Programme Area: Smart Systems and Heat

Project: WP1 Consumer Insights

Title: Exploratory Data Analysis for ETI

Abstract:

This analysis evaluated a number of questions posed by the Smart Systems and Heat team and used the data from the CRaB Project to explore whether there were relationships between factors. For example whether there was a relationship between house type and form of water heating.

Context:

This project will provide insights into consumer behaviour relating to heat decisions. The project will be made up of four small pieces of consultancy work looking at specific issues:
 - Consumer Response & Behavious Analysis
 - Literature Review Personality and Risky Heat Decisions
 - Household Heating Design Aids
 - Segmentation Analysis

Exploratory Data Analysis for ETI

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Contents

1.0   Interpretation of Statistical tests

Using statistical tests for exploratory analysis is generally discouraged because the analyst normally only tests data when there appears to be a relationship between the variables being examined. By doing this, the chances of finding a significant effect are inflated.

However, I consider that they can assist in deciding whether it would be worthwhile to conduct further research into an aspect of the data provided they are interpreted cautiously. Hence I have occasionally carried out some testing on these data. I recommend interpreting a significant statistical test from this analysis as indicating that there may be a relationship between the variables being tested.

To confirm whether the effect exists or if it is just a random feature of this particular survey, another data set containing the variables of interest needs to be acquired and tested. This could either be as a result of primary data collection or secondary analysis could be carried out of an existing dataset.

Since the statistical tests in this analysis can only be interpreted as indicating a possible relationship between variables, I have not carried them out when I think the data clearly show a potential relationship (or clearly do not demonstrate one).

The tests that I have occasionally carried out during this analysis were all gamma tests. These tests evaluate the strength of the relationship between two ordinal variables (variables which have an intrinsic order). The Gamma test statistic will have a value between -1 and +1. If the gamma statistic is positive, it means that as one variable increases, so does the other. If the gamma statistic is negative, it means that as one variable increases, the other decreases (If the gamma statistic is 0, it indicates that there is no relationship between the two variables being tested).

2.0 Organising the data

2.1 Characterize the different socio groups, for example, singles, couples, families with teenage or adult children.

2.1.1 Basic Household types

Type of household	Frequency	Percent	Valid Percent	Cumulative Percent
Household with children under school age	174	7.6	7.6	7.6
Household with children started or completed school	538	23.5	23.5	31.1
Households with no children and all adults over 60	828	36.2	36.2	67.3
Households with no children and at least one adult under 60	747	32.7	32.7	100.0
Total	2287	100.0	100.0	

2.1.2 Expanded Household types

NB due to low numbers the final 2 categories (3 or more adults some under 60 some over and 3 or more adults all over 60) will be amalgamated into a single category (3 or more adults at least one over 60).

Type of household		Frequency	Percent	Valid Percent	Cumulative Percent
	Household with children under school age	174	7.6	7.7	7.7
	household with children started or completed school	537	23.5	23.7	31.4
	Single adult under 60	193	8.4	8.5	39.9
	Single adult over 60	428	18.7	18.9	58.8
	2 adults both under 60	211	9.2	9.3	68.2
	2 adults one over 60	104	4.5	4.6	72.7
	2 adults, both over 60	395	17.3	17.4	90.2
	3 or more adults all under 60	141	6.2	6.2	96.4
	3 or more adults some under 60, some over	77	3.4	3.4	99.8
	3 or more adults all over 60	4	.2	.2	100.0
	Total	2264	99.0	100.0	
Missing	Not known	23	1.0		
Total		2287	100.0		

2.1.3 Ages of children in households with children

Age of children in HH	Household type					
	Household with children under school age		household with children start or completed school		Total	
	Count	%	Count	%	Count	%
Under 5yrs only	171	98.3	0	.0	171	24.1
0 to 11 yrs	0	.0	135	25.1	135	19.0
0 to 17 yrs	3	1.7	39	7.3	42	5.9
5 to 11 yrs	0	.0	146	27.2	146	20.5
5 to 17 yrs	0	.0	93	17.3	93	13.1
11 to 17 yrs	0	.0	124	23.1	124	17.4

2.2 Expanded Household types and their homes

2.2.1 Type of homes

Household type	Type of home									
	Flat or maisonette		Bungalow		Detached or link-detached house		Semi-detached or end terrace house		Mid terrace house	
	Count	%	Count	%	Count	%	Count	%	Count	%
Household with children under school age	53	11.0	10	3.4	18	4.3	55	8.1	38	10.0
household with children start or completed school	72	14.9	30	10.3	125	29.8	201	29.7	107	28.1
Single adult under 60	106	22.0	12	4.1	18	4.3	30	4.4	26	6.8
Single adult over 60	114	23.7	92	31.7	54	12.9	105	15.5	58	15.2
2 adults both under 60	67	13.9	20	6.9	39	9.3	53	7.8	30	7.9
2 adults one over 60	14	2.9	18	6.2	20	4.8	30	4.4	21	5.5
2 adults, both over 60	32	6.6	90	31.0	93	22.2	118	17.5	58	15.2
3 or more adults all under 60	19	3.9	13	4.5	23	5.5	53	7.8	32	8.4
3 or more adults at least one over 60	5	1.0	5	1.7	29	6.9	31	4.6	11	2.9
Total	482	100.0	290	100.0	419	100.0	676	100.0	381	100.0

2.2.2 Size of homes (number of rooms)

Household type	combined number of rooms							
	6 or less rooms		7-10 rooms		11-15 rooms		16+ rooms	
	Count	%	Count	%	Count	%	Count	%
Household with children under school age	32	9.2	91	10.1	46	5.5	5	2.8
household with children start or completed school	34	9.7	212	23.6	216	25.7	75	42.6
Single adult under 60	89	25.5	74	8.2	28	3.3	2	1.1
Single adult over 60	106	30.4	194	21.6	122	14.5	6	3.4
2 adults both under 60	44	12.6	92	10.2	58	6.9	17	9.7
2 adults one over 60	7	2.0	44	4.9	46	5.5	7	4.0
2 adults, both over 60	25	7.2	117	13.0	209	24.9	44	25.0
3 or more adults all under 60	8	2.3	54	6.0	74	8.8	5	2.8
3 or more adults at least one over 60	4	1.1	22	2.4	40	4.8	15	8.5
Total	349	100.0	900	100.0	839	100.0	176	100.0

2.3 House type and Boiler Type

| Household type | Main way to heat water | | | | | |
| | combi boiler | | Standard boiler | | Other methods | |
	Count	%	Count	%	Count	%
Household with children under school age	98	8.3	46	7.4	22	7.1
household with children start or completed school	328	27.9	143	23.1	32	10.3
Single adult under 60	103	8.8	34	5.5	49	15.8
Single adult over 60	200	17.0	107	17.3	95	30.6
2 adults both under 60	115	9.8	57	9.2	23	7.4
2 adults one over 60	47	4.0	29	4.7	21	6.8
2 adults, both over 60	165	14.1	138	22.3	44	14.2
3 or more adults all under 60	77	6.6	44	7.1	15	4.8
3 or more adults at least one over 60	41	3.5	21	3.4	9	2.9
Total	1174	100.0	619	100.0	310	100.0

3.0 Archetypes (Socio-Technical Groups production)

3.1.1 Occupancy: Is there a relationship between household size and size of dwelling?

Household size and Number of rooms in dwelling

<div align="right">Row percentages</div>

Size of household	combined number of rooms									
	6 or fewer rooms		7-10 rooms		11-15 rooms		16+ rooms		Total	
	Count	%	Count	%	Count	%	Count	%	Count	%
1	195	(31.4)	269	(43.2)	150	(24.1)	8	(1.3)	622	(100.0)
2	92	(11.6)	297	(37.4)	336	(42.3)	70	(8.8)	795	(100.0)
3	33	(9.5)	145	(41.9)	139	(40.2)	29	(8.4)	346	(100.0)
4	24	(7.4)	126	(38.9)	142	(43.8)	32	(9.9)	324	(100.0)
5 or more	6	(3.0)	72	(36.2)	82	(41.2)	39	(19.6)	199	(100.0)
Total	**350**	**(15.3)**	**909**	**(39.8)**	**849**	**(37.1)**	**178**	**(7.8)**	**2286**	**(100.0)**

Notes: I tested this using the Gamma statistic. The test statistic for these data is 0.332, which indicates that as the size of the household increases, so does the number of rooms in their home, however, the relationship is not particularly strong. It was significant however ($P < 0.0005$), which suggests there may be a fairly weak relationship between the number of people in a HH and the size of their home (measured by the number of rooms in the house).

3.1.2 Occupancy: Is there a relationship between household size and type of dwelling?

Number of people in HH and dwelling type

Size of household	Type of home											
	Flat or maisonette		Bungalow		Detached or link-detached house		Semi-detached or end terrace house		Mid terrace house		Total	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
1	221	35.9	104	16.9	72	11.7	135	21.9	84	13.6	616	100.0
2	136	17.3	134	17.0	161	20.4	230	29.2	127	16.1	788	100.0
3	58	16.8	22	6.4	73	21.1	123	35.5	70	20.2	346	100.0
4	48	14.9	22	6.8	75	23.3	123	38.2	54	16.8	322	100.0
5 or more	21	10.6	11	5.6	43	21.7	69	34.8	54	27.3	198	100.0

Notes:
Single person households are most likely to live in flats or maisonettes (36%), although they are also fairly likely to live in semi-detached or end terraced houses (22%).
Households containing two or more people are most likely to live in semi-detached or terraced houses.
Age also appears to be related to the type of dwelling households live in (see Figure 1 below). As the type of dwelling is also related to the size of the dwelling, this could explain why the relationship between the size of the household and the size of the dwelling is not particularly strong.
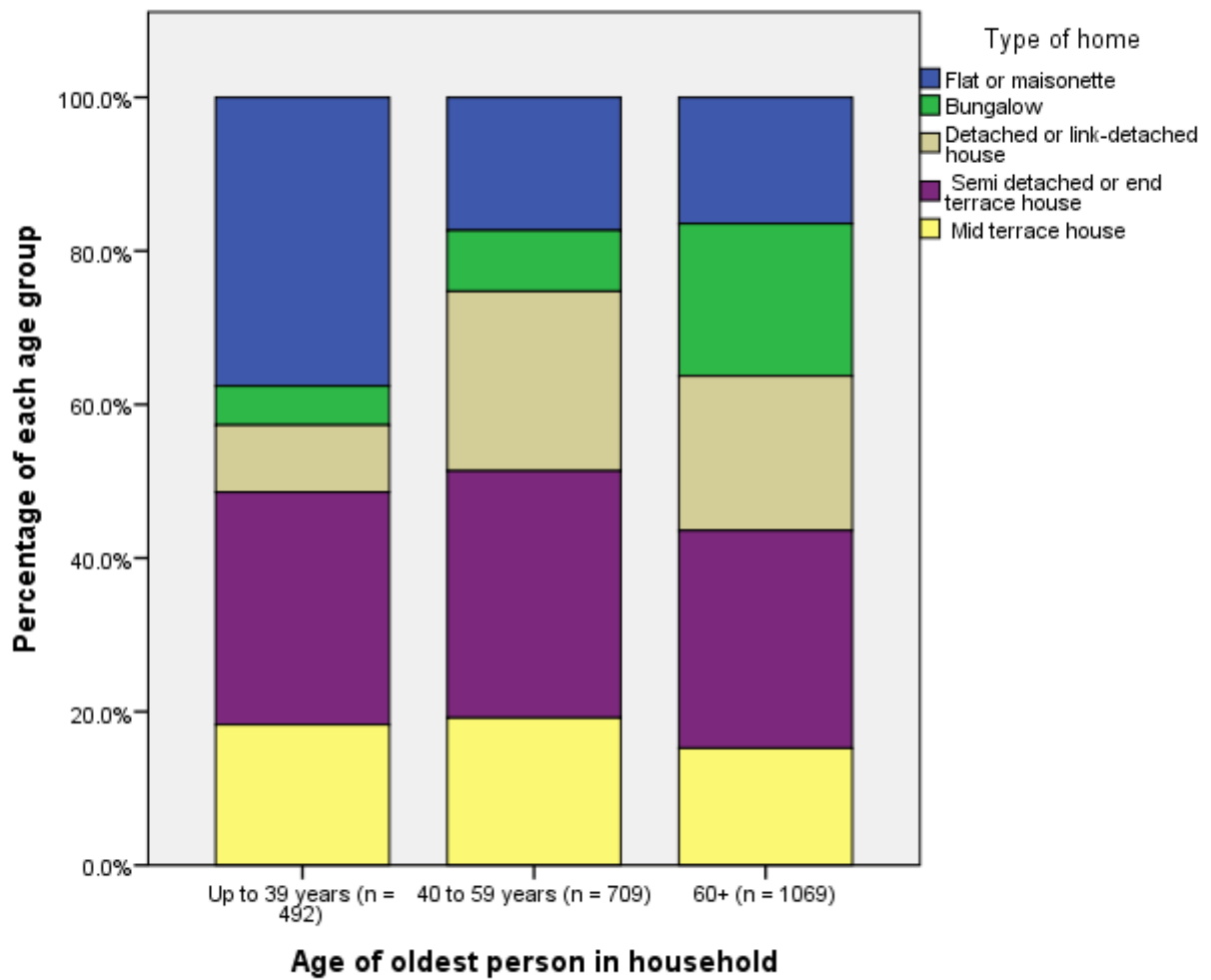
Figure 1: Age of oldest person in households and the type of home they occupy

3.2 Water: Do water heating systems and shower types vary with building type and / or household size?

3.2.1 Water: Do water heating systems and shower types vary with building type and / or household size

3.2.1.1 House type and water heating

House type and main way of heating water

| Type of home | Main way of heating water | | | | | | | |
| | Combi boiler | | Boiler with HW tank | | Immersion Heater | | Total | |
	Count	%	Count	%	Count	%	Count	%
Flat or maisonette	264	(63.6)	78	(18.8)	73	(17.6)	415	(100.0)
Bungalow	149	(56.4)	84	(31.8)	31	(11.7)	264	(100.0)
Detached or link-detached house	135	(39.4)	188	(54.8)	20	(5.8)	343	(100.0)
Semi detached or end terrace house	395	(63.9)	178	(28.8)	45	(7.3)	618	(100.0)
Mid terrace house	236	(65.4)	90	(24.9)	35	(9.7)	361	(100.0)
Total	1179	(58.9)	618	(30.9)	204	(10.2)	2001	(100.0)

3.2.1.2 House age and water heating

House age and main way of heating water

| home age | Main way of heating water | | | | | | | |
| | Combi boiler | | Boiler with HW tank | | Immersion Heater | | Total | |
	Count	%	Count	%	Count	%	Count	%
Pre 1930	279	(67.2)	104	(25.1)	32	(7.7)	415	(100.0)
1931 to 1980	631	(61.5)	284	(27.7)	111	(10.8)	1026	(100.0)
1981 or later	141	(39.4)	171	(47.8)	46	(12.8)	358	(100.0)
Total	1051	(58.4)	559	(31.1)	189	(10.5)	1799	(100.0)

Note: 41% of the houses in the sample built after 1980 were detached houses, which are less likely to have combi boilers than other house types.

3.2.1.3 Household size and water heating

Size of HH and main way of heating water

Size of household	Main way of heating water							
	Combi boiler		Boiler with HW tank		Immersion Heater		Total	
	Count	%	Count	%	Count	%	Count	%
1	304	(56.7)	141	(26.3)	91	(17.0)	536	(100.0)
2	379	(55.3)	238	(34.7)	68	(9.9)	685	(100.0)
3	198	(62.3)	98	(30.8)	22	(6.9)	318	(100.0)
4	182	(62.3)	96	(32.9)	14	(4.8)	292	(100.0)
5 or more	122	(67.4)	50	(27.6)	9	(5.0)	181	(100.0)
Total	1185	(58.9)	623	(31.0)	204	(10.1)	2012	(100.0)

3.2.1.4 Airing Cupboards: What proportion of each building (type, age, number of rooms) has an airing cupboard?

There seem to be only 411 HH with airing cupboards (based on HWvis).

3.2.1.5 Hot water Cylinders: What proportion of each building (type, age, number of rooms) has a hot water cylinder?

3.2.1.5.1 Use of hot water cylinders and dwelling type

		Does the home use a HW tank as the main way to heat their water?			
		Yes		No	
		Count	%	Count	%
Type of home	Flat or maisonette	151	32.6	312	67.4
	Bungalow	117	43.7	151	56.3
	Detached or link-detached house	210	60.3	138	39.7
	Semi-detached or end terrace house	224	35.9	400	64.1
	Mid terrace house	125	34.2	241	65.8
	Total	827	40.0	1242	60.0

3.2.1.5.2 Use of hot water cylinders and dwelling age

Age of home by whether they use a tank as the main way to heat water

		Does the home use a HWtank as the main way to heat their water?			
		Yes		No	
		Count	%	Count	%
home age	Pre 1930	136	31.7	293	68.3
	1931 to 1980	395	37.3	665	62.7
	1981 or later	220	59.5	150	40.5
	Total	751	40.4	1108	59.6

Note: 41% of homes built after 1980 are detached houses, so this table is not independent of the table in 2.2.1.5.1

3.2.1.5.3 Use of hot water cylinders and number of rooms

Number of rooms in home by whether they use a tank as the main way to heat water

		Does the home use a HWtank as the main way to heat their water?			
		Yes		No	
		Count	%	Count	%
combined number of rooms	6 or less rooms	109	32.3	228	67.7
	7-10 rooms	323	37.8	532	62.2
	11-15 rooms	319	42.7	428	57.3
	16+ rooms	81	57.0	61	43.0
	Total	832	40.0	1249	60.0

4.0 Usage profile (Use of hot water and space heating in the different socio-technical groups)

4.1 What are the current heating profiles for different households (household size, occupants ages, building size / type) and do they deliver thermal comfort?

4.1.1 Do usual methods of keeping warm deliver thermal comfort?

Type of household		Do your usual ways of keeping warm in Winter always keep everyone in the HH warm enough?			
		Yes - always	Yes - sometimes	No	Total
Household with children under school age	Count	127	39	8	174
	%	73.0%	22.4%	4.6%	100.0%
Household with children started or completed school	Count	358	151	29	538
	%	66.5%	28.1%	5.4%	100.0%
Households with no children and all adults over 60	Count	662	142	24	828
	%	80.0%	17.1%	2.9%	100.0%
Households with no children and at least one adult under 60	Count	506	200	41	747
	%	67.7%	26.8%	5.5%	100.0%
Total	Count	1653	532	102	2287
	%	72.3%	23.3%	4.5%	100.0%

4.2 Of those people with a timer in the home, are those people with regular occupancy patterns more likely to use a timer to warm their home than those with irregular occupancy patterns?

		Heating controls used in the home				
Predictability of occupancy		HH do not set either timer or thermostat	HH sets timers only	HH set room thermostat only	HH set timer/programmer and room thermostat	Total
Predictable	Count	144	198	78	112	532
	%	27.1%	37.2%	14.7%	21.1%	100.0%
Not predictable	Count	17	24	11	9	61
	%	27.9%	39.3%	18.0%	14.8%	100.0%
Total	Count	161	222	89	121	593
	%	27.2%	37.4%	15.0%	20.4%	100.0%

Note: There are extremely low numbers of households with unpredictable occupancy patterns

4.2.1 Which homes have timers?

Does home have a heating timer / timing programmer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1351	59.1	85.6	85.6
	No	145	6.3	9.2	94.8
	Unsure	51	2.2	3.2	98.0
	Interviewer couldn t check	30	1.3	1.9	99.9
	9	1	.0	.1	100.0
	Total	1578	69.0	100.0	
Missing	Item not applicable	709	31.0		
Total		2287	100.0		

We know whether 1496 (=65% of the whole sample) have timers or not (1496 = 1351 where timer = yes and 145 where timer = no). Of the 709 HH for which this question is coded as not applicable, 215 do not use whole house heating (i.e. central heating or district heating) as their main heating method. It's not clear why the others are classed as not applicable (the interviewer did not have a chance to look for timers etc?)

NB there are 51 households which say they do not use whole house heating as their main heating, but who have timers. However, there are a small number of HH (approx. 3% of the sample) who have central heating but do not use it as their main heating method, so the apparent discrepancy between heating type and timers can be explained by these households.

4.2.1.2 Which homes have timers?

The following table uses a derived variable which assumes that the 215 homes which do not have central or district heating and for which the original timer variable was not applicable do not have timers.

Is there a heating timer or timing programmer in the home?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1351	59.1	79.0	79.0
	No	360	15.7	21.0	100.0
	Total	1711	74.8	100.0	
Missing	Not known	82	3.6		
	Item not applicable	494	21.6		
	Total	576	25.2		
Total		2287	100.0		

4.2.1.3 Which types of homes do not have timers?

| | Is there a heating timer or timing programmer in the home? | | | |
| | Yes | | No | |
Type of home	Count	%	Count	%
Flat or maisonette	231	62.6	138	37.4
Bungalow	184	79.7	47	20.3
Detached or link-detached house	277	89.1	34	10.9
Semi-detached or end terrace house	430	84.1	81	15.9
Mid terrace house	216	78.5	59	21.5
Total	1338	78.8	359	21.2

Flats are least likely to have timers (although nearly 2/3 do have them) detached houses most likely. With respect to flats, this may be because flats are less likely to have central heating. Detached houses in this sample are more likely to have been built since 1981 so central heating was more likely to be installed when the houses were built (43% of detached house were built since 1981 compared to between 9% and 21% of other dwelling types).

4.2.1.4 Whether HH with timers use them

Does HH use their heating timer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	HH does not have a timer	360	15.7	15.9	15.9
	Have timer but heating is never switched off during heating season	330	14.4	14.5	30.4
	Timer is used to control heating	763	33.4	33.6	64.0
	Timer is not used to control heating	818	35.8	36.0	100.0
	Total	2271	99.3	100.0	
Missing	Not known	16	.7		
Total		2287	100.0		

4.2.1.5 Exploring which HH with timers never switch the heating off during the heating season and why they do not switch it off

Type of household * Does HH use their heating timer

Type of household		Does HH use their heating timer			Total
		Have timer but heating is never switched off during heating season	Timer is used to control heating	Timer is not used to control heating	
Household with children under school age	Count	32	40	78	150
	%	21.3%	26.7%	52.0%	100.0%
Household with children started or completed school	Count	81	195	208	484
	%	16.7%	40.3%	43.0%	100.0%
Households with no children and all adults over 60	Count	123	286	264	673
		18.3%	42.5%	39.2%	100.0%
Households with no children and at least one adult under 60	Count	94	242	268	604
	%	15.6%	40.1%	44.4%	100.0%
Total	Count	330	763	818	1911
	%	17.3%	39.9%	42.8%	100.0%

The following observations should be interpreted cautiously because they are based on low numbers

Of the households who left their heating on all the time, all the household types tended to do it because:
the house got too cold otherwise (between 56% and 64% of individual household types said this was a reason)

Generally, households who left the heating on all the time tended not to give the following reasons:
we believe it uses less energy than turning the heating on and off (between 22 and 28% of household types said this was a reason)
we believe it costs less than turning the heating on and off (between 6 and 15% of household types said this was a reason)
Not sure if it's possible to set the heating to come on at different times (between 0 and 3% said this was a reason)
Don't know how to set the heating to come on and off at different times (between 2 and 4% of households said this was a reason)

There were some differences between households with regard to the following reasons
it's easier to do this: 47% of households with children under school age mentioned this reason compared to between 13 and 20% of the other household types.

like it to be warm when getting up: households with no children and all adults over 60 were the least likely to say this (15%), followed by households with children (19% for households with children under school age and households with children of school age). It was most commonly mentioned as a reason by households with no children and at least one adult under 60 (29%)

not able to access controls: Overall this was rarely mentioned as a reason, however, it was never mentioned by the 2 household types with children, but it was occasionally mentioned by households without children (4% of households with at least one adult under 60 and 3% when all the adults were over 60)

make sure pipes don't freeze: This was not a common reason overall, but there may be a tendency for households containing older people to say this. It was never mentioned by households with children under school age, but 5% of households with children of school age said it, 6% of HH with at least one adult under 60 said it and 8% of households with all adults over 60 said it

other (unspecified) reasons: 8% of households with all adults over 60 said this, and 10% of households with children of school age. In households where at least one adult was under 60 14% of households said this and 19% of households with children under school age said it.

4.3 Exploring what controls households have for their heating

Heating controls in the home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No controls	126	5.5	9.8	9.8
	Timer/programmer only	217	9.5	16.8	26.6
	Room thermostat only	91	4.0	7.1	33.7
	timer/programmer and room thermostat	855	37.4	66.3	100.0
	Total	1289	56.4	100.0	
Missing	Not known	99	4.3		
	Not applicable	899	39.3		
	Total	998	43.6		
Total		2287	100.0		

4.3.1 Exploring which controls households use (households with at least one way to control their temperature)

	Heating controls used in the home							
	HH do not set either timer or thermostat		HH sets timers only		HH set room thermostat only		HH set timer/programmer and room thermostat	
Heating controls in the home	Count	%	Count	%	Count	%	Count	%
Timer/programmer only	59	19.8	76	23.5	29	18.0	13	7.0
Room thermostat only	32	10.7	9	2.8	15	9.3	10	5.4
timer/programmer and room thermostat	207	69.5	239	73.8	117	72.7	162	87.6
Total	298	100.0	324	100.0	161	100.0	185	100.0

Note: The heating controls in the home were based on the controls the interviewer saw. The heating controls used were based on what the households said they used. This may account for the occasional discrepancies between the controls available and the controls used.

4.3.1.2 Exploring which households use which controls (households with thermostats and timers/programmers)

Type of household		Heating controls used in the home				
		HH do not set either timer or thermostat	HH sets timers only	HH set room thermostat only	HH set timer/programmer and room thermostat	Total
Household with children under school age	Count	25	17	10	5	57
	%	43.9%	29.8%	17.5%	8.8%	100.0%
Household with children started or completed school	Count	53	58	23	43	177
	%	29.9%	32.8%	13.0%	24.3%	100.0%
Households with no children and all adults over 60	Count	64	90	48	72	274
	%	23.4%	32.8%	17.5%	26.3%	100.0%
Households with no children and at least one adult under 60	Count	65	74	36	42	217
	%	30.0%	34.1%	16.6%	19.4%	100.0%
Total	Count	207	239	117	162	725
	%	28.6%	33.0%	16.1%	22.3%	100.0%

4.3.1.3 Exploring the age of householders (based on oldest person in the households) and use of controls (households with thermostats and timers/programmers)

Age of oldest person in household		HH do not set either timer or thermostat	HH sets timers only	HH set room thermostat only	HH set timer/programmer and room thermostat	Total
Up to 39 years	Count	53	48	20	16	137
	%	38.7%	35.0%	14.6%	11.7%	100.0%
40-59 years	Count	63	78	28	62	231
	%	27.3%	33.8%	12.1%	26.8%	100.0%
60+ years	Count	91	113	69	84	357
	%	25.5%	31.7%	19.3%	23.5%	100.0%
Total	Count	207	239	117	162	725
	%	28.6%	33.0%	16.1%	22.3%	100.0%

4.4 Is there a relationship between the type of heating control people are using and their attitude to technology? (Households with timers/programmers and thermostats)

Use of smart phones		Heating controls used in the home				
		HH do not set either timer or thermostat	HH sets timers only	HH set room thermostat only	HH set timer/programme and room thermostat	Total
Have smart phone, use apps every day	Count	53	80	34	42	209
	%	25.4%	38.3%	16.3%	20.1%	100.0%
Have smart phone, use apps most days	Count	6	12	0	7	25
	%	24.0%	48.0%	0.0%	28.0%	100.0%
Have smart phone, use apps less often	Count	21	26	10	21	78
	%	26.9%	33.3%	12.8%	26.9%	100.0%
Have smart phone, never use apps	Count	12	19	9	17	57
	%	21.1%	33.3%	15.8%	29.8%	100.0%
Do not have smart phone	Count	114	102	63	75	354
	%	32.2%	28.8%	17.8%	21.2%	100.0%
Total	Count	206	239	116	162	723
	%	28.5%	33.1%	16.0%	22.4%	100.0%

Note: The use of smart phones is being used as a proxy variable for attitude to technology as no variables in the dataset directly questioned this.

4.5 Investigate the relationship of the number of showers / baths per person for each household and their heating system

4.5.1 Number of showers per person per week

There are a lot of apparent outliers (extreme data points) in the showering data. These data points were checked and appear to be genuine. However, the distribution of the showering data is unusual (see section 4.5.2) and this appears to be causing SPSS to identify data points as outliers.

4.5.1.1 Number of showers per person per week in Winter
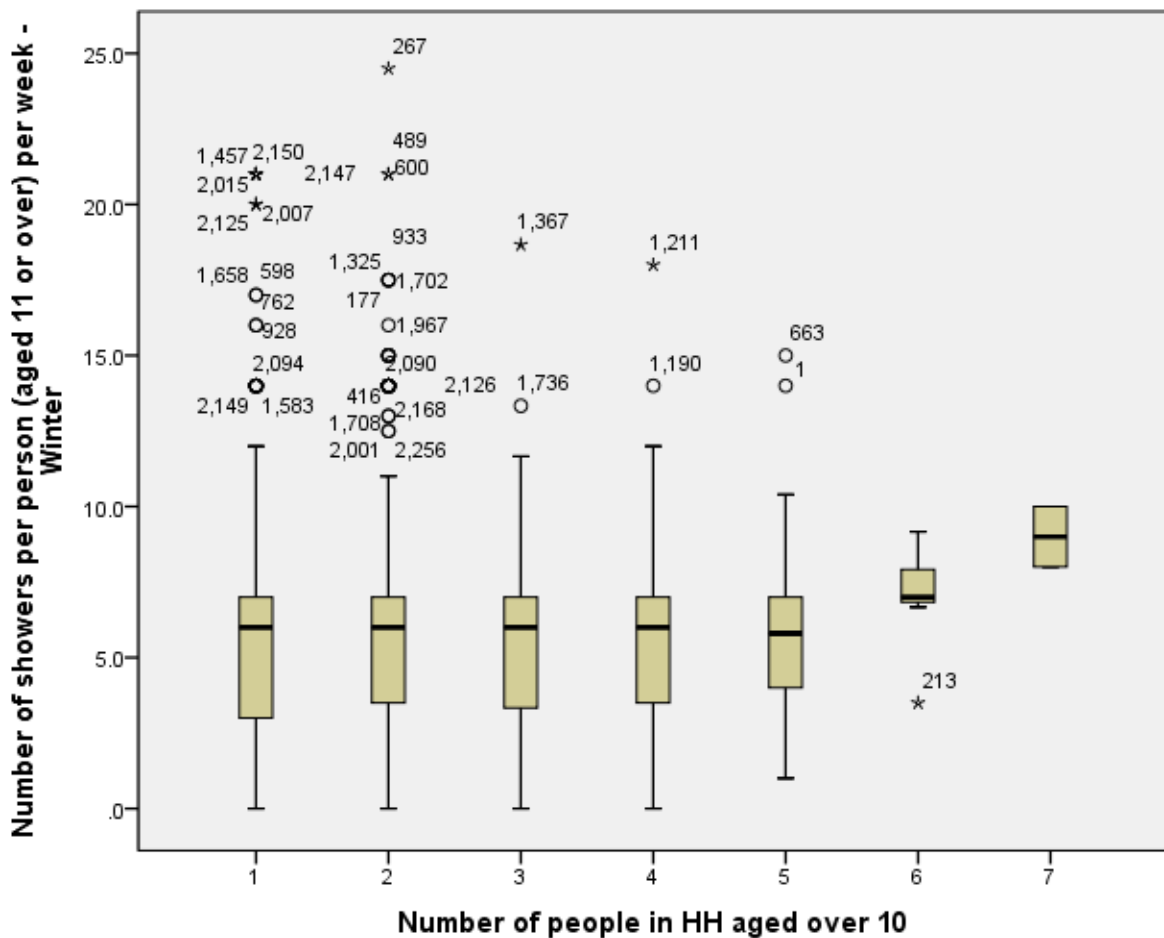
Figure 2: Number of showers per person per week - Winter

Note: There were only 6 households containing 6 people aged over 10 and 2 households containing 7 people over 10. As this was an exploratory analysis, these households were not removed. However, the data concerning these households should be interpreted cautiously as they are based on so few households.

The median number of showers per person per week was similar in households containing up to 5 people aged over 10, however more data points have been identified as extremely high in households containing 1 or 2 people aged over 10.

Possibly, in households containing more than 2 people, household members are inhibited from showering more than twice a day, but in smaller households those wanting to shower more often can do so more easily.

4.5.1.1 Number of showers per person per week in Summer
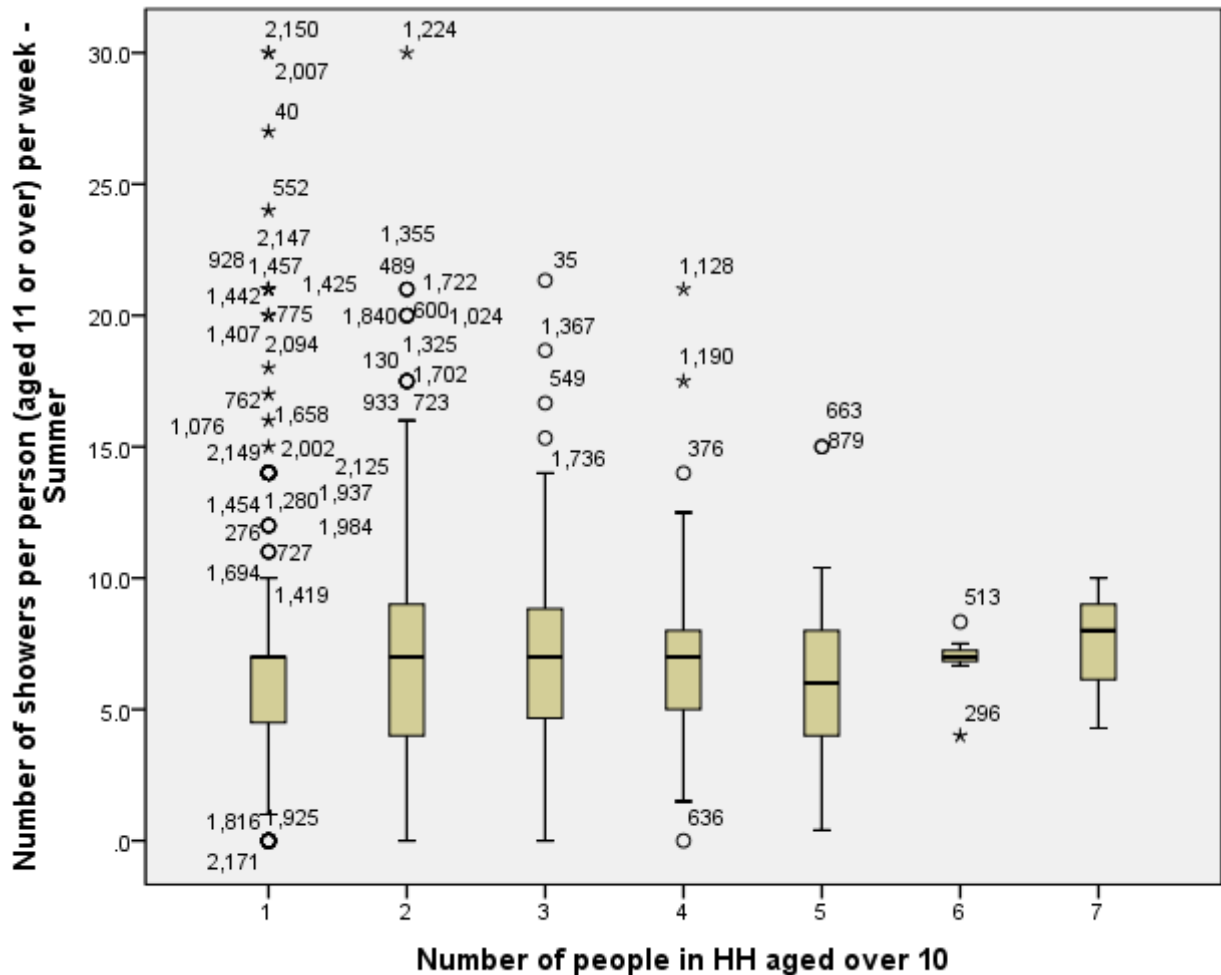
Figure 3: Number of showers per person per week - Summer

Note: As for the Winter showering data, there were very few households containing 6 or 7 people aged over 10 and the data from these households should be interpreted cautiously.

4.5.3 Distribution of shower data
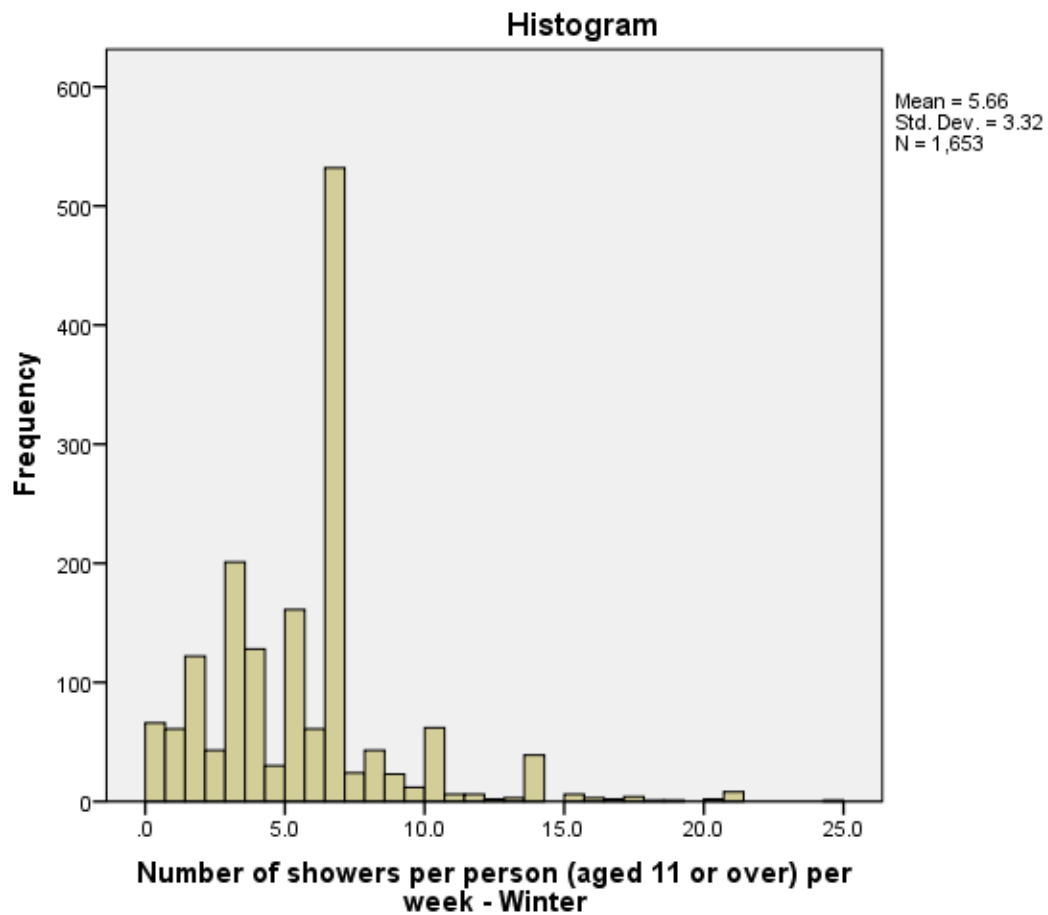
Figure 4: Distribution of showers in Winter

As Figure 4 demonstrates, the distribution of the showering data is clearly not normal. The single most common response that people have 7 showers per week, however some people have considerably more.

4.6 Is there a relationship between the water heating system HH use and how they control their hot water?

4.6.1 Could HH run out of hot water?

		Could shower run out of hot water?					
		Yes		No		Total	
		Count	%	Count	%	Count	%
Size of household	1	81	15.1	456	84.9	537	100.0
	2	148	22.1	521	77.9	669	100.0
	3	55	17.7	255	82.3	310	100.0
	4	58	20.4	226	79.6	284	100.0
	5 or more	26	14.9	149	85.1	175	100.0

I tested this using the gamma test which had a test statistic of -0.033. This indicates that there was at best an extremely weak negative association between number of occupants and whether shower could run out of hot water (i.e. as the HH size increased the proportion of HH with showers that could run out of hot water decreased). This was just significant ($p = 0.041$).

4.7 When do people take baths or shower?
The most frequently reported time to shower was in the morning (43% of households with showers), whereas for baths, the most frequently reported time to take a bath was in the evening (53% of households).

5.0 Problems

5.1 Over Heating

91% of households suffer from some overheating in summer and 63% have to do something to avoid overheating in winter. The most common things which households do to avoid overheating in Winter are as follows:
50% turn their heating down or off
28% open their windows during the day
18% wear light clothing.
14% open their windows at night and

NB overall 32% of households open their windows during the day and/or at night

6.0 Priorities

The priority questions did not provide much useful data. The most popular "big" factors for heating are being comfortable (mentioned by 85% of respondents), energy costs (mentioned by 76%) and avoiding wasting energy (70%). These appear to be the top three priorities regardless of household type etc.

Cross tabulations of each heating priority were carried out (Examples are shown in Appendix A2.1). These showed that no pairs of priorities could be identified which appeared to be chosen together. An analysis was carried out to investigate this further. (an example of the output is shown in Appendix A2.2). This analysis was examining the pairs of priorities in terms of their ranking from most frequently chosen pairing to least frequently chose. This showed that the overall ranking of the priorities did not change overall when different pair of priorities were mentioned. These two analyses suggested that in general the households ranked the priorities in a fairly uniform way.

I attempted a cluster analysis of the heating priorities. This showed that some households were attempting to be selective (i.e. chose less than one half of the options) while other did not. The households which were being selective could not be distinguished from those that were not (based on their socio demographic attributes).

These analyses suggested that the priority questions were not working correctly and the number of times each factor was mentioned as very important, somewhat important or not important at all was summed. This should have produced only two responses missing (i.e. no priorities chosen at all) or 1. However, individual priorities were not mentioned at all up to by up to 137 households (i.e. they had prioritised some factors, but not all of them). In addition, a small number of households had prioritised some factors more than once. This suggests that some households were confused by this question and this may be the reason the priorities did not provide much valuable information.

I recommend that these questions are not analysed any further in this dataset and that the format of the questions be reconsidered if they are to be used in any other surveys.

7.0   Other Questions

7.1 Occupancy

During the weekdays, nearly one half of all households (48%) said the house was always or usually occupied all the time and close to one third (32%) said that the house was always or usually occupied at night and in 1 section of the day (i.e. the house was occupied overnight and also during the morning, afternoon or evening). So overall, around 80% of the households were occupied for at least one section of the day and overnight.

Grouped occupancy patterns on weekdays

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always or usually in at night, varies during day	38	1.7	2.4	2.4
	Always or usually in night and day	751	32.8	47.5	49.9
	Always or usually in at night and in 2 sections of the day	108	4.7	6.8	56.7
	Always or usually in at night and in 1 section of the day	512	22.4	32.4	89.1
	Occupancy varies at night and day	57	2.5	3.6	92.7
	Never or rarely in night, varies in day	37	1.6	2.3	95.0
	Never or rarely in night always or usually in during day	16	.7	1.0	96.0
	Never or rarely in night always or usually in for 2 sections of the day	3	.1	.2	96.2
	Never or rarely in night always or usually in for 1 section of the day	41	1.8	2.6	98.8
	Never or rarely in at any time	19	.8	1.2	100.0
	Total	1582	69.2	100.0	
Missing	Insufficient data (At least 4 of 7 time periods missing)	128	5.6		
	All data Missing	577	25.2		
	Total	705	30.8		
Total		2287	100.0		

Overall, there does not appear to be a relationship between the occupancy of the home and the size of the household (see section 7.1.1). However, the household type did appear to be related to occupancy.

Households with no children and all adults over 60 were mostly likely to say their house was always occupied (58%) and households with children at school or with no children and at least one adult under 60 were least likely to say this (36% and 35% respectively). Households with no children and at least one adult aged under 60 were also more likely to have a different occupancy pattern to the 2 main patterns identified in the sample as a whole (24% compared to between 17 and 19% for the other household types). This suggests that occupancy may be driven by work and childcare responsibilities.

There was also pretty clear trend between increasing age and saying that the house was always or usually occupied. Households where the oldest person was under 40 were more likely to say they had other occupancy patterns to the 2 main occupancy patterns identified in the data as a whole. Households where the oldest person was over 60 were also more likely to say the house was always or usually occupied, however this is not surprising given the findings for the relationship between household types and occupancy.

The age of the oldest person in the household was derived in 5 year groupings to explore this in more detail (detail not shown) and between 28 and 26% of households with the oldest person aged 55 or under said their house was always or usually occupied. There was no trend within these age groups. However, for households where the oldest person was older than 55 there was an increasing trend with increasing age.   This may partly be account for by retirement, however the trend increased for ages past retirement age, which suggests that other factors affect the occupancy of people past retirement age. Two possible factors which may affect the occupancy patterns of people after retirement age are income and health.

7.1.1 Occupancy and size of household

There's little sign of a relationship between the size of the household and the occupancy patterns. Households containing 3 or 4 people are least likely to say their house is always occupied and households containing 2 people are most likely to say it is always occupied (although the percentage point difference between households containing 2 people and those containing 5 people is small).

Main occupancy patterns		Size of household					Total
		1	2	3	4	5 or more	
Always or usually in night and day	Count	185	318	93	83	71	750
	%	41.5%	53.4%	34.3%	32.7%	50.0%	43.9%
Always or usually in night and 2 sections of the day	Count	38	19	14	24	13	108
	%	8.5%	3.2%	5.2%	9.4%	9.2%	6.3%
Always or usually in night and 1 section of the day	Count	125	151	104	99	33	512
	%	28.0%	25.3%	38.4%	39.0%	23.2%	30.0%
Other occupancy pattern	Count	98	108	60	48	25	339
	%	22.0%	18.1%	22.1%	18.9%	17.6%	19.8%
Total	Count	446	596	271	254	142	1709
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

7.1.2 Occupancy and household composition

Main occupancy patterns during the week		Type of household				
		children under school age	children started at school	no children and all adults over 60	no children and at least one adult under 60	Total
Always or usually in night and day	Count	59	150	347	195	751
	%	43.4%	36.3%	57.5%	35.0%	43.9%
Always or usually in night and 2 sections of the day	Count	10	34	33	31	108
	%	7.4%	8.2%	5.5%	5.6%	6.3%
Always or usually in night and 1 section of the day	Count	43	151	120	198	512
	%	31.6%	36.6%	19.9%	35.5%	29.9%
Other occupancy pattern	Count	24	78	104	133	339
	%	17.6%	18.9%	17.2%	23.9%	19.8%
Total	Count	136	413	604	557	1710
	%	100.0%	100.0%	100.0%	100.0%	100.0%

7.1.2 Occupancy and age of oldest person in the household

Main occupancy patterns		Age of oldest person in household			Total
		Up to 39 years	40-59 years	60+ years	
Always or usually in night and day	Count	112	189	449	750
	%	30.8%	34.7%	56.1%	43.9%
Always or usually in night and 2 sections of the day	Count	29	36	43	108
	%	8.0%	6.6%	5.4%	6.3%
Always or usually in night and 1 section of the day	Count	135	212	165	512
	%	37.1%	39.0%	20.6%	30.0%
Other occupancy pattern	Count	88	107	144	339
	%	24.2%	19.7%	18.0%	19.8%
Total	Count	364	544	801	1709
	%	100.0%	100.0%	100.0%	100.0%

7.3 Inverse of priorities

This was briefly examined, but given the concerns regarding the priority questions, it was not pursued.

Appendix A: Details of analysis

A1: Archetypes

A1.2.1 Water heating systems

Number of ways water heated in home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2088	91.3	91.4	91.4
	2	186	8.1	8.1	99.6
	3	10	.4	.4	100.0
	Total	2284	99.9	100.0	
Missing	Not known	3	.1		
Total		2287	100.0		

196 homes heated their water using more than one method.

186 homes used two methods to heat water. These are the combinations of methods used

	District heating	Combi boiler	Boiler with hot water cylinder/tank	Immersion heater	Instant hot water tap	Solar thermal hot water	Other
District heating	-	0	1	3	0	0	0
Combi boiler	0	-	9	16	4	3	2
Boiler with hot water cylinder/tank	1	9	-	127	2	3	4
Immersion heater	3	16	127	-	1	2	8
Instant hot water tap (heats water near the tap)	0	4	2	1	-	0	0
Solar thermal hot water	0	3	3	2	0	-	1
Another method	0	2	4	8	0	1	-

10 homes used three methods:

8 of them used a combination of immersion heater and boiler with hot water tank plus one other method. The third method was an instant hot water tap (3 homes), solar thermal hot water (2 homes) and just descried as "other" (3 homes).
The remaining 2 homes said they used a mixture of a combi boiler, a boiler with a hot water tank and an instant hot water tap.

A2: Priorities

A2.1 Cross tabulations of Priorities – Looking for relationships among the priorities

Heating factors - Big factors - percentage of HH mentioning both factors

	Being comfortable	Keeping healthy	Feel clean	clean home	rest and relax	be productive	feel safe
Being comfortable							
Keeping healthy	54.4						
Feel clean	59.9	45.4					
clean home	45.6	37	43				
rest and relax	64.5	45.7	50.3	38.2			
be productive	30.2	24	25.8	21.2	27.1		
feel safe	41.1	33.9	37.1	31.7	34.8	19.5	
energy costs	65	47.2	52.2	40.8	53.5	26.3	38.5
value or cost of home	35.8	27.9	30.7	26.3	30.2	17.7	25.8
doing what is easiest	30.2	21.9	24.7	19.6	26	13.6	18.4
feeling in control	53.3	38.7	43.7	33.7	45.4	23.5	31.4
appearance of home	12	10.8	11.2	10.1	10.6	7	9.4
needs of visitors	30.3	22.3	25.4	19.8	25.7	15.6	17.8
concern for environment	30.7	23.6	24.9	20.4	25.4	16.1	20.9
avoid energy waste	60	43.3	48.4	36.9	49.6	25	36.5
keeping home nice	42.6	34.8	38.8	34.2	36.9	20.2	29.3
avoid arguements	11.1	9.2	9.6	5.4	9.7	6.5	8.5
what most people do	7	5.7	6.1	5.4	6.2	4.2	5.4
Routines	24.7	19.4	21.3	17.3	22	12.2	15.8
Tradition	14.3	11.7	12.8	10.7	31.1	7.5	10.6
Caring for other members of household	46.6	36.5	39.5	31.3	39.4	21.5	29.3

Appendix A2.2 Priorities – analysis of ranking of pairs of priorities

Heating factors - Big factors - percentage mentioning both factors

Being comfortable		Keeping healthy		Feel clean	
Number of responses 1938		1396		1529	
Being comfortable		Being comfortable	89.2	Being comfortable	89.5
energy costs	65	energy costs	47.2	Keeping healthy	68
rest and relax	64.5	rest and relax	45.7	energy costs	52.2
avoid energy waste	60	Feel clean	45.4	Feel clean	
Feel clean	59.9	avoid energy waste	43.3	rest and relax	50.3
Keeping healthy	54.4	Keeping healthy		avoid energy waste	48.4
feeling in control	53.3	feeling in control	38.7	feeling in control	43.7
Caring for other members of household	46.6	clean home	37	clean home	43
clean home	45.6	Caring for other members of household	36.5	Caring for other members of household	39.5
keeping home nice	42.6	keeping home nice	34.8	keeping home nice	38.8
feel safe	41.1	feel safe	33.9	feel safe	37.1
value or cost of home	35.8	value or cost of home	27.9	value or cost of home	30.7
concern for environment	30.7	be productive	24	be productive	25.8
needs of visitors	30.3	concern for environment	23.6	needs of visitors	25.4
be productive	30.2	needs of visitors	22.3	concern for environment	24.9
doing what is easiest	30.2	doing what is easiest	21.9	doing what is easiest	24.7

Heating factors - Big factors - percentage mentioning both factors

clean home		rest and relax		be productive	
Being comfortable	89.6	Being comfortable	93.5	Being comfortable	91
Feel clean	84.6	Feel clean	72.9	rest and relax	81.6
Keeping healthy	72.7	Keeping healthy	66.2	Feel clean	77.7
energy costs	40.8	clean home	55.3	Keeping healthy	72.3
rest and relax	38.2	energy costs	53.5	clean home	63.8
avoid energy waste	36.9	avoid energy waste	49.6	energy costs	26.3
keeping home nice	34.2	feeling in control	45.4	avoid energy waste	25
clean home		Caring for other members of household	39.4	feeling in control	23.5
feeling in control	33.7	keeping home nice	36.9	Caring for other members of household	21.5
feel safe	31.7	feel safe	34.8	keeping home nice	20.2
Caring for other members of household	31.3	Tradition	31.1	feel safe	19.5
value or cost of home	26.3	value or cost of home	30.2	value or cost of home	17.7
be productive	21.2	be productive	27.1	concern for environment	16.1
concern for environment	20.4	doing what is easiest	26	be productive	
needs of visitors	19.8	needs of visitors	25.7	needs of visitors	15.6
doing what is easiest	19.6			doing what is easiest	13.6