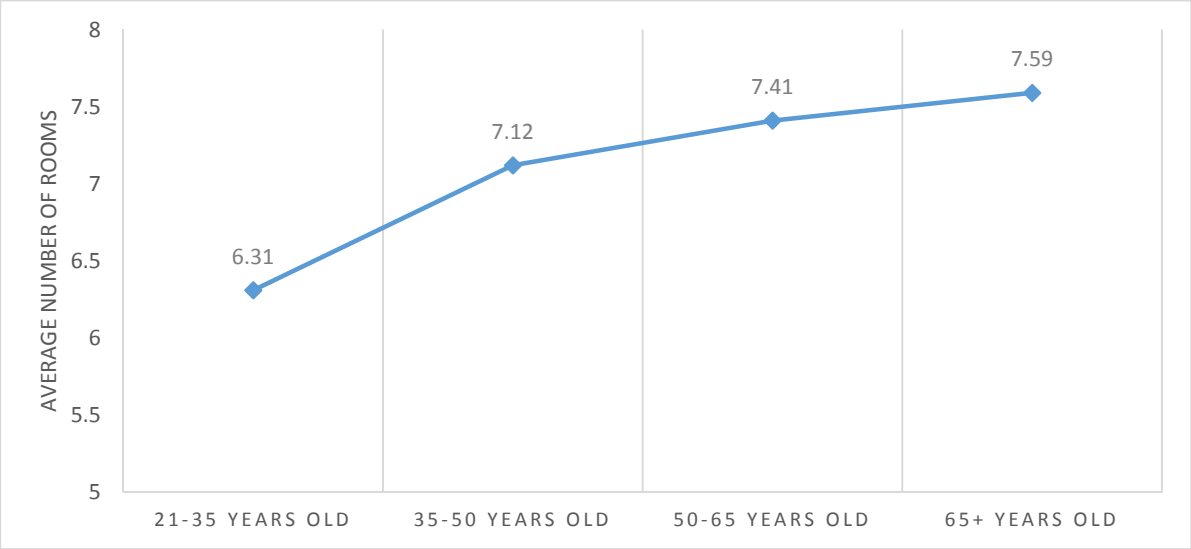


Figure 6.3 House size (based on number of rooms) with age of the oldest occupant of the house

6.6. Further data analysis

As mentioned before, this study has three main data sets, with different numbers of sample households and individuals in each. This will lead to minor changes in the average number of similar items and parameters in the various parts of the analysis. However, because finally everything will be connected under the umbrella of house or household size, such minor differences are not noticeable. The main data set is too big and complicated for analysis of everything at the same time and at the same time analysis of each part is not highly dependent on the results of other parts. Based on these reasons, data analysis will be broken down into and presented in three parts in Chapters 8, 9 and 10 as described below:

- *House/Household part:* Various aspects of house size and number/configuration of rooms and sanitary spaces and their relationship with occupants' characteristics are discussed in this chapter. Such information is useful for the embodied and life cycle energy analysis of different sized houses which is discussed in Chapter 9. Additionally, because house/household

parameters also need to be compared with time-use and furniture/appliances, these will be analysed again in Chapters 8 (time-use) and 10 (furniture/appliances).

- *Time-use:* All analysis related to the time-use part of this study is presented in Chapter 8.
- *Furniture/Appliances:* All analysis related to furniture/appliances part of this study is presented in Chapter 10.

However, to complete the data analysis, information about the size of rooms and houses is required. This part of the survey was not successful as only 6 floor plans were received. The funds were not available to buy plans of all the houses from the relevant territorial authorities. Consequently a floor plan study of New Zealand houses was undertaken, as described in Chapter 7. A combination of the results of the floor plan study (Chapter 7) and the house/household part of Study 2 provide the data needed for life cycle analysis (Chapter 9).

7. A floor plan study of New Zealand houses

7.1. Introduction

The on-line survey asked participants for the floor area of their house and garage(s) and if possible to send an electronic or hard copy of the floor plan of their house using a prepaid envelope. Many participants provided data for the floor area although very few sent floor plans. For those who did, a comparison was made between given floor area and measured floor area through an AutoCAD 2015/2016 analysis. This showed significant differences in some cases. The main reason was the different ways the house floor area was calculated and what was and was not included. Additionally, with so few plans it was difficult to find average areas of rooms and NZ databanks could not be used as the survey was anonymous and postal addresses were not supplied. A search failed to find a similar study of New Zealand houses, and those of other countries could not be used because New Zealand houses differ both in size and their features. However, the survey had information on the number and type of rooms. Consequently, a floor plan study of New Zealand houses was undertaken. Several floor plans of various sized of New Zealand houses were selected for analysis with the following aims for this study:

1- Finding the average floor area of New Zealand houses according to the number of rooms (e.g. the average floor area of 3 room houses, 4 room houses etc.)
2- Finding the average floor area of different room types in New Zealand houses and how these change with house size
3- Developing a tool to give researchers an opportunity for estimating the average floor area of a New Zealand house according to the number and type of its rooms.

7.2. Methodology

7.2.1. Data sources

Several sources indicate the average floor area of New Zealand houses has increased in recent years and that new New Zealand houses are larger than their older counterparts (see section 1.4.2). To cover

this, it was decided sample houses should be selected from a combination of old and new New Zealand houses. All sample houses were selected from those built in New Zealand or designed for the New Zealand market so all sample houses relate to the existing or potential New Zealand housing stock. The main sources of floor plans were old/new books, New Zealand housing journals (for old plans), and the catalogues and websites of New Zealand design companies (for new and current plans). In total 26 main sources were used (Stewart (1992), Salmond (1986), Shaw et al. (2003), Shaw and Morrison (1991), Wood (1993), Cheetham and Bateman (1991), Platinumhomes (2016b), Toomath (1996), Willson (1975), Firth (1949), Cochran (1980), Navigation homes (2014a), New Zealand *Home and Building* (1937-1982) archive, Certifiedplans (2016a), Heritage Buildings & Homes (2016o), Geniushomes (2016a), Kapiti Retirement Trust (2016b), Chatsford Management Ltd. (2016i), Masonic Villages Limited (2016c), Houseplans (2016), Rosenfeld (1951), Black Hut Ltd. (2016a), Coastal Homes NZ Ltd. (2016a), Greenhaven Smart Homes NZ (2016b), Stone Wood Homes (2016c) and Versatile Homes & Buildings (2016e)).

7.2.2. How house and room floor areas are calculated

All sample houses selected for this study had a reported total floor area (or floor area for rooms) or a means of estimating the scale of the drawing. Figure 7.1 shows one of the selected case study houses Wood (1993:8), which usefully gave the dimensions of each room. All selected floor plans were first saved as an image (JPEG or Tiff) and then transferred to an AutoCAD 2016 file for further analysis, where the image was scaled appropriately from the information in the original image. The scaled floor plan was then redrawn in AutoCAD 2016. Figure 7.2 shows the redrawing of Figure 7.1 in AutoCAD 2016.

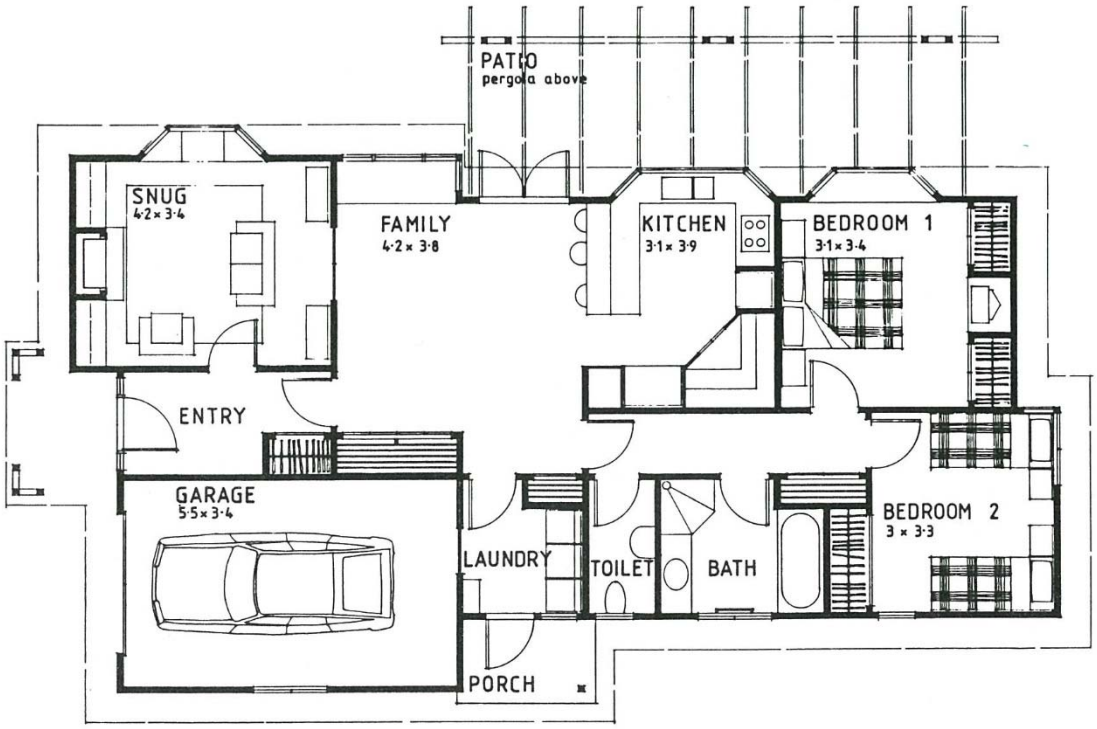


Figure 7.1 Selected floor plan as it appeared in the source (Design 301 Wood (1993:8))

In measuring the floor area of each room the areas of internal walls were divided between adjacent rooms as shown in Figure 7.2. Room areas also included all external wall areas in accordance with the way areas would be measured for insurance rebuilding purposes, and as is common when houses are sold. As garages are excluded in this study, walls between room and an integral garage were treated as external walls (see Figure 7.2).

In total 23 room types were defined in this study (master bedroom, other bedroom(s), study (including library and office), games room (including rumpus room and gym), studio (or workshop), separate living room, separate dining room, separate kitchen, combined living room/kitchen, combined living room/dining room, combined dining room/kitchen, combined living room/dining room/kitchen, bathroom with no toilet, toilet, en-suite, combined bathroom/toilet, combined toilet/laundry, combined bathroom/toilet/laundry, laundry, utility room, conservatory, storage (other than a fitted cupboard), and circulation space (including corridor, hall, staircase, and landing). Where more than one example of a particular room type (except bedrooms) occurred these were numbered in size order with the largest room being 1 (living room 1, living room 2). For bedrooms, the largest bedroom was

called the master bedroom rather than bedroom 1 and other bedrooms were numbered, again in size order (bedroom 2, bedroom 3 etc.). In selected plans with a combined living room/kitchen, combined dining room/kitchen or combined living room/dining room/kitchen, these living areas were considered as the first living room (or dining room) and other living areas, if they existed were called living room 2 etc.

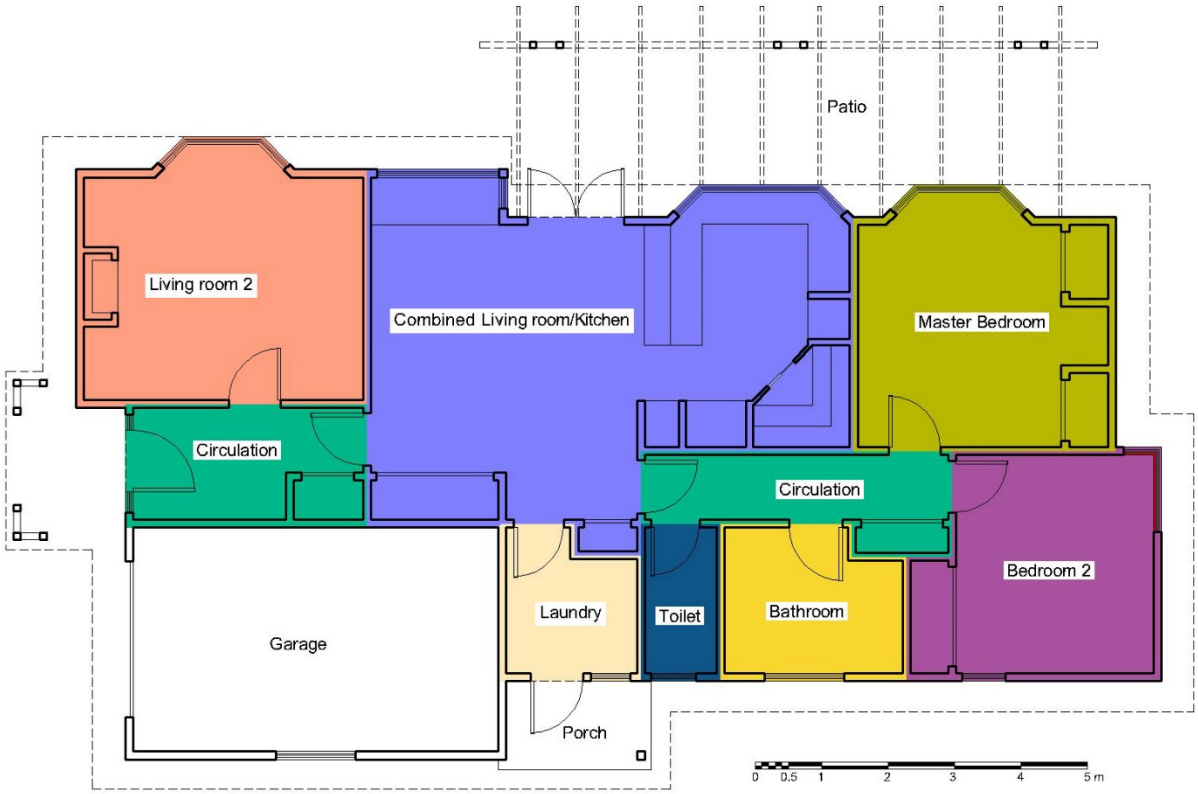


Figure 7.2 Redrawing of Design 301 (Wood, 1993:8) in AutoCAD 2016 and how floor area of each room type is calculated

Table 7.1 gives measured floor areas of rooms in Figure 7.2. In the measurement of the each house the following rules are followed:

1- Where circulation spaces are located in more than one place, the circulation floor area is the subtotal of all circulation areas (see Figure 7.2 and Table 7.1).

2- All parts of a room regardless of usefulness for furnishing purposes are included in the floor area of that room.

3- A room, including a room with combined functions, is physically separated from adjacent rooms by a door or door-sized opening.

4- The room usage and name generally follow the nomenclature of the floor plan although for combined rooms this was only considered valid if the room is big enough to contain all usages or each usage was well defined in the arrangement of the walls and furniture.

5- Floor areas of integral garages are excluded from the total floor area of the house.

6- Only indoor spaces are included in the house floor (i.e. patio, porch, balcony and conservatory are excluded).

7- All built-in wardrobes, shelves and cupboards are included in the floor area of the room from which they can be accessed (see Figure 7.2).

8- Walk-in wardrobes (or dressing rooms) were included in the floor area of the bedroom from which they are accessed.

9- Pantries, sculleries and fitted kitchens are included in the floor area of the kitchen.

10- Laundries in garages are excluded from this study.

Floor areas		**House characteristics**	
Room type	**Floor area (m^2)**		
Combined living room/kitchen	25.53	Number of rooms	5
Living room 2	16.35	Number of bedrooms	2
Master bedroom	14.84	Number of living rooms	2
Bedroom 2	12.24	Number of dining rooms	0
Bathroom	6.24	Number of kitchens	1
Toilet	2.85	Number of bathrooms	1
Laundry	4.95	Number of toilets	1
Circulation	16.93	Number of en-suites	0
Total floor area (circulation spaces excluded)	86.00	Number of specialised rooms	0
Total floor area (garage excluded)	102.93	Circulation space as a percentage of floor area of other rooms (excluding garage)	19.69%

Table 7.1 Floor area of the house and each room type and house characteristics extracted from the AutoCAD drawing file

Based on the drawings and measurements made in AutoCAD 2015/2016, information such as number of rooms of each type in each house plan and the floor area of the circulation spaces as a percentage of the total floor area of other rooms could be produced. The number of habitable rooms in this study follow Statistics New Zealand room standard (see section 2.2). In counting the various rooms in each house the following rules are considered:

1- The total number of living rooms comprises all living rooms and any living room in a combined room. For example a combined living room/dining room counts as one living room and one dining room and if the same house also has a separate living room, the total would be 2 living rooms.
2- In counting the number of bathrooms the rule for living rooms is followed (an en-suite counts as 1 bathroom). For example a house with 1 combined bathroom/toilet and 1 bathroom/toilet/laundry has 2 bathrooms.
3- The rule for living rooms applies to counting the total number of toilets. For instance a house with 1 combined bathroom/toilet, 1 toilet/laundry and 1 en-suite has 3 toilets.
4- A combined bathroom/toilet that is only accessed from a bedroom is an en-suite.
5- The count of specialised rooms includes all studies, games rooms and studios. The name on the plan is what leads to the categorisation, not how the room might be used. Number of house plans

As a first step at least 30 published plans of New Zealand houses with differing numbers of rooms were selected and analysed in AutoCAD 2015/2016 to find room and whole house areas. The number of rooms was selected as an indicator of house size and houses were categorised as 3, 4, 5, 6, 7, 8 and 9-9+ room houses. Data for all houses were gathered in an Excel spread sheet and an average floor area was produced for each room type as well as for the whole house (garage excluded). Before all samples were analysed, the average floor area for the whole house and the master bedroom (which was found in all houses) were produced at different stages and compared to the previous average (i.e. the average floor area of 15 three room houses was compared to the average floor area of 16 three room houses) to see the percentage change from adding a new house plan. The aim was to reach an increase/decrease of ±1% or ±2% in the total floor area of each size of house by adding a new plan and to check that this pattern remained consistent for at least the next 10 cases. Table 7.2 shows the point this was reached for different sized houses. As see, to reach a consistent average floor area with a change of less than ±2%, needed at least 25 house plans while to reach a consistent average floor

area with a change less than ±1%, needed at least 40 house plans. The latter was selected for the minimum number analysed in each house size category, although because of the popularity of some house sizes (i.e. 6 room houses are the popular 3 bedroom house type) the number of analysed plans is more in some size categories (Table 7.3).

	House size (based on number of rooms)					
	4	5	6	7	8	9-9+
Number of plans which gave a consistent average in the total floor area (±2% change)	20	18	13	21	11	25
Number of plans which gave a consistent average in the total floor area (±1% change)	31	29	29	30	40	32

Table 7.2 Number of plans needed to reach a consistent average floor area within ±1% or ±2%

7.2.3. Spread sheet and statistical analyses

Data for all houses were gathered in an Excel spread sheet and then transferred to SPSS for statistical analyses. The presence of different types of room in various sized houses was analysed using an independent sample *t* test. In addition, the number and size of different types of room were compared to house size to see how these might change as house size increased using an ANOVA one-way test. Where the ANOVA test showed a significant different at 0.05 level a further post-hoc Tukey test was performed to see the details of the difference between the various groups (the relevant tables for the latter are in Appendix 7.1).

7.3. Results

7.3.1. Sample

Given the results in Table 7.2 the aim was to have at least 40 plans of different sized houses for analysis. However, the search for 3 room house plans was not successful and only 9 were found and analysed. Statistics New Zealand (2013b) state this is the least common house size in New Zealand. As the results for this house size are not reliable, 3 room houses are not included in most analyses. Table 7.3 presents the number of plans used and the mean, minimum, maximum, median and standard deviation of the floor area for each house size. A full list of all sample houses including relevant references is presented in Appendix 7.2.

	Number of samples	Average floor area (m^2)	Minimum (m^2)	Maximum (m^2)	Median (m^2)	Standard Deviation
3 room Houses	9	51.73	37.08	79.71	51.94	13.58
4 room Houses	41	70.70	44.99	96.57	71.73	14.32
5 room Houses	45	96.17	59.89	128.87	96.14	14.89
6 room Houses	70	120.21	79.18	224.95	116.25	26.38
7 room Houses	40	161.26	94.93	237.92	155.70	30.57
8 room Houses	40	190.01	119.83	331.23	177.86	41.19
9-9+ room Houses	42	254.87	167.33	367.55	253.29	48.84
Total	287	142.38	37.08	367.55	126.17	67.92

Table 7.3 Number of plans used and mean, minimum, maximum, median and standard deviation of the floor area for each house size

Though areas of integral garages are not included, the number of these is compared with house size. Table 7.4 lists the number of houses with integral garages and their percentage of the total sample houses, showing integral double garaging to be the most popular type. This is in line with a study by BRANZ (Page, 2007) which found double garaging was the most important design feature when people came to buy a new house in New Zealand.

Table 7.4 also gives the number of storeys for the houses in this study, showing 74.6% of the sample plans are single storey houses, which is comparable to the 2013 census data where 75.4% of New Zealand detached houses were single storey (Statistics New Zealand, 2014b).

	Integral garage capacity					Number of storeys		
	No garages	Single garage	Double garage	Triple garage	Quadruple garage	Single storey	Double storey	Three storey
Frequency	177	17	73	19	1	214	70	3
Percentage of the whole sample	61.7%	5.9%	25.4%	6.6%	0.3%	74.6%	24.4%	1.0%

Table 7.4 Number of integral garage spaces and storeys in the sample plans

7.3.2. Average room floor areas

Both the number and size of rooms affect the total floor area of a house. Table 7.5 presents the average room floor area for various sized houses, showing room areas increase with house size. Using a post stratification method as described in section 7.4.1, it is possible to the find the average floor area per room for a New Zealand house.

House size (Based on number of rooms)	Mean floor area per room	N	Std. Deviation
3 room houses	17.24	9	4.53
4 room houses	17.68	41	3.58
5 room houses	19.23	45	2.98
6 room houses	20.04	70	4.40
7 room houses	23.04	40	4.37
8 room houses	23.75	40	5.15
9-9+ room houses	26.10	42	4.22
Average for this sample	21.44	278	4.99
Adjusted average for New Zealand	21.16	NA	NA

Table 7.5 The average room floor area for various house sizes in this sample

To find out whether average floor area per room is significantly different by house size an ANOVA one-way test was performed in SPSS. The results show the average floor area per room is significantly different by house size at 0.05 level ($F_{(5,272)}$=24.83, p= 0.000). To see the details of this difference, a post-hoc using Tukey test was also performed and the results presented in Table 7.6. Apart from between consecutive house sizes (i.e. 4 and 5 room houses or 5 and 6 room houses), the average room floor area is significantly different between all houses sizes and generally larger houses have larger room floor areas. Table 7.6 shows the average room size in a 9-9+ room house is 6.06m^2 more than in a 6 room house.

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	1.56	0.90	0.515	×
6 room house	4 room house	2.36	0.82	0.050	✓
6 room house	5 room house	0.80	0.80	0.916	×
7 room house	4 room house	5.36	0.93	0.000	✓
7 room house	5 room house	3.80	0.91	0.001	✓
7 room house	6 room house	3.00	0.83	0.005	✓
8 room house	4 room house	6.08	0.93	0.000	✓
8 room house	5 room house	4.52	0.91	0.000	✓
8 room house	6 room house	3.72	0.83	0.000	✓
8 room house	7 room house	0.71	0.93	0.973	×
9-9+ room house	4 room house	8.42	0.92	0.000	✓
9-9+ room house	5 room house	6.86	0.90	0.000	✓
9-9+ room house	6 room house	6.06	0.81	0.000	✓
9-9+ room house	7 room house	3.06	0.92	0.013	✓
9-9+ room house	8 room house	2.35	0.92	0.116	×

Table 7.6 Results of the post-hoc test for comparing average room area in various house sizes

7.3.3. Presence of different room types

As mentioned before, all rooms in this study are put into 21 categories. Table 7.7 shows the frequency and percentage of houses with at least one of each room type. A master bedroom, other bedroom, separate living room, combined bathroom/toilet, separate toilet, separate laundry and circulation space are found in more than 50% of the sample houses. Table 7.7 also shows that some rooms like

study, games room, studio, and en-suite are only seen in larger houses, while having a combined living room/kitchen mainly occurs in very small houses.

Rooms	Frequency and Percentage	Number/Percentage of houses with at least 1 of each room type by house size (based on number of rooms)							Total sample
		3 rooms	4 rooms	5 rooms	6 rooms	7 rooms	8 rooms	9-9+ rooms	
Master Bedroom	Frequency	9	41	45	70	40	40	42	287
	Percentage	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Other bedroom	Frequency	0	36	45	70	40	40	42	273
	Percentage	0.0%	87.8%	100.0%	100.0%	100.0%	100.0%	100.0%	95.1.0%
Study	Frequency	0	0	1	4	10	21	31	67
	Percentage	0.0%	0.0%	2.2%	5.7%	25.0%	52.5%	73.8%	23.3%
Games room	Frequency	0	0	0	0	0	2	7	9
	Percentage	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	16.7%	3.1%
Studio	Frequency	0	0	0	0	2	1	5	8
	Percentage	0.0%	0.0%	0.0%	0.0%	5.0%	2.5%	11.9%	2.8%
Separate kitchen	Frequency	2	23	27	19	15	6	5	97
	Percentage	22.2%	56.1%	60.0%	27.1%	37.5%	15.0%	11.9%	33.8%
Separate living room	Frequency	2	23	19	21	23	36	35	159
	Percentage	22.2%	56.1%	42.2%	30.0%	57.5%	90.0%	83.3%	55.4%
Separate dining room	Frequency	0	0	5	9	7	9	9	39
	Percentage	0.0%	0.0%	11.1%	12.9%	17.5%	22.5%	21.4%	13.6%
Combined Living room/Kitchen	Frequency	7	14	2	3	1	3	3	33
	Percentage	77.8%	34.1%	4.4%	4.3%	2.5%	7.5%	7.1%	11.5%
Combined Living room/Dining	Frequency	0	1	12	9	9	3	7	41
	Percentage	0.0%	2.4%	26.7%	12.9%	22.5%	7.5%	16.7%	14.3%
Combined Dining/Kitchen	Frequency	0	1	3	10	7	3	5	29
	Percentage	0.0%	2.4%	6.7%	14.3%	17.5%	7.5%	11.9%	10.1%
Combined Living room/Dining room/Kitchen	Frequency	0	3	13	38	17	28	29	128
	Percentage	0.0%	7.3%	28.9%	54.3%	42.5%	70.0%	69.0%	44.6%
Separate bathroom	Frequency	0	8	27	42	21	21	18	137
	Percentage	0.0%	19.5%	60.0%	60.0%	52.5%	52.5%	42.5%	47.7%
Bathroom/Toilet	Frequency	6	24	18	30	20	19	29	146
	Percentage	66.7%	58.5%	40.0%	42.9%	50.0%	47.5%	69.0%	50.9%
En-suite	Frequency	1	0	4	26	25	36	39	131
	Percentage	11.1%	0.0%	8.9%	37.1%	62.5%	90.0%	92.9%	45.6%
Separate toilet	Frequency	0	8	30	46	32	30	31	177
	Percentage	0.0%	19.5%	66.7%	65.7%	80.0%	75.0%	73.8%	61.7%
Toilet/Laundry	Frequency	0	0	0	0	2	0	1	3
	Percentage	0.0%	0.0%	0.0%	0.0%	5.0%	0.0%	2.4%	1.0%
Bathroom/Toilet/Laundry	Frequency	2	9	0	0	0	0	1	12
	Percentage	22.2%	22.0%	0.0%	0.0%	0.0%	0.0%	2.4%	4.2%
Separate laundry	Frequency	2	11	31	52	22	30	39	187
	Percentage	22.2%	26.8%	68.9%	74.3%	55.0%	75.0%	92.9%	65.2%
Utility room	Frequency	0	0	0	2	0	0	1	3
	Percentage	0.0%	0.0%	0.0%	2.9%	0.0%	0.0%	2.4%	1.0%
Storage	Frequency	0	0	5	12	11	7	19	54
	Percentage	0.0%	0.0%	11.1%	17.1%	27.5%	17.5%	45.2%	18.8%
Circulation space	Frequency	6	37	44	70	40	40	42	279
	Percentage	66.7%	90.2%	97.8%	100.0%	100.0%	100.0%	100.0%	97.2%

Table 7.7 Percentage and frequency of houses with at least one of each room type by different sized houses

An ANOVA one-way test was performed to see if the presence of various room types is significantly different by house size and the results are given in Table 7.8. Master bedrooms were excluded from this analysis because all houses have this room type. As seen in Table 7.8, apart from combined dining room/kitchen, combined bathroom/toilet, combined toilet/laundry and utility room the presence (and absence) of all other room types is significantly different by house size.

Room type	F (5,272)	Sig.	Result
Other bedroom	6.44	0.000	✓
Study	36.77	0.000	✓
Games room	6.86	0.000	✓
Studio	3.66	0.003	✓
Kitchen	9.05	0.000	✓
Living room	13.21	0.000	✓
Dining room	2.41	0.037	✓
Livingroom/Kitchen	8.03	0.000	✓
Livingroom/Dining room	2.87	0.015	✓
Dining room/Kitchen	1.45	0.208	×
Living room/Dining room/Kitchen	12.04	0.000	✓
Bathroom	4.41	0.001	✓
Bathroom/Toilet	2.16	0.059	×
En-suite	50.92	0.000	✓
Toilet	10.11	0.000	✓
Toilet/Laundry	1.73	0.128	×
Bathroom/Toilet/Laundry	11.15	0.000	✓
Laundry	11.29	0.000	✓
Utility room	0.91	0.478	×
Storage	7.01	0.000	✓
Corridor	3.83	0.002	✓

Table 7.8 ANOVA one-way test results for significance of presence/absence of various room types with house size

For more detail a post-hoc test was performed for rooms with positive ANOVA results (Tables A.7.1.2-18 in Appendix 7.1). The post-hoc test results enables the presence of room types to be put into five categories:

Category 1- Rooms that are only significantly absent in 4 and/or 5 room houses (other bedroom, combined living room/dining room/kitchen, separate bathroom, separate toilet, separate laundry, and circulation space).

Category 2- Rooms that are only significantly present in 9-9+ room houses (storage, studio and games room).

Category 3- Rooms which might exist in all house sizes but where the chance of their presence is higher as house size increases (study and en-suite).

Category 4- Rooms that are only significantly present in 4 and/or 5 room houses (combined living room/kitchen, separate kitchen and combined bathroom/toilet/laundry).

Category ≤5 Rooms where their presence or absence does not follow any particular pattern (separate living room, separate dining room, combined living room/dining room).

To gain a better understanding of these patterns and categories, Figure 7.3 presents the percentage of houses with at least one of each room type categorised by house size.

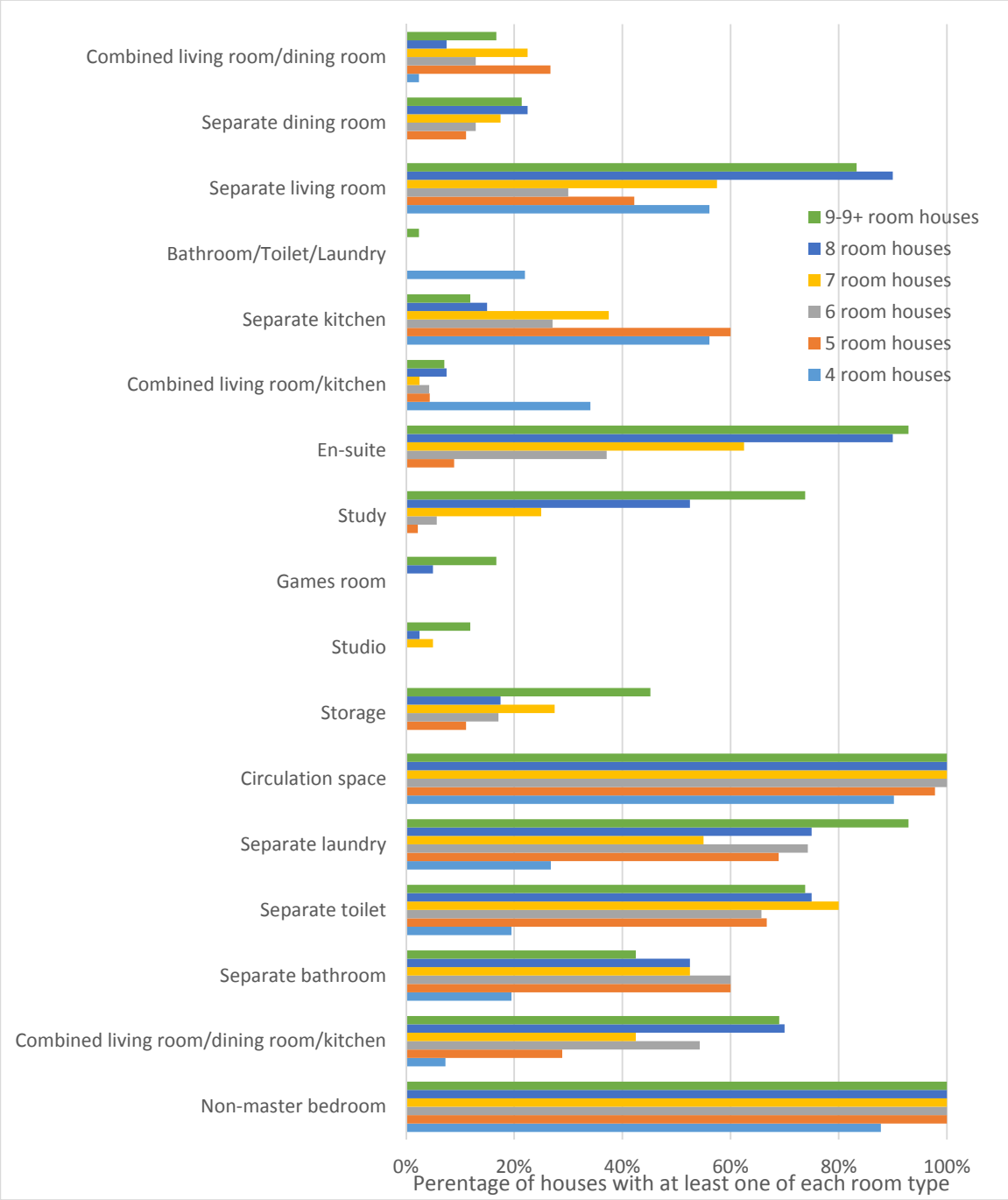


Figure 7.3 Percentage of houses with at least one of each room type categorised by house size

7.3.4. Number of room types

Table 7.7 shows the number of some room types is very limited in the sample and is even more limited when it comes to subcategories of different house sizes. This makes a comparison of room types in different house sizes difficult. To avoid this problem, various room types were re-categorised as below:

- *Bedroom:* Each master bedrooms, bedroom 2, bedroom 3, bedroom 4, bedroom 5 and bedroom 6 (if available) will be counted as a bedroom and added to find number of bedrooms.
- *Living room:* Each separate living room, combined living room/dining room, combined living room/kitchen and combined living room, dining room/kitchen (if available) will be counted as one living room.
- *Dining room:* Each separate dining room, combined living room/dining room, combined dining room/kitchen and combined living room, dining room/kitchen (if available) will be treated as one dining room.
- *Kitchen:* Each separate kitchen, combined dining room/kitchen, combined living room/kitchen and combined living room, dining room/kitchen (if available) will be treated as one kitchen.
- *Specialised room:* Each study, games room and studio will be counted as one specialised room and added to find the total number of specialised rooms.
- *Bathroom:* Each separate bathroom, combined bathroom/toilet, combined bathroom/toilet/laundry and en-suite will be counted as one bathroom and numbers added for each house.
- *En-suites:* Each combined bathroom/toilet with internal access from only one bedroom is counted as one en-suite.
- *Toilet:* Each separate toilet, combined bathroom/toilet, combined bathroom/toilet/laundry, combined toilet/laundry and en-suite will be counted as one toilet.
- *Laundry:* Each separate laundry, combined bathroom/toilet/laundry and combined toilet/laundry will be counted as one laundry.

Table 7.9 and Figure 7.4 present the average number of each room type by house size. As seen, the number of bedrooms, dining rooms, bathrooms, en-suites, and toilets gradually increases with houses size. In contrast number of living rooms and specialised rooms is quite constant in small houses but with a jump up for 7 room houses and then a gradual increase with house size. Kitchens are constant at one per house, while laundries do not follow any particular pattern. The ANOVA one-way test also shows the average number of all room types is significantly different by house size (Table 7.10).

	House size (based on number of rooms)					
	4	5	6	7	8	9-9+
Number of bedrooms	1.88	2.31	2.99	3.45	3.48	4.50
Number of living rooms	1.00	1.02	1.01	1.25	1.85	2.02
Number of dining rooms	0.12	0.73	0.94	1.00	1.08	1.19
Number of kitchens	1.00	1.00	1.00	1.00	1.00	1.00
Number of specialised rooms	0.00	0.02	0.06	0.30	0.60	1.05
Number of bathrooms	1.02	1.16	1.47	1.80	2.13	2.45
Number of en-suites	0.00	0.09	0.37	0.65	1.00	1.17
Number of toilets	1.02	1.16	1.51	2.08	2.40	2.90
Number of laundries	0.49	0.69	0.74	0.60	0.75	0.98
Number of sanitary spaces	1.46	2.44	2.83	3.05	3.40	3.79

Table 7.9 Average number of various room types by house size

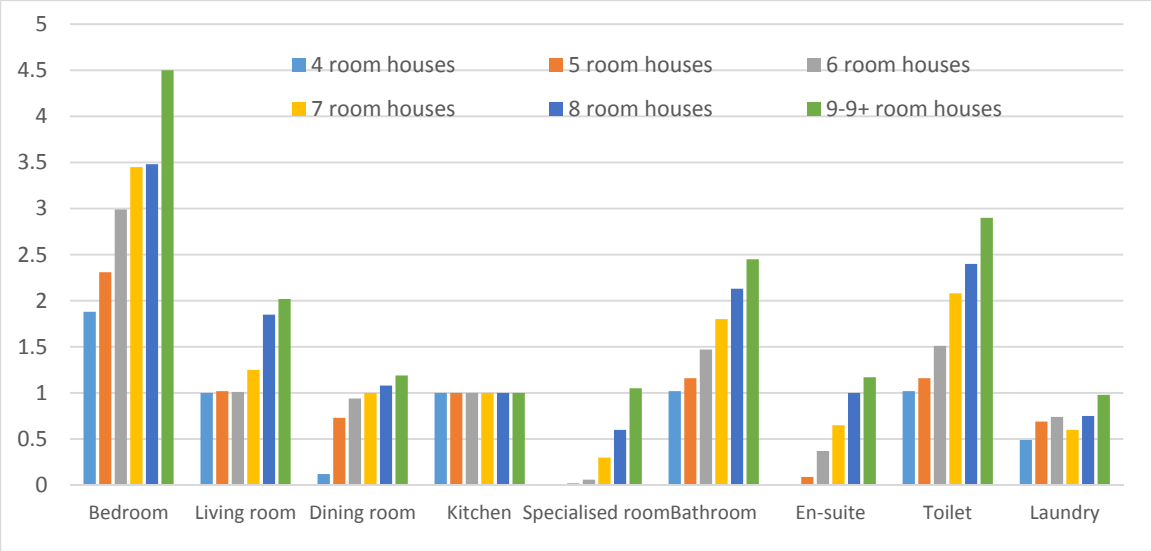


Figure 7.4 Average number of various room types by house size

	F (5,272)	Sig.	Result
Number of bedrooms	122.22	0.000	✓
Number of living rooms	100.04	0.000	✓
Number of dining rooms	59.27	0.000	✓
Number of specialised rooms	44.73	0.000	✓
Number of bathrooms	51.84	0.000	✓
Number of en-suites	49.80	0.000	✓
Number of toilets	65.12	0.000	✓
Number of laundries	5.98	0.000	✓

Table 7.10 Results of ANOVA one-way test to see if number of various room types is significantly different by house size

To see the details of these differences, a complementary post-hoc test was also performed for each room type (see Tables A.7.1.19-26 in Appendix 7.1). The post-hoc test results indicate that numbers of bedrooms and bathrooms are significantly different for all house sizes while numbers of living rooms and specialised rooms are only significantly different for 7+ room houses. Numbers of en-suites are significantly different for the majority of house sizes.

7.3.5. Size of rooms

Apart from the number of rooms, the room size can also affect overall house size. Table 7.11 presents the average floor area of all room types and number of samples included for various sized houses.

Room type	Average floor area of different rooms by house size (based on number of rooms)											
	4		5		6		7		8		9-9+	
	N	Average	N	Average	N	Average	N	Average	N	Average	N	Average
Master bedroom	41	14.85	45	16.78	70	17.44	40	21.19	40	23.37	42	27.92
Bedroom 2	36	11.55	45	12.81	70	13.15	40	14.98	40	15.60	42	17.53
Bedroom 3	NA	NA	10	10.47	65	11.11	40	12.71	40	13.56	42	14.83
Bedroom 4	NA	NA	NA	NA	4	11.80	18	11.88	18	12.31	39	13.80
Bedroom 5	NA	NA	NA	NA	NA	NA	NA	NA	1	9.26	20	13.21
Bedroom 6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	11.39
Study	NA	NA	1	9.91	4	9.10	10	10.06	21	10.33	31	10.56
Games room	NA	NA	NA	NA	NA	NA	NA	NA	2	28.03	7	27.96
Studio	NA	NA	NA	NA	NA	NA	2	28.25	1	23.45	6	27.41
Kitchen	23	11.62	27	12.63	19	11.50	15	14.82	6	15.30	5	18.71
Living room 1	23	21.81	18	22.17	20	24.92	14	30.18	9	32.69	8	29.59
Living room 2	NA	NA	1	16.35	1	14.77	9	19.17	31	22.88	34	24.89
Living room 3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	21.81
Dining room	NA	NA	5	14.61	9	16.31	7	17.54	9	16.84	9	17.50
Living room/Kitchen	14	29.17	2	28.65	3	33.60	1	45.25	3	33.43	3	46.74
Living/Dining	1	30.88	12	32.35	9	33.93	9	37.53	3	29.34	7	40.68
Dining/Kitchen	1	13.35	3	24.89	10	22.81	7	29.82	3	25.15	5	31.68
Living/Dining/Kitchen	3	35.30	13	40.93	38	49.45	17	53.76	28	53.59	29	62.16
Bathroom 1	8	4.26	27	4.82	42	4.68	21	6.25	21	7.17	18	7.20
Bathroom 2	NA	NA	3	2.02	5	2.00	2	3.03	3	3.42	1	5.16
Bathroom/Toilet 1	24	5.47	18	5.28	30	6.53	20	7.56	19	7.09	29	9.39
Bathroom/Toilet 2	1	4.17	NA	NA	NA	NA	3	5.27	2	6.09	5	5.10
En-suite 1	NA	NA	4	3.87	26	4.77	25	5.37	36	6.32	39	8.30
En-suite 2	NA	NA	NA	NA	NA	NA	1	5.58	3	5.69	10	5.95
En-suite 3	NA	NA	NA	NA	NA	NA	NA	NA	1	7.91	NA	NA
Toilet 1	8	1.86	30	1.96	46	2.12	32	2.42	30	3.01	31	2.98
Toilet 2	NA	NA	NA	NA	4	2.03	NA	NA	5	2.39	6	2.90
Toilet/Laundry	NA	NA	NA	NA	NA	NA	2	7.07	NA	NA	1	8.74
Bath/Toilet/Laundry	9	7.49	NA	NA	NA	NA	NA	NA	NA	NA	1	8.44
Laundry	11	4.76	31	5.61	52	5.12	22	6.52	30	6.00	39	6.22
Utility room	NA	NA	NA	NA	2	13.98	NA	NA	NA	NA	1	5.58
Storage	NA	NA	5	4.01	12	3.39	11	2.10	7	2.11	19	4.79
Circulation space	41	5.94	45	11.12	70	15.88	40	24.41	40	27.58	42	36.84

Table 7.11 The average floor area of all room types investigated and number of sample for various sized houses

As can be seen in Table 7.11, the number of some room types is very few in some cases and further analysis on these will not be reliable. To remove this problem, rooms were grouped into 5 categories and the floor areas added noting that storage spaces are excluded from this part of the analysis. This gave a bigger sample in each category and made the comparison easier, although where the sample of any room type in each group was sufficient (i.e. master bedroom) these were also analysed separately. The five groups of rooms are as below:

Bedrooms: This is the subtotal floor area of master bedroom and all other bedrooms for each house.

Specialised rooms: This is the subtotal floor area of all specialised rooms (study, games room and studio) for each house.

Living, dining, kitchen areas: This is the subtotal floor area of all such spaces, whether separate or combined for each house.

Sanitary spaces: This is the subtotal floor area of all bathrooms, toilets, en-suites, utility rooms and laundries whether separate or combined for each house.

Circulation spaces: This is the subtotal floor area of corridors, entrance spaces and landings for each house.

Figure 7.5 gives the average floor area of these five room categories by house size. An ANOVA one-way test was performed for each of the 5 categories to see if the average floor area is significantly different by houses size (Table 7.12), and significant differences by house size were found for all room categories.

Room category	F (5, 272)	Sig.	Result
Bedrooms	102.37	0.000	✓
Specialised rooms	29.06	0.000	✓
Living, dining and kitchen areas	99.01	0.000	✓
Sanitary spaces	87.42	0.000	✓
Circulation spaces	89.05	0.000	✓

Table 7.12 ANOVA one-way test results to see if average floor area of 5 room categories is significantly different by house size

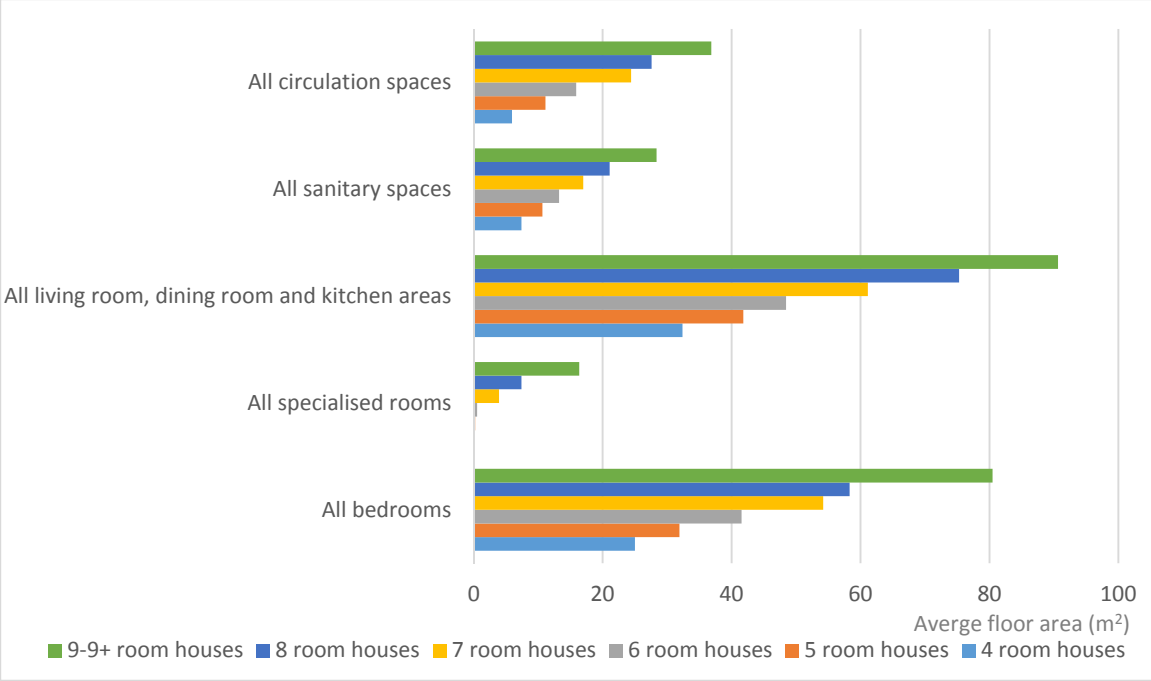


Figure 7.5 Average floor area (m^2) of different room categories in various house sizes

To see the details of these differences, a post-hoc test was also performed for each room category (see Table A.7.1.27-31 in Appendix 7.1), leading to the following results:

- The average floor area allocated to bedrooms is significantly different between all house sizes apart from 5 & 4, 8 & 7 room houses.
- The average floor area allocated to all specialised rooms is only significantly different between 8 & 4, 8 & 5, 8 & 6, 9-9+ & 4, 9-9+ & 5, 9-9+ & 6, 9-9+ & 7 and 9-9+ & 8 room houses. In fact there are no specialised rooms in most small houses (4, 5 and 6 room), which is why these pairs do not feature.
- The average floor area allocated to all living, dining and kitchen areas, including kitchens, is significantly different between all house sizes apart from 6 & 5 room houses.
- The average floor area allocated to all sanitary spaces is significantly different between all house sizes apart from 5 & 4 and 6 & 5 room houses.
- The average floor area allocated to circulation space is significantly different between all house sizes apart from 8 & 7 room houses.

In some room categories, there are enough case studies to repeat the ANOVA one-way test for individual room types to see change in area with house size (Table 7.13). As seen in Table 7.13, the average floor area is significantly different by house size for all room types apart from study, living room 2, dining room and laundry. Figure 7.6 shows how an increase in house size might affect the average floor area of selected rooms.

Room type	df	F	P-value	Result
Master bedroom	5, 272	36.20	0.000	✓
Second bedroom	5, 267	17.77	0.000	✓
Third bedroom	4, 192	14.47	0.000	✓
Fourth bedroom	2, 72	3.62	0.032	✓
Study	6, 62	0.29	0.834	×
Kitchen	5, 89	4.56	0.001	✓
Living room 1	5, 86	5.87	0.000	✓
Living room 2	2, 71	2.22	0.116	×
Dining room	4, 34	0.53	0.713	×
Combined living room/dining room/kitchen	5, 122	6.46	0.000	✓
Bathroom 1	5, 131	13.42	0.000	✓
Bathroom/Toilet 1	5, 134	12.05	0.000	✓
En-suite 1	4, 125	15.11	0.000	✓
Toilet 1	5, 171	11.71	0.000	✓
Laundry	5, 179	2.08	0.070	×
Circulation spaces	5, 272	89.05	0.000	✓

Table 7.13 ANOVA one-way test results to see how average floor area of selected rooms changes with house size

For all rooms with a positive ANOVA one-way test result, a further post-hoc test was performed (Tables A.7.1.32-43 in Appendix 7.1) and the results for some of the selected rooms are discussed below:

Size of master bedrooms: Overall master bedrooms of larger houses are bigger than those of smaller houses. However, when it comes to similar sized houses (e.g. 4 and 5 room houses) the difference in the average floor area of master bedrooms is usually not significant.

Size of second bedrooms: The results of this study show that second bedrooms of larger houses are bigger than those of smaller houses, although the average difference between houses of similar sizes is usually not significant. The same pattern was seen in the size of the third and fourth bedrooms (see Tables A.7.1.33-35 in Appendix 7.1).

Size of separate kitchens: Kitchens only differ in size significantly between the largest house (9 and 9+) and the three smallest (4, 5 and 6 rooms).

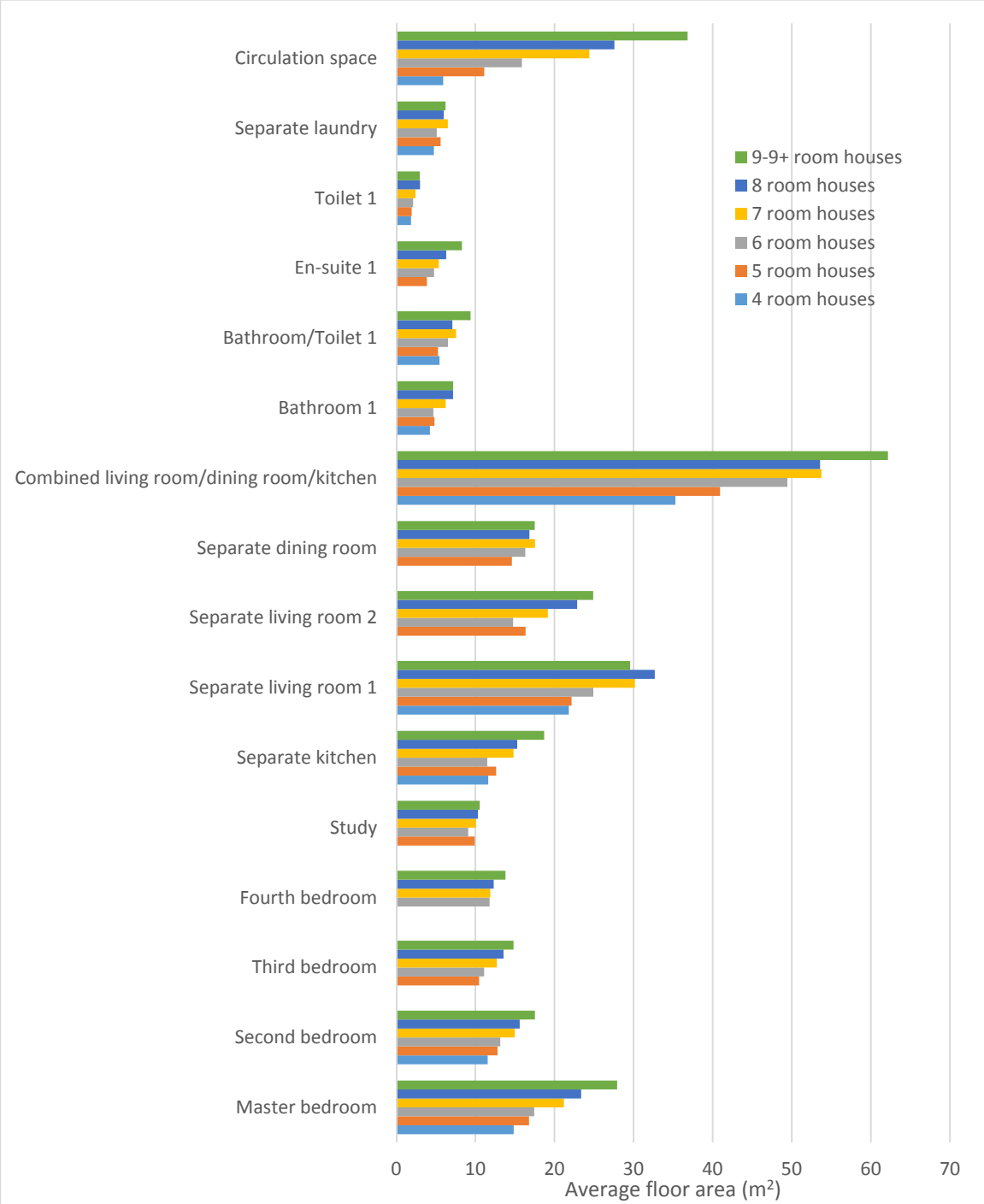


Figure 7.6 Average floor area (m^2) of selected rooms in different sized houses

Size of living room 1: The results for this post-hoc test (Table A.7.1.37 in Appendix 7.1) are complicated and worth considering in detail. Only houses with at least one separate living room are included in this test. The size of living room 1 is only significantly different between 7 & 4, 8 & 4, 8 & 5 and 7 & 5 room

houses. It appears there is no logic for the significant difference in size of separate living rooms of 4 and 7 and 4 and 8 room houses but not between 4 and 9-9+ room houses. The only possible reason was that some separate living rooms in very large houses (i.e. 9-9+ room houses) are second living rooms and these are being compared with first living room of a small house. To cover this issue, the ANOVA one-way test was repeated excluding houses with more than 1 living room. Because such houses were very few in the categories of 8 (3 cases) and 9-9+ room houses (1 case) these were excluded from the analysis. The results of this test indicate the average floor area of living rooms is significantly different at 0.05 level with house size ($F_{(3,70)}$=7.36, p=0.000). Results of a further post-hoc test (Table A.7.1.38 in Appendix 7.1) indicates that the living room size is only significantly different between pairs of 7 & 4, 7 & 5 and 7 & 6 room houses.

Size of combined living room/dining room/kitchen: Overall a combined living room/dining room/kitchen in 9-9+ room houses is larger than in small houses.

Size of bathroom 1: The size of bathrooms increases with house size although the difference for the size of bathrooms in houses of similar size is not significant.

Size of bathroom/toilet 1: The size of combined bathroom/toilets is only significantly bigger in very large houses (9-9+ room houses).

Size of en-suite 1: Overall the size of en-suites increases with house size although most significant differences happen between 9-9+ room houses and other house sizes. It should be noted that 4 room houses were excluded from this test as the number of such houses with an en-suite was very limited.

Size of toilet 1: The toilet area increases with house size although most significant differences happen between 9-9+ room houses and other house sizes.

7.3.6. House size and number of garages

Table 7.14 presents the mean, number of cases and standard deviation for the average number of available integral garage spaces in different sized houses. The ANOVA one-way test results indicate

the average number of garage spaces is significantly different with house size ($F_{(5, 272)}$=46.22, p=0.000). Overall, results of this study (see Table A.7.1.44 in Appendix 7.1) indicate that apart from 4 and 5 room houses (which mostly do not have an integral garage) the number of garage spaces increases with house size, although the rate of increase between similar sized houses is usually not significant.

House size (number of rooms based)	Mean of available garage spaces	N	Std. Deviation
4 room house	0.07	41	0.26
5 room house	0.04	45	0.21
6 room house	0.41	70	0.73
7 room house	1.05	40	0.99
8 room house	1.65	40	1.05
9-9+ room house	1.95	42	1.08
Total	0.81	278	1.07

Table 7.14 Mean, number of cases and standard deviation for the average number of available garage spaces in different sized houses

7.3.7. Effect of number of storeys on circulation floor area

As seen in section 7.3.5 the average floor area of circulation space increases with house size. To investigate the effect of number of storeys an independent sample *t* test was performed. This showed the average floor area of circulation spaces in 2-2+ storey houses is significantly more than in single storey houses at 0.05 level ($t_{(285)}$=9.83, p=0.000). Ignoring house size, further analysis shows that the average floor area of circulation spaces in 2-2+ storey houses is 30.25m^2 which is almost double that of single storey houses (15.43m^2).

A table of average floor area by number of storeys in different sized houses was created and the difference between the average size of circulation spaces in single and 2-2+ storey houses calculated as a percentage. According to Table 7.15, apart from 4 room houses where there are no two storey examples, the average floor area of circulation spaces is greater in 2-2+ storey houses than in all single storey house sizes. Table 7.15 also shows the increase in number of storeys increases the average floor area of circulation spaces in small houses much more than in large houses. An independent sample *t* test indicated the average floor area of circulation spaces is significantly higher in double storey houses for 5 room houses ($t_{(43)}$=3.17, p=0.003), 6 room houses ($t_{(68)}$=4.79, p=0.000), 7 room houses ($t_{(38)}$=5.18, p=0.000) and 8 room houses ($t_{(38)}$=2.63, p=0.012) but is not significantly different for 9-9+ room houses ($t_{(23)}$=1.69, p=0.104).

	Number of storeys	House size (Based on number of rooms)					
		4 room	5 room	6 room	7 room	8 room	9-9+ room
Average floor area of circulation spaces	1	5.94	10.51	13.30	18.87	24.98	34.56
	2-2+	NA	17.32	21.90	31.90	32.40	40.20
Percentage increase in the average floor area with increase in number of storeys		NA	64.8%	64.7%	69.1%	29.7%	16.3%

Table 7.15 Average floor area of circulation spaces based on number storeys in different sized houses

7.4. Discussion

7.4.1. Average floor area of New Zealand houses

As expected, this study found the average floor area of New Zealand houses increases with an increase in the number of rooms. According to Figure 7.7, the change in the average floor area of 3 to 6 room houses follows a linear pattern but there is a jump in the averages of 6 to 7 and 8 to 9 room houses. Given 6 room houses are the standard 3 bedroom house, it seems the change in the pattern of house size starts from 7 room houses. It should be noted that the significant jump between the average floor area of 8 and 9-9+ room houses is rooted in the fact that the latter includes 9, 10, 11 and 12-12+ room houses.

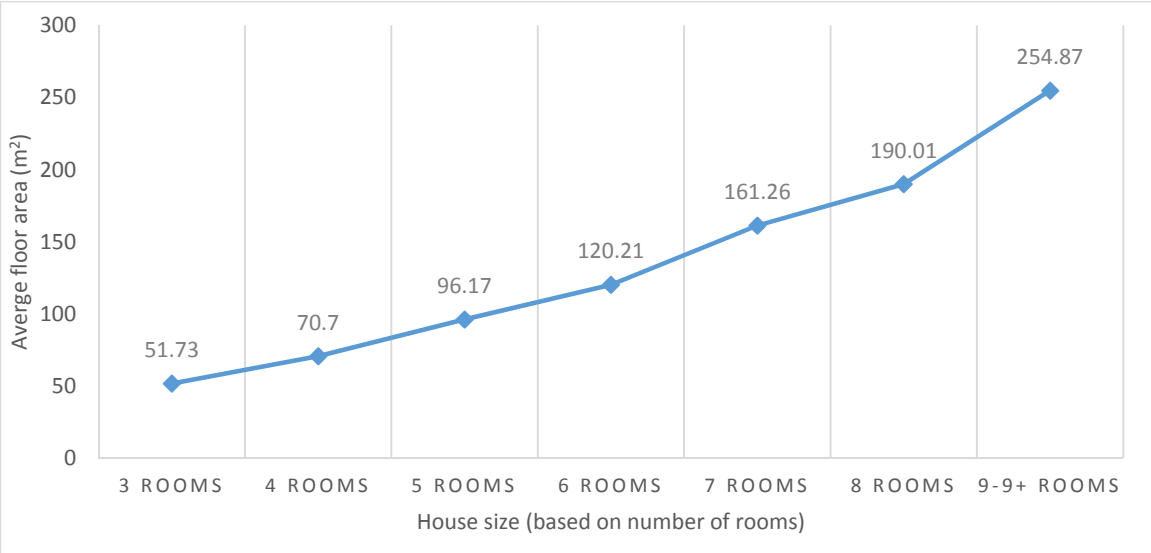


Figure 7.7 Average floor area by house size (based on number of rooms)

Using the results of this study it is possible to estimate the average floor area of the New Zealand dwelling. Based on the 2013 census (Statistics New Zealand, 2013d) the percentage of dwellings with differing numbers of rooms is presented in column 2 of Table 7.16. The third column of Table 7.16 shows how the sample houses in this study are distributed between the various house size categories.

A comparison shows the distribution of samples in this study differs from census 2013 (probably because this study only includes houses whereas the census data includes apartments and some of these are small) and so the average from this study (142.38m^2 see Table 7.3) does not represent the New Zealand house size. To solve this issue averages from this study were scaled using a post stratification method (Groves et al., 2009). The average floor area of each house size from this study was multiplied by the relevant percentage from census 2013 (column 4 Table 7.16). The subtotal of column 4 figures shows an average floor area of 137.86m^2 for New Zealand dwellings (garages excluded) based on this study.

House size (based on number of rooms)	Percentage of total housing stock based on New Zealand census 2013	Percentage of total housing stock based on samples of this study	Floor area (m^2) of different sized houses based on samples of this study	Floor area (m^2) share in the NZ housing stock
≤3 rooms	6.41%	3.13%	51.73	3.11
4 rooms	10.20%	14.29%	70.70	7.24
5 rooms	17.27%	15.68%	96.17	16.67
6 rooms	25.45%	24.39%	120.21	30.70
7 rooms	17.11%	13.94%	161.26	27.69
8 rooms	11.60%	13.94%	190.01	22.12
9-9+ rooms	11.97%	14.63%	254.87	30.69
The estimated average floor area of NZ housing stock based on this study (excluding garages)				137.86

Table 7.16 Percentage of various dwelling sizes (based on number of rooms) in New Zealand housing stock based on census 2013 and the average floor area of various house sizes based on this study

There are two sources for the average floor area of New Zealand houses. Based on Statistics New Zealand (2014i) consent figures in 2013 the average floor area of new New Zealand houses was 191.9m^2. As most new New Zealand houses have attached garages, this average is assumed to include the floor area of the garage. The other source for the average floor area of all New Zealand houses is QV (2014) which is a website powered by Property IQ (2014). Based on QV (2011a), in 2011 the average house floor area in New Zealand was 149m^2 for all new and old houses. Following a personal enquiry to the QV website customer support on the 8 June 2016 they confirmed that only garages with internal access to the house are included in this average. A comparison of the estimated average of 137.86m^2 (Table 7.16) with the QV (2011a) average of 149m^2 gives a 11.1m^2 difference which could be related to the floor area of integral garages included in the QV (2011) average.

7.4.2. House size and number of rooms

This study shows that with an increase in house size the number of rooms also increases. The logical reason for having larger houses with more rooms is normally for housing larger families. Figure 7.8 presents the average number of rooms and bedrooms in different sized houses. It shows that as house size increases the proportion of bedrooms as part of the total number of rooms drops. Figure 7.9 compares the number of rooms and the bedroom share of this for different sized houses.

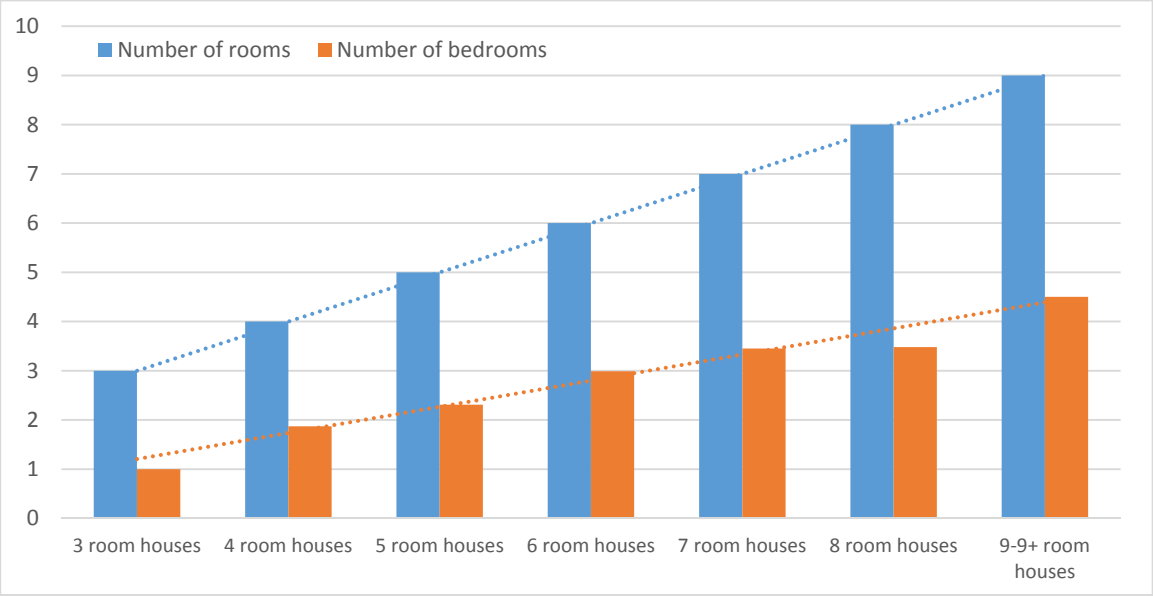


Figure 7.8 Average number of rooms and bedrooms in different sized houses and trends

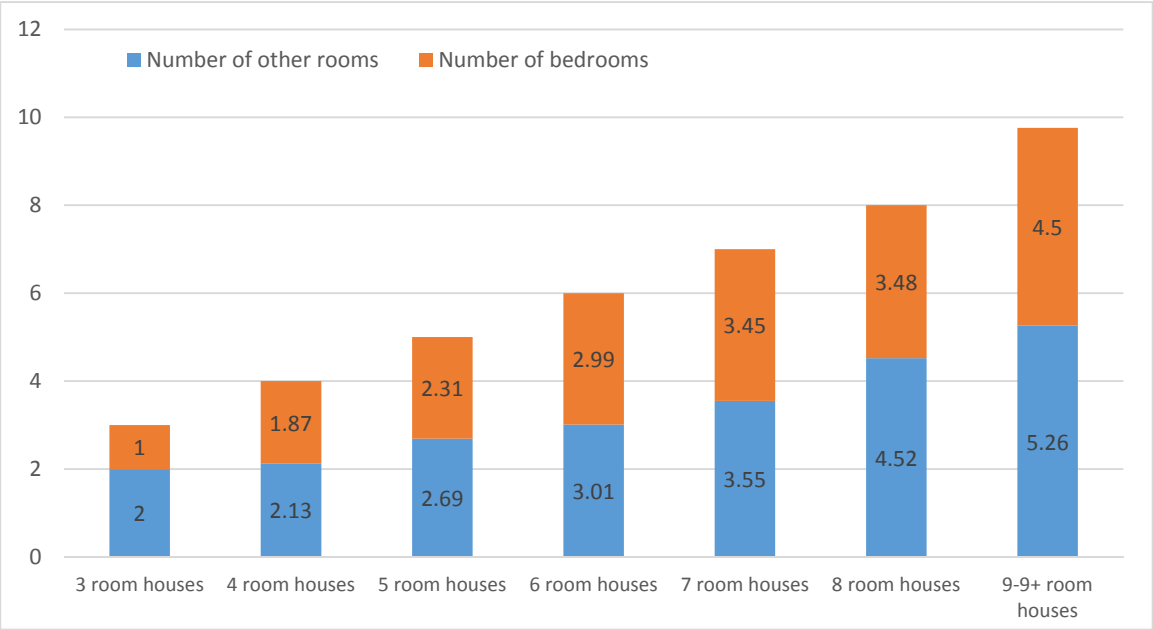


Figure 7.9 Total rooms in different sized houses and split between bedrooms and other rooms

Figure 7.9 shows that moving from a 7 room to an 8 room house only adds 0.03 bedrooms but 0.97 other rooms. In contrast, by moving from a 3 room to a 4 room house, 0.87 bedrooms and 0.13 other rooms will be added. This also indicates that adding extra rooms to small and large houses could have different meanings; in small houses this means an additional bedroom while in a large house this means an additional room of another type.

Service areas (i.e. bathrooms and toilets and combinations of these) are not included when rooms are counted in the New Zealand room standard (see section 2.2). However, this study shows that they form an important part of larger houses. The total number of all sanitary spaces in 8 room houses is 3.4 and only 1.5 in 4 room houses, mostly formed of bathroom spaces including en-suites. Figure 7.10 presents the total number of bathrooms in different sized houses and the share of en-suites in this. It shows that while number of bathrooms and en-suites increases with house size, number of non-en-suite bathrooms is almost consistent at 1 per house for all house sizes. This shows that additional bathrooms in larger houses are mostly en-suites which is important when it comes to considering efficient use of resources in housing.

Figure 7.10 Average number of all bathrooms in different sized houses and en-suites as part of this

7.4.3. House size and size of rooms

This study found that not only does the number of rooms increase with house size but also the size of the same type of room. For example, the average size of a master bedroom in an 8 room house is 57% bigger than the same room in a 4 room house. The same pattern can also be seen in the size of a combined bathroom/toilet which in an 8 room houses is 30% bigger than in a 4 room house. This is important given that such service rooms are not even counted as a room in the Statistics New Zealand room standard.

Figure 7.11 presents the share of five different room categories in the total floor area of different sized houses. It shows the average size of all sanitary spaces in an 8 room house is over 21m^2 and only 7m^2 in a 4 room house. The floor area allocated to sanitary spaces in 8 room houses is near to the floor area of all bedrooms in a 4 room house (25m^2). Some new large houses in New Zealand have en-suites as large as 15m^2 (Navigation homes, 2014ai) and laundries of 14m^2 (Wood, 1993:38) which are bigger than the master bedrooms of 4 room New Zealand houses and a standard double bedroom in UK houses (Vale & Vale, 2009).

The increase in the number of rooms not only affects the total floor area and the floor area of various room types but also the average floor area allocated to circulation spaces. Like any room circulation space takes resources for its construction and maintenance but may be little used. According to Figure 7.11, the average floor area allocated to circulation space in an 8 room New Zealand house is 66% of the floor area of all bedrooms in a 6 room house (standard 3 bedroom house) and 39% of the total floor area of a 4 room house.

According to Figure 7.11, the difference between the floor area allocated to all living rooms, dining rooms and the kitchen in an 8 and 6 room house is 26.8m^2 which is 52% of the total floor area needed for an average 3 room house in New Zealand.

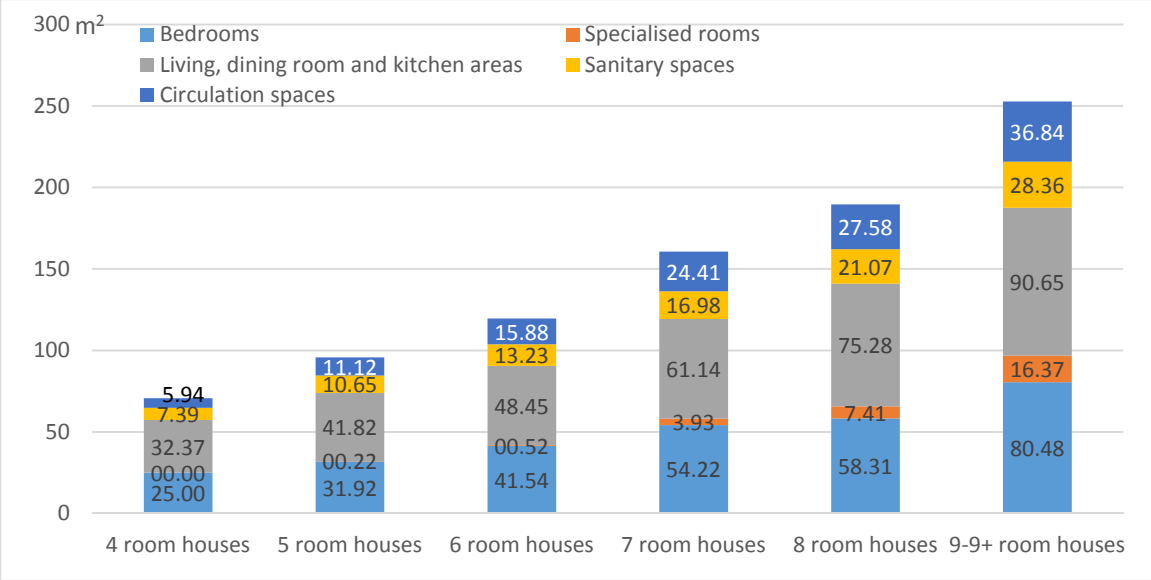


Figure 7.11 Share of five different room categories in the total floor area of different sized houses (storage excluded)

7.4.4. Plan layout and construction age

Living rooms, dining rooms and kitchens can either appear as separate rooms or be combined together and serve as a space large enough to include all functions which separate equivalent rooms normally have. The open plan is also a feature of modern architecture. This section will investigate if results of this study also support this historic trend. As mentioned before, the samples are taken from many different sources including books, websites and journal archives. A great part of the sample houses were designed for the New Zealand market but there is little or no information about the construction date. The only information available is the date these houses have been cited or published in the references. The assumption is that the construction date could be a few years before the citation date for older houses and before for new ones. For this reason, for all samples from journal archives, the publication year is taken as the construction date. For samples from books and catalogues, the publication date is the assumed construction date, and for websites, the date of access became the construction date. However, this will mean that some house types, like the early 20th century villa, will have a much more recent date to represent when they were constructed.

Houses with at least one combined living room/dining room/kitchen, combined living room/dining room, combined living room/kitchen or combined dining room/kitchen are assumed to have some

sort of open plan layout and form the open plan houses and houses with none of these are the cellular plan houses.

For this investigation, houses were put into 6 categories. Table 7.17 and Figure 7.12 give the percentage of open plan and cellular plan houses in different decades noting that there is no sample house in the 1960s. This shows open plan houses have become more popular in recent years. Figure 7.12 also show two significant jumps in the percentage of open plan houses, the first occurring between the 1940s and before and 1950s, and the second between the 1990s and 2000s and after.

Construction date in decades	Percentage of houses with cellular plan	Percentage of houses with open plan
1940s and before	80.0%	20.0%
1950s	38.9%	61.1%
1970s	29.6%	70.4%
1980s	28.6%	71.4%
1990s	17.1%	82.9%
2000s and after	0.8%	99.2%

Table 7.17 Percentage of houses with cellular and open plans in different decades

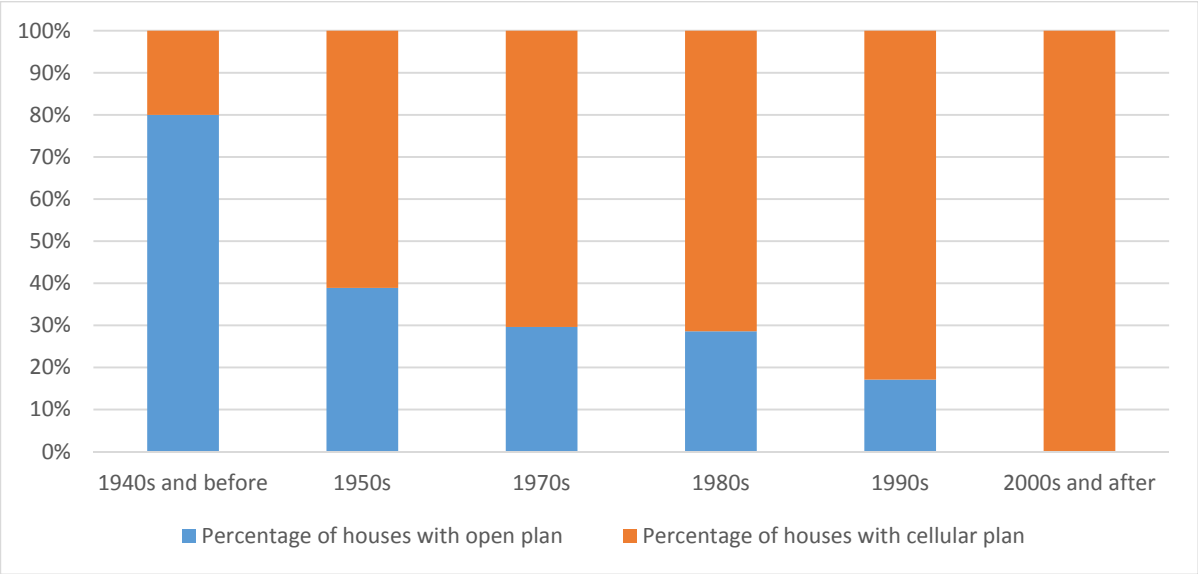


Figure 7.12 Percentage of houses with cellular and open plans in different decades

An ANOVA one-way test was performed to see if the difference between numbers of cellular and open plan houses are significantly different in various decades and the result was positive ($F_{(5, 281)}$=23.30, p=0.000). A further post-hoc test was also performed (see Table A.7.1.45 in Appendix 7.1 for full results) that showed that houses built in the 1940s and before, 1950s and 2000s and after have a

different layout pattern from other decades, with the percentage of cellular plan houses greater in the first two decades and very few in the latter.

7.4.5. A tool to estimate the floor area of houses

All over the world statistics are used to investigate the condition of housing as an indicator of quality of life (Statistics New Zealand, 2016a). House size is regarded as an important parameter for showing the quality of housing and reflecting the wealth and social aspirations of occupants. Measuring the floor area of a house is a time consuming and expensive process, and would be very difficult for big census samples. It also requires a degree of expert knowledge to have confidence in the results. To simplify this process house size is normally estimated from the reported number of rooms and bedrooms in census data. Using the results of this study, it is possible to create a tool for estimating the floor area of a house based on its number and types of rooms.

This tool was initially designed for estimating the floor area of a house by number of rooms for use in life cycle analysis. However, it could also be used by the New Zealand government to monitor increase/decrease in house size and see how various strategies might affect the average floor area of the house. The other use of this tool is in energy and lighting simulation tools as it gives an accurate estimation of the average floor area of various room types.

This study found the average floor area of most room types is significantly different for house size (based on number of rooms). This suggests two different strategies, one for rooms which fit this pattern and one for those that do not fit, noting there are also some exceptions:

Rooms whose floor area is significantly different by house size: For these rooms, each house is first sized according to the number of rooms (e.g. 5 room house) based on the Statistics New Zealand room standard. Then for each room type, including service spaces which are omitted from the room standard, where there are sufficient sample numbers (at least 30) the average floor area of that particular room type for 5 room houses from this study is used. Where the number of samples is less than 30 an equal number of samples from one size more and one size less are used to give a new

average floor area for that room type. For instance, if there are only 20 kitchens in 5 room houses, then 5 from both 4 and 6 room houses will also be included in the average for this house size. Master bedroom, second, third, fourth, fifth, and sixth bedroom, kitchen, living room 1, combined living room/kitchen, combined living room/dining room/kitchen, bathroom 1, bathroom/toilet 1, en-suite 1, and toilet 1 fall into this category.

Rooms whose floor area is not significantly different by house size: The assumption here is that regardless of house size, all such rooms have a similar floor area in various sized houses. So all samples with such room types are used to create an average floor area for that particular room type for all house sizes. Room types with less than 30 samples are also included in this category. Study, games room, studio 1, studio 2, living room 2, living room 3, dining room, combined living room/dining room, combined dining room/kitchen, bathroom 2, bathroom/toilet 2, en-suite 2, en-suite 3, toilet 2, toilet/laundry, bathroom/toilet/laundry, laundry, utility room and storage fall into this category.

Exceptions: There are some exceptions. For instance, the average floor area of a games room ($27.97m^2$) is taken from 8 and 9-9+ room houses as other house sizes do not have this room type. At the same time, people might use the rooms in their house in a different way, and a 6 room house for a couple might have a games room (in what might be in bedroom 2 or 3). Allocating $27.97m^2$ to this room is wrong because a 6 room house does not have such large rooms. The same might be true of a study and studio. The assumption is that people would usually allocate the largest spare bedroom to a games room and studio and the smallest spare bedroom to the study. Based on this, for these rooms, the average floor area of the largest bedroom (after the master bedroom) of the same sized house will be allocated to games room and studio and the average floor area of the smallest bedroom to the study.

From these three categories Table 7.18 gives the average floor area for various room types based on this study.

Room type	House size (based on number of rooms)					
	4 room	5 room	6 room	7 room	8 room	9-9+ room
Master bedroom	14.85	16.78	17.44	21.19	23.37	27.92
Second bedroom	11.55	12.81	13.15	14.98	15.60	17.53
Third bedroom	NA	10.90	11.11	12.71	13.56	14.83
Fourth bedroom	NA	NA	11.98	11.95	12.52	13.80
Fifth bedroom	NA	NA	NA	NA	13.02	13.02
Sixth bedroom	NA	NA	NA	NA	NA	11.39
Study	11.55	10.06	10.06	10.06	10.33	10.56
Games room	11.55	12.81	13.15	14.98	27.97	27.97
Studio 1	11.55	12.81	13.15	28.09	28.09	28.09
Studio 2	NA	10.90	11.98	19.65	19.65	19.65
Kitchen	11.62	12.63	11.50	16.23	18.76	18.76
Living room 1	21.81	22.17	24.92	29.45	30.78	30.78
Living room 2	11.55	21.15	21.15	21.15	21.15	21.15
Living room 3	NA	12.81	13.15	14.98	15.60	21.81
Dining room	11.55	16.71	16.71	16.71	16.71	16.71
Combined living/kitchen	29.35	34.59	35.82	35.82	35.82	35.82
Combined living/dining	35.00	35.00	35.00	35.00	35.00	35.00
Combined dining/kitchen	26.16	26.16	26.16	26.16	26.16	26.16
Combined living room/dining room/kitchen	44.34	44.34	49.45	52.86	53.59	62.16
Bathroom 1	4.67	4.82	4.68	6.25	7.17	7.19
Bathroom 2	2.68	2.68	2.68	2.68	2.68	2.68
Bathroom/Toilet 1	5.47	5.28	6.53	7.56	7.21	9.39
Bathroom/Toilet 2	5.24	5.24	5.24	5.24	5.24	5.24
En-suite 1	4.59	4.59	4.77	5.37	6.32	8.30
En-suite 2	5.86	5.86	5.86	5.86	5.86	5.86
En-suite 3	NA	7.91	7.91	7.91	7.91	7.91
Toilet 1	1.92	1.96	2.12	2.42	3.01	2.98
Toilet 2	2.50	2.50	2.50	2.50	2.50	2.50
Toilet/Laundry	7.63	7.63	7.63	7.63	7.63	7.63
Bathroom/Toilet/Laundry	7.40	7.40	7.40	7.40	7.40	7.40
Laundry	5.69	5.69	5.69	5.69	5.69	5.69
Utility room	11.18	11.18	11.18	11.18	11.18	11.18
Storage	3.51	3.51	3.51	3.51	3.51	3.51

Table 7.18 Assumed floor area for various room types in different sized houses based on this study

The average floor area of circulation spaces is also significantly different by house size and is highly dependent on the overall floor area of the house, so a different strategy is used for these. The floor area of circulation spaces was calculated as a percentage of the overall floor area of all other rooms in each house size. An average of these percentages was then calculated for each house size (Table 7.19). Using Table 7.19, it is possible to estimate the floor area of circulation spaces in different sized houses. For instance, in a 5 room house with a master bedroom, second bedroom, combined living room/dining room/kitchen, bathroom/toilet and a laundry, based on Table 7.18, the floor area of these rooms respectively is 16.78m^2, 12.81m^2, 44.34m^2, 5.28m^2 and 5.69m^2. The subtotal floor area of all rooms in this house (excluding circulation spaces) is 84.90m^2. Using 12.99% of total floor area

for circulation spaces of 5 room houses from Table 7.19, the estimated floor area of circulation spaces in this house is 11.03m^{2,} and the total floor area is 95.93m^2.

House size (based on number of rooms)	4 room	5 room	6 room	7 room	8 room	9-9+
Circulation spaces as a percentage of all other rooms	9.06%	12.99%	15.18%	17.98%	17.18%	17.13%

Table 7.19 Floor area of circulation spaces as a percentage of the floor area of all rooms in different sized houses

It should be noted that the average floor area estimated for individual houses using this tool might be quite different from the reality although this tool gives a statistically valid result when talking about the average for a number of similar houses.

Before the results of this study can be used in further analysis, the time-use results from the main survey are discussed in Chapter 8.

8. Time-use analysis

8.1. Introduction

Unlike most developed countries there have been no time-use microenvironment studies in New Zealand (Baker et al., 2007). The "NZ Time use Survey" (1998-99 and 2009-2010) conducted by Statistics New Zealand (2011d) for age groups 12+ and the "NZ Travel Survey" (1997-98) by the New Zealand Transport Safety Authority (1998) are the only studies providing data on how New Zealanders spend their time although both are activity-based rather than location-based. Additionally, the NZ time-use survey 2009-2010 does not cover age group 12- and also does not investigate all the rooms and spaces in a dwelling as defined locations for activities. This research addresses this by endeavouring to discover where New Zealanders spend their time at home. The big difference between this study and international time-use microenvironment studies is that the focus here is on time-use at home indoors, and particularly in the various rooms of the house.

On average 60-70% of each day is spent at home indoors in all countries. The relationship between time-use and weather was discussed in section 5.8.2 and that with day type in 5.8.3. Most international studies have found gender affects time-use at home indoors (Matz et al. (2014), Briggs et al. (2003), Schwab et al. (1990), Schweizer et al. (2007), Brasche and Bischof (2005), Hussein et al. (2012), Yang et al. (2011)), showing women spend more time at home indoors compared to men. Age can also have a significant effect on time-use at home indoors (Matz et al. (2014), Wu et al. (2011), Schwab et al. (1990), Schweizer et al. (2007), Brasche and Bischof (2005), Hussein et al. (2012), Conrad et al. (2013), Yang et al. (2011), Freeman et al. (1998)), generally indicating younger age groups and seniors spend more time at home indoors. International studies also reveal work type is one of the most important predictors of time-use at home indoors (Hussein et al. (2012), Echols et al. (1998), Leech et al. (2002), Yang et al. (2011)). However, few studies have considered the effect of house size on time-use at home indoors and outdoors. Brasche and Bischof (2005) did this for a large sample of 5530 German homes (11,918 persons) using the number of rooms as an indicator of house size and found no significant difference in time-use at home indoors and house size.

Many time-use studies are related to measuring the level of human exposure to pollutants in different microenvironments. Although house indoor environments have fewer pollutants than other microenvironments, spending significant time at home can lead to the chance of greater exposure (Broich et al. (2012); Yoon et al. (2012)). Broich et al. (2012) claim home indoor air quality is affected by outdoor pollutants migrating in and indoor pollutant sources like cooking and cleaning. Consequently, this study looked at time spent in three microenvironments: home indoors, home outdoors and out of home with a deeper analysis of how individuals in selected owner-occupied households distribute their time between different rooms which could help to distinguish groups which might be more at risk from exposure to indoor pollutants. In addition, this study set out to reveal whether people living in larger houses make more use of their house, which is important in terms of the resources bound up in large houses, and also whether New Zealanders, with their love of the outdoors (New Zealand Tourism, n.d.) use their private open spaces more than their international counterparts, which again is important in terms of resource-use. The results could also benefit studies focussing on energy efficiency simulation tools, which ideally need to know accurately whether and for how long rooms are occupied (Martinaitis et al. (2015), Motuziene and Vilutiene (2013) and Blight and Coley (2013)).

8.2. Methodology

The questionnaire has been introduced in chapter 6. The last part of the questionnaire for Study 2 (see Appendix 6.1) dealt with time spent in each space of the house. This part had two objectives:

The first was to collect data about time spent in each room of the house on the day before for each family member. A table was automatically created of all reported rooms in the house (one room per row), plus two rows for garden and deck, a row for garage but only if the respondent mentioned using the garage for something other than parking cars, and a row for time spent away from home. This table was created separately for each family member and headed with gender/age and occupant number as appropriate. Respondents were asked to drag the slider alongside each room to indicate

the time spent in that room from midnight to midnight on the previous day, as a figure between 0-24 hours. For each person, the total time spent in all rooms, garage, garden/deck and away from home had to total 24 hours (Elgethun et al., 2007). If the total time was not 24 hours, an error message appeared asking the respondent to review their answers. The questionnaire automatically only asked time-use for the reported rooms in each house and where participants had more than one room type (e.g. 2 living rooms), these were numbered Living room 1 and Living room 2.

The second objective was to collect data about how much time each car owned by the household had been parked in the previous day using the same sliding tool, although here 'garage', 'parking space', 'carport' and 'on road' were used instead of rooms. An additional row showed the time the car(s) had been away from home. Each household had an automatic table that reflected the parking options in Part 2. This table was repeated and headed Car 1, Car 2 and etc. according to the number of cars (up to 6) in each household. The subtotals of the time car had been parked and used had to total 24 hours. Analysis of this data is not included here because of the thesis word limit.

The details of the recruitment method were given in section 6.2 and of the number and nature of the respondents in section 6.4, noting that out of the 445 participating households, 214 finished the whole questionnaire with some doing the timetable only for the first or second occupants. Of the completed time-use questionnaires, 19.3% were single person households with 37.3% couples, 23.1% couples with 1 child and 20.3% couples with 2 children.

The survey was designed to be filled out by an adult family member on behalf of all family members. The results showed that 75.0% of these were female and 25.0% male. Results also showed that only 1.2% of respondents were dependent children with the remaining 98.8% being parents and other adults. Respondents were free to start the survey any day of the week and any time of the day. Respondents were encouraged to do the timetables for each family member with his/her assistance if possible although parents were responsible for their children, as in prior time-use studies (Dörre

(1996), Wu et al. (2011), Leech et al. (2002) and Conrad et al. (2013)). In fact 63.8% of the surveys were started after 4 pm when all children and some adult family members would probably be around.

Splitting the participating households into data for each family member created 1026 potential individual participants. Of these, 538 had completed timetables (52.44% success rate). Baruch and Holtom (2008) investigated survey response rate levels by analysing the results of 1607 published articles in 17 refereed academic journals. They found the average response rate for studies based on data collection from individuals was 52.7% with a standard deviation of 20.4% (Baruch & Holtom, 2008). In another study of occupant behaviour and control of the indoor environment in Danish dwellings by Andersen et al. (2009), the invitation to participate in an online survey was successfully sent to 5000 home addresses in Denmark only 19% of which successfully filled out the online survey. Acknowledging that the average completion time was 32 minutes and that the information sheet and consent form were included in the survey, meaning anyone who only went this far was registered as starting and that some were not eligible to continue, 52.44% is an acceptable response rate for this time-consuming survey.

Successful respondents (538 individuals) were 44.8% in a full-time job, 16.9% in a part-time job, 13.9% not in a paid job and 24.3% in full-time education. Analysis showed that the successful respondents were 54.6% female and 45.4% male. Table 8.1 shows a breakdown of the 538 individuals who successfully completed timetables by age group. These were compared to percentages for the same age groups from census 2013 customised data (Statistics New Zealand, 2015) for people living in owner-occupied houses. As seen in Table 8.1, samples in this study do not match the age distribution of the New Zealand owner-occupied population. The potential implication of this mismatch will be that any overall average taken from the whole sample might over represent age groups 0-4, 5-11 and 20-65 and underrepresent age groups 12-19 and 65+. To control this potential problem, in a discussion of the whole of New Zealand, results are weighted according to census 2013 age distribution. Otherwise, all other discussions are based on a particular age group.

Age group	Frequency	Percent	Percentage according to Census 2013 for owner-occupied houses
0-4	42	7.8%	6.0%
5-11	55	10.2%	8.9%
12-19	31	5.8%	10.3%
20-65	356	66.2%	58.2%
65+	54	10.0%	16.6%
Total	538	100.0%	100.0%

Table 8.1 Frequency and percentage of participants in different age groups compared to census 2013 (Statistics New Zealand, 2015) data for owner-occupied households

The majority of respondents (82.9%) started the survey on weekdays rather than at the weekend (17.1%), leading to more weekday timetables as shown in Table 8.2.

		Days questionnaires were filled out			Timetable days		
		Frequency	Percent	Percent	Frequency	Percent	Percent
Weekdays	Monday	73	13.6%	82.9%	103	19.1%	81.6%
	Tuesday	103	19.1%		87	16.2%	
	Wednesday	87	16.2%		52	9.7%	
	Thursday	52	9.7%		131	24.3%	
	Friday	131	24.3%		66	12.3%	
Weekends	Saturday	66	12.3%	17.1%	26	4.8%	18.4%
	Sunday	26	4.8%		73	13.6%	
Total		538	100.0%	100.0%	538	100.0%	100.0%

Table 8.2 Frequency and percentage of successful participants and days concerned

8.3. Results

8.3.1. Time-use at home indoors/outdoors

As discussed in section 5.9.1 (see Table 5.15) choosing one day to represent the time-use of a week leads to an average error of 12.95%, although this error refers to 14 individual time-uses while this study is based on 538 individual time-uses. This means that this error decreases when talking the average of the whole sample. In other words, results of the time-use part of this study always have a potential level of error although this depends on the number of samples considered in each average, with a low level of error when the sample is large. For instance, because the whole 538 respondents are considered in the average time-use at home indoors the level of error is low, but when discussing time-use in a play room (N=34) the level of error is relatively high. Even in the latter case the sample size is double that of Study 1 and so the error level should be less than 12.95%.

Talking about an average time-use at home indoors/outdoors is very difficult because people in different age/job/gender groups can have a very different average. However, as Yang et al. (2011) state, it is useful to compare time-use in different countries and see cultural differences. For this sample, the average time-use at home indoors/outdoors can be calculated and weighted in different

ways as discussed below and summarised in Table 8.3, where results are compared with four other developed countries and another New Zealand estimated time-use study:

- *Using the sample average:* In this method, time-use of all successful respondents is included with an equal weight in the average. Using this method, this sample spent on average 15.85 and 0.54 hours/day at home indoors and home outdoors.

- *Using the sample average for normal days:* International time-use studies do not consider whether days are normal or abnormal when discussing average times spent in different micro-environments. This study asked whether the day for which the timetable was completed was a normal day for each person. Out of 538 respondents, only 392 individuals said their reported day was a normal day for them. Using only those reporting time-use for a normal day gives on average 16.14 and 0.56 hours/day at home indoors and home outdoors. This shows a respective increase of 1.8% for time spent at home indoors and 3.7% for time spent at home outdoors compared to the sample average. It should be noted that normal and abnormal days are part of real life and averages including all normal/abnormal days are probably more realistic.

- *Weighting averages based on age groups averages:* Based on international literature, age is an important predictor of time-use at home indoors (see section 8.1). The effect of other parameters like job type can also be linked to age and so this parameter can be a reliable one for weighting averages. Because the sample in this study is not the same as the total New Zealand population, average time was weighted using the "Post stratification" weighting method (Groves et al., 2009) according to the Census 2013 population data for owner-occupied houses reported in Table 8.1. This average will be representative of New Zealanders living in owner-occupied houses. Using this method the average time spent at home indoors and outdoors becomes 15.94 and 0.55 hours/day, with an increase of 0.6% for time-use at home indoors and 1.9% for time-use at home outdoors.

- *Weighting averages based on seasons:* The summer timeframe of this study is not indicative of the whole year as international studies have found summer time-use to be less than winter and the whole year (Matz et al. (2014), Wu et al. (2011), Wu et al. (2012), Hussein et al. (2012), Leech et al. (2002), McCurdy and Graham (2003), Schweizer et al. (2007), Yoon et al. (2012), Glorieux and Minnen (2009), Conrad et al. (2013), Yang et al. (2011)). A look at two international studies shows that the ratio of time-use at home indoors to the whole year and summer is 1.042 in USA (Leech et al., 2002) and 1.037 in Canada (Matz et al., 2014) although none of those studies give a clear home outdoors time-use difference for summer and winter. Considering the average of these two figures and accepting 15.94 hours/day for summer time-use in New Zealand owner-occupied houses, the whole year average for New Zealand owner-occupied houses is estimated to be 16.53 hours/day. In addition, Brasche and Bischof (2005) state there is no noticeable difference between owner-occupied and rental house time-use.

	Time at home indoors		**Time at home outdoors**	
	Whole year	Summer	Whole year	Summer
Average for all samples of this study (without weighting)	NA	15.85	NA	0.54
Average for all samples of this study reported a normal day (without weighting)	NA	16.14	NA	0.56
Average for New Zealanders living in owner-occupied houses-summer only	NA	15.94	NA	0.55
Estimated average for New Zealand based on results of this study	16.53	NA	NA	NA
Estimated average for New Zealand (Baker et al., 2007)	16.73	NA	0.58	NA
USA (Leech et al., 2002)	15.60	14.97	0.60	NA
Canada (Matz et al. (2014) and Leech et al. (2002))	16.78	16.18	0.34	NA
Germany (Brasche & Bischof, 2005)	15.70	NA	NA	NA
UK (Briggs et al., 2003)	16.20	NA	NA	NA

Table 8.3 Time spent at home indoors/outdoors for New Zealand compared to other developed countries

Based on this New Zealanders are estimated yearly to spend on average 68.9% of day time at home indoors which is near to the estimated time of 69.7% by Baker et al. (2007) using other data sources in New Zealand. Time-use at home indoors in New Zealand is more than in other developed countries (65.0% in the USA, 69% in Canada, 65.4% in Germany, 67.5% in the UK and 59.3%-67.3% for weekdays-weekends in Korea). Although differences with western countries are not big the difference with Korea as an example of a non-western culture is greater. In the case of Korea, weekend time-use is more

similar to that of western countries and big differences are mostly rooted in weekday time-use, which might be related to different working hours.

8.3.2. Time-use at home indoors/outdoors and influential parameters

Prior time-use studies have proved that time-use at home indoors differs according to age, gender, job, and day type. Table 8.4 presents the average time at home indoors/outdoors for these parameters from this study, followed by a discussion of each.

		N	Time-use at home outdoors			Time-use at home indoors	
			Mean time	N	Std. Deviation	Mean time	Std. Deviation
Gender	Female	294	0.61	278	1.20	16.17	4.04
	Male	244	0.54	226	1.05	15.47	4.64
Age	0-4	42	0.55	41	0.65	17.72	2.93
	5-11	55	0.87	52	1.47	15.97	2.33
	12-19	31	0.25	29	0.59	14.74	6.50
	20-65	356	0.49	335	1.11	15.38	4.42
	65+	54	1.09	47	1.33	17.98	3.73
Job type	Full-time work	241	0.35	228	0.92	14.36	3.87
	Part-time work	91	0.59	84	1.07	17.50	4.19
	Not in paid work	75	1.22	69	1.62	18.45	4.19
	Full-time education	131	0.63	123	1.08	15.95	4.23
Day type	Weekday	439	0.56	413	1.12	15.53	4.22
	Weekend	99	0.66	91	1.22	17.25	4.58
Family role	Living as a single person	43	0.74	36	1.46	15.53	4.45
	Living as a couple	162	0.60	150	1.19	15.71	4.62
	Living as a parent	197	0.50	189	1.07	16.06	4.08
	Living as a child	136	0.61	129	1.08	15.81	4.33
House size (based on number of rooms)	4 rooms	16	0.51	13	1.80	15.04	3.43
	5 rooms	52	0.85	44	1.71	15.83	4.87
	6 rooms	138	0.56	129	1.08	16.16	3.92
	7 rooms	132	0.54	127	0.94	16.04	4.23
	8 rooms	82	0.58	80	1.36	15.78	3.94
	9+ rooms	110	0.50	103	0.81	15.31	4.94

Table 8.4 Mean and Standard deviation of time spent at home indoors and outdoors for influential parameters

As seen in Table 8.4, Standard Deviations are very high (majority in the range of 4-5 hours), which is similar to many time-use studies (Yang et al., 2011) because one person may be at home and another may be out all day. To clarify this, a distribution graph was drawn to show how time-use at home indoors/outdoors is distributed from 0-24 hours by the sample in this study (Figure 8.1). Analysis shows that time-uses of 0 and 24 hours at home indoors respectively are only 2.0% and 2.6% of the total sample. In addition, time-uses of less than 10 hours/day and more than 20 hours/day at home indoors are respectively 5.8% and 16.4% of the total sample, meaning that the time-use of 77.8% of the sample fits in the 10-20 hours/day range. Analysis also shows that 57.3% of the sample with some

open space (garden/deck) never used home-outdoors on the survey day. In fact, only 16.1% of the sample spent more than 1 hour/day at home-outdoors, so the majority of people who used home-outdoors (62.3%), used it for less than 1 hour/day.

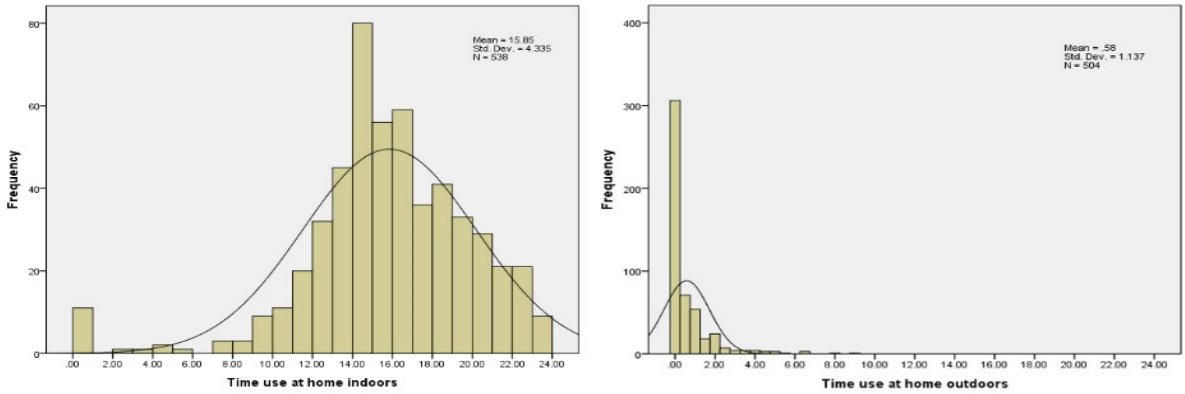


Figure 8.1 Time-use distribution at home indoors and home outdoors by frequency in sample

8.3.2.1. Gender

As mentioned in section 8.1, most international studies have found gender affects time-use at home indoors. This study is in line with these showing females on average spend 42 minutes/day more at home indoors and 5 minutes/day more at home outdoors (Table 8.4). CHAPS 2 (Matz et al., 2014) in Canada also showed females on average spend 44 minutes more at home indoors compared to males. To see if this difference is statistically important an independent sample *t* test was performed. The results show that time spent at home indoors is statistically significant by gender at 0.1 level ($t_{(536)}$=1.86, p=0.06) although time spent at home outdoors is not significantly different by gender ($t_{(502)}$=0.70, p=0.49).

8.3.2.2. Age

As mentioned in section 8.1, international studies show that age can also have a significant effect on time-use at home indoors. This study also aligns with international studies by showing that very young children and seniors spend more time at home indoors compared to other age groups. According to Table 8.4 children aged 0-4 years old and seniors aged 65+ respectively spend 1.78 and 2.04 hours/day more at home indoors in comparison to the New Zealand summer average (15.94 hours/day). Time-use by age was also compared with the CHAPS 2 (Matz et al., 2014) results for Canada. Figure 8.2

shows the New Zealand trend is almost the same as Canada with respective 5.0% and 10.6% differences for age groups 5-11 and 12-19. For all other age groups time-use at home indoors in Canada is 1-3% more than New Zealand, which could be because of the colder weather over the whole year in Canada. Conrad et al. (2013) believe time-activity patterns of children are highly dependent on the type of educational system. A search showed that school hours in Canada and New Zealand are very similar. Considering New Zealand school (New Zealand Ministry of Education, 2015) and university (New Zealand Vice-Chancellors' Committee website, 2015) timetables, this study does not include school holidays for non-university students and only covers 20 days of holidays and 1 mid-trimester break for university students. Covering the whole year, CHAPS 2 averages include more holidays, which could also lead to more time at home indoors.

To see if differences in time-use at home indoors are statistically significant by age group an ANOVA one-way test was performed in SPSS and showed a significant difference by age group at 0.05 level ($F_{(4,533)}$=7.08, p=0.00). To look at significance between age groups a post-hoc multiple comparisons using Tukey's HSD test was performed. As expected, the results show that time spent indoors by age group 0-4 is significantly more than age groups 12-19 (M=2.99, SD=1.00) and 20-65 (M=2.34, SD=0.69). In addition time spent at home indoors by age group 65+ is significantly more than age groups 12-19 (M=3.24, SD=0.96) and 20-65 (M=2.60, SD=0.62) but not different from age group 0-4.

Table 8.4 also shows that different age groups spent different amounts of time at home outdoors and age group 65+ is very different. This study found seniors spent almost double the New Zealand summer average (0.55 hour/day) at home outdoors. The results of the ANOVA one-way test for time spent outdoors by age groups show a significant difference at 0.05 level ($F_{(4,499)}$=4.50, p=0.001). The results of a post-hoc multiple comparisons using Tukey's HSD test show that time spent outdoors is only significantly different for the pairs of 65+ and 12-19 (M=0.84, SD=0.26) and 65+ and 20-65 (M=0.60, SD=0.17).

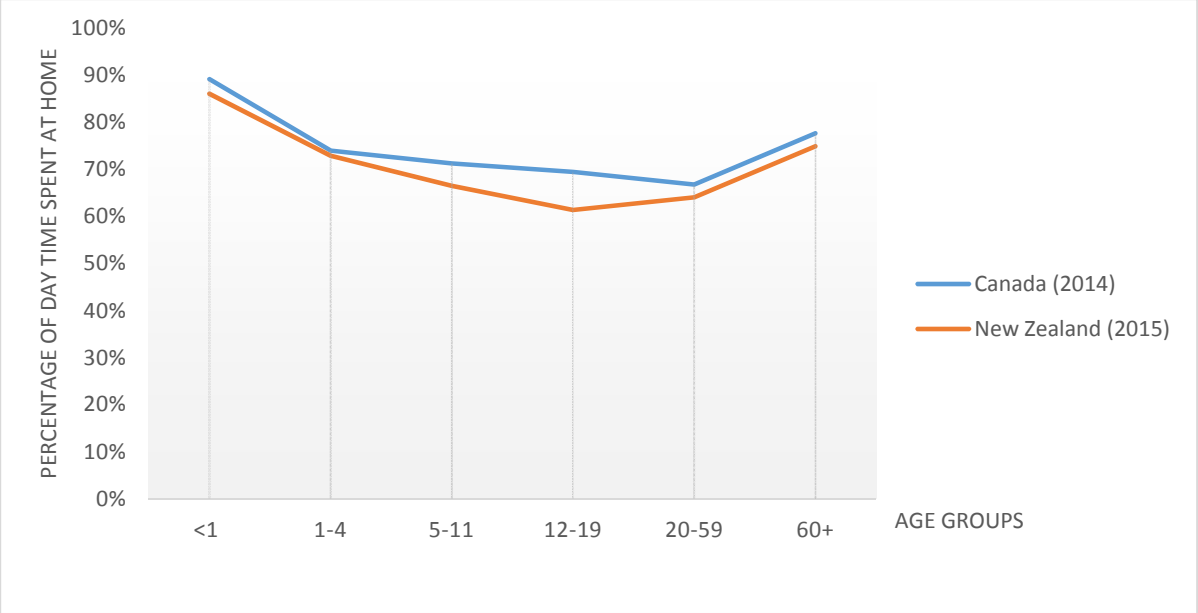


Figure 8.2 A comparison of time spent at home by different age groups in Canada-CHAPS 2 (Matz et al., 2014) and New Zealand

Note 1- Data for Canada reflects the whole year compared to summer time-use in New Zealand.
Note 2- CHAPS 2 considers age groups 20-59 and 60+ although in this study, these are 20-65 and 65+.

8.3.2.3. Work type

As mentioned in section 8.1, most international studies have proved that work type is one of the most important predictors of time-use at home. This study aligns as people with full-time work spend 1.58 hours/day less at home indoors than the New Zealand summer average (15.94 hours/day) and people with part-time work, not in paid work and in full-time education respectively spend 1.56, 2.50 and 0.01 hours/day more at home indoors in comparison to the average (see Table 8.4). An ANOVA one-way test indicates that time-use at home indoors is significantly different at 0.05 level by work type ($F_{(3,534)}$=26.13, p=0.00). A further post-hoc multiple comparisons using Tukey's HSD test shows time spent at home indoors by people in full-time work was significantly less than those in part-time work (M=-3.14, SD=0.50), not in paid work (M=-4.09, SD=0.54) and in full-time education (M=-1.59, SD=0.44). In addition, time spent at home indoors by people in full-time education was also significantly less than those in part-time work (M=-1.55, SD=0.55) and not in paid work (M=-2.50, SD=0.59). Time spent at home indoors by people in part-time work and not in paid work was not significantly different.

Time spent at home outdoors is also affected by work type. Table 8.4 shows people in full-time work spend 0.2 hours/day (12 minutes/day) less and people with part-time work, no paid work and in full-time education respectively spend 0.04 (2 minutes/day), 0.67 (40 minutes/day) and 0.08 hours/day (5 minutes/day) more time at home outdoors. This means people with no paid job, which could be very young children and seniors, spend almost double the time of the New Zealand summer average (0.55 hours/day) in the outdoor spaces of their home. ANOVA one-way test results also indicate that time spent at home outdoors is significantly different for work type at 0.05 level ($F_{(3,500)}$=11.25, p=0.00). Post-hoc multiple comparisons using Tukey's HSD test results show that time spent at home outdoors was significantly more for people not in a paid job than all other work groups (full-time work (M=0.88, SD=0.15), part-time work (M=0.63, SD=0.18) and in full-time education (M=0.59, SD=0.167)). Time-use at home outdoors was not significantly different between other work groups. This shows that time-use patterns for home-outdoors differ from patterns for home-indoors and work type is important only for people who spend more time at home (people with no paid work). Study 1 (pilot study) found weather parameters highly affected time spent at home outdoors (see section 5.8.2).

8.3.2.4. Day type

It seems that differences between weekdays and weekends are rooted in the job/study schedules of individuals and weekends are different because these are non-work/study days for most people and this has an effect on time-use at home (see section 5.8.3). This study made similar findings as the sample spent an average 1.7 hours more at home indoors at weekends compared with weekdays (Table 8.4). Results of the independent sample *t* test indicate average times spent at home indoors on weekdays are significantly less than weekends at 0.05 level ($t_{(536)}$=-3.60, p=0.00).

Despite this, Table 8.4 shows the average times spent at home outdoors on weekdays and at weekends are very similar with a difference of 0.1 hour/day (6 minutes/day). Results of the independent sample *t* test also indicate no significant difference at 0.05 level ($t_{(502)}$=-0.77, p=0.044) for average times spent at home outdoors on weekdays and at weekends. This is not in line with the

results of the prior pilot study which was performed in winter (see section 5.8.4). Although the pilot study only had 7 households and 14 individuals investigated for 14 consecutive days and the results are therefore not representative of the New Zealand population, it is possible that people use outdoor spaces differently in winter but this would need further investigation. A potential reason for very similar home outdoor time-uses between weekdays and weekends could be because the majority of open space time-use is related to the 65+ age group, the majority of whom are retired and might, therefore, spend time at home outdoors on any day of the week subject to the weather conditions.

8.3.2.5. Family role

The role each person takes in the family (family role) has not yet been considered in time studies. People might live as a single person, as one member of a couple (wife/husband or partner), a parent (mother/father or step mother/step father) or a child (children of any age who live with a parent/guardian). Depending on the relationships adults with similar ages might have one of the three family roles (single, couple, parent) although dependent children always have the same role as they always live with a parent/guardian.

To see whether the family role has an effect on time-use at home average times were produced for participants with any family role excluding children and these are presented in Table 8.4. As seen, single persons spend the least time at home indoors while couples and parents spend more time at home indoors although differences are not big. An ANOVA one-way test was performed for the whole sample (excluding samples with 'child' role) and showed that average time-uses at home indoors are not significantly different for family role ($F_{(2,399)}$=0.44, p=0.65). The test was repeated for samples fitting in age group 20-65 who could have any of the three family roles and the results showed that time-use at home indoors is significantly different by family role for this particular age group at 0.05 level ($F_{(2,343)}$=3.26, p=0.04). A post-hoc test showed that parents significantly spend more time at home indoors compared to couples (M=1.21, SD=0.50).

The patterns for time-use at home outdoors are completely the reverse as single persons spend more time outdoors than couples and parents although again differences are not big (Table 8.4). Results of the ANOVA one-way test for the whole sample and age group 20-65 also indicate average time-uses at home outdoors by family role are not significantly different (($F_{(2,372)}$=0.84, p=0.44) and ($F_{(2,323)}$=0.80, p=0.45)).

8.3.2.6. House size

Apart from Brasche and Bischof (2005) (see section 8.1) the effect of house size on time-use at home indoors and outdoors has not been investigated. As seen in Table 8.4, in this study occupants of the 4 room houses spend the minimum (15.04 hours/day) and occupants of 6 room houses the maximum time (16.16 hours/day) at home indoors. The number of rooms follows Statistics New Zealand room standard (see section 2.2).

As seen in Figure 8.3, time-use at home indoors increases with the number of rooms peaking for 6 room houses and then decreases for larger houses. An ANOVA one-way test, however, showed that time spent at home indoors was not significantly different for different sized houses at 0.05 level ($F_{(5,524)}$=0.65, p=0.66). Nevertheless, it seems that having a big house does not mean it is used more, which is important when the resources that go into larger houses are considered.

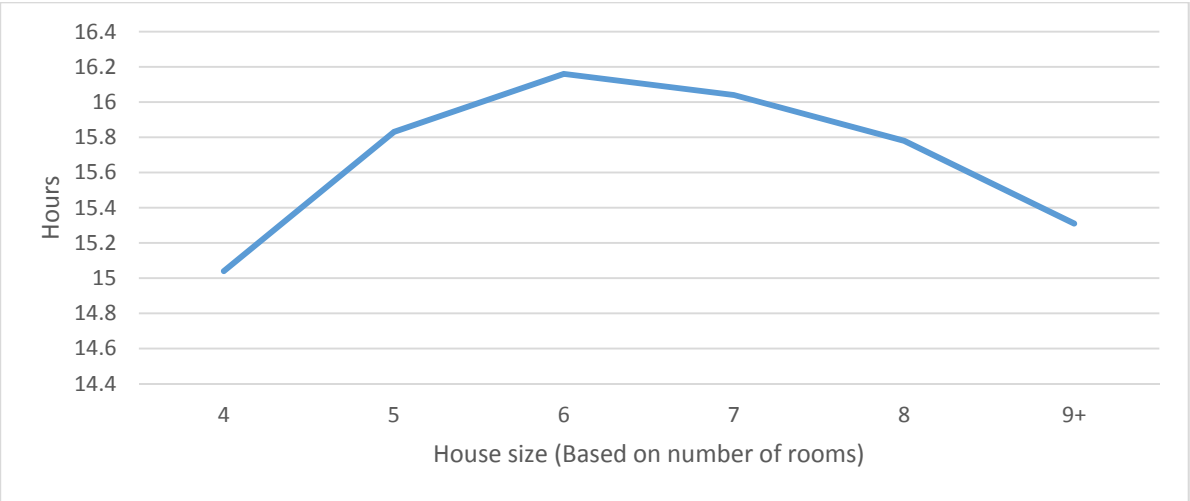


Figure 8.3 Average time spent at home indoors and number of rooms

According to Table 8.4, occupants of 9+ room houses spend the minimum time at home outdoors (0.50 hours/day) and occupants of 5 room houses the maximum (0.85 hours/day). Overall differences are very small and do not follow any pattern. The results of the ANOVA one-way test also shows no significant difference between house size and time-use at home outdoors ($F_{(5,490)}$=0.66, p=0.66).

8.3.3. Time-use in different rooms of a house

8.3.3.1. Definitions

Spaces in this study are those most commonly found in New Zealand houses. Participants were requested to select rooms from a table offering 20 popular room names in New Zealand houses (Bedroom, Living room (separate), Dining room (separate), Kitchen (separate), Combined Living room/Dining room/Kitchen, Combined Living room/Dining room, Combined Living room /Kitchen, Combined Dining room/Kitchen, Study room/Office/Library, Games room/Rumpus room/Gym, Play room, Studio/Workshop, Conservatory, Utility room/Scullery, Sleep out/Shed/Green house, Combined Bathroom/Toilet, Bathroom, Toilet, Laundry, Combined Bathroom/Toilet/Laundry). Respondents were also able to add up to 6 new names to the table. As this study is trying to find time-use in what might be considered 'extra rooms', the analysis has grouped rooms with similar functions together, as listed below. Where a respondent has named more than one room in each grouped category (i.e. a house with both a games room and gym or two games rooms) the time-use is the total of time spent in all named rooms within the category.

Usual bedrooms: Bedrooms are defined as rooms that always contain a bed, thus excluding rooms with sofa beds. Usual bedrooms are used daily by a single family member (or couple in the case of couple or family households) for sleeping. In addition, unlike crowding indices (Reynold et al., 2004), regardless of age and gender each child was allotted 1 bedroom as their usual bedroom. Based on this, for single person households, couples, couples with 1 child and couples with 2 children respectively 1, 1, 2 and 3 bedrooms were considered usual bedrooms.

Extra bedrooms: All bedrooms other than usual bedrooms (e.g. guest room).

Usual living areas: The living room, dining room and kitchen (or combination of these) used more than other similar rooms (or combinations) by a household.

Extra living areas: All living rooms, dining rooms, kitchens (or combination of these) other than usual living areas.

Study: Includes study, office, and library and any room used for reading and/or paper or computer work.

Games room: All games rooms, rumpus rooms, and gyms.

Play room: All rooms known by this name.

Studio: Includes all rooms known as studio and workshop and used for creative work such as painting, carpentry, music etc.

Usual Bathroom/Toilet: The bathroom/toilet (separate or combined) used more than other similar rooms by the household.

Extra Bathroom/Toilets: All bathroom/toilets (separate or combined) other than the usual bathroom/toilet.

Service rooms: Laundry, utility room, and scullery are included in this category. Where a laundry is combined with another room in the house (i.e. Combined Bathroom/Toilet/Laundry, Combined Bathroom/Laundry, Combined Toilet/Laundry), the first step is whether the combined room is the only available Bathroom/Toilet in the house. If yes, then the combined room will be the usual Bathroom/Toilet. If not it will be considered as a Service room for the time-use study.

Garden rooms: Sleep out, shed, greenhouse, and conservatory are included in this category. Essentially these are rooms outside the main house envelope.

Other rooms: All habitable rooms with names not in any of above categories. As there were only 6 samples with other rooms, this category was not included in the analysis.

8.3.3.2. Time-use by individuals and influential parameters

Individual time-use of each room category was analysed using SPSS. Table 8.5 presents the Mean, Median, Minimum/Maximum, Standard Deviation and number considered in the analysis. As seen, high variations in the individual time-use in some room categories appears as a high Standard Deviation compared to the Mean.

Room categories	All potential users						Real users		
	N	Mean	Median	Minimum	Maximum	Standard Deviation	N	Mean	Standard Deviation
Usual bedroom(s)	538	8.72	8.80	0.00	18.30	3.20	513	9.14	2.62
Extra bedroom(s)	384	0.61	0.00	0.00	24.00	2.28	80	2.91	4.29
Usual living areas	538	4.77	4.50	0.00	20.20	2.86	515	4.98	2.73
Extra living area(s)	143	0.99	0.00	0.00	6.10	1.53	65	2.17	1.60
Study room	252	1.10	0.00	0.00	12.00	1.89	124	2.24	2.17
Games room	60	0.36	0.00	0.00	4.30	0.91	14	1.54	1.35
Play room	34	0.46	0.00	0.00	4.10	0.94	11	1.44	1.16
Studio	53	0.50	0.00	0.00	6.20	1.19	15	1.77	1.69
Usual bathroom/toilet	502	0.53	0.50	0.00	1.50	0.39	406	0.66	0.33
Extra bathroom/toilet(s)	311	0.13	0.00	0.00	1.40	0.25	95	0.50	0.43
Service rooms	403	0.14	0.00	0.00	1.80	0.29	121	0.48	0.35
Other rooms	8	0.08	0.00	0.00	0.50	0.18	2	0.30	0.28
Garden rooms	204	0.22	0.00	0.00	5.00	0.70	39	1.15	1.22

Table 8.5 Mean, Median, Minimum/Maximum, Standard Deviation and number of cases considered in time-use of each room type

To see the reason for this, a distribution graph was drawn of time-use in each room category by frequencies for all room categories (except for garden rooms) and presented in Figure 8.4. This shows individual time-uses in all room categories are very different. The distribution graph for time-use in usual bedrooms is the only one with a symmetric form while the one for usual living areas has a semi-symmetric form. According to Figure 8.4, time-use in extra bedrooms, extra living areas, study, play room, games room, studio and extra bathroom toilets for a great proportion of samples is zero, which is a reason for high Standard Deviations and for the Median of 0.00. For some rooms, like Games room, only 20% of the sample used the space on the day of reporting and the Mean use of 0.36 hours/day reflects their collective time-use divided by the total sample (n=60). Thus the Median value of 0.00 could be viewed as more representative of the use of a Games room, as 80% of the sample with this room never used it on the day of reporting. However, in the following analysis the Mean value is used for all room categories.

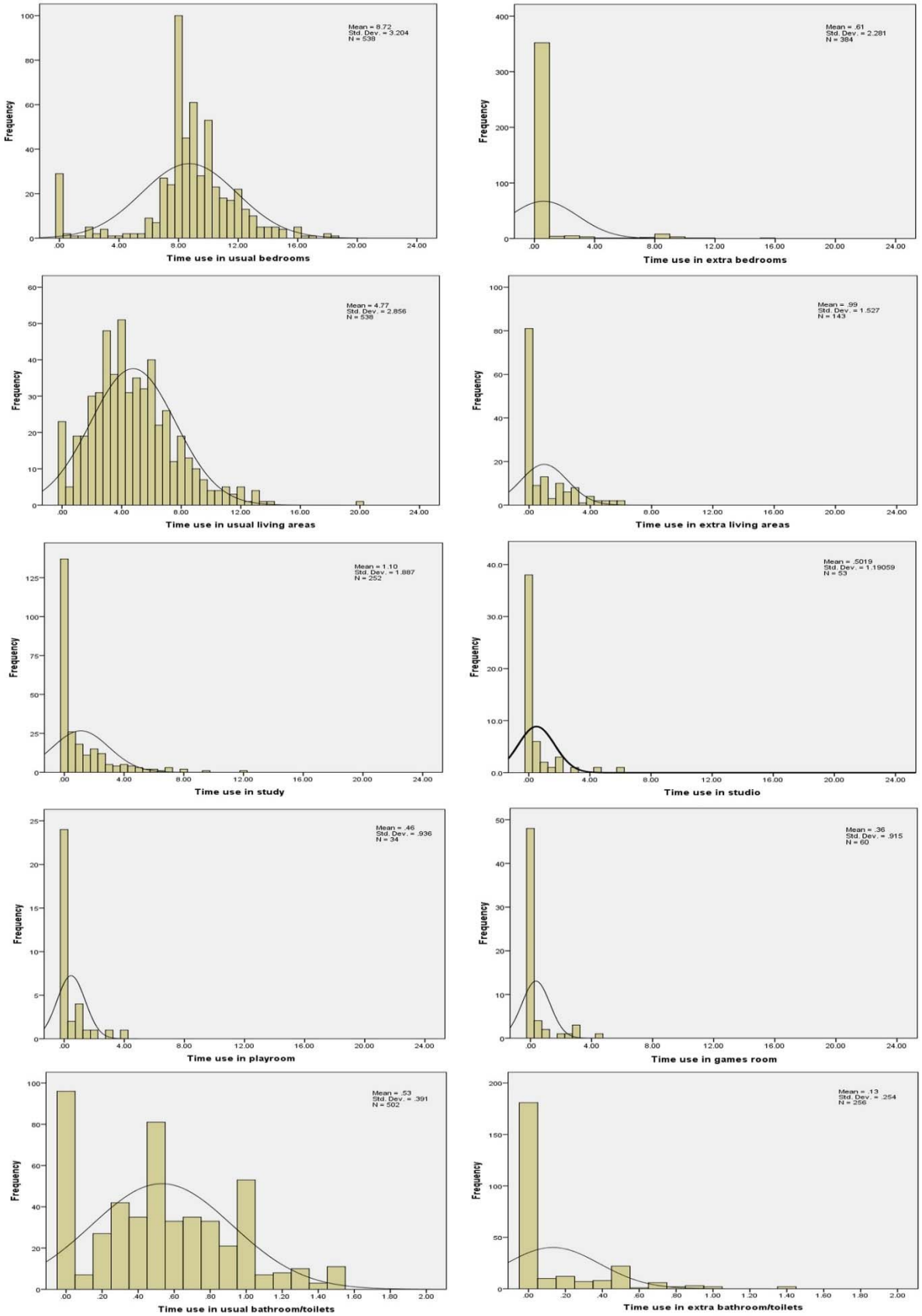


Figure 8.4 Time-use distribution in different room categories

As many participants had a zero time-use in some room categories an attempt was made to find out how long “real users” spend in each room category. “Potential users” of each room category are those who live houses with at least one of that particular room regardless of whether they do or do not spend time in that room. Real users are defined as users who live in houses with at least one of that room category and have spent more than 0 hours in that room in the previous day.

As seen in Table 8.5 the number of real users is much lower than potential users for all room categories although the difference between the two is much bigger for extra and specialized rooms. For all room categories the Mean time-use for real users is higher than for potential users. In addition, Standard Deviation for real users is lower than potential users in usual living areas, usual bedroom(s) and usual bathroom/toilet although the pattern is diverse for all other room categories (unusual/extra rooms). This also shows the nature of casual use of unusual/extra rooms. Among all specialised rooms, the study is most used, which is in line with findings by BRANZ (Page, 2007) who showed this room is an important feature for people buying new houses in New Zealand.

Though time-use by real users is more than potential ones, from the view point of this study the Mean time reflecting all sample usage is more valuable because it shows the real use of resources. So in this study, the mean for all potential users will be used as the basis for further analysis.

The first analysis showed that time-use at home indoors can be affected by age, gender, job type, day type and family role while house size had no significant effect on time-use at home indoors (section 8.3.2). How these parameters can affect time-use for each room type are investigated next. To see if time-use in each room type is significantly different by gender and day type an independent sample *t* test was performed in SPSS and the results are presented in Table 8.6.

In addition, an ANOVA one-way test was also performed to see significant differences in time-use according to age, job type, family role and house size and the results are presented in Table 8.7. Significant figures at 0.05 and 0.1 levels are respectively highlighted in yellow and blue. Where a

significant difference occurred at 0.05 level, a post-hoc multiple comparisons using Tukey's HSD test was also performed to see the details of the differences and these are presented in Table 8.8.

Room type	Gender			Day type		
	df	t	Sig. (2-tailed)	df	t	Sig. (2-tailed)
Usual bedroom(s)	536	2.19	0.03	536	-0.57	0.57
Extra bedroom(s)	382	-1.03	0.30	382	0.02	0.99
Usual living areas	536	1.44	0.15	536	-3.76	0.00
Extra living areas	141	-0.23	0.82	141	-1.21	0.23
Study	250	-1.78	0.08	250	-0.16	0.88
Games room	58	-0.75	0.46	58	1.25	0.22
Play room	Levene's test for equality of variances rejected			Levene's test for equality of variances rejected		
Studio	51	1.10	0.27	51	-0.66	0.51
Usual bathroom/Toilets	500	1.09	0.28	500	-2.70	0.01
Extra bathroom/Toilets	309	-0.83	0.44	309	-1.12	0.26
Service rooms	Levene's test for equality of variances rejected			Levene's test for equality of variances rejected		
Garden rooms	202	-0.92	0.36	202	0.60	0.55

Table 8.6 Results of an independent sample t test for time-use in different room categories by gender and day type

Room type	Age			Job type			Family role			House size		
	df	F	Sig.	df	F	Sig.	df	F	Sig.	df	F	Sig.
Usual bedroom(s)	4, 533	29.38	0.00	3, 534	18.46	0.00	3, 534	28.15	0.00	2, 535	7.38	0.00
Extra bedroom(s)	4, 379	3.49	0.01	3, 380	7.75	0.00	3, 380	2.30	0.08	2, 381	1.43	0.24
Usual living areas	4, 533	3.61	0.01	3, 534	10.43	0.00	3, 534	6.08	0.00	2, 535	12.92	0.00
Extra living areas	4, 138	0.80	0.53	3, 139	0.60	0.61	3, 139	1.04	0.38	1, 141	0.02	0.90
Study	4, 247	4.26	0.00	3, 248	4.64	0.00	3, 248	3.60	0.01	2, 249	0.05	0.95
Games room	4, 55	0.54	0.71	3, 56	1.06	0.38	3, 56	0.67	0.57	1, 58	1.82	0.18
Play room	4, 29	5.36	0.00	3, 30	1.70	0.19	2, 31	1.84	0.18	1, 32	1.02	0.32
Studio	4, 48	0.39	0.82	3, 49	1.34	0.27	3, 49	0.80	0.50	2, 50	1.08	0.35
Usual bathroom/Toilets	4, 497	5.52	0.00	3, 498	11.82	0.00	3, 498	10.14	0.00	2, 499	4.79	0.01
Extra bathroom/Toilets	4, 306	0.45	0.77	3, 307	1.09	0.35	3, 307	1.45	0.23	2, 308	2.66	0.07
Service rooms	4, 398	4.24	0.00	3, 399	11.69	0.00	3, 399	8.48	0.00	2, 400	1.22	0.30
Garden rooms	4, 199	1.45	0.22	3, 200	1.51	0.21	3, 200	3.35	0.02	2, 201	1.31	0.27

Table 8.7 Results of an ANOVA one-way test for time-use in different room categories by age, job type, family role and house size type

According to Tables 8.7 and 8.8, age, job type and family role seem to affect time-use compared to other parameters, although effects are different for each room category as discussed below.

Dependent Variable	Group 1	Group 2	Mean Difference (G1-G2)	Std. Error	Sig.
Time-use in usual bedrooms	Age group 0-4	Age group 5-11	+1.64	0.60	0.05
	Age group 0-4	Age group 12-19	+4.06	0.69	0.00
	Age group 0-4	Age group 20-65	+4.30	0.48	0.00
	Age group 0-4	Age group 65+	+4.70	0.60	0.00
	Age group 5-11	Age group 12-19	+2.43	0.65	0.00
	Age group 5-11	Age group 20-65	+2.66	0.42	0.00
	Age group 5-11	Age group 65+	+3.06	0.56	0.00
	People in full-time job	People in part-time job	-1.19	0.38	0.01
	People in full-time education	People in full-time job	+2.44	0.33	0.00
	People in full-time education	People in part-time job	+1.25	0.42	0.02
	People in full-time education	People not in paid job	+1.84	0.44	0.00
	Family role-child	Family role-single person	+3.22	0.52	0.00
	Family role-child	Family role-couple	+2.94	0.35	0.00
	Family role-child	Family role-parent	+2.15	0.33	0.00
	House size-6-8 rooms	House size-5- rooms	+1.13	0.42	0.02
	House size-6-8 rooms	House size-9+ rooms	+1.09	0.34	0.00
Time-use in extra bedrooms	Age group 65+	Age group 5-11	-1.55	0.54	0.03
	Age group 65+	Age group 20-65	-1.07	0.35	0.02
	People not in paid job	People in full-time job	+1.56	0.34	0.00
	People not in paid job	People in part-time job	+1.42	0.41	0.00
	People not in paid job	People in full-time education	+1.64	0.39	0.00
	Family role-child	Family role-couple	-0.82	0.32	0.05
Time-use in usual living areas	Age group 12-19	Age group 65+	-1.94	0.64	0.02
	People in full-time job	People in part-time job	-1.29	0.34	0.00
	People in full-time job	People not in paid job	-1.44	0.37	0.00
	People in full-time education	People in part-time job	-1.52	0.38	0.00
	People in full-time education	People not in paid job	-1.66	0.40	0.00
	Family role-child	Family role-single person	-1.68	0.49	0.00
	Family role-child	Family role-couple	-0.91	0.33	0.03
	Family role-child	Family role-parent	-1.14	0.31	0.00
	House size-6-8 rooms	House size-5- rooms	-1.37	0.37	0.00
	House size-6-8 rooms	House size-9+ rooms	+0.79	0.30	0.02
	House size-5- rooms	House size-9+ rooms	+2.16	0.43	0.00
Time-use in study	Age group 65+	Age group 0-4	+1.82	0.58	0.02
	Age group 65+	Age group 5-11	+1.83	0.53	0.01
	People in full-time education	People not in paid job	-1.41	0.38	0.00
	Family role-child	Family role-couple	-0.89	0.31	0.02
	Family role-child	Family role-parent	-0.87	0.32	0.04
Time-use in play room	Age group 0-4	Age group 5-11	+1.99	0.55	0.01
	Age group 0-4	Age group 12-19	+2.37	0.69	.015
	Age group 0-4	Age group 20-65	+2.06	0.47	.001
	Age group 0-4	Age group 65+	+2.37	0.69	0.02
Time-use in usual bathroom/toilets	Age group 0-4	Age group 20-65	-0.20	0.06	0.01
	Age group 0-4	Age group 65+	-0.26	0.08	0.01
	People in full-time education	People in full-time job	-0.19	0.04	0.00
	People in full-time education	People in part-time job	-0.30	0.05	0.00
	People in full-time education	People not in paid job	-0.17	0.06	0.02
	Family role-child	Family role-single person	-0.24	0.07	0.00
	Family role-child	Family role-couple	-0.23	0.05	0.00
	Family role-child	Family role-parent	-0.18	0.04	0.00
	House size-5- rooms	House size-9+ rooms	+0.19	0.06	0.01
Time-use in service rooms	Age group 0-4	Age group 65+	-0.20	0.07	0.02
	People not in paid job	People in full-time job	+0.22	0.04	0.00
	People in full-time education	People in part-time job	-0.13	0.04	0.02
	People in full-time education	People not in paid job	-0.25	0.05	0.00
	Family role-child	Family role-single person	-0.21	0.06	0.00
	Family role-child	Family role-parent	-0.17	0.04	0.00
Time-use in garden rooms	Family role-child	Family role-couple	-0.38	0.13	0.02

Table 8.8 Results of post-hoc multiple comparisons using Tukey's HSD test showing details of significant differences according to age, job type, family role and house size for time-use of room types of a house which were significant in Table 8.7

8.3.3.2.1. Time-use in usual bedrooms

According to Table 8.5, samples in this study on average spent 8.72 hours/day in usual bedroom(s). Given the summer time-use of 15.94 hours/day for New Zealanders, 54.7% of the time people spend at home indoors in summer is in the usual bedroom. To check the validity of the result, this was compared to the Time-use survey 2009-2010 (Statistics New Zealand, 2011) which shows New Zealanders aged 12+ daily sleep 8:48 (8.8 hours) on average. To make a valid comparison, time-use in usual bedrooms was calculated separately for age group 12+ for individuals whose time-use in usual bedrooms was more than zero. This results in an average 8.59 hours/day (8:35) spent in usual bedrooms. Acknowledging that sleeping could happen elsewhere at home (i.e. on a couch in the living room) and this study is a summer rather than a whole year average the results are comparable.

Tables 8.6 and 8.7 show time-use in usual bedrooms is significantly different by gender, age, job type, family role and house size but not by day type. Females on average spend 36 minutes more than males in usual bedrooms. Children in age groups 0-4 and 5-11 spend significantly more time in usual bedrooms compared to other age groups and this difference ranges from 1.6-4.7 hours/day (see Table 8.8). People in full-time jobs also spend significantly less time in usual bedrooms compared to those in part-time jobs. People in full-time education (again probably children) also spend more time in usual bedrooms than all other job type groups. Family roles also follow the same pattern as those in a child role spend 2.2-3.2 hours/day more in usual bedrooms than those in other family roles (see Table 8.8). House size is also important for time-use in usual bedrooms as people living in medium-size houses (6-8 rooms) spend significantly more time in usual bedrooms than those in small (5- rooms) and large houses (9+ rooms) (Table 8.8). These results imply young children spend much more time in sleeping bedrooms than other family members and living in optimum-size houses could have positive effects on time-use in usual bedrooms. This finding could be important for architects (in designing appropriate bedrooms) and psychologists (see section 2.5).

8.3.3.2.2. Time-use in extra bedrooms

On the survey day 79.2% of respondents with at least 1 extra bedroom never used this room(s) (see Figure 8.4). So the average time of 0.61 hours/day does not reflect the real time-use for the majority of the sample for whom the Median (0.00 hours/day) is more realistic (Table 8.5). Results of the ANOVA one-way and the independent sample *t* test show that time-use in extra bedrooms is not affected by gender, day type and house size but is affected by age, job type and family role. Time-use of extra bedrooms for age group 65+ is significantly less than age groups 5-11 and 20-65. People not in paid work spent significantly more time in extra bedrooms than all other job groups. In addition people in a "couple" role spent more time in extra bedrooms than those in a child role. This suggests users of extra bedrooms are mainly adults not in paid work, who are more likely to be at home in the day.

House size (based on number of rooms), interestingly does not have a significant effect on time-use in extra bedrooms, meaning that living in large houses does not necessarily mean the occupants spend more time in extra bedrooms. The average time-use in extra bedrooms was also compared to the number of extra bedrooms using the ANOVA one-way test, showing that time-use in extra bedrooms is significantly different by number of extra bedrooms ($F_{(3,380)}=3.70$, $p=0.01$) although the post-hoc test showed this is only significantly different between houses with 1 and 2 extra bedrooms at 0.1 level. The mean times spent in extra bedrooms for houses with 1, 2, 3 and 4 extra bedrooms were respectively 0.31, 0.94, 1.35 and 1.82 hours/day. Though averages show an increase in time-use with an increasing number of extra bedrooms this was not statistically proved.

8.3.3.2.3. Time-use in usual living areas

According to Table 8.5, samples in this study on average spent 4.77 hours/day in usual living areas, or 29.9% of the time that people spend at home indoors in summer (15.94 hours/day). This shows that after usual bedrooms, usual living areas are the most important rooms regarding time-use at home indoors.

Statistical analysis shows time-use in usual living areas is significantly different by all parameters apart from gender. Analysis shows that usual living area(s) with usual bathroom/toilets are the two room categories in which people spend more time at weekends than on weekdays (see Table 8.6). Section 8.3.2.4 showed that time-use at home indoors at weekends was significantly higher than on weekdays. Considering the small amount of time spent in usual bathroom/toilets, the differences in the overall time-use at home indoors comes from more time-use in usual living areas at weekends.

Additionally seniors (65+) spend significantly more time in usual living areas than adolescents (12-19). People in full-time jobs and full-time education also spend significantly less time in usual living areas than those in part-time jobs and not in paid work. People with a "child" family role also spend significantly less time in usual living areas than other family roles. House size seems to affect time-use in usual living areas as time-use in usual living areas decreases with house size. Analysis shows that people living in large houses (9+ rooms) spend less time in usual living areas than those living in small (5< rooms) and medium (6-8 rooms) houses. People living in small houses also spend more time in living areas than those in medium size houses. This shows that house size can impact on time-use in usual living areas and those living in smaller houses tend to spend more time in these parts of the house.

8.3.3.2.4. Time-use in extra living areas

Analysis shows that 54.5% of respondents with at least 1 extra living area never used this room(s) on the survey day, meaning the average time of 0.99 hours/day does not reflect the real time-use for the majority of the sample for whom the Median (0.00 hours/day) seems more realistic (Table 8.5). Unlike usual living areas, time-use in extra living areas is not significantly dependent on any of the parameters in this study, showing the casual use of this room category.

8.3.3.2.5. Time-use in study

On the survey day this room category was never used by 50.8% of respondents who reported having it. Again the average time of 1.10 hours/day is not a true reflection of use and the Median (0.00 hours/day) is more realistic (Table 8.5).

Statistical analysis shows time-use of a study is significantly affected by gender, age, job type and family role but not by day type and house size (see Tables 8.6 and 8.7). On average, males spend 25 minutes/day more in study than females, and time-use of this room is similar for weekdays and weekends. Occupants 65+ spend more time than other age groups in a study although the results of the post-hoc test proves this time-use difference is only significant in comparison with age groups 0-4 and 5-11 (Table 8.8). People in full-time education also spend significantly less time in a study compared to those not in a paid job. Family role can significantly affect time-use in a study as people in a "child" role spend less time there than those in a "couple" or "parent" role but not those in a "single person" role (Table 8.8).

This suggests that a study is used by adults (mainly seniors 65+) and especially in larger families where more noise might be expected. However, providing a study/office/library in a single person household might be unnecessary.

8.3.3.2.6. Time-use in games room

According to Table 8.5, samples in this study spent on average 0.36 hour/day in a games room, although further analysis shows that 76.7% of respondents with at least 1 of this room category never used it on the survey day. Results of the ANOVA one-way and independent sample *t* test also proves that time-use in this room category is not significantly dependent to any of the parameters considered in this study (Table 8.6 and 8.7). This can indicate that this room has a casual use.

8.3.3.2.7. Time-use in play room

According to Table 8.5, those with a play room spent on average 0.46 hour/day in it, although further analysis show that 67.6% of respondents with at least 1 play room never used it on the survey day. An independent sample *t* test could not be performed for time-use in this room by gender and day type because the Levene's test for equality of variances was rejected. An ANOVA one-way test was performed and showed that time-use in play rooms is significantly different by age but not by job type, family role and house size. Results of the post-hoc test showed that children in age group 0-4

significantly spend 1.99-2.37 hours/day more time in a play room than all other age groups. Further analysis show that parents usually supervise their children while using this room type.

8.3.3.2.8. Time-use in studio

According to Table 8.5, the sample in this study spent on average 0.50 hour/day in a studio, but with 71.7% of respondents who had at least 1 studio never using it on the surveyed day. Results of the ANOVA one-way and independent sample *t* test also prove time-use in this room is not significantly dependent to any of the influential parameters (Tables 8.6 and 8.7). This can be indicative of this room having a casual use, and perhaps use by only one family member.

8.3.3.2.9. Time-use in usual bathroom/toilet(s)

Study 1 showed that some people spent unusual amounts of time in bathroom/toilets for cleaning or repair jobs. As these unusual time-uses could affect the overall average and analysis, analysis of this part was limited to samples with time-uses less than or equal to 1.5 hours/day. Based on Table 8.5, in this study on average people spend 0.53 hour/day in usual bathroom/toilets.

Results of the independent sample *t* test show that time-use in usual bathroom/toilets is significantly different by day type but not by gender (Table 8.6). On average usual bathroom /toilets were used for 7 minutes more at weekends. Results of the ANOVA one-way test also prove that time-use in usual bathroom/toilets is significantly different by age, job type, family role and house size (Table 8.7). According to the results of the post-hoc test presented in Table 8.8, age group 0-4 spend significantly less time in usual bathroom/toilets compared to age groups 20-65 and 65+. People who were in full-time education on average spent 10-18 minutes/day in usual bathroom/toilets compared to those in other job types (see Table 8.8). This could be related to the amount of time out of home for this particular age group. People in a “child” role also spend 11-14 minutes/day less in usual bathroom/toilets than all other family roles. In addition, people living in large houses (9+ rooms) spend significantly less time in usual bathroom/toilets than those in small houses (5> rooms) (see Table 8.8), which could be an indicator of having less time at home indoors in large houses or of using more than

one available bathroom. Based on these results it seems students and young children spend less time in usual bathroom/toilets than other household members.

8.3.3.2.10. Time-use in extra bathroom/toilet

According to Table 8.5, those in houses with more than one set of bathroom/toilets on average spent 0.13 hour/day in the extra bathroom/toilet(s). Further analysis show that 80.4% of these individual respondents never used this room(s) on the survey day. Results of the independent sample *t* test and the ANOVA one-way test also show that apart from house size other parameters do not significantly affect time-use in extra bathroom/toilets (Tables 8.6 and 8.7) although the post-hoc test rejected any significant effect of house size on time-use in extra bathroom/toilets. These can be indicators of the fact these extra bathroom/toilets have a casual use.

On the other hand, it should be noted that bathroom/toilets are types of room that do not necessarily have individual users but could be used by all family members. To clarify this, an average time-use was calculated for each household for usual and extra bathroom/toilets. This analysis showed that each household on average spend 1.23 hours/day in usual bathroom/toilets and 0.35 hour/day in extra bathroom/toilets. Additionally, it showed 48.5% of households with at least 1 extra bathroom/toilet have never used it on the survey day.

8.3.3.2.11. Time-use in service rooms

According to Table 8.5 the sample in this study on average spent 0.14 hour/day in service rooms. Further analysis showed 70.0% of respondents with at least 1 room of this category never used it on the survey day.

An independent sample *t* test could not be performed for gender and day type because the Levene's test for equality of variances was rejected. An ANOVA one-way test showed that time-use of service rooms is significantly different according to age, job type and family role but not by house size (Table 8.7). According to the post-hoc test (Table 8.8), children in age group 0-4 spend significantly less time in service rooms than seniors (65+). People who were not in a paid job spent significantly more time

than those in a full-time job and people in full-time education spent significantly less time than those in part-time and not in paid jobs. In addition, samples who were in a “child” role also spent significantly less time in service rooms than those in a “single person” or “parent” roles.

As service rooms could be used by all family members, the average time-use in this room type was calculated separately for each household. This showed that households on average spend 0.35 hour/day in the service rooms. Further analysis show that 42.9% of households with at least 1 service room never used it on the survey day. This is in line with the results of study 1 showing that laundries are only used on some days of a week, depending on the family schedule.

8.3.3.2.12. Time-use in garden rooms

The sample in this study spent on average 0.22 hours/day in garden rooms, although 80.9% of the sample with at least 1 room in this category never used it on the survey day. Results of the independent sample *t* test and the ANOVA one-way test indicate that apart from family role, other parameters have no effect on time-use in this room category (see Tables 8.6 and 8.7). The results of the post-hoc test indicate that people who are in a “child” family role spend significantly less time in garden rooms than those in a “couple” role (Table 8.8).

8.4. Implications

8.4.1. Effects of large housing on occupant behaviour

The question arises as to whether the presence or absence of extra bedrooms, extra living areas and new room types (study room, play room, games room and studio) affects the time-use in the main rooms of the house, as the majority of daily time at home indoors is spent in two room categories: usual bedrooms and usual living areas. An independent sample *t* test was performed to investigate this and the results are presented in Tables 8.9, 8.10 and 8.11.

Table 8.9 shows the presence of extra rooms in general does not significantly affect time-use at home indoors ($p=0.126 > 0.05$). It also shows that time-use at home indoors is not significantly different when people live in houses with extra bedrooms, extra living areas ($p=0.227 > 0.05$), study ($p=0.299 >$

0.05), games room (p=0.998 > 0.05) and play room but is significantly different for people who live in houses with a studio (p=0.035 < 0.05) who spend more time at home indoors. This means that living in larger houses with additional rooms does not necessarily lead to more time-use at home indoors, unless the extra room is a studio.

Extra room(s) type	df	t	Sig. (2-tailed)	Time-use at home indoors with extra rooms	Time-use at home indoors without extra rooms
Extra room(s)	536	1.53	0.126	15.73	16.54
Extra bedroom(s)	Equal variances assumption rejected			15.63	16.40
Extra living areas	536	1.21	0.227	15.47	15.99
Study	536	1.04	0.299	15.64	16.03
Games room	536	-0.00	0.998	15.85	15.85
Play room	Equal variances assumption rejected			15.94	15.84
Studio	536	-2.12	0.035	17.04	15.72

Table 8.9 Results of an independent sample t test to see the effect of presence/absence of extra rooms on time-use at home indoors

Table 8.10 reveals the presence/absence of extra rooms in general significantly affects time-use in usual bedrooms (p=0.011 < 0.05) and people living in houses with extra rooms on average spend 1 hour less in these. It also shows that time-use in usual bedrooms is significantly lower when people live in houses with extra bedrooms (p=0.00 < 0.05), extra living areas (p=0.097 < 0.1), study (p=0.00 < 0.05) and games room (p=0.094 < 0.1). This suggests that people who live in small houses may do activities in their usual bedrooms that could be undertaken in these extra rooms if they lived in large houses.

Extra room(s) type	t (536)	Sig.	Time-use in usual bedrooms with extra rooms	Time-use in usual bedrooms without extra rooms
Extra room(s)	2.55	0.011	8.57	9.56
Extra bedroom(s)	4.10	0.000	8.37	9.58
Extra living areas	1.67	0.097	8.34	8.86
Study	3.90	0.000	8.15	9.22
Games room	1.68	0.094	8.06	8.80
Play room	1.26	0.208	8.06	8.76
Studio	0.03	0.974	8.70	8.72

Table 8.10 Results of an independent sample t test to see the effect of presence/absence of extra rooms on time-use in usual bedrooms

Table 8.11 shows having extra rooms significantly affects time-use in usual living areas (p=0.005 < 0.05) as people who have these on average spend 1 hour less in them. Time-use in usual living areas is significantly lower when people live in houses with extra bedrooms (p=0.009 < 0.05), extra living

areas (p=0.000 < 0.05), study (p=0.009 < 0.05) and play room (p=0.094 < 0.1), again showing that usual living rooms will be used for activities where specialized rooms are not available.

Extra room(s) type	t (536)	Sig.	Time-use in usual bedrooms with extra rooms	Time-use in usual bedrooms without extra rooms
Extra room(s)	2.79	0.005	4.63	5.59
Extra bedroom(s)	2.64	0.009	4.56	5.28
Extra living areas	3.59	0.000	4.04	5.03
Study	2.63	0.009	4.43	5.07
Games room	1.47	0.143	4.26	4.83
Play room	1.68	0.094	3.99	4.82
Studio	-0.32	0.753	4.89	4.76

Table 8.11 Results of an independent sample t test to see the effect of presence/absence of extra rooms on time-use in usual living areas

Tables 8.9, 8.10 and 8.11 reveal that living in larger houses with additional rooms does not lead to more time-use at home indoors although having extra rooms has significant effects on time-use in usual bedrooms and usual living areas. Unlike other extra room categories, having a studio does not affect time-use in usual bedrooms and usual living areas but significantly affects time-use at home indoors.

To clarify this, the subtotal of time spent in usual bedrooms, usual living areas and usual bathroom/toilets (now called the core house) was calculated as a percentage of time-use at home indoors for all participants who spent more than 0 hours at home indoors. This shows that time-use of the core house is significantly different by number of extra rooms ($F_{(3,523)}$=22.21, p=0.00). Figure 8.5 as expected shows participants who live in houses with no extra rooms spent 100% of the home indoors time-use in the core house, while people living in houses with 1-2, 3-4 and 5-5+ extra rooms respectively spend 96%, 90% and 84% of time at home indoors in the core house. The post-hoc test also proves that apart from pairs of 0 and 1-2, these percentages are significantly different for all pairs. This suggests that large housing affects occupant behaviour by spreading activities around the extra rooms, most of which are used only for a small part of the day. However, whatever the house size people spend 84-100% of the time they are at home indoors in the core house, which is important

when considering resource-use. This means that regardless of house size people live in a 'small house' within large houses.

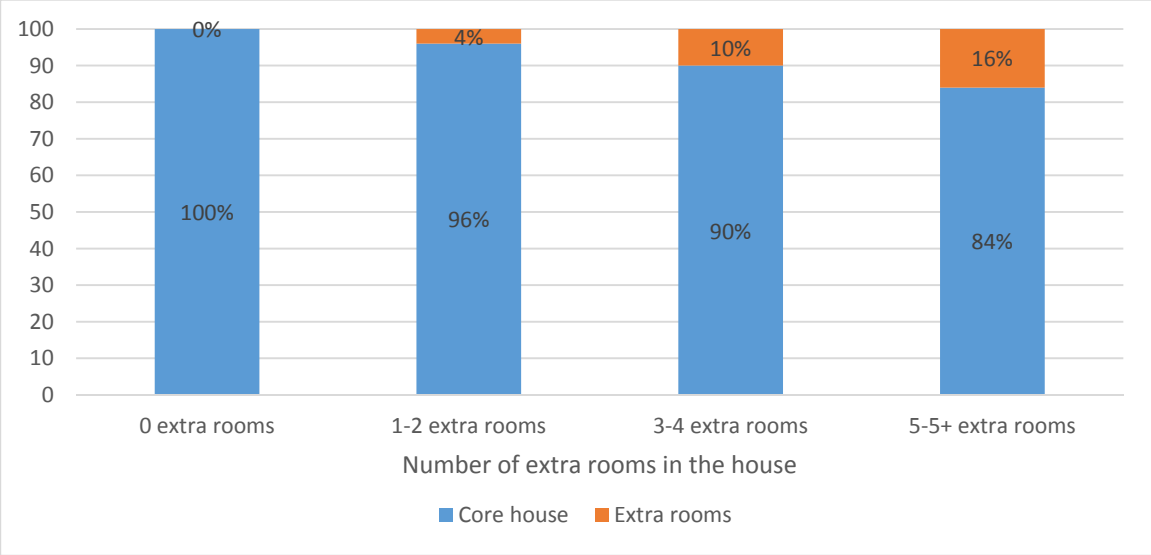


Figure 8.5 Time spent in the core part of the house and extra rooms as a percentage of time spent at home indoors for different sized houses

8.4.2. How "time-use at home indoors" can predict time-use in rooms of a house

As seen in the previous part, time-use in most room types is affected by the same parameters which influence time-use at home indoors. It seems the non-significant results for some spaces could result from the small sample, as for other spaces with a high number of participants this was proven. Overall, it seems that as time-use at home indoors increases/decreases, time-use in room types will also increase/decrease, although it is not clear if this is true for all room types. The extent to which time indoors can predict time in each room is investigated using a simple Linear Regression test in SPSS for each separate room category. Table 8.12 presents the results for all room categories, where the R value shows the degree of correlation, the R^2 value how much of the total variation in the dependent variable can be explained by the independent variable, p-value indicates the statistical significance of the regression model (should be less than 0.05) and df shows the number of participants in the test.

As seen in Table 8.12, apart from games room, play room, studio/workshop and other rooms, time-use at home indoors can significantly predict the time-use in all other rooms ($p < 0.05$) although the p-value of coefficients is not significant at 0.05 level for extra living areas and laundry/other service

areas. In addition, R^2 value shows that 37.0% of time in usual living areas and 23.0% of time in usual bedrooms can be explained by time spent at home indoors. These two room categories are the most used rooms in the house.

This test also provides an equation to predict time-use in each room category according to the time-use at home indoors by each occupant as presented in the last column of Table 8.12. As this equation has been created using the average time-use at home indoors, the predicted time also represents an average use, which might be wrong for some age/work groups and day types. To reach an accurate prediction for any particular rooms enough participants are required, and this forms an area for further research.

	df	F	R	R^2	p-value (model)	p-value (coefficient)	Time-use prediction equation
Usual bedrooms	1, 536	163.70	0.48	0.23	0.000	0.000	$T_{\text{Usual bedrooms}} = 3.05+0.36\times T_{\text{Home indoors}}$
Extra bedrooms	1, 382	18.78	0.22	0.05	0.000	0.008	$T_{\text{Extra bedrooms}} = -1.08+0.11\times T_{\text{Home indoors}}$
Usual living areas	1, 536	310.84	0.61	0.37	0.000	0.000	$T_{\text{Usual living areas}} = -1.56+0.40\times T_{\text{Home indoors}}$
Extra living areas	1, 141	9.41	0.25	0.06	0.003	0.469	$T_{\text{Extra living areas}} = -0.32+0.09\times T_{\text{Home indoors}}$
Study	1, 250	20.32	0.27	0.08	0.000	0.000	$T_{\text{Study}} = -0.68+0.11\times T_{\text{Home indoors}}$
Game room	1,58	1.32	0.15	0.02	0.256	0.256	$T_{\text{Games room}} = -0.06+0.03\times T_{\text{Home indoors}}$
Play room	1, 32	3.72	0.32	0.10	0.063	0.063	$T_{\text{Play room}} = -0.72+0.08\times T_{\text{Home indoors}}$
Studio	1, 51	0.42	0.09	0.01	0.519	0.837	$T_{\text{Studio}} = 0.13+0.02\times T_{\text{Home indoors}}$
Usual bathroom/Toilets	1, 500	31.21	0.24	0.06	0.000	0.004	$T_{\text{Usual bathroom/Toilets}} = 0.19+0.02\times T_{\text{Home indoors}}$
Extra bathroom/Toilets	1, 312	5.84	0.14	0.02	0.016	0.989	$T_{\text{Extra bathroom/Toilets}} = -0.001+0.01\times T_{\text{Home indoors}}$
Service rooms	1, 401	15.14	0.19	0.04	0.000	0.270	$T_{\text{Service rooms}} = -0.06+0.01\times T_{\text{Home indoors}}$
Garden rooms	1, 202	13.78	0.25	0.06	0.000	0.024	$T_{\text{Garden rooms}} = -0.39+0.04\times T_{\text{Home indoors}}$

Table 8.12 Results of the Linear Regression test to see if time spent in room categories of a house can be predicted by time spent at home indoors

8.4.3. The effect of internal plan layout on time-use

There are seven rooms (combined or separate) which can form usual living areas in this study. These rooms are separate living room, separate dining room, separate kitchen, combined living room/dining

room, combined living room/kitchen, combined dining room/kitchen and combined living room/dining room/kitchen. This part of the study investigates whether internal plan layout in the form of cellular and open plans affects occupant behaviour in terms of time-use. As extra room(s) especially extra living area(s) can affect time-use in usual living areas, houses with only 1 set of living areas were analysed. This produced five options for comparison:

Option 1- Houses with only 1 combined living room/dining room/kitchen and no other spaces with these functions (N=156).

Option 2- Houses with only 1 of each separate living room, dining room and kitchen (N=56).

Option 3- Houses with only 1 combined living room/dining room and only 1 separate kitchen (N=49).

Option 4- Houses with only 1 combined living room/kitchen and only 1 separate dining room (N=1).

Option 5- Houses with only 1 combined dining room/kitchen and only 1 separate living room (N=114).

Table 8.13 presents the subtotal of time spent in living areas for each option. It shows the average time spent in a combined living room/dining room/kitchen (option 1) is less than that of people who live in option 2 houses, who spend 1.15 hours/day more in living spaces. The same trend is repeated for the other four options, as people who live in option 3, 4 and 5 houses spend respectively 27, 41 and 52 minutes less than people in option 2 houses.

Plan layout type	Mean time spent in living areas	Number of houses	Std. Deviation
Combined living room/dining room/kitchen (option 1)	4.63	156	2.61
Separate living room + Separate kitchen + Separate dining room (option 2)	5.78	56	2.87
Combined living room/dining room + Separate kitchen (option 3)	5.33	49	3.87
Combined Living room/kitchen + Separate dining room (option 4)	5.10	1	NA
Combined dining room/kitchen + Separate living room (option 5)	4.92	114	2.56
Total	4.98	376	2.84

Table 8.13 Mean average time spent in living areas, number of houses and standard deviation in each option

To see if these differences are statistically significant, an ANOVA one-way test was performed in SPSS, but excluding option 4 (n=1). The results showed that time-use in any combination of living room, dining room and kitchen was significantly different for internal layout type ($F_{(3,371)}$=2.56, p=0.05) at 0.05 level. A post-hoc multiple comparisons test was also performed and showed time spent in option

1 living areas is significantly less than option 2 at 0.05 level (M=-1.16, SD=0.44, p=0.045). No significant difference was seen between other pairs of plan layout types (options 1 and 3 (M=-0.70, SD=0.46, p=0.43 > 0.05), options 1 and 5 (M=-0.29, SD=0.35, p=0.84 > 0.05)).

The big difference in time usage for options 1 and 2 could result from a non-balanced distribution of participants. For instance having more participants who reported their time-use at a weekend could easily lead to a bigger average in one group. The same problem could be produced for the other parameters considered. To see the effects of these, Table 8.14 compares average times for each sub-category of options 1 and 2 for the parameters and a scaled average was produced for each option for each parameter. As seen, apart from the average time spent by people not in paid work, age group 0-4 and single persons, in all other sub-categories the subtotal of time spent in option 2 was higher than in option 1 (see Table 8.14). Scaled averages also show the same trend. So it seems this trend is not related to gender, age, job type, day type, family role and house size but to differences in the internal plan layout.

In this survey people who live in houses with open plan layouts (option 1) spent on average 1.15 hour/day less in living areas compared to non-open plan layout houses (option 2). The question arises as to where people spend this extra time. To answer this, an average time was produced for each space category of options 1 and 2 (see Table 8.15). For all space categories the average time reflects all spaces and if a house does not have a particular space then time-use in it is recorded as zero. This leads to an under-estimation for spaces with low occurrence but helps to find comparable averages for all space categories. Prior time-use studies show spaces with very low usage like bathrooms and laundries are not reported accurately (Schweizer et al. 2006), and is the reason why results for these spaces are very different for the two plan types. Figures 8.6 and 8.7 present time-uses in different rooms as a daily percentage, with low usage spaces grouped. As seen in Table 8.15 and Figures 8.6 and 8.7, occupants of open plan houses spend less time in living areas and the time difference is mainly spent in bedrooms and out of home with differences between other space categories not noticeable.

		Combined living room/dining room/kitchen Option 1			Separate living room, dining room and kitchen Option 2		
		Mean	N	Std. Deviation	Mean	N	Std. Deviation
Day type	Weekday	4.51	129	2.52	5.24	34	2.69
	Weekend	5.21	27	2.99	6.62	22	3.00
	Scaled average	4.71			5.64		
Job type	Full time job	4.05	74	2.08	5.24	19	2.69
	Part time job	5.21	23	3.20	6.94	11	2.70
	Not in paid job	6.40	22	3.13	5.33	8	2.25
	Full time education	4.37	37	2.38	5.86	18	3.36
	Scaled average	4.93			5.83		
Age group	0-4	5.04	13	2.81	4.50	6	3.75
	5-11	3.92	12	1.45	6.97	7	3.33
	12-19	3.93	14	2.97	4.52	5	1.56
	20-65	4.53	103	2.63	5.89	34	2.86
	65^{+}	6.26	14	2.26	6.30	4	1.46
	Scaled average	4.74			5.64		
Gender	Female	4.72	77	2.59	5.88	33	2.69
	Male	4.54	79	2.64	5.65	23	3.16
	Scaled average	4.63			5.76		
Family role	Single person	5.01	16	2.74	3.85	4	1.47
	couple	4.81	48	2.78	5.80	4	1.88
	parent	4.71	51	2.49	6.23	30	2.88
	child	4.18	41	2.53	5.47	18	3.18
	Scaled average	4.66			5.43		
House size	≤5 rooms	4.36	21	1.59	7.09	10	3.80
	6-8 rooms	4.71	125	2.76	5.50	46	2.59
	9+ rooms	4.17	10	2.56	NA	0	NA
	Scaled average	4.41			6.30		

Table 8.14 Mean, number and standard deviation for time-use in living areas in options 1 and 2 by day type, job type, age group, gender, family role and house size

	Time spent in open plan houses (Option 1)	Time spent in cellular plan houses (Option 2)	Difference of options 1 and 2 in minutes
Usual bedrooms	9.29	8.80	+29
Extra bedrooms	0.23	0.27	- 2
Study	0.68	0.64	+ 2
Games room	0.06	0.13	- 4
Play rooms	0.00	0.26	-16
Studio	0.03	0.00	+ 2
Usual bathroom/toilets	0.66	0.87	-13
Extra bathroom/toilets	0.04	0.18	- 8
Service rooms	0.06	0.13	- 4
Other rooms	0.02	0.00	+ 1
Garden rooms	0.06	0.03	+ 2
Garage	0.12	0.14	- 1
Gardens and decks	0.48	0.44	+ 2
Out of home	7.88	6.62	+76

Table 8.15 Average time spent in all space categories of a house for houses with open and non-open plan layouts

To see if time-use in room categories is significantly different for plan layouts an independent sample t test was performed for each room category listed in Table 8.15. The results indicate that time-uses were significantly different by layout for usual bathroom/toilets ($t_{(210)}$=-1.98, p=0.049) at 0.05 level and for time spent out of home ($t_{(210)}$=1.84, p=0.07) at 0.1 level showing that occupants of open plan houses spend significantly more time out of home compared to occupants of cellular plan houses.

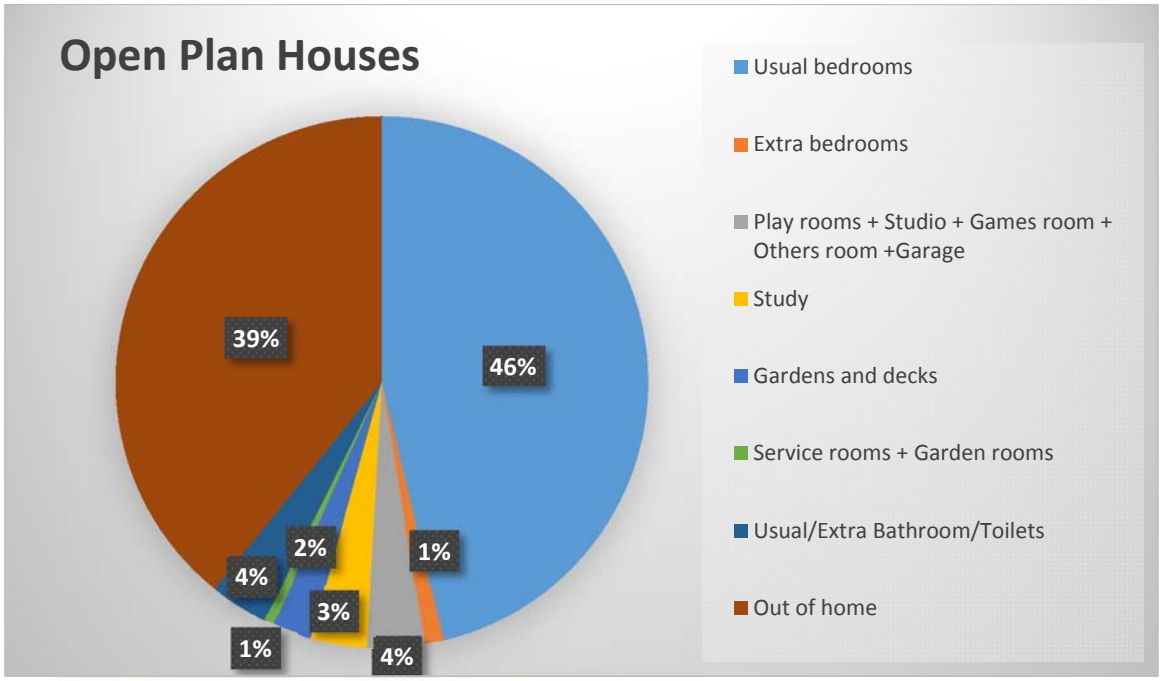


Figure 8.6 Average times spent in different rooms by occupants of open-plan houses

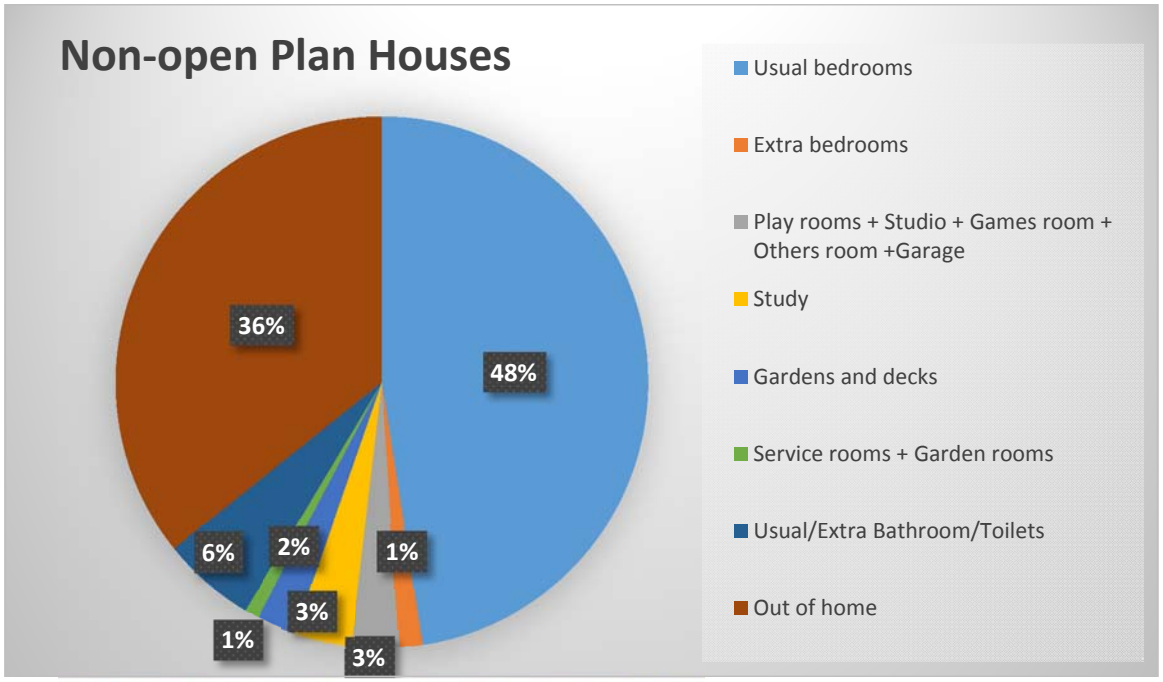


Figure 8.7 Average times spent in different rooms by occupants of non-open-plan houses

8.4.4. Exposure-time effect of living in houses with two different plan layouts

After usual bedrooms, usual living areas are the most used room category in New Zealand houses. From the architectural view point, these spaces can be combined in an open plan or separated by doors in a cellular plan. As shown, living in open-plan houses appears to decrease the time-use in living areas compared to a cellular plan house.

No international time-use study discusses high levels of pollutants in living rooms and dining rooms although several studies have found that cooking activities can raise the level of indoor pollutants (Schiavon et al. (2015), Isaxon et al. (2015), Broich et al. (2012), Schwab et al. (1990), Fromme (2012), Wierzbicka et al. (2015), Yassin et al. (2012), Poon et al. (2016), Gao et al. (2013) and Evans et al. (2008)). In a study on the level of pollutants in different microenvironments, Broich et al. (2012) found that pollutant levels are highest (6000 N cm^{-3}) at home indoors during cooking, compared to a peak pollutant level of 2500 N cm^{-3} in a smoker's flat. Normally cooking happens in kitchens so the time spent there could be important for occupant exposure at home. For open plans, in this study it is not clear what percentage of time in the usual combined living area is spent in which part but time-use in cellular plan houses is distributed 21.7% in kitchen, 61.6% in living and 16.7% in dining.

Plan layout can easily affect the level of human exposure to pollutants as time in an open plan combined living area is effectively time spent in a kitchen. Based on this and the results of this study, people with a living room/dining room/kitchen, living room/kitchen or dining room/kitchen spend respectively 3.23, 1.36 and 0.53 hours/day more in the kitchen compared to those with a separate kitchen.

Given that Yoon et al. (2012:350) found that "staying time in a specific microenvironment could contribute more to inhaled particulate mass than could the airborne concentrations in that microenvironment", this becomes more important as in cellular plans children are not the main users of kitchens but in open plan combined living areas children are forced to spend time in kitchens. Figure 8.8 compares time spent in separate kitchens and other kitchen/room combinations by different age groups. It shows unnecessary time in the kitchen is highest for young children and seniors. Having a combined living room/dining room/kitchen gives the highest level of unnecessary time in the kitchen, which other combinations do to a lesser degree (see Figure 8.8).

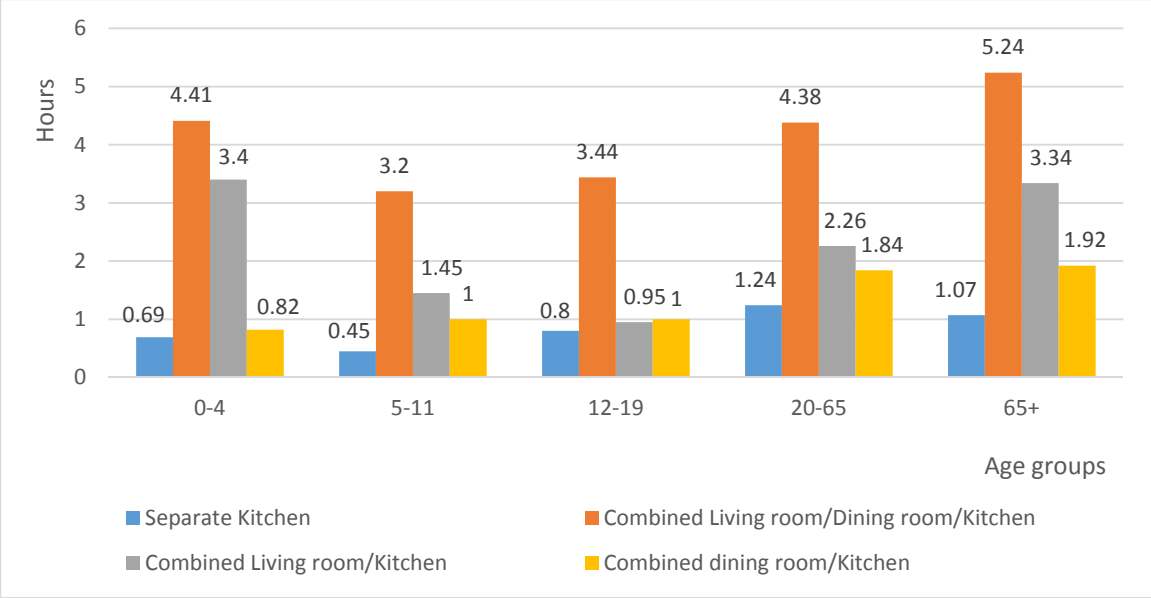


Figure 8.8 Time spent in separate kitchen for different age groups for different living space plan forms

8.4.5. Use of large houses

Figure 8.3 shows living in larger houses fails to lead to spending more time at home indoors. An ANOVA one-way test was also performed which showed large housing does affect time-use at home indoors ($F_{(2,535)}$=3.67, p=0.035) at 0.05 level. The results of the post-hoc test reveal people living in houses with 0-1 and 2-4 extra rooms significantly spend 1.2 and 1.4 hours more in usual bedrooms than those living in houses with 5+ extra rooms.

The effect of large housing on time-use in room categories was also analysed using an ANOVA one-way test, showing that large housing significantly affects time-use in usual bedrooms ($F_{(2,535)}$=13.52, p=0.000) and usual living areas ($F_{(2,535)}$=9.40, p=0.000). The results of the post-hoc test show people in houses with 0-1 and 2-4 extra rooms significantly spend 2.1 and 1.6 hours more in usual bedrooms and 1.5 and 0.7 hours more in usual living areas compared to those in houses with 5+ extra rooms.

An ANOVA one-way test was also performed to see if the number of extra living areas, extra bedrooms, and extra bathrooms has any effect on time-use of these. For extra bedrooms time-use is significantly different by number of extra bedrooms ($F_{(3,380)}$=3.70, p=0.012) although a post-hoc test showed no significant difference between time-use of any sub-groups at 0.05 level. The results also showed that

time-use in extra living areas ($F_{(5,135)}$=0.81, p=0.55) and extra bathroom/toilets ($F_{(3,303)}$=0.28, p=0.84) is not significantly different by number of these.

This shows that living in houses with several living areas, extra bedrooms and extra bathrooms does not necessarily lead to more time-use in those extra rooms. Putting these alongside the brief time spent in specialized rooms (study, play room, games room) it seems that a large house does not mean more time spent at home.

It is also clear that larger houses need more resources for their building and operation over their life cycle, and their furnishing. In the next Chapters the energy used for each type of housing over its life will be analysed and compared.

9. Embodied and life cycle energy of selected houses

9.1. Introduction

As mentioned in section 2.7, Life Cycle Assessment (LCA) is a useful method for the environmental assessment of services and products. One of the most important usages of LCA is in the built environment as LCA makes it is possible to calculate the energy used over the life cycle of a building. This life cycle energy includes the energy used for extraction, processing, manufacturing and transportation of raw materials, construction, operation and maintenance of the building (including energy used for replacement of building elements, heating, cooling, ventilation, electric lighting, appliance use and hot water use), building demolition and disposal, and reuse or recycling of the building's elements and components (Alcorn, 2010; Crawford, 2011).

Some elements affecting the life cycle energy of a house are directly related to the building while others are related to its users and some are related to both. In other words, it is not always the larger house but sometimes the larger households who consume more energy over the life cycle of the house. The energy used in building materials and their replacement and maintenance over the life of the house is directly affected by houses size, whereas the energy for water heating, lighting and appliances depends on household rather than house size. Obviously the larger the household the more hot water is used. In contrast, the energy for cooking and running the refrigerator could be the same for both large and small households. Results of the study of time-use in different rooms (Chapter 8) revealed the time spent in the various rooms of a house is a parameter affected by occupant age, gender and job type but not house size. This means that the same household living in different sized houses does not spend more time at home in its various rooms. Given the use of electric light and many appliances (television, games consoles etc.) are affected by time-use at home indoors, living in larger houses does not necessarily mean using more energy for lighting and appliances if the number of occupants remains the same.

In terms of energy for heating, cooling and ventilation both house and household size could be important. More occupants living in a house could mean more energy for heating, cooling and ventilation, although for a healthy indoor environment, heating all parts of the house is desirable, meaning larger houses need more energy for space conditioning even with the same number of occupants. Because of these issues, this study excludes life cycle energy related to water heating, electric lighting, cooking and appliances. So the term life cycle energy (LCE) used in chapters 9-12 is a partial LCE and does not represent the overall LCE of a house.

Large houses need more resources to be built, maintained, operated and potentially recycled at the end of their life. They thus contain greater embodied energy in their building materials and bathroom and kitchen fittings (Vale & Vale, 2009). Apart from this, the energy associated with maintenance, which will be greater for larger houses, will also be added to the life-cycle energy consumption, along with the energy associated with any end of life materials and components recycling. In addition, large houses need more furniture and appliances to fill their rooms, an aspect that will be investigated in Chapter 10.

If large houses are associated with increased energy consumption over their life cycle this will have environmental impacts, such as creating higher levels of CO_2 emissions (Crawford, 2011). Accepting the fact that large houses could be more flexible for occupants, this part of the study aimed to develop a method to show the energy impact of selecting different sized houses and how sustainable each size of house could be for different sized households.

Life cycle analysis studies of houses are mainly dependent on pre-determined embodied energy coefficients of building materials. These are highly location based for many reasons, including how energy is produced in the country of origin, the efficiency of the production process, and the distance travelled from factory to the building site (Crawford, 2011). Usually modern products need less energy to produce than their older versions. Apart from building materials, construction type is also important. For instance, New Zealand houses are mainly light weight timber frame with timber

cladding (Isaacs, 2015) while more bricks (which have a higher embodied energy coefficient because they have to be fired) are used in Australian houses. Differences in geographical location of the house can also affect operating energy. For example, many Australian households use energy for cooling while this is very limited in New Zealand houses. Because of these issues and the fact this study is focussed on New Zealand houses, data from New Zealand life cycle assessment studies is used. A discussion of prior New Zealand life cycle studies is found in section 2.7.2. As a summary of these Table 9.1 gives the total initial embodied energy (EE) of houses by area as first constructed, excluding furniture, fittings and appliances from three of these studies with references.

House type	Floor area (m^2)	Total EE (GJ)	EE per m^2 (GJ/m^2)	Reference
Light construction	94	179.3	1.91	Mithraratne et al. (2007:164)
Heavy construction	94	262.5	2.79	Mithraratne et al. (2007:164)
Super-insulated construction	94	230.1	2.45	Mithraratne et al. (2007:171)
Timber frame, brick veneer	100	264.0	2.64	Vale and Vale (2009:146)
Straw bale	100	185.0	1.85	Vale and Vale (2009:146)
Straw stabilized adobe block	100	234.0	2.34	Vale and Vale (2009:146)
Light construction	146	236.3	1.62	Mithraratne et al. (2007:171)
Super-insulated construction	146	315.7	2.16	Mithraratne et al. (2007:171)
Light construction	194	305.0	1.57	Mithraratne et al. (2007:171)
Super-insulated construction	194	395.0	2.04	Mithraratne et al. (2007:171)
Timber frame, brick veneer	200	461.0	2.31	Vale and Vale (2009:146)
Straw bale	200	349.0	1.75	Vale and Vale (2009:146)
Straw stabilized adobe block	200	418.0	2.09	Vale and Vale (2009:146)
Light weight 1970s-slab	200	331.7	1.66	Alcorn (2010:267)
Light weight 2000s-slab	200	352.3	1.76	Alcorn (2010:267)
Light weight 2000s-suspended	200	354.7	1.77	Alcorn (2010:261,267)
Light weight 2010s-slab	200	412.9	2.06	Alcorn (2010:267)

Table 9.1 Total embodied energy and embodied energy per square metre based on three New Zealand house LCA studies

This Chapter calculates the embodied and life cycle energy associated with different sized houses which single person households, couples and couples with 1 or 2 children might select, using data from the existing New Zealand LCA studies. Page (2007) reports that most New Zealanders choose to live in existing rather than new houses because the latter are scarce in New Zealand. Often people refurbish and modernise these older houses and Page (2007) states this can consume 90% of the cost of building a new house. However, to make the discussion of this study simple, it is assumed all houses are built new. The aim of this Chapter is to find the difference in energy use of various house sizes for

each household type and reveal what selecting to live in different sized houses, for different lengths of time might mean in terms of energy use.

9.2. A definition for small, suitable-size, and large housing

In this analysis, a core house for each household is one living room, dining room and kitchen (either combined or separate) and a bedroom for each usual occupant, assuming couples share a bedroom. This definition is more generous than crowding indices such as BBS and CNOS in which children and adolescents, according to gender and age, share bedrooms (Goodyear et al., 2011). Children sharing bedrooms is ignored here because as Reynolds et al. (2004) say people might not wish to upsize their house as their children grow. Based on this, Table 9.2 shows the combination and number of rooms for each household, following the Statistics New Zealand (2014k) room standard as described in section 2.2.

Household type	Type and number of rooms needed for core house	Number of rooms needed
Single person	1 Kitchen + 1 Living room + 1 Dining room + 1 Bedroom	4
Couple	1 Kitchen + 1 Living room + 1 Dining room + 1 Bedroom	4
Couple with 1 child	1 Kitchen + 1 Living room + 1 Dining room + 2 Bedrooms	5
Couple with 2 children	1 Kitchen + 1 Living room + 1 Dining room + 3 Bedrooms	6

Table 9.2 A basic house for 4 different household types and the minimum number of rooms

Following this definition, in this analysis households in houses with the same number of rooms as in Table 9.2 are categorised as living in suitable-size houses. In addition those living in houses with fewer rooms than the basic needs are said to live in small houses, which is similar to but not the same as crowded houses, which are outside the scope of this study. Those with more rooms than this basic definition live in large houses. Table 9.3 summarises these definitions for the four household types.

Household type	Small housing	Suitable size housing	Large housing
Single person	Number of rooms < 4	Number of rooms = 4	Number of rooms > 4
Couple	Number of rooms < 4	Number of rooms = 4	Number of rooms > 4
Couple with 1 child	Number of rooms < 5	Number of rooms = 5	Number of rooms > 5
Couple with 2 children	Number of rooms < 6	Number of rooms = 6	Number of rooms > 6

Table 9.3 Number of rooms needed in small, suitable-size or large houses for 4 household types

According to Table 9.3, a couple living in a house with 5 rooms lives in large housing, as does a couple in a house with 10 rooms although there is a big difference between a 5 and 10 room house in terms of energy use. To remove this problem, those living in large houses are further categorised by the

number of extra rooms they have beyond the core house need for each particular household type. For instance, couples living in 5 and 10 room houses will be shown as large housing with 1 and 6 extra rooms (i.e. 1 EXR and 6 EXR). Based on this, house size for each household is shown by the number of extra rooms they have. Table 9.4, shows the number of rooms each household type needs for each level of large housing, together with the average floor area of each, based on the floor plan study (see section 7.3.1).

House size (based on number of extra rooms)	Single person households and couples		Couples with 1 child		Couples with 2 children	
	Number of rooms	Average floor area (m^2)	Number of rooms	Average floor area (m^2)	Number of rooms	Average floor area (m^2)
0 EXR	4	70.70	5	96.17	6	120.21
1 EXR	5	96.17	6	120.21	7	161.26
2 EXR	6	120.21	7	161.26	8	190.01
3 EXR	7	161.26	8	190.01	9	234.30
4 EXR	8	190.01	9	234.30	10	251.83
5 EXR	9	234.30	10	251.83	11	304.04

Table 9.4 Number of rooms and average floor area for each level of large housing for 4 different household types

9.3. Method

9.3.1. Embodied energy per square metre of different sized houses

The life cycle energy calculation for a house is a complicated and time-consuming process that needs data on the type and quantity of materials used in its building and maintenance, the type of heating and the heating regime over the life of the house, leading to the need to make assumptions. To date, many studies have calculated this, some looking at existing houses and some at designs or generic houses (see section 2.7). This study aims to compare the life cycle energy of a number of houses, for which an estimated average will be sufficient. Consequently, the data from Mithraratne et al. (2007) was used as this covers a range of small (94m^2), medium (146m^2) and large (194m^2) houses. To control the effects of different technologies and materials, all houses were assumed to be timber frame with timber or other lightweight cladding, as these are the most popular house types in New Zealand (Isaacs, 2015). As houses in this study are not necessarily the same size as those investigated by Mithraratne et al. (2007), a graph was constructed of house size/embodied energy per square metre (Figure 9.1). The numbers in boxes show the initial embodied energy per square metre for the three

Mithraratne et al. (2007) case study houses. These values were extrapolated so an approximate embodied energy could be read off for any size of house.

Mithraratne et al. (2007:171) calculated the life cycle energy of their three case study houses for 25, 50, 75 and 100 years. Life cycle energy for each stage includes initial embodied energy and maintenance and heating energies over the period but excludes energy used during the construction and demolition phases and that associated with fittings and furniture. The former, which form a small percentage of the total, are also ignored here but allowance will be made for fittings and furniture as these are affected by size of house.

In the study by Mithraratne et al. (2007:157, 168, 171) the annual space conditioning energy is 2,123kWh for the 94m^2, 3,016kWh for the 146m^2, and 3862kWh for the 194m^2 light construction houses based on an all-day heating pattern. Though the latter seems unrealistic for NZ houses (in New Zealand people usually do not heat the house overnight), this pattern was used to avoid accounting for the energy required to heat up the mass diurnally, as the study included light and heavy constructions. However, several studies including one by BRANZ (Isaacs et al., 2010) and another by Howden-Chapman et al. (2012) report that New Zealand houses are heated below the international standards and as Howden-Chapman et al. (2012:140) state "low housing and heating standards are having serious effects on New Zealand's population health". Consequently, the same heating values were used in this comparison. The maintenance schedules for the building fabric, plumbing and electrics were also taken from Mithraratne et al. (2007) (Table 9.5).

	Building elements/parts								
	Structural elements	Wall cladding	Roof covering	Electrical works	Joinery	Plumbing	Flooring finishes	Repainting finishes	Kitchen upgrade
Useful life (years)	100	30-60	40	50	60	16-50	17-50	8-10	30

Table 9.5 Useful life of different building elements/parts according to Mithraratne et al. (2007)

Following the same method for the initial embodied energy, life cycle energy per square metre was created for different stages of building life cycle (Figure 9.1). The second, third, fourth, and fifth lines respectively represent trend lines after 25, 50, 75 and 100 years. The figures in boxes are those of Mithraratne et al. (2007) while other figures are extrapolations. Knowing the floor area of a house, it

is possible to extract the embodied and life cycle energy per square metre at different life stages. Multiplying the embodied or life cycle energy per square metre by the floor area gives the values for each size of house.

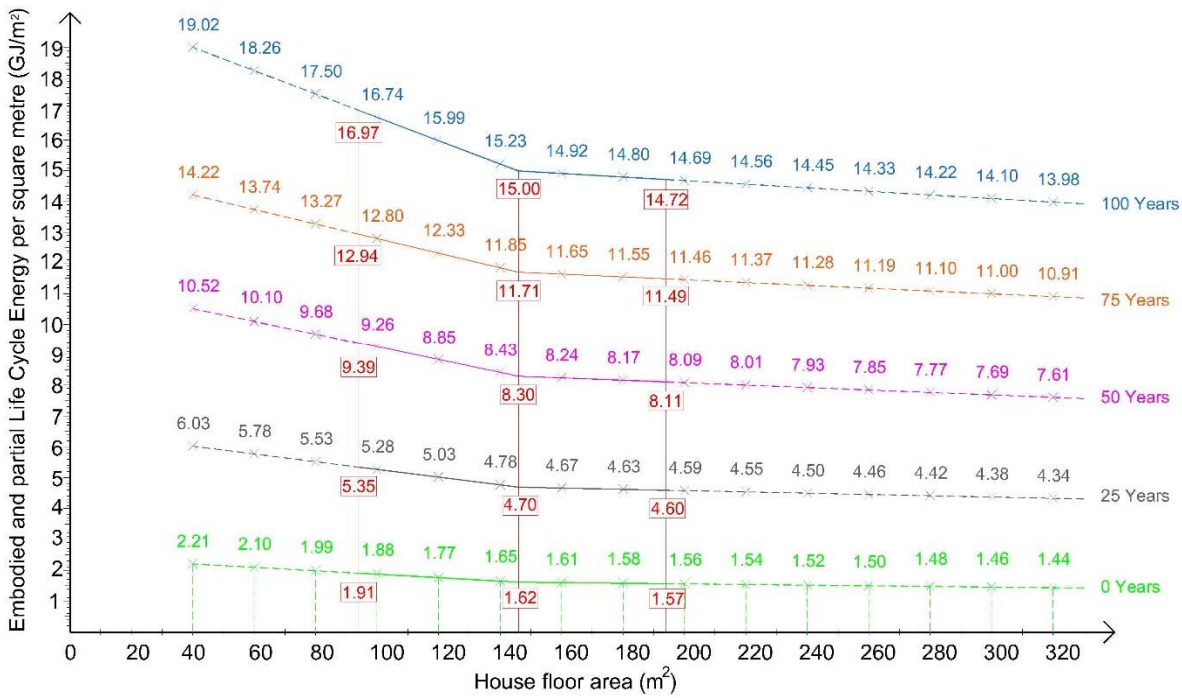


Figure 9.1 Estimated initial embodied energy and life cycle energy per square metre based on Mithraratne et al. (2007)

9.3.2. Embodied and life cycle energy of kitchen and sanitary fittings

In terms of the energy embodied in building materials, some aspects of larger houses (such as larger rooms or double living rooms, double/triple bathrooms) are reflected in the floor area of the house, but not all. For instance, according to the floor plan study (see sections 7.3.4-5), larger houses have more sanitary spaces and larger kitchens, which means more bathroom and kitchen fittings. In the calculation of the EE and LCE, it is not clear which of the sanitary space fittings are included in the Mithraratne et al. (2007) calculations. What is clear, is that Mithraratne et al. (2007) have not considered the fact that larger NZ houses have several sanitary spaces. Based on this, two possible scenarios could be followed:

Scenario 1- Assume that Mithraratne et al. (2007) values include EE and LCE of fittings. Following this assumption means no double counting of the EE and LCE of fittings but impact of larger houses having several sanitary spaces is ignored.

Scenario 2- Assume the Mithraratne et al. (2007) values do not include the EE and LCE of fittings. These are then calculated separately and added to Mithraratne et al. (2007) values. This leads to the potential double counting of the EE and LCE of sanitary fittings but will guarantee the presence of several sanitary spaces in larger houses is taken into account.

To overcome the problem both scenarios were calculated and the results compared. This showed that in second scenario the rates of increase in EE and LCE of houses by potential double counting is on average 2.3-3.9%. Given this small increase it was decided to proceed with the second scenario. As a result, the embodied and life cycle energy associated with sanitary and kitchen fittings were calculated separately and added to the values for the house.

9.3.2.1. Sanitary fittings

Vale and Vale (2009) give a table of the embodied energy of fittings for a combined bathroom/toilet. The floor plan study in this research revealed seven types of sanitary space (excluding utility rooms): bathroom, bathroom/toilet, en-suite, toilet, toilet/laundry, laundry, and bathroom/toilet/laundry. Based on the number rooms, it is possible to extract the average number of these spaces from the floor plan study (Table 9.6).

Number of rooms	Average number of sanitary spaces						
	Bathroom	Bathroom/Toilet	En-suite	Toilet	Toilet/Laundry	Laundry	Bathroom/Toilet/Laundry
4	0.20	0.61	0.00	0.20	0.00	0.27	0.22
5	0.67	0.40	0.09	0.67	0.00	0.69	0.00
6	0.67	0.43	0.37	0.71	0.00	0.74	0.00
7	0.58	0.58	0.65	0.80	0.05	0.55	0.00
8	0.60	0.53	1.00	0.88	0.00	0.75	0.00
9	0.52	0.70	1.09	0.83	0.04	0.96	0.00
10	0.56	0.78	1.11	1.00	0.00	0.78	0.11
11	0.13	1.13	1.50	0.88	0.00	1.00	0.00

Table 9.6 Average number of sanitary spaces in different sized houses

Using the Vale and Vale (2009) data but excluding fittings that are not applicable and adjusting copper pipe length and number of taps and valves based on the number of fittings in each scenario, the

embodied energies of each were calculated. As the Vale and Vale (2009) data did not include figures for a laundry tub, this was calculated separately. A family sized tub with single bowl, model number: ST7001, ST7001A, was selected from the Monaco Corporation Limited (2016) catalogue.

The weight of materials and embodied energy coefficients from Alcorn (2010) allowed calculation of the initial embodied energy of a typical laundry tub). Using the useful life of each fitting according to Mithraratne et al. (2007:132), life cycle energies for each space were calculated for 25, 50, 75 and 100 years (Tables 9.7-9.12). It is assumed that the combined bathroom/toilet and en-suite contain the same fittings (Table 9.9) but all other sanitary spaces have separate tables.

Element	Mass (kg)	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
9m copper pipe	7	20	16.8	33.6	50.4	67.2	100.8
Bath, pressed steel and white enamel	55	20	1760.0	3520.0	5280.4	7040.0	10560.0
Shower over bath	3	20	96.0	192.0	288.0	384.0	576.0
Glass screen (toughened)	20	20	520.0	1040.0	1560.0	2080.0	3120.0
Vanity basin, vitreous china	12	20	30.0	60.0	90.0	120.0	180.0
Taps and valves for bath, basin and shower	3	20	186.0	372.0	558.0	744.0	1116.0
Heated towel rail	6	15	192.0	384.0	768.0	1152.0	1344.0
Mains-pressure 135 l hot water cylinder in steel	14	15	448.0	896.0	1792.0	2688.0	3136.0
Subtotal embodied/life cycle energy (MJ) for one unit			3248.8	6497.6	10386.4	14275.2	20132.8

Table 9.7 Embodied and life cycle energy of bathroom fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132))

Element	Mass (kg)	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
5m copper pipe	4	20	9.6	19.2	28.8	38.4	57.6
Vanity basin, vitreous china	12	20	30.0	60.0	90.0	120.0	180.0
Toilet pan, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Cistern, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Plastic seat and accessories	3	20	309.0	618.0	927.0	1236.0	1854.0
Taps and valves for basin	2	20	124.0	248.0	372.0	496.0	744.0
Toilet-paper holder	0.1	15	3.0	6.0	12.0	18.0	21.0
Subtotal embodied/life cycle energy (MJ) for one unit			560.6	1121.2	1684.8	2248.4	3366.6

Table 9.8 Embodied and life cycle energy of toilet fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132))

Element	Mass (kg)	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
14m copper pipe	11	20	26.4	52.8	79.2	105.6	158.4
Bath, pressed steel and white enamel	55	20	1760.0	3520.0	5280.0	7040.0	10560.0
Shower over bath	3	20	96.0	192.0	288.0	384.0	576.0
Glass screen (toughened)	20	20	520.0	1040.0	1560.0	2080.0	3120.0
Vanity basin, vitreous china	12	20	30.0	60.0	90.0	120.0	180.0
Toilet pan, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Cistern, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Plastic seat and accessories	3	20	309.0	618.0	927.0	1236.0	1854.0
Taps and valves for bath, basin and shower	5	20	310.0	620.0	930.0	1240.0	1860.0
Heated towel rail	6	15	192.0	384.0	768.0	1152.0	1344.0
Toilet-paper holder	0.1	15	3.0	6.0	12.0	18.0	21.0
Mains-pressure 135 l hot water cylinder in steel	14	15	448.0	896.0	1792.0	2688.0	3136.0
Subtotal embodied/life cycle energy (MJ) for one unit			3779.4	7558.8	11981.2	16403.6	23319.4

Table 9.9 Embodied and life cycle energy of combined bathroom/toilet and en-suite fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132))

Element	Mass (kg)	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
9m copper pipe	7	20	16.8	33.6	50.4	67.2	100.8
Vanity basin, vitreous china	12	20	30.0	60.0	90.0	120.0	180.0
Toilet pan, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Cistern, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Plastic seat and accessories	3	20	309.0	618.0	927.0	1236.0	1854.0
Taps and valves for bath, basin and shower	4	20	248.0	496.0	744.0	992.0	1488.0
Toilet-paper holder	0.1	15	3.0	6.0	12.0	18.0	21.0
Laundry tub	25.2	20	237.6	475.2	712.8	950.4	1425.6
Subtotal embodied/life cycle energy (MJ) for one unit			929.4	1858.8	2791.2	3723.6	5579.4

Table 9.10 Embodied and life cycle energy of combined toilet/laundry fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132))

Element	Mass (kg)	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
5m copper pipe	4	20	9.6	19.2	28.8	38.4	57.6
Taps and valves for tub	2	20	124.0	248.0	372.0	496.0	744.0
Laundry tub	25.2	20	237.6	475.2	712.8	950.4	1425.6
Subtotal embodied/life cycle energy (MJ) for one unit			371.2	742.4	1113.6	1484.8	2227.2

Table 9.11 Embodied and life cycle energy of laundry fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132))

Element	Mass (kg)	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
21m copper pipe	16.5	20	39.6	79.2	118.8	158.4	237.6
Bath, pressed steel and white enamel	55	20	1760.0	3520.0	5280.0	7040.0	10560.0
Shower over bath	3	20	96.0	192.0	288.0	384.0	576.0
Glass screen (toughened)	20	20	520.0	1040.0	1560.0	2080.0	3120.0
Vanity basin, vitreous china	12	20	30.0	60.0	90.0	120.0	180.0
Toilet pan, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Cistern, vitreous china	17	20	42.5	85.0	127.5	170.0	255.0
Plastic seat and accessories	3	20	309.0	618.0	927.0	1236.0	1854.0
Taps and valves for bath, basin, shower and tub	7	20	434.0	868.0	1302.0	1736.0	2604.0
Heated towel rail	6	15	192.0	384.0	768.0	1152.0	1344.0
Toilet-paper holder	0.1	15	3.0	6.0	12.0	18.0	21.0
Mains-pressure 135 l hot water cylinder in steel	14	15	448.0	896.0	1792.0	2688.0	3136.0
Laundry tub	25.2	20	237.6	475.2	712.8	950.4	1425.6
Subtotal embodied/life cycle energy (MJ) for one unit			4154.2	8308.4	13105.6	17902.8	25568.2

Table 9.12 Embodied and life cycle energy of bathroom/toilet/laundry fittings (based on Vale and Vale (2009:150) and Mithraratne et al. (2007:132))

9.3.2.2. Kitchen fittings and components

Vale and Vale (2009) also calculated the embodied energy of kitchen components. Their table includes major appliances and finishes for walls and floor. As figures by Mithraratne et al. (2007) include finishes and this part of the analysis does not cover appliances, both were excluded from the Vale and Vale (2009) table. By considering the useful life of each component according to Mithraratne et al. (2007:132) life cycle energies per square metre were calculated for 25, 50, 75 and 100 years.

The floor plan study did not show a clear size difference between the floor area of kitchens of different sized houses (see section 7.3.5) although when houses were grouped into two categories (houses with 4-6 and 7-7+ rooms), the difference in kitchen sizes became significant. The average floor area of

kitchens in houses with 4-6 rooms is 12.0m^2 becoming 15.7m^2 for house with 7-7+ rooms. Typical floor plans of a 12m^2 and 15.7m^2 kitchen were drawn (Figure 9.2) with the fittings and large appliances. The larger kitchen has more base cupboards, wall cupboards and worktop and a larger sink but the number of taps and sink units are the same for both (Tables 9.13 and 9.14). Using Figure 9.2 and the Vale and Vale (2009) values Tables 9.13 and 9.14 give the embodied and life cycle energy of kitchen fittings for 4-6 and 7-7+ room houses.

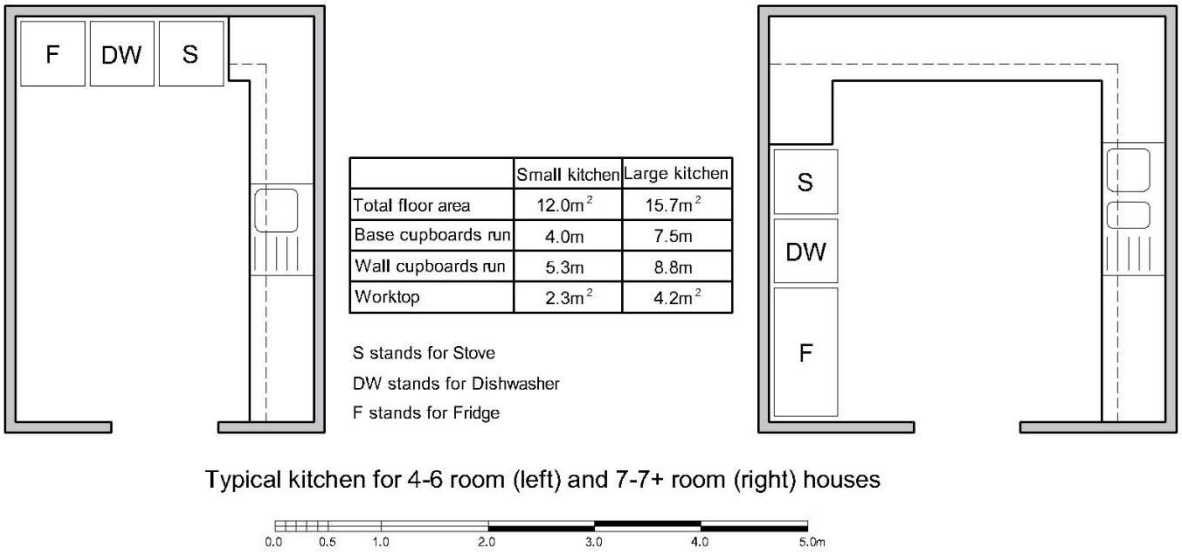


Figure 9.2 Floor area of typical small (12m^2) and large (15.7m^2) kitchen and quantities of fittings

Element	Size or quantity	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
Base cupboards (chipboard, hw doors)	4.0m run	25	644	1288	1932	2576	3220
Wall cupboards (chipboard, hw doors)	5.3m run	25	360	720	1080	1440	1800
Workshop (imported granite, 25 mm thick)	2.3m^2	25	1012	2024	3036	4048	5060
Sink (stainless steel) and taps	44×86cm	20	428	856	1284	1712	2568
Subtotal embodied/life cycle energy (MJ) for one unit			2444	4888	7332	9776	12648

Table 9.13 Embodied and life cycle energy of kitchen fittings of 4-6 room houses (based on Vale and Vale (2009:188))

Element	Size or quantity	Useful life	Embodied energy (MJ)	Life cycle energy at different stages (MJ)			
				25 years	50 years	75 years	100 years
Base cupboards (clipboard, hardwood doors)	7.5m run	25	1208	2416	3624	4832	6040
Wall cupboards (clipboard, hardwood doors)	8.8m run	25	597	1194	1791	2388	2985
Workshop (imported granite, 25 mm thick)	4.2m^2	25	1848	3696	5544	7392	9240
Sink (stainless steel) and taps	44×124cm	20	617	1234	1851	2468	3702
Subtotal embodied/life cycle energy (MJ) for one unit			4270	8540	12810	17080	21967

Table 9.14 Embodied and life cycle energy of kitchen fittings of 7-7+ room houses fittings (based on Vale and Vale (2009:188))

9.4. Results:

Using Figure 9.1, the appropriate embodied and life cycle energy per square metre for different life stages were extracted and multiplied by the floor area of each house. Tables 9.15-9.17 present the results for the four household types living in houses with 0-5 extra rooms excluding bathroom and kitchen fixings at this stage.

House size (based on number of extra rooms)	Average floor area (m^2)	Embodied/Life cycle energy per square metre (GJ/m^2) (years)					Embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100	0	25	50	75	100
0 extra room	70.70	2.00	5.56	9.75	13.34	17.61	141.74	393.27	689.06	943.29	1245.31
1 extra room	96.17	1.90	5.32	9.34	12.89	16.89	182.52	511.90	898.66	1239.51	1624.10
2 extra rooms	120.21	1.76	5.02	8.84	12.32	15.98	212.03	603.74	1062.73	1480.99	1920.60
3 extra rooms	161.26	1.60	4.67	8.24	11.64	14.91	258.68	752.79	1328.72	1877.08	2404.55
4 extra rooms	190.01	1.57	4.61	8.13	11.51	14.74	299.11	875.62	1543.98	2186.69	2801.37
5 extra rooms	234.30	1.53	4.52	7.95	11.31	14.48	358.01	1058.10	1862.80	2648.83	3393.81

Table 9.15 Average floor area, embodied and life cycle energy per square metre and total embodied and life cycle energy of 6 housing options for single person households and couples

House size (based on number of extra rooms)	Average floor area (m^2)	Embodied/Life cycle energy per square metre (GJ/m^2) (years)					Embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100	0	25	50	75	100
0 extra room	96.17	1.90	5.32	9.34	12.89	16.89	182.52	511.90	898.66	1239.51	1624.10
1 extra room	120.21	1.76	5.02	8.84	12.32	15.98	212.03	603.74	1062.73	1480.99	1920.60
2 extra rooms	161.26	1.60	4.67	8.24	11.64	14.91	258.68	752.79	1328.72	1877.08	2404.55
3 extra rooms	190.01	1.57	4.61	8.13	11.51	14.74	299.11	875.62	1543.98	2186.69	2801.37
4 extra rooms	234.30	1.53	4.52	7.95	11.31	14.48	358.01	1058.10	1862.80	2648.83	3393.81
5 extra rooms	251.83	1.51	4.48	7.88	11.22	14.38	380.21	1128.07	1984.70	2826.77	3622.00

Table 9.16 Average floor area, embodied and life cycle energy per square metre and total embodied and life cycle energy of 6 housing options for couples with one child

House size (based on number of extra rooms)	Average floor area (m^2)	Embodied/Life cycle energy per square metre (GJ/m^2) (years)					Embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100	0	25	50	75	100
0 extra room	120.21	1.76	5.02	8.84	12.32	15.98	212.03	603.74	1062.73	1480.99	1920.60
1 extra room	161.26	1.60	4.67	8.24	11.64	14.91	258.68	752.79	1328.72	1877.08	2404.55
2 extra rooms	190.01	1.57	4.61	8.13	11.51	14.74	299.11	875.62	1543.98	2186.69	2801.37
3 extra rooms	234.30	1.53	4.52	7.95	11.31	14.48	358.01	1058.10	1862.80	2648.83	3393.81
4 extra rooms	251.83	1.51	4.48	7.88	11.22	14.38	380.21	1128.07	1984.70	2826.77	3622.00
5 extra rooms	304.04	1.46	4.37	7.67	10.99	14.08	442.47	1328.87	2333.32	3340.06	4280.31

Table 9.17 Average floor area, embodied and life cycle energy per square metre and total embodied and life cycle energy of 6 housing options for couples with two children

For each house size, the embodied and life cycle energy of each type of sanitary space was extracted from Tables 9.7-9.12, and multiplied by the average number of that type for each house size, and values for all sanitary spaces were added. These were then added to the embodied and life cycle energies of kitchen fittings extracted from Tables 9.13 and 9.14 for each house size and household type (Tables 9.18-9.20).

House size (based on number of extra rooms)	Number of rooms	Embodied/Life cycle energy (GJ) of sanitary spaces and kitchen fittings (years)				
		0	25	50	75	100
0 extra rooms (core house)	4	6.34	12.69	19.69	26.70	36.70
1 extra room	5	6.85	13.70	21.29	28.88	39.82
2 extra rooms	6	8.04	16.08	25.07	34.06	47.18
3 extra rooms	7	11.28	22.56	35.00	47.45	65.19
4 extra rooms	8	12.50	24.99	38.86	52.72	72.69
5 extra rooms	9	13.21	26.42	41.12	55.82	77.11

Table 9.18 Embodied and life cycle energy of sanitary spaces and kitchen fittings for different house sizes for single person households and couples

House size (based on number of extra rooms)	Number of rooms	Embodied/Life cycle energy (GJ) of sanitary spaces and kitchen fittings (years)				
		0	25	50	75	100
0 extra rooms (core house)	5	6.85	13.70	21.29	28.88	39.82
1 extra room	6	8.04	16.08	25.07	34.06	47.18
2 extra rooms	7	11.28	22.56	35.00	47.45	65.19
3 extra rooms	8	12.50	24.99	38.86	52.72	72.69
4 extra rooms	9	13.21	26.42	41.12	55.82	77.11
5 extra rooms	10	14.21	28.42	44.27	60.13	83.25

Table 9.19 Embodied and life cycle energy of sanitary spaces and kitchen fittings for different house sizes for couples with one child

House size (based on number of extra rooms)	Number of rooms	Embodied/Life cycle energy (GJ) of sanitary spaces and kitchen fittings (years)				
		0	25	50	75	100
0 extra rooms (core house)	6	8.04	16.08	25.07	34.06	47.18
1 extra room	7	11.28	22.56	35.00	47.45	65.19
2 extra rooms	8	12.50	24.99	38.86	52.72	72.69
3 extra rooms	9	13.21	26.42	41.12	55.82	77.11
4 extra rooms	10	14.21	28.42	44.27	60.13	83.25
5 extra rooms	11	15.13	30.25	47.15	64.06	88.88

Table 9.20 Embodied and life cycle energy of sanitary spaces and kitchen fittings for different house sizes for couples with two children

Adding these to the embodied energies of the house (Tables 9.15-9.17) gives the overall embodied and life cycle energy of each house option as presented in Tables 9.21-9.23.

House size (based on number of extra rooms)	Number of rooms	Total embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100
0 extra rooms (core house)	4	148.08	405.95	708.75	969.98	1282.01
1 extra room	5	189.37	525.60	919.95	1268.39	1663.92
2 extra rooms	6	220.07	619.83	1087.80	1515.05	1967.78
3 extra rooms	7	269.96	775.35	1363.72	1924.53	2469.74
4 extra rooms	8	311.61	900.61	1582.84	2239.41	2874.06
5 extra rooms	9	371.22	1084.52	1903.93	2704.65	3470.92

Table 9.21 Total embodied and life cycle energy of different houses for single person households and couples

House size (based on number of extra rooms)	Number of rooms	Total embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100
0 extra rooms (core house)	5	189.37	525.60	919.95	1268.39	1663.92
1 extra room	6	220.07	619.83	1087.80	1515.05	1967.78
2 extra rooms	7	269.96	775.35	1363.72	1924.53	2469.74
3 extra rooms	8	311.61	900.61	1582.84	2239.41	2874.06
4 extra rooms	9	371.22	1084.52	1903.93	2704.65	3470.92
5 extra rooms	10	394.42	1156.49	2028.97	2886.90	3705.24

Table 9.22 Total embodied and life cycle energy of different houses for couples with one child

House size (based on number of extra rooms)	Number of rooms	Total embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100
0 extra rooms (core house)	6	220.07	619.83	1087.80	1515.05	1967.78
1 extra room	7	269.96	775.35	1363.72	1924.53	2469.74
2 extra rooms	8	311.61	900.61	1582.84	2239.41	2874.06
3 extra rooms	9	371.22	1084.52	1903.93	2704.65	3470.92
4 extra rooms	10	394.42	1156.49	2028.97	2886.90	3705.24
5 extra rooms	11	457.59	1359.12	2380.48	3404.12	4369.18

Table 9.23 Total embodied and life cycle energy of different houses for couples with two children

9.5. Discussion

9.5.1. Initial embodied energy of different house sizes

As could be predicted, couples with 2 children live in the largest core houses (0EXR) and use more initial embodied energy than other household types. A couple with 2 children use 48.6% more energy in their house when first constructed than a couple (or a single person) for a core house, although this difference decreases to 42.1, 41.8, 37.8, 26.6 and 23.1% respectively when they select a house with 1, 2, 3, 4 and 5 extra rooms.

According to Figure 9.3, the initial embodied energy of a house with 1, 2, 3, 4 and 5 extra rooms for a single person or a couple is respectively 28.4, 48.6, 82.4, 110.8 and 151.4% more than that of a core house for the same household. In other words, with the energy equivalent of opting to live in a core house rather than a house with 5 extra rooms, a couple (or a single person) will be able to build 1.5 houses with a floor area of 70.7m^2 for couples (or single persons). By making the same decision, a couple with one child and a couple with two children will respectively be able to build 1.1 and 1.1 houses with floor areas of 96.17 and 120.21m^2 for their peer households.

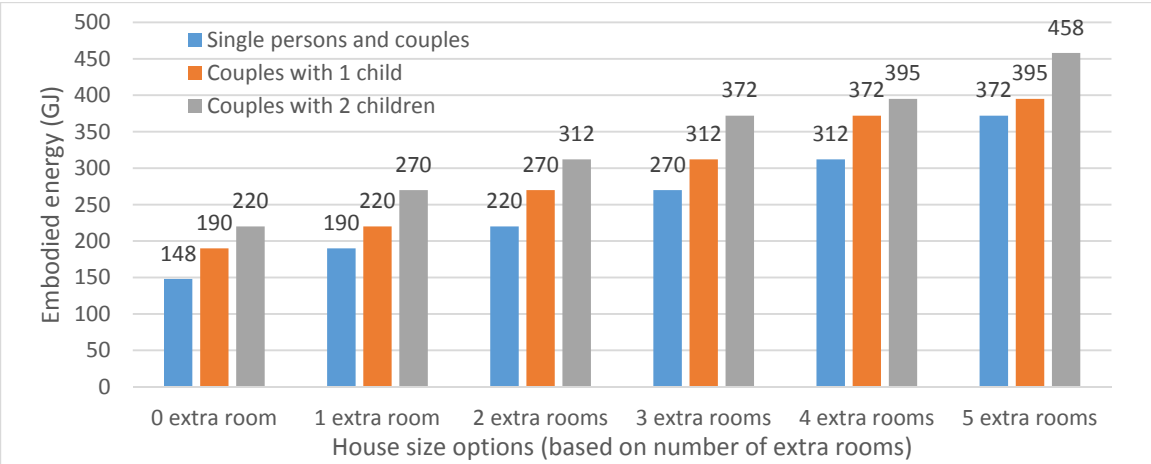


Figure 9.3 Initial embodied of houses and fittings based on number of extra rooms for four household types

In Figure 9.4 the embodied energy of different sized houses is broken down into building materials and sanitary space/kitchen fittings. This shows the embodied energy of fittings in a house with 5 extra rooms for a couple (or single person) is more than double that of a core house for the same household type. However, when the embodied energy of fittings was considered as a percentage of the total embodied energy, it was similar for all sizes of house, being 3.7-4.4% of total.

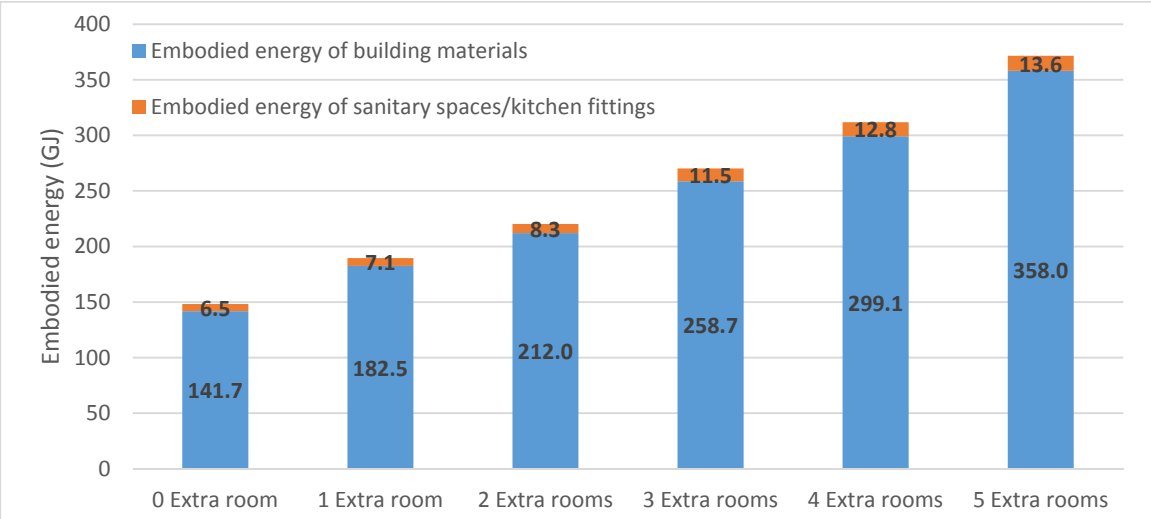


Figure 9.4 Embodied energy of building materials and sanitary/kitchen fittings for various sizes of house for a single person (or couple)

When people move from a core house to a larger house, apart from an increase in the overall embodied energy, how this embodied energy is distributed between the various parts of the house could also be important. Using the average floor area of each room type in each size of house (from section 7.4.5), this analysis shows that the distribution of embodied energy allocated to the various rooms changes with house size. As seen in Figure 9.5, the embodied energy allocated to bedrooms and living room/dining room/kitchen in core houses for single persons and couples is 34.4% and 46.3% although it decreases to 30.3% and 37.0% in houses with 5 EXR. On the other hand, the percentage of embodied energy allocated to specialised rooms and circulation spaces in core houses for the same two households is 0.0% and 7.9% although it increases to 6.9% and 14.6% in houses with 5 EXR. The embodied energy in sanitary spaces fluctuates between 9.0-11.4% for the variously sized houses.

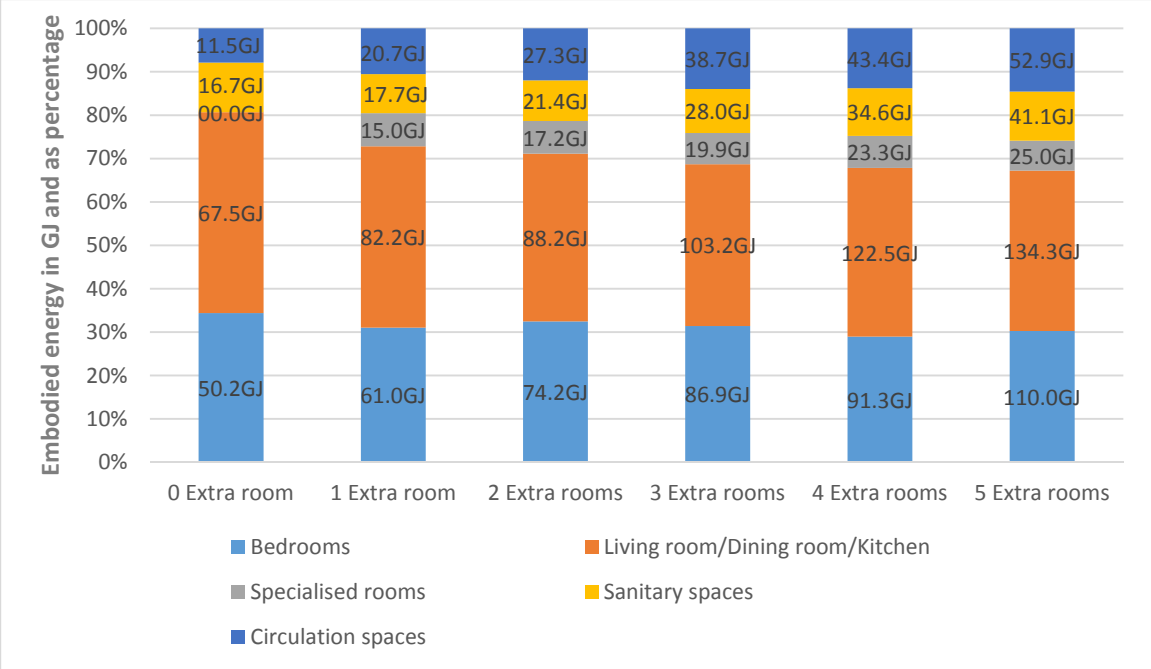


Figure 9.5 Distribution of embodied energy between various rooms in different sized houses for single persons and couples

Note- The share of the embodied energy of Laundry/Utility/Storage is not included in this graph because the average floor area of this room category, and hence the embodied energy, is very small. The small difference between the subtotal values of this graph and those of Figure 9.4 are related to this omission.

9.5.2. Life cycle energy of different sizes of house

Tables 9.21-9.23 show the embodied and life cycle energy after 0, 25, 50, 75 and 100 years for single person households, couples, and couples with one and two children living in 6 house sizes. Like embodied energy, the life cycle energy of larger households is bigger because they need larger core houses. By subtracting the life cycle energy of a house after 100 years from its initial embodied energy, it is possible to find the energy used for maintenance and heating of the house over 100 years. This reveals the maintenance and heating energy of a core house for a single person household or a couple over 100 years is 1135GJ, rising to 1475GJ (30.0% increase), 1749 (54.1% increase), 2201 (93.9% increase), 2564 (125.9% increase) and 3101GJ (173.2% increase) if this household selects to live in a house with 1, 2, 3, 4 and 5 EXR.

Table 9.24 summarizes the percentage increase in energy use if a single person household or couple select to live in a house larger than a core house. According to Table 9.24, larger houses have higher

increase rates of energy use for all life stages of the house. Table 9.24 also shows that for all house sizes rates of increase are higher at later life stages.

	Percentage energy use increase by selecting to live in larger houses rather than a core house (0 extra rooms)				
	1 extra room	2 extra rooms	3 extra rooms	4 extra rooms	5 extra rooms
Year 0	28.4%	48.6%	82.4%	110.8%	151.4%
Year 25	29.5%	52.7%	90.9%	121.8%	167.1%
Year 50	29.8%	53.5%	92.4%	123.3%	168.6%
Year 75	30.8%	56.2%	98.4%	130.8%	178.8%
Year 100	29.8%	53.5%	92.6%	124.1%	170.7%

Table 9.24 Increase in energy use by selecting to live in larger houses for a single person household (or couple)

9.5.3. Embodied and life cycle energy per person of different sized houses

As discussed, the embodied and life cycle energy associated with housing larger households is more than that of small households. However, this same energy is shared between more people. What is important in terms of energy use is how much energy is used by individuals. As a next step, the embodied and life cycle energy of each housing option is divided by number of people in each household (Figures 9.6-9.8).

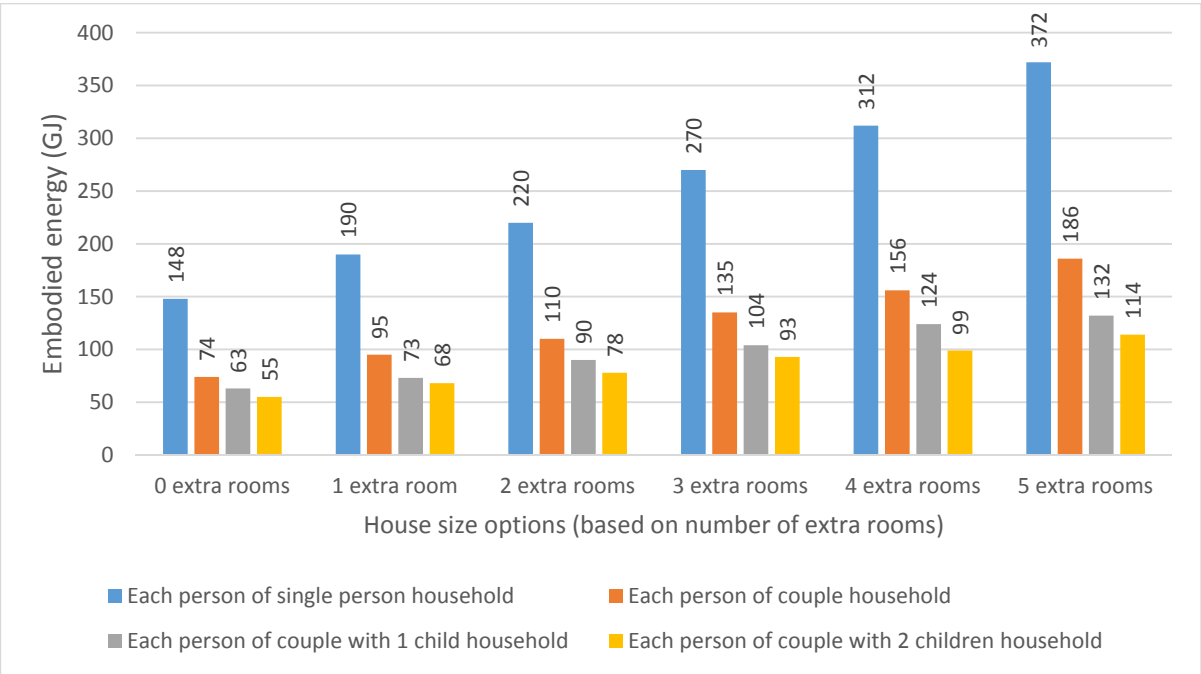


Figure 9.6 Embodied energy per person (year 0) of houses and fittings per person living as a single person household, couple, couple with one child and couple with two children

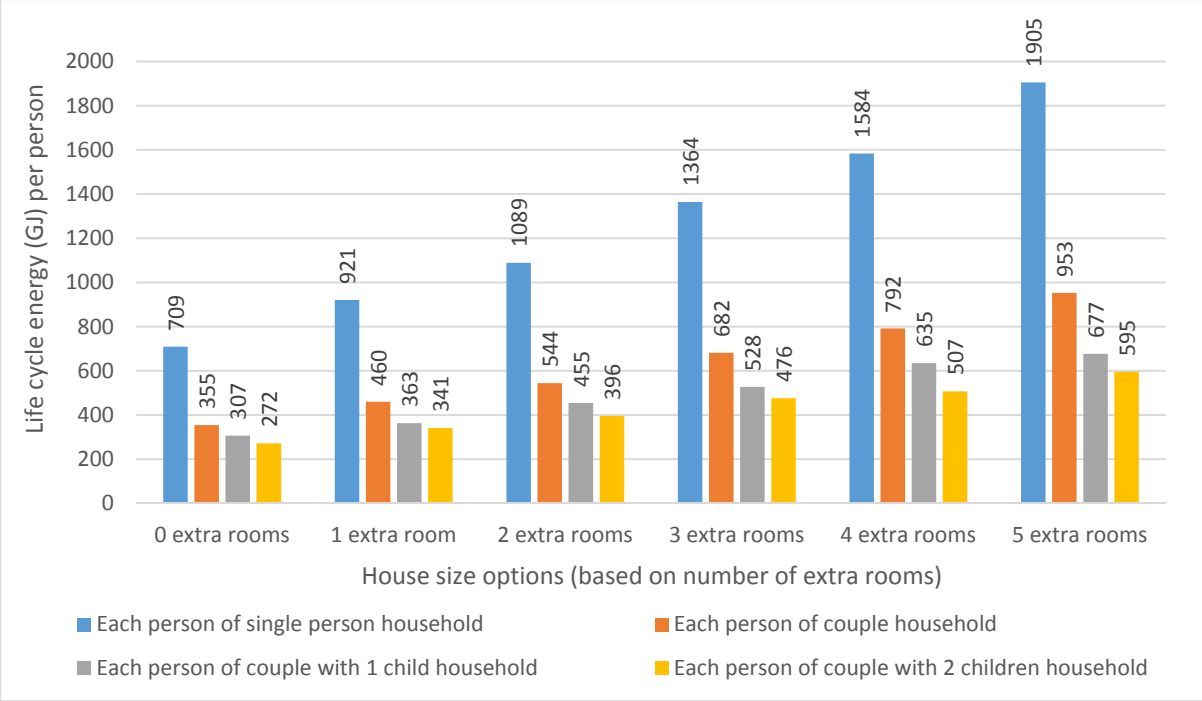


Figure 9.7 Life cycle energy per person (after 50 years) per person living in a single person household, couple, couple with one child and couple with two children

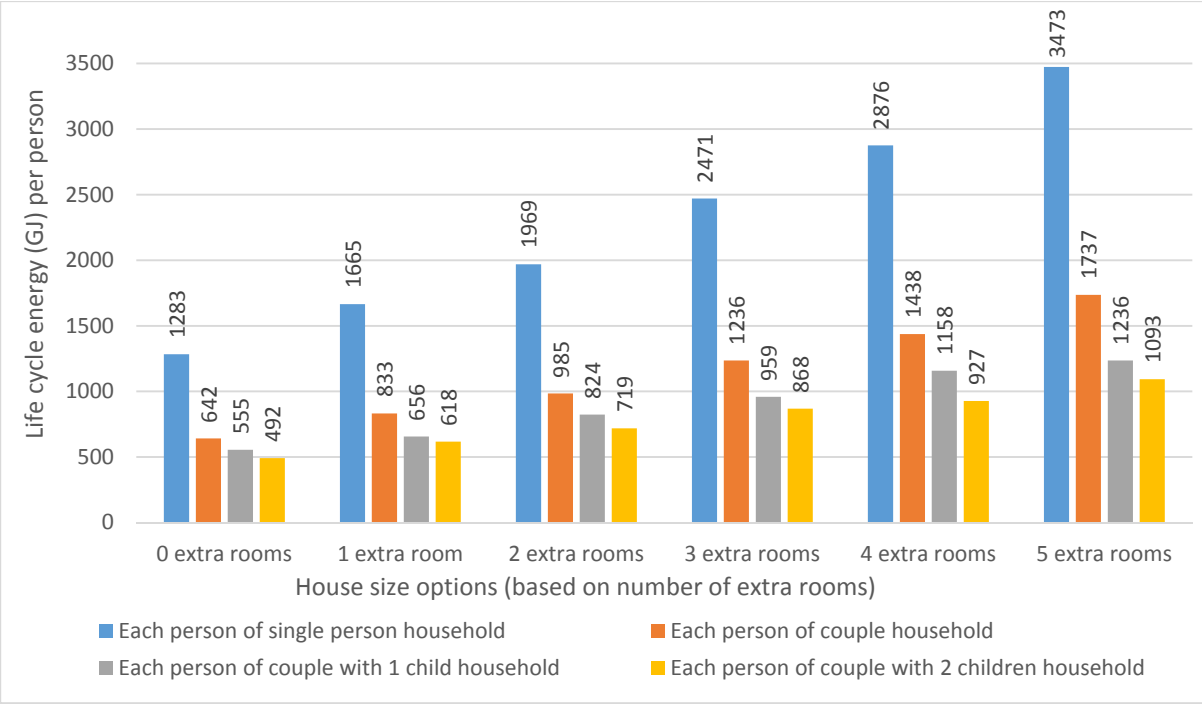


Figure 9.8 Life cycle energy per person (after 100 years) per person living in a single person household, couple, couple with one child and couple with two children

According to Figure 9.6, embodied energy per person is highest for single person households and lowest for couple with 2 children households. The energy use per person (in year 0) for someone in a single person household in a core house is 169% more than that for someone in a 4-person family in

a core house, while this difference increases to 226% when the single person lives in a house with 5 extra rooms.

9.6. Conclusion

This analysis indicates that human decisions in terms of selecting house size have a significant effect on the embodied and life cycle energy of the house, with the latter several times the size of the former. By selecting to build a core house with 0 extra rooms rather than 3, a single person household, couple, couple with 1 child and couple with 2 children will respectively save 122, 122, 122 and 152GJ of initial embodied energy. With this energy equivalent it is possible to build respectively 0.8, 0.8, 0.6 and 0.7 core houses for same sized households.

Over the life cycle of the house, the energy saving becomes even more, as with the energy equivalent of living in a core house rather than a house with 3 extra rooms over 100 years, it is possible to build and operate 0.9, 0.9, 0.7 and 0.8 core houses for same sized households. It should be noted that this includes heating the whole house to a reasonable comfort level over the winter, which would bring health benefits with it (Howden-Chapman et al., 2012). A house with 3 extra rooms for a single person or couple means a combined living/dining/kitchen with 3 bedrooms and a study, which is the most frequent house layout in New Zealand (44.5% of the total private occupied dwellings in census 2013 (Statistics New Zealand, 2013b)) while for a couple with 2 children it means a 4 bedroom house with a combined living/dining/kitchen, a study and a games room, which is also popular. The energy difference is even more if living in houses with more than 3 extra rooms.

This clearly shows that the existing trend in New Zealand housing means each household is using almost double the energy required to satisfy core housing needs. However, having larger houses than strictly necessary also means having more furniture and appliances inside these, and the impact of this is explored in Chapter 10.

10. Furniture and appliances

10.1. Introduction

Large houses are believed to include more appliances (Mithraratne, 2013). Fuller et al. (2009:8) in a study of the effect of house size on the life cycle energy of typical Australian houses state "it is self-evident that people do not live in houses with empty rooms" meaning houses with more rooms will have more furniture. It seems, therefore that furniture and appliances could have a significant effect on the life cycle energy of a house although it is not clear how a change in house size might affect this. At the same time, considering that larger households should need more furniture and appliance items, it is also not clear whether house size or household size is the key parameter for number of furniture items and appliances in a house.

The energy associated with furniture and appliances could become significant as these items generally have a short life and are changed several times over the life cycle of a building (Treloar et al. (1999) and Vale and Vale (2009)). People do not always change their furniture and appliances because of planned obsolescence, or wearing out through heavy use, but sometimes because of changes in fashion or technology (Mithraratne et al., 2007). Most residential life cycle studies do not consider furniture and appliances (Alcorn, 2010), or only include selected items of both (Mithraratne et al. (2007), Fay (1999) and Fay et al. (2000)). A study by Treloar et al. (1999) of an office building showed office furniture, fixtures and fittings formed a significant part of the life cycle energy of the office building over 40 years. Vale and Vale (2009) showed that by living in a 100m^2 rather than a 200m^2 house, it is possible to save 87-137GJ over the life cycle of the house [50 years] although it is not clear what type of furniture was included in their analysis.

Some furniture and appliance items such as a fridge, washing machine and somewhere to sleep and sit are essential for all households regardless of their housing tenure and house size, although the number of other furniture and appliance items could be higher in larger houses (Vale & Vale, 2009). Comparing a house with a formal living room and a family room with a house with only one living

room, it is obvious the former needs more sofas and armchairs, and possibly two TVs, to furnish the two living rooms. This will also happen for beds in houses with extra bedrooms. However, it is unlikely that a large house would have two ovens or laundry tubs, although having a large house on a large plot could be a reason for having more outdoor furniture (Vale & Khajehzadeh, 2016). The unsettling part of this latter point is that a report by the International Tropical Timber Organization and International Trade Centre (2005) says that while tropical countries are the main producers of the raw material for wooden furniture, none are among the world's eight leading furniture markets (US, Japan, Germany, UK, France, Canada, China and Belgium/Netherlands/Luxemburg). A press report released by Green Peace New Zealand (2008) indicates that "the majority of outdoor timber furniture sold in New Zealand is contributing to the destruction of tropical forests in Indonesia and Papua New Guinea".

Some households will use second hand or antique furniture and even second hand appliances. In this case, the embodied energy of these items should be considered zero as the first owner is assumed to be responsible for these, although the operating energy for second hand appliances should still be taken into account in a house life cycle analysis. It seems probable that people with higher incomes might make less use of second hand furniture and appliances, although there is no study to show whether this is true. This issue has started to be addressed in this chapter.

Overall it seems that opting to live in a large house implies there will be more of some furniture items and appliances, and these will probably be new. This means house size will have an effect not just on the resources that go into house but also on the things it contains. This chapter, therefore, investigates the different types of furniture/appliances people report in different sized houses/households and whether or not they were obtained new or second hand. The resources attached to these furniture and appliances are then analysed employing a life cycle approach to see how decisions in terms of house size affect the life cycle energy of a house. Having more appliances can also affect the life cycle energy of a house by increasing the operation energy attached to these additional items. However, it

is assumed that these are included in the overall operation energy of the house, which was discussed in Chapter 9.

10.2. Methodology

As discussed in Chapter 6, a significant part of the questionnaire survey of study 2 was allocated to reporting the type and number of furniture items each participating household has. Overall 445 households took part in the survey of which 260 (58.4%) finished the furniture section, which forms the focus of this chapter. Apart from the items which were included in the questionnaire, respondents were able to add unlisted items. From the feedback received from studies 1 and 2, most respondents felt they had forgotten to include all their furniture/appliance items, which means that any calculation of the number of items or the energy associated with furniture, appliances and tools in the results of this study is an underestimate.

In total 131 items of furniture, appliances, tools and vehicles were covered in this survey. For this analysis, all items were put into 8 categories as presented in Table 10.1. Data on the number of furniture items, appliances and tools for all 260 households were gathered into a SPSS data set for further analysis. The subtotal of furniture items/appliances/tools in each of the 8 categories was calculated for each respondent. Several ANOVA one-way tests were performed in SPSS for each furniture/appliance category and for some selected items to see how the average number of each changed with house and household size.

The initial embodied energy of furniture and appliances was calculated using the input-output analysis on the basis of cost method developed by Treloar (1998). This method has been previously used by Fay (1999), Mithraratne et al. (2007) and Vale and Vale (2009) and is based on an estimated 8MJ/$ for furniture and 10MJ/$ for appliances (Treloar, 1998). It should be noted that Treloar's (1998) values are based on the Australian dollar although the difference between Australian and New Zealand dollar is ignored here.

Categories	Furniture/appliances included in the category
Bedroom/study furniture (12 items)	king/queen/double bed, single bed, bunk bed, cot, desk, wardrobe, desk chair, free standing rack, chest of drawers/dressing table, free standing mirror, shelves/book cases, bedside table/cabinet
Living room/dining room/kitchen furniture (27 items)	piano, 4-seater dining suite/table with chairs, 6-seater dining suite/table with chairs, 8-seater dining suite/table with chairs, 12-seater dining suite/table with chairs, armchair, double-seat couch/sofa, three-seat couch/sofa, four-seat couch/sofa, side table, coffee table, chair, chaise longue, stool, TV cabinet, ornamental sculptures/vases, buffet/sideboard, entertainment unit, display cabinet/unit, rug, chest, ottoman/footstool, floor lamp/standard lamp, wall clock, bench, bean bags, ironing board
Large appliances (13 items)	LED/LCD TV, Plasma TV, Cathode ray TV, fridge/freezer, fridge, bar fridge, freezer/chest freezer, dishwasher, cook top/hob, oven, stove/range, washing machine, dryer
Games/exercise furniture/equipment (6 items)	treadmill, exercise/weight machine, exercise cycle, table tennis table, billiard table, pool table
Outdoor furniture/appliances/tools (27 items)	outdoor chair/couch, drying/airing rack, spa pool, BBQ, outdoor umbrella/gazebo, outdoor dining/picnic table, outdoor coffee table, swing seat/hammock, sun lounger/deck recliner chair, trampoline, climbing frame, slide, swing, sand box, paddling pool, play house, lawn mower, leaf blower, hedge trimmer, weed eater, chipper, work bench, water blaster, chain saw, drop saw, drill, outdoor heater
Small appliances (33 items)	sewing machine, microwave, blender/mixer, sandwich maker, slow cooker/rice cooker, electric frying pan, electric deep fryer, bread maker, juicer, popcorn maker, coffee maker, ice cream maker, food processor, toaster, waffle iron, electric jug, water cooler, iron, hair dryer, hair straighter/hair curler, electric blanket, vacuum cleaner, steam cleaner, stereo, games console, DVD/Blu-ray player, laptop, desktop computer, combined printer-scanner-fax, combined printer-scanner, scanner, printer, fax
Heating/Ventilation appliances (8 items)	Electric bar heater, gas heater, electric oil filled radiator, heat pump, convector heater, wood burner/pellet burner, dehumidifier, fan
Vehicles (5 items)	car, boat, motorcycle/ scooter, bike, kayak

Table 10.1 Furniture, appliances and tools investigated in this study classified into 8 categories

For all furniture, appliance and tool items investigated in this study (excluding vehicles), the median price was obtained from major New Zealand suppliers (Briscoes (2016), Bunnings Warehouse (2016), Farmers (2016), Fishpond (2016), Freedom furniture (2016), Hammock shop (2016), Hart sport (2016), Harvey Norman (2016), Hoekstra Pianos (2016), Ifurniture (2016), Jump Flex (2016), Just Spas (2016), Morrison outdoor (2016), Noel Leeming (2016), Number one fitness (2016), Piano traders (2016), Pot Black (2016), PriceMe (2016), Rebel sport (2016), Rugs & More (2016), The Warehouse (2016), TradeMe (2016), Trampoline & Swing factory (2016), Vortex Spas (2016), Warehouse Stationary (2016) and Wellington water filters (2016)). A full list including median, minimum and maximum prices for all items is presented in Appendix 10.1.

As mentioned, in the survey all respondents were asked to report the number of each furniture, appliance and tool item. A spread sheet was created in Excel and, for each respondent, the number of each of these was multiplied by the relevant median price and then by 8 (for furniture) or 10 (for

appliances) to calculate the initial embodied energy of each item for each household in MJ. The values for each furniture/appliance/tool item were then added to become the initial embodied energy of furniture, appliances and tools for each household. In addition, the initial embodied energy of furniture, appliances and tools in each of the 7 categories (excluding vehicles) was calculated for each household. The results were then transferred to the source SPSS data set for further analysis.

Finding the useful life of each furniture, appliance or tool item (Appendix 10.1) gives the number of replacements at particular life stages (25, 50, 75 and 100 years). A spreadsheet was created for each life stage and the initial embodied energy of each furniture, appliance and tool item was multiplied by number of times it would be replaced at each life stage and the result added to its initial embodied energy. The subtotal of all items at each life stage is thus the embodied energy of furniture, appliances and tools for each household at each life stage. These values were also transferred to the source SPSS file for further analysis.

As the survey asked participants to report what percentage of each furniture, appliance or tool category they bought new, the effect of second hand furniture/appliances can also be taken to account and the results with and without second hand items compared. The number of each furniture, appliance or tool item for each house size was multiplied by the percentage of bought new items from the relevant category. This removes the second hand items from the life cycle analysis calculation.

Using number of rooms as an indicator of house size, the overall embodied energy of furniture, appliances and tools at different life stages was calculated and compared by house size. Adding the results to the embodied and life cycle energy of the house (including its fittings, maintenance, and operating energy) the overall energy used for different sizes of house was calculated and compared for the four household types.

10.3. Results

10.3.1. Average number of furniture items and appliances

Table 10.2 presents the most popular furniture items, appliances and tools, where popular is defined as an item possessed by at least 70% of the sample (the complete list of all items is in Appendix 10.2). Because a double, queen, king and bunk bed can all sleep two people and a single bed one person, the total number of bedspaces was also calculated (Table 10.2). In addition, because households might use a 4, 6, 8 or 12-seater dining suite, dining suites were also calculated according to the number seats. The same method is used for couches and sofas.

Furniture/Appliance item	Average per household	Average per person	Samples with at least one
King/Queen/Double bed	1.84	0.74	98.5%
Total number of bedspaces	4.83	1.94	99.6%
Desk	1.58	0.63	82.7%
Shelf/Bookcase	3.16	1.27	89.6%
Desk chair	1.47	0.59	80.4%
Chest of drawers/Dressing table	2.91	1.17	93.5%
Bedside table	2.60	1.04	89.6%
Total number of seats in a dining table	5.98	2.40	94.6%
Total number of seats in a couch or sofa	7.40	2.97	99.2%
Coffee table	1.12	0.45	77.7%
Ironing board	0.91	0.37	87.3%
Drying/Airing rack	1.30	0.52	81.5%
BBQ	0.79	0.32	71.5%
Outdoor dining/picnic table	0.91	0.37	73.1%
Drill	1.12	0.45	83.1%
All TVs	1.55	0.62	92.3%
Fridge/Freezer	1.07	0.43	92.3%
Oven/Stove/Range	1.19	0.48	97.3%
Dishwasher	0.82	0.33	79.2%
Washing machine	0.99	0.40	98.1%
Dryer	0.74	0.30	73.1%
Microwave	0.92	0.37	88.8%
Blender/Mixer	1.05	0.42	87.3%
Toaster	0.99	0.40	93.8%
Electric jug	1.00	0.40	92.3%
Iron	0.97	0.39	89.6%
Hair dryer	0.98	0.39	80.8%
Vacuum cleaner	1.15	0.46	95.4%
Stereo	1.05	0.42	76.2%
Laptop	1.05	0.42	87.3%
Car	1.55	0.62	95.0%

Table 10.2 Average number of popular furniture items and appliances and percentage of houses with at least one item

With 1 person in a single person household, 2 in couple households, 3 for couples with 1 child and 4 for couples with 2 children, on average 2.49 persons live in the sample houses, which is near the 2013 census occupancy rate of 2.65 persons/household (Statistics New Zealand, 2014c). Comparing the

average number of each item with the overall occupancy rate gives the average number of each item per person. According to Table 10.2, there are 1.9 bedspaces, 1.2 chest of drawers/dressing tables, 2.4 seats in a dining suite and 3.0 seats in a couch/sofa per person in the sample houses. In addition, on average, each household has more than one drill, TV, Fridge/Freezer, blender/mixer, vacuum cleaner, stereo which are all items that could be shared by household members. Do larger households have more furniture, appliances and tools?

The aim behind having a furniture item, appliance or tool is its use, although it is not clear whether having a larger household necessarily means having more furniture, appliances and tools. To investigate this, the subtotals of all furniture items, appliances and tools reported were added for each respondent household. Table 10.3 shows the mean, number of samples, Standard Deviation, and minimum and maximum number of furniture, appliance and tool items for the four household types. According to Table 10.3, the average number of these items increases with household size although the difference between number of items used by couples and couples with 1 and 2 children is very low. Looking at the minimum, maximum, and the Standard Deviation for number of items available to each household type, shows high variations between the four household types in terms of the number of furniture items, appliance and tools each have.

Household type	Mean	N	Std. Deviation	Minimum	Maximum
Single person	67.7	48	26.8	18	151
Couple	84.2	93	28.4	10	162
Couple with 1 child	89.5	63	27.6	45	160
Couple with 2 children	90.8	56	27.2	35	159
Total	83.9	260	28.7	10	162

Table 10.3 Mean, Standard Deviation, minimum and maximum number of all furniture, appliance and tool items by household type

An ANOVA one-way test showed that the subtotal of all furniture items/appliances/tools is significantly different by household size at 0.05 level ($F_{(3, 256)}$=7.49, p=0.000), although the further post-hoc test indicated that the significant difference occurs only between single person households and all other household types (Single person households & couples (M=-16.50, SD=4.92), Single person households & couples with 1 child (M=-21.73, SD=5.30), Single person households & couples with 2 children (M=-23.09, SD=5.44)). When the ANOVA test was repeated controlling the effect of house

size (the test was repeated for ≤5, 6, 7, 8 and 9-9+ room houses separately) the differences no longer remained significant at 0.05 level.

The subtotal of furniture items, appliances and tools in each of the 8 categories in Table 10.1 was calculated for each respondent household. Figure 10.1 shows the average number of furniture/appliance/tool items for each household type. This average increases with household size for some categories (Bedroom/Study furniture, Small appliances and Vehicles) but not for all. For instance, the average number of Living room/Dining room/Kitchen furniture items peaks for couples, which might be related to possible higher incomes compared to other household types. Another reason could also be age because couples in the 65+ age group usually live in larger houses (see Figure 6.3 in section 6.5). The ANOVA one-way test was repeated to see the correlation between total number of furniture, appliance and tool items in each of the eight categories of Table 10.1 and household size (Table 10.4). Results of a further post-hoc test for each category (Table A.10.3.1 in Appendix 10.3), again indicated that single person households are usually the only household type with significantly fewer items in all categories, while no significant difference was found in the average number of furniture, appliances and tool items between other household types.

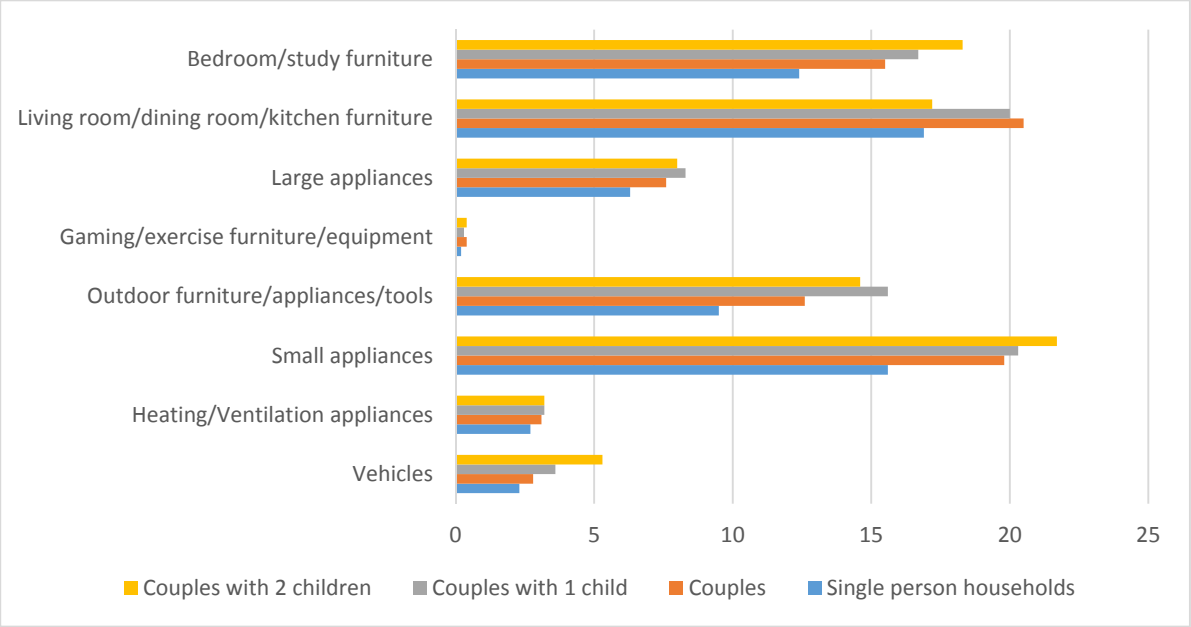


Figure 10.1 Average number of furniture/appliance/tool items of each category by household type

Category	F (3,256)	p-value	Result
Bedroom/study furniture	8.63	0.000	✓
Living room/dining room/kitchen furniture	2.56	0.056	×
Large appliances	7.46	0.000	✓
Gaming/exercise furniture/equipment	1.14	0.336	×
Outdoor furniture/appliances/tools	6.91	0.000	✓
Small appliances	6.06	0.001	✓
Heating/Ventilation appliances	0.77	0.513	×
Vehicles	20.92	0.000	✓

Table 10.4 Results of the ANOVA one-way test for dependency between average number of furniture, appliances and tool items (in 8 categories) and household size

10.3.2. Do larger houses have more furniture, appliances and tools?

As seen, the average number of all furniture items/appliances/tools does not necessarily increase with household size. An alternative assumption could be that people who live in larger houses have more of these. Accepting the number of rooms as an indicator of house size, this study shows that the average number of all furniture, appliances and tool items increases with house size (Table 10.5), although again the Standard Deviation and the difference between minimum and maximum values for each house size show variations. At the same time, comparing the Standard Deviation and mean for different house sizes, shows the ratio of Standard Deviation to mean is high for small houses but lower for large houses, meaning that having a high number of furniture, appliance and tool items tends to correspond with having a large house.

House size (Based on number of rooms)	Mean	N	Std. Deviation	Minimum	Maximum
≤5 rooms	58.5	41	22.9	18	123
6 rooms	74.3	68	21.9	37	162
7 rooms	86.0	55	22.7	43	145
8 rooms	97.2	34	22.3	55	158
9-9+ rooms	102.0	62	30.4	10	160
Total	83.9	260	28.7	10	162

Table 10.5 Mean, Standard Deviation, minimum and maximum numbers of all furniture, appliance and tool items by house size

An ANOVA one-way test was also performed and showed that the average number of all furniture, appliances and tool items is significantly different by house size at 0.05 level ($F_{(4, 255)}$=24.59, p=0.000). A further post-hoc test shows that generally larger houses have more furniture, appliances and tool items and the difference is significant between all house sizes apart from some consecutive sizes (i.e. 6 & 7, 7 & 8 and 8 & 9-9+ room houses) (see Table A.10.3.2 in Appendix 10.3). To control the effect of

household size on the results, the ANOVA test was repeated for samples of each household type separately and differences remained significant for all house sizes.

Figure 10.2 shows a breakdown of all furniture, appliance and tool items in the 8 categories for various house sizes. Looking just at the average number of furniture/appliances/tools for different house sizes shows, with some exceptions, generally larger houses have more furniture, appliances and tools compared to small houses although it is not clear if these differences are statistically significant. To examine this, an ANOVA one-way test was performed for the eight categories of these (Table 10.6). These tests show that apart from "Gaming/Exercise furniture/equipment" the average number of all furniture items/appliances/tools significantly changes by house size at 0.05 level. Results of a further post-hoc test indicates that significant differences occur between most house size categories apart from consecutive house sizes (e.g. ≤5 & 6 or 7 & 8 room house) (Table A.10.3.3 in Appendix 10.3).

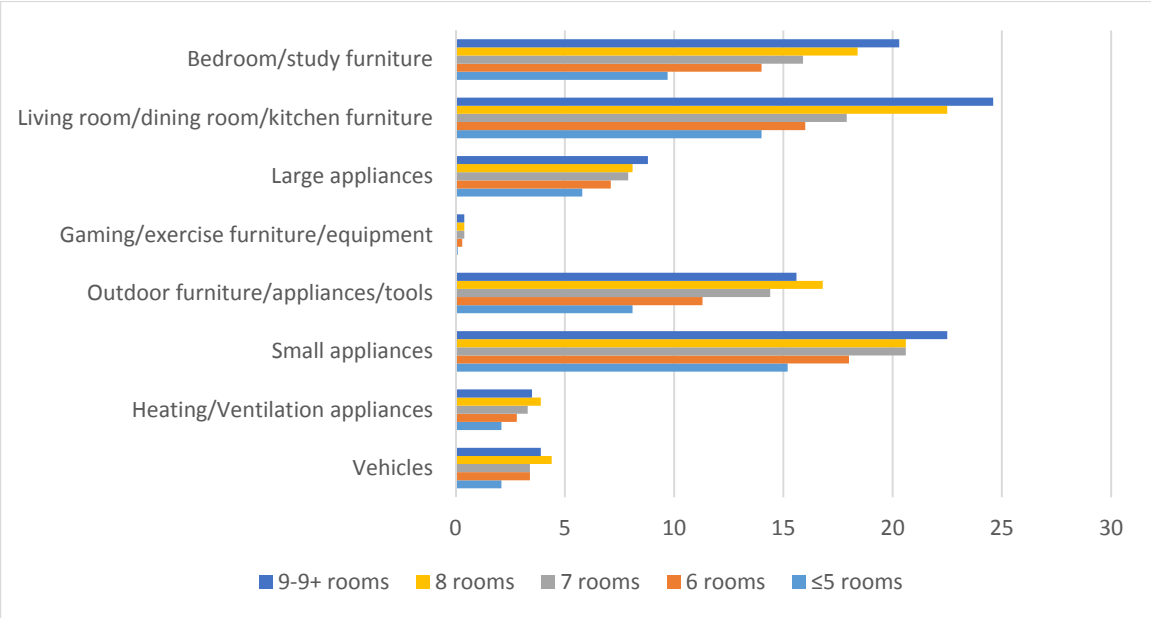


Figure 10.2 Average number of furniture/appliance/tool items for each category by house size

Category	F (4,255)	p-value	Result
Bedroom/study furniture	27.63	0.000	✓
Living room/dining room/kitchen furniture	13.63	0.000	✓
Large appliances	13.35	0.000	✓
Gaming/exercise furniture/equipment	1.78	0.134	×
Outdoor furniture/appliances/tools	10.80	0.000	✓
Small appliances	7.08	0.000	✓
Heating/Ventilation appliances	5.09	0.001	✓
Vehicles	5.17	0.001	✓

Table 10.6 Results of the ANOVA one-way test showing dependency between average number of furniture, appliances and tool items (in 8 categories) and house size

Results of this part of this study show that by adding 3 more occupants to a house, the average number of furniture, appliances and tool items increases by 34.1% while by adding 3 rooms to the house the increase rate is 66.2%, indicating that house size is a stronger reason for there being more furniture, appliances and tools in a house.

10.4. Embodied and life cycle energy of furniture, appliances and tools

10.4.1. Initial embodied energy of furniture, appliances and tools

After building a house, it has to be furnished to be used. In this study, it is assumed that all participating households start their life in their house with the items they state they have. At this stage all items are assumed to be new. Based on this, in year zero, the initial embodied energy of furniture, appliances and tools needs to be added to that of the house (building materials and fittings).

Table 10.7 presents the average, standard deviation, minimum and maximum of the initial embodied energy of furniture, appliances and tools for different sized houses. As seen, the average initial embodied energy increases with house size. Comparing the Standard Deviation to the mean for each house size shows that the former is 19.5-31.0% of the mean indicating that the mean for each house size does represent the majority of the sample for that size. An ANOVA one-way test was performed and showed that the average initial embodied energy of furniture, appliances and tools is significantly different by house size at 0.05 level ($F_{(4,255)}$=26.66, p=0.000). Results of a further post-hoc test indicate that apart from pairs of 7 & 8 and 8 & 9-9+ room houses, the difference is significant at 0.05 level between all house size pairs (Table A.10.3.4 in Appendix 10.3).

House size (based on number of rooms)	Mean (GJ)	N	Std. Deviation (GJ)	Minimum (GJ)	Maximum (GJ)
≤5 rooms	286.54	41	97.34	88.32	569.65
6 rooms	354.01	68	91.80	197.96	699.30
7 rooms	418.40	55	109.10	202.73	707.11
8 rooms	454.67	34	88.51	269.45	675.62
9-9+ rooms	497.66	62	154.22	68.95	902.09
Total	404.41	260	134.34	68.95	902.09

Table 10.7 Average, standard deviation, minimum and maximum initial embodied energy of furniture, appliances and tools in different sized houses

Initial embodied energy of furniture, appliances and tools was also calculated for 7 of the 8 categories (excluding vehicles). Figure 10.3 presents the share of each category in the initial embodied energy of

each house size, and reveals the initial embodied energy of all categories increases with house size, although the rate of increase differs. According to Table 10.7, the difference between the initial embodied energy of furniture, appliances and tools of a 9-9+ room and ≤5 room house is 211.1GJ. According to Figure 10.3 and comparing ≤5 and 9-9+ room houses, it can be concluded that 17.8% of this difference is rooted in Bedroom/Study furniture, 27.8% in Living room/Dining room/Kitchen furniture, 20.5% in Large appliances, 3.0% in Gaming/Exercise furniture/equipment, 13.3% in Outdoor furniture/appliances/tools, 10.7% in Small appliances and 6.9% in Heating/Ventilation appliances. Figure 10.3 also shows that the share of small and large appliances in the total initial embodied energy of furniture, appliances and tools of a house is 44-53%, with the share in small houses (53%) being greater than in large houses (44%). How this share might change over the life cycle of the house will be investigated in section 10.4.2.2.

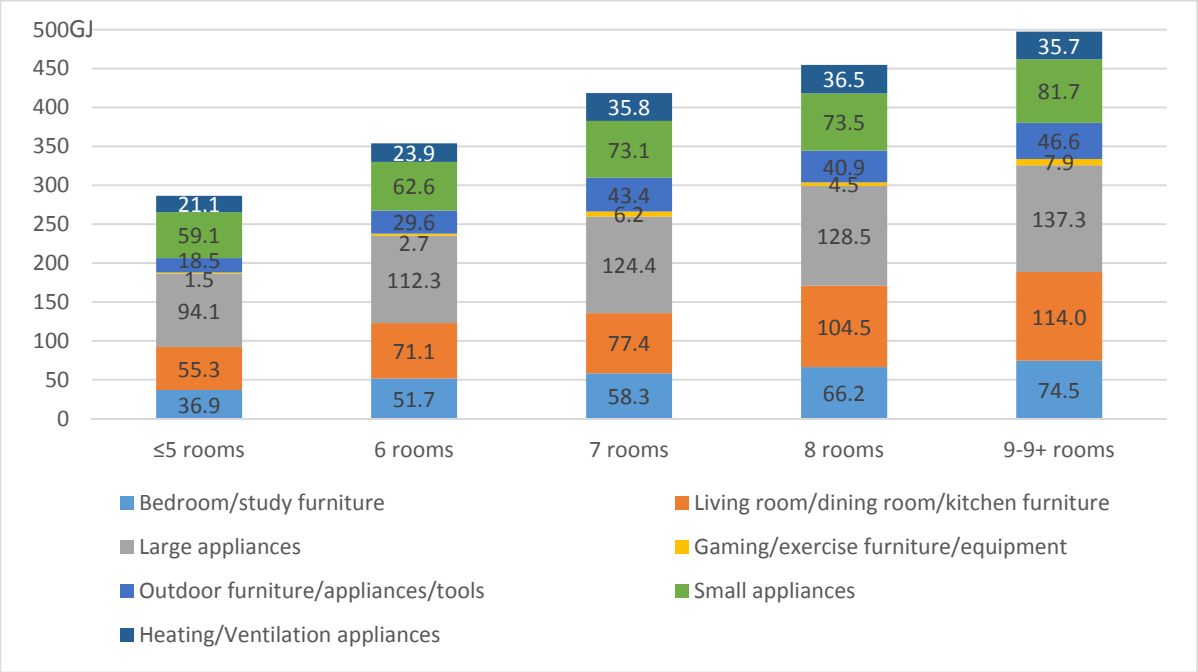


Figure 10.3 Initial embodied energy of furniture, appliances and tool categories (GJ) and the share of each category in the total for each house size

Several ANOVA one-way tests were performed to see if the initial embodied energy allocated to the various furniture, appliance and tool categories is different by house size. The results show that the initial embodied energy allocated to Bedroom/Study furniture ($F_{(4,255)}$=33.89, p=0.000), Living room/Dining room/Kitchen furniture ($F_{(4,255)}$=18.87, p=0.000), Large appliances ($F_{(4,255)}$=10.50,

p=0.000), Outdoor furniture/appliances/tools ($F_{(4,255)}$=7.19, p=0.000), Small appliances ($F_{(4,255)}$=4.49, p=0.002) and Heating/Ventilation appliances ($F_{(4,255)}$=5.85, p=0.000) is significantly different by house size at 0.05 level but not for Gaming/Exercise furniture/equipment ($F_{(4,255)}$=1.43, p=0.225). Figure 10.4 shows the details of these differences for the 7 categories.

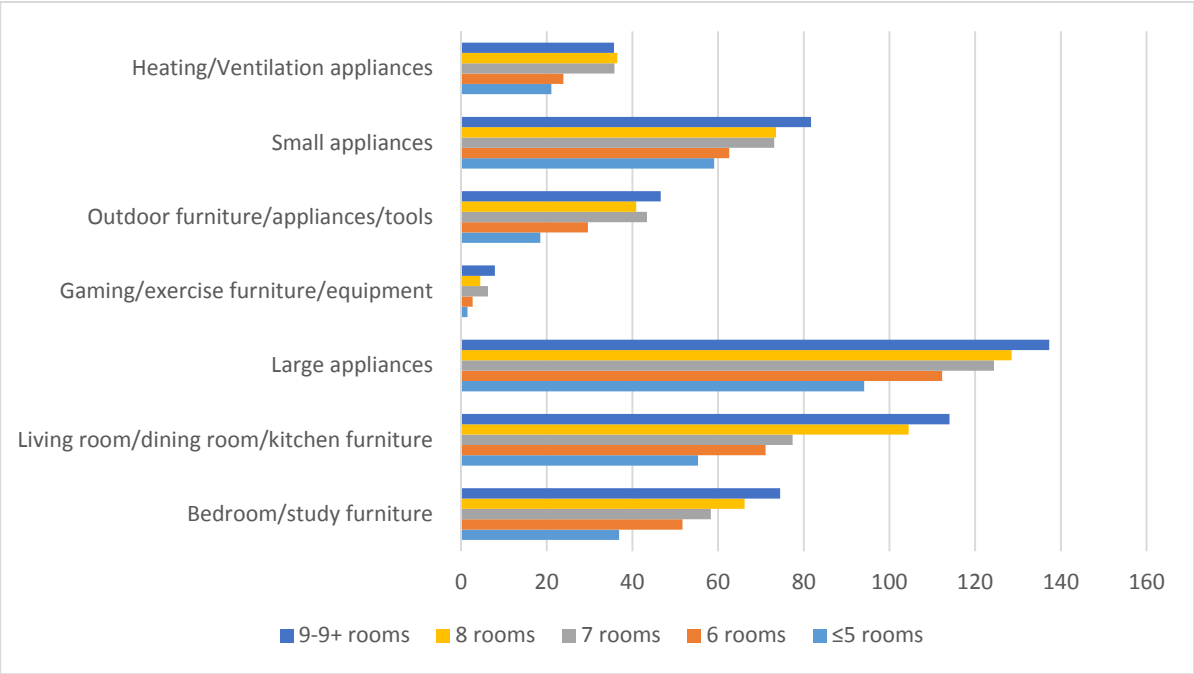


Figure 10.4 Initial embodied energy (GJ) of seven furniture, appliances and tool categories by house size

Initial embodied energies of furniture, appliances and tools were also compared between various household types (Table 10.8). This revealed the initial embodied energies of these as used by couples, couples with 1 child and couples with 2 children were quite similar but different from single person households. An ANOVA one-way test also indicates the average initial embodied energy of furniture, appliances and tools is significantly different by household type at 0.05 level ($F_{(3,256)}$=8.64, p=0.000) although a further post-hoc test shows that the significant difference only happens between single person and all other household types at 0.05 level. This study shows that the energy embodied in furnishing a house for a single person household is 74-77% that of other household types, which is important in terms of resource-use for an aging population, which will lead to an increase in small households (Saville-Smith et al. (2008) and Williams (2007)).

Household type	Mean	N	Std. Deviation	Minimum	Maximum
Single person	320.31	48	103.36	88.32	561.30
Couple	414.48	93	139.16	68.95	902.09
Couple with 1 child	429.77	63	132.53	226.71	855.54
Couple with 2 children	431.25	56	125.88	202.73	796.72

Table 10.8 Average, standard deviation, minimum and maximum initial embodied energy used by different sized households for furniture, appliances and tool

Figure 10.5 presents the breakdown of the 7 furniture, appliance, and tool categories for each household type. It shows the energy in Bedroom/Study furniture, Outdoor furniture/appliances/tools and small appliances increases with household size, while couples have the highest embodied energy in living room/dining room/kitchen furniture and gaming/exercise furniture/equipment. Figure 10.5, shows that energy used for small and large appliances increases by household size although the difference between energy used by couples and couples with 1 or 2 children is not very big.

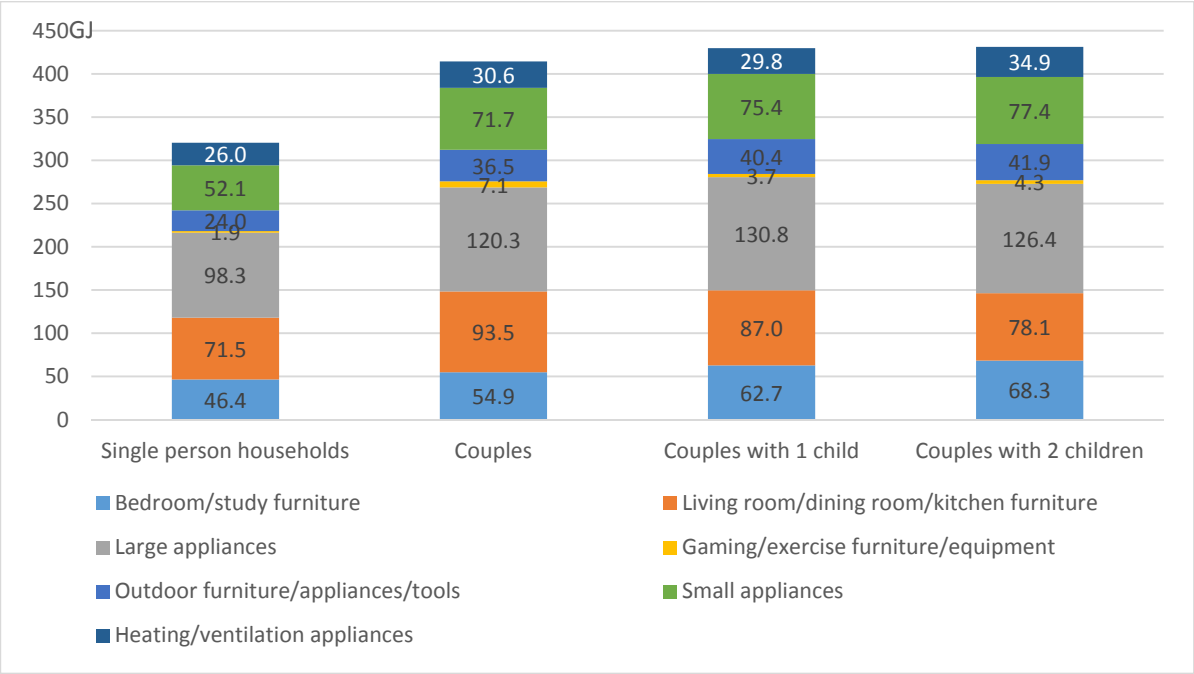


Figure 10.5 Breakdown of initial embodied energy of categories of furniture, appliances and tools (GJ) for each household type

10.4.2. Life cycle energy of furniture, appliances and tools

10.4.2.1. Useful life of furniture, appliances and tools

As noted in 10.4.1, all households need some furniture and appliances and energy is embodied in these. Over the life of the house people will probably change their furniture and appliances several times (Mithraratne et al., 2007). Seiders et al. (2007) believe “quality of installation”, “level of

maintenance", "weather and climate conditions" and "intensity of use" are the four parameters affecting the life expectancy of home components. They also believe that while some home components remain functional, people might wish to replace them because of changes in styles and preferences or technological improvements in new products. Many studies report the useful life of various furniture and appliance items although values are sometimes dramatically different. Mithraratne et al. (2007) and Fay (1999) used 14 years as the useful life of a washing machine although a study of the life expectancy of home components by Seiders et al. (2007) in the US and a study by Cooper (2004) in the UK report 10 years for the same appliance and, in contrast, Welch and Rogers (2010) assume 17 years as the useful life of a washing machine. The assumed useful life of an electric range varies from 13 to 25 years in studies by Seiders et al. (2007) and FannieMae (2014).

Considering these variations, Table 10.9 compares the useful life of types of furniture and appliances from various sources with references. As seen, the number of reported items is limited and there is no data for many furniture and appliance items found in this study. The New Zealand Inland Revenue (2015) publishes a comprehensive report on general depreciation rates in various business sectors. These rates have a relationship with useful life, although years for depreciation will be less than the useful life of an item. Noting this, values from "Hotels, motels, restaurants, cafes, taverns and takeaway bars", "Leisure", "Residential rental property chattels" and "Office equipment and furniture" categories are used for estimating useful life in this study. From Table 10.9 for each item, a useful life is selected by looking at all values, the average, and the average of values that most agree. It should be noted that reference N (New Zealand Inland Revenue, 2015) is not included in the average and final selected figures and is only there for comparison. As seen in Table 10.9, the useful life of most items in reference N is half that of the other references. Based on this, reference N is used for some items but is multiplied by 1, 2 or 4 based on experience. Appendix 10.1 presents the assumed useful life for each item and the reference on which the decision is based.

Furniture item/appliance/tool	Useful life (year) from other studies														Useful life in this study (Years) + selected reference(s)
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
Stove/Range (electric)	15	15	15	25	13-15	16	16	13-15	13	-	17	13	13	8	15 (A, B, C, E and H)
Stove/Range (gas)	-	-	-	-	-	19	18	15-17	15	-	19	15	-	-	17 (H)
Oven (electric)	15	-	-	-	-	-	-	10-18	-	-	-	-	-	-	15 (A)
Microwave	12	12	-	12	-	8	10	9	8-9	-	10	9	9	8	9 (H, I, L and M)
Fridge/freezer	17	17	15	20	13-19	14	13	9-13	9	17	14-19	13	12	-	15 (C)
Freezer	17	-	-	-	-	16	12	10-20	11	19	-	11	12	8	11 (I and L)
Toaster	8	-	-	-	-	-	-	-	-	-	-	-	-	4	8 (A)
Electric Jug	8	-	-	-	-	-	-	-	-	-	-	-	-	4	8 (A)
Washing machine	14	14	15	-	10-14	12	11	5-15	12	17	11-14	10	10	-	12 (E, F, H, I and K)
Dryer	18	18	15	-	10-13	14	12	13	13	16	13	13	10	7	14 (F)
TV	10	-	-	10	-	-	-	-	-	-	-	-	11	5	10 (A and D)
DVD player	10	-	-	-	-	-	-	-	-	-	-	-	10	5	10 (A and M)
Iron	8	-	-	-	-	-	-	-	-	-	-	-	-	4	8 (A)
Vacuum cleaner	8	-	-	-	-	-	-	-	-	-	-	-	9	3	9 (M)
Desktop computer	5	-	-	-	-	-	-	-	-	-	-	-	9	4	5 (A)
Dishwasher	-	13	20	10-12	9	12	11	9	13	13	10	9	10	7	12 (D and F)
Heater	-	20	-	20	-	-	-	-	-	-	-	-	-	-	20 (B and D)
Furniture (in general)	25	25	-	-	-	-	-	-	-	-	-	-	-	10	Varied
Heat pump	-	-	-	20	15-20	-	-	10-15	-	-	-	16	-	-	16 (E and L)
Dehumidifier	-	-	-	-	-	-	-	8	8	-	-	8	-	4	8 (H, I and L)
Cooktop	-	-	-	-	-	-	-	-	-	-	13-20	-	-	-	17 (K)
Stereo	-	-	-	-	-	-	-	-	-	-	-	-	11	5	11 (M)
Home and garden tools	-	-	-	-	-	-	-	-	-	-	-	-	10	-	10 (M)
Fax	-	-	-	-	-	-	-	-	-	-	-	-	10	4	10 (M)
Toys	-	-	-	-	-	-	-	-	-	-	-	-	6	-	6 (M)

Table 10.9 Useful life of some furniture/appliance items from other studies compared with values from New Zealand Inland Revenue (2015) and the useful life assumed in this study

A: Mithraratne et al. (2007) B: Fay (1999) C: Blanchard and Reppe (1998)
D: FannieMae (2014) E: Fiol (2013) F: Mr. Appliance (2016)
G: Statista (2011) H: InterNACHI (2016) I: Brown (2011)
J: Welch and Rogers (2010) K: Demesne (2010) L: Seiders et al. (2007)
M: Cooper (2004) N: New Zealand Inland Revenue (2015)

10.4.2.2. Life cycle energy of furniture, appliances and tools after 25, 50, 75 and 100 years

Using the initial embodied energy values (year 0) and the useful life of each furniture, appliance or tool item, a spread sheet was created and the life cycle energy of furniture, appliance and tools of each household was calculated for 25, 50, 75 and 100 years. For the reasons explained in section 9.1, operating energy of appliances over the life cycle of the house is excluded from this analysis. Hence, the term life cycle energy used in this chapter indicates a partial life cycle energy.

Table 10.10 and Figure 10.6 show the subtotal embodied energy of furniture, appliances and tools for different sized houses after 0, 25, 50, 75 and 100 years. Looking at the average value of the whole sample shows that after 25 years the embodied energy value of furniture and appliances triples showing an increase rate of 182%. Accepting a 6 room house is a standard 3 bedroom house, by living

in a house with 2 more rooms (i.e. 8 room house), a typical household will use 100.7GJ more in year 0 for furnishing their larger house and this difference will increase to 255.7, 456.3, 624.1 and 834.3GJ after 25, 50, 75 and 100 years. This clearly shows that the embodied energy of furniture, appliances and tools becomes significant over the life of a house because of the short replacement cycles.

House size (based on number of rooms)		Embodied energy of furniture, appliances and tools at different life stages (GJ)				
		Year 0	Year 25	Year 50	Year 75	Year 100
≤5 rooms (N=41)	Mean	286.5	843.5	1532.7	2155.5	2837.4
	Std. Deviation	97.3	303.9	556.6	776.4	1038.9
6 rooms (N=68)	Mean	354.0	1004.2	1806.0	2525.2	3330.9
	Std. Deviation	91.8	267.9	482.1	668.1	896.8
7 rooms (N=55)	Mean	418.4	1184.9	2136.6	2981.9	3941.6
	Std. Deviation	109.1	319.1	585.9	818.4	1089.8
8 rooms (N=34)	Mean	454.7	1259.9	2262.3	3149.3	4165.2
	Std. Deviation	88.5	312.5	576.9	807.7	1090.6
9-9+ rooms (N=62)	Mean	497.7	1386.6	2485.2	3461.4	4574.4
	Std. Deviation	154.2	487.0	879.2	1230.5	1643.8
Total (N=260)	Mean	404.4	1141.7	2054.5	2868.4	3787.9
	Std. Deviation	134.3	397.5	717.5	998.3	1334.2

Table 10.10 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size

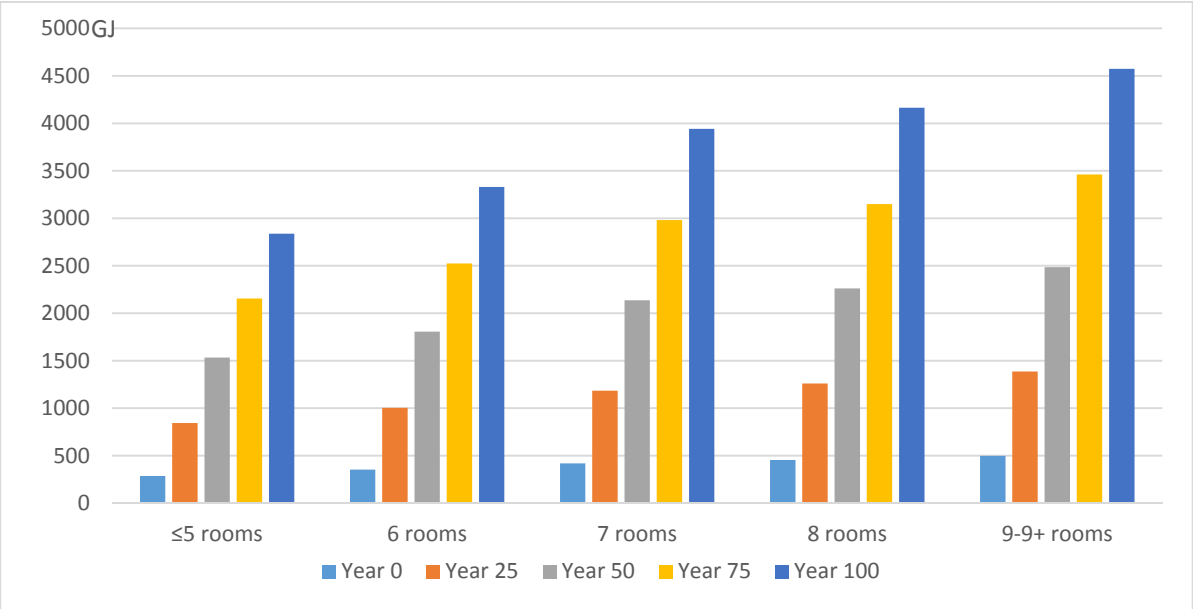


Figure 10.6 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size

Apart from the overall changes in the life cycle energy related to furniture, appliances and tools over the life of a house, where these increases are mainly rooted is also important. Figure 10.7 presents the breakdown of the 7 furniture, appliance and tools categories at the various life stages. The share of small appliances increases over the life of the house and the increase rate is quite significant. On the other hand, the contribution of the embodied energy in Bedroom/study furniture and Living

room/dining room/kitchen furniture decreases over the life of the house, while the contribution of other categories fluctuates (Large appliances, Gaming/exercise furniture/equipment, Outdoor furniture/appliances/tools and Heating/ventilation appliances). Figure 10.7 also shows that together small and large appliances make up 50.6% of the total life cycle energy of furniture/appliances/tools in a house in year 0, increasing to 58.5%, 60.3%, 62.3% and 62.1% after 25, 50, 75 and 100 years. The reason is that most appliances have a short useful life and are replaced several times over the house life cycle. In addition, the number of appliances is quite high in New Zealand houses.

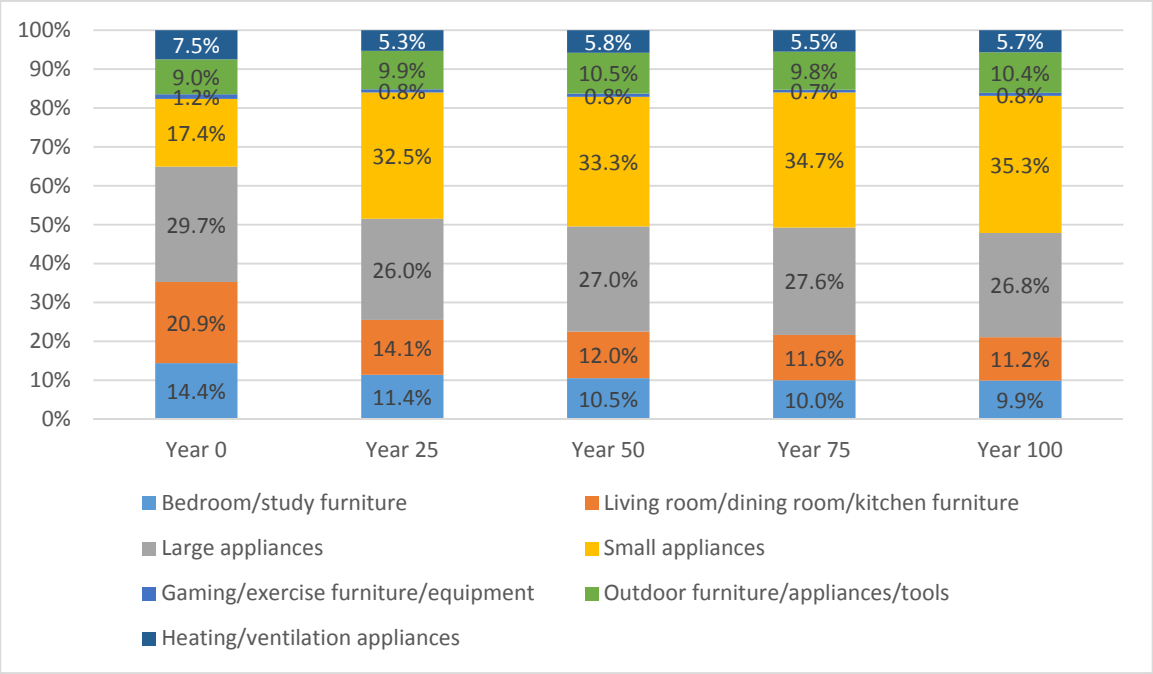


Figure 10.7 Break down of the embodied energy of furniture, appliances and tools at various life stages of a house

10.4.3. Second hand furniture/appliances

This survey asked participants to report the percentage of each furniture item/appliance they obtained new or second hand for their house. Table 10.11 presents the average results by house size noting that only the percentage of bought new items is shown (second hand items are this figure subtracted from 100). Overall larger houses contain more new items. In addition, Table 10.11 indicates kitchen and laundry appliances account for the highest level of new items and Vehicles and Exercise/Play equipment the most second hand items.

The energy embodied in a second hand item is calculated for the first user and would be zero for the household using the second hand item. Figures in Table 10.11 indicate that a significant percentage of furniture, appliances and tools are provided second hand and this can affect the life-cycle embodied energy of houses.

	Percentage of items bought new							
House size	Bedroom furniture	Living room/Dining room furniture	Kitchen appliances	Laundry appliances	Outdoor furniture	Gardening equipment/ tools	Vehicles	Exercise/Play equipment
≤5 rooms	61.2%	53.0%	74.2%	53.0%	44.7%	58.0%	27.2%	23.2%
6 rooms	61.2%	54.0%	82.1%	78.9%	57.4%	71.9%	16.3%	33.4%
7 rooms	67.1%	66.2%	80.2%	84.6%	62.7%	80.1%	27.7%	42.1%
8 rooms	72.1%	67.9%	84.6%	86.0%	78.4%	81.4%	24.9%	43.8%
9-9+ rooms	76.6%	65.5%	91.7%	85.0%	74.6%	70.8%	35.5%	44.3%
Total	67.1%	60.7%	82.7%	78.0%	62.8%	72.4%	25.7%	37.2%

Table 10.11 Percentage of furniture items/appliances bought new in different sized houses

To consider the effect of second hand items, the number of each furniture, appliance or tool item for each household was multiplied by the percentage of bought new items from the relevant category in Table 10.11. For instance, if a household has 4 double beds and also stated that only 30% of bedroom furniture is bought new, then only 1.2 double beds (30% × 4) will be included in calculations of the initial embodied and life cycle energy of the house. Apart from this, all other calculations remain as previously.

The effect of second hand furniture, appliances and tool items is adjusted in this way for all sample households. Table 10.12 is an update of Table 10.7 showing the average, number of samples, standard deviation, minimum and maximum initial embodied energy of different sized houses considering the effect of second hand items. A comparison of figures in Tables 10.7 and 10.12 indicates that generally the average initial embodied energy of furniture, appliances and tools has decreased between 37-44% for all houses sizes and the decrease rate is higher for small houses. In addition, standard deviation has increased for all house sizes. Considering an increase in the average and a decrease in the standard deviation, it can be concluded that there are higher variations between different households using second hand items. Finally, it is interesting to note that the minimum initial embodied energy has decreased to 0.00GJ for all house sizes showing that there are samples in all house sizes using only second hand (or antique) items.

House size (based on number of rooms)	Mean (GJ)	N	Std. Deviation (GJ)	Minimum (GJ)	Maximum (GJ)
≤5 rooms	159.69	41	107.47	0.00	518.64
6 rooms	210.59	68	124.30	0.00	537.44
7 rooms	247.40	55	154.47	0.00	523.63
8 rooms	288.21	34	168.11	0.00	628.13
9-9+ rooms	291.71	62	222.12	0.00	841.91
Total	239.84	260	167.87	0.00	841.91

Table 10.12 Average, standard deviation, minimum and maximum initial embodied energy in different sized houses for furniture, appliances and tools considering the effect of second hand items

Figure 10.8 illustrates the initial embodied energy of furniture, appliances and tools with and without the effect of second hand items. The energy saved through using second hand items in large houses is more than in small houses, which is related to having more furniture, appliances and tools in larger houses.

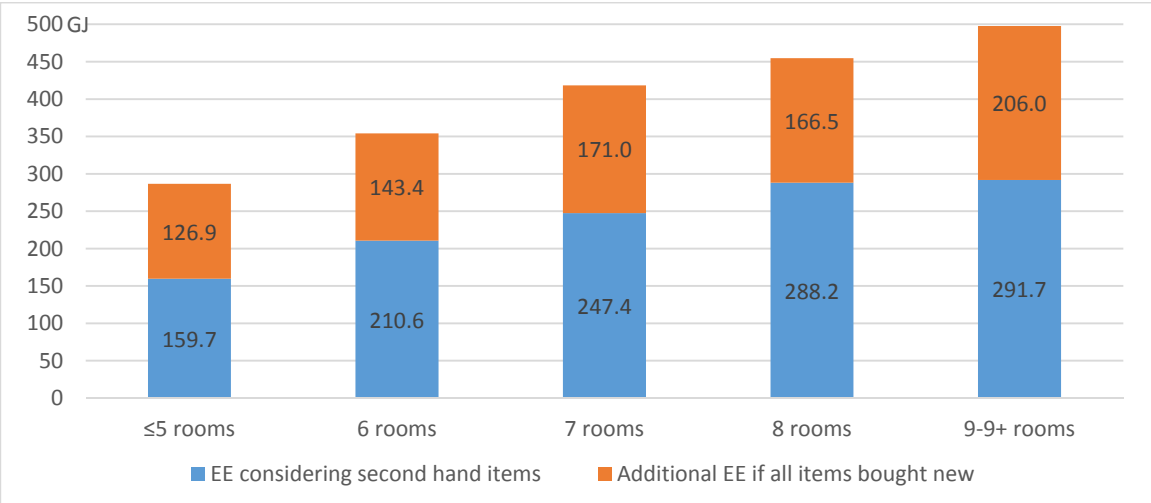


Figure 10.8 Initial embodied energy of furniture, appliances and tools with and without considering second hand items

An ANOVA one-way test was performed again using the initial embodied energy values after considering the effect of second hand items. This showed the average initial embodied energy of furniture, appliances and tools remains significantly different by house size at 0.05 level ($F_{(4,255)}$=5.41, p=0.000), although results of a further post-hoc test indicate that the significant difference does not occur between houses of consecutive sizes (6 and 7 or 7 and 8 room houses).

Table 10.13 is an update of Table 10.8 considering the effect of second hand items. A comparison of Tables 10.8 and 10.13 indicates that for all household types, the average initial embodied energy of furniture, appliances and tools has decreased but the standard deviation has increased. Again the reason lies in the variation in the number of households using or not using second hand items. The

ANOVA one-way test was repeated using modified values after considering the effect of second hand items and showed that the initial embodied energy of furniture, appliances and tools remains significantly different by household size at 0.05 level ($F_{(3,256)}$=4.37, p=0.005) and again the post-hoc test results indicate that only single person households are significantly different from other household types at 0.05 level.

Household type	Mean (GJ)	N	Std. Deviation (GJ)	Minimum (GJ)	Maximum (GJ)
Single person	165.97	48	124.63	0.00	430.00
Couple	256.91	93	173.77	0.00	841.91
Couple with 1 child	240.39	63	171.35	0.00	587.18
Couple with 2 children	274.20	56	171.37	0.00	681.36

Table 10.13 Average, standard deviation, minimum and maximum initial embodied energy (Year 0) used by different household sizes for furniture, appliances and tools

Table 10.14 and Figure 10.9 show the revised initial and life cycle energy of furniture, appliances and tools after 0, 25, 50, 75 and 100 years. A comparison of Tables 10.10 and 10.14 indicates that by using second hand items, samples in this study have saved 165GJ in year 0 and 517, 934, 1312 and 1748GJ after 25, 50, 75 and 100 years. In percentage terms this means a 41% energy saving in year 0 and 45, 45, 46 and 46% energy savings in years 25, 50, 75 and 100. By using the level of second hand items found in the survey rather than all bought new, occupants of ≤5 room houses will respectively save 127, 427, 778, 1102 and 1465GJ after 0, 25, 50, 75 and 100 years. The comparable figures for occupants of 9-9+ room houses are 206, 628, 1130, 1580 and 2110GJ, nearly double the values of ≤5 room houses.

House size (based on number of rooms)		Embodied energy of furniture, appliances and tools at different life stages (GJ)				
		Year 0	Year 25	Year 50	Year 75	Year 100
≤5 rooms (N=41)	Mean	159.7	416.7	755.0	1053.7	1372.1
	Std. Deviation	107.5	284.7	513.6	713.6	936.0
6 rooms (N=68)	Mean	210.6	553.0	993.7	1385.3	1809.9
	Std. Deviation	124.3	330.0	590.3	817.2	1078.8
7 rooms (N=55)	Mean	247.4	647.6	1163.7	1614.3	2122.7
	Std. Deviation	154.5	403.3	725.4	1003.4	1324.3
8 rooms (N=34)	Mean	288.2	735.4	1317.3	1822.1	2395.1
	Std. Deviation	168.1	437.7	788.2	1087.0	1433.8
9-9+ rooms (N=62)	Mean	291.7	758.2	1355.6	1881.1	2464.5
	Std. Deviation	222.1	593.4	1064.8	1472.3	1940.5
Total (N=260)	Mean	239.8	624.3	1120.6	1556.8	2039.7
	Std. Deviation	167.9	442.9	794.3	1097.8	1447.9

Table 10.14 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size and considering the effect of second hand items

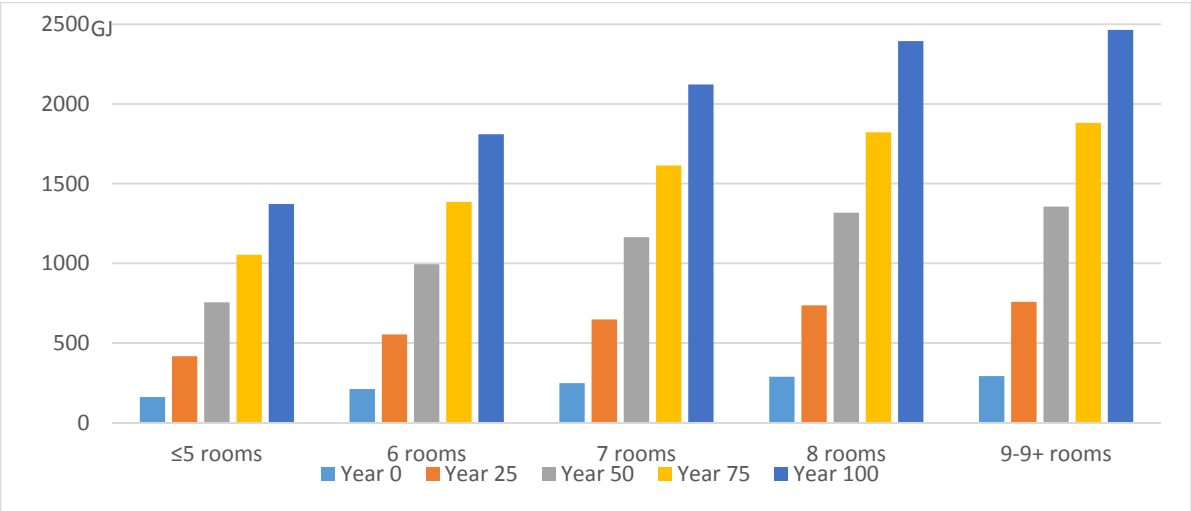


Figure 10.9 Initial and life cycle energy (GJ) of furniture, appliances and tools after 25, 50, 75 and 100 years by house size and considering the effect of second hand items

The breakdown of the total embodied energy accounting for use of second hand items into the 7 furniture, appliance and tool categories of all sample houses at various life stages is shown Figure 10.10 (an update of Figure 10.7). A comparison of these two figures shows that by considering the effect of second hand items, the shares of "Large appliances" and "Outdoor furniture/appliances" increase but the share of small appliances decreases significantly. However, small and large appliances still account for 48.2% of the initial embodied energy of the sample houses in year 0, which increases to 55.3%, 57.0%, 59.1% and 58.3% after 25, 50, 75 and 100 years.

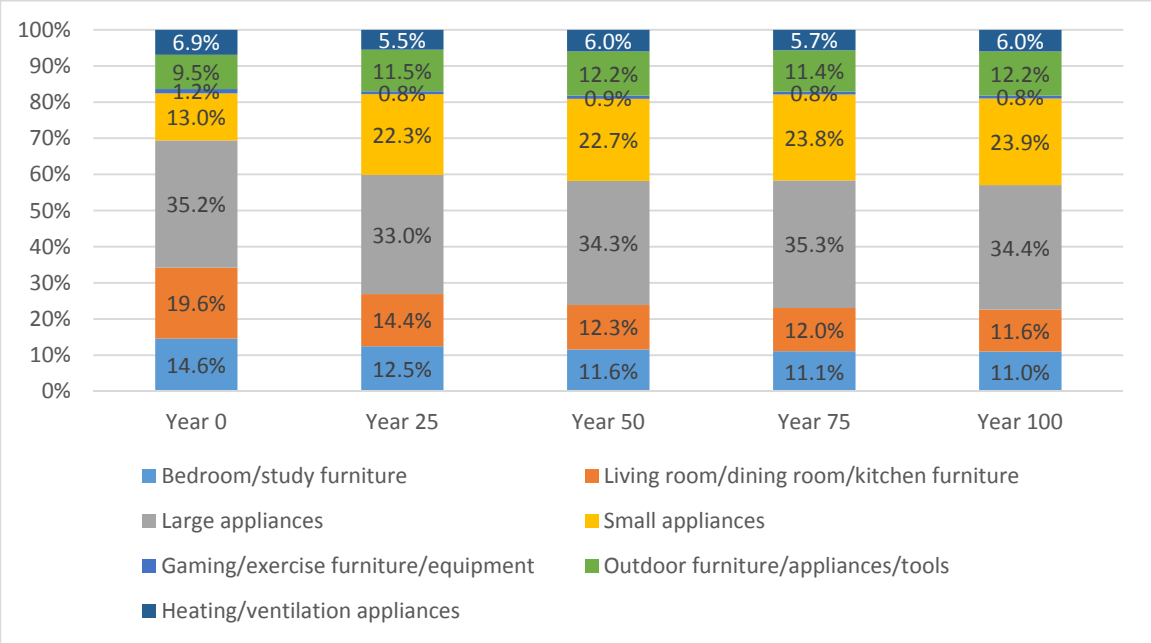


Figure 10.10 Breakdown of the embodied energy of furniture, appliances and tools at various house life stages considering the effect of second hand items

10.5. Discussion

The average embodied and life cycle energy for typical light construction houses of different sizes was calculated for four household types in Chapter 9. These values included the embodied energy of building materials, bathroom and kitchen fittings, maintenance and operating energy. They are now added to the embodied/life cycle energy of furniture, appliances and tools of the same sized houses for the four household types at different life stages (Tables 10.15-10.17).

House size (based on number of extra rooms)	Embodied energy component	Embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100
0 extra rooms (4 room house)	EE/LCE of house materials and heating	148.08	405.95	708.75	969.98	1282.01
	EE/LCE of furniture, appliances and tools	168.90	451.06	817.58	1140.12	1484.23
	Subtotal	316.98	857.01	1526.33	2110.1	2766.24
1 extra room (5 room house)	EE/LCE of house materials and heating	189.37	525.60	919.95	1268.39	1663.92
	EE/LCE of furniture, appliances and tools	157.09	407.00	737.41	1029.38	1340.57
	Subtotal	346.46	932.6	1657.36	2297.77	3004.49
2 extra rooms (6 room house)	EE/LCE of house materials and heating	220.07	619.83	1087.80	1515.05	1967.78
	EE/LCE of furniture, appliances and tools	210.59	553.02	993.67	1385.35	1809.94
	Subtotal	430.66	1172.85	2081.47	2900.4	3777.72
3 extra rooms (7 room house)	EE/LCE of house materials and heating	269.96	775.35	1363.72	1924.53	2469.74
	EE/LCE of furniture, appliances and tools	247.40	647.59	1163.66	1614.29	2122.75
	Subtotal	517.36	1422.94	2527.38	3538.82	4592.49
4 extra rooms (8 room house)	EE/LCE of house materials and heating	311.61	900.61	1582.84	2239.41	2874.06
	EE/LCE of furniture, appliances and tools	288.21	735.43	1317.30	1822.13	2395.06
	Subtotal	599.82	1636.04	2900.14	4061.54	5269.12
5 extra rooms (9 room house)	EE/LCE of house materials and heating	371.22	1084.52	1903.93	2704.65	3470.92
	EE/LCE of furniture, appliances and tools	325.70	852.70	1528.03	2120.52	2781.87
	Subtotal	696.92	1937.22	3431.96	4825.17	6252.79

Table 10.15 Total embodied and life cycle energy of different furnished houses for single person and couple households

House size (based on number of extra rooms)	Embodied energy component	Embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100
0 extra rooms (5 room house)	EE/LCE of house materials and heating	189.37	525.60	919.95	1268.39	1663.92
	EE/LCE of furniture, appliances and tools	157.09	407.00	737.41	1029.38	1340.57
	Subtotal	346.46	932.6	1657.36	2297.77	3004.49
1 extra room (6 room house)	EE/LCE of house materials and heating	220.07	619.83	1087.80	1515.05	1967.78
	EE/LCE of furniture, appliances and tools	210.59	553.02	993.67	1385.35	1809.94
	Subtotal	430.66	1172.85	2081.47	2900.4	3777.72
2 extra rooms (7 room house)	EE/LCE of house materials and heating	269.96	775.35	1363.72	1924.53	2469.74
	EE/LCE of furniture, appliances and tools	247.40	647.59	1163.66	1614.29	2122.75
	Subtotal	517.36	1422.94	2527.38	3538.82	4592.49
3 extra rooms (8 room house)	EE/LCE of house materials and heating	311.61	900.61	1582.84	2239.41	2874.06
	EE/LCE of furniture, appliances and tools	288.21	735.43	1317.30	1822.13	2395.06
	Subtotal	599.82	1636.04	2900.14	4061.54	5269.12
4 extra rooms (9 room house)	EE/LCE of house materials and heating	371.22	1084.52	1903.93	2704.65	3470.92
	EE/LCE of furniture, appliances and tools	325.70	852.70	1528.03	2120.52	2781.87
	Subtotal	696.92	1937.22	3431.96	4825.17	6252.79
5 extra rooms (10 room house)	EE/LCE of house materials and heating	394.42	1156.49	2028.97	2886.90	3705.24
	EE/LCE of furniture, appliances and tools	262.17	688.49	1232.14	1717.13	2238.13
	Subtotal	656.59	1844.98	3261.11	4604.03	5943.37

Table 10.16 Total embodied and life cycle energy of different furnished houses for couples with one child

Table 10.15 shows that if a single person or couple live in a core house (0 EXR) rather than a house with 2 EXR, they will save 114GJ in Year 0 and 316, 555, 790 and 1011GJ after 25, 50, 75 and 100 years.

Similarly, a couple with one child will save 171, 490, 870, 1241 and 1588GJ and a couple with two children 169, 463, 819, 1161 and 1491GJ after 0, 25, 50, 75 and 100 years.

House size (based on number of extra rooms)	Embodied energy component	Embodied/Life cycle energy (GJ) (years)				
		0	25	50	75	100
0 extra room (6 room house)	EE/LCE of house materials and heating	220.07	619.83	1087.80	1515.05	1967.78
	EE/LCE of furniture, appliances and tools	210.59	553.02	993.67	1385.35	1809.94
	Subtotal	430.66	1172.85	2081.47	2900.4	3777.72
1 extra room (7 room house)	EE/LCE of house materials and heating	269.96	775.35	1363.72	1924.53	2469.74
	EE/LCE of furniture, appliances and tools	247.40	647.59	1163.66	1614.29	2122.75
	Subtotal	517.36	1422.94	2527.38	3538.82	4592.49
2 extra rooms (8 room house)	EE/LCE of house materials and heating	311.61	900.61	1582.84	2239.41	2874.06
	EE/LCE of furniture, appliances and tools	288.21	735.43	1317.30	1822.13	2395.06
	Subtotal	599.82	1636.04	2900.14	4061.54	5269.12
3 extra rooms (9 room house)	EE/LCE of house materials and heating	371.22	1084.52	1903.93	2704.65	3470.92
	EE/LCE of furniture, appliances and tools	325.70	852.70	1528.03	2120.52	2781.87
	Subtotal	696.92	1937.22	3431.96	4825.17	6252.79
4 extra rooms (10 room house)	EE/LCE of house materials and heating	394.42	1156.49	2028.97	2886.90	3705.24
	EE/LCE of furniture, appliances and tools	262.17	688.49	1232.14	1717.13	2238.13
	Subtotal	656.59	1844.98	3261.11	4604.03	5943.37
5 extra rooms (11 room house)	EE/LCE of house materials and heating	457.59	1359.12	2380.48	3404.12	4369.18
	EE/LCE of furniture, appliances and tools	316.62	787.36	1398.47	1927.35	2533.75
	Subtotal	774.21	2146.48	3778.95	5331.47	6902.93

Table 10.17 Total embodied and life cycle energy of different furnished houses for couples with two children

Figures 10.11 and 10.12 compare the share of furniture, appliances and tools and house materials, fittings, maintenance, and heating energy in the overall life cycle energy of five different house sizes, assuming all furniture, appliances and tools are bought new (Figure 10.11) and when some are provided second hand at the average rates found in the survey (Figure 10.12). Figures 10.11 and 10.12 also show how the pattern changes over the life cycle of different sized houses.

As seen, the share of furniture, appliances and tools in the overall embodied/life cycle energy of a house is 55-64% (average 60%) when all items are bought new although this decreases to 44-49% (average 47%) when the effect of second hand items is considered. According to Figures 10.11 and 10.12, this share remains almost consistent over the life cycle of the house for each house size. Figure 10.11 shows the share of furniture, appliances and tools in the total increases with an increase in house size but the pattern is reversed in Figure 10.12. This means that when the role of second hand items is taken into account small houses use less energy for furniture compared to large houses.

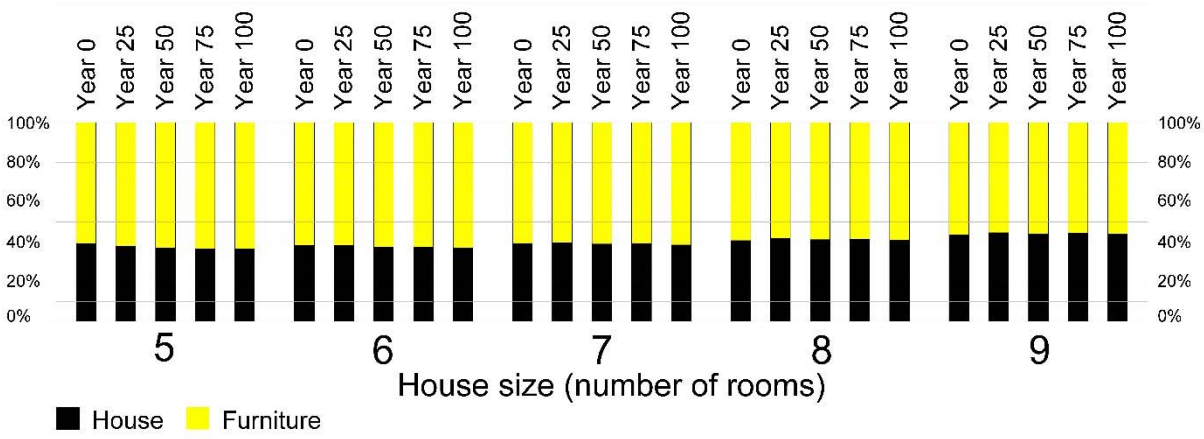


Figure 10.11 Share of furniture/appliance/tools and building materials, fittings, maintenance, and heating energy in total embodied and life cycle energy of different sized houses at different life stages (all furniture/appliance/tools bought new)

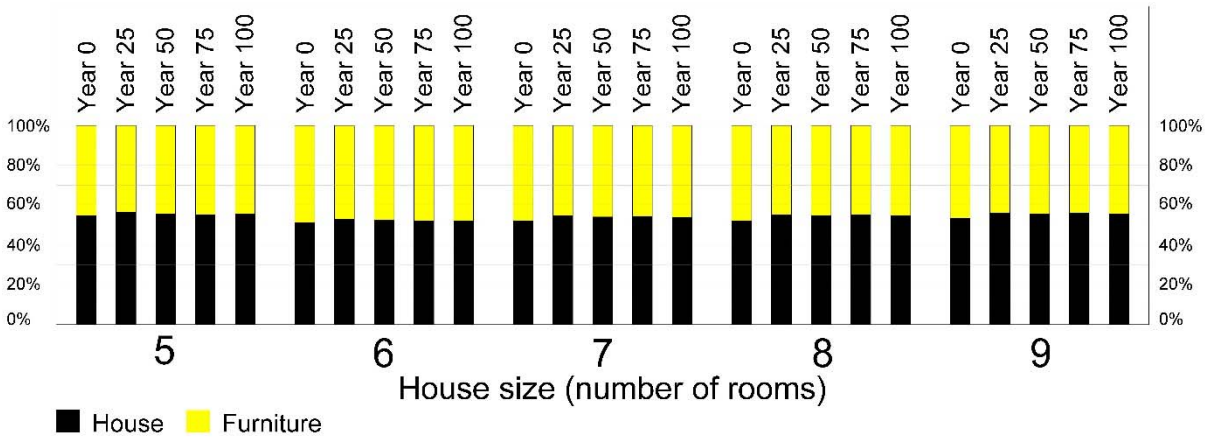


Figure 10.12 Share of furniture/appliance/tools and building materials, fittings and maintenance and heating energy in total embodied and life cycle energy of different sized houses at different life stages (considering the effect of second hand furniture/appliance/tools)

10.6. Conclusion

This study shows that living in a large house not only means people use more energy for building materials, fittings, maintenance, and heating but also means more energy is needed for the furniture to fill the seldom-used rooms of the bigger house. On average, people living in larger houses use more furniture/appliance/tool items, although the study also shows that apart from single person households, household size does not affect the level of furniture and appliances. So regardless of how many people live in a house, it is the size of the house that determines the number of furniture, appliances and tool items owned by its occupants.

By selecting to live in a core rather than a large house, a household can save energy in year 0 by having less furniture, appliance and tool items. This energy saving becomes greater and more important over the life of the house.

Assuming all furniture, appliances and tool items in a house are bought new, this study shows that these make up 60% of the total embodied energy of a house in year 0. This share decreases to 47% when second hand items are considered. Allowing for second hand items, the share of furniture, appliances and tools in the total embodied/life cycle energy of the house is less in small houses than large houses because the latter have more new furniture items/appliances. Regardless of furniture and appliances being new or second hand, they are responsible for around half the energy used in New Zealand housing. This means furniture and appliances, are as, if not more, important than the house in terms of life cycle energy use.

This study also shows that different furniture items and appliances have different effects on the life cycle energy of a house. Given that furniture and appliances found in higher numbers or with higher initial embodied energy have greater impacts on the life cycle energy of a house, in this study the former seems more significant. The useful life of various furniture/appliance items also seems important in terms of the overall life cycle energy of a house. Using second hand items and thus extending the useful life of an item can lead to lower life cycle energies. Cooper (2010:28) believes "sustainability will only be achieved if the prevailing throwaway culture in industrial countries is transformed and there is a shift towards longer lasting products". This study also shows that among the investigated items appliances have highest energy impact over the life cycle of a house. A study by Elias et al. (2007) in the UK shows that, among all space at home, the kitchen has the highest energy use for operation of appliances.

The other parameter which is important and ignored in all LCA studies (including this one) is the potential effect of different prices for similar furniture and appliance items. Normally, a house is an indicator of the occupants' wealth and owners of larger houses might have more expensive furniture.

This consideration could make a larger difference in the life cycle energy of large compared to small houses.

This study concludes that decisions in terms of house size section can significantly affect the total life cycle energy of houses, particularly through the need to have more furniture and appliances. There remains doubt over whether all these furniture and appliance items are used over the life of a house or just changed with fashion and technological advances, but this is an area for further research.

The next step in the this analysis is to combine time-use and the environmental impact of the houses and its contents to derive values for the efficiency of use of the resources that go into New Zealand houses. The method and results are set out in Chapter 11.

11. Time-use and resource-use

11.1. Introduction

Life cycle analysis (LCA) shows how materials and building technology affect the initial embodied energy and life cycle energy of a house (Vale & Vale, 2009). Highly insulated buildings of better quality materials tend to have higher initial embodied energy but reduced life cycle energy because they need less operating and maintenance and refurbishment energy (Crawford, 2011). House size, as shown in this research also affects the initial embodied and life cycle energy of houses.

However, architecture is a combination of the built environment and human users, and considering energy consumption without investigating the decisions and behaviour of users gives an incomplete picture of housing life-cycle. An LCA study by Mithraratne et al. (2007) showed operating energy, construction materials and techniques, and maintenance and refurbishment energy form the three largest components of house LCA, while at the same time design and user decisions can affect all three aspects directly or indirectly. They compared the life cycle energy of a 194m^2 light construction with a super-insulated house of the same size found the 100 year life cycle energy was 2857GJ for the former and 1441GJ for the latter. Assuming the super-insulated house is occupied by a single person and the light construction occupied by a couple with two children, the life cycle energy per person after 100 years for the light construction and super-insulated houses will be 714 and 1441GJ respectively, meaning the total energy use per person of the former is less than half that of the latter. This shows how household size can affect house resource-use.

While much of the life cycle energy of a house (such as its materials) is not dependent on the occupants, the number of these will directly affect its life cycle energy particularly in terms of the energy for hot water, lights, furniture and appliances (see Chapter 10) as well as heating/cooling energy (Martinaitis et al. (2015) and Motuziene and Vilutiene (2013)). So how much energy a household uses is one side of the story but how often people are at home to make use of both energy and the resources in the houses and its furniture and fittings is the other unknown side of the story.

Results of the time-use part of this study (see section 8.3.1) align with international studies and show that New Zealanders on average spend 69% of day time at home indoors which is considered high (Baker et al., 2007). As a result, the fact 31% of the life cycle energy of a house remains underused seems important. In addition, as discussed in section 1.5.1, New Zealanders tend to live in houses with extra bedrooms (bedrooms with no usual occupants) and specialised rooms (study, playroom etc.). The time-use part of this study also showed some rooms are used regularly (sleeping bedrooms) while others such as playrooms are generally much less used (see section 8.3.3). This chapter is a first attempt to develop a method to combine house life cycle energy (or that of rooms within a house) with the time the occupant(s) of that house use it (them) to reveal the underused energy, aiming to show how efficiently resources have been used.

11.2. Methodology

This chapter uses the data sets on embodied and life cycle energy of the house and its components from Chapters 9 and 10 while data about time-use at home indoors or in different rooms of the house is taken from Chapter 8. Where the average floor area of different sized houses or different room types in different sized houses is needed, such data comes from the floor plan study (Chapter 7).

As discussed, the time-use and life cycle energy of housing varies for different people and houses so any study of these needs to assume a particular house and household type. According to Statistics New Zealand (2014a) and based on census 2013, 68.3% of all New Zealand households are one-family. Among these one-family households, childless couples form the largest share (40.9%) although Statistics New Zealand (2016b) project the number of childless couples will increase from 513,500 in 2013 to 728,300 by 2038, which is a 41.8% increase. Taken together, it seems that childless couples are (and will remain) the most popular household type in New Zealand, making it worth tracking the housing energy-use of this particular household type. To simplify the analysis, the couple household will be formed from a small family (a couple with one child). This chapter therefore, will simulate the time-use of two typical households (a couple with one child and a childless couple) who could choose

to live in 6 different sized houses from birth to death. For each of the 6 different houses a sample occupant was considered as living with parents for 20 years (age 0-20) and then living with a partner for 80 years (age 20-100) in another 6 different sized sample houses. The average time-use at home indoors (and in the different rooms of a house) was extracted from the time-use study for different age groups and for weekdays and at weekends. Considering the number of weekdays, weekends and holidays in each year at each life stage, and multiplying by the average time-use at home indoors (or in a room) relevant for that age group on the relevant day (weekday or weekend) the subtotal time sample persons spend at home indoors (or in each room) was calculated for an assumed life period of 100 years.

The life cycle energies of 6 different sized houses after 100 years were taken from Chapters 9 and 10. These values were then divided by the number of people in the household to find the life cycle energy per person. The result was then divided by the overall time the sample person would spend at home indoors to reach a life cycle energy for each hour of use (LCE/use-hour) for each house size for that person. This figure can be compared to the life cycle energy for all hours (LCE/total-hour) to show how efficiently resources in each different house size are used. To control the effects of different technologies and materials, all sample houses are assumed to be timber frame with timber or other lightweight cladding, as these are the commonest types in New Zealand.

The method was repeated for selected room types by comparing the overall average time (from the survey) each room would be used by all household members over a particular life of the house (eg. 20 years, 80 years) with the life cycle energy for the same period to find the selected room resource-use efficiency. The LCE/total-hour (GJ/Hour) shows the energy needed for each hour of **having** that particular house size/room while the LCE/use-hour (GJ/Hour) shows the energy needed for each hour of **using** that particular house size/room. A small difference between LCE/total-hour and LCE/use-hour signifies more efficient use of housing resources.

11.3. Analysis

11.3.1. Sample households, sample occupants, sample houses and related life cycle energy

A sample boy (George) lives with his parents (a 3 person family) from birth to his 20th birthday in the 6 different size sample houses (Houses A0-A5). These are houses with 0, 1, 2, 3, 4 and 5 EXR for a couple with 1 child. The average floor areas of houses A0-A5 are calculated according to the results of the floor plan study (Chapter 7) and are presented in Table 11.1. For this analysis all houses are assumed to be built when George was born.

At 21, George marries and for 80 years lives in a house (House B) with his partner (with no child) until both die aged 100. House B is assumed to be built when George marries, and like House A comes in 6 sizes (B0-B5). These have respectively 0, 1, 2, 3, 4 and 5 EXR for a couple with no child. The areas of houses B0-B5 are similarly calculated and are presented in Table 11.2. Using the life-cycle energy results (see Tables 10.15 and 10.16 in Chapter 10), the life cycle energy per household of each house size and its furniture and appliances at various life stages was extracted and is presented in Tables 11.1 and 11.2.

House	Number of rooms	Floor area (m^2)	Subtotal life cycle energy (GJ) per household at different life stages (years)						Subtotal life cycle energy (GJ) per person at different life stages (years)					
			0	20	25	50	75	100	0	20	25	50	75	100
A0	5	96.2	346	815	933	1657	2298	3004	115	272	311	552	766	1001
A1	6	120.2	431	1024	1173	2081	2900	3778	144	341	391	694	967	1259
A2	7	161.3	517	1242	1423	2527	3539	4592	172	414	474	842	1180	1531
A3	8	190.0	600	1429	1636	2900	4062	5269	200	476	545	967	1354	1756
A4	9	234.3	697	1689	1937	3432	4825	6253	232	563	646	1144	1608	2084
A5	10	251.8	657	1607	1845	3261	4604	5943	219	536	615	1087	1535	1981

Table 11.1 Floor area of houses A0-A5 and life cycle energy per household and per person at different life stages

House	Number of rooms	Floor area (m^2)	Subtotal life cycle energy (GJ) per household at different life stages (years)						Subtotal life cycle energy (GJ) per person at different life stages (years)					
			0	25	50	75	80	100	0	25	50	75	80	100
B0	4	70.7	317	857	1526	2110	2241	2766	158	429	763	1055	1121	1383
B1	5	96.2	346	933	1657	2298	2439	3004	173	466	829	1149	1220	1502
B2	6	120.2	431	1173	2081	2900	3076	3778	215	586	1041	1450	1538	1889
B3	7	161.3	517	1423	2527	3539	3750	4592	259	711	1264	1769	1875	2296
B4	8	190.0	600	1636	2900	4062	4303	5269	300	818	1450	2031	2152	2635
B5	9	234.3	697	1937	3432	4825	5111	6253	348	969	1716	2413	2555	3126

Table 11.2 Floor area of houses B0-B5 and life cycle energy per household and per person at different life stages

George thus lived in his parental house (House A) for 20 years and in his own house (House B) for 80 years. This study only examines the LCA of living in selected combinations of house pairs for the whole

life of the sample person (i.e. A0+B0, A1+B1, A2+B2, A3+B3, A4+B4 and A5+B5). Based on this, the life cycle energy of housing options A0-A5 after 20 years (highlighted in Table 11.1) was added to life cycle energy of housing options B0-B5 after 80 years (highlighted in Table 11.2) and presented in Table 11.3. Table 11.3 shows the George's share of housing energy for 100 years when he elects to live in 6 different house sizes for his whole life.

House option combination	LCE (GJ) share of houses A0-A5 (20 years)	LCE (GJ) share of houses B0-B5 (80 years)	Subtotal share of LCE (GJ) for George, living in different sizes of Houses A and B over 100 years
A0 + B0	272	1121	1393
A1 + B1	341	1220	1561
A2 + B2	414	1538	1952
A3 + B3	476	1875	2351
A4 + B4	563	2152	2715
A5 + B5	536	2555	3091

Table 11.3 Share of housing life cycle energy over 100 years for the sample occupant in 6 different sized houses

11.3.2. Time-use analysis for sample occupant over 100 years

Apart from the number of occupants, the time each occupant spends at home (and in the rooms of the house) can show how efficiently resources have been used. As discussed in section 8.3.2 gender, work type, day type and age are significant predictors of time-use at home indoors. Although this study looks at an average New Zealander, to simplify the methodology the first two parameters are ignored and analysis is based on day type and age time-use from the survey. The reason for ignoring gender is that, based on the time-use survey results (Chapter 8), the time-use differences by gender are small while the impact of work type is covered by age group. For people of working age, weekends, public holidays and annual leave are categorised as a weekend time-use pattern and the rest a weekday pattern (Hussein et al., 2012). Young children usually cannot stay at home without parental supervision (Dörre, 1996) and so their time-use at home indoors is assumed to be the same as adults of working age. For school age occupants, weekends, school holidays and public holidays follow a weekend time-use pattern and all others a weekday pattern (Schwab et al., 1990). According to the New Zealand Ministry of Business Innovation and Employment (2016), children start school on their fifth birthday and finish when they turn 17. For the retired in this analysis (65+) only weekends and public holidays are considered days with a weekend time-use.

Based on this, age groups were categorised into four as shown in Table 11.4. Over the 52 weeks in a year, there are 11 public holidays in New Zealand (New Zealand at work, 2016), 13 weeks of school holidays (6 public holidays are in this period) (New Zealand public holidays, 2016) and 3 weeks annual leave for people of working age (3 public holidays are assumed in this period). Based on these assumptions, Table 11.4 shows the number of days with weekday and weekend time-use patterns for each age group.

Age group	Number of days with weekend time-use pattern	Number of days with weekday time-use pattern
0-4	127	238
5-17	175	190
18-65	127	238
65+	115	250

Table 11.4 Number of days with weekday and weekend time-use patterns for different age groups

Using the average time-use at home indoors at weekends and on weekdays for different age groups (from Table 8.4) and number of assumed weekday/weekend days for each age group (from Table 11.4), an excel spreadsheet was developed and average time-use at home indoors for a New Zealander (gender ignored) was calculated for each life stage over 100 years (i.e. age 0-1, 1-2, 2-3…97-98, 98-99, 99-100). These time-uses were then added, giving a subtotal for a typical New Zealander of 600,509 hours spent at home indoors. Given 100 years equals 876,000 hours (100×365×24), this shows that on average, a New Zealander spends 68.5% of his/her life at home indoors.

11.3.3. A tool to combine time-use and resource-use (life cycle energy)

By dividing the energy used by a person over his/her life time by the overall hours in his/her life it is possible to find a personal energy-use per hour (MJ/hour) for housing using two steps:

- Divide life cycle energy per person by the subtotal of hours over the life cycle (i.e. House age × 365 (days) × 24 (Hours)). This becomes **LCE/total-hour** and shows the energy needed for each hour of **having** this type of housing regardless of its occupancy.
- Divide life cycle energy per person by the subtotal of hours spent at home indoors by a particular person over the life cycle of the house. This becomes **LCE/use-hour** for this type of

housing for that person. This shows the energy needed for each hour of **using** this type of housing.

Assuming a person lives for 100 years, this is 876,000 hours while as described above, a New Zealander on average spends 600,509 hours at home indoors. Figure 11.1 compares the LCE/total-hour and LCE/use-hour for George for 6 different housing options, and shows that for all house sizes LCE/use-hour is more than LCE/total-hour, but that the difference between the former and the latter increases with house size. Accepting bigger differences are indicators of less resource-use efficient houses, the pattern in Figure 11.1 shows larger houses are less resource-use efficient. Figure 11.1 shows that if George selects to live in a core house, 0.73MJ/hour of his energy use for housing remains unused (wasted) and this increases to 0.82, 1.02, 1.24, 1.42 and 1.62MJ/hour for houses with 1EXR, 2EXR, 3EXR, 4EXR and 5EXR.

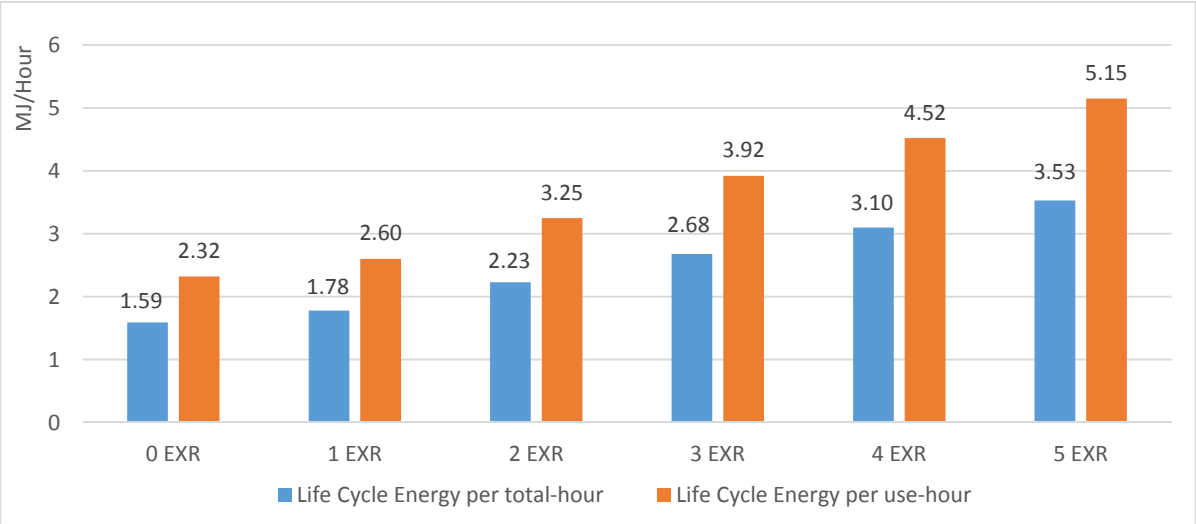


Figure 11.1 Life cycle energy per total-hour and use-hour for the sample occupant living in 6 different sized houses

11.3.4. Resource-use efficiency of the rooms of a house

Using the same method, it is possible to compare the resource-use efficiency of different rooms in New Zealand houses. To do this it is necessary to know whether rooms are used individually or shared by two or more family members. For instance, a master bedroom is normally used by a couple and a single bedroom by one person while a living room is used by all family members. The time-use part of this study gives data about how much time each age group on average spends in each room type at

weekends and on weekdays. Knowing the size of the same room type is different for different sized houses (see section 7.3.5) assumptions have to be made about the size of the house. Additionally, different household types have different numbers of people in them and each person's life stage can also affect the overall time-use of rooms (a very young child is unlikely to spend time in a study or games room).

Returning to the sample house A3 (George's parental house) with 3 extra rooms, the assumption is this house has a separate living room, dining room, kitchen, master bedroom, study, games room, and a play room for 10 years, after which it will be used as an extra bedroom (Extra bedroom 1) together with a single bedroom for George for 20 years, which will be used as a second extra bedroom (Extra bedroom 2). When George marries at 20, he leaves the parental house and his parents stay in the same house until they die aged 100. Assuming that George's parents started living in this house aged 20 years when George was born, overall the parents will live in the sample house 80 and George 20 years. Table 11.5 shows the number of years each room will be occupied and by how many people. It should be noted that while a young child might not use a games room or study, he is considered a user in Table 11.5 although his absence in such rooms will be reflected in his time-use which is zero (or near to zero) for this age range.

Room type	**Number of years used under this usage**	**Number of users and length of use**
Living room	80	3 for the first 20 years and 2 for the last 60 years
Dining room	80	3 for the first 20 years and 2 for the last 60 years
Kitchen	80	3 for the first 20 years and 2 for the last 60 years
Master bedroom	80	2 for 80 years
Play room/Extra bedroom 1	80	3 for the first 10 years and no usual user for the last 70 years
Playroom	*10*	*3 for the first 10 years*
Extra bedroom 1	*70*	*No usual user for 70 years (i.e. used by guests)*
Single bedroom/Extra bedroom 2	80	1 for the first 20 years and no usual user for the last 60 years
Single bedroom	*20*	*1 for the first 20 years*
Extra bedroom 2	*60*	*No usual user for 60 years (i.e. used by guests)*
Study	80	3 person for the first 20 years and 2 person for the last 60 years
Games room	80	3 for the first 20 years and 2 for the last 60 years

Table 11.5 Different rooms in sample house A3 with the number of use years and number of persons using each room

Using the results of the floor plan study, the average floor area of house A3 is 190.0m^2. Using the existing sources (see section 7.4.5) Table 11.6 gives the average floor area of each room type for house

A3. Using the same method described in Chapter 9, the life cycle energy per square metre of house A3 (excluding kitchen and bathroom fittings and furniture and appliances for the whole house) is 1.57, 4.61, 8.13, 11.51 and 14.74GJ/m^2 after 0, 25, 50, 75 and 100 years. Using the floor area the life cycle energy of each room (excluding furniture and appliances) was calculated and is presented in Table 11.6. Because the kitchen was the only room in the list with fittings, the life cycle energy of kitchen fittings was extracted from Tables 9.13 and 9.14 in Chapter 9 and added to the life cycle energy of this room type (Table 11.6).

For the life cycle energy associated with furniture and appliances, it was necessary to assume the number and type of each in the rooms. From the results of the survey, the average number of all furniture items, appliances and tools for an 8 room house was calculated and only those found in at least in 70% of all 8 room houses were included in this analysis (this number is generally near the average for all 8 room houses in the survey (N=34)). The list of what is included is below noting that no particular furniture was considered for the play room as it is assumed this room will only contain toys.

Living room: 1 Three-seater couch, 1 Two-seater couch, 1 Armchair, 2 side tables, 1 Coffee table, 2 Stools, 1 TV cabinet, 1 Rug, 1 Floor lamp, 1 Wall clock, 1 TV, 1 Buffet/Side board, 1 Vacuum cleaner, 1 Stereo and 1 DVD/Blu-Ray player.

Dining room: 1 Six-seater dining suite.

Kitchen: 1 Fridge/Freezer, 1 Dishwasher, 1 Cooktop/Hub, 1 Oven, 1 Microwave, 1 Blender/Mixer, 1 Sandwich maker, 1 Slow cooker/Rice cooker, 1 Toaster, 1 Electric jug, 1 Food processor.

Master Bedroom: 1 Double bed, 1 Double mattress, 1 Chest of drawer/Dressing table, 2 Bedside table/cabinets, 1 Hair dryer and 1 Electric blanket.

Single bedroom: 1 Single bed, 1 Single mattress, 1 Chest of drawer/Dressing table, 1 Bedside table/cabinet, 1 Electric blanket, 1 Desk and 1 Desk chair.

Extra bedroom: 1 Double bed, 1 Double mattress, 1 Chest of drawer/Dressing table, 2 Bedside table/cabinets and 1 Electric blanket.

Study: 1 Desk, 1 Desk chair, 1 combined printer/scanner, 2 Shelf/Book cases, 1 Normal chair, 1 Laptop and 1 Desktop computer.

Games room: 1 Pool table, 1 Three-seater couch, 1 Armchair, 1 Coffee table and 1 Bar fridge.

Using the same method described in Chapter 10, the life cycle energy of furniture and appliances was calculated for the whole life of each room type noting that all items are considered to have been bought new. Table 11.6 presents the overall life cycle energy of furniture and appliances for the whole life of each room type. By adding the life cycle energy of the building (including building materials, fittings, maintenance, and operation energy) and furniture and appliances, the subtotal life cycle energy of each room for this particular house/household was calculated and presented in Table 11.6.

Room type	Average floor area (m^2)	Life stage (Years)	Life cycle energy (GJ) of different components		
			Building and fittings	Furniture and appliances	Subtotal
Living room	30.78	80	374.1	444.3	818.4
Dining room	16.71	80	203.1	38.3	241.4
Kitchen	18.76	80	246.1	531.2	777.3
Master bedroom	23.37	80	284.1	130.4	414.5
Playroom/Extra bedroom 1	13.56	80	164.8	102.2	267.0
Playroom	*13.56*	*10*	*37.8*	*0.0*	*37.8*
Extra bedroom 1	*13.56*	*70*	*127.0*	*102.2*	*229.2*
Single bedroom/Extra bedroom 2	15.60	80	189.6	129.2	318.8
Single bedroom	*15.60*	*20*	*62.4*	*35.1*	*97.5*
Extra bedroom 2	*15.60*	*60*	*127.2*	*94.1*	*221.3*
Study	10.33	80	125.6	668.1	793.7
Games room	27.97	80	340.0	175.5	515.5

Table 11.6 Average floor area of different rooms and life cycle energy of the house and components at relevant life stage of each room

From the time-use study, as for time at home indoors, time-use in the different rooms of a house varies with age and day type. Using the same method described earlier together with the average time spent in each room type by each age group over weekdays and at weekends, the overall time all members of this household spend in each room over 80 years was calculated (for rooms where their usage changes before 80 years (i.e. playroom and single bedroom), the time-use is for each usage (i.e. 10 years for play room and 20 years for single bedroom).

For extra bedrooms, apart from the time family members might be in them, they will also be used for guests. Participants in the survey were asked about the number guests and number of times that guest might sleep in their house on a weekly, monthly, 3 monthly, 6 monthly and yearly basis. The answers were analysed and the number of guest-nights for each sample household calculated. (This step could be ignored on the basis that a guest also has a house which they are not using whilst they are being a guest, but for the moment guest use has been included). Results were compared according to the number of rooms, number of extra rooms and number of extra bedrooms but no particular pattern emerged.

Three ANOVA one-way tests were also performed to see if the average number of guest-nights is significantly different by number rooms ($F_{(4,246)}$=1.60, p=0.176), number of extra rooms ($F_{(5,245)}$=0.70, p=0.623) and number of extra bedrooms ($F_{(3,247)}$=0.79, p=0.499) at 0.05 level and the results were negative for all. This means that having a large house or having more extra rooms/bedrooms does not necessarily mean having more guests to sleep there. The results of this study for all samples show that on average each household has 28.3 guest-nights per year.

Considering an average person in the survey sleeps 8.7hours/day, the number of hours per year of guest use were calculated and added to the time-use of Extra bedrooms 1 and 2. There is no extra bedroom in the first 10 years. In the years 11-20, there is only 1 extra bedroom (Extra bedroom 1) and so all 28.3hours/year were allotted to this while there are 2 extra bedrooms in years 21-80, so over this period, the 28.3hours/year was equally distributed between them.

Adding the guests' time-use to the results of the time-use study (chapter 8), Table 11.7 presents how many person-hours have been spent in each room over its whole life. Table 11.7 shows the 80 year family time-use of a Games room is 3.4% that of a master bedroom (shared by a couple) and 7.5% that of a living room. In addition, the 80 year family time-use of a study is 19.1% that of a master bedroom and 42.7% of a living room.

Room type	Number of years	Overall person-hours the room has been occupied
Living room	80	198,977
Dining room	80	58,906
Kitchen	80	76,180
Master bedroom	80	444,513
Playroom/Extra bedroom 1	80	40,911
Playroom	*10*	*7,288*
Extra bedroom 1	*70*	*33,623*
Single bedroom/Extra bedroom 2	80	101,863
Single bedroom	*20*	*74,438*
Extra bedroom 2	*60*	*27,425*
Study	80	84,996
Games room	80	15,019

Table 11.7 Total person-hours each room has been occupied over its whole life

Using the same method described before, by dividing the life cycle energy of a room by the number of total and use hours, the life cycle energy per total-hour (LCE/total-hour) and use-hour (LCE/use-hour) were calculated for each room and are shown in Figure 11.2.

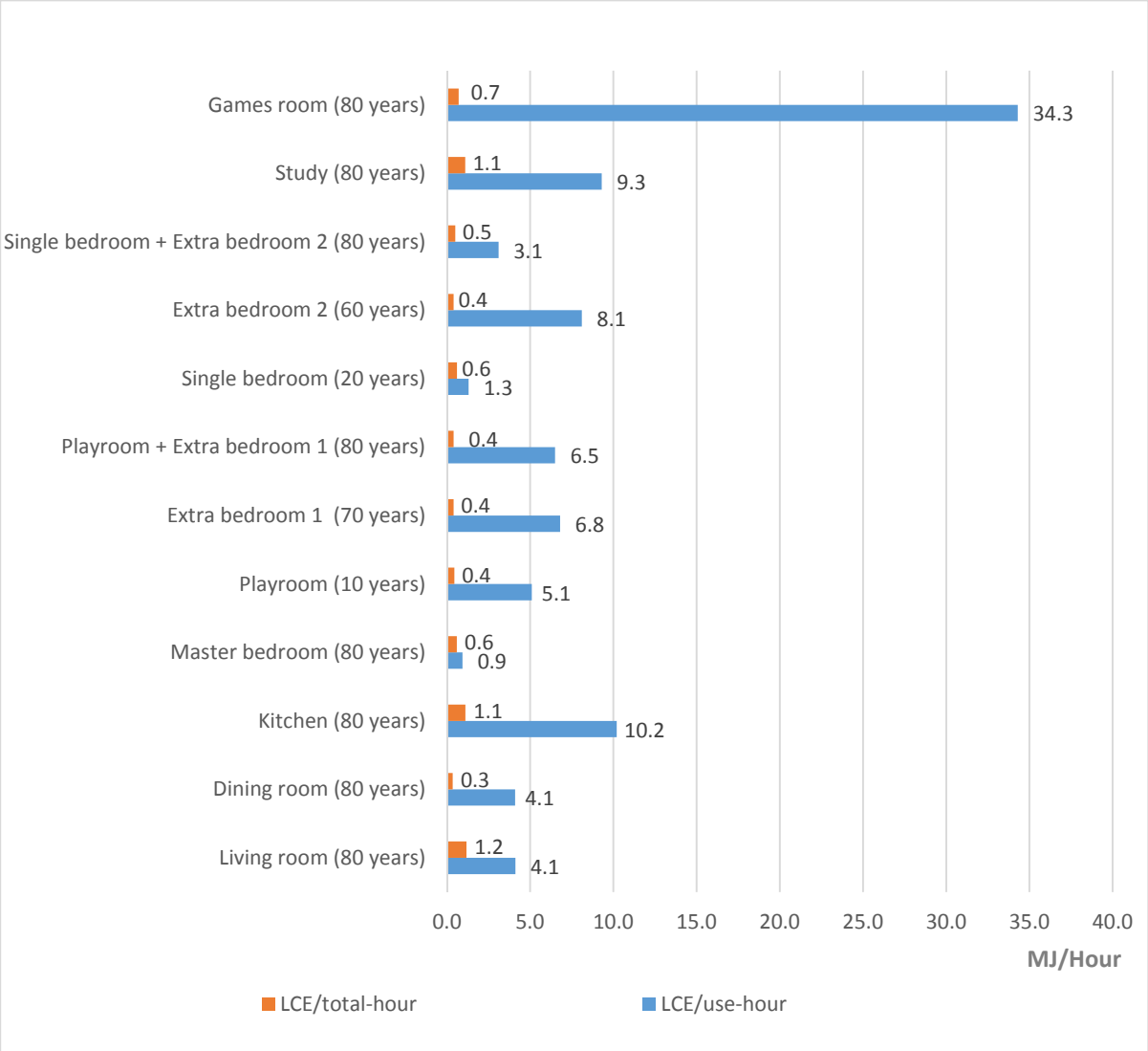


Figure 11.2 Life cycle energy/total-hour and use-hour (MJ/hour) for selected rooms

Figure 11.2 shows the games room has the highest LCE/use-hour (34.3MJ/hour) while the second, third and fourth highest LCE/use-hours belong to kitchen (10.2MJ/hour), study (9.3MJ/hour) and extra bedroom 2 (8.1MJ/hour). The Master bedroom has the lowest LCE/use-hour (0.9 MJ/hour) followed by single bedroom (1.3MJ/hour), living room (4.1MJ/hour) and dining room (4.1MJ/hour). The difference between LCE/use-hour and LCE/total-hour shows the energy which remains unused (or wasted) over the life of the room. A lower difference between LCE/use-hour and LCE/total-hour means the resources in that particular room are used more efficiently. Accepting this, Table 11.8 ranks various room types based on resource-use efficiency. Table 11.8 reveals the Master bedroom is the most resource efficient room, as generally this does not have a large floor area, has limited furnishing and few if any appliances and has a shared use. Table 11.8 also shows that a games room is the least efficient because people spend little time in it and its life cycle energy is high because of its size and components. Table 11.8 also shows that the resource-use efficiency of a kitchen is very low because of the very high life cycle energy associated with appliances in this room. According to Table 11.8, the study is the third least resource-use efficient room. The reason was investigated showing that the laptop and desktop computer in it make 74% of its total life cycle energy over 80 years (because of their high initial embodied energy and short life). Excluding these two appliances from this room, drops the LCE/use-hour and LCE/total-hour to 2.4 and 0.3MJ/hour.

Room type	Difference between LCE/Use-Hour and LCE/Total-Hour	Rank for efficiency in resource-use
Master bedroom (80 years)	0.3	1
Single bedroom (20 years)	0.8	2
Single bedroom/Extra bedroom 2 (80 years)	2.7	3
Living room (80 years)	2.9	4
Dining room (80 years)	3.8	5
Playroom (10 years)	4.8	6
Playroom/Extra bedroom 1 (80 years)	6.1	7
Extra bedroom 1 (70 years)	6.4	8
Extra bedroom 2 (60 years)	7.6	9
Study (80 years)	8.2	10
Kitchen (80 years)	9.1	11
Games room (80 years)	33.6	12

Table 11.8 Difference between LCE/use-hour and LCE/total-hour and resource-use efficiency ranking for rooms of the sample house for the sample household

11.4. Discussion

People elect to live in different sized houses. Chapter 9 shows that larger houses use several times the energy of small houses because of the energy in building materials, fittings, maintenance, and heating. Chapter 10 showed that people do not keep the extra rooms of their large houses empty and the furniture, appliances and tools in these increase the life cycle energy of larger houses. Additionally, the time-use part of this study indicates no statistical correlation between time-use at home indoors and house size, meaning that people who live in larger houses do not necessarily use their house more than those living in small houses. This raises the question of how efficiently resources are used in different sized houses.

The online survey supports the observations of others (see section 1.5.3) that new specialised rooms (i.e. study, games room, play room and studio) and bedrooms with no usual occupants (extra bedrooms) are integral parts of existing New Zealand houses. The results of the time-use part of this study indicate that some of these rooms are rarely used. Apart from the resources used to build and renovate these rooms, operation energy is needed for their space conditioning, and energy is also embodied in the furniture and appliances that furnish these rooms. This suggests that how resources in each part of a house are used is important because this can give a better understanding of how the name, and hence intended purpose, of a room might affect housing energy use.

This chapter has attempted to develop a way of combining life cycle energy for houses and rooms with the time spent at home indoors and in its rooms by the occupants. The aim was to compare the LCE/use-hour with the LCE/total-hour as a measure of resource-use efficiency for New Zealand houses. The results show that the choice of house size can have a significant effect on these two values and living in smaller houses is more resource-use efficient. For the sample person discussed, the energy used per hour for the whole life period (100 years) in a house with 3 and 5 extra rooms is respectively 68.6% and 122.0% higher than that of living in a core house. The significance of this figure becomes clearer when considering what could be done with the energy equivalent of this change in

house size. Assuming the sample person elects to live in a core house rather than a house with 5 extra rooms, the difference between the LCE/total-hour of these two types of house is 1.94MJ/hour. According to Table 10.16 in Chapter 10, the embodied energy needed to build and fully furnish a timber frame core house with light weight cladding for a couple is 346.46GJ. The calculation below shows that the energy difference saved via this change in house size over 20 years and 5 months of **having** these houses makes it is possible to build a core house for a couple.

Time = 346460 (MJ) ÷ 1.94 (MJ/Hour) = 178,588 Hours = 7,441 days = 20 years and 5 months

This study also shows that rooms also have different resource-use efficiency ratings. Among the 10 room types investigated, the Master bedroom is the most resource-use efficient and the games room the least. The reason is the considerable time people spend in a bedroom, which is also shared. In contrast, the playroom is not resource-use efficient because it is little used. Using the same method the resource energy equivalent of **using** a games room (Figure 11.2), is 34.3MJ/hour. This reveals the resource energy equivalent of using a games room for 10,101 person-hours or 421 person-days (1 year and 2 months) makes it is possible to build and furnish a core house for a couple.

As mentioned, the laptop and desktop computer have a critical effect on the resource-use efficiency of a study. Table 11.9 shows the critical furniture/appliance items for different rooms and the share of those items in the subtotal life cycle energy of the room. This suggests that by controlling the use of some items or choosing brands with longer lifetimes, it could be possible to reduce the overall life cycle energy of the room and make it more resource-use efficient.

Room type	Critical furniture/appliance item	Share in the subtotal life cycle energy of the room
Living room	TV	18.7%
Kitchen	Oven	17.0%
Master bedroom	Electric blanket	9.1%
Single bedroom	Electric blanket	10.1%
Study	Laptop and Desktop computer	74.1%
Games room	Pool table	14.3%

Table 11.9 Critical furniture and appliance items and their share in the subtotal life cycle energy of the room

The very low resource-use efficiency of a kitchen, which is an integral part of all houses, and the very low time-use of this room raises the question of whether all houses should have a fully fitted kitchen with many appliances, given many people are not cooking at home anymore (Smith et al., 2013). Maybe more attention should be given to housing options where kitchens are shared, such as co-housing (McCamant and Durrett (2011) and Sanguinetti (2012)).

Previous parts of this study have revealed that the householder's decision in terms of selecting house size has a great impact on the life cycle energy of his or her housing. Assuming a person elects to buy a larger rather than a core house, this part of the study reveals that how this person uses the various rooms of his/her house can also affect its overall life cycle. Generally, electing to keep the extra rooms of the house as extra bedrooms or extra dining rooms is more energy efficient than having a games room. The latter might be better as part of a multi-function room, maybe through combining it with an extra bedroom, or having a joint study and extra bedroom. Multi-function rooms would seem a better alternative to single function rooms where usage is low.

12. Conclusion

12.1. Introduction

This study showed that decisions in terms of selecting house size can affect housing resource-use. Choosing a larger than core house equates to using more natural resources and this can be significant for small households in very large houses. The problem of choosing a large house is not limited to the initial energy needed for building and furnishing it because the impacts of this decision increase over the life of the house. Such impacts are normally ignored by owner-occupiers.

By living in a larger than core house, the occupants inevitably use more resources for heating/cooling and maintaining it, noting the operating energy over the life of the house is several times that of the initial energy-use difference between building a large and core house. A large house also means more furniture and appliance items to fill the extra rooms. The problem with such items is that regardless of whether they are used or not, their life is very short, sometimes because of changes in fashion and technological improvements. This study shows that the life cycle energy of furniture and appliances, is as, if not more, important than the house.

The energy used for building, furnishing and operating a large house is one side of the story while how these resources are used is the other. This study reveals that people who live in larger than core house do not use the various parts of these effectively, and a significant proportion of resources in such houses usually remain virtually un-used. In other words, it seems many people work very hard to earn the money to buy and furnish a large house, then pay a lot to run and maintain it but do not have the time to use it fully.

Having a large house is less significant for large families as energy-use per capita is not high but this study shows house size is an issue for single person households and childless couples. This is important because many such people are either of working age and have a high income to buy a large house or are retired and left with a large house. The latter group often suffers from the expenses associated

with the operation and maintenance of these large houses. Finding an alternative solution for housing such groups could be important for governments and policy makers.

12.2. Why do people have large houses?

The survey asked respondents to select from a list of reasons for buying a house with spare rooms. Figure 12.1 shows the results for the 8 parameters. The top three reasons were "more flexibility in use", "location" and "more comfort", while "can place more furniture in it", "investment" and "getting more out of the same money" were the three least important. As seen, what people say is that they need large houses because these are more comfortable and flexible and not just to fill them with more furniture. However, the reality from the survey is that larger houses contain more furniture, with a consequent increased environmental impact. This raises the question of the extent to which people should be allowed to use natural resources. As Schumacher (1973:109) states the question of how to use land and natural resources "is not a question of what we can afford but of what we choose to spend our money on".

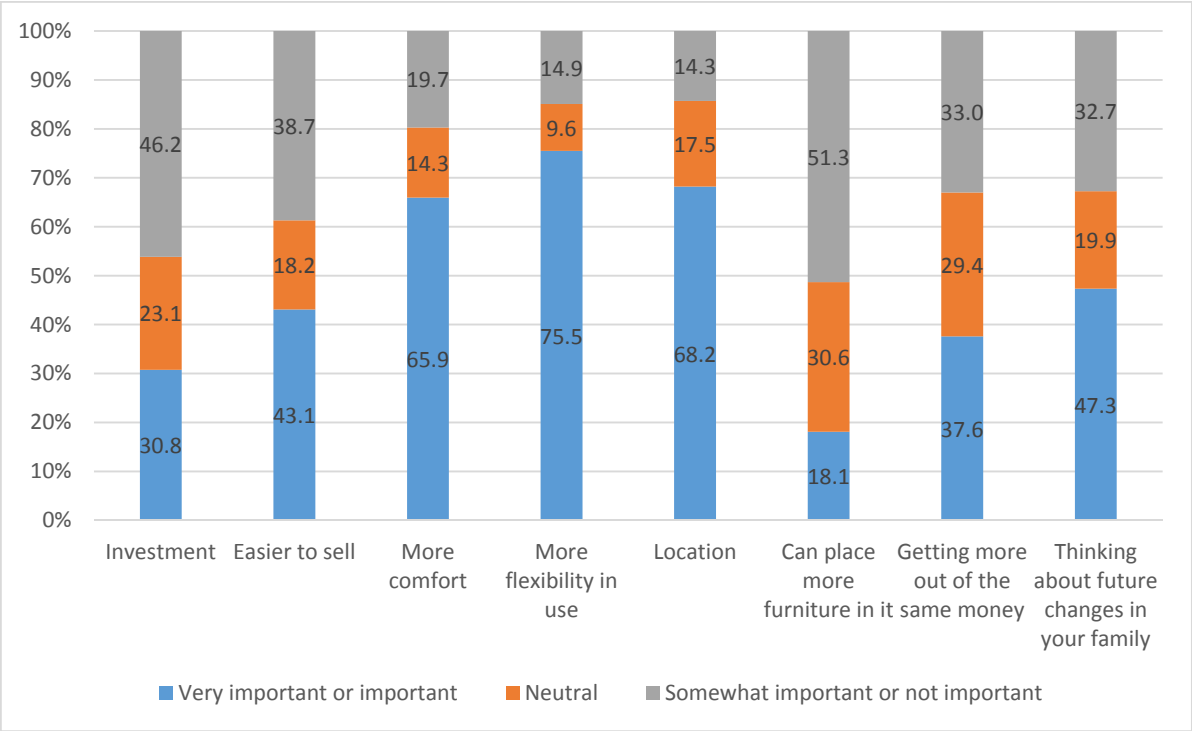


Figure 12.1 Rating the eight reasons for having a large house

12.3. How much are houses used?

Accepting that larger houses are perceived as being more flexible and giving greater comfort, this study shows that regardless of house size people spend 84-100% of their time at home indoors in the core part of the house, comprising a living room, dining room, kitchen and one bedroom per occupant. So, larger houses are not well used and as discussed in chapters 9 and 10 the energy paid for this small use is significant. This questions the value of what people extract from what they spend. As seen in Chapter 6, many people use spare rooms for guests, or as a games room or play room. Comparing the energy used for keeping these spaces for very little use questions whether paying for a hotel, gym or playgroup could be cheaper for both occupants and the environment although this is an area for further study.

12.4. Answers to research questions

What is the impact of house size selection on the embodied and life cycle energy of owner occupied New Zealand houses occupied by small households?

By selecting to live in houses larger than the core house, a household spends more energy for building materials (and their maintenance), heating and providing furniture and appliances to fill these. Depending on the level of large housing (based on number of extra rooms) in year 0, larger houses need 80-120% more energy for their construction and furnishing compared to core houses. A comparison between the share of house construction materials and furnishings of the same house shows that the house and its materials form 59-69% and house furnishing 31-41% of this increase. This means that when it comes to selecting the size of a new house, in life-cycle embodied energy terms construction materials are more important than house furnishings.

The problem becomes more significant over the life of the house because the heating energy, maintenance and furniture/appliance replacement add more energy-use to larger houses. The results show that after 100 years, houses larger than a core house need 83-126% more energy. Again comparing the share of the house and its heating energy with furnishings of the same house it

becomes apparent that the house and its heating energy form 63-77% and house furnishings 23-37% of this increase. This means that although furniture and appliances form a significant part of the life cycle energy of a house, building materials, house maintenance materials and heating energy remain more important than the furniture and appliances as the house ages.

Accepting the fact that energy use per capita might be a more reliable indicator of energy use for housing, this study shows the energy-use per capita of living in a core house for each member of a single person household, childless couple, couples with 1 child and couples with 2 children in year 0 is respectively 317, 158, 115 and 108GJ, although these values increase to 697, 348, 219 and 194GJ if living in houses with 5 extra rooms. Accepting a human life span of 75 years in one house, over this time the energy use per capita for each member of a single person household, childless couple, couples with 1 child and couples with 2 children is respectively 2110, 1055, 766 and 725GJ, although these values increase to 4825, 2413, 1535 and 1333GJ if they live in houses with 5 extra rooms. Together these figures show that large housing is not very important when it comes to large families but is very important when it comes to single person households and childless couples. This finding becomes more important because single person households are becoming more popular in New Zealand. Statistics New Zealand (2016b) predict the number of single person households will increase from 392,700 in 2013 to 582,600 by 2038, a 48.4% increase.

Do small households live in large houses?

Accepting 1 living room, 1 dining room, 1 kitchen and 1 bedroom per family member (couples share a bedroom) as a core house, based on the survey on average single person households live in houses with 2.6 extra rooms, which becomes 2.9 for childless couples, 2.5 for couples with 1 child and 2.2 for couples with 2 children. Although these are averages, it seems the trend is to occupy houses larger than the core house. Although it makes sense for large families to have larger houses because the occupants might need additional rooms for personal reasons such as having a quiet space or a place to work from home, it is the smaller households who on average have more space.

Childless couples probably choose to live in larger houses because they usually have two sources of income, so they can afford to do this and in New Zealand housing is seen as an investment. Whether people choose to live in large houses or this happens as a matter of change in family circumstances is also important. For instance, a proportion of single person households and childless couples are 'empty nesters' and elderly people. While appropriate housing for an aging population is important, as noted earlier, the trend towards living alone is both increasing and projected to increase in New Zealand meaning some small households are (and will be) younger people. What is important in this regard is the fact that there are few available small or core houses for this group of New Zealanders, meaning that even if they wish to downsize, it will be very difficult to find suitable housing to buy. It is thus important that policy makers steer developers to provide housing to cope with these needs.

How is the recent increase in New Zealand house size reflected in the type and number of rooms?

The recent increase in the average floor area of New Zealand houses has affected type, number of rooms and size of similar room types. New New Zealand houses have more rooms compared to their old counterparts, usually containing informal and formal living and dining rooms, and specialised rooms (e.g. study, games room, play room). Most new houses have more than 1 bathroom and many of them are en-suite with private users. These new room types are not necessarily defined by their designers but many of the 'spare bedrooms' are given new, specialised functions by their occupants. Apart from these changes, similar room types seem to be larger in newer houses. For instance, the master bedroom of many new houses includes a walk-in dressing room and en-suite which can make the overall floor area double that of a master bedroom in an older house.

How does house size selection impact on the number of furniture, appliance and tool items?

Regardless of how big the household is, house size is the parameter that defines the amount of furniture, appliance and tool items in a house. This study shows the average number furniture, appliance and tool items in ≤5 houses is 59, increasing to 74, 86, 97 and 102 items for 6, 7, 8 and 9-9+ room houses, which is an average 15% increase for each additional room. When the number of

furniture, appliance and tool items is compared with household size, apart from single person households (68 items), the average number of these items is quite similar with childless couples (84 items), couples with one child (90 items) and couples with two children (91 items). So if a household elects to live in a large house, they inevitably use more furniture, appliances and tools to fill it, even if initially they did not intend to do this.

Further analysis shows that living in larger houses equates to having significantly more "Bedroom/study furniture", "Living room/dining room/kitchen furniture", "Large appliances", "Outdoor furniture/appliances/tools", "Small appliances", "Heating/Ventilation appliances" and "Vehicles". The energy embodied in "Living room/dining room/kitchen" and "Bedroom/study" furniture of a 9-9+ room house is respectively 106% and 102% more than that of a ≤5 house.

Because furniture, appliance and tool items have a short replacement time, the life cycle energy allocated to these becomes more important. By living in an 8 rather than a ≤5 house, 168GJ more energy will be used for furnishing it in year 0 although, increasing to 416, 730, 994 and 1328GJ after 25, 50, 75 and 100 years.

The embodied energy of second hand furniture, appliance and tool items is zero as this is paid by the first user. So using second hand items can decrease the embodied and life cycle energy associated with the furnishing part of housing. On average participants in this study used 41% less energy for furnishing their houses by using some second hand furniture, appliance and tools, with this energy saving higher in small compared to large houses.

Do people living in large houses with access to a number of rooms use these, and if yes for how long are they used?

This study show that people living in larger houses do not necessarily spend more time at home to enjoy their various rooms and flexibility, although room use does vary. From the survey, New Zealanders on average spend 15.94 hours/day at home indoors in summer. While time-use at home

indoors is significantly affected by age and work type, house size has no significant impact on time-use at home indoors.

However, time spent in the rooms of different sized houses is quite different. The research shows people have different strategies for using extra rooms. The majority of people never use these rooms while others do. Accepting that the time-use part of this study has only captured one day time-use, the best way to explain this usage is that these extra rooms have been given names that express their casual use, but on average their use is very limited. Among the new room types, the study is the most used in New Zealand houses, with survey participants spending on average 1.1 hour/day in this room. The average time-use in a games room, play room and studio is only 0.4, 0.5 and 0.5 hour/day. It is important to note that the median time-use for all these room types is zero showing that the average only represents a small part of the sample.

What is important is that even if people use these rooms, this does not mean they spend extra time at home indoors doing this, but that they share their time-use in the main rooms of the house with these extra rooms. For instance, people who use a second living room share the time that they would have spent in the main living room. For this small usage occupants have to maintain and heat these rooms and install furniture to make them useable. This all means additional housing energy for limited usage.

How efficiently are resources in different sized houses used at the house and room scale?

Generally living in core houses is more resource-use efficient. For a typical New Zealander, 0.73MJ remains un-used for each hour of living in a core house, and this increases to 1.02 and 1.62MJ/hour if this person elects to live in a house with 3 or 5 extra rooms. This means that to have more flexibility and comfort people are willing to use more energy for their housing even if the majority of them do not have time to make use of this flexibility and comfort.

When it comes to resource-use efficiency of various room types, extra rooms are generally very non-efficient compared to the core rooms of the house. The master bedroom and living room are the most

and games room, kitchen and study are the least resource-use efficient rooms in New Zealand houses. Generally rooms that are shared by more users, even if they consume more resources, are more resource-use efficient. This questions the logic behind the fully private house. Considering the changes in modern life styles and the fact from the survey people spent less than 1 hour/day in the kitchen and very little time in the laundry, maybe it is time to consider other options, such as co-housing, so that little used spaces can be shared by more people.

12.5. Further research:

This study has opened new windows to other research areas as listed below:

Time-use in different rooms of a house:

Time-use and human exposure assessment studies could both benefit from detailed time-use in the different rooms of a house. This study made a first effort to create a tool to predict time-use in the various rooms of a house for each occupant based on his/her time-use at home indoors. This tool needs to be developed through a survey of a larger sample. Data about time-use in various rooms of a house by different age groups and family members is important for social and behavioural researchers and psychologists. This type of data if mapped with the features of each room (including materials, air quality, and natural light) could show how the built environment and its features affect users' behaviour and relationships. This study found signs that people tend to spend more time in cellular rooms rather than their equivalent open plan room types. The validity of this and the reasons behind it need further investigation.

Occupant behaviour in energy-use simulation tools:

Important input data for energy simulation tools is occupant behaviour. Providing data about when and for how long various age groups spend time in different room types can lead to more precise simulation output. This part of the study needs further research in terms of a survey taking in wider parts of the population to support these tools.

The impact of floor plan layout on occupant health:

How long people spend in different rooms is important because this time equates to exposure to various indoor pollutants. This exposure varies according to parameters including age group, gender, job type, and day type. So understanding how long a person spends time in various rooms can help in identifying groups at risk of exposure to pollutants. In particular, the kitchen, as the main source of indoor pollutants, can affect occupants' health. Further study is needed to measure the level and distribution of kitchen-sourced pollutants in both cellular and open plans and map these to time-use in such rooms.

Resource-use in private open spaces:

New Zealand houses are usually built on large plots. Apart from the building footprint, a significant part of the land is not productive but consumes energy from activities such as lawn maintenance. Additionally, New Zealand houses contain a lot of outdoor furniture, which forms a significant part of the life cycle energy of a New Zealand house, although people do not spend much time in the outdoor spaces of the house and so these resources are not used efficiently. Further research is needed to identify fully the environmental impacts of private open spaces.

Resource-use in private parking facilities:

This study shows that the capacity of available parking facilities in existing New Zealand houses is double the number of household cars. The resources needed to build and maintain these facilities and how much time people use these for parking cars is also an area for further research.

Sharing resources: an idea towards more resource-use efficiency:

This study shows that while large housing leads to use of more natural resources, where a house (or a room within a house) is shared, the resources of that house (or room) are used more efficiently. At the same time, various ethnic groups have different level of acceptance of sharing spaces. In particular private open spaces and kitchens are spaces that consume significant resources over their life cycle and people use theses spaces very little. A further study is needed to discover how and to what extent

various ethnic groups can accept sharing these spaces and the effect this would have on life-time resource use.

Second-hand furniture and appliances

This study shows that using second-hand items can save significant housing energy. There is very limited information of the "how"s and "why"s of using second-hand furniture and appliance items in different countries. Public awareness about the impacts of using second-hand items as a way towards more sustainable use of natural resources is also an area for further research.

12.6. Study limits

This study has a number of limitations which should be taken into account when using the results.

- The first is that that the time-use data is based on one day time-use self-reporting. As discussed in section 5.9.1, choosing one day to represent a week could lead to a level of error in the results, and self-reporting data is always an estimate. The level of error caused by one-day sampling varies based on the sample size. For instance, when talking about the average time-use at home indoors or usual bedroom(s), the average result has little error because the whole sample (538) is considered in the average, but when talking about average time-use in some rooms like a play room, because the sample number is small (34) the error level is greater (see also section 5.9.1).

- The time-use study was conducted in summer which should give a lower average time-use at home indoors in comparison to the whole year. This might have also affected the time-use results for rooms of the house, although as discussed in section 8.3.1 the anticipated impact of this is small.

- The time-use patterns of New Zealanders could be different from other countries. While the method for time-use data collection is useable in other countries, the results are not.

- The life cycle analysis was performed for New Zealand houses, and while the method is usable in other countries, the results are not generalizable. The main reason is that the technology of New Zealand houses is different and generally the embodied energy of these is much lower than other

countries. Apart from this, the type and quantity of furniture and appliance items in New Zealand houses is not necessarily comparable to other countries.

- The method used for estimating embodied and life cycle energy of various sized houses gives an estimation average for each house size. It does not necessarily give a precise result for individual houses.

- The method used for calculating the embodied energy of furniture and appliances is only an approximation, given the lack of accurate data for the embodied energy of each item.

12.7. What is next?

The information on the impact of house size selection on energy use for housing could be used in a number of ways.

- The results could be used by policy makers to define new regulations to control large housing. Considering that those living in large houses are using more than their fair share of natural resources, which also belong to future human generations, governments need to consider restricting this unsustainable trend. Maybe it is time for all developed countries to define policies like the extra bedroom tax in the UK.

- This study could also be used by NGOs and those active in environmental issue to create public awareness about the impacts of large housing and what this means in terms of energy use. In the current affordable housing debate little attention has yet been paid to house size.

13. Bibliography

A. J. Hart Ltd. (1957a). Two storey expanding house (first stage). *Home and Building, XIX*(12), 30.

A. J. Hart Ltd. (1957b). Two storey expanding house (second stage). *Home and Building, XIX*(12), 31.

Abbott Hole and Annabell. (1957). A "Parade of Homes" house. *Home and Building, XIX*(12), 25-27.

Adalberth, K. (1997). Energy use during the life cycle of single-unit dwellings: examples. *Building and Environment, 32*(4), 321-329.

Adalberth, K. (1999). Energy use in four multi-family houses during their life cycle. *International Journal of Low Energy and Sustainable Buildings, 1*, 1-20.

Adalberth, K., Almgren, A., & Petersen, E. H. (2001). Life-cycle assessment of four multi-family buildings. *International Journal of Low Energy and Sustainable Buildings*.

Alcorn, A. (1996). Embodied energy coefficients of building materials (3rd ed.). Wellington: Centre for Building Performance Research, Victoria University of Wellington.

Alcorn, A. (1998). Embodied energy coefficients of building materials (3rd ed.). Wellington: Centre for Building Performance Research, Victoria University of Wellington.

Alcorn, A. (2003). Embodied energy and CO2 coefficients for NZ building materials. Wellington: Centre for Building Performance Research, Victoria University of Wellington.

Alcorn, A., & Wood, P. (1998). New Zealand Building Materials Embodied Energy Coefficients Database (Vol. II-Coefficients). Wellington: Centre for Building Performance Research, Victoria University of Wellington.

Alcorn, J. A. (2010). *Global Sustainability and the New Zealand House.* (PhD thesis), Victoria University of Wellington, Wellington.

Allingham, J. D. (1955). Four bedrooms in 1050 sq. feet. *Home and Building, XVIII*(3), 27.

American houses Inc. (1954a). United States packaged housing: The "PATRIOT" - 2-4 bedrooom prefabricated houses (2 bedroom type). *Home and Building, XVII*(1), 29.

American houses Inc. (1954b). United States packaged housing: The "PATRIOT" - 2-4 bedrooom prefabricated houses (3 bedroom type). *Home and Building, XVII*(1), 29.

American houses Inc. (1954c). United States packaged housing: The "PATRIOT" - 2-4 bedrooom prefabricated houses (4 bedroom type). *Home and Building, XVII*(1), 28.

Ancber, S. E. (1958). Good to live in: Houses by Australian architects. *Home and Building, XXI*(2), 35.

Andersen, R. V., Toftum, J., Andersen, K. K., & Olesen, B. W. (2009). Survey of occupant behaviour and control of indoor environment in Danish dwellings. *Energy and Buildings, 41*(1), 11-16. doi:10.1016/j.enbuild.2008.07.004

Angus, D. H. (1959). Family house Hamilton. *Home and Building, XXI*(10), 44-45.

Asif, M., Muneer, T., & Kelley, R. (2007). Life cycle assessment: a case study of a dwelling home in Scotland. *Building and Environment, 42*(3), 1391-1394.

Auckland Council. (2011). *Appendix 12: Minimum residential apartment standards*. Auckland: Auckland Council,.

Australian Bureau of Statistics. (n.d.). Australian Bureau of Statistics website. Retrieved 4/09/2016 from http://www.abs.gov.au/

Baird, G., & Chan, S. A. (1983). *Energy cost of houses and light construction buildings*. Auckland: New Zealand Energy Research and Development Committee, University of Auckland.

Baker, M., Keall, M., Au, E. L., & Howden-Chapman, P. (2007). Home is where the heart is--most of the time. *The New Zealand Medical Journal, 120*(1264), 113-116.

Bartlett, A., & Bartlett. (1954). A well-tailored house. *Home and Building, XVII*(6), 26-29.

Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. *Human relations, 61*(8), 1139-1160.

Bassett, M., & Malpass, L. (2013). *Priced out: How New Zealand lost its housing affordability?* Wellington: The New Zealand Initiative

Bates, S., & Kane, C. (2005). *The future of housing in New Zealand*. Wellington: CHRANZ.

Bennett, R., Glennerster, H., & Nevison, D. (1992). Investing in skill: to stay on or not to stay on? *Oxford Review of Economic Policy, 8*(2), 130-145.
Benson deK. Mason. (1958). Model house copetition (third award). *Home and Building, XXI*(1), 38-39.
Black Hut Ltd. (2016a). Black Hut designs website. Retrieved 19/05/2016 from http://blackhut.co.nz/
Black Hut Ltd. (2016b). Black Hut designs: The Kapiti Hut (43m2). Retrieved 19/05/2016 from http://blackhut.co.nz/the-hut-designs/kapiti-hut/
Blair, J. (1982). Blackler house (Otatara, Invercargill). *New Zealand Home and Building*(4), 51-52.
Blanchard, S., & Reppe, P. (1998). *Life cycle analysis of a residential home in Michigan.* (Master's thesis), University of Michigan, Michigan.
Blight, T. S., & Coley, D. A. (2013). Sensitivity analysis of the effect of occupant behaviour on the energy consumption of passive house dwellings. *Energy and Buildings, 66*, 183-192.
Bloomfield, W. S. R. (1954). A sloping triangular site governs the plan. *Home and Building, XVII*(3), 20-23.
Bloomfield, W. S. R. (1955). A straightforward house simple and echonomical to build. *Home and Building, XVII*(10), 30-31.
Bowman, A. (1957). Hillside house at Nelson. *Home and Building, XX*(2), 33-35.
Brasche, S., & Bischof, W. (2005). Daily time spent indoors in German homes--baseline data for the assessment of indoor exposure of German occupants. *International journal of hygiene and environmental health, 208*(4), 247-253.
Brauer, R. L. (1974). The importance of individual differences in buildings. In D. V. Canter & T. Lee (Eds.), *Psychology and the built environment*. New York: Wiley.
Brian Elliott Associates. (1982). Monk house Palmerston North. *New Zealand Home and Building*(5), 57.
Briggs, D. J., Denman, A. R., Gulliver, J., Marley, R., Kennedy, C., Philips, P., . . . Crockett, R. (2003). Time activity modelling of domestic exposures to radon. *Journal of Environmental Management, 67*(2), 107-120.
Briscoes. (2016). Briscoes homeware website. Retrieved 8/08/2016 from http://www.briscoes.co.nz/
Broich, A. V., Gerharz, L. E., & Klemm, O. (2012). Personal monitoring of exposure to particulate matter with a high temporal resolution. *Environmental Science and Pollution Research, 19*(7), 2959-2972.
Brown, J. G. (1957a). One storey expanding house (completed house). *Home and Building, XIX*(12), 29.
Brown, J. G. (1957b). One storey expanding house (first stage). *Home and Building, XIX*(12), 28.
Brown, S. (2011). Expected useful life for home components and appliances. Retrieved 16/08/2016 from http://www.midamericainspection.com/content/expected-useful-life-home-components-and-appliances
Brundtland, G. H. (1987). *Our common future: World Commission on Environment Development*. Oxford; New York: Oxford University Press.
BSHF, & Moreton, R. (2013). *Perceptions of overcrowding : public views of space in the home*. Coalville: Building and Social Housing Foundation.
Bunnings Warehouse. (2016). Bunnings Warehouse website: Garden tools. Retrieved 11/05/2016 from http://www.bunnings.co.nz/
CABE, & RIBA. (2009). *Space in new homes: What residents think*. Retrieved from London: http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/files/space-in-new-homes.pdf
Canter, D. (1972). Royal hospital for sick children, Yorkhill, Glasgow, by Baxter Clark & Paul: a psychological analysis. *Architects' Journal Information Library, September*, 525-564.
Canter, D., Gilchrist, J., Miller, J., & Roberts, N. (1974). An Empirical study of focal point in living room. In D. V. Canter & T. Lee (Eds.), *Psychology and the built environment*. New York: Wiley.

Canter, D., & Lee, K. H. (1974a). A non-reactive study of room usage in modern Japanese apartments. In D. Canter & T. Lee (Eds.), *Psychology and the built environment*. New York: Wiley.
Canter, D., & Lee, T. (1974b). *Psychology and the built environment*. New York: Wiley.
Canter, D., & Tagg, S. (1980). The empirical classification of building aspects and their attributes. In G. Broadbent, R. Bunt, & T. Llorens Serra (Eds.), *Meaning and behaviour in the built environment*. Chichester [England]; New York: J. Wiley.
Canter, D. V. (1977). *The psychology of place*. London: Architectural Press.
Carmona, M., Gallent, N., & Sarkar, R. (2010). *Space standards: the benefits*. London: University College.
Certifiedplans. (2016a). Certified plans designers website. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/
Certifiedplans. (2016b). Collection of Certified plans-Kauri. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/kauri/
Certifiedplans. (2016c). Collection of Certified plans-Kea. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/kea/
Certifiedplans. (2016d). Collection of Certified plans-Kereru. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/kereru/
Certifiedplans. (2016e). Collection of Certified plans-Mamaku. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/mamaku/
Certifiedplans. (2016f). Collection of Certified plans-Manuka. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/manuka/
Certifiedplans. (2016g). Collection of Certified plans-Matai. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/matai/
Certifiedplans. (2016h). Collection of Certified plans-Pohtukawa. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/pohutukawa/
Certifiedplans. (2016i). Collection of Certified plans-Pukeko. Retrieved 05/04/2016 from http://www.certifiedplans.co.nz/plan/pukeko/
Chapin, F. S. (1974). *Human activity patterns in the city : things people do in time and in space*. New York [etc.]: John Wiley & Sons.
Charmaz, K. (2008). Grounded theory in the 21th century: Applications for advancing social justice studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Strategies of qualitative inquiry*. California: Sage.
Chatsford Management Ltd. (2016a). Chatsford homes: Apartments (Argyle). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016b). Chatsford homes: Apartments (Cambridge). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016c). Chatsford homes: Apartments (Chiswick apartment-Type A). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016d). Chatsford homes: Apartments (Chiswick apartment-Type B). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016e). Chatsford homes: Apartments (Chiswick apartment-Type C). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016f). Chatsford homes: Apartments (Chiswick apartment-Type D). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016g). Chatsford homes: Apartments (Oxford). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016h). Chatsford homes: Apartments (Winchester). Retrieved 13/04/2016 from http://www.chatsford.co.nz/apartments.php
Chatsford Management Ltd. (2016i). Chatsford Retirement Village website. Retrieved 13/04/2016 from http://www.chatsford.co.nz/

Cheetham, D., & Bateman, D. (1991). *The Bateman book of New Zealand house plans*. Auckland: David Bateman Ltd.
Chrystall, L. (1982). Design for life. *New Zealand Home and Building*(2), 52-53.
Citherlet, S., & Defaux, T. (2007). Energy and environmental comparison of three variants of a family house during its whole life span. *Building and Environment, 42*(2), 591-598.
Coastal Homes NZ Ltd. (2016a). Coastal Homes NZ Ltd. website. Retrieved 19/05/2016 from http://www.coastalhomesnz.com/
Coastal Homes NZ Ltd. (2016b). House designs: Harbour series-Harbour 59 (1). Retrieved 19/05/2016 from http://www.coastalhomesnz.com/House+Designs/Harbour+Series/Wave+59+1.html
Coastal Homes NZ Ltd. (2016c). House designs: Harbour series-Harbour 72 (2). Retrieved 19/05/2016 from http://www.coastalhomesnz.com/House+Designs/Harbour+Series/Wave+72+2.html
Cochran, C. (1980). *Restoring a New Zealand house*. Wellington: New Zealand Historic Places Trust: Ministry of Works and Development.
Commission for Architecture and the Built Environment. (2005). *What home buyers want : attitudes and decision making among consumers*. London: CABE.
Committee on National Statistics. (2000). *Time-use measurement and research : report of a workshop* M. V. Ploeg, J. Altonji, N. Bradburn, J. DaVanzo, W. Nordhaus, & F. Samaniego (Eds.), Retrieved from /z-wcorg/ database
Conrad, A., Seiwert, M., Hünken, A., Quarcoo, D., Schlaud, M., & Groneberg, D. (2013). The German Environmental Survey for Children (GerES IV): Reference values and distributions for time-location patterns of German children. *International journal of hygiene and environmental health, 216*(1), 25-34.
Cook Hitchcock Sargisson. (1982). Enterprising practice moves to parnell: Sargisson townhouse. *New Zealand Home and Building*(3), 17-19.
Cooper, T. (2004). Inadequate life? Evidence of consumer attitudes to product obsolescence. *Journal of Consumer Policy, 27*(4), 421-449.
Cooper, T. (2010). The significance of product longevity. In T. Cooper (Ed.), *Longer lasting products : alternatives to the throwaway society* (pp. 3-36). Farnham, Surrey [England]; Burlington, VT: Gower ; Ashgate Pub. Co.
Crandall, A. S., & Cook, D. J. (2013). Tracking systems for multiple smart home residents. In H. W. Güsgen & S. Marsland (Eds.), *Human behavior recognition technologies : intelligent applications for monitoring and security*. Hershey: IGI Global.
Crawford, R. (2011). *Life cycle assessment in the built environment*. London: Spon Press.
Creswell, J. W. (2014). *Research design : qualitative, quantitative, and mixed methods approaches*. Los Angeles: SAGE Publications.
Curlett, B. M. (1976a). Town houses: Remuera. *New Zealand Home and Building, XXXVIII*(4), 29.
Curlett, B. M. (1976b). Town houses: Remuera. *New Zealand Home and Building, XXXVIII*(4), 27-28.
Curlett, B. M. (1976c). Town houses: Remuera. *New Zealand Home and Building, XXXVIII*(4), 30-31.
D. A. & Lillian. (1976). House design competition (3rd place equal). *New Zealand Home and Building, XXXVIII*(2), 21.
D. E. Donnithorne. (1959). Four children in 900 Square feet. *Home and Building, XXI*(11), 34-37.
Davey, J., Joux, V. d., Nana, G., & Arcus, M. (2004). *Accommodation options for older people in Aotearoa/New Zealand*. Retrieved from Wellington: https://www.beehive.govt.nz/sites/all/files/Accomodation%20Options%20for%20Older%20People.pdf
Demesne. (2010). Appliance Life Expectancy: How long should an appliance last? Retrieved 16/08/2016 from http://www.demesne.info/Home-Maintenance/Appliance-Life-Expectancy.htm

Demographia. (2014). 10th annual demographia international housing affordability survey: 2014. Retrieved 22/10/2015 from http://apo.org.au/node/37239

Demographia. (2016). *12th Annual Demographia International Housing Affordability Survey: 2016*. Retrieved from Illinois: http://www.demographia.com/dhi.pdf

Denman, A., Gulliver, J., Kennedy, C., Briggs, D., & Phillips, P. (2000). *The impact of occupancy patterns on the assessment of the value of domestic radon remediation programmes in the UK.* Paper presented at the Proceedings of the 10th International Congress of the International Radiation Protection Association, Hiroshima 14-19 May.

Denniston and Hodgson. (1981). Denniston house-Tauranga. *New Zealand Home and Building*(2), 31-36.

Department of Building and Housing. (2010). *New Zealand housing report 2009/2010: structure, pressures and issues*. Retrieved from Wellington: http://www.mbie.govt.nz/publications-research/research/housing-and-property/2009-2010-nz-housing-report.pdf

Department of Building and Housing. (2011). *Compliance Document for New Zealand Building Code: Clause G5-Interior Environment*. Wellington: Department of Building and Housing.

Department of the Prime Minister and Cabinet. (2008). *Final report of the House Prices Unit: House price increases and housing in New Zealand*. Retrieved from Wellington: http://www.dpmc.govt.nz/sites/all/files/publications/hpr.pdf

Dol, K., & Haffner, M. (2010). *Housing statistics in the European Union 2010*. Hague: OTB Research Institute for the Built Environment, Delft University of Technology.

Donnithorne, D. E. (1982). St. Lukes village, Napier. *New Zealand Home and Building*(6), 42-43.

Dörre, W. (1996). Time-activity-patterns of some selected small groups as a basis for exposure estimation: a methodological study. *Journal of exposure analysis and environmental epidemiology, 7*(4), 471-491.

Dresner, S. (2008). *The Principles of Sustainability*: Earthscan.

Easton, L., & Saville Smith, K. (2008). *Sustainable Building for Affordable Housing*. Paper presented at the Resource Management Law Association Conference, Dunedin.

Echols, S. L., MacIntosh, D. L., Hammerstrom, K. A., & Ryan, P. B. (1998). Temporal variability of microenvironmental time budgets in Maryland. *Journal of exposure analysis and environmental epidemiology, 9*(5), 502-512.

Edwards, M. (1974). Comparison of some expectations of a sample of housing architects with known data. In D. V. Canter & T. Lee (Eds.), *Psychology and the built environment*. New York: Wiley.

Eggers, F. J., & Moumen, F. (2013). *Between-survey changes in the number of bedrooms in a unit: How Often? Why? Effect on measures of rental affordability?* Retrieved from Maryland: https://www.census.gov/content/dam/Census/programs-surveys/ahs/publications/AHS_NumberOfBedrooms.pdf

Elgethun, K., Yost, M. G., Fitzpatrick, C. T., Nyerges, T. L., & Fenske, R. A. (2007). Comparison of global positioning system (GPS) tracking and parent-report diaries to characterize children's time–location patterns. *Journal of Exposure Science and Environmental Epidemiology, 17*(2), 196-206.

Elias, E. W. A., Dekoninck, E. A., & Culley, S. J. (2007). *The Potential for Domestic Energy Savings through Assessing User Behaviour and Changes in Design*. Paper presented at the EcoDesign 2007: 5th International Symposium on Environmentally Conscious Design and Inverse Manufacturing Tokyo.

Ericksen, K., & Quest, T. (1979a). Four small houses: Cassidy house. *New Zealand Home and Building*(2), 27.

Ericksen, K., & Quest, T. (1979b). Four small houses: Elliott house. *New Zealand Home and Building*(2), 25-26.

Ericksen, K., & Quest, T. (1979c). Four small houses: Rowe house. *New Zealand Home and Building*(2), 26.

Eurostat. (2004). *Guidelines on harmonised European time use surveys*. Luxembourg: Office for Official Publications of the European Communities.
Evans, G., Peers, A., & Sabaliauskas, K. (2008). Particle dose estimation from frying in residential settings. *Indoor Air, 18*(6), 499-510.
FannieMae. (2014). Instructions for performing a mutifamily property condition assessment (Version 2.0). Retrieved 16/08/2016 from https://www.fanniemae.com/content/guide_form/4099f.pdf
Farmers. (2016). Farmers store website. Retrieved 10/03/2016 from http://www.farmers.co.nz/
Fay, M. R. (1999). *Comparative life cycle energy studies of typical Australian suburban dwellings.* (PhD thesis), Deakin University, Geelong.
Fay, R., Treloar, G., & Iyer-Raniga, U. (2000). Life-cycle energy analysis of buildings: a case study. *Building Research & Information, 28*(1), 31-41.
Fiol, T. (2013). The life expectancy of 7 major appliances. Retrieved 16/08/2016 from http://blogs.hrblock.com/2013/10/21/the-life-expectancy-of-7-major-appliances/
Firth, C. H. (1949). *State housing in New Zealand*. Wellington: Ministry of Works.
Fishpond. (2016). Fishpond website. Retrieved 8/08/2016 from http://www.fishpond.co.nz/
Fleming, R., & Spellerberg, A. (1999). *Using time use data: A history of time use surveys and uses of time use data*. Wellington: Statistics New Zealand.
Foroughi, H., Aski, B. S., & Pourreza, H. (2008). *Intelligent video surveillance for monitoring fall detection of elderly in home environments*. Paper presented at the th International Conference on Computer and Information Technology, Khulna, Bangladesh.
Freedom furniture. (2016). Freedom furniture website. Retrieved 9/03/2016 from http://www.freedomfurniture.co.nz/
Freeman, N., Lioy, P. J., Pellizzari, E., Zelon, H., Thomas, K., Clayton, A., & Quackenboss, J. (1998). Responses to the region 5 NHEXAS time/activity diary. National Human Exposure Assessment Survey. *Journal of exposure analysis and environmental epidemiology, 9*(5), 414-426.
Friedman, D. (2010). *Social impact of poor housing*. Retrieved from London: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.476.9406&rep=rep1&type=pdf
Fromme, H. (2012). Particles in the indoor environment. In S. Kumar (Ed.), *Air Quality-Monitoring and Modeling*. Rijeka: InTech.
Fuller, R., & Crawford, R. (2011). Impact of past and future residential housing development patterns on energy demand and related emissions. *Journal of housing and the built environment, 26*(2), 165-183.
Fuller, R., Crawford, R., & Leonard, D. (2009). *What is wrong with a big house?* Paper presented at the ANZAScA 2009: Performative ecologies in the built environment| Sustainable research across disciplines: Proceedings of the 43rd Annual Conference of the Architectural Science Association, University of Tasmania.
Galvin, R. (2013). Targeting 'behavers' rather than behaviours: a 'subject-oriented'approach for reducing space heating rebound effects in low energy dwellings. *Energy and Buildings, 67*, 596-607.
Gao, J., Cao, C., Zhang, X., & Luo, Z. (2013). Volume-based size distribution of accumulation and coarse particles (PM0. 1–10) from cooking fume during oil heating. *Building and Environment, 59*, 575-580.
Geniushomes. (2016a). Genius homes Ltd. company website. Retrieved 12/04/2016 from http://geniushomes.co.nz/
Geniushomes. (2016b). House designs: 2 bedroom homes (Inchbonnie). Retrieved 12/04/2016 from http://geniushomes.co.nz/2bedroom_homes.html
Geniushomes. (2016c). House designs: 2 bedroom homes (Peketa). Retrieved 12/04/2016 from http://geniushomes.co.nz/2bedroom_homes.html

Geniushomes. (2016d). House designs: Farm houses (Dunrobin). Retrieved 12/04/2016 from http://geniushomes.co.nz/farm_homes.html
Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory : strategies for qualitative research*. Chicago: Aldine Pub. Co.
Gleeson, B. M. (1976). Russell flats (unit 1). *New Zealand Home and Building, XXXVIII*(1), 26-27.
Global Footprint Network. (2016). Earth Overshoot Day. Retrieved 9/09/2016 from http://www.footprintnetwork.org/en/index.php/GFN/page/earth_overshoot_day_2015_press_release
Glorieux, I., & Minnen, J. (2009). How many days? A comparison of the quality of time-use data from 2-day and 7-day diaries. *electronic International Journal of Time Use Research, 6*(2), 314-327.
Glossop, D. (1979). "Croft Glen" Farmstead Ardmore. *New Zealand Home and Building*(4), 42-45.
Goodyear, R. K., Fabian, A., & Hay, J. (2011). *Finding the crowding index that works best for New Zealand applying different crowding indexes to census of population and dwellings data for 1986-2006*. Wellington: Statistics New Zealand.
Gray, A. (2001). *Definitions of crowding and the effects of crowding on health: A literature review*. Wellington: Ministry of Social Policy.
Great Britain Department of the Environment. (1975). *Homes for today and tomorrow*. London: HMSO.
Green Peace New Zealand. (2008). New Zealand's outdoor furniture is fueling forest destruction: Forest Friendly Outdoor Furniture Guide. Retrieved 29/10/2015 from http://www.greenpeace.org/new-zealand/en/press/furniture-fueling-forest-destruction/
Greenhaven Smart Homes NZ. (2016a). Floor plans: One bedroom modules (GH19). Retrieved 19/05/2016 from http://www.greenhavenhomes.co.nz/gh19
Greenhaven Smart Homes NZ. (2016b). Greenhaven Smart Homes NZ website. Retrieved 19/05/2016 from http://www.greenhavenhomes.co.nz/
Grierson, H. C. (1954). On the cliffs at shag point. *Home and Building, XVII*(6), 30-31.
Groves, R., Fowler, F., Couper, M., Lepkowski, J., Singer, E., & Tourangeau, R. (2009). *Survey methodology*. Hoboken, N.J: John Wiley & Sons.
Guerin, D. A., Yust, B. L., & Coopet, J. G. (2000). Occupant Predictors of Household Energy Behavior and Consumption Change as Found in Energy Studies Since 1975. *Family and Consumer Sciences Research Journal, 29*(1), 48-80. doi:10.1177/1077727X00291003
Guerra-santin, O., & Itard, L. (2012). The effect of energy performance regulations on energy consumption. *Energy Efficiency, 5*(3), 269-282. doi:http://dx.doi.org/10.1007/s12053-012-9147-9
Gunter, D. C. (1958). House at seatoun heights, Wellington. *Home and Building, XX*(11), 40-42.
Habinteg. (2010). Lifetime Home revised criteria. London: Habinteg.
Hammock shop. (2016). Hammock shop website. Retrieved 8/08/2016 from http://www.hammockshop.co.nz/
Harker, L. (2006). *Chance of a lifetime: the impact of bad housing on children's lives*. London: Shelter.
Hart sport. (2016). Hart sport website. Retrieved 8/08/2016 from https://www.hartsport.co.nz/
Harvey Norman. (2016). Harvey Norman store website. Retrieved 10/03/2016 from http://www.harveynorman.co.nz/
HATC. (2006). *Housing space standards*. London: Greater London Authority.
Helmore & Cotterill. (1955). An old established garden. *Home and Building, XVIII*(7), 26-27.
Heritage buildings & homes. (2016a). Bungalow range: The chico. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/chico-floor.jpg
Heritage buildings & homes. (2016b). Bungalow range: The Fresno. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/fresno-details.jpg
Heritage buildings & homes. (2016c). Bungalow range: The Laguna. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/laguna-details.jpg

Heritage buildings & homes. (2016d). Bungalow range: The pasadena. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/pasadena-home-details.jpg
Heritage buildings & homes. (2016e). Bungalow range: The Sacramento. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/sacramento-details.jpg
Heritage buildings & homes. (2016f). Bungalow range: The San Diego. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/sandiego-details.jpg
Heritage buildings & homes. (2016g). Bungalow range: The Santa Monica. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/santamonica-details.jpg
Heritage buildings & homes. (2016h). Bungalow range: The santa Monica+Garage. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/bungalow-Santa-Monica+-garage-plan.jpg
Heritage buildings & homes. (2016i). Cottage range: The appleby. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/Appleby-img-lg-floorplan.jpg
Heritage buildings & homes. (2016j). Cottage range: The Ivy. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/ivy-details.jpg
Heritage buildings & homes. (2016k). Cottage range: The Orchard house. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/orchardhouse-details.jpg
Heritage buildings & homes. (2016l). Cottage range: The Rose. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/rose-details.jpg
Heritage buildings & homes. (2016m). Cottage range: The Sunny side. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/sunnyside-details.jpg
Heritage buildings & homes. (2016n). Cottage range: The Woodlands. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/woodlands-home-details.jpg
Heritage Buildings & Homes. (2016o). Heritage Buildings & Homes company website. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/
Heritage buildings & homes. (2016p). Other homes and character and style: The Balmoral. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/balmoral-details.jpg
Heritage buildings & homes. (2016q). Other homes of character and style: Art Deco. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/Art-deco-details.jpg
Heritage buildings & homes. (2016r). Other homes of character and style: Arundel. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/arundel-home-details.jpg
Heritage buildings & homes. (2016s). Pioneer range: The Riverton. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/riverton-details.jpg
Heritage buildings & homes. (2016t). Pioneer range: The Waipu. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/waipu-details.jpg
Heritage buildings & homes. (2016u). Villa range: Avondale. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/avondale-details.jpg
Heritage buildings & homes. (2016v). Villa range: The Howick. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/howick-details.jpg
Heritage buildings & homes. (2016w). Villa range: The Kingsland. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/kingsland-details.jpg
Heritage buildings & homes. (2016x). Villa range: The Newmarket. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/newmarket-details.jpg
Heritage buildings & homes. (2016y). Villa range: The Newmarket+Garage. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/Newmarket-garage-details.jpg
Heritage buildings & homes. (2016z). Villa range: The Parnell. Retrieved 07/04/2016 from http://heritagebuildings.co.nz/images/parnell-details.jpg
Hoekstra Pianos. (2016). Hoekstra pianos website. Retrieved 10/03/2016 from http://www.piano.co.nz/buy.html
Home and Building. (1937-1982). *The New Zealand Home and Building archive (1937-1982)*. Wellington: Home and Building.

House plans. (2016a). Zen Lifestyle5, 5 Bedroom. Retrieved from http://houseplans.co.nz/house-plans/2733/
House plans. (2016b). Zen Lifestyle6, 4 Bedroom. Retrieved from http://houseplans.co.nz/house-plans/zen-lifestyle-6/
House plans. (2016c). Zen Lifestyle 1, 6 Bedroom. Retrieved from http://houseplans.co.nz/house-plans/zen-homes-lifestyle-1/
Houseplans. (2016). House plans New Zealand Ltd. website. Retrieved 21/04/2016 from http://houseplans.co.nz/
Housing New Zealand Corporation. (2002a). Architecture design guide. Wellington: Housing New Zealand Corporation.
Housing New Zealand Corporation. (2002b). Ki te Hau Kainga: New perspectives on Maori housing solutions. Wellington: Housing New Zealand Corporation.
Housing New Zealand Corporation. (2002c). Pacific housing design guide. Wellington: Housing New Zealand Corporation.
Howden-Chapman, P., Viggers, H., Chapman, R., O'Sullivan, K., Telfar Barnard, L., & Lloyd, B. (2012). Tackling cold housing and fuel poverty in New Zealand: A review of policies, research, and health impacts. *Energy Policy, 49*, 134-142. doi:http://dx.doi.org/10.1016/j.enpol.2011.09.044
Hussein, T., Paasonen, P., & Kulmala, M. (2012). Activity pattern of a selected group of school occupants and their family members in Helsinki—Finland. *Science of the Total Environment, 425*, 289-292.
Ifurniture. (2016). Ifurniture website. Retrieved 10/03/2016 from http://www.ifurniture.co.nz/index.asp
InterNACHI. (2016). InterNACHI's standard estimated life expectancy chart for homes. Retrieved 16/08/2016 from https://www.nachi.org/life-expectancy.htm
International Tropical Timber Organization, & International Trade Centre (UNCTAD / WTO). (2005). *International wooden furniture markets : a review*. Geneva: International Trade Centre UNCTAD/WTO, International Tropical Timber Organization.
Isaacs, N., Camilleri, M., Burrough, L., Pollard, A., Saville-Smith, K., Fraser, R., . . . Jowett, J. (2010). *Energy use in New Zealand households: Final report on the household energy end-use project (HEEP)*. Porirua: BRANZ.
Isaacs, N. P. (2015). *Making the New Zealand house 1792-1982.* (PhD thesis), Victoria University of Wellington, Wellington.
Isaxon, C., Gudmundsson, A., Nordin, E., Lönnblad, L., Dahl, A., Wieslander, G., . . . Wierzbicka, A. (2015). Contribution of indoor-generated particles to residential exposure. *Atmospheric Environment, 106*, 458-466.
Iseke, F. G. (1959). Low cost house in steel and concrete. *Home and Building, XXI*(11), 38-41.
Ishikawa, T., Nakata, S., & Asami, Y. (2011). Perception and conceptualization of house floor plans: An experimental analysis. *Environment and Behavior, 43*(2), 233-251.
James Hardie & Coy. PTY. LTD. (1954). Hardie's Fibrolite asbestos cement sheets. *Home and Building, XVII*(3), 46.
James Hardie & Coy. PTY. LTD. (1955). Hardie's Fibrolite asbestos cement sheets. *Home and Building, XVIII*(7), 18.
James Hardie & Coy. PTY. LTD. (1956a). Hardie's Fibrolite asbestos cement sheets. *Home and Building, XVIII*(9), 64.
James Hardie & Coy. PTY. LTD. (1956b). Hardie's Fibrolite asbestos cement sheets. *Home and Building, XVIII*(11), 12.
Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative science quarterly, 24*(4), 602-611.
Johns, B. W. (1938). Paragon: The home of Mr. & Mrs. J. Ashford Harris, at Lower Hutt. *Home and Building, II*(4), 8.

Johns, B. W., & Meldrum. (1941). A Wellington house. *Home and Building, V*(4), 6-7.
Johnston, G. W. (1956). Looking towards Matakana island. *Home and Building, XVIII*(9), 18-19.
Jump Flex. (2016). Jump flex website. Retrieved 8/08/2016 from http://www.jumpflex.co.nz/
Just Spas. (2016). Just Spas website. Retrieved 8/08/2016 from http://www.justspas.co.nz/
Kapiti Retirement Trust. (2016a). Accommodation types: Villas (Sevenoaks Duplex Villa). Retrieved 13/04/2016 from http://www.retirekapiti.co.nz/images/duplex-villas.jpg
Kapiti Retirement Trust. (2016b). Kapiti Retirement Trust website. Retrieved 13/04/2016 from http://retirekapiti.co.nz/
Kiernan, G. (2012). Will new dwellings keep getting bigger? Retrieved 27/01/2014 from http://www.infometrics.co.nz/Forecasting/6094/901/Will-new-dwellings-keep-getting-bigger
King Cook and Dawson. (1957). House for a Wellington doctor. *Home and Building, XIX*(9), 32-35.
King, P. (1959). Two houses at Matamata (townhouse). *Home and Building, XXI*(10), 41.
Klöpffer, W. (2014). Introducing Life Cycle Assessment and its presentation in 'LCA Compendium'. In W. Klöpffer & M. A. Curran (Eds.), *Background and future prospects in life cycle assessment*. Dordrecht; Heidelberg; New York; London: Springer
Leech, J. A., Nelson, W. C., Burnett, R. T., Aaron, S., & Raizenne, M. E. (2002). It's about time: a comparison of Canadian and American time-activity patterns. *Journal of exposure analysis and environmental epidemiology, 12*(6), 427-432.
Lifetime Design Ltd. (2012). Lifemark design standards handbook. Auckland: Lifetime Design.
Lindsay W. Johnson. (1956a). Attached houses (House 1). *Home and Building, XIX*(5), 36.
Lindsay W. Johnson. (1956b). Attached houses (House 2). *Home and Building, XIX*(5), 36.
M. K. & R. F. Draffin. (1957). Air of rightness and belonging. *Home and Building, XX*(3), 34-35.
Mark Brown & Fairbead. (1957). House in amirror key. *Home and Building, XIX*(8), 26-27.
Marriage, G. (2010). *Minimum vs Maximum: Size and the New Zealand House*. Paper presented at the 5th Australian Housing Researchers' conference, University of Auckland.
Martinaitis, V., Zavadskas, E. K., Motuzienė, V., & Vilutienė, T. (2015). Importance of occupancy information when simulating energy demand of energy efficient house: a case study. *Energy and Buildings, 101*, 64-75.
Masonic Villages Limited. (2016a). Woburn Apartments (One bedroom). Retrieved 21/04/2016 from http://www.woburnapartments.co.nz/our-offering/
Masonic Villages Limited. (2016b). Woburn Apartments (Two bedroom). Retrieved 21/04/2016 from http://www.woburnapartments.co.nz/our-offering/
Masonic Villages Limited. (2016c). Woburn Apartments website. Retrieved 21/04/2016 from http://www.woburnapartments.co.nz/
Matz, C. J., Stieb, D. M., Davis, K., Egyed, M., Rose, A., Chou, B., & Brion, O. (2014). Effects of age, season, gender and urban-rural status on time-activity: Canadian human activity pattern survey 2 (CHAPS 2). *International journal of environmental research and public health, 11*(2), 2108-2124.
Mayor of London. (2010). *London Housing Design Guide*. Retrieved from London: https://www.london.gov.uk/sites/default/files/interim_london_housing_design_guide.pdf
McCamant, K., & Durrett, C. (2011). *Creating cohousing : building sustainable communities*. Gabriola Island, BC: New Society Publishers.
McCoy, E. J. (1956). Two-level house with a harbour view. *Home and Building, XIX*(1), 18-21.
McCurdy, T., & Graham, S. E. (2003). Using human activity data in exposure models: analysis of discriminating factors. *Journal of Exposure Science and Environmental Epidemiology, 13*(4), 294-317.
McGowan, H. D. S., & Sanderson, C. (1955a). Three houses under £2500 (1. Easy access to the garden). *Home and Building, XVIII*(5), 22-23.
McGowan, H. D. S., & Sanderson, C. (1955b). Three houses under £2500 (2. A house of one's own). *Home and Building, XVIII*(5), 24-25.

McGowan, H. D. S., & Sanderson, C. (1955c). Three houses under £2500 (3. House on concrete floor slab). *Home and Building, XVIII*(5), 26-27.
McKenna, K., Broome, K., & Liddle, J. (2007). What older people do: Time use and exploring the link between role participation and life satisfaction in people aged 65 years and over. *Australian Occupational Therapy Journal, 54*(4), 273-284.
Middleton, P. (1955). A house in the classical manner. *Home and Building, XVIII*(4), 22-25.
Middleton, P. (1956). The bronze medal 1956. *Home and Building, XVIII*(11), 22-23.
Miller White & Dunn. (1956). A Dunedin residence. *Home and Building, XIX*(2), 32-33.
Ministry of Business Innovation and Employment. (2016). The school system. Retrieved 23/02/2016 from https://www.newzealandnow.govt.nz/living-in-nz/education/school-system
Ministry of Housing. (1956a). 1956 parade of homes, Auckland: architect's group plans-3 economical houses (750 sqf). *Home and Building, XVIII*(11), 25.
Ministry of Housing. (1956b). 1956 parade of homes, Auckland: architect's group plans-3 economical houses (980 sqf). *Home and Building, XVIII*(11), 27.
Ministry of Housing. (1956c). 1956 parade of homes, Auckland: architect's group plans-3 economical houses (1060 sqf). *Home and Building, XVIII*(11), 27.
Ministry of Housing. (1956d). 1956 parade of homes, Auckland: architect's group plans-3 economical houses (1060 sqf). *Home and Building, XVIII*(11), 25.
Mitchell, H. M. (1980). Vicent house-Campbells Bay. *New Zealand Home and Building*(5), 35-39.
Mithraratne, N. (2013). The dwelling. In B. Vale & R. J. D. Vale (Eds.), *Living within a fair share ecological footprint*. Abingdon; Oxon; New York: Routledge.
Mithraratne, N., Vale, B., & Vale, R. (2007). *Sustainable living: The role of whole life costs and values*. Amsterdam; Boston: Butterworth-Heinemann.
Moller, G. (1982). Penington house. *New Zealand Home and Building*(4), 14-19.
Monaco Corporation Limited. (2016). Supertub ST7001 (Product and technical sheet). Retrieved 2/08/2016 from http://www.robinhood.co.nz/products/Supertub_ST7001
Montoliu, R., Blom, J., & Gatica-Perez, D. (2013). Discovering places of interest in everyday life from smartphone data. *Multimedia tools and applications, 62*(1), 179-207.
Morris, M., & Easton, C. (2008). *Narrowing the Gap in Outcomes: Further Overview of Data and Evidence on the ECM Outcomes for Vulnerable Groups. Progress Report and Update*. Slough: NFER.
Morrison outdoor. (2016). Morrison outdoor website: Outdoor garden products. Retrieved 9/08/2016 from http://www.morrisonoutdoor.co.nz/
Motuziene, V., & Vilutiene, T. (2013). Modelling the effect of the domestic occupancy profiles on predicted energy demand of the energy efficient house. *Procedia Engineering, 57*, 798-807.
Mr. Appliance. (2016). Appliance life expectancy. Retrieved 16/08/2016 from http://www.mrappliance.com/expert-tips/appliance-life-guide/
Murray, R. (1974). The influence of crowding on children's behaviour. In D. V. Canter & T. Lee (Eds.), *Psychology and the built environment*. New York: Wiley.
Nait-Charif, H., & McKenna, S. J. (2004). *Activity summarisation and fall detection in a supportive home environment.* Paper presented at the 17th International Conference on Pattern Recognition (ICPR'04), University of Dundee, Scotland.
Nathaniel Lichfield & Partners Ltd. (2010). *The relationship between household size and dwelling size in future housing provision*. Retrieved from London: http://www.gedling.gov.uk/media/documents/planningbuildingcontrol/dsr_final_report_-_march_2010.pdf
National Housing Federation. (2013a). *The Bedroom Tax in Merseyside 100 days on*. Retrieved from London:
National Housing Federation. (2013b). *Briefing size criteria ('Bedroom Tax')*. London: National Housing Federation.

National Institute of Water and Atmospheric Research. (2014). "National Climate Data Base" official website. Retrieved 5/09/2014 from http://cliflo.niwa.co.nz/
Navigation homes. (2014a). Navigation homes book of ideas. Auckland: Navigation homes.
Navigation homes. (2014b). Navigation homes book of ideas (Compass series: Plan C1). Auckland: Navigation homes.
Navigation homes. (2014c). Navigation homes book of ideas (Compass series: Plan C2). Auckland: Navigation homes.
Navigation homes. (2014d). Navigation homes book of ideas (Compass series: Plan C3). Auckland: Navigation homes.
Navigation homes. (2014e). Navigation homes book of ideas (Compass series: Plan C4). Auckland: Navigation homes.
Navigation homes. (2014f). Navigation homes book of ideas (Compass series: Plan C5). Auckland: Navigation homes.
Navigation homes. (2014g). Navigation homes book of ideas (Compass series: Plan C6). Auckland: Navigation homes.
Navigation homes. (2014h). Navigation homes book of ideas (Compass series: Plan C7). Auckland: Navigation homes.
Navigation homes. (2014i). Navigation homes book of ideas (Compass series: Plan C8). Auckland: Navigation homes.
Navigation homes. (2014j). Navigation homes book of ideas (Compass series: Plan C9). Auckland: Navigation homes.
Navigation homes. (2014k). Navigation homes book of ideas (Compass series: Plan C10). Auckland: Navigation homes.
Navigation homes. (2014l). Navigation homes book of ideas (Designer series: Plan D1). Auckland: Navigation homes.
Navigation homes. (2014m). Navigation homes book of ideas (Designer series: Plan D2). Auckland: Navigation homes.
Navigation homes. (2014n). Navigation homes book of ideas (Designer series: Plan D3). Auckland: Navigation homes.
Navigation homes. (2014o). Navigation homes book of ideas (Designer series: Plan D4). Auckland: Navigation homes.
Navigation homes. (2014p). Navigation homes book of ideas (Designer series: Plan D5). Auckland: Navigation homes.
Navigation homes. (2014q). Navigation homes book of ideas (Designer series: Plan D6). Auckland: Navigation homes.
Navigation homes. (2014r). Navigation homes book of ideas (Designer series: Plan D7). Auckland: Navigation homes.
Navigation homes. (2014s). Navigation homes book of ideas (Designer series: Plan D8). Auckland: Navigation homes.
Navigation homes. (2014t). Navigation homes book of ideas (Designer series: Plan D9). Auckland: Navigation homes.
Navigation homes. (2014u). Navigation homes book of ideas (Designer series: Plan D10). Auckland: Navigation homes.
Navigation homes. (2014v). Navigation homes book of ideas (Nautical series: Plan N1). Auckland: Navigation homes.
Navigation homes. (2014w). Navigation homes book of ideas (Nautical series: Plan N2). Auckland: Navigation homes.
Navigation homes. (2014x). Navigation homes book of ideas (Nautical series: Plan N3). Auckland: Navigation homes.
Navigation homes. (2014y). Navigation homes book of ideas (Nautical series: Plan N4). Auckland: Navigation homes.

Navigation homes. (2014z). Navigation homes book of ideas (Nautical series: Plan N5). Auckland: Navigation homes.
Navigation homes. (2014aa). Navigation homes book of ideas (Nautical series: Plan N6). Auckland: Navigation homes.
Navigation homes. (2014ab). Navigation homes book of ideas (Nautical series: Plan N7). Auckland: Navigation homes.
Navigation homes. (2014ac). Navigation homes book of ideas (Nautical series: Plan N8). Auckland: Navigation homes.
Navigation homes. (2014ad). Navigation homes book of ideas (Nautical series: Plan N9). Auckland: Navigation homes.
Navigation homes. (2014ae). Navigation homes book of ideas (Nautical series: Plan N10). Auckland: Navigation homes.
Navigation homes. (2014af). Navigation homes book of ideas (Villa series: Plan V1). Auckland: Navigation homes.
Navigation homes. (2014ag). Navigation homes book of ideas (Villa series: Plan V2). Auckland: Navigation homes.
Navigation homes. (2014ah). Navigation homes book of ideas (Villa series: Plan V3). Auckland: Navigation homes.
Navigation homes. (2014ai). Navigation homes book of ideas (Villa series: Plan V4). Auckland: Navigation homes.
Navigation homes. (2014aj). Navigation homes book of ideas (Villa series: Plan V5). Auckland: Navigation homes.
Navigation homes. (2014ak). Navigation homes book of ideas (Villa series: Plan V6). Auckland: Navigation homes.
Navigation homes. (2014al). Navigation homes book of ideas (Villa series: Plan V7). Auckland: Navigation homes.
Navigation homes. (2014am). Navigation homes book of ideas (Villa series: Plan V8). Auckland: Navigation homes.
Navigation homes. (2014an). Navigation homes book of ideas (Villa series: Plan V9). Auckland: Navigation homes.
Navigation homes. (2014ao). Navigation homes book of ideas (Villa series: Plan V10). Auckland: Navigation homes.
Navigation homes. (2015). Navigation homes book of ideas: Villa series: Plan V4. Porirua: Navigation homes.
Neuman, W. L. (2011). *Social research methods : qualitative and quantitative approaches*. Boston: Allyn & Bacon.
New Zealand at work. (2016). Public holiday dates 2016. Retrieved 23/02/2016 from http://employment.govt.nz/er/holidaysandleave/publicholidays/publicholidaydates/current.asp
New Zealand Government. (2013). *Housing improvement regulations 1947 (SR 1947/200)*. Retrieved from Wellington:
New Zealand Inland Revenue. (2015). *General Depreciation rates (IR 265)*. Retrieved from Wellington: https://www.ird.govt.nz/resources/6/5/6576ff004ba3cf748844bd9ef8e4b077/ir265.pdf
New Zealand Ministry of Education. (2015). The New Zealand Ministry of Education official website. Retrieved 20/7/2015 from http://www.education.govt.nz/ministry-of-education/school-terms-and-holidays/
New Zealand public holidays. (2016). NZ school holidays. Retrieved 23/02/2016 from http://publicholiday.co.nz/nz-school-holidays.html
New Zealand Tourism. (n.d.). 100% Pure New Zealand. Retrieved May 2015 from http://www.newzealand.com/int/feature/new-zealand-people/

New Zealand Transport Safety Authority. (1998). *New Zealand Travel Survey*. Wellington: New Zealand Transport Safety Authority.
New Zealand Vice-Chancellors' Committee website. (2015). New Zealand universities semester dates. Retrieved 20/7/2015 from http://www.universitiesnz.ac.nz/studying-in-nz/semesters
Newman, F. H. (1958). Problem of urban sprawl trackled by the Government (Duplex flat-3 bedroom-Upper floor). *Home and Building, XX*(12), 42.
Newman, F. H. (1959a). Atrium flats (Mark II). *Home and Building, XXI*(12), 34.
Newman, F. H. (1959b). Atrium flats (Mark III). *Home and Building, XXI*(12), 35.
Niemi, I. (1995). *Time use of women in Europe and North America*. New York; Geneva: UN.
Noel Leeming. (2016). Noel Leeming store website. Retrieved 10/03/2016 from https://www.noelleeming.co.nz
Number one fitness. (2016). Number one fitness website. Retrieved 8/08/2016 from https://www.no1fitness.co.nz/
NZ Transport Agency. (2013). *New Zealand motor vehicle registration statistics 2012*. Palmerston North: NZ Transport Agency.
O'Callaghan, B., Green, H. J., Hyde, R. A., Wadley, D., & Upadhyay, A. (2012). Exploring the influence of housing design and occupant environmental attitudes on energy and water usage. *Architectural Science Review, 55*(3), 176-185.
Office of Deputy Prime Minister. (2004). *The impact of overcrowding on health & education: A review of evidence and literature*. London: Office of Deputy Prime Minister
Office of L. S. Piper. (1956). This house and cultivated garden complement their native bush stting. *Home and Building, XIX*(1), 22-23.
Page, I. C. (2007). *Changing housing need*. Porirua: BRANZ.
Pasco & Hall. (1956). Farm houses-Plan two. *Home and Building, XIX*(3), 35.
Pascoe, P. (1941a). Enfield Homestead, Methven, Canterbury. *Home and Building, V*(3), 6-7.
Pascoe, P. (1941b). Malory: a house at Dunedin *Home and Building, V*(4), 12-13.
Pascoe, P. (1959). Seaside house with "hypoid" roof. *Home and Building, XXI*(9), 28-31.
Pepper and Dixon. (1976). Holmes house Whangaparoa. *New Zealand Home and Building, XXXVIII*(6), 12-15.
Pepper and Dixon. (1977). Turnbull house Whangaparaoa. *New Zealand Home and Building, XXXIX*(1), 12-18.
Peuportier, B. (2001). Life cycle assessment applied to the comparative evaluation of single family houses in the French context. *Energy and Buildings, 33*(5), 443-450.
Piano traders. (2016). Piano traders website. Retrieved 10/03/2016 from http://www.pianotraders.co.nz/
Platinumhomes. (2016a). Beach series: Onetangi. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/onetangi
Platinumhomes. (2016b). Platinum homes designers website. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz
Platinumhomes. (2016c). Platinum series: Barbados. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/barbados
Platinumhomes. (2016d). Platinum series: Brookfield. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/brookfield
Platinumhomes. (2016e). Platinum series: Caterbury. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/canterbury
Platinumhomes. (2016f). Platinum series: Corfu. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/corfu
Platinumhomes. (2016g). Platinum series: Kaiwaka. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/kaiwaka

Platinumhomes. (2016h). Platinum series: Kent. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/kent
Platinumhomes. (2016i). Platinum series: Lucia. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/lucia
Platinumhomes. (2016j). Platinum series: Merivale. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/merivale
Platinumhomes. (2016k). Platinum series: Palmerston. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/palmerston
Platinumhomes. (2016l). Platinum series: Plymouth. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/plymouth
Platinumhomes. (2016m). Platinum series: Portsmouth. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/portsmouth
Platinumhomes. (2016n). Platinum series: Rivera. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/riviera
Platinumhomes. (2016o). Platinum series: Roma. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/roma
Platinumhomes. (2016p). Platinum series: Westham. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/westham
Platinumhomes. (2016q). Platinum series: Wiltshire. Retrieved 03/03/2016 from http://www.platinumhomes.co.nz/wiltshire
Poon, C., Wallace, L., & Lai, A. C. (2016). Experimental study of exposure to cooking emitted particles under single zone and two-zone environments. *Building and Environment, 104*, 122-130.
Pot Black. (2016). Pot Black pool tables & accessories. Retrieved 8/08/2016 from https://www.potblack.co.nz/
PriceMe. (2016). PriceMe smarter shopping website. Retrieved 12/08/2016 from http://www.priceme.co.nz/
Property IQ. (2014). Property IQ website. Retrieved 13/ 02/ 2014 from http://www.propertyiq.co.nz/
Qualtrics. (2015). The online service for questionnaire surveys (used under Victoria University of Wellington account). Retrieved 1/11/2014 from http://www.qualtrics.com
QV. (2011a). Average house size by age. Retrieved 13/ 02/ 2014 from http://www.qv.co.nz/resources/news/article?blogId=62
QV. (2011b). Average house size by area. Retrieved 13/ 02/ 2014 from http://www.qv.co.nz/resources/news/article?blogId=61
QV. (2014). QV website. Retrieved 13/ 02/ 2014 from http://www.qv.co.nz/
Radaelli, L., Moses, Y., & Jensen, C. S. (2014). *Using Cameras to Improve Wi-Fi Based Indoor Positioning.* Paper presented at the International Symposium on Web and Wireless Geographical Information Systems.
Ramesh, T., Prakash, R., & Shukla, K. (2010). Life cycle energy analysis of buildings: An overview. *Energy and Buildings, 42*(10), 1592-1600.
Rebel sport. (2016). Rebel sport website. Retrieved 8/08/2016 from http://www.rebelsport.co.nz/
Rees, W. E., & Moore, J. (2013). Ecological footprints, fair earth-shares and urbanization. In B. Vale & R. J. D. Vale (Eds.), *Living within a fair share ecological footprint*. Abingdon, Oxon.; New York: Routledge.
Reynolds, I. (1959). Book review: Houses and Bungalows (by June Park). *Home and Building, XXI*(9), 36-37.
Reynolds, L., & Robinson, N. (2005). *Full house? How overcrowded housing affects families*. Retrieved from London: https://england.shelter.org.uk/__data/assets/pdf_file/0004/39532/Full_house_overcrowding_effects.pdf

Reynolds, L., Robinson, N., & Diaz, R. (2004). *Crowded house: Cramped living in England's housing*. Retrieved from London: http://england.shelter.org.uk/__data/assets/pdf_file/0003/39234/Crowded_House.pdf

Robert-Hughes, R., Fox, W., & Scott-Marshall, A. (2011). *The case for space: The size of England's new homes*. Retrieved from London: https://www.architecture.com/files/ribaholdings/policyandinternationalrelations/homewise/caseforspace.pdf

Robinson, J. P. (1988). Time-diary research and human exposure assessment: some methodological considerations. *Atmospheric Environment, 22*(10), 2085-2092.

Rosenfeld, M. (1951). *The New Zealand House* (3rd edition ed.). Auckland: Whitcombe & Tombs.

Ross, B. (2014). *Dead end : suburban sprawl and the rebirth of American urbanism*. Oxford: Oxford University Press.

Rpdata. (2014). Rpdata website. Retrieved 13/02/2014 from http://www.rpdata.com/

Rugs & More. (2016). Rugs & More online store website. Retrieved 12/08/2016 from http://rugsandmore.co.nz/store/index.php?route=common/home

Sales, R. (1978). Comact and economical: Titirangi storey and a half. *New Zealand Home and Building, XXXX*(5), 24-27.

Salmond, J. (1986). *Old New Zealand houses 1800-1940*. Auckland: Reed Methuen.

Sanderson, C. (1959). Farmhouse at Glenbrook. *Home and Building, XXI*(9), 32-35.

Sanguinetti, A. (2012). The design of intentional communities: A recycled perspective on sustainable neighborhoods. *Behavior and Social Issues, 21*, 5.

Sarkar, M. (2011). *How American homes vary by the year they were built*. Retrieved from Washington DC: http://www.census.gov/hhes/www/housing/housing_patterns/pdf/Housing%20by%20Year%20Built.pdf

Saville-Smith, K., James, B., & Fraser, R. (2008). *Older People's House Performance and Their Repair and Maintenance Practices: Analysis from a 2008 National Survey of Older People and Existing Datasets*. Retrieved from Wellington: http://repairsandmaintenance.goodhomes.co.nz/resources/downloads/Older%20Peoples%20Combined%20Report%20Final.pdf

Schiavon, M., Rada, E., Ragazzi, M., Antognoni, S., & Zanoni, S. (2015). Domestic activities and PM generation: A contribution to the understanding of indoor sources of air pollution. *International Journal of Sustainable Development and Planning, 10*(3), 347-360.

Schumacher, E. F. (1973). *Small is beautiful; economics as if people mattered*. New York: Harper & Row.

Schwab, M., Colome, S., Spengler, J., Ryan, P., & Billick, I. (1990). Activity patterns applied to pollutant exposure assessment: data from a personal monitoring study in Los Angeles. *Toxicology and industrial health, 6*(6), 517-532.

Schweizer, C., Edwards, R. D., Bayer-Oglesby, L., Gauderman, W. J., Ilacqua, V., Jantunen, M. J., . . . Künzli, N. (2007). Indoor time-microenvironment-activity patterns in seven regions of Europe. *Journal of Exposure Science and Environmental Epidemiology, 17*(2), 170-181. doi:http://dx.doi.org/10.1038/sj.jes.7500490

Seiders, D., Ahluwalia, G., Melman, S., Quint, R., Chaluvadi, A., Liang, M., . . . Bechler, C. (2007). *Study of life expectancy of home components*. Retrieved from Washington DC: http://stevesmallman.com/wp-content/uploads/2013/05/NAHB-Lifetimes.pdf

Shaw, P., & Morrison, R. (1991). *New Zealand architecture : from Polynesian beginnings to 1990*. Auckland: Hodder & Stoughton.

Shaw, P., Morrison, R., & McCredie, P. (2003). *A history of New Zealand architecture*. Auckland: Hodder Moa Beckett.

Shelter. (2007). *Shelter factsheet: Homelessness*. Retrieved from London: https://england.shelter.org.uk/__data/assets/pdf_file/0004/66379/Homelessness_factsheet.pdf

Smith, L. P., Ng, S. W., & Popkin, B. M. (2013). Trends in US home food preparation and consumption: analysis of national nutrition surveys and time use studies from 1965–1966 to 2007–2008. *Nutrition Journal, 12*(1), 1.

Statista. (2011). Average life expectancy of major household appliances as of 2011 (in years). Retrieved 16/08/2016 from http://www.statista.com/statistics/220020/average-life-expectancy-of-major-household-appliances/

Statistics Japan. (2013). Japan Statistical Yearbook *Chapter 18: Housing and Estate*. Japan.

Statistics New Zealand. (2002a). 2001 Census: Housing-All tables, Table 1. Retrieved 30/01/2014 from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2002b). 2001 Census: Housing-All tables, Table 18. Retrieved from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2008). *Hot off the press, National family and household projections: 2006(base)-2031*. Retrieved from Wellington: http://www.stats.govt.nz/browse_for_stats/people_and_communities/Families/SubnationalFamilyandHouseholdProjections_HOTP06-31update/Commentary.aspx

Statistics New Zealand. (2011a). 2006 Census: Quick stats about housing revised 31 Mar 2011, Table 10. Retrieved 06/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2011b). 2006 Census: Quick stats about housing revised 31 Mar 2011, Table 30. Retrieved 06/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2011c). *The effect of geographical location on New Zealanders' use of time: facts from the New Zealand Time Use Survey 2009/10*. Retrieved from Wellington: http://www.stats.govt.nz/browse_for_stats/people_and_communities/time_use/effect-geographical-location-nz-use-of-time.aspx

Statistics New Zealand. (2011d). *Time use survey: 2009/2010*. Retrieved from Wellington: file:///C:/Users/khajehim/Downloads/TimeUseSurvey2009-10HOTP%20(2).pdf

Statistics New Zealand. (2011e). *User Guide for Statistics New Zealand's 2009/10 Time Use Survey*. Wellington: Statistics New Zealand.

Statistics New Zealand. (2011f). *Who are Kiwis spending their time with? – Findings from the 2009/10 Time Use Survey*. Retrieved from Wellington: http://www.stats.govt.nz/browse_for_stats/people_and_communities/time_use/who-nzers-spend-their-time-with-0910.aspx

Statistics New Zealand. (2012). *Ethnicity and crowding: A detailed examination of crowding among ethnic groups in New Zealand 1986–2006*. Wellington: Statistics New Zealand.

Statistics New Zealand. (2013a). 2013 Census QuickStats about national highlights: Families and Households. Retrieved 13/02/2014 from http://www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-national-highlights/families-households.aspx

Statistics New Zealand. (2013b). 2013 Census totals by topic: Table 49. 2013.Retrieved 11/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=census%201996&ds=1&mp=50&sp=50&sort=r

Statistics New Zealand. (2013c). 2013 Census totals by topic: Table 52. Retrieved 11/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=census%201996&ds=1&mp=50&sp=50&sort=r

Statistics New Zealand. (2013d). 2013 Census totals by topic: Table 53. Retrieved 11/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=census%201996&ds=1&mp=50&sp=50&sort=r

Statistics New Zealand. (2013e). *Caring for children: Findings from the 2009/10 Time Use Survey*. Wellington: Statistics New Zealand

Statistics New Zealand. (2014a). 2013 Census QuickStats about families and households (Table 27). Retrieved 20/01/2017 from http://www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/qstats-families-households.aspx

Statistics New Zealand. (2014b). 2013 Census QuickStats about housing. Retrieved 12/02/2016 from http://www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-housing/types-occupied-dwellings.aspx

Statistics New Zealand. (2014c). 2013 Census: Quick stats about housing revised 30 April 2014, Table 10. Retrieved 12/02/2016 from http://www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-housing/types-occupied-dwellings.aspx

Statistics New Zealand. (2014d). 2013 Census: Quick stats about housing revised 30 April 2014, Table 37. Retrieved 12/02/2016 from http://www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-housing/types-occupied-dwellings.aspx

Statistics New Zealand. (2014e). 2013 Census: Quick stats about housing, Table 19. Retrieved 06/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2014f). Crowding index and tenure of household: Customised data commissioned for Victoria University of Wellington. Wellington: Statistics New Zealand.

Statistics New Zealand. (2014g). Explanatory Notes: Household crowding. Retrieved 15/02/2014 from http://www.stats.govt.nz/browse_for_stats/people_and_communities/Geographic-areas/urban-rural-profile/explanatory-notes.aspx#household-crowding

Statistics New Zealand. (2014h). *Housing statistics strategy*. Retrieved from Wellington: http://www.stats.govt.nz/searchresults.aspx?q=housing statistic strategy&mp=0&sp=0&sort=r

Statistics New Zealand. (2014i). Infoshare: Building consents (Annual-Dec). Retrieved 13/02/2014 from http://www.stats.govt.nz/infoshare/

Statistics New Zealand. (2014j). Number of motor vehicles for households in private occupied dwellings 2006. Retrieved 11/02/2014 from http://www.stats.govt.nz/searchresults.aspx?q=census%201996&ds=1&mp=50&sp=50&sort=r

Statistics New Zealand. (2014k). Statistical standard for number of rooms/bedrooms. Retrieved 25/06/2014 from http://www.stats.govt.nz/searchresults.aspx?q=bedroom%20definition

Statistics New Zealand. (2014l). Subnational crowding tables: 1991-2006: Table 1a. Retrieved 20/01/2014 from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2014m). Subnational crowding tables: 1991-2006: Table 3a, 3b, 3c, 3d, 3e and 3f. Retrieved 20/01/2014 from http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006

Statistics New Zealand. (2014n). Subnational crowding tables: 1991-2006: Tables 1a, 1b, 1c, and 1d. Retrieved 20/01/2014 from

http://www.stats.govt.nz/searchresults.aspx?q=substantial%20crowding%20table%201991-2006
Statistics New Zealand. (2015). Census of Population and Dwellings (2013-costomised data), Prepared for: CONZUL (Victoria University of Wellington-Reference Number: JOB-06653). Christchurch: Statistic New Zealand-Customised Data Services.
Statistics New Zealand. (2016a). Introduction to housing quality and measuring it. Retrieved 5/5/2016 from http://www.stats.govt.nz/browse_for_stats/people_and_communities/housing/measuring-housing-quality/intro-to-housing-quality-measuring.aspx
Statistics New Zealand. (2016b). National family projections, by family type, 2013(base)-2038. Retrieved 20/01/207 from http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7537
Statistics New Zealand. (n.d.). Statistics New Zealand website. Retrieved 4/09/2016 from http://www.stats.govt.nz/
Steinle, S., Reis, S., & Sabel, C. E. (2013). Quantifying human exposure to air pollution—moving from static monitoring to spatio-temporally resolved personal exposure assessment. *Science of the Total Environment, 443*, 184-193.
Stewart, D. (1992). *The New Zealand villa : past and present*. Auckland, N.Z.: Viking Pacific.
Stone wood homes. (2016a). Farm life series: Fixed 2BD 60. Retrieved 19/05/2016 from http://www.stonewood.co.nz/house-plans/fixed-2bd-60-farm-life-series#60-content
Stone wood homes. (2016b). Farm life series: Flexi 2. Retrieved 19/05/2016 from http://www.stonewood.co.nz/house-plans/flexi-2-farm-life-series#80-content
Stone Wood Homes. (2016c). Stone Wood Homes website. Retrieved 19/05/2016 from http://www.stonewood.co.nz/
Sutherland, J. (1977). Architects OWN. *New Zealand Home and Building, XXXIX*(1), 24-27.
Tagg, S. K. (1974). The subjective meaning of rooms: some analyses and investigations. In D. V. Canter & T. Lee (Eds.), *Psychology and the built environment*. New York: Wiley.
The Center for Universal Design. (2006). *Universal design in housing*. Retrieved from http://www.ncsu.edu/ncsu/design/cud/pubs_p/docs/UDinHousing.pdf
The Warehouse. (2016). The Warehouse website. Retrieved 9/08/2016 from http://www.thewarehouse.co.nz/red/
Thorn, I. (1976). House design competition (3rd place equal). *New Zealand Home and Building, XXXVIII*(2), 20.
Toomath, W. (1996). *Built in New Zealand : the houses we live in*. Auckland: HarperCollins.
TradeMe. (2014). TradeMe website. Retrieved 26 May 2014 from http://www.trademe.co.nz/about-trade-me/our-story
TradeMe. (2016). TradeMe website. Retrieved 8/08/2016 from http://www.trademe.co.nz
Trampoline & Swing factory. (2016). Trampoline & Swing factory website. Retrieved 12/08/2016 from http://www.trampoline.co.nz/
Treloar, G. J. (1998). *A comprehensive embodied energy analysis framework.* (PhD Thesis), Deakin University, Geelong.
Treloar, G. J., McCoubrie, A., Love, P. E., & Iyer-Raniga, U. (1999). Embodied energy analysis of fixtures, fittings and furniture in office buildings. *Facilities, 17*(11), 403-410.
U.S. Energy Information Administration (EIA). (2016). *International Energy Outlook 2016 with projections to 2040*. Retrieved from Washington DC: www.eia.gov/forecasts/ieo/pdf/0484(2016).pdf
United Kingdom Ministry of Housing and Local Government. (1961). *Homes for today and tomorrow*. London: Her Majesty's Stationery Office.
United States Census Bureau. (2014). Income, Poverty and Health Insurance Coverage in the United States: 2013. Retrieved 9/09/2016 from http://www.census.gov/newsroom/press-releases/2014/cb14-169.html

United States Census Bureau. (n.d.-a). Median and Average Square Feet of Floor Area in New Single-Family Houses Completed by Location. United States of America: United States Census Bureau

United States Census Bureau. (n.d.-b). United States Census Bureau website. Retrieved 4/09/2016 from http://www.census.gov/en.html

United States Central Intelligence Agency. (2009). CIA world factbook. Retrieved 30/12/2013 from http://www.credoreference.com/book/cia

Utama, A., & Gheewala, S. H. (2008). Life cycle energy of single landed houses in Indonesia. *Energy and Buildings, 40*(10), 1911-1916.

Vale, B., & Khajehzadeh, I. (2016). *Time-use and resource use in private open space in New Zealand*. Paper presented at the The 9th Australasian housing researchers conference, The University of Auckland.

Vale, R., & Vale, B. (2009). *Time to eat the dog: the real guide to sustainable living*. London: Thames & Hudson.

Van Geem, M. G., & Marceau, M. L. (2006). Comparison of the life cycle assessments of an insulating concrete form house and a wood frame house. *Journal of ASTM International, 3*(9), 1-11.

Vautier Murray Associates. (1956). In a New England tradition. *Home and Building, XIX*(7), 32-33.

Versatile homes & buildings. (2016a). House designs: Karamea. Retrieved 19/05/2016 from http://www.versatile.co.nz/homes/house-designs/karamea

Versatile homes & buildings. (2016b). House designs: Naseby. Retrieved 19/05/2016 from http://www.versatile.co.nz/homes/house-designs/naseby

Versatile homes & buildings. (2016c). House designs: Ohoka. Retrieved 19/05/2016 from http://www.versatile.co.nz/homes/house-designs/ohoka

Versatile homes & buildings. (2016d). House designs: Papamoa. Retrieved 19/05/2016 from http://www.versatile.co.nz/homes/house-designs/papamoa

Versatile Homes & Buildings. (2016e). Versatile homes & buildings website. Retrieved 19/05/2016 from http://www.versatile.co.nz/

Vortex Spas. (2016). Vortex Spas website. Retrieved 8/08/2016 from http://www.vortexspas.co.nz/

Walker Packaged Homes Ltd. (1955). Hers's a house you'll thrill to come home to. *Home and Building, XVII*(8), 10.

Walker, R. (1981). The Roger Walker phenomenon: Harris house. *New Zealand Home and Building*(5), 15-21.

Warehouse Stationary. (2016). Warehouse Stationary Ltd. website. Retrieved 10/08/2016 from http://www.warehousestationery.co.nz/

Watkin, C. B. (1955). Sunlight & shadow: Play on contrasting textures. *Home and Building, XVII*(11), 32-35.

Wei, S., Jones, R., & de Wilde, P. (2013). Driving factors for occupant-controlled space heating in residential buildings. *Energy and Buildings, 70*, 36-44. doi:10.1016/j.enbuild.2013.11.001

Weihl, J. S., & Gladhart, P. M. (1990). *Occupant behavior and successful energy conservation: Findings and implications of behavioral monitoring.* Paper presented at the Proceedings of the 1990 ACEEE Summer Study on Energy Efficiency in Buildings.

Welch, C., & Rogers, B. (2010). *Estimating the remaining useful life of residential appliances.* Paper presented at the ACEEE Summer Study on Energy Efficiency in Buildings.

Wellington water filters. (2016). Wellington water filters: Kapiti pure water website. Retrieved 12/08/2016 from http://www.wellingtonwaterfilters.co.nz/index.html

Wierzbicka, A., Bohgard, M., Pagels, J., Dahl, A., Löndahl, J., Hussein, T., . . . Gudmundsson, A. (2015). Quantification of differences between occupancy and total monitoring periods for better assessment of exposure to particles in indoor environments. *Atmospheric Environment, 106*, 419-428.

William Pearson & Associates. (1979a). Renovation (after). *New Zealand Home and Building*(3), 23-25.

William Pearson & Associates. (1979b). Renovation (before). *New Zealand Home and Building*(3), 23-25.

Williams, J. (2007). Innovative solutions for averting a potential resource crisis—the case of one-person households in England and Wales. *Environment, Development and Sustainability, 9*(3), 325-354. doi:10.1007/s10668-006-9068-x

Willson, R. J. (1975). *Selected house plans for New Zealand*. Auckland: Heinemann Educational.

Wilson, L. (2012). How big is a house? Average house size by country. Retrieved 30/12/2013 from http://shrinkthatfootprint.com/how-big-is-a-house

Wood, D. (1993). *New Zealand houses for town and country*. Auckland: Splinter Group.

World Atlas. (2016). Countries with the largest aging population in the world. Retrieved 11/09/2016 from http://www.worldatlas.com/articles/countries-with-the-largest-aging-population-in-the-world.html

Wu, X., Bennett, D. H., Lee, K., Cassady, D. L., Ritz, B., & Hertz-Picciotto, I. (2011). Longitudinal variability of time-location/activity patterns of population at different ages: a longitudinal study in California. *Environmental Health, 10*(1), 80.

Wu, X., Bennett, D. H., Lee, K., Cassady, D. L., Ritz, B., & Hertz-Picciotto, I. (2012). Feasibility of using web surveys to collect time–activity data. *Journal of Exposure Science and Environmental Epidemiology, 22*(2), 116-125.

Yang, W., Lee, K., Yoon, C., Yu, S., Park, K., & Choi, W. (2011). Determinants of residential indoor and transportation activity times in Korea. *Journal of Exposure Science and Environmental Epidemiology, 21*(3), 310-316.

Yassin, M. F., AlThaqeb, B. E., & Al-Mutiri, E. A. (2012). Assessment of indoor PM 2.5 in different residential environments. *Atmospheric Environment, 56*, 65-68.

Yoon, C., Ryu, K., Kim, J., Lee, K., & Park, D. (2012). New approach for particulate exposure monitoring: determination of inhaled particulate mass by 24 h real-time personal exposure monitoring. *Journal of Exposure Science and Environmental Epidemiology, 22*(4), 344-351.

Yoshimura, Y., Girardin, F., Carrascal, J. P., Ratti, C., & Blat, J. (2012). New tools for studying visitor behaviours in museums: A case study at the Louvre. In M. Fuchs, F. Ricci, & L. Cantoni (Eds.), *Information and communication technologies in tourism 2012 : proceedings of the International Conference in Helsingborg, Sweden, January 25-27, 2012* (pp. 391-402). Vienna-New York: Springer Wien NewYork, .

Appendices

Please note Appendices are not numbered consecutively but are numbered according to the relevant chapter number, so Appendix 4.2 is the second appendix to chapter 2. Cross references to appendices follow this pattern.

Appendix 4.1: Proforma for TradeMe observations

Part 1- House specifications in the website:

House size category: 1 Bedroom house☐ 2 Bedroom house☐ 3 Bedroom house☐

4 Bedroom house☐ 5 Bedroom house☐ 6 Bedroom house☐

Property ID:

Part 2- Physical characteristics:

Floor area (m^2):____ Land area (m^2):_____ Building age:_____

Part 3- Spaces:

Name and number of all rooms from the written description and photo captions:

Name of space	Number

Type and capacity of parking facilities using the written description:

Name of parking facility	Capacity

Features of bathrooms:

Bathroom1	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom2	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom3	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom4	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet☐ Toilet☐

Features of bedrooms:

	Does this bedroom have an En-suite Bathroom?	Does this bedroom have a built in wardrobe?
Bedroom1	Yes☐ No☐	Yes☐ No☐
Bedroom2	Yes☐ No☐	Yes☐ No☐
Bedroom3	Yes☐ No☐	Yes☐ No☐
Bedroom4	Yes☐ No☐	Yes☐ No☐
Bedroom5	Yes☐ No☐	Yes☐ No☐
Bedroom6	Yes☐ No☐	Yes☐ No☐

Part 4- Furniture/appliances:

Furniture observed **in any of the spaces** in the house from the photos:

A- Bedroom furniture:

B- Living room/Dining room/Lounge furniture:

C- Kitchen furniture/Large appliances:

D- Bathroom/toilet/ Laundry furniture:

E- Outdoor furniture:

F- Games furniture/equipment:

G- Gardening equipment/tools:

H- Small appliances:

Appendix 5.1: Questionnaire for Study 1

Questionnaire for day 1 of interview (the aim is to help the interviewee fill out the questionnaire)

Part 1- contact address:

Postal address:

Contact number or email:

Part 2- Occupants:

How many people usually live in this house?

Occupant 1: Gender: Age: Job:

Occupant 2: Gender: Age: Job:

Occupant 3: Gender: Age: Job:

Occupant 4: Gender: Age: Job:

Part 3- Spaces:

Do you have these spaces in your home? For each space please give the number you have.

Name of space Note: Please write number only if you have any of these spaces as a separate room, not as a part of other spaces	**How many?**
Bedroom (a room that always contains a bed)	
Combined Dining room/Kitchen	
Combined Living room/Kitchen	
Combined Living room/Dining room	
Combined Living room/Dining room/Kitchen	
Living room (separate)	
Dining room (separate)	
Kitchen (separate)	
Bathroom/Toilet	
Bathroom/Toilet/Laundry	
Laundry	
Playroom	
Library	
Study/Office	
Games room	
Garage (Suitable for how many cars?)	
Carport (Suitable for how many cars?)	
Parking space (Suitable for how many cars?)	
Storage (attic, a storage cage or off-site storage)	
Garden (front)	

Garden (back)	
Deck	
Other (please name)	
Other (please name)	
Other (please name)	

Please tick the features which best reflect the content of each bathroom in your home:

Bathroom1	Single vanity☐ Double vanity☐ Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom2	Single vanity☐ Double vanity☐ Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom3	Single vanity☐ Double vanity☐ Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom4	Single vanity☐ Double vanity☐ Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐ Heated towel rail☐ Bidet☐ Toilet☐

Please identify user(s) of each bedroom? (You can select more than one usual occupant for a bedroom if it is shared e.g. couples)

	Does this bedroom have an En-suite Bathroom?	Does this bedroom have a built in wardrobe?	Who normally occupies this bedroom?
Bedroom1	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom2	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom3	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom4	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom5	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom6	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐

Part 4- Furniture/appliances:

Please tick the furniture you have **in any of the spaces** in your home (Please add unlisted items in blank cells):

A- Bedroom furniture:

King/Queen Double bed☐	Single bed☐	Bunk bed☐	Bedside table☐	Desk☐
Wardrobe (not built in)☐	Book case☐	Chair (for desks only)☐	Desktop/PC☐	Clothes rack☐
Chest of drawers☐	Large mirror☐			

B- Living room/Dining room/ Lounge furniture:

Couch/Sofa	Single seater (i.e. armchair)☐	TV	LED☐	Dining suite/table	4 seater☐	Chairs (for dining table)☐	Entertainment unit☐
	Double seater☐		LCD☐		6 seater☐		
	Three seater☐		Plasma☐		8 seater☐		

	Four seater☐		Cathode ray☐		12 seater☐		
Chair (other than desk chair and dining table chairs)☐		TV cabinet☐		Side table (not bedside ones)☐		Piano☐	Large sculptures/Vases☐
Buffet/Sideboard☐		Coffee table☐		Rug☐		Chest☐	Display cabinet/unit☐
Ottoman/ Footstool☐		Floor lamps☐		Wall clock☐			

C- Kitchen furniture/Large appliances:

Fridge☐	Freezer☐	Bar fridge☐	Chest freezer☐	Fridge/Freezer☐
Dishwasher☐	Stool☐	Cook top/Oven☐	Stove/Range☐	Microwave☐

D- Bathroom/toilet/ Laundry furniture:

Ironing board☐	Clothes rack dryer☐	Washing machine☐	Dryer☐	Heated towel rail☐
Storage cupboard☐				

E- Outdoor furniture (please tick each item which is permanently kept in your outdoor space)**:**

BBQ☐	Swimming pool☐	Spa pool☐	Outdoor chair☐	Outdoor umbrella/ gazebo☐
Bench☐	Outdoor table☐	Swing seat☐	Hammock☐	
Trampoline☐	Climbing frame☐	Slides (for kids)☐	Swing (for kids)☐	Sand box☐
Paddling pool☐	Play house (for kids) ☐			

F- Games furniture/equipment:

Exercise equipment☐	Table tennis table☐	Billiard table☐	Pool table☐	

G- Gardening equipment/tools:

Lawn mower☐	Leaf blower☐	Hedge trimmer☐	Water blaster☐	Work bench☐
Drop saw☐	Drill☐			

H- Vehicles:

Car☐	Motorcycle/ Scooter☐	Bike☐	Scooter (for kids)☐	Boat☐

I- Small appliances:

Please write how many of these you have in your home, leaving boxes blank if you don't have the appliance (Please add additional items in blank cells as needed):

Iron□	Hair dryer□	Vacuum cleaner□	Steam cleaner□	Ice cream maker□
Juicer□	Electric jug□	Food processor□	Coffee maker□	Toaster□
Electric fry pan□	Electric deep fryer□	Blender/mixer□	Sandwich maker□	Slow cooker/Rice cooker□
Water cooler□	Games Console□	Laptop□	Desktop computer□	Scanner□
Printer□	DVD/Blu-Ray player□	Fans□	Dehumidifier□	Electric blanket□
Heaters: Electric Bar heater□ Gas heater□ Electric oil filled radiator□ Heat pump□ Convector heater□ Wood burner□ Other□……..				
Water heating: Electric□ Gas storage water heater□ Gas instantaneous water heater□ Solar water heater□				

Questionnaire for day 2 (this will be developed for each participant household based on the answers to day 1 questionnaire)

Note: All parts can be filled by an adult member of the family on behalf of the whole family though in the pilot study (Study 1) the interviewer will be there to help the participant.

Part 5- Number/place of furniture:

This part asks about the amount and place of furniture in your home. Please tick the appropriate number and place. You can select more than one place if needed.

❖ How many **Double King/Queen beds** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Double King/Queen bed**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Study/Office□	Garage□	Storage□	Other□		

❖ How many **Single beds** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Single bed**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Study/Office□	Garage□	Storage□	Other□		

❖ How many **Bunk beds** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Bunk bed**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Study/Office□	Garage□	Storage□	Other□		

❖ How many **Bedside tables** do you have in your home? (Please only count ones beside a bed)
1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□ 11□ 12□ 13□ 14□ 15□ 16□

In which of the following spaces do you have a **Bedside table**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Study/Office□	Garage□	Storage□	Other□		

❖ How many **Desks** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Desk**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Garage□	Games room□	Study/Office□	Storage□	Other□ .....

❖ How many **Desk chairs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Desk chair?**

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Garage□	Games room□	Study/Office□	Storage□	Other□ .....

❖ How many **Desktop/PCs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Desktop/PC**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Storage□	Other□			

❖ How many **Chests of drawers** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Chest of drawers**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study/Office□	Storage□	Other□		

❖ How many **Book cases** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Book case**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study/Office□	Storage□	Other□		

❖ How many **Wardrobes** do you have in your home (other than built-in wardrobes)?
1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Wardrobe**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Laundry□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **Clothes racks** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Clothes rack**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Playroom□	Library□	Games room□	Study/Office□	Laundry□	Storage□
Other□					

❖ How many **large Mirrors** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **large Mirror**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Combined Living room/Dining room/Kitchen□	Study/Office□
Library□	Bathroom/Toilet1□	Bathroom/Toilet2□	Bathroom/Toilet3□	Bathroom/Toilet/Laundry□	Storage□
Other□					

❖ How many **Single seater Couches/Sofas (i.e. armchairs)** do you have in your home? (Please do not count outdoor couches)

1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□

In which of the following spaces do you have a **Single seater Couch/Sofa**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□ …….	

❖ How many **Double seater Couches/Sofas** do you have in your home? (Please do not count outdoor couches)

1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Double seater Couch/Sofa**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□ …….	

❖ How many **three seater Couches/Sofas** do you have in your home? (Please do not count outdoor couches)

1□ 2□ 3□ 4□ 5□ 6□

In which of the following spaces do you have a **three seater Couch/Sofa**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□ …….	

❖ How many **four seater Couches/Sofas** do you have in your home? (Please do not count outdoor couches)

1□ 2□ 3□ 4□ 5□ 6□

In which of the following spaces do you have a **four seater Couch/Sofa**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□ …….	

❖ How many **Coffee tables** do you have in your home?

1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□ 11□ 12□ 13□ 14□ 15□ 16□

In which of the following spaces do you have a **Coffee table**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Garage□	Study/Office□	Laundry□	Storage□
Other□ …….					

❖ How many **LED TVs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **LED TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□ …….	

❖ How many **LCD TVs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **LCD TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **Plasma TVs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Plasma TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **Cathode ray TVs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Cathode ray TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **TV Cabinets** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **TV Cabinets**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **Entertainment units** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have an **Entertainment unit**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study/Office□	Storage□	Other□		

❖ How many **Buffets/Sideboards** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Buffet/Sideboard**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Kitchen□	Storage□
Other□					

❖ How many **Side tables** do you have in your home?

1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□ 11□ 12□ 13□ 14□ 15□ 16□

In which of the following spaces do you have a **Side table**? (not bedside table)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **Pianos** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Piano**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study room/Office□	Storage□	Other□		

❖ How many **four seater Dining suites** do you have in your home?(not outdoor ones) 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **four seater Dining suite**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Garage□	Study/Office□	Storage□	Other□ .....

❖ How many **six seater Dining suites** do you have in your home? (not outdoor ones) 1□ 2□ 3□ 4□

In which of the following spaces do you have a **six seater Dining suite**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Garage□	Study/Office□	Storage□	Other□ .....

❖ How many **eight seater Dining suites** do you have in your home? (not outdoor ones) 1□ 2□ 3□

In which of the following spaces do you have an **eight seater Dining suite**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Garage□	Study/Office□	Storage□	Other□ .....

❖ How many **twelve seater Dining suites** do you have in your home? (not outdoor ones)1□ 2□

In which of the following spaces do you have a **twelve seater Dining suite**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Garage□	Study/Office□	Storage□	Other□ .....

❖ How many **Rugs** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Rug**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Laundry□	Storage□	Other□ .....

❖ How many **Chests** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Chest**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study/Office□	Garage□	Storage□	Other□	

❖ How many **Display cabinets/units** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Display cabinet/unit**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Storage□	Other□	

❖ How many **Floor lamps** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Floor lamp**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study/Office□	Storage□	Other□		

❖ How many **large Sculptures/Vases** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **large Sculpture/Vase**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Garden (front)□	Garden (back)□	Storage□
Other□					

❖ How many **Ottomans/Footstools** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have an **Ottoman/Footstool**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Games room□	Study/Office□	Storage□	Other□		

❖ How many **Bar Fridges** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Bar Fridge**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Garage□	Storage□	Other□ .....

❖ How many **Freezers/Chest Freezers** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Chest Freezer**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Playroom□	Kitchen□
Games room□	Study/Office□	Garage□	Storage□	Other□	

❖ How many **Fridge/freezers** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Fridge/freezer**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Playroom□	Kitchen□
Games room□	Study/Office□	Garage□	Storage□	Other□	

❖ How many **Fridges** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Fridge**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Playroom□	Kitchen□
Games room□	Study/Office□	Garage□	Storage□	Other□ …….	

❖ How many **Dishwashers** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Dishwasher**?

Kitchen□	Living room 1□	Dining room□	Combined Living room/Dining room/Kitchen□	Study/Office□	Garage□
Storage□	Other□ …….				

❖ How many **Stools** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Stool**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□
Kitchen□	Games room□	Study/Office□	Garage□	Carport□	Laundry□
Toilet/Bath/ Laundry□	Storage□	Other□ …….			

❖ How many **Cooktop/Ovens** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Cooktop/Oven**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Combined Living room/Kitchen□	Combined Dining room/Kitchen□
Kitchen□	Storage□	Other□ …….			

❖ How many **Stoves/Ranges** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Stove/Range**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Combined Living room/Kitchen□	Combined Dining room/Kitchen□
Kitchen□	Storage□	Other□ …….			

❖ How many **Microwaves** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Microwave**?

Living room 1□	Living room 2□	Dining room□	Combined Living room/Dining room/Kitchen□	Combined Living room/Kitchen□	Combined Dining room/Kitchen□
Kitchen□	Storage□	Other□ …….			

❖ How many **Ironing boards** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have an **Ironing board**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Dining room□	Combined Living room/Dining room□	Playroom□	Library□	Games room□
Study/Office□	Laundry□	Storage□	Other□ …….		

❖ How many **Clothes rack dryers** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Clothes rack dryer**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Dining room□	Combined Living room/Dining room/Kitchen□	Combined Living room/Kitchen□	Combined Dining room/Kitchen□	Playroom□
Kitchen□	Games room□	Study/Office□	Garage□	Carport□	Garden (front)□
Garden (back)□	Deck□	Laundry□	Storage□	Other□ …….	

❖ How many **Washing machines** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Washing machine**?

Laundry□	Toilet/Laundry□	Dining room□	Combined Living room/Dining room/Kitchen□	Combined Living room/Kitchen□	Combined Dining room/Kitchen□
Kitchen□	Garage□	Storage□	Other□ …….		

❖ How many **Dryers** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Dryer**?

Laundry□	Toilet/Laundry□	Dining room□	Combined Living room/Dining room/Kitchen□	Combined Living room/Kitchen□	Combined Dining room/Kitchen□
Kitchen□	Garage□	Storage□	Other□ …….		

❖ How many **BBQs** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **BBQ**?

Deck□	Garden (front)□	Garden (back)□	Kitchen□	Garage□	Carport□
Storage□	Other□ …….				

❖ How many **Spa pools** do you have in your home? 1□ 2□ 3□
❖ In which of the following spaces do you have a **Spa pool**?

Deck□	Garden (front)□	Garden (back)□	Garage□	Carport□	Storage□
Storage□	Other□ …….				

❖ How many **Sand boxes** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Sand box**?

Garden (front)□	Garden (back)□	Deck□	Playroom□	Games room□	Carport□
Garage□	Storage□	Other□ …….			

❖ How many **Outdoor tables** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have an **Outdoor table**?

Garden (front)□	Garden (back)□	Deck□	Storage□	Kitchen□	Garage□
Carport□	Storage□	Other□ …….			

❖ How many **Outdoor chairs** do you have in your home?

1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□ 9□ 10□ 11□ 12□ 13□ 14□ 15□ 16□ 17□ 18□

In which of the following spaces do you have an **Outdoor chair**?

Garden (front)□	Garden (back)□	Deck□	Storage□	Kitchen□	Garage□
Carport□	Storage□	Other□			

❖ How many **Outdoor umbrellas/Gazeboes** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have an **Outdoor umbrella/Gazebo**?

Garden (front)□	Garden (back)□	Deck□	Storage□	Garage□	Carport□
Other□					

❖ How many **Benches** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you have a **Bench**?

Deck□	Garden (front)□	Garden (back)□	Garage□	Carport□	Storage□
Kitchen□	Games room□	Other□			

❖ How many **Climbing frames** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Climbing frame**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Storage□
Other□					

❖ How many **Swing seats** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Swing seat**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Storage□
Other□					

❖ How many **Slides** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Slide**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Playroom□
Storage□	Other□				

❖ How many big **Trampolines** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a big **Trampoline**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Storage□
Other□					

❖ How many **Workbenches** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Workbench**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Games room□
Storage□	Other□				

❖ How many **Hammocks** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Hammock**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Playroom□
Storage□	Other□				

❖ How many pieces of **Exercise equipment** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have **Exercise equipment**?

Games room□	Playroom□	Library□	Study/Office□	Bedroom 1□	Bedroom 2□
Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□	Living room 1□	Living room 2□
Dining room□	Combined Living room/Dining room□	Garage□	Carport□	Garden (front)□	Garden (back)□
Deck□	Storage□	Other□			

❖ How many **Paddling pools** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Paddling pool**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Storage□
Other□					

❖ How many **Swings** do you have in your home? 1□ 2□ 3□ 4□

In which of the following spaces do you have a **Swing**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Storage□
Other□					

❖ How many **Play houses** (for kids) do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Play house**?

Garden (front)□	Garden (back)□	Deck□	Garage□	Carport□	Playroom□
Storage□	Other□				

❖ How many **Table tennis tables** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Table tennis table**?

Games room□	Playroom□	Garden (front)□	Garden (back)□	Deck□	Garage□
Carport□	Storage□	Other□			

❖ How many **Billiard tables** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Billiard table**?

Games room□	Playroom□	Library□	Study/Office□	Garage□	Storage□
Other□					

❖ How many **Pool tables** do you have in your home? 1□ 2□ 3□

In which of the following spaces do you have a **Pool table**?

Games room□	Playroom□	Library□	Study/Office□	Garage□	Living room 1□
Living room 2□	Dining room□	Storage□	Other□		

❖ How many **Lawn mowers** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Lawn mower**?

Garage□	Storage□	Garden shed□	Other□		

❖ How many **Leaf blowers** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Leaf blower**?

Garage□	Storage□	Garden shed□	Other□		

❖ How many **Hedge trimmers** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Hedge trimmer**?

Garage□	Storage□	Garden shed□	Other□		

❖ How many **Water blasters** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Water blaster**?

Garage□	Storage□	Garden shed□	Other□		

❖ How many **Cars** does your family have? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you usually park a **Car**?

Garage□	Carport□	Parking space□	Other□		

❖ How many **Motorcycles/Scooters** does your family have? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you usually park a **Motorcycle/Scooter**?

Garage□	Carport□	Parking space□	Garden (front)□	Garden (back)□	Deck□
Storage□	Other□				

❖ How many **Bicycles** do you have in your home? 1□ 2□ 3□ 4□ 5□ 6□ 7□ 8□

In which of the following spaces do you usually put a **Bicycle**?

Garage□	Carport□	Parking space□	Garden (front)□	Garden (back)□	Deck□
Storage□	Games room□	Other□			

❖ How many **Scooters (for kids)** do you have in your home? 1□ 2□ 3□ 4□ 5□

In which of the following spaces do you have a **Scooter**?

Garage□	Carport□	Parking spaces□	Garden (front)□	Garden (back)□	Deck□
Playroom□	Storage□	Games room□	Other□		

Part 6- Gatherings and parties

1- On average how often do you have a gathering/party at your house?

Once a week☐ Once a month☐ Once every three months☐ Twice a year☐ Once a year☐ Other☐……

2- How many people would normally be at each type of the following gatherings/parties when you have these?

Type of party/gathering	No attending	Where you gather (You can select more than one)	When you gather
Weekly parties	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Monthly parties	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Parties held every three months	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Parties held every six months	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Yearly parties	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Other parties ……	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐

3-On average how often do you have a guest(s) who stay(s) at your house for more than one day?

Once a week☐ Once a month☐ Once every three months☐ Twice a year☐ Once a year☐ Other☐……

4-On average, how many people are your guests for each situation?

	Weekly guests	Monthly guests	Guests who come every 3 months	Guests who come every 6 months	Yearly guests	Other guests
How many guests?	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐

Part 7- General question about satisfaction with your house

1- What do you think about your house size?

Very large☐ Large☐ Not large- not small☐ Small☐ Very small☐

2-What do you think about your furniture at home?

Very much more than needed☐ More than needed☐ Enough☐ More needed☐ Very much more needed☐

3- Please state how important each of these parameters are when you come to select a house with spare bedroom(s)?

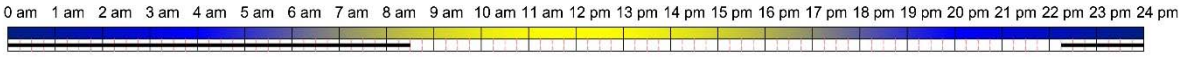
	Not important	Somewhat important	Neutral	Important	Very important
Investment					
Easier to sell					
More comfort					
More flexibility					
Location					
Can place more furniture in it					
Getting more out of the same money					
Thinking about future changes in your family					
Other (please write)					
Other (please write)					
Other (please write)					

Questionnaire to be left with participants and customised for each based on answers to day 1

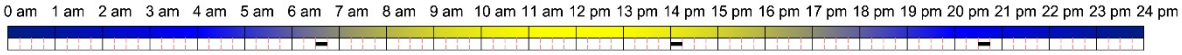
This questionnaire aims to estimate amount of time spent in each space of your house by each occupant over 2 weeks. Please fill out this form for each occupant for 2 weeks starting on a Monday. Please note that the form can be filled by an adult member of the family on behalf of the whole family.

Part 8- Time spent in each space:

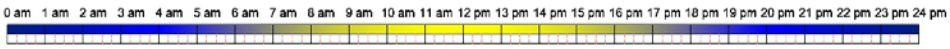
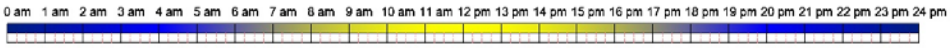
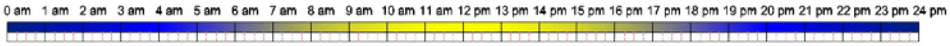
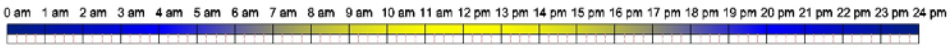
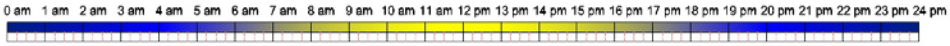
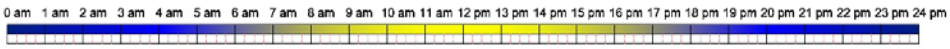
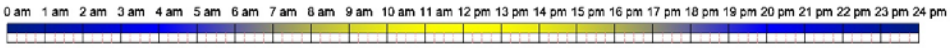
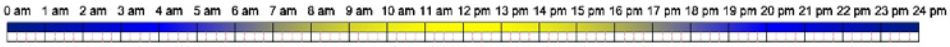
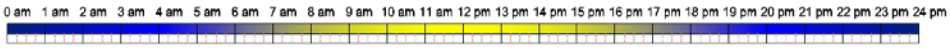
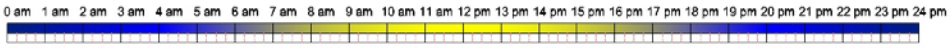
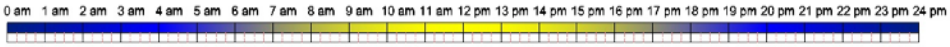
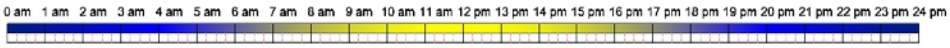
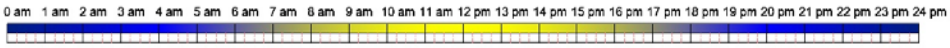
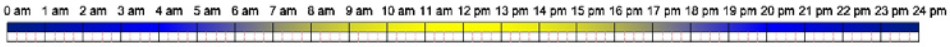
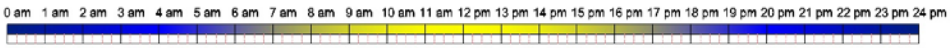
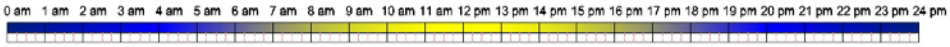
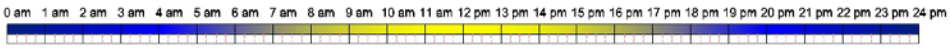
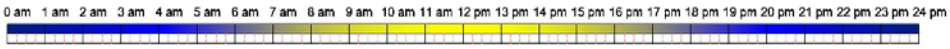
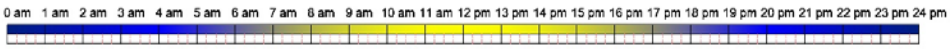
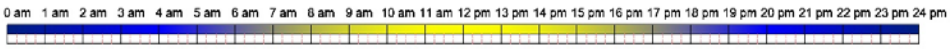
Please estimate how much time you used each of these spaces. Please draw a line through the times you have used each space up to the nearest 15 minute period. For instance if you have been in bedroom 1 from 10:15 PM to 6:30 AM it would look like the following picture:



For usages less than 15 minutes (like going to bathroom) please just put a line through one cell (15 minutes). For instance if you used the bathroom at 6:35AM, 2:09PM and 8:37PM it would look like this:



Report for: **Occupant1**	Reported day: **Monday**
Bedroom 1	
Bedroom 2	
Bedroom 3	
Bedroom 4	
Bedroom 5	
Bedroom 6	
Combined Living room/Dining room	
Living room 1	
Living room 2	
Living room 3	
Dining room	
Kitchen	
Bathroom/Toilet1	
Bathroom/Toilet2	

Bathroom/Toilet3	
Bathroom/Toilet/ Laundry1	
Bathroom/Toilet/ Laundry2	
Laundry	
Playroom	
Library	
Study/Office	
Garage 1	
Garage 2	
Garage 3	
Carport 1	
Carport 2	
Carport 3	
Parking Space 1	
Parking Space 2	
Parking Space 3	
Storage	
Garden (front)	
Garden (back)	
Deck	

Part 9- To be filled out by interviewer:

Questionnaire is completed in a: Heating month☐ Non-heating month☐

Questionnaire is filled out from DD / MM / YY to DD / MM / YY

Table of physical characteristics:

Date of build	Number of storeys	Lot/Section area	Total floor area

Floor area of spaces:

	Front Yard	**Back Yard**	**Bedroom1**	**Bedroom2**	**Bedroom3**	**Bedroom4**	**Bedroom5**	**Bedroom6**
Floor area (m^2)								
Floor covering								
	Livingroom1	**Livingroom2**	**Dining room**	**Kitchen**	**Bathroom1**	**Bathroom2**	**Bathroom3**	**Laundry**
Floor area (m^2)								
Floor covering								
	Playing room	**Library**	**Study**	**Sport room**	**Gust room**	**Garage**	**Storage**	**Other**
Floor area (m^2)								
Floor covering								

Weather situation in the day questionnaire filled:

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Date														
Sunny														
Cloudy														
Rainy														
Max. Temp														
Min. Temp														
Ave. Temp														
Cold														
Neutral														
Warm														
Windy														
Non-windy														

Appendix 5.2: Human Ethics approval for Studies 1 and 2

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Phone 0-4-463 5676
Fax 0-4-463 5209
Email Allison.kirkman@vuw.ac.nz

MEMORANDUM

TO	Iman Khajehzadeh
COPY TO	Brenda Vale
FROM	Dr Allison Kirkman, Convener, Human Ethics Committee
DATE	2 June 2014
PAGES	1
SUBJECT	**Ethics Approval: 21012** Behavioural effect of large housing in New Zealand

Thank you for your application for ethical approval, which has now been considered by the Standing Committee of the Human Ethics Committee.

Your application has been approved from the above date and this approval continues until 31 August 2016. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Allison Kirkman
Human Ethics Committee

Appendix 5.3: The weather data taken from Kelburn station for the Study 1 period

Date	Max. Temp. (C°)	Min. Temp. (C°)	Rain rate (mm)	Wind speed (Km/h)*		Date	Max. Temp. (C°)	Min. Temp. (C°)	Rain rate (mm)	Wind speed (Km/h)
20140616	14.4	14.4	1.8	14.63		20140718	8.1	5.4	0.6	23.54
20140617	15.2	15.2	0.2	26.25		20140719	8.4	6.6	3.8	17.92
20140618	12.4	12.4	0.8	20.08		20140720	8.0	7.2	9.6	28.00
20140619	15.6	15.6	0.2	18.88		20140721	7.8	6.5	0.0	24.79
20140620	13.2	13.2	0.0	7.58		20140722	9.0	5.3	8.6	33.83
20140621	14.1	14.1	1.6	19.79		20140723	10.1	5.4	0.0	30.17
20140622	11.0	11.0	0.0	30.29		20140724	14.1	4.7	5.4	17.54
20140623	12.7	12.7	0.0	13.54		20140725	12.6	5.1	0.0	6.58
20140624	13.5	13.5	2.4	11.21		20140726	12.2	4.6	0.0	18.79
20140625	15.2	15.2	3.6	22.58		20140727	11.0	6.4	0.2	11.00
20140626	15.8	15.8	10.8	39.29		20140728	11.1	4.7	0.0	16.79
20140627	14.8	14.8	0.6	19.42		20140729	12.1	7.3	1.4	17.83
20140628	15.0	15.0	0.0	20.50		20140730	13.8	9.6	1.2	24.21
20140629	13.9	13.9	3.2	5.13		20140731	14.4	11.9	0.0	32.71
20140630	13.0	13.0	12.0	22.54		20140801	14.1	13.2	18.4	29.75
20140701	14.2	10.6	0.0	22.00		20140802	14.6	12.2	12.6	35.46
20140702	11.3	7.6	4.2	22.42		20140803	11.3	10.3	0.4	29.13
20140703	10.8	2.0	0.0	21.46		20140804	11.4	7.3	0.2	23.33
20140704	12.6	3.8	0.0	12.79		20140805	12.9	3.2	0.8	7.88
20140705	16.8	6.0	1.4	23.25		20140806	10.9	6.7	2.4	18.08
20140706	11.2	7.0	2.0	20.92		20140807	12.9	4.4	0.2	25.13
20140707	11.1	7.2	0.2	18.54		20140808	12.2	9.0	5.8	32.13
20140708	12.2	3.1	0.0	10.38		20140809	9.4	2.4	0.0	23.29
20140709	12.4	6.8	0.0	16.79		20140810	11.6	3.1	0.2	8.96
20140710	15.5	9.0	0.0	14.67		20140811	12.0	7.1	4.6	23.96
20140711	14.9	8.1	0.2	7.79		20140812	11.9	8.4	4.4	24.63
20140712	14.1	8.7	3.4	6.71		20140813	11.3	3.9	0.0	15.88
20140713	13.3	10.5	2.2	16.92		20140814	11.2	3.0	6.4	15.17
20140714	8.8	8.6	3.8	16.63		20140815	11.4	4.2	0.6	37.13
20140715	10.7	7.3	1.8	26.58		20140816	12.0	7.9	0.0	28.54
20140716	7.8	6.9	47.8	23.17		20140817	13.7	5.3	0.0	12.83
20140717	8.4	3.8	10.4	26.58						

Table A.5.3.10 Weather data for investigation period (Source: National Institute of Water and Atmospheric Research (2014))

Note 1- Data is based on Wellington, Kelburn Aws station: Agent number 25354 and Network number E1427P.

Note 2 *- National Institute of Water and Atmospheric Research (2014) provides a total wind run (in km) for 24 hours. Wind speed (km/h) is produced by dividing wind run (km) by 24 (hours)

Appendix 6.1: Questionnaire for Study 2

If you currently live in an owner occupied house (not an apartment) thank you so much for taking part in this survey.

This is a survey of four types of household (please select the one that matches your situation):

Single person☐

Couple☐

Couple with 1 child☐

Couple with 2 children☐

- Are you interested in the results of this survey? (If yes, I will provide you with the link to an electronic version of my PhD thesis which will be available at VUW Faculty of Architecture and Design library from late 2016.) Yes, I am interested☐ No, thanks☐

Part 1- General information:

- Postal address:
- Contact number or email:

- Please select appropriate gender, age and job situation for each family member:

*Note 1- Qualtrics will automatically adjust the following question to the number of occupants selected in the first part

**Note 2- This option will appear only if they select "Under 21" as age.

*Occupant 1: Gender: Male☐ Female☐

Age: Under 21☐ 21-35☐ 35-50☐ 50-65☐ 65+☐ **Please write exact age ___

Job situation: Full time☐ Part time☐ Not in paid work☐

*Occupant 2: Gender: Male☐ Female☐

Age: Under 21☐ 21-35☐ 35-50☐ 50-65☐ 65+☐ **Please write exact age ___

Job situation: Full time☐ Part time☐ Not in paid work☐

*Occupant 3: Gender: Male☐ Female☐

Age: Under 21☐ 21-35☐ 35-50☐ 50-65☐ 65+☐ **Please write exact age ___

Job situation: Full time☐ Part time☐ Not in paid work☐

*Occupant 4: Gender: Male☐ Female☐

Age: Under 21☐ 21-35☐ 35-50☐ 50-65☐ 65+☐ **Please write exact age ___

Job situation: Full time☐ Part time☐ Not in paid work☐

❖ Who is filling out this questionnaire? (Choices will only appear for participants over 13 years old)

Occupant 1☐ Occupant 2☐ Occupant 3☐ Occupant 4☐ Other (e.g. occupants 1 & 2)☐

❖ Do you have a drawing of your house you could scan or copy and send me? (If you can copy it rather than scanning. Let me know and I will send you a postage paid envelope)
Yes I have and will email it to you☐ Yes I have but need a postage paid envelope to send☐
No, I don't have☐

Part 2- Spaces:

❖ Do you have these rooms/spaces in your home?
For each room/space please drag slider so that the appropriate number appears at the right hand side of the table.
Please note a 'Combined' room such as 'Combined living room-dining room' means there is no door or door-sized opening between the rooms. Where room names are separated by a slash this indicates a type of room that could be known by various names (e.g. Study/Office/Library).

Name of rooms/spaces	How many?	No
Bedroom (a room that always contains a bed) Note- rooms with sofa beds are not counted as bedrooms	0 1 2 3 4 5 6 7	
Combined Living room-Dining room-Kitchen	0 1 2 3 4 5 6 7	
Combined Dining room-Kitchen	0 1 2 3 4 5 6 7	
Combined Living room-Kitchen	0 1 2 3 4 5 6 7	
Combined Living room-Dining room	0 1 2 3 4 5 6 7	
Living room	0 1 2 3 4 5 6 7	
Dining room	0 1 2 3 4 5 6 7	
Kitchen	0 1 2 3 4 5 6 7	
Combined Bathroom-Toilet	0 1 2 3 4 5 6 7	

Combined Bathroom-Toilet-Laundry	0 1 2 3 4 5 6 7	
Toilet	0 1 2 3 4 5 6 7	
Bathroom	0 1 2 3 4 5 6 7	
Laundry	0 1 2 3 4 5 6 7	
Playroom	0 1 2 3 4 5 6 7	
Study/Office/Library	0 1 2 3 4 5 6 7	
Games room/Rumpus room/Gym room	0 1 2 3 4 5 6 7	
Studio/Workshop	0 1 2 3 4 5 6 7	
Conservatory	0 1 2 3 4 5 6 7	
Utility room	0 1 2 3 4 5 6 7	
Sleep out/Shed/Greenhouse	0 1 2 3 4 5 6 7	
Garden	0 1 2 3 4 5 6 7	
Deck/Patio	0 1 2 3 4 5 6 7	
Garage	0 1 2 3 4 5 6 7	
Your Garage is suitable for how many cars? (This will appear only if the previous row is ≥1)	0 1 2 3 4 5 6 7	
Carport	0 1 2 3 4 5 6 7	

Your Carport is suitable for how many cars? (This will appear only if the previous row is ≥1)	0 1 2 3 4 5 6 7	
Parking space	0 1 2 3 4 5 6 7	
Your Parking space is suitable for how many cars? (This will appear only if the previous row is ≥1)	0 1 2 3 4 5 6 7	
Other (please name) _____	0 1 2 3 4 5 6 7	
Other (please name) _____	0 1 2 3 4 5 6 7	
Other (please name) _____	0 1 2 3 4 5 6 7	

❖ Please identify user(s) and features of each bedroom? (You can select more than one usual occupant for a bedroom if it is shared e.g. couples)

Qualtrics will automatically give the number of bedrooms/occupants according to the numbers in previous parts.

	Does this bedroom have an En-suite Bathroom?	Does this bedroom have a built in wardrobe?	Does this bedroom have a dressing room?	Who normally occupies this bedroom?
Bedroom1	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom2	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom3	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom4	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom5	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom6	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom7	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐
Bedroom8	Yes☐ No☐	Yes☐ No☐	Yes☐ No☐	occupant 1☐ occupant 2☐ occupant 3☐ occupant 4☐ No usual occupants☐

❖ Please tick the features which best reflect the content of each bathroom in your home (you can select more than 1 item in each part):

Qualtrics will automatically give the number of bathrooms according to the number in the previous table.

Bathroom1	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐

Bathroom2	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom3	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom4	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom5	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom6	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐
Bathroom7	Single vanity☐ Double vanity☐	Separate shower☐ Bath☐ Spa bath☐ Bath with Shower☐	Heated towel rail☐ Bidet ☐ Toilet☐

Part 3- Furniture/appliances:

❖ Please select how many items of furniture/large appliances you have in your home. For each item please drag the slider so that the appropriate number appears at the right hand side of the table.

Name of furniture	**How many?**	**No**
King/Queen/Double bed	0 1 2 3 4 5 6 7 8	
Single bed	0 1 2 3 4 5 6 7 8	
Bunk bed	0 1 2 3 4 5 6 7 8	
Cot	0 1 2 3 4 5 6 7 8	
Desk	0 1 2 3 4 5 6 7 8	
Wardrobe (not built in)	0 1 2 3 4 5 6 7 8	
Desk Chair	0 1 2 3 4 5 6 7 8	
Free standing rack (for storing cloths)	0 1 2 3 4 5 6 7 8	
Chest of drawers/Dressing table	0 1 2 3 4 5 6 7 8	
Free standing mirror	0 1 2 3 4 5 6 7 8	
Shelves/ Book cases	0 1 2 3 4 5 6 7 8	

Name of furniture	**How many?**	**No**
Piano	0 1 2 3 4 5	
4 seater Dining suite/table with chairs	0 1 2 3 4 5	

6 seater Dining suite/table with chairs	0 1 2 3 4 5	
8 seater Dining suite/table with chairs	0 1 2 3 4 5	
12 seater Dining suite/table with chairs	0 1 2 3 4 5	

Name of furniture	**How many?**	**No**
Armchair	0 1 2 3 4 5 6 7 8 9 10	
Double seater Couch/Sofa	0 1 2 3 4 5 6 7 8 9 10	
Three seater Couch/Sofa	0 1 2 3 4 5 6 7 8 9 10	
Four seater Couch/Sofa	0 1 2 3 4 5 6 7 8 9 10	
Bedside table/cabinet	0 1 2 3 4 5 6 7 8 9 10	
Side table (other than bedside table)	0 1 2 3 4 5 6 7 8 9 10	
Coffee table	0 1 2 3 4 5 6 7 8 9 10	
Chair (other than desk/dining table chair)	0 1 2 3 4 5 6 7 8 9 10	
Outdoor chair/couch*	0 1 2 3 4 5 6 7 8 9 10	
Chaise longue	0 1 2 3 4 5 6 7 8 9 10	
LED TV	0 1 2 3 4 5 6 7 8 9 10	
LCD TV	0 1 2 3 4 5 6 7 8 9 10	
Plasma TV	0 1 2 3 4 5 6 7 8 9 10	

Cathode ray TV	0 1 2 3 4 5 6 7 8 9 10	
Stool	0 1 2 3 4 5 6 7 8 9 10	
TV cabinet	0 1 2 3 4 5 6 7 8 9 10	
Ornamental sculptures/Vases (at least 1m high)	0 1 2 3 4 5 6 7 8 9 10	
Buffet/Sideboard	0 1 2 3 4 5 6 7 8 9 10	
Entertainment unit	0 1 2 3 4 5 6 7 8 9 10	
Display cabinet/unit	0 1 2 3 4 5 6 7 8 9 10	
Rug	0 1 2 3 4 5 6 7 8 9 10	
Chest	0 1 2 3 4 5 6 7 8 9 10	
Ottoman/ Footstool	0 1 2 3 4 5 6 7 8 9 10	
Floor lamp/Standard lamp	0 1 2 3 4 5 6 7 8 9 10	
Wall clock	0 1 2 3 4 5 6 7 8 9 10	
Bench	0 1 2 3 4 5 6 7 8 9 10	

*Note- Please count the total number of seats, so a double couch is two seats and a triple couch three seats etc.

Name of furniture/appliance	**How many?**	**No**
Built-in chest of drawers	0 1 2 3 4 5 6 7 8 9	
Built-in shelves	0 1 2 3 4 5 6 7 8 9	
Built-in book cases	0 1 2 3 4 5 6 7 8 9	
Built-in display cabinet	0 1 2 3 4 5 6 7 8 9	

Name of furniture/appliance	How many?	No
Fridge/Freezer	0 1 2 3 4	
Fridge	0 1 2 3 4	
Bar fridge	0 1 2 3 4	
Freezer/Chest freezer	0 1 2 3 4	
Dishwasher	0 1 2 3 4	
Cook top/Hob	0 1 2 3 4	
Oven	0 1 2 3 4	
Stove/Range	0 1 2 3 4	
Microwave	0 1 2 3 4	

Name of furniture/appliance	How many?	No
Ironing board	0 1 2 3 4 5	
Drying/airing rack	0 1 2 3 4 5	
Washing machine	0 1 2 3 4 5	
Dryer	0 1 2 3 4 5	
Laundry tub	0 1 2 3 4 5	

Name of furniture	How many?	No
Swimming pool	0 1 2 3 4 5	
Spa pool	0 1 2 3 4 5	
BBQ	0 1 2 3 4 5	
Outdoor umbrella/ gazebo	0 1 2 3 4 5	
Outdoor dining/ Picnic table	0 1 2 3 4 5	

Outdoor coffee table	0 1 2 3 4 5	
Swing seat /Hammock	0 1 2 3 4 5	
Sun lounger/Deck recliner chair	0 1 2 3 4 5	
Trampoline	0 1 2 3 4 5	
Climbing frame	0 1 2 3 4 5	
Slide	0 1 2 3 4 5	
Swing	0 1 2 3 4 5	
Sand box	0 1 2 3 4 5	
Paddling pool	0 1 2 3 4 5	
Play house	0 1 2 3 4 5	

Name of furniture/appliance	**How many?**	**No**
Treadmill	0 1 2 3 4 5	
Exercise weight machine	0 1 2 3 4 5	
Exercise cycles	0 1 2 3 4 5	
Table tennis table	0 1 2 3 4 5	
Billiard table	0 1 2 3 4 5	
Pool table	0 1 2 3 4 5	

Name of equipment	**How many?**	**No**
Lawn mower	0 1 2 3 4 5	
Leaf blower	0 1 2 3 4 5	
Hedge trimmer	0 1 2 3 4 5	
Weed eater	0 1 2 3 4 5	

Chipper	0 1 2 3 4 5	
Work bench	0 1 2 3 4 5	
Water blaster	0 1 2 3 4 5	
Chain saw	0 1 2 3 4 5	
Drop saw	0 1 2 3 4 5	
Drill	0 1 2 3 4 5	

Name of vehicle	**How many?**	**No**
Car	0 1 2 3 4 5 6 7 8	
Boat	0 1 2 3 4 5 6 7 8	
Motorcycle/ Scooter	0 1 2 3 4 5 6 7 8	
Bike	0 1 2 3 4 5 6 7 8	

❖ Please name any furniture/large appliances that you have unlisted above, dragging the slider to the appropriate number as before.

Name of furniture/Large appliance	**How many?**	**No**
Other (name) _____	0 1 2 3 4 5 6 7	
Other (name) _____	0 1 2 3 4 5 6 7	
Other (name) _____	0 1 2 3 4 5 6 7	
Other (name) _____	0 1 2 3 4 5 6 7	
Other (name) _____	0 1 2 3 4 5 6 7 8 9	
Other (name) _____	0 1 2 3 4 5 6 7 8 9	
Other (name) _____	0 1 2 3 4 5 6 7 8 9	

❖ Please select how many small appliance items you have in your home, dragging the slider as before.

Name of small appliance	How many?	No
Blender/mixer	0 1 2 3 4 5	
Sandwich maker	0 1 2 3 4 5	
Slow cooker/Rice cooker	0 1 2 3 4 5	
Electric frying pan	0 1 2 3 4 5	
Electric deep fryer	0 1 2 3 4 5	
Bread maker	0 1 2 3 4 5	
Juicer	0 1 2 3 4 5	
Popcorn maker	0 1 2 3 4 5	
Coffee maker	0 1 2 3 4 5	
Ice cream maker	0 1 2 3 4 5	
Food processor	0 1 2 3 4 5	
Toaster	0 1 2 3 4 5	
Waffle iron	0 1 2 3 4 5	
Electric jug	0 1 2 3 4 5	
Water cooler	0 1 2 3 4 5	
Iron	0 1 2 3 4 5	
Hair dryer	0 1 2 3 4 5	
Hair straighter/Hair curler	0 1 2 3 4 5	
Electric blanket	0 1 2 3 4 5	
Sewing machine	0 1 2 3 4 5	
Vacuum cleaner	0 1 2 3 4 5	
Steam cleaner	0 1 2 3 4 5	
Stereo	0 1 2 3 4 5	

Games Console	0 1 2 3 4 5	
DVD/Blu-Ray player	0 1 2 3 4 5	
Laptop	0 1 2 3 4 5	
Desktop computer	0 1 2 3 4 5	
Combined printer-scanner-fax	0 1 2 3 4 5	
Combined printer-scanner	0 1 2 3 4 5	
Scanner	0 1 2 3 4 5	
Printer	0 1 2 3 4 5	
Fax	0 1 2 3 4 5	

- Please select space conditioning appliance items you have in your home. You can select more than one choice:
  Electric Bar heater☐ Gas heater☐ Electric oil filled radiator☐
  Heat pump Convector heater☐ Wood burner/Pellet burner☐ Under floor heating system☐
  Central heating☐ Central radiator (gas unit)☐ Dehumidifier☐ Fan☐
  Other (please name) ☐ _____

- Please select how many of each space conditioning appliance item you have in your home, dragging the slider as before.
  Note- Only appliances were selected in the previous part will appear here.

Name of space conditioning	**How many?**	**No**
Electric Bar heater	0 1 2 3 4 5	
Gas heater	0 1 2 3 4 5	
Electric oil filled radiator	0 1 2 3 4 5	
Heat pump	0 1 2 3 4 5	
Convector heater	0 1 2 3 4 5	
Wood burner/Pellet burner	0 1 2 3 4 5	
Under floor heating system	0 1 2 3 4 5	

Dehumidifier	0 1 2 3 4 5	
Fan	0 1 2 3 4 5	
Other (name comes from previous question automatically if added by participant)	0 1 2 3 4 5	

❖ Please select how many water heating appliance items you have in your home, dragging the slider as before.

Name of water heater	**How many?**	**No**
Electric water heater	0 1 2 3 4 5	
Gas storage water heater	0 1 2 3 4 5	
Gas instantaneous water heater	0 1 2 3 4 5	
Solar water heater	0 1 2 3 4 5	
Wetback	0 1 2 3 4 5	
Other (name) _____	0 1 2 3 4 5	
Other (name) _____	0 1 2 3 4 5	

Part 4- Place of furniture/large appliance:

This part asks about the place of furniture/large appliances in your home. Please tick the appropriate place. You can select more than one place if needed.

In this part only furniture and large appliances selected in previous parts will appear, together with only those spaces which exist in the house (selected in part 2). So what is presented here is the biggest possible situation for this part.

❖ In which of the following spaces do you have a **Double/King/Queen bed**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Study/Office/Library☐	Garage☐	Other☐	I don't have this type of furniture☐	

❖ In which of the following spaces do you have a **Single bed**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Study/Office/Library☐	Garage☐	Other☐	I don't have this type of furniture☐	

❖ In which of the following spaces do you have a **Cot**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Study/Office/Library☐	Garage☐	Other☐	I don't have this type of furniture☐	

❖ In which of the following spaces do you have a **Bunk bed**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Study/Office/Library☐	Garage☐	Other☐	I don't have this type of furniture☐	

❖ In which of the following spaces do you have a **Bedside table/cabinet**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Study/Office/Library☐	Garage☐	Other☐	I don't have this type of furniture☐	

❖ In which of the following spaces do you have a **Desk**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Living room 1☐	Living room 2☐	Dining room☐	Combined Living room-Dining room-Kitchen☐	
Combined Living room-Kitchen☐		Combined Living room-Dining room☐			Combined Dining room-Kitchen☐
Kitchen☐	Playroom☐	Games room/Rumpus room/Gym room☐		Garage☐	Other☐ .....
I don't have this type of furniture☐					

❖ In which of the following spaces do you have a **Desk chair?**

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Living room 1☐	Living room 2☐	Dining room☐	Combined Living room-Dining room-Kitchen☐	
Combined Living room-Kitchen☐		Combined Living room-Dining room☐			Combined Dining room-Kitchen☐
Kitchen☐	Playroom☐	Games room/Rumpus room/Gym room☐		Garage☐	Other☐ .....
I don't have this type of furniture☐					

❖ In which of the following spaces do you have a **Chest of drawers/Dressing table**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Bedroom 7☐	Combined Living room-Dining room-Kitchen☐		Combined Living room-Dining room☐		Living room 1☐
Living room 2☐	Games room/Rumpus room/Gym room☐		Dining room☐	Playroom☐	Laundry/Utility room☐
Study/Office/Library☐		Other☐	I don't have this type of furniture☐		

❖ In which of the following spaces do you have a **Built-in chest of drawers**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□		Garage□	Study/Office/Library□	Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Shelf/Book case**? (not built-in ones)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Combined Living room-Dining room-Kitchen□		Combined Living room-Dining room□		Living room 1□
Living room 2□	Games room/Rumpus room/Gym room□		Dining room□	Playroom□	
Study/Office/Library□		Other□ …….	I don't have this type of furniture□		

❖ In which of the following spaces do you have a **Built-in shelf/book case**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Wardrobe**? (other than built-in wardrobes)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Combined Living room-Dining room-Kitchen□		Combined Living room-Dining room□		Living room 1□
Living room 2□	Games room/Rumpus room/Gym room□		Dining room□	Playroom□	Laundry □
Utility room□	Study/Office/Library□	Other□ …….	I don't have this type of furniture□		

❖ In which of the following spaces do you have a **free standing Rack** for storing clothes?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Playroom□	Games room/Rumpus room/Gym room□		Study/Office/Library□	
Laundry□	Utility room□	Other□ …….	I don't have this type of furniture□		

❖ In which of the following spaces do you have a **free standing Mirror**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	
Combined Living room-Kitchen□		Combined Dining room-Kitchen□		Combined Living room-Dining room-Kitchen□	
Study/Office/Library□		Combined Bathroom-Toilet□	Combined Bathroom-Toilet/Laundry □	Toilet□	Other□ …….
I don't have this type of furniture□					

❖ In which of the following spaces do you have an **Armchair**? (indoors only)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Living room 1□	Living room 2□	Dining room□		
Combined Living room-Dining room□		Combined Living room-Kitchen□			
Combined Dining room-Kitchen□	Combined Living room-Dining room-Kitchen□			Kitchen□	Playroom□
Games room/Rumpus room/Gym room□	Study/Office/Library□		Other□ …….	Garage□	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Double seater Couch/Sofa**? (indoors only)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Living room 1□	Living room 2□	Dining room□		
Combined Living room-Dining room□		Combined Living room-Kitchen□			
Combined Dining room-Kitchen□	Combined Living room-Dining room-Kitchen□			Kitchen□	Playroom□
Games room/Rumpus room/Gym room□	Study/Office/Library□		Other□ …….	Garage□	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **three seater Couch/Sofa**? (indoors only)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Living room 1□	Living room 2□	Dining room□		
Combined Living room-Dining room□		Combined Living room-Kitchen□			
Combined Dining room-Kitchen□	Combined Living room-Dining room-Kitchen□			Kitchen□	Playroom□
Games room/Rumpus room/Gym room□	Study/Office/Library□		Other□ …….	Garage□	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **four seater Couch/Sofa**? (indoors only)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Bedroom 7□	Living room 1□	Living room 2□	Dining room□		
Combined Living room-Dining room□		Combined Living room-Kitchen□			
Combined Dining room-Kitchen□	Combined Living room-Dining room-Kitchen□			Kitchen□	Playroom□
Games room/Rumpus room/Gym room□	Study/Office/Library□		Other□ …….	Garage□	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Coffee table**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□		Garage□	Study/Office/Library□	Laundry□	Playroom□
	Other□ …….	I don't have this type of furniture□			

❖ In which of the following spaces do you have a **LED TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Playroom□	Other□ …….
I don't have this type of appliance□					

❖ In which of the following spaces do you have a **LCD TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Playroom□	Other□ …….
I don't have this type of appliance □					

❖ In which of the following spaces do you have a **Plasma TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Playroom□	Other□ …….
I don't have this type of appliance □					

❖ In which of the following spaces do you have a **Cathode ray TV**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Playroom□	Other□ …….
I don't have this type of appliance □					

❖ In which of the following spaces do you have a **TV Cabinet**? (not built-in)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Playroom□	Other□ …….
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **built-in TV Cabinet**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Kitchen□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Playroom□	Other□ …….
I don't have this type of furniture□					

❖ In which of the following spaces do you have an **Entertainment unit**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Chaise longue**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Wall clock**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□	Kitchen□	Other□ …….	Combined Bathroom-Toilet□
I don't have this type of appliance□					

❖ In which of the following spaces do you have a **Buffet/Sideboard**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Kitchen□	
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have a **Side table**? (not bedside table)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Study/Office/Library□		Other□ …….
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Piano**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Other□ …….	Garage□
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Built-in display cabinet**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **four seater Dining suite**? (not outdoor ones)

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Kitchen□	Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Conservatory□	Garage□
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have a **six seater Dining suite**? (not outdoor ones)

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Kitchen□	Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Conservatory□	Garage□
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have an **eight seater Dining suite**? (not outdoor ones)

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Kitchen□	Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Conservatory□	Garage□
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have a **twelve seater Dining suite**? (not outdoor ones)

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Kitchen□	Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Conservatory□	Garage□
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have a **Chair (for dining table)**? (not outdoor ones)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Kitchen□	Playroom□
Games room/Rumpus room/Gym room□		Study/Office/Library□		Conservatory□	Garage□
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have a **chair** (other than dining table/desk chairs)?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Garage□	Study/Office/Library□	Conservatory□
Other□ …….	I don't have this type of furniture□				

❖ In which of the following spaces do you have a **Rug**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Laundry□	Study/Office/Library□	Conservatory□
Other□ …….	Garage□	I don't have this type of furniture□			

❖ In which of the following spaces do you have a **Chest**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□			Garage□	Study/Office/Library□	Other□ …….
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Display cabinet/unit**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□	Study/Office/Library□	
Playroom□	Kitchen□	Games room□	I don't have this type of furniture□	Other□ …….	

❖ In which of the following spaces do you have a **Floor lamp/Standard lamp**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□		Garage□	Study/Office/Library□	Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have an **ornamental Sculpture/Vase**? (at least 1m high)

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
	Kitchen□	Games room/Rumpus room/Gym room□		Study/Office/Library□	Garden□
	Other□ ……	I don't have this type of furniture□			

❖ In which of the following spaces do you have an **Ottoman/Footstool**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Games room/Rumpus room/Gym room□			Study/Office/Library□	Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Stool**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room□		Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Study/Office/Library□	Garage□	Carport□
Laundry□	Toilet/Bath/ Laundry□		Utility room□	Other□ …….	
I don't have this type of furniture□					

❖ In which of the following spaces do you have a **Fridge/freezer**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Study/Office/Library□	Utility room□
Garage□	Other□ …….	I don't have this type of appliance□		

❖ In which of the following spaces do you have a **Fridge**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Study/Office/Library□	Utility room□
Garage□	Other□ …….	I don't have this type of appliance□		

❖ In which of the following spaces do you have a **Bar Fridge**?

Bedroom 1□	Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□
Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□		Kitchen□
Games room/Rumpus room/Gym room□		Playroom□	Study/Office/Library□	Utility room□	
Garage□	Other□ …….	I don't have this type of appliance□			

❖ In which of the following spaces do you have a **Freezer/Chest Freezer**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Playroom□
Kitchen□	Games room/Rumpus room/Gym room□		Study/Office/Library□	Utility room□
Garage□	Other□ …….	I don't have this type of appliance□		

❖ In which of the following spaces do you have a **Dishwasher**?

Kitchen□	Living room 1□	Dining room□	Combined Living room-Dining room-Kitchen□	Utility room□
Study/Office/Library□	Garage□		Other□ …….	I don't have this type of appliance□

❖ In which of the following spaces do you have a **Cooktop/Hob**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Combined Living room-Kitchen□
Combined Dining room-Kitchen□		Kitchen□	Other□ …….	I don't have this type of appliance□

❖ In which of the following spaces do you have an **Oven**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Combined Living room-Kitchen□
Combined Dining room-Kitchen□		Kitchen□	Other□ …….	I don't have this type of appliance□

❖ In which of the following spaces do you have a **Stove/Range**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Combined Living room-Kitchen□
Combined Dining room-Kitchen□		Kitchen□	Other□ …….	I don't have this type of appliance□

❖ In which of the following spaces do you have a **Microwave**?

Living room 1□	Living room 2□	Dining room□	Combined Living room-Dining room-Kitchen□	Combined Living room-Kitchen□
Combined Dining room-Kitchen□		Kitchen□	Utility room□	Other□ …….
I don't have this type of appliance□				

❖ In which of the following spaces do you have a **Treadmill**?

Games room/Rumpus room/Gym room□		Playroom□	Study/Office/Library□		Bedroom 1□
Bedroom 2□	Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□	Living room 1□
Living room 2□	Dining room□	Combined Living room-Dining room□		Garage□	Carport□
Deck/Patio□	Garden□		Other□ …….	I don't have this type of equipment□	

❖ In which of the following spaces do you have an **Exercise cycle**?

	Playroom□	Study/Office/Library□		Bedroom 1□	Bedroom 2□
Bedroom 3□	Bedroom 4□	Bedroom 5□	Bedroom 6□	Living room 1□	Living room 2□
Dining room□	Combined Living room-Dining room□		Games room/Rumpus room/Gym room□		
Garage□	Carport□	Garden□		Deck/Patio□	Other□ …….
I don't have this type of equipment□					

❖ In which of the following spaces do you have an **Exercise weight machine**?

	Playroom□		Study/Office/Library□		Bedroom 1□	Bedroom 2□
Bedroom 3□	Bedroom 4□		Bedroom 5□	Bedroom 6□	Living room 1□	Living room 2□
Dining room□	Combined Living room-Dining room□		Games room/Rumpus room/Gym room□			
Garage□	Carport□	Garden□		Deck/Patio□	Other□ …….	
I don't have this type of equipment□						

❖ In which of the following spaces do you have a **Table tennis table**?

Games room/Rumpus room/Gym room□	Playroom□	Garden□		Deck/Patio□	Garage□
Carport□		Other□ …….	I don't have this type of equipment□		

❖ In which of the following spaces do you have a **Billiard table**?

Games room/Rumpus room/Gym room□	Playroom□	Study/Office/Library□	Garage□		Other□ …….
I don't have this type of equipment□					

❖ In which of the following spaces do you have a **Pool table**?

Games room/Rumpus room/Gym room☐	Playroom☐	Study/Office/Library☐	Garage☐	Living room 1☐	Living room 2☐
Dining room☐		Other☐	I don't have this type of equipment☐		

❖ In which of the following spaces do you have a **Drying/Airing rack**?

Bedroom 1☐	Bedroom 2☐	Bedroom 3☐	Bedroom 4☐	Bedroom 5☐	Bedroom 6☐
Living room 1☐	Dining room☐	Combined Living room-Dining room-Kitchen☐		Combined Living room-Kitchen☐	
Combined Dining room-Kitchen☐		Playroom☐	Kitchen☐	Games room/Rumpus room/Gym room☐	
Study/Office/Library☐		Garage☐	Carport☐	Garden☐	Garden (back)☐
Deck/Patio☐	Laundry☐		Utility room☐	Other☐	
I don't have this type of furniture☐					

❖ In which of the following spaces do you have a **Washing machine**?

Laundry☐	Toilet/Laundry☐	Dining room☐	Combined Living room-Dining room-Kitchen☐	Combined Living room-Kitchen☐
Combined Dining room-Kitchen☐		Utility room☐	Kitchen☐	Garage☐
Other☐	I don't have this type of appliance☐			

❖ In which of the following spaces do you have a **Dryer**?

Laundry☐	Toilet/Laundry☐	Dining room☐	Combined Living room-Dining room-Kitchen☐	Combined Living room-Kitchen☐
Combined Dining room-Kitchen☐		Kitchen☐	Utility room☐	Garage☐
Other☐	I don't have this type of appliance ☐			

❖ In which of the following spaces do you have a **Laundry tub**?

Laundry☐	Toilet/Laundry☐	Dining room☐	Combined Living room-Dining room-Kitchen☐	Combined Living room-Kitchen☐
Combined Dining room-Kitchen☐		Kitchen☐	Utility room☐	Garage☐
Other☐	I don't have this type of furniture☐			

❖ In which of the following spaces do you have a **Swimming pool**?

Outdoors (Garden)☐	Indoors☐	Other☐	I don't have Swimming pool☐	

❖ In which of the following spaces do you have a **Spa pool**?

Deck/Patio☐	Garden☐		Garage☐	Carport☐	
	Other☐	I don't have this type of equipment☐			

❖ In which of the following spaces do you have a **BBQ**?

Deck/Patio☐	Garden☐		Kitchen☐	Garage☐	Carport☐
	Other☐	I don't have this type of furniture☐			

❖ In which of the following spaces do you have a **Coffee table**?

Garden☐		Deck/Patio☐	Playroom☐	Games room/Rumpus room/Gym room☐	Carport☐
Garage☐		Other☐		I don't have this type of furniture☐	

❖ In which of the following spaces do you have an **Outdoor dining/Picnic table**?

Garden☐		Deck/Patio☐		Kitchen☐	Garage☐
Carport☐	Other☐	I don't have this type of furniture☐			

❖ In which of the following spaces do you have an **Outdoor chair/couch**?

Garden☐		Deck/Patio☐		Kitchen☐	Garage☐
Carport☐	Other☐	I don't have this type of furniture☐			

❖ In which of the following spaces do you have a **Sun lounger/Deck recliner chair**?

Garden☐		Deck/Patio☐		Kitchen☐	Garage☐
Carport☐	Other☐ …….	I don't have this type of furniture☐			

❖ In which of the following spaces do you have an **Outdoor umbrella/Gazebo**?

Garden☐		Deck/Patio☐		Garage☐	Carport☐
Other☐ …….	I don't have this type of furniture☐				

❖ In which of the following spaces do you have a **Bench**?

Deck/Patio☐	Garden☐		Garage☐	Carport☐	Laundry☐
Kitchen☐	Games room/Rumpus room/Gym room☐	Other☐ …….	I don't have this type of furniture☐		

❖ In which of the following spaces do you have a **Climbing frame**?

Garden☐		Deck/Patio☐	Garage☐	Carport☐	
Other☐ …….	I don't have this type of equipment☐				

❖ In which of the following spaces do you have a **Slide**?

Garden☐		Deck/Patio☐	Garage☐	Carport☐	Playroom☐
	Other☐ …….	I don't have this type of equipment☐			

❖ In which of the following spaces do you have a big **Trampoline**?

Garden☐		Deck/Patio☐	Garage☐	Carport☐	
Other☐ …….	I don't have this type of equipment☐				

❖ In which of the following spaces do you have a **Play house**?

Garden☐		Deck/Patio☐	Garage☐	Carport☐	Playroom☐
	Other☐ ……..	I don't have this type of furniture☐			

❖ In which of the following spaces do you have a **Paddling pool**?

Garden☐		Deck/Patio☐	Garage☐	Carport☐	
Other☐ …….	I don't have this type of equipment☐				

❖ In which of the following spaces do you have a **Workbench**?

Garden☐		Deck/Patio☐	Garage☐	Carport☐	Games room☐
Studio/Workshop☐	Utility room☐	Other☐ …….	I don't have this type of furniture☐		

❖ In which of the following spaces do you have a **Lawn mower**?

Garage☐		Sleep out/Shed/Greenhouse☐	Studio/Workshop☐	Other☐ ……..	I don't have this type of equipment☐

❖ In which of the following spaces do you usually park a **Car**?

Garage☐	Carport☐	Parking space☐	On road☐	Other☐ …….	I don't have any car☐	

❖ In which of the following spaces do you usually park a **Boat**?

Garage□	Carport□	Parking space□	On road□	Other□	I don't have any boat□

❖ In which of the following spaces do you usually park a **Motorcycle/Scooter**?

Garage□	Carport□	Parking space□	Garden□		Deck/Patio□
On road□	Other□	I don't have any Motorcycle/Scooter□			

❖ In which of the following spaces do you usually put a **Bicycle**?

Garage□	Carport□	Parking space□	Garden□		Deck/Patio□
On road□	Games room/Rumpus room/Gym room□	Other□	I don't have any Bicycle□		

Part 5- Gatherings and parties

❖ On average how often do you have a gathering/party at your house?

Once a week☐ Once a month☐ Once every three months☐ Twice a year☐ Once a year☐ Other☐……

❖ How many people would normally be at each type of the following gatherings/parties when you have these?

Type of party/gathering	No attending	Where you gather (You can select more than one)	When you gather
Weekly parties	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Monthly parties	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Parties held every three months	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Parties held every six months	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Yearly parties	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐
Other parties ……	<10☐ 10-20☐ >20☐	One of Bedrooms☐ Front garden☐ Back garden☐ Living room☐ Whole indoors☐ whole outdoors☐ Other☐……	Week days☐ Weekends☐

❖ On average how often do you have a guest(s) who stay(s) at your house for more than one day?

Once a week☐ Once a month☐ Once every three months☐ Twice a year☐ Once a year☐ Other☐……

❖ On average, how many people are your guests for each situation?

	Weekly guests	Monthly guests	Guests who come every 3 months	Guests who come every 6 months	Yearly guests	Other guests
How many guests?	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐	1☐ 2☐ 3☐ 4☐ 5☐ 6☐ >6☐

Part 6- General question about satisfaction with your house

❖ What do you think about your house size?

Very large☐ Large☐ Not large- not small☐ Small☐ Very small☐

❖ What do you think about your furniture at home?

Very much more than needed☐ More than needed☐ Enough☐ Not quite enough☐ Not enough☐

❖ For each furniture category in your house please estimate what percentage you bought new and what second hand? (0% is completely second hand and 100 is all bought new):

Furniture/Appliance category	**0 = Second hand** **100 = Brand new**
Bedroom furniture	0 10 20 30 40 50 60 70 80 90 100
Living room/Dining room furniture	0 10 20 30 40 50 60 70 80 90 100
Kitchen large appliances	0 10 20 30 40 50 60 70 80 90 100
Laundry appliances	0 10 20 30 40 50 60 70 80 90 100
Outdoor furniture	0 10 20 30 40 50 60 70 80 90 100
Gardening equipment/Tools	0 10 20 30 40 50 60 70 80 90 100
Vehicles	0 10 20 30 40 50 60 70 80 90 100
Exercise/Playing equipment	0 10 20 30 40 50 60 70 80 90 100
Small appliances	0 10 20 30 40 50 60 70 80 90 100

❖ Please state how important each of these parameters are when you come to select a house with spare bedroom(s)?

	Not at all important	Not very important	Neutral	Somewhat important	Very important
Investment					
Easier to sell					
More comfort					
More flexibility					

Cheaper location					
Can place more furniture in it					
Getting more out of the same money					
Thinking about future changes in your family					
Space for entertaining					
Other (please write)					
Other (please write)					
Other (please write)					

Part 7- Time spent in each space:

In this part you are asked to estimate how much time you spent in each sub space/room of your house yesterday (24 hours). This needs to be filled in for each family member separately. You can fill out timetables on behalf of all family members.

❖ **Occupant 1:** Thinking of occupant 1 (details inserted here automatically by Qualtrics) yesterday, please estimate how much time to the nearest quarter of an hour was spent in each of the following spaces. By moving the slider a time in hours will appear to the right hand side. The subtotal must be 24 hours. Please leave unused spaces free. Note that hours are shown as metric values; for example $1^{1/2}$ hours = 1.50 hours, $3^{3/4}$ hours = 3.75 hours and 15 minutes = 0.25 hours.

Note- Qualtrics will automatically include only the rooms/spaces found in the house and add the day of the week

Report for: **Occupant 1**		Reported day: **Monday**
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time spent away from home and garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bedroom (a room that always contains a bed)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Living room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Bathroom-Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Combined Bathroom-Toilet-Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bathroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Playroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Study/Office/Library	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Games room/Rumpus room/Gym room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Studio/Workshop	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garage (If used for something rather than parking cars e.g. play room, workshop and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Conservatory	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Utility room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Sleep out/Shed/Greenhouse	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Deck/Patio	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal for all spaces (this is always 24 hours)		24

❖ **Occupant 2:** (The instructions the same for occupant 1) Thinking of occupant 2 (details inserted here automatically by Qualtrics) yesterday, please estimate how much time to the nearest quarter of an hour was spent in each of the following spaces. By moving the slider a time in hours will appear to the right hand side. The subtotal must be 24 hours. Please leave unused spaces free. Note that hours are shown as metric values; for example $1^{1/2}$ hours = 1.50 hours, $3^{3/4}$ hours = 3.75 hours and 15 minutes = 0.25 hours.

Note- Qualtrics will automatically include only the rooms/spaces found in the house and add the day of the week

Report for: **Occupant 2**		Reported day: **Monday**
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time spent away from home and garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bedroom (a room that always contains a bed)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Living room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Bathroom-Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Combined Bathroom-Toilet-Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bathroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Playroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Study/Office/Library	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Games room/Rumpus room/Gym room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Studio/Workshop	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garage (If used for something rather than parking cars e.g. play room, workshop and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Conservatory	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Utility room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Sleep out/Shed/Greenhouse	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Deck/Patio	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal for all spaces (this is always 24 hours)		24

❖ **Occupant 3:** (The instructions the same for occupant 1) Thinking of occupant 3 (details inserted here automatically by Qualtrics) yesterday, please estimate how much time to the nearest quarter of an hour was spent in each of the following spaces. By moving the slider a time in hours will appear to the right hand side. The subtotal must be 24 hours. Please leave unused spaces free. Note that hours are shown as metric values; for example $1^{1/2}$ hours = 1.50 hours, $3^{3/4}$ hours = 3.75 hours and 15 minutes = 0.25 hours.

Note- Qualtrics will automatically include only the rooms/spaces found in the house and add the day of the week

Report for: **Occupant 3**		Reported day: **Monday**
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time spent away from home and garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bedroom (a room that always contains a bed)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Living room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Bathroom-Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Combined Bathroom-Toilet-Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bathroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Playroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Study/Office/Library	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Games room/Rumpus room/Gym room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Studio/Workshop	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garage (If used for something rather than parking cars e.g. play room, workshop and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Conservatory	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Utility room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Sleep out/Shed/Greenhouse	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Deck/Patio	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal for all spaces (this is always 24 hours)		24

❖ **Occupant 4:** (The instructions the same for occupant 1) Thinking of occupant 4 (details inserted here automatically by Qualtrics) yesterday, please estimate how much time to the nearest quarter of an hour was spent in each of the following spaces. By moving the slider a time in hours will appear to the right hand side. The subtotal must be 24 hours. Please leave unused spaces free. Note that hours are shown as metric values; for example $1^{1/2}$ hours = 1.50 hours, $3^{3/4}$ hours = 3.75 hours and 15 minutes = 0.25 hours.

Note- Qualtrics will automatically include only the rooms/spaces found in the house and add the day of the week

Report for: **Occupant 4**		Reported day: **Monday**
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time spent away from home and garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bedroom (a room that always contains a bed)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Dining room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Living room-Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Living room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Dining room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Kitchen	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Combined Bathroom-Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Combined Bathroom-Toilet-Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Toilet	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Bathroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Laundry	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Playroom	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Study/Office/Library	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Games room/Rumpus room/Gym room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Studio/Workshop	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garage (If used for something rather than parking cars e.g. play room, workshop and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Conservatory	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Utility room	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Sleep out/Shed/Greenhouse	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Garden	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Deck/Patio	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Other (name automatically appears if participants add space at the end of part 2)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal for all spaces (this is always 24 hours)		24

❖ **Car 1:** Thinking of yesterday please estimate how much time Car 1 was parked in any of the following. The subtotal must be 24 hours and please leave unused spaces free.

Report for: **Car 1**		Reported day: **Monday**
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time car has been used (shopping, work and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in Garage	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in Parking space	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in carport	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked on road	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal (this is always 24 hours)		24

❖ **Car 2:** Thinking of yesterday please estimate how much time Car 2 was parked in any of the following. The subtotal must be 24 hours and please leave unused spaces free.

Report for: **Car 1**		Reported day: **Monday**
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time car has been used (shopping, work and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in Garage	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	

Parked in Parking space	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in carport	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked on road	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal (this is always 24 hours)		24

❖ **Car 3:** Thinking of yesterday please estimate how much time Car 3 was parked in any of the following. The subtotal must be 24 hours and please leave unused spaces free.

Report for: **Car 1**	Reported day: **Monday**	
Name of space	**How much time (in hours)?**	**Time for each space will appear here**
Time car has been used (shopping, work and etc.)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in Garage	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in Parking space	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked in carport	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Parked on road	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	
Subtotal (this is always 24 hours)		24

Appendix 6.2: Human Ethics approvals for amendments of questionnaire for Study 2

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Phone 0-4-463 5676
Fax 0-4-463 5209
Email Allison.kirkman@vuw.ac.nz

MEMORANDUM

TO	Iman Khajehzadeh
COPY TO	Brenda Vale
FROM	Dr Allison Kirkman, Convener, Human Ethics Committee

DATE	21 November 2014
PAGES	1

SUBJECT	**Ethics Approval: 21012** Behavioural effect of large housing in New Zealand

Thank you for your request to amend your ethics approval. This has now been considered and the request granted.

Your application has approval until 31 August 2016. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Allison Kirkman
Human Ethics Committee

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

MEMORANDUM

Phone 0-4-463 5676
Fax 0-4-463 5209
Email Allison.kirkman@vuw.ac.nz

TO	Iman Khajehzadeh
COPY TO	Brenda Vale
FROM	Dr Allison Kirkman, Convener, Human Ethics Committee

DATE	16 February 2015
PAGES	1

SUBJECT	**Ethics Approval: 21012** Behavioural effect of large housing in New Zealand

Thank you for your request to amend your ethics approval. This has now been considered and the request granted.

Your application has approval until 31 August 2016. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with your research.

Allison Kirkman
Human Ethics Committee

Appendix 6.3: Results of the post-hoc test to examine house size by household/house size

Dependent Variable	Household type A	Household type B	Mean Difference (A-B)	Std. Error	Sig.
Number of rooms	Single person	Couple	-1.02030*	0.29121	0.003
		Couple with 1 child	-1.06551*	0.31750	0.005
		Couple with 2 children	-1.34517*	0.32440	0.000
	Couple	Couple with 1 child	-0.04521	0.27198	0.998
		Couple with 2 children	-0.32487	0.28000	0.652
	Couple with 1 child	Couple with 2 children	-0.27967	0.30725	0.799
Number of bedrooms	Single person	Couple	-0.50783*	0.14085	0.002
		Couple with 1 child	-0.79630*	0.15357	0.000
		Couple with 2 children	-1.20613*	0.15690	0.000
	Couple	Couple with 1 child	-0.28846	0.13155	0.128
		Couple with 2 children	-0.69830*	0.13543	0.000
	Couple with 1 child	Couple with 2 children	-0.40984*	0.14861	0.031
Number of living rooms	Single person	Couple	-0.09366	0.07805	0.627
		Couple with 1 child	-0.06855	0.08510	0.852
		Couple with 2 children	-0.06072	0.08694	0.898
	Couple	Couple with 1 child	0.02511	0.07289	0.986
		Couple with 2 children	0.03294	0.07504	0.972
	Couple with 1 child	Couple with 2 children	0.00783	0.08235	1.000
Number of dining rooms	Single person	Couple	0.03561	0.05913	0.931
		Couple with 1 child	0.01437	0.06447	0.996
		Couple with 2 children	0.00850	0.06587	0.999
	Couple	Couple with 1 child	-0.02124	0.05523	0.981
		Couple with 2 children	-0.02711	0.05686	0.964
	Couple with 1 child	Couple with 2 children	-0.00587	0.06239	1.000
Number of specialised rooms	Single person	Couple	-0.52564*	0.15298	0.004
		Couple with 1 child	-0.25871	0.16680	0.409
		Couple with 2 children	-0.07104	0.17042	0.976
	Couple	Couple with 1 child	0.26693	0.14288	0.244
		Couple with 2 children	0.45460*	0.14709	0.012
	Couple with 1 child	Couple with 2 children	0.18767	0.16141	0.651
Number of bathrooms	Single person	Couple	-0.42272*	0.12532	0.005
		Couple with 1 child	-0.38047*	0.13709	0.030
		Couple with 2 children	-0.54614*	0.13960	0.001
	Couple	Couple with 1 child	0.04225	0.11758	0.984
		Couple with 2 children	-0.12342	0.12049	0.735
	Couple with 1 child	Couple with 2 children	-0.16567	0.13270	0.597
Number of en-suites	Single person	Couple	-0.32372*	0.09933	0.007
		Couple with 1 child	-0.29602*	0.10830	0.034
		Couple with 2 children	-0.24317	0.11065	0.126
	Couple	Couple with 1 child	0.02770	0.09277	0.991
		Couple with 2 children	0.08055	0.09551	0.834
	Couple with 1 child	Couple with 2 children	0.05285	0.10480	0.958

Table A.6.3.1 Results of the post-hoc test to examine the details of differences of the average number of selected rooms by household type

Dependent Variable	House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.
Number of rooms	5.00	6.00	-1.23810*	0.09796	0.000
		7.00	-2.23810*	0.10063	0.000
		8.00	-3.23810*	0.11160	0.000
		9.00	-5.11111*	0.10126	0.000
	6.00	7.00	-1.00000*	0.08614	0.000
		8.00	-2.00000*	0.09873	0.000
		9.00	-3.87302*	0.08687	0.000
	7.00	8.00	-1.00000*	0.10137	0.000
		9.00	-2.87302*	0.08987	0.000
	8.00	9.00	-1.87302*	0.10200	0.000
Number of bedrooms	5.00	6.00	-0.74476*	0.13317	0.000
		7.00	-1.06886*	0.13680	0.000
		8.00	-1.40883*	0.15170	0.000
		9.00	-1.95238*	0.13765	0.000
	6.00	7.00	-0.32410*	0.11710	0.047
		8.00	-0.66407*	0.13421	0.000
		9.00	-1.20762*	0.11809	0.000
	7.00	8.00	-0.33996	0.13781	0.101
		9.00	-0.88352*	0.12216	0.000
	8.00	9.00	-0.54355*	0.13865	0.001
Number of living rooms	5.00	6.00	-0.02667	0.06657	0.995
		7.00	-0.06154	0.06839	0.897
		8.00	-0.36585*	0.07584	0.000
		9.00	-0.79365*	0.06881	0.000
	6.00	7.00	-0.03487	0.05854	0.976
		8.00	-0.33919*	0.06709	0.000
		9.00	-0.76698*	0.05903	0.000
	7.00	8.00	-0.30432*	0.06889	0.000
		9.00	-0.73211*	0.06107	0.000
	8.00	9.00	-0.42780*	0.06931	0.000
Number of dining rooms	5.00	6.00	-0.17714*	0.05782	0.020
		7.00	-0.19048*	0.05940	0.013
		8.00	-0.21487*	0.06587	0.011
		9.00	-0.57143*	0.05977	0.000
	6.00	7.00	-0.01333	0.05084	0.999
		8.00	-0.03772	0.05827	0.967
		9.00	-0.39429*	0.05128	0.000
	7.00	8.00	-0.02439	0.05984	0.994
		9.00	-0.38095*	0.05305	0.000
	8.00	9.00	-0.35656*	0.06020	0.000
Number of specialised rooms	5.00	6.00	-0.30000	0.14958	0.266
		7.00	-0.86410*	0.15366	0.000
		8.00	-1.22358*	0.17040	0.000
		9.00	-1.43651*	0.15461	0.000
	6.00	7.00	-0.56410*	0.13153	0.000
		8.00	-0.92358*	0.15075	0.000
		9.00	-1.13651*	0.13264	0.000
	7.00	8.00	-0.35947	0.15479	0.141
		9.00	-0.57241*	0.13722	0.000
	8.00	9.00	-0.21293	0.15574	0.649
Number of bathrooms	5.00	6.00	-0.20455	0.12171	0.448
		7.00	-0.42814*	0.12497	0.006
		8.00	-0.87805*	0.13840	0.000
		9.00	-1.23693*	0.12574	0.000
	6.00	7.00	-0.22359	0.10619	0.221
		8.00	-0.67350*	0.12171	0.000
		9.00	-1.03238*	0.10709	0.000
	7.00	8.00	-0.44991*	0.12497	0.003
		9.00	-0.80879*	0.11079	0.000

	8.00	9.00	-0.35889*	0.12574	0.037
Number of en-suites	5.00	6.00	-0.17905	0.10639	0.446
		7.00	-0.32161*	0.10929	0.029
		8.00	-0.58653*	0.12120	0.000
		9.00	-0.69841*	0.10997	0.000
	6.00	7.00	-0.14256	0.09355	0.548
		8.00	-0.40748*	0.10722	0.002
		9.00	-0.51937*	0.09435	0.000
	7.00	8.00	-0.26492	0.11010	0.117
		9.00	-0.37680*	0.09760	0.001
	8.00	9.00	-0.11189	0.11077	0.851

Table A.6.3.2 Results of the post-hoc test to examine the details of differences of the average number of selected rooms by house size

Appendix 7.1: Results of the post-hoc tests for floor plan study

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	1.56	0.90	0.515	×
6 room house	4 room house	2.36	0.82	0.050	✓
6 room house	5 room house	0.80	0.80	0.916	×
7 room house	4 room house	5.36	0.93	0.000	✓
7 room house	5 room house	3.80	0.91	0.001	✓
7 room house	6 room house	3.00	0.83	0.005	✓
8 room house	4 room house	6.08	0.93	0.000	✓
8 room house	5 room house	4.52	0.91	0.000	✓
8 room house	6 room house	3.72	0.83	0.000	✓
8 room house	7 room house	0.71	0.93	0.973	×
9-9+ room house	4 room house	8.42	0.92	0.000	✓
9-9+ room house	5 room house	6.86	0.90	0.000	✓
9-9+ room house	6 room house	6.06	0.81	0.000	✓
9-9+ room house	7 room house	3.06	0.92	0.013	✓
9-9+ room house	8 room house	2.35	0.92	0.116	×

Table A.7.1.1 The results of the post-hoc test for comparing the average room size in various house sizes

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.12	0.03	0.000	✓
6 room house	4 room house	0.12	0.02	0.000	✓
	5 room house	0.00	0.02	1.000	×
7 room house	4 room house	0.12	0.03	0.000	✓
	5 room house	0.00	0.03	1.000	×
	6 room house	0.00	0.03	1.000	×
8 room house	4 room house	0.12	0.03	0.000	✓
	5 room house	0.00	0.03	1.000	×
	6 room house	0.00	0.03	1.000	×
	7 room house	0.00	0.03	1.000	×
9-9+ room house	4 room house	0.12	0.03	0.000	✓
	5 room house	0.00	0.03	1.000	×
	6 room house	0.00	0.02	1.000	×
	7 room house	0.00	0.03	1.000	×
	8 room house	0.00	0.03	1.000	×

Table A.7.1.2 results of the post-hoc test to see the details of significant differences of presence/absence of non-master bedroom by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.02	0.07	1.000	×
6 room house	4 room house	0.06	0.07	0.953	×
	5 room house	0.03	0.06	0.994	×
7 room house	4 room house	0.25	0.07	0.011	✓
	5 room house	0.23	0.07	0.023	✓
	6 room house	0.19	0.07	0.044	✓
8 room house	4 room house	0.53	0.07	0.000	✓
	5 room house	0.50	0.07	0.000	✓
	6 room house	0.47	0.07	0.000	✓
	7 room house	0.28	0.07	0.004	✓
9-9+ room house	4 room house	0.74	0.07	0.000	✓
	5 room house	0.72	0.07	0.000	✓
	6 room house	0.68	0.07	0.000	✓
	7 room house	0.49	0.07	0.000	✓
	8 room house	0.21	0.07	0.048	✓

Table A.7.1.3 results of the post-hoc test to see the details of significant differences of presence/absence of study room by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.00	0.04	1.000	×
6 room house	4 room house	0.00	0.03	1.000	×
	5 room house	0.00	0.03	1.000	×
7 room house	4 room house	0.00	0.04	1.000	×
	5 room house	0.00	0.04	1.000	×
	6 room house	0.00	0.03	1.000	×
8 room house	4 room house	0.05	0.04	0.766	×
	5 room house	0.05	0.04	0.748	×
	6 room house	0.05	0.03	0.667	×
	7 room house	0.05	0.04	0.770	×
9-9+ room house	4 room house	0.17	0.04	0.000	✓
	5 room house	0.17	0.04	0.000	✓
	6 room house	0.17	0.03	0.000	✓
	7 room house	0.17	0.04	0.000	✓
	8 room house	0.12	0.04	0.023	✓

Table A.7.1.4 results of the post-hoc test to see the details of significant differences of presence/absence of games room by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.00	0.04	1.000	×
6 room house	4 room house	0.00	0.03	1.000	×
	5 room house	0.00	0.03	1.000	×
7 room house	4 room house	0.05	0.04	0.742	×
	5 room house	0.05	0.04	0.723	×
	6 room house	0.05	0.03	0.637	×
8 room house	4 room house	0.03	0.04	0.983	×
	5 room house	0.03	0.04	0.981	×
	6 room house	0.03	0.03	0.972	×
	7 room house	-0.03	0.04	0.984	×
9-9+ room house	4 room house	0.12	0.04	0.013	✓
	5 room house	0.12	0.04	0.010	✓
	6 room house	0.12	0.03	0.003	✓
	7 room house	0.07	0.04	0.398	×
	8 room house	0.09	0.04	0.100	×

Table A.7.1.5 results of the post-hoc test to see the details of significant differences of presence/absence of studio by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.04	0.10	0.999	×
6 room house	4 room house	-0.29	0.09	0.013	✓
	5 room house	-0.33	0.08	0.002	✓
7 room house	4 room house	-0.19	0.10	0.414	×
	5 room house	-0.23	0.10	0.185	×
	6 room house	0.10	0.09	0.848	×
8 room house	4 room house	-0.41	0.10	0.001	✓
	5 room house	-0.45	0.10	0.000	✓
	6 room house	-0.12	0.09	0.739	×
	7 room house	-0.23	0.10	0.212	×
9-9+ room house	4 room house	-0.44	0.10	0.000	✓
	5 room house	-0.48	0.10	0.000	✓
	6 room house	-0.15	0.09	0.495	×
	7 room house	-0.26	0.10	0.098	×
	8 room house	-0.03	0.10	1.000	×

Table A.7.1.6 results of the post-hoc test to see the details of significant differences of presence/absence of separate kitchen by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	-0.14	0.10	0.709	×
6 room house	4 room house	-0.26	0.09	0.040	✓
	5 room house	-0.12	0.09	0.713	×
7 room house	4 room house	0.01	0.10	0.000	✓
	5 room house	0.15	0.10	0.623	×
	6 room house	0.28	0.09	0.027	✓
8 room house	4 room house	0.34	0.10	0.010	✓
	5 room house	0.48	0.10	0.000	✓
	6 room house	0.60	0.09	0.000	✓
	7 room house	0.33	0.10	0.017	✓
9-9+ room house	4 room house	0.27	0.10	0.067	×
	5 room house	0.41	0.10	0.000	✓
	6 room house	0.53	0.09	0.000	✓
	7 room house	0.26	0.10	0.101	×
	8 room house	-0.07	0.10	0.985	×

Table A.7.1.7 results of the post-hoc test to see the details of significant differences of presence/absence of separate living room by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.11	0.07	0.666	×
6 room house	4 room house	0.13	0.07	0.403	×
	5 room house	0.02	0.07	1.000	×
7 room house	4 room house	0.18	0.08	0.201	×
	5 room house	0.06	0.07	0.956	×
	6 room house	0.05	0.07	0.984	×
8 room house	4 room house	0.23	0.08	0.040	✓
	5 room house	0.11	0.07	0.648	×
	6 room house	0.10	0.07	0.717	×
	7 room house	0.05	0.08	0.987	×
9-9+ room house	4 room house	0.21	0.08	0.054	×
	5 room house	0.10	0.07	0.727	×
	6 room house	0.09	0.07	0.797	×
	7 room house	0.04	0.08	0.995	×
	8 room house	-0.01	0.08	1.000	×

Table A.7.1.8 results of the post-hoc test to see the details of significant differences of presence/absence of separate dining room by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	-0.30	0.06	0.000	✓
6 room house	4 room house	-0.30	0.05	0.000	✓
	5 room house	0.00	0.05	1.000	×
7 room house	4 room house	-0.32	0.06	0.000	✓
	5 room house	-0.02	0.06	1.000	×
	6 room house	-0.02	0.05	0.999	×
8 room house	4 room house	-0.27	0.06	0.000	✓
	5 room house	0.03	0.06	0.996	×
	6 room house	0.03	0.05	0.992	×
	7 room house	0.05	0.06	0.965	×
9-9+ room house	4 room house	-0.27	0.06	0.000	✓
	5 room house	0.03	0.06	0.997	×
	6 room house	0.03	0.05	0.995	×
	7 room house	0.05	0.06	0.973	×
	8 room house	0.00	0.06	1.000	×

Table A.7.1.9 results of the post-hoc test to see the details of significant differences of presence/absence of combined living room/kitchen by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.24	0.08	0.018	✓
6 room house	4 room house	0.10	0.07	0.654	×
	5 room house	-0.14	0.07	0.307	×
7 room house	4 room house	0.20	0.08	0.105	×
	5 room house	-0.04	0.08	0.994	×
	6 room house	0.10	0.07	0.732	×
8 room house	4 room house	0.05	0.08	0.987	×
	5 room house	-0.19	0.08	0.121	×
	6 room house	-0.05	0.07	0.972	×
	7 room house	-0.15	0.08	0.392	×
9-9+ room house	4 room house	0.14	0.08	0.432	×
	5 room house	-0.10	0.07	0.766	×
	6 room house	0.04	0.07	0.994	×
	7 room house	-0.06	0.08	0.974	×
	8 room house	0.09	0.08	0.843	×

Table A.7.1.10 results of the post-hoc test to see the details of significant differences of presence/absence of combined living room/dining room by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.22	0.10	0.245	×
6 room house	4 room house	0.47	0.09	0.000	✓
	5 room house	0.25	0.09	0.044	✓
7 room house	4 room house	0.35	0.10	0.008	✓
	5 room house	0.14	0.10	0.743	×
	6 room house	-0.12	0.09	0.783	×
8 room house	4 room house	0.63	0.10	0.000	✓
	5 room house	0.41	0.10	0.001	✓
	6 room house	0.16	0.09	0.507	×
	7 room house	0.28	0.10	0.079	×
9-9+ room house	4 room house	0.62	0.10	0.000	✓
	5 room house	0.40	0.10	0.001	✓
	6 room house	0.15	0.09	0.560	×
	7 room house	0.27	0.10	0.092	×
	8 room house	-0.01	0.10	1.000	×

Table A.7.1.11 results of the post-hoc test to see the details of significant differences of presence/absence of combined living room/dining room/kitchen by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.40	0.10	0.002	✓
6 room house	4 room house	0.40	0.10	0.000	✓
	5 room house	0.00	0.09	1.000	×
7 room house	4 room house	0.33	0.10	0.030	✓
	5 room house	-0.08	0.11	0.981	×
	6 room house	-0.08	0.10	0.971	×
8 room house	4 room house	0.33	0.11	0.030	✓
	5 room house	-0.08	0.11	0.981	×
	6 room house	-0.08	0.10	0.971	×
	7 room house	0.00	0.11	1.000	×
9-9+ room house	4 room house	0.23	0.11	0.247	×
	5 room house	-0.17	0.10	0.570	×
	6 room house	-0.17	0.09	0.463	×
	7 room house	-0.10	0.11	0.947	×
	8 room house	-0.10	0.11	0.947	×

Table A.7.1.12 results of the post-hoc test to see the details of significant differences of presence/absence of separate bathroom by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.09	0.08	0.866	×
6 room house	4 room house	0.37	0.07	0.000	✓
	5 room house	0.28	0.07	0.001	✓
7 room house	4 room house	0.63	0.08	0.000	✓
	5 room house	0.54	0.08	0.000	✓
	6 room house	0.25	0.07	0.006	✓
8 room house	4 room house	0.90	0.08	0.000	✓
	5 room house	0.81	0.08	0.000	✓
	6 room house	0.53	0.07	0.000	✓
	7 room house	0.28	0.08	0.010	✓
9-9+ room house	4 room house	0.93	0.08	0.000	✓
	5 room house	0.84	0.08	0.000	✓
	6 room house	0.56	0.07	0.000	✓
	7 room house	0.30	0.08	0.003	✓
	8 room house	0.03	0.08	0.999	×

Table A.7.1.13 results of the post-hoc test to see the details of significant differences of presence/absence of en-suite by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.47	0.10	0.000	✓
6 room house	4 room house	0.46	0.09	0.000	✓
	5 room house	-0.01	0.09	1.000	×
7 room house	4 room house	0.60	0.10	0.000	✓
	5 room house	0.13	0.10	0.743	×
	6 room house	0.14	0.09	0.590	×
8 room house	4 room house	0.55	0.10	0.000	✓
	5 room house	0.08	0.10	0.956	×
	6 room house	0.09	0.09	0.901	×
	7 room house	-0.05	0.10	0.996	×
9-9+ room house	4 room house	0.54	0.10	0.000	✓
	5 room house	0.07	0.10	0.976	×
	6 room house	0.08	0.09	0.939	×
	7 room house	-0.06	0.10	0.989	×
	8 room house	-0.01	0.10	1.000	×

Table A.7.1.14 results of the post-hoc test to see the details of significant differences of presence/absence of separate toilet by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	-0.22	0.04	0.000	✓
6 room house	4 room house	-0.22	0.03	0.000	✓
	5 room house	0.00	0.03	1.000	×
7 room house	4 room house	-0.22	0.04	0.000	✓
	5 room house	0.00	0.04	1.000	×
	6 room house	0.00	0.03	1.000	×
8 room house	4 room house	-0.22	0.04	0.000	✓
	5 room house	0.00	0.04	1.000	×
	6 room house	0.00	0.03	1.000	×
	7 room house	0.00	0.04	1.000	×
9-9+ room house	4 room house	-0.20	0.04	0.000	✓
	5 room house	0.02	0.04	0.987	×
	6 room house	0.02	0.03	0.980	×
	7 room house	0.02	0.04	0.989	×
	8 room house	0.02	0.04	0.989	×

Table A.7.1.15 results of the post-hoc test to see the details of significant differences of presence/absence of bathroom/toilet/laundry by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.42	0.09	0.000	✓
6 room house	4 room house	0.47	0.09	0.000	✓
	5 room house	0.05	0.08	0.987	×
7 room house	4 room house	0.28	0.10	0.044	✓
	5 room house	-0.14	0.09	0.682	×
	6 room house	-0.19	0.09	0.222	×
8 room house	4 room house	0.48	0.10	0.000	✓
	5 room house	0.06	0.09	0.987	×
	6 room house	0.01	0.09	1.000	×
	7 room house	0.20	0.10	0.311	×
9-9+ room house	4 room house	0.66	0.10	0.000	✓
	5 room house	0.24	0.09	0.107	×
	6 room house	0.19	0.08	0.245	×
	7 room house	0.38	0.10	0.001	✓
	8 room house	0.18	0.10	0.428	×

Table A.7.1.16 results of the post-hoc test to see the details of significant differences of presence/absence of separate laundry by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.11	0.08	0.747	×
6 room house	4 room house	0.17	0.07	0.191	×
	5 room house	0.06	0.07	0.960	×
7 room house	4 room house	0.28	0.08	0.014	✓
	5 room house	0.16	0.08	0.343	×
	6 room house	0.10	0.07	0.734	×
8 room house	4 room house	0.18	0.08	0.295	×
	5 room house	0.06	0.08	0.971	×
	6 room house	0.00	0.07	0.000	✓
	7 room house	-0.10	0.08	0.842	×
9-9+ room house	4 room house	0.45	0.08	0.000	✓
	5 room house	0.34	0.08	0.000	✓
	6 room house	0.28	0.07	0.002	✓
	7 room house	0.18	0.08	0.274	×
	8 room house	0.28	0.08	0.012	✓

Table A.7.1.17 results of the post-hoc test to see the details of significant differences of presence/absence of storage by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.08	0.03	0.081	×
6 room house	4 room house	0.10	0.03	0.002	✓
	5 room house	0.02	0.02	0.947	×
7 room house	4 room house	0.10	0.03	0.011	✓
	5 room house	0.02	0.03	0.969	×
	6 room house	0.00	0.03	1.000	×
8 room house	4 room house	0.10	0.03	0.011	✓
	5 room house	0.02	0.03	0.969	×
	6 room house	0.00	0.03	1.000	×
	7 room house	0.00	0.03	1.000	×
9-9+ room house	4 room house	0.10	0.03	0.009	✓
	5 room house	0.02	0.03	0.968	×
	6 room house	0.00	0.03	1.000	×
	7 room house	0.00	0.03	1.000	×
	8 room house	0.00	0.03	1.000	×

Table A.7.1.18 results of the post-hoc test to see the details of significant differences of presence/absence of circulation space by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room houses	5 room houses	-0.43	0.12	0.004	✓
4 room houses	6 room houses	-1.11	0.11	0.000	✓
4 room houses	7 room houses	-1.57	0.12	0.000	✓
4 room houses	8 room houses	-1.60	0.12	0.000	✓
4 room houses	9-9+ room houses	-2.62	0.12	0.000	✓
5 room houses	6 room houses	-0.67	0.10	0.000	✓
5 room houses	7 room houses	-1.14	0.12	0.000	✓
5 room houses	8 room houses	-1.16	0.12	0.000	✓
5 room houses	9-9+ room houses	-2.19	0.12	0.000	✓
6 room houses	7 room houses	-0.46	0.11	0.000	✓
6 room houses	8 room houses	-0.49	0.11	0.000	✓
6 room houses	9-9+ room houses	-1.51	0.11	0.000	✓
7 room houses	8 room houses	-0.03	0.12	1.000	×
7 room houses	9-9+ room houses	-1.05	0.12	0.000	✓
8 room houses	9-9+ room houses	+1.60	0.12	0.000	✓

Table A.7.1.19 Results of the post-hoc test to see the significant differences in the average number of bedrooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room houses	5 room house	-0.02	0.07	0.999	×
4 room houses	6 room house	-0.01	0.07	1.000	×
4 room houses	7 room house	-0.25	0.07	0.004	✓
4 room houses	8 room house	-0.85	0.07	0.000	✓
4 room houses	9-9+ room house	-1.02	0.07	0.000	✓
5 room houses	6 room house	+0.01	0.06	1.000	×
5 room houses	7 room house	-0.23	0.07	0.009	✓
5 room houses	8 room house	-0.83	0.07	0.000	✓
5 room houses	9-9+ room house	-1.00	0.07	0.000	✓
6 room houses	7 room house	-0.24	0.06	0.002	✓
6 room houses	8 room house	-0.84	0.06	0.000	✓
6 room houses	9-9+ room house	-1.01	0.06	0.000	✓
7 room houses	8 room house	-0.60	0.07	0.000	✓
7 room houses	9-9+ room house	-0.77	0.07	0.000	✓
8 room houses	9-9+ room house	-0.17	0.07	0.109	×

Table A.7.1.20 Results of the post-hoc test to see the significant differences in the average number of living rooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room houses	5 room house	-0.61	0.07	0.000	✓
4 room houses	6 room house	-0.82	0.06	0.000	✓
4 room houses	7 room house	-0.88	0.07	0.000	✓
4 room houses	8 room house	-0.95	0.07	0.000	✓
4 room houses	9-9+ room house	-1.07	0.07	0.000	✓
5 room houses	6 room house	-0.21	0.06	0.010	✓
5 room houses	7 room house	-0.27	0.07	0.002	✓
5 room houses	8 room house	-0.34	0.07	0.000	✓
5 room houses	9-9+ room house	-0.46	0.07	0.000	✓
6 room houses	7 room house	-0.06	0.06	0.947	×
6 room houses	8 room house	-0.13	0.06	0.306	×
6 room houses	9-9+ room house	-0.25	0.06	0.001	✓
7 room houses	8 room house	-0.08	0.07	0.903	×
7 room houses	9-9+ room house	-0.19	0.07	0.083	×
8 room houses	9-9+ room house	-0.12	0.07	0.584	×

Table A.7.1.21 Results of the post-hoc test to see the significant differences in the average number of dining rooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room house	5 room house	-0.02	0.09	1.000	×
4 room house	6 room house	-0.06	0.08	0.982	×
4 room house	7 room house	-0.30	0.09	0.016	✓
4 room house	8 room house	-0.60	0.09	0.000	✓
4 room house	9-9+ room house	-1.05	0.09	0.000	✓
5 room house	6 room house	-0.03	0.08	0.998	×
5 room house	7 room house	-0.28	0.09	0.027	✓
5 room house	8 room house	-0.58	0.09	0.000	✓
5 room house	9-9+ room house	-1.03	0.09	0.000	✓
6 room house	7 room house	-0.24	0.08	0.039	✓
6 room house	8 room house	-0.54	0.08	0.000	✓
6 room house	9-9+ room house	-0.99	0.08	0.000	✓
7 room house	8 room house	-0.30	0.09	0.017	✓
7 room house	9-9+ room house	-0.75	0.09	0.000	✓
8 room house	9-9+ room house	-0.45	0.09	0.000	✓

Table A.7.1.22 Results of the post-hoc test to see the significant differences in the average number of specialised rooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room house	5 room house	-0.13	0.11	0.836	×
4 room house	6 room house	-0.45	0.10	0.000	✓
4 room house	7 room house	-0.78	0.11	0.000	✓
4 room house	8 room house	-1.10	0.11	0.000	✓
4 room house	9-9+ room house	-1.43	0.11	0.000	✓
5 room house	6 room house	-0.32	0.10	0.015	✓
5 room house	7 room house	-0.64	0.11	0.000	✓
5 room house	8 room house	-0.97	0.11	0.000	✓
5 room house	9-9+ room house	-1.30	0.11	0.000	✓
6 room house	7 room house	-0.33	0.10	0.015	✓
6 room house	8 room house	-0.65	0.10	0.000	✓
6 room house	9-9+ room house	-0.98	0.10	0.000	✓
7 room house	8 room house	-0.33	0.11	0.049	✓
7 room house	9-9+ room house	-0.65	0.11	0.000	✓
8 room house	9-9+ room house	-0.33	0.11	0.042	✓

Table A.7.1.23 Results of the post-hoc test to see the significant differences in the average number of bathrooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room house	5 room house	-0.09	0.10	0.938	×
4 room house	6 room house	-0.37	0.09	0.000	✓
4 room house	7 room house	-0.65	0.10	0.000	✓
4 room house	8 room house	-1.00	0.10	0.000	✓
4 room house	9-9+ room house	-1.17	0.10	0.000	✓
5 room house	6 room house	-0.28	0.08	0.012	✓
5 room house	7 room house	-0.56	0.10	0.000	✓
5 room house	8 room house	-0.91	0.10	0.000	✓
5 room house	9-9+ room house	-1.08	0.10	0.000	✓
6 room house	7 room house	-0.28	0.09	0.020	✓
6 room house	8 room house	-0.63	0.09	0.000	✓
6 room house	9-9+ room house	-0.80	0.09	0.000	✓
7 room house	8 room house	-0.35	0.10	0.006	✓
7 room house	9-9+ room house	-0.52	0.10	0.000	✓
8 room house	9-9+ room house	-0.17	0.10	0.526	×

Table A.7.1.24 Results of the post-hoc test to see the significant differences in the average number of en-suites by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room house	5 room house	-0.13	0.13	0.914	×
4 room house	6 room house	-0.49	0.12	0.001	✓
4 room house	7 room house	-1.05	0.13	0.000	✓
4 room house	8 room house	-1.38	0.13	0.000	✓
4 room house	9-9+ room house	-1.88	0.13	0.000	✓
5 room house	6 room house	-0.36	0.11	0.024	✓
5 room house	7 room house	-0.92	0.13	0.000	✓
5 room house	8 room house	-1.24	0.13	0.000	✓
5 room house	9-9+ room house	-1.75	0.13	0.000	✓
6 room house	7 room house	-0.56	0.12	0.000	✓
6 room house	8 room house	-0.89	0.12	0.000	✓
6 room house	9-9+ room house	-1.39	0.12	0.000	✓
7 room house	8 room house	-0.33	0.13	0.154	×
7 room house	9-9+ room house	-0.83	0.13	0.000	✓
8 room house	9-9+ room house	-0.50	0.13	0.002	✓

Table A.7.1.25 Results of the Post-hoc test to see the significant differences in the average number of toilets by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
4 room house	5 room house	-0.20	0.09	0.268	×
4 room house	6 room house	-0.26	0.09	0.036	✓
4 room house	7 room house	-0.11	0.10	0.854	×
4 room house	8 room house	-0.26	0.10	0.075	✓
4 room house	9-9+ room house	-0.49	0.10	0.000	✓
5 room house	6 room house	-0.05	0.08	0.987	×
5 room house	7 room house	0.09	0.09	0.935	×
5 room house	8 room house	-0.06	0.09	0.987	×
5 room house	9-9+ room house	-0.29	0.09	0.027	✓
6 room house	7 room house	0.14	0.09	0.560	×
6 room house	8 room house	-0.01	0.09	1.000	×
6 room house	9-9+ room house	-0.23	0.08	0.069	×
7 room house	8 room house	-0.15	0.10	0.636	×
7 room house	9-9+ room house	-0.38	0.10	0.002	✓
8 room house	9-9+ room house	-0.23	0.10	0.176	×

Table A.7.1.26 Results of the post-hoc test to see the significant differences in the average number of laundries by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	6.92	2.80	0.137	×
6 room house	4 room house	16.55	2.55	0.000	✓
	5 room house	9.63	2.48	0.002	✓
7 room house	4 room house	29.23	2.89	0.000	✓
	5 room house	22.31	2.82	0.000	✓
	6 room house	12.68	2.57	0.000	✓
8 room house	4 room house	33.31	2.89	0.000	✓
	5 room house	26.39	2.82	0.000	✓
	6 room house	16.76	2.57	0.000	✓
	7 room house	4.08	2.90	0.723	×
9-9+ room house	4 room house	55.48	2.85	0.000	✓
	5 room house	48.56	2.79	0.000	✓
	6 room house	38.93	2.53	0.000	✓
	7 room house	26.25	2.87	0.000	✓
	8 room house	22.17	2.87	0.000	✓

Table A.7.1.27 Results of the post-hoc test to see the significant differences in the average floor area of all bedrooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	0.22	1.70	1.000	×
6 room house	4 room house	0.52	1.55	0.999	×
	5 room house	0.30	1.51	1.000	×
7 room house	4 room house	3.93	1.75	0.222	×
	5 room house	3.71	1.71	0.258	×
	6 room house	3.41	1.56	0.250	×
8 room house	4 room house	7.41	1.75	0.000	✓
	5 room house	7.19	1.71	0.001	✓
	6 room house	6.89	1.56	0.000	✓
	7 room house	3.48	1.76	0.359	×
9-9+ room house	4 room house	16.37	1.73	0.000	✓
	5 room house	16.15	1.69	0.000	✓
	6 room house	15.85	1.54	0.000	✓
	7 room house	12.45	1.74	0.000	✓
	8 room house	8.96	1.74	0.000	✓

Table A.7.1.28 Results of the post-hoc test to see the significant differences in the average floor area of all specialised rooms by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	9.44	3.10	0.030	✓
6 room house	4 room house	16.08	2.82	0.000	✓
	5 room house	6.63	2.74	0.153	×
7 room house	4 room house	28.77	3.19	0.000	✓
	5 room house	19.33	3.12	0.000	✓
	6 room house	12.69	2.84	0.000	✓
8 room house	4 room house	42.91	3.19	0.000	✓
	5 room house	33.46	3.12	0.000	✓
	6 room house	26.83	2.84	0.000	✓
	7 room house	14.13	3.21	0.000	✓
9-9+ room house	4 room house	58.28	3.15	0.000	✓
	5 room house	48.83	3.08	0.000	✓
	6 room house	42.20	2.80	0.000	✓
	7 room house	29.50	3.17	0.000	✓
	8 room house	15.37	3.17	0.000	✓

Table A.7.1.29 Results of the post-hoc test to see the significant differences in the average floor area of all living room, dining room, kitchens by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	3.26	1.15	0.054	×
6 room house	4 room house	5.84	1.04	0.000	✓
	5 room house	2.58	1.02	0.115	×
7 room house	4 room house	9.58	1.18	0.000	✓
	5 room house	6.33	1.15	0.000	✓
	6 room house	3.74	1.05	0.006	✓
8 room house	4 room house	13.67	1.18	0.000	✓
	5 room house	10.42	1.15	0.000	✓
	6 room house	7.83	1.05	0.000	✓
	7 room house	4.09	1.19	0.009	✓
9-9+ room house	4 room house	20.97	1.17	0.000	✓
	5 room house	17.71	1.14	0.000	✓
	6 room house	15.13	1.04	0.000	✓
	7 room house	11.39	1.17	0.000	✓
	8 room house	7.29	1.17	0.000	✓

Table A.7.1.30 Results of the post-hoc test to see the significant differences in the average floor area of all sanitary spaces by house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	Result
5 room house	4 room house	5.17	1.71	0.032	✓
6 room house	4 room house	9.94	1.55	0.000	✓
	5 room house	4.76	1.51	0.022	✓
7 room house	4 room house	18.46	1.76	0.000	✓
	5 room house	13.29	1.72	0.000	✓
	6 room house	8.52	1.57	0.000	✓
8 room house	4 room house	21.63	1.76	0.000	✓
	5 room house	16.46	1.72	0.000	✓
	6 room house	11.70	1.57	0.000	✓
	7 room house	3.17	1.77	0.470	×
9-9+ room house	4 room house	30.90	1.73	0.000	✓
	5 room house	25.72	1.70	0.000	✓
	6 room house	20.96	1.54	0.000	✓
	7 room house	12.43	1.75	0.000	✓
	8 room house	9.26	1.75	0.000	✓

Table A.7.1.31 Results of the post-hoc test to see the significant differences in the average floor area of all circulation spaces by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	1.92	1.15	0.553	×
6 room house	4 room house	2.59	1.05	0.138	×
	5 room house	0.67	1.02	0.987	×
7 room house	4 room house	6.33	1.19	0.000	✓
	5 room house	4.41	1.16	0.002	✓
	6 room house	3.74	1.06	0.006	✓
8 room house	4 room house	8.52	1.19	0.000	✓
	5 room house	6.59	1.16	0.000	✓
	6 room house	5.93	1.06	0.000	✓
	7 room house	2.19	1.19	0.447	×
9-9+ room house	4 room house	13.07	1.17	0.000	✓
	5 room house	11.15	1.15	0.000	✓
	6 room house	10.48	1.04	0.000	✓
	7 room house	6.74	1.18	0.000	✓
	8 room house	4.55	1.18	0.002	✓

Table A.7.1.32 Results of the post-hoc test to see how the average floor area of master bedrooms is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	1.26	0.75	0.537	×
6 room house	4 room house	1.60	0.68	0.183	×
	5 room house	0.34	0.64	0.995	×
7 room house	4 room house	3.44	0.77	0.000	✓
	5 room house	2.17	0.72	0.035	✓
	6 room house	1.84	0.66	0.064	×
8 room house	4 room house	4.05	0.77	0.000	✓
	5 room house	2.79	0.72	0.002	✓
	6 room house	2.46	0.66	0.003	✓
	7 room house	0.62	0.75	0.962	×
9-9+ room house	4 room house	5.98	0.76	0.000	✓
	5 room house	4.72	0.72	0.000	✓
	6 room house	4.38	0.65	0.000	✓
	7 room house	2.55	0.74	0.008	✓
	8 room house	1.93	0.74	0.096	×

Table A.7.1.33 Results of the post-hoc test to see how the average floor area of second bedrooms is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
6 room house	5 room house	0.64	0.93	0.958	×
7 room house	5 room house	2.24	0.97	0.146	×
	6 room house	1.60	0.55	0.034	✓
8 room house	5 room house	3.09	0.97	0.014	✓
	6 room house	2.45	0.55	0.000	✓
	7 room house	0.85	0.61	0.633	×
9-9+ room house	5 room house	4.36	0.96	0.000	✓
	6 room house	3.72	0.54	0.000	✓
	7 room house	2.13	0.61	0.005	✓
	8 room house	1.27	0.61	0.224	×

Table A.7.1.34 Results of the post-hoc test to see how the average floor area of third bedrooms is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
8 room house	7 room house	0.43	0.93	0.887	×
9-9+ room house	7 room house	1.92	0.79	0.047	✓
	8 room house	1.49	0.79	0.153	×

Table A.7.1.35 Results of the post-hoc test to see how the average floor area of fourth bedrooms is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	1.01	1.09	0.937	×
6 room house	4 room house	-0.12	1.19	1.000	×
	5 room house	-1.13	1.15	0.920	×
7 room house	4 room house	3.20	1.27	0.131	×
	5 room house	2.19	1.23	0.489	×
	6 room house	3.32	1.32	0.133	×
8 room house	4 room house	3.68	1.76	0.299	×
	5 room house	2.67	1.73	0.638	×
	6 room house	3.80	1.80	0.287	×
	7 room house	0.48	1.85	1.000	×
9-9+ room house	4 room house	7.10	1.89	0.004	✓
	5 room house	6.08	1.87	0.019	✓
	6 room house	7.22	1.93	0.004	✓
	7 room house	3.90	1.98	0.369	×
	8 room house	3.41	2.32	0.684	×

Table A.7.1.36 Results of the post-hoc test to see how the average floor area of kitchens is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	0.36	2.19	1.000	×
6 room house	4 room house	3.11	2.13	0.692	×
	5 room house	2.75	2.27	0.829	×
7 room house	4 room house	8.38	2.36	0.008	✓
	5 room house	8.02	2.48	0.021	✓
	6 room house	5.27	2.43	0.263	×
8 room house	4 room house	10.88	2.74	0.002	✓
	5 room house	10.52	2.85	0.005	✓
	6 room house	7.78	2.80	0.071	×
	7 room house	2.50	2.98	0.959	×
9-9+ room house	4 room house	7.78	2.86	0.082	×
	5 room house	7.42	2.96	0.135	×
	6 room house	4.67	2.92	0.600	×
	7 room house	-0.60	3.09	1.000	×
	8 room house	-3.11	3.39	0.941	×

Table A.7.1.37 Results of the post-hoc test to see how the average floor area of separate living rooms is different by house size (for all houses with at least one separate living room)

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	0.36	1.78	0.997	×
6 room house	4 room house	3.11	1.73	0.282	×
	5 room house	2.75	1.83	0.444	×
7 room house	4 room house	8.52	1.96	0.000	✓
	5 room house	8.16	2.06	0.001	✓
	6 room house	5.41	2.01	0.043	✓

Table A.7.1.38 Results of the post-hoc test to see how the average floor area of separate living rooms is different by house size (for all houses with only one separate living room)

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	5.634	8.547	0.986	×
6 room house	4 room house	14.148	8.003	0.490	×
	5 room house	8.514	4.288	0.357	×
7 room house	4 room house	18.459	8.357	0.241	×
	5 room house	12.825	4.917	0.103	×
	6 room house	4.310	3.894	0.878	×
8 room house	4 room house	18.288	8.107	0.220	×
	5 room house	12.654	4.479	0.060	×
	6 room house	4.140	3.324	0.813	×
	7 room house	-0.170	4.103	1.000	×
9-9+ room house	4 room house	26.864*	8.093	0.015	✓
	5 room house	21.230*	4.454	0.000	✓
	6 room house	12.715*	3.290	0.002	✓
	7 room house	8.405	4.076	0.314	×
	8 room house	8.575	3.536	0.156	×

Table A.7.1.39 Results of the post-hoc test to see how the average floor area of combined living room/dining room/kitchen is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	0.56	0.65	0.955	×
6 room house	4 room house	0.43	0.62	0.983	×
	5 room house	-0.13	0.40	0.999	×
7 room house	4 room house	1.99	0.67	0.040	✓
	5 room house	1.43	0.47	0.031	✓
	6 room house	1.56	0.43	0.005	✓
8 room house	4 room house	2.91	0.67	0.000	✓
	5 room house	2.36	0.47	0.000	✓
	6 room house	2.49	0.43	0.000	✓
	7 room house	0.93	0.50	0.426	×
9-9+ room house	4 room house	2.95	0.68	0.000	✓
	5 room house	2.39	0.49	0.000	✓
	6 room house	2.52	0.45	0.000	✓
	7 room house	0.96	0.52	0.433	×
	8 room house	0.03	0.52	1.000	×

Table A.7.1.40 Results of the post-hoc test to see how the average floor area of bathroom is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	-0.19	0.68	1.000	×
6 room house	4 room house	1.06	0.60	0.485	×
	5 room house	1.25	0.65	0.393	×
7 room house	4 room house	2.09	0.66	0.023	✓
	5 room house	2.28	0.71	0.020	✓
	6 room house	1.03	0.63	0.581	×
8 room house	4 room house	1.62	0.67	0.157	×
	5 room house	1.81	0.72	0.125	×
	6 room house	0.56	0.64	0.952	×
	7 room house	-0.47	0.70	0.985	×
9-9+ room house	4 room house	3.92	0.60	0.000	✓
	5 room house	4.12	0.66	0.000	✓
	6 room house	2.85	0.57	0.000	✓
	7 room house	1.83	0.64	0.052	✓
	8 room house	2.29	0.65	0.007	✓

Table A.7.1.41 Results of the post-hoc test to see how the average floor area of combined bathroom/toilet is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
6 room house	5 room house	0.91	1.12	0.927	×
7 room house	5 room house	1.50	1.12	0.667	×
	6 room house	0.60	0.58	0.843	×
8 room house	5 room house	2.46	1.10	0.173	×
	6 room house	1.55	0.54	0.035	✓
	7 room house	0.95	0.54	0.402	×
9-9+ room house	5 room house	4.44	1.09	0.001	✓
	6 room house	3.53	0.53	0.000	✓
	7 room house	2.93	0.53	0.000	✓
	8 room house	1.98	0.48	0.001	✓

Table A.7.1.42 Results of the post-hoc test to see how the average floor area of en-suite is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	0.10	0.30	0.999	×
6 room house	4 room house	0.25	0.29	0.952	×
	5 room house	0.15	0.18	0.957	×
7 room house	4 room house	0.56	0.30	0.420	×
	5 room house	0.46	0.19	0.167	×
	6 room house	0.31	0.17	0.491	×
8 room house	4 room house	1.15	0.30	0.002	✓
	5 room house	1.05	0.19	0.000	✓
	6 room house	0.90	0.18	0.000	✓
	7 room house	0.59	0.19	0.029	✓
9-9+ room house	4 room house	1.12	0.30	0.003	✓
	5 room house	1.02	0.19	0.000	✓
	6 room house	0.87	0.18	0.000	✓
	7 room house	0.56	0.19	0.040	✓
	8 room house	-0.03	0.19	1.000	×

Table A.7.1.43 Results of the post-hoc test to see how the average floor area of toilet is different by house size

House size group 1	House size group 2	Mean Difference (G1-G2)	Std. Error	Sig.	Result
5 room house	4 room house	-0.03	0.17	1.000	×
6 room house	4 room house	0.34	0.16	0.246	×
	5 room house	0.37	0.15	0.145	×
7 room house	4 room house	0.98	0.18	0.000	✓
	5 room house	1.01	0.17	0.000	✓
	6 room house	0.64	0.16	0.001	✓
8 room house	4 room house	1.58	0.18	0.000	✓
	5 room house	1.61	0.17	0.000	✓
	6 room house	1.24	0.16	0.000	✓
	7 room house	0.60	0.18	0.010	✓
9-9+ room house	4 room house	1.88	0.17	0.000	✓
	5 room house	1.91	0.17	0.000	✓
	6 room house	1.54	0.15	0.000	✓
	7 room house	0.90	0.17	0.000	✓
	8 room house	0.30	0.17	0.514	×

Table A.7.1.44 Results of the post-hoc test to see how the average floor area of garages is different by house size

Number of open plan houses in decade A	Number of open plan houses in decade B	Mean difference (A-B)	Std. Error	Sig.	Result
1940s and before	1950s	-0.41	0.09	0.000	✓
	1970s	-0.50	0.10	0.000	✓
	1980s	-0.51	0.12	0.001	✓
	1990s	-0.63	0.10	0.000	✓
	2000s and after	-0.79	0.09	0.000	✓
1950s	1970s	-0.09	0.08	0.852	×
	1980s	-0.10	0.10	0.916	×
	1990s	-0.22	0.07	0.035	✓
	2000s and after	-0.38	0.05	0.000	✓
1970s	1980s	-0.01	0.12	1.000	×
	1990s	-0.12	0.09	0.735	×
	2000s and after	-0.29	0.07	0.002	✓
1980s	1990s	-0.11	0.11	0.908	×
	2000s and after	-0.28	0.10	0.062	×
1990s	2000s and after	-0.16	0.07	0.156	×

Table A.7.1.45 Results of the post-hoc test to see the difference between the average number of open plan and cellular houses in different decades

Appendix 7.2: Full list of references for floor plan study

House code	Reference	Type of reference	Number of rooms
House 66	(Firth, 1949:71)	Book	3
House 232	(Chatsford Management Ltd., 2016a)	Website	3
House 238	(Chatsford Management Ltd., 2016g)	Website	3
House 239	(Chatsford Management Ltd., 2016h)	Website	3
House 240	(Masonic Villages Limited, 2016a)	Website	3
House 264	(Rosenfeld, 1951:72)	Book	3
House 272	(Rosenfeld, 1951:90)	Book	3
House 278	(Black Hut Ltd., 2016b)	Website	3
House 279	(Coastal Homes NZ Ltd., 2016b)	Website	3

Table A.7.2.1 References for 3 room houses

House code	Reference	Type of reference	Number of rooms
House 55	(Firth, 1949:32)	Book	4
House 60	(Firth, 1949:43)	Book	4
House 62	(Firth, 1949:59)	Book	4
House 63	(Firth, 1949:60)	Book	4
House 65	(Firth, 1949:68)	Book	4
House 69	(Firth, 1949:77)	Book	4
House 70	(Firth, 1949:78)	Book	4
House 122	(American houses Inc., 1954a)	Journal	4
House 128	(Ministry of Housing, 1956a)	Journal	4
House 151	(A. J. Hart Ltd., 1957a)	Journal	4
House 154	(Lindsay W. Johnson, 1956a)	Journal	4
House 194	(Donnithorne, 1982)	Journal	4
House 228	(Geniushomes, 2016d)	Website	4
House 229	(Geniushomes, 2016b)	Website	4
House 230	(Geniushomes, 2016c)	Website	4
House 231	(Kapiti Retirement Trust, 2016a)	Website	4
House 233	(Chatsford Management Ltd., 2016b)	Website	4
House 241	(Masonic Villages Limited, 2016b)	Website	4
House 260	(Rosenfeld, 1951:53)	Book	4
House 261	(Rosenfeld, 1951:55)	Book	4
House 262	(Rosenfeld, 1951:60)	Book	4
House 263	(Rosenfeld, 1951:61)	Book	4
House 265	(Rosenfeld, 1951:72)	Book	4
House 266	(Rosenfeld, 1951:83)	Book	4
House 267	(Rosenfeld, 1951:84)	Book	4
House 268	(Rosenfeld, 1951:85)	Book	4
House 269	(Rosenfeld, 1951:86)	Book	4
House 270	(Rosenfeld, 1951:88)	Book	4
House 271	(Rosenfeld, 1951:89)	Book	4
House 273	(Rosenfeld, 1951:104)	Book	4
House 274	(Rosenfeld, 1951:109)	Book	4
House 275	(Rosenfeld, 1951:114)	Book	4
House 276	(Rosenfeld, 1951:119)	Book	4
House 277	(Rosenfeld, 1951:121)	Book	4
House 280	(Coastal Homes NZ Ltd., 2016c)	Website	4
House 281	(Greenhaven Smart Homes NZ, 2016a)	Website	4
House 282	(Stone wood homes, 2016a)	Website	4
House 283	(Stone wood homes, 2016b)	Website	4
House 284	(Versatile homes & buildings, 2016d)	Website	4
House 285	(Versatile homes & buildings, 2016a)	Website	4
House 286	(Versatile homes & buildings, 2016c)	Website	4

Table A.7.2.2 References for 4 room houses

House code	Reference	Type of reference	Number of rooms
House 2	(Stewart, 1992:57)	Book	5
House 4	(Salmond, 1986:198-199)	Book	5
House 5	(Salmond, 1986:199)	Book	5
House 6	(Salmond, 1986:98)	Book	5
House 8	(Shaw et al., 2003:132)	Book	5
House 11	(Wood, 1993:8)	Book	5
House 37	(Cheetham & Bateman, 1991:2)	Book	5
House 40	(Toomath, 1996:126)	Book	5
House 41	(Toomath, 1996:139)	Book	5
House 56	(Firth, 1949:34)	Book	5
House 57	(Firth, 1949:36)	Book	5
House 59	(Firth, 1949:41)	Book	5
House 64	(Firth, 1949:66)	Book	5
House 67	(Firth, 1949:75)	Book	5
House 68	(Firth, 1949:77)	Book	5
House 71	(Cochran, 1980:68-69)	Book	5
House 90	(Navigation homes, 2014d)	Catalogue	5
House 114	(Pascoe, 1941b)	Journal	5
House 117	(Walker Packaged Homes Ltd., 1955)	Journal	5
House 118	(Bloomfield, 1955)	Journal	5
House 120	(Grierson, 1954)	Journal	5
House 123	(American houses Inc., 1954b)	Journal	5
House 125	(James Hardie & Coy. PTY. LTD., 1954)	Journal	5
House 126	(James Hardie & Coy. PTY. LTD., 1956b)	Journal	5
House 133	(James Hardie & Coy. PTY. LTD., 1955)	Journal	5
House 135	(Johnston, 1956)	Journal	5
House 136	(James Hardie & Coy. PTY. LTD., 1956a)	Journal	5
House 138	(McGowan & Sanderson, 1955b)	Journal	5
House 139	(McGowan & Sanderson, 1955c)	Journal	5
House 147	(Office of L. S. Piper, 1956)	Journal	5
House 149	(Brown, 1957b)	Journal	5
House 153	(Lindsay W. Johnson, 1956b)	Journal	5
House 155	(Gunter, 1958)	Journal	5
House 166	(King, 1959)	Journal	5
House 167	(Angus, 1959)	Journal	5
House 170	(Gleeson, 1976)	Journal	5
House 173	(Curlett, 1976b)	Journal	5
House 193	(Brian Elliott Associates, 1982)	Journal	5
House 220	(Heritage buildings & homes, 2016s)	Website	5
House 226	(Heritage buildings & homes, 2016t)	Website	5
House 227	(Heritage buildings & homes, 2016n)	Website	5
House 234	(Chatsford Management Ltd., 2016c)	Website	5
House 235	(Chatsford Management Ltd., 2016d)	Website	5
House 236	(Chatsford Management Ltd., 2016e)	Website	5
House 237	(Chatsford Management Ltd., 2016f)	Website	5

Table A.7.2.3 References for 5 room houses

House code	Reference	Type of reference	Number of rooms
House 1	(Stewart, 1992:38)	Book	6
House 9	(Shaw et al., 2003:162)	Book	6
House 10	(Shaw & Morrison, 1991:163)	Book	6
House 12	(Wood, 1993:10)	Book	6
House 13	(Wood, 1993:12)	Book	6
House 15	(Wood, 1993:16-17)	Book	6
House 36	(Cheetham & Bateman, 1991:1)	Book	6
House 39	(Toomath, 1996:159)	Book	6
House 43	(Toomath, 1996:159)	Book	6
House 44	(Willson, 1975:14)	Book	6
House 45	(Willson, 1975:17)	Book	6

House 46	(Willson, 1975:19)	Book	6
House 47	(Willson, 1975:20)	Book	6
House 48	(Willson, 1975:23)	Book	6
House 49	(Willson, 1975:24)	Book	6
House 50	(Willson, 1975:27)	Book	6
House 51	(Willson, 1975:28)	Book	6
House 52	(Willson, 1975:30)	Book	6
House 53	(Willson, 1975:33)	Book	6
House 54	(Willson, 1975:35)	Book	6
House 58	(Firth, 1949:38)	Book	6
House 61	(Firth, 1949:45)	Book	6
House 83	(Navigation homes, 2014s)	Catalogue	6
House 93	(Navigation homes, 2014g)	Catalogue	6
House 99	(Navigation homes, 2014w)	Catalogue	6
House 100	(Navigation homes, 2014x)	Catalogue	6
House 102	(Navigation homes, 2014z)	Catalogue	6
House 104	(Navigation homes, 2014ah)	Catalogue	6
House 109	(Navigation homes, 2014am)	Catalogue	6
House 119	(Bartlett & Bartlett, 1954)	Journal	6
House 121	(American houses Inc., 1954c)	Journal	6
House 124	(Bloomfield, 1954)	Journal	6
House 127	(Middleton, 1956)	Journal	6
House 129	(Ministry of Housing, 1956d)	Journal	6
House 130	(Ministry of Housing, 1956b)	Journal	6
House 131	(Ministry of Housing, 1956c)	Journal	6
House 137	(McGowan & Sanderson, 1955a)	Journal	6
House 140	(Middleton, 1955)	Journal	6
House 144	(Mark Brown & Fairbead, 1957)	Journal	6
House 146	(McCoy, 1956)	Journal	6
House 148	(Abbott Hole and Annabell, 1957)	Journal	6
House 152	(A. J. Hart Ltd., 1957b)	Journal	6
House 158	(Newman, 1958)	Journal	6
House 159	(D. E. Donnithorne, 1959)	Journal	6
House 160	(Iseke, 1959)	Journal	6
House 161	(Reynolds, 1959)	Journal	6
House 163	(Sanderson, 1959)	Journal	6
House 165	(Benson deK. Mason, 1958)	Journal	6
House 168	(Newman, 1959a)	Journal	6
House 169	(Newman, 1959b)	Journal	6
House 171	(Thorn, 1976)	Journal	6
House 172	(D. A. & Lillian, 1976)	Journal	6
House 174	(Curlett, 1976a)	Journal	6
House 175	(Curlett, 1976c)	Journal	6
House 176	(Pepper and Dixon, 1976)	Journal	6
House 179	(Sales, 1978)	Journal	6
House 180	(Ericksen & Quest, 1979b)	Journal	6
House 181	(Ericksen & Quest, 1979c)	Journal	6
House 182	(Ericksen & Quest, 1979a)	Journal	6
House 190	(Cook Hitchcock Sargisson, 1982)	Journal	6
House 203	(Heritage buildings & homes, 2016i)	Website	6
House 206	(Heritage buildings & homes, 2016u)	Website	6
House 208	(Heritage buildings & homes, 2016h)	Website	6
House 209	(Heritage buildings & homes, 2016a)	Website	6
House 210	(Heritage buildings & homes, 2016b)	Website	6
House 211	(Heritage buildings & homes, 2016v)	Website	6
House 215	(Heritage buildings & homes, 2016x)	Website	6
House 216	(Heritage buildings & homes, 2016y)	Website	6
House 221	(Heritage buildings & homes, 2016l)	Website	6
House 224	(Heritage buildings & homes, 2016g)	Website	6

Table A.7.2.4 References for 6 room houses

House code	Reference	Type of reference	Number of rooms
House 3	(Salmond, 1986:227)	Book	7
House 7	(Shaw et al., 2003:45)	Book	7
House 14	(Wood, 1993:14)	Book	7
House 17	(Wood, 1993:22-23)	Book	7
House 21	(Wood, 1993:30-31)	Book	7
House 27	(Wood, 1993:44-45)	Book	7
House 29	(Wood, 1993:50-51)	Book	7
House 32	(Wood, 1993:56-57)	Book	7
House 75	(Navigation homes, 2014ae)	Catalogue	7
House 86	(Navigation homes, 2014af)	Catalogue	7
House 91	(Navigation homes, 2014e)	Catalogue	7
House 103	(Navigation homes, 2014aa)	Catalogue	7
House 111	(Navigation homes, 2014ao)	Catalogue	7
House 113	(Johns & Meldrum, 1941)	Journal	7
House 115	(Pascoe, 1941a)	Journal	7
House 116	(Watkin, 1955)	Journal	7
House 132	(Allingham, 1955)	Journal	7
House 134	(Helmore & Cotterill, 1955)	Journal	7
House 141	(Pasco & Hall, 1956)	Journal	7
House 150	(Brown, 1957a)	Journal	7
House 156	(M. K. & R. F. Draffin, 1957)	Journal	7
House 162	(Pascoe, 1959)	Journal	7
House 164	(Ancber, 1958)	Journal	7
House 177	(Pepper and Dixon, 1977)	Journal	7
House 183	(William Pearson & Associates, 1979b)	Journal	7
House 187	(Walker, 1981)	Journal	7
House 195	(Certifiedplans, 2016h)	Website	7
House 196	(Certifiedplans, 2016f)	Website	7
House 197	(Certifiedplans, 2016d)	Website	7
House 198	(Certifiedplans, 2016i)	Website	7
House 202	(Certifiedplans, 2016c)	Website	7
House 204	(Heritage buildings & homes, 2016q)	Website	7
House 207	(Heritage buildings & homes, 2016p)	Website	7
House 212	(Heritage buildings & homes, 2016j)	Website	7
House 214	(Heritage buildings & homes, 2016c)	Website	7
House 217	(Heritage buildings & homes, 2016k)	Website	7
House 218	(Heritage buildings & homes, 2016z)	Website	7
House 219	(Heritage buildings & homes, 2016d)	Website	7
House 222	(Heritage buildings & homes, 2016e)	Website	7
House 225	(Heritage buildings & homes, 2016m)	Website	7

Table A.7.2.5 References for 7 room houses

House code	Reference	Type of reference	Number of rooms
House 16	(Wood, 1993:18-19)	Book	8
House 18	(Wood, 1993:24)	Book	8
House 19	(Wood, 1993:26)	Book	8
House 20	(Wood, 1993:28)	Book	8
House 24	(Wood, 1993:38)	Book	8
House 25	(Wood, 1993:40-41)	Book	8
House 26	(Wood, 1993:42-43)	Book	8
House 28	(Wood, 1993:46-47)	Book	8
House 72	(Navigation homes, 2014ab)	Catalogue	8
House 74	(Navigation homes, 2014ad)	Catalogue	8
House 76	(Navigation homes, 2014l)	Catalogue	8
House 77	(Navigation homes, 2014m)	Catalogue	8
House 78	(Navigation homes, 2014n)	Catalogue	8
House 79	(Navigation homes, 2014o)	Catalogue	8

House 80	(Navigation homes, 2014p)	Catalogue	8
House 81	(Navigation homes, 2014q)	Catalogue	8
House 85	(Navigation homes, 2014u)	Catalogue	8
House 88	(Navigation homes, 2014b)	Catalogue	8
House 89	(Navigation homes, 2014c)	Catalogue	8
House 92	(Navigation homes, 2014f)	Catalogue	8
House 94	(Navigation homes, 2014h)	Catalogue	8
House 95	(Navigation homes, 2014i)	Catalogue	8
House 96	(Navigation homes, 2014j)	Catalogue	8
House 97	(Navigation homes, 2014k)	Catalogue	8
House 98	(Navigation homes, 2014v)	Catalogue	8
House 101	(Navigation homes, 2014y)	Catalogue	8
House 105	(Navigation homes, 2014ai)	Catalogue	8
House 107	(Navigation homes, 2014ak)	Catalogue	8
House 108	(Navigation homes, 2014al)	Catalogue	8
House 110	(Navigation homes, 2014an)	Catalogue	8
House 143	(King Cook and Dawson, 1957)	Journal	8
House 145	(Miller White & Dunn, 1956)	Journal	8
House 157	(Bowman, 1957)	Journal	8
House 185	(Glossop, 1979)	Journal	8
House 188	(Denniston and Hodgson, 1981)	Journal	8
House 189	(Chrystall, 1982)	Journal	8
House 191	(Blair, 1982)	Journal	8
House 223	(Heritage buildings & homes, 2016f)	Website	8
House 244	(House plans, 2016b)	Website	8
House 287	(Versatile homes & buildings, 2016b)	Website	8

Table A.7.2.6 References for 8 room houses

House code	Reference	Type of reference	Number of rooms
House 22	(Wood, 1993:32-33)	Book	9
House 30	(Wood, 1993:52-53)	Book	9
House 33	(Wood, 1993:58-59)	Book	9
House 73	(Navigation homes, 2014ac)	Catalogue	9
House 82	(Navigation homes, 2014r)	Catalogue	9
House 87	(Navigation homes, 2014ag)	Catalogue	9
House 112	(Johns, 1938)	Journal	9
House 178	(Sutherland, 1977)	Journal	9
House 186	(Mitchell, 1980)	Journal	9
House 192	(Moller, 1982)	Journal	9
House 199	(Certifiedplans, 2016e)	Website	9
House 200	(Certifiedplans, 2016g)	Website	9
House 201	(Certifiedplans, 2016b)	Website	9
House 213	(Heritage buildings & homes, 2016w)	Website	9
House 245	(Platinumhomes, 2016l)	Website	9
House 247	(Platinumhomes, 2016q)	Website	9
House 249	(Platinumhomes, 2016e)	Website	9
House 250	(Platinumhomes, 2016f)	Website	9
House 253	(Platinumhomes, 2016j)	Website	9
House 255	(Platinumhomes, 2016k)	Website	9
House 256	(Platinumhomes, 2016d)	Website	9
House 257	(Platinumhomes, 2016m)	Website	9
House 259	(Platinumhomes, 2016g)	Website	9
House 23	(Wood, 1993:36-37)	Book	10
House 31	(Wood, 1993:54-55)	Book	10
House 38	(Platinumhomes, 2016p)	Website	10
House 42	(Toomath, 1996:105)	Book	10
House 106	(Navigation homes, 2014aj)	Catalogue	10
House 142	(Vautier Murray Associates, 1956)	Journal	10

House 248	(Platinumhomes, 2016c)	Website	10
House 252	(Platinumhomes, 2016i)	Website	10
House 258	(Platinumhomes, 2016a)	Website	10
House 34	(Wood, 1993:60-61)	Book	11
House 35	(Wood, 1993:62-63)	Book	11
House 84	(Navigation homes, 2014t)	Catalogue	11
House 184	(William Pearson & Associates, 1979a)	Journal	11
House 205	(Heritage buildings & homes, 2016r)	Website	11
House 242	(House plans, 2016c)	Website	11
House 243	(House plans, 2016a)	Website	11
House 251	(Platinumhomes, 2016h)	Website	11
House 254	(Platinumhomes, 2016o)	Website	12
House 246	(Platinumhomes, 2016n)	Website	13

Table A.7.2.7 References for 9-9+ room houses

Appendix 10.1: Price of furniture items, appliances and tools in New Zealand

Furniture, appliances and tool item	Price in New Zealand market (NZ$)			Useful life	Reference for useful life
	Median price	Minimum price	Maximum price		
King/Queen/Double bed frame	739	149	1999	25	B
Double mattress	479	129	1999	10	Estimated
Single bed frame	279	95	1800	25	B
Single mattress	450	75	1379	10	Estimated
Bunk bed frame	635	299	1597	25	B
Two Single mattresses for bunk	900	150	2758	10	Estimated
Cot	899	699	1299	25	B
Mattress for cot	169	40	299	10	Estimated
Desk	280	79	1169	15.5	N
Wardrobe	931	179	1989	25	
Desk chair	150	79	859	12.5	N
Free standing rack	50	24	119	5	Estimated
Chest of drawers/Dressing table	500	199	1699	25	B
Free standing mirror	150	49	499	25	
Shelf/Book case	320	35	1299	25	B
Bedside table/cabinet	170	49	529	25	B
Piano	4750	1599	33495	100	Estimated (N×4)
4-seater dining suite/table with chairs	590	231	2285	25	B
6-seater dining suite/table with chairs	1198	377	3953	25	B
8-seater dining suite/table with chairs	1961	933	4871	25	B
12-seater dining suite/table with chairs	2317	1065	6307	25	B
Armchair	749	169	1999	25	B
2-seater couch/sofa	951	249	2199	25	B
3-seater couch/sofa	1080	286	2699	25	B
4-seater couch/sofa	1080	286	2699	25	B
Side table	140	29	599	25	B
Coffee table	364	69	1089	25	B
Chair (other than desk/dining table chair)	102	27	1099	25	B
Chaise longue	874	619	1299	25	B
Stool	75	15	229	25	B
TV cabinet	599	149	1899	25	B
Ornamental sculptures/Vases	89	10	1650	30	Estimated
Buffet/Sideboard	1150	499	2999	25	B
Entertainment unit	589	149	1899	25	B
Display cabinet/unit	700	279	2549	25	B
Rug	699	60	10672	15	Estimated
Chest	315	139	950	25	B
Ottoman/Footstool	364	55	1299	25	B
Floor lamp/Standard lamp	249	70	349	20	Estimated
Wall clock	32	4	249	10	N
Bench	235	55	799	20	N
Beanbags	110	80	120	10	Estimated
Ironing board	80	35	210	10	Estimated
Cathode-ray TV	500	NA	NA	10	A and D
LCD/LED TV	1698	169	29230	10	A and D
Plasma TV	2799	599	15000	10	A and D
Fridge/Freezer	1749	699	8999	15	C
Fridge	1299	597	2399	13	Estimated
Bar fridge	450	217	799	13	Estimated
Freezer/Chest freezer	1200	337	2599	11	I and L
Dishwasher	1300	498	2847	12	D and F
Cook-top/Hob	1500	500	5774	17	K
Oven	2199	799	8649	15	A

Stove/Range	2199	799	8649	15	A, B, C, E and H
Washing machine	1299	599	3499	12	E, F, H, I and K
Dryer	975	347	2795	14	F
Treadmill	1449	399	10999	10	Estimated (N×2)
Exercise/weight machine	549	64	3099	25	Estimated (N×2)
Exercise cycles	847	119	6306	25	Estimated
Table tennis table	600	149	1150	25	Estimated (N×2)
Billiard table	16761	9010	54073	50	Estimated (N×4)
Pool table	4613	1820	6210	50	Estimated (N×4)
Outdoor chair/couch	166	66	907	10	Estimated
Drying/Airing rack	30	8	100	8	Estimated
Spa pool	9499	4999	13999	12.5	N
BBQ	679	99	2000	10	Estimated
Outdoor umbrella/Gazebo	298	80	1199	10	Estimated
Outdoor dining/Picnic table	238	99	1099	10	Estimated
Outdoor coffee table	82	39	349	10	Estimated
Swing seat/Hammock	250	54	3659	10	Estimated
Sun lounger/Deck recliner chair	219	100	400	10	Estimated
Trampoline	314	79	897	8	N
Climbing frame	463	60	950	20	Estimated
Slide	240	39	850	20	Estimated
Swing	109	15	1700	20	Estimated
Sand box	175	42	675	6	M
Paddling pool	29	20	90	6	M
Play house	990	480	2500	12.5	N
Lawn mower	549	99	2400	8	Estimated (N×2)
Leaf blower	199	49	689	10	M
Hedge trimmer	178	55	439	10	M
Weed eater	234	35	789	10	M
Chipper	999	189	2499	10	M
Work bench	75	25	499	10	Estimated
Water blaster	544	138	2650	10	M
Chain saw	279	99	749	10	M
Drop saw	399	109	1499	10	M
Drill	248	29	839	10	M
Outdoor heater	249	32	889	10	Estimated
Sewing machine	299	230	599	32	Estimated (N×4)
Projector	495	86	3499	8	N
Microwave	328	65	1000	9	H, I, L and M
Blender/mixer	169	15	1485	8	N
Sandwich maker	69	10	170	8	N
Slow cooker/Rice cooker	100	15	330	8	N
Electric frying pan	109	60	250	8	N
Electric deep fryer	175	30	369	8	N
Bread maker	279	119	390	8	N
Juicer	270	99	429	8	N
Popcorn maker	60	30	120	8	N
Coffee maker	255	90	2199	8	N
Ice cream maker	120	80	500	8	N
Food processor	280	64	2299	8	N
Toaster	150	10	300	8	A
Waffle iron	115	60	748	8	N
Electric jug	130	10	300	8	A
Water cooler	749	550	890	8	N
Iron	129	10	499	8	A
Hair dryer	69	20	259	8	N
Hair straighter/Hair curler	79	20	200	8	N
Electric blanket	140	20	569	3	N
Vacuum cleaner	410	60	1749	9	M
Steam cleaner	169	70	299	8	N

Stereo	279	88	897	11	M
Games Console	545	209	650	6	Estimated (N×2)
DVD/Blu-Ray player	145	34	1199	10	A and M
Laptop	1589	229	5799	4	N
Desktop computer	1499	738	3679	5	A
Combined printer-scanner-fax	200	48	2000	5	Estimated
Combined printer-scanner	200	48	2000	5	Estimated
Scanner	200	180	499	8	N
Printer	315	99	1493	5	N
Fax	125	40	300	10	M
Electric bar heater	100	26	239	20	B and D
Gas heater	1224	899	2899	10	Estimated (N×2)
Electric oil filled radiator	180	30	380	10	Estimated (N×2)
Heat pump	2650	1680	4997	16	E and L
Convector heater	179	19	800	20	B and D
Wood burner/Pellet burner	2300	1150	5995	30	Estimated
Dehumidifier	549	30	850	8	H, I and L
Fan	100	10	272	15.5	N

Table A.10.1.1 Estimated NZ median market price, minimum/maximum price and useful life (years) for investigated furniture, appliance and tool items

A: Mithraratne et al. (2007) B: Fay (1999) C: Blanchard and Reppe (1998)
D: FannieMae (2014) E: Fiol (2013) F: Mr. Appliance (2016)
G: Statista (2011) H: InterNACHI (2016) I: Brown (2011)
J: Welch and Rogers (2010) K: Demesne (2010) L: Seiders et al. (2007)
M: Cooper (2004) N: New Zealand Inland Revenue (2015)

Appendix 10.2: The average number of various furniture, appliance and tool items per household and per person

Furniture, appliances and tool item	Average per household	Average per person	Sample with at least one
King/Queen/Double bed	1.84	0.74	98.5%
Single bed	0.87	0.35	57.3%
Bunk bed	0.14	0.06	12.3%
Cot	0.18	0.07	17.7%
Desk	1.58	0.63	82.7%
Wardrobe	0.35	0.14	11.5%
Desk chair	1.47	0.59	80.4%
Free standing rack	0.23	0.09	15.0%
Chest of drawers/Dressing table	2.91	1.17	93.5%
Free standing mirror	0.51	0.20	33.1%
Shelves/Book case	3.16	1.27	89.6%
Bedside table/cabinet	2.60	1.04	89.6%
Piano	0.19	0.08	18.8%
4 seater dining suite/table with chairs	0.38	0.15	36.5%
6 seater dining suite/table with chairs	0.52	0.21	51.2%
8 seater dining suite/table with chairs	0.13	0.05	12.7%
12 seater dining suite/table with chairs	0.03	0.01	2.7%
Armchair	1.75	0.70	73.1%
Double seater Couch/Sofa	0.95	0.38	65.0%
Three seater Couch/Sofa	1.01	0.41	74.6%
Four seater Couch/Sofa	0.18	0.07	15.0%
Side table	1.14	0.46	54.2%
Coffee table	1.12	0.45	77.7%
Chair (other than desk/dining table chair)	1.05	0.42	44.2%
Chaise longue	0.12	0.05	9.5%
Stool	1.21	0.49	52.7%
TV cabinet	0.60	0.24	53.8%
Ornamental sculptures/Vases	0.35	0.14	16.2%
Buffet/Sideboard	0.73	0.29	55.4%
Entertainment unit	0.38	0.15	31.5%
Display cabinet/unit	0.47	0.19	33.5%
Rug	1.65	0.66	63.1%
Chest	0.57	0.23	42.7%
Ottoman/Footstool	0.62	0.25	43.1%
Floor lamp/Standard lamp	1.23	0.49	66.5%
Wall clock	1.06	0.43	60.8%
Bench	0.48	0.19	31.9%
Beanbags	0.02	0.01	1.2%
Ironing board	0.91	0.37	87.3%
LCD/LED TV	1.22	0.49	78.8%
Plasma TV	0.24	0.10	19.2%
Cathode ray TV	0.08	0.03	6.9%
Fridge/Freezer	1.07	0.43	92.3%
Fridge	0.15	0.06	13.5%
Bar fridge	0.08	0.03	8.1%
Freezer/Chest freezer	0.40	0.16	38.1%
Dishwasher	0.82	0.33	79.2%
Cook-top/Hob	0.63	0.25	61.5%
Oven	0.77	0.31	71.5%
Stove/Range	0.43	0.17	41.2%
Washing machine	0.99	0.40	98.1%
Dryer	0.74	0.30	73.1%
Treadmill	0.10	0.04	10.0%
Exercise/weight machine	0.05	0.02	4.6%
Exercise cycles	0.13	0.05	12.3%
Table tennis table	0.02	0.01	2.3%

Billiard table	0.01	0.00	0.8%
Pool table	0.03	0.01	2.7%
Outdoor chair/couch	3.50	1.41	66.2%
Drying/Airing rack	1.30	0.52	81.5%
Spa pool	0.06	0.02	5.8%
BBQ	0.79	0.32	71.5%
Outdoor umbrella/Gazebo	0.54	0.22	45.4%
Outdoor dining/Picnic table	0.91	0.37	73.1%
Outdoor coffee table	0.13	0.05	13.1%
Swing seat/Hammock	0.19	0.08	15.8%
Sun lounger/Deck recliner chair	0.32	0.13	19.6%
Trampoline	0.17	0.07	16.9%
Climbing frame	0.02	0.01	1.9%
Slide	0.08	0.03	7.7%
Swing	0.12	0.05	10.4%
Sand box	0.07	0.03	6.9%
Paddling pool	0.16	0.06	15.0%
Play house	0.09	0.04	8.5%
Lawn mower	0.72	0.29	64.6%
Leaf blower	0.21	0.08	18.8%
Hedge trimmer	0.28	0.11	26.5%
Weed eater	0.63	0.25	60.0%
Chipper	0.12	0.05	12.3%
Work bench	0.62	0.25	55.8%
Water blaster	0.37	0.15	26.2%
Chain saw	0.41	0.16	34.6%
Drop saw	0.25	0.10	23.1%
Drill	1.12	0.45	83.1%
Outdoor heater	0.02	0.01	0.8%
Sewing machine	0.70	0.28	58.8%
Microwave	0.92	0.37	88.8%
Blender/mixer	1.05	0.42	87.3%
Sandwich maker	0.73	0.29	68.5%
Slow cooker/Rice cooker	0.76	0.31	61.5%
Electric frying pan	0.35	0.14	33.5%
Electric deep fryer	0.12	0.05	11.5%
Bread maker	0.37	0.15	35.8%
Juicer	0.33	0.13	32.7%
Popcorn maker	0.19	0.08	19.2%
Coffee maker	0.40	0.16	35.4%
Ice cream maker	0.14	0.06	12.3%
Food processor	0.64	0.26	61.9%
Toaster	0.99	0.40	93.8%
Waffle iron	0.20	0.08	19.2%
Electric jug	1.00	0.40	92.3%
Water cooler	0.03	0.01	2.7%
Iron	0.97	0.39	89.6%
Hair dryer	0.98	0.39	80.8%
Hair straighter/Hair curler	0.53	0.21	45.4%
Electric blanket	1.10	0.44	57.3%
Vacuum cleaner	1.15	0.46	95.4%
Steam cleaner	0.19	0.08	18.5%
Stereo	1.05	0.42	76.2%
Games Console	0.54	0.22	33.1%
DVD/Blu-Ray player	0.77	0.31	57.7%
Laptop	1.50	0.60	87.3%
Desktop computer	0.73	0.29	56.9%
Combined printer-scanner-fax	0.31	0.12	28.8%
Combined printer-scanner	0.38	0.15	35.4%
Scanner	0.09	0.04	8.1%

Printer	0.27	0.11	24.2%
Fax	0.03	0.01	3.1%
Electric bar heater	0.25	0.10	18.1%
Gas heater	0.27	0.11	11.2%
Electric oil filled radiator	0.73	0.29	41.9%
Heat pump	0.58	0.23	46.2%
Convertor heater	0.22	0.09	15.0%
Wood burner/Pellet burner	0.33	0.13	31.5%
Dehumidifier	0.30	0.12	27.3%
Fan	0.41	0.16	24.2%
Car	1.55	0.62	95.0%
Boat	0.08	0.03	5.8%
Motorcycle/Scooter	0.17	0.07	13.1%
Bike	1.62	0.65	60.8%
Kayak	0.04	0.02	1.9%
Total number of sleeping spaces	4.83	1.94	99.6%
Total number seats in a couch or sofa	7.40	2.97	99.2%
Total number of seats in a dining table	5.98	2.40	94.6%
Total number of TVs	1.55	0.62	92.3%
Total number of fridges	1.30	0.52	99.2%

Table A.10.2.1 Average number per person and per household for all investigated furniture, appliances and tools and percentage of houses with at least 1 item of each

Appendix 10.3: Post-hoc test results for Chapter 10

Dependent Variable	Group A	Group B	Mean Difference (A-B)	Std. Error	Sig.
Bedroom/Study furniture	Single person	Couple	-3.14	1.09	0.023
		Couple with 1 child	-4.31	1.18	0.002
		Couple with 2 children	-5.96	1.21	0.000
	Couple	Couple with 1 child	-1.17	1.00	0.652
		Couple with 2 children	-2.82	1.04	0.036
	Couple with 1 child	Couple with 2 children	-1.66	1.13	0.460
Livingroom/Dining room/Kitchen furniture	Single person	Couple	-3.64	1.66	0.128
		Couple with 1 child	-3.08	1.79	0.316
		Couple with 2 children	-0.32	1.84	0.998
	Couple	Couple with 1 child	0.56	1.52	0.983
		Couple with 2 children	3.32	1.58	0.155
	Couple with 1 child	Couple with 2 children	2.76	1.72	0.377
Large appliances	Single person	Couple	-1.28	0.42	0.013
		Couple with 1 child	-2.01	0.45	0.000
		Couple with 2 children	-1.74	0.46	0.001
	Couple	Couple with 1 child	-0.73	0.38	0.228
		Couple with 2 children	-0.47	0.40	0.646
	Couple with 1 child	Couple with 2 children	0.27	0.43	0.927
Gaming/Exercise furniture/equipment	Single person	Couple	-0.21	0.12	0.290
		Couple with 1 child	-0.13	0.13	0.741
		Couple with 2 children	-0.19	0.13	0.484
	Couple	Couple with 1 child	0.08	0.11	0.882
		Couple with 2 children	0.02	0.11	0.997
	Couple with 1 child	Couple with 2 children	-0.06	0.12	0.966
Outdoor furniture/appliances /tools	Single person	Couple	-3.10	1.31	0.087
		Couple with 1 child	-6.01	1.42	0.000
		Couple with 2 children	-5.07	1.45	0.003
	Couple	Couple with 1 child	-2.91	1.21	0.077
		Couple with 2 children	-1.96	1.25	0.398
	Couple with 1 child	Couple with 2 children	0.95	1.36	0.897
Small appliances	Single person	Couple	-4.14	1.33	0.011
		Couple with 1 child	-4.63	1.44	0.008
		Couple with 2 children	-6.04	1.48	0.000
	Couple	Couple with 1 child	-0.49	1.22	0.978
		Couple with 2 children	-1.90	1.27	0.442
	Couple with 1 child	Couple with 2 children	-1.41	1.38	0.738
Heating/Ventilation appliances	Single person	Couple	-0.41	0.36	0.660
		Couple with 1 child	-0.51	0.39	0.542
		Couple with 2 children	-0.52	0.40	0.548
	Couple	Couple with 1 child	-0.10	0.33	0.989
		Couple with 2 children	-0.11	0.34	0.987
	Couple with 1 child	Couple with 2 children	-0.01	0.37	1.000
Vehicles	Single person	Couple	-0.52	0.39	0.545
		Couple with 1 child	-1.26	0.42	0.015
		Couple with 2 children	-3.03	0.43	0.000
	Couple	Couple with 1 child	-0.74	0.36	0.160
		Couple with 2 children	-2.51	0.37	0.000
	Couple with 1 child	Couple with 2 children	-1.77	0.40	0.000

Table A.10.3.1 The post-hoc test results for the correlation between the average number of furniture, appliances and tools in 8 categories and household size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
≤5 rooms	6 rooms	-15.81	4.85	0.011	-29.14	-2.47
	7 rooms	-27.48	5.07	0.000	-41.39	-13.56
	8 rooms	-38.69	5.70	0.000	-54.34	-23.04
	9-9+ rooms	-43.51	4.94	0.000	-57.09	-29.93
6 rooms	7 rooms	-11.67	4.45	0.070	-23.90	0.56
	8 rooms	-22.88	5.16	0.000	-37.05	-8.71
	9-9+ rooms	-27.71	4.31	0.000	-39.55	-15.86
7 rooms	8 rooms	-11.21	5.36	0.226	-25.93	3.50
	9-9+ rooms	-16.04	4.55	0.005	-28.53	-3.54
8 rooms	9-9+ rooms	-4.82	5.24	0.889	-19.22	9.57

Table A.10.3.2 The post-hoc test results for the correlation between the average number of furniture, appliances and tools and house size

Dependent Variable	Category A	Category B	Mean Difference (A-B)	Std. Error	Sig.
Bedroom/Study furniture	6 rooms	≤5 rooms	4.34	1.07	0.001
	7 rooms	≤5 rooms	6.22	1.12	0.000
		6 rooms	1.88	0.98	0.309
	8 rooms	≤5 rooms	8.73	1.25	0.000
		6 rooms	4.40	1.14	0.001
		7 rooms	2.51	1.18	0.210
	9-9+ rooms	≤5 rooms	10.60	1.09	0.000
		6 rooms	6.26	0.95	0.000
		7 rooms	4.38	1.00	0.000
		8 rooms	1.87	1.15	0.488
Livingroom/Dining room/Kitchen furniture	6 rooms	≤5 rooms	2.04	1.70	0.752
	7 rooms	≤5 rooms	3.87	1.78	0.192
		6 rooms	1.83	1.56	0.769
	8 rooms	≤5 rooms	8.47	2.00	0.000
		6 rooms	6.43	1.81	0.004
		7 rooms	4.60	1.88	0.107
	9-9+ rooms	≤5 rooms	10.61	1.74	0.000
		6 rooms	8.57	1.51	0.000
		7 rooms	6.74	1.60	0.000
		8 rooms	2.14	1.84	0.772
Large appliances	6 rooms	≤5 rooms	1.33	0.44	0.023
	7 rooms	≤5 rooms	2.19	0.46	0.000
		6 rooms	0.86	0.41	0.217
	8 rooms	≤5 rooms	2.39	0.52	0.000
		6 rooms	1.06	0.47	0.163
		7 rooms	0.20	0.49	0.994
	9-9+ rooms	≤5 rooms	3.07	0.45	0.000
		6 rooms	1.73	0.39	0.000
		7 rooms	0.88	0.41	0.215
		8 rooms	0.68	0.48	0.617
Gaming/Exercise furniture/equipment	6 rooms	≤5 rooms	0.23	0.13	0.424
	7 rooms	≤5 rooms	0.28	0.14	0.236
		6 rooms	0.06	0.12	0.989
	8 rooms	≤5 rooms	0.28	0.15	0.349
		6 rooms	0.06	0.14	0.993
		7 rooms	0.00	0.15	1.000
	9-9+ rooms	≤5 rooms	0.34	0.13	0.088
		6 rooms	0.11	0.12	0.873
		7 rooms	0.05	0.12	0.992
		8 rooms	0.05	0.14	0.996
Outdoor furniture/appliances/tools	6 rooms	≤5 rooms	3.12	1.41	0.177
	7 rooms	≤5 rooms	6.25	1.47	0.000

		6 rooms	3.14	1.29	0.111
	8 rooms	≤5 rooms	8.68	1.65	0.000
		6 rooms	5.56	1.50	0.002
		7 rooms	2.42	1.55	0.524
	9-9+ rooms	≤5 rooms	7.47	1.43	0.000
		6 rooms	4.35	1.25	0.005
		7 rooms	1.21	1.32	0.889
		8 rooms	-1.21	1.52	0.931
Small appliances	6 rooms	≤5 rooms	2.77	1.46	0.321
	7 rooms	≤5 rooms	5.36	1.52	0.005
		6 rooms	2.59	1.34	0.304
	8 rooms	≤5 rooms	5.40	1.71	0.015
		6 rooms	2.63	1.55	0.438
		7 rooms	0.05	1.61	1.000
	9-9+ rooms	≤5 rooms	7.21	1.49	0.000
		6 rooms	4.44	1.30	0.006
		7 rooms	1.85	1.37	0.658
		8 rooms	1.80	1.58	0.782
Heating/Ventilation appliances	6 rooms	≤5 rooms	0.60	0.38	0.519
	7 rooms	≤5 rooms	1.16	0.40	0.033
		6 rooms	0.56	0.35	0.509
	8 rooms	≤5 rooms	1.74	0.45	0.001
		6 rooms	1.13	0.41	0.047
		7 rooms	0.57	0.42	0.660
	9-9+ rooms	≤5 rooms	1.32	0.39	0.008
		6 rooms	0.72	0.34	0.223
		7 rooms	0.16	0.36	0.992
		8 rooms	-0.41	0.42	0.856
Vehicles	6 rooms	≤5 rooms	1.32	0.46	0.039
	7 rooms	≤5 rooms	1.28	0.48	0.066
		6 rooms	-0.04	0.43	1.000
	8 rooms	≤5 rooms	2.26	0.54	0.000
		6 rooms	0.94	0.49	0.315
		7 rooms	0.98	0.51	0.310
	9-9+ rooms	≤5 rooms	1.77	0.47	0.002
		6 rooms	0.45	0.41	0.816
		7 rooms	0.49	0.43	0.796
		8 rooms	-0.50	0.50	0.860

Table A.10.3.3 The post-hoc test results for the correlation between the average number of furniture, appliances and tools in 8 categories and house size

House size category A	House size category B	Mean Difference (A-B)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
≤5 rooms	6 rooms	-67.46	22.48	0.024	-129.22	-5.71
	7 rooms	-131.86	23.46	0.000	-196.31	-67.42
	8 rooms	-168.13	26.37	0.000	-240.57	-95.68
	9-9+ rooms	-211.12	22.88	0.000	-273.99	-148.25
6 rooms	7 rooms	-64.40	20.62	0.017	-121.04	-7.75
	8 rooms	-100.66	23.88	0.000	-166.27	-35.06
	9-9+ rooms	-143.66	19.96	0.000	-198.50	-88.81
7 rooms	8 rooms	-36.26	24.80	0.588	-104.40	31.88
	9-9+ rooms	-79.26	21.06	0.002	-137.12	-21.41
8 rooms	9-9+ rooms	-43.00	24.26	0.392	-109.65	23.66

Table A.10.3.4 Results of the post-hoc test comparing the average initial embodied energy of furniture, appliances and tools with house size