



Department for
Business, Energy
& Industrial Strategy

energy
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trust

Measurement of the in-situ performance of solid biomass boilers

Annex D: Social research

Preface

This document is the Social Research annex to “Measurement of the in-situ performance of solid biomass boilers”, a report prepared for BEIS which details work carried out from 2015 to 2018 where the real-life efficiencies and pollutant emissions of a range of biomass boilers were measured.

The work was carried out by a consortium of Kiwa Gastec, Ricardo Energy and Environment, Energy Saving Trust, HETAS, and Optimum Consultancy.

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1 Executive summary

This report presents the results of the social research element of a biomass boiler field trial commissioned by BEIS and delivered by a consortium of organisations consisting of Kiwa, Ricardo, Energy Saving Trust and Optimum Consultancy. The research includes analysis and evaluation of behaviours, motivations and satisfaction of trial participants.

A two stage data collection method was employed. Stage one consisted of 16 qualitative telephone interviews and stage two consisted of a quantitative online survey which 23 out of 61 participating sites completed. After the telephone interviews were complete, a thematic analysis of responses by question was conducted which was primarily used to inform questions and answer categories for the stage two online survey.

The results from the survey show that the two most important reasons for installing a biomass boiler were to achieve financial savings and benefit from the Renewable Heat Incentive (RHI). Twenty (87%) out of 23 respondents received an induction or initial training from the boiler installer which highlights the importance of ensuring consistent best practice information is disseminated through the installer network. Some operators reported that they would like more general information, professional support and a service contractor list at the time of induction or training. The majority of respondents described the boiler's maintenance positively in terms of quickness, simplicity and ease. Despite 15 (65%) out of 23 respondents having had maintenance or breakdown issues with their system, respondents still reported a positive level of satisfaction with the boiler.

Respondents were also less likely to install a biomass system if the RHI had not existed even though it was not given as the most important reason for installing the boiler. Three out of 16 interview participants mentioned prolonged maintenance issues. One survey respondent stated that they would not have installed a biomass boiler if they had been made aware of the true cost of fuel and system prior to installation.

This research was limited by the response rate of the participants; it was originally planned to randomly sample sites, however due to a low response rate the sample for both the telephone interviews and online service were predominantly self-selecting. Also, the small sample size made it difficult to compare the relationship between the two most important reasons for installing a biomass boiler.

This report recommends that operational advice provided by boiler installers and manufacturers contains should be made consistent where possible and require in-depth training, reference material and specific technical guidance. Further investigation could confirm the importance of the RHI and the most favourable conditions for installing a biomass boiler system.

2 Introduction

A biomass boiler field trial has been commissioned by the Department for Business, Energy and Industrial Strategy (BEIS) and delivered by a consortium comprised of Kiwa, Ricardo, Energy Saving Trust (EST) and Optimum Consultancy. 67 biomass boilers across 61 sites were installed across the UK. The majority are used to heat domestic and commercial buildings and hot water, as well as heating for industrial buildings such as poultry houses and greenhouses.

Kiwa is acting as overall project managers for the field trial. The site visits and monitoring equipment installation have been done by Kiwa and Ricardo, with support from electrical subcontractors. Energy Saving Trust with support from Kiwa conducted social research at a sample of these sites.

Broadly, the social research aims to provide greater insight into how individuals operate new technology and help ensure the adoption of positive or beneficial behaviours. This report states the findings of the social research element of this project.

This social research had three objectives:

- (O1) to document how participants in the trial currently use their boilers
- (O2) to understand their motivations
- (O3) to collect additional contextual information relating to the sites and boilers

3 Methodology

The research consists of two stages; semi-structured interviews and an online survey. This section explains the sampling methods of each stage as well as format which both took as part of this research. Challenges to data collection will also be addressed in Section 2.3

3.1 Stage One - Semi-structured interviews

Stage one consisted of qualitative telephone interviews which were conducted with 16 participating sites. The aims of these interviews were to inform the stage two survey questions and answer categories by exploring motivations for biomass boiler installation, the breadth of behaviours that are being conducted by operators and to obtain greater context.

3.1.1 Sampling

It was originally planned that the sites sampled in this phase of the research would be randomly selected. However, due to a low response rate the sample was opened up to all properties meaning that the sample is dominantly self-selected. This means the results may not be representative of the wider population.

3.1.2 The interviews

The question format was either single select response, or an open ended response. See Appendix 1 for the full question list.

Following data collection from stage one, a thematic analysis was conducted on appropriate open response questions. The thematic analysis considers each response and then determines specific categories. Categories are then considered by underlying theme and these themes form new categories e.g. sustainable fuel use and self-sufficiency can both be attributed to the theme of sustainability. The data is then reviewed again and re-assigned based on the theme-based categories. Results from stage one were then used to provide answer categories for the online survey and additional questions which would enable the data collected from the survey to be interpreted as predominantly quantitative. These results from stage one and can be seen in Appendix 2 and Appendix 3.

3.2 Stage Two - Online survey

An online survey was done with all sites to quantify the results of stage one. The survey script is in Appendix 4.

3.2.1 Sampling

The survey was sent to the 37 sites from which relevant email addresses were available, with 23 responses. These respondents were made up of interviewees and non-interviewees. Of the 16 original interviewees, 13 responded to the survey, two did not respond and one individual opted out. An additional 10 surveys were done with boiler owners who did not participate in the interviews.

3.2.2 The survey

Questions for the survey were developed from the stage one thematic analysis, as previously mentioned, as well as technical recommendations from Kiwa. The survey aimed to estimate the

prevalence of motivations, behaviours and identify common context. Thermal comfort and recommendation questions were also asked in this stage.

The format consisted of a combination of closed single/multiple-choice select, Likert scale¹ and open ended questions. Surveys were identical, except that those field trial participants who took part in the interviews received a modified introduction to the survey given to those who did not. The survey also included an “other comments” question which will be used to inform the discussion of this report.

The number of responses obtained varies by question due to question logic and whether the respondent chose to complete that specific question. Percentages provided in the results section of this report will always be calculated from the number of specific question respondents not the overall sample size. Number of respondents by question will also be provided where relevant in the results section.

¹ where respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements

4 Results

This section presents results from stage two of the research; the online survey. The questions are grouped by common sections. The thematic analyses from stage one can be found in Appendix 2.

4.1 Main operator information

Information about the main operator helps to provide contextual information to those who are taking part in the field trial.

Figure 1 shows that six (26%) out of 23 respondents work in agriculture, five (21%) out of 23 respondents identified providing professional services and five (26%) out of 23 respondents chose the “other” option, which included a retired individual, the “construction trade” and the “public sector”.

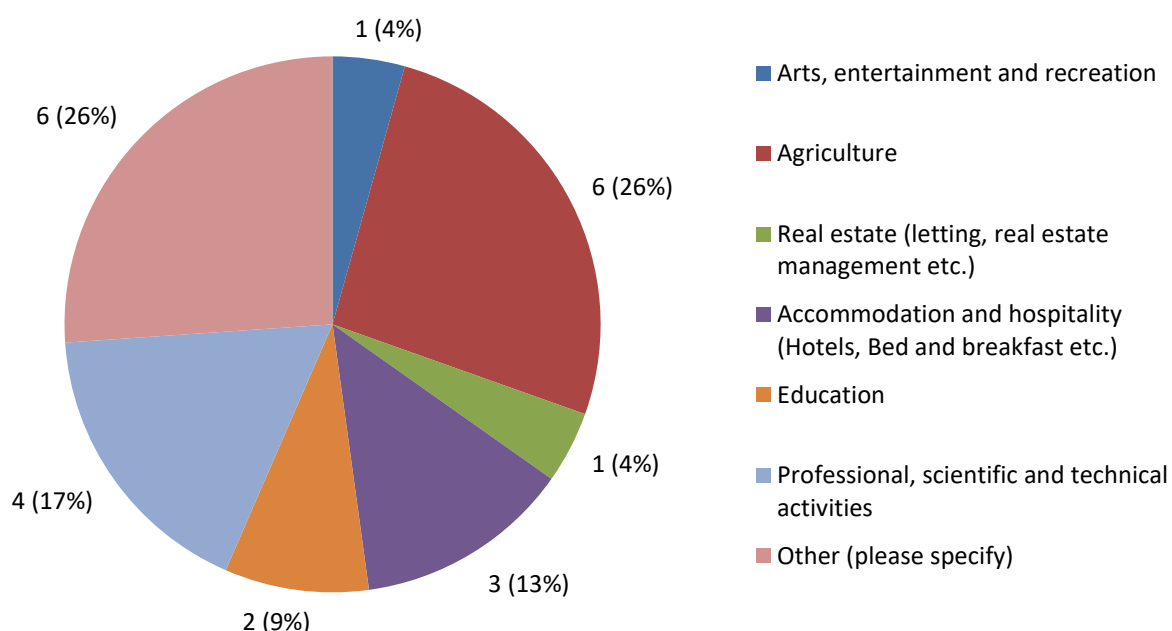


Figure 1 Please tell us which industry you work in” (n=23) (Appendix 4 Question 2)

A wide range of professions identified as the main operator of the boiler including; Poultry Farmer, Teacher, Hotelier, Transport Planner, Company Director, Product Energy Efficiency Compliance Expert etc. Of the 23 survey respondents, seven (30%) carry out boiler-related activities every few days, six (26%) do so daily, and five (22%) do so weekly. Only two of the 23 respondents performed a boiler-related activity more than once a day (Figure 2).

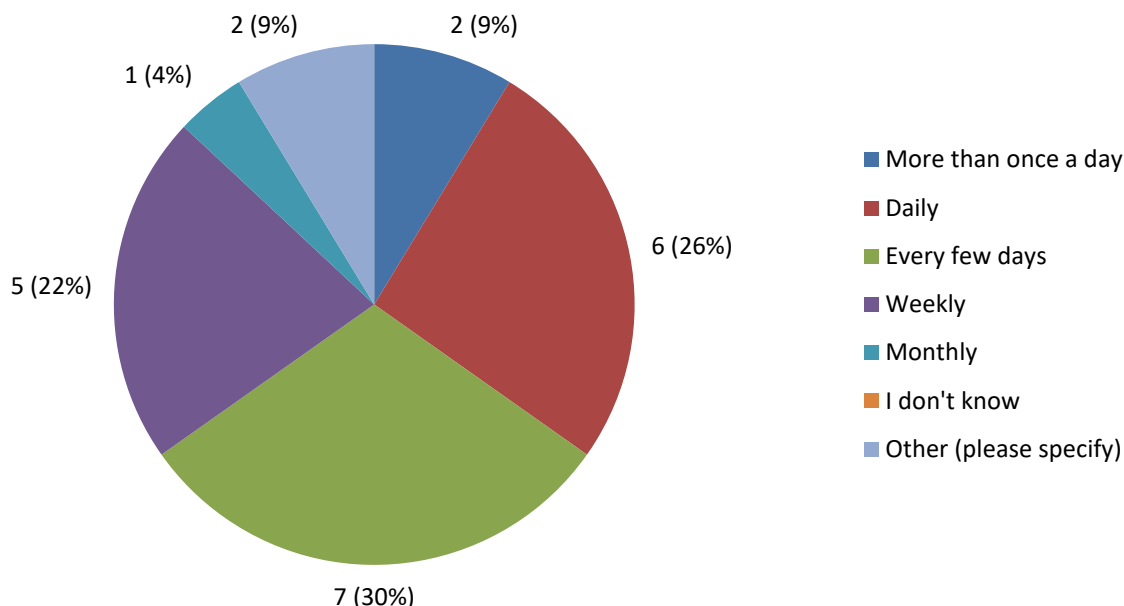


Figure 2 “How often do you spend time on activities related to the biomass boiler?” (n=23) (Appendix 4, Question 3B)

4.2 Purpose

This section explores the uses of the boilers and the motivations for being involved in the field trial. 16 (70%) of the 23 survey respondents use their biomass boiler to heat residential buildings; only one (4%) use their boiler to heat industrial buildings such as barns (Figure 3). All 23 (100%) respondents use their boiler to heat buildings and 20 of these (87%) also use the boiler to heat water (Table 1). This question was a multiple choice answer so respondents could choose all those that applied. Two (9%) of the 23 respondents selected “other” and stated the boiler is used for activities such as “grain drying” and “brooding chicks”.

The most important reason given by respondents to install a biomass boiler was to obtain financial savings on fuel expenses with a mean ranking of 2.4 out of six potential reasons for installing the biomass boiler (Figure 4). The second most important reason, with a mean value of 2.9, was to receive the Renewable Heat Incentive (RHI). Self-sufficiency (3.5), lack of access to mains gas (3.8) and company or personal strategy (3.9) are relatively equal in their level of importance; these values are within one standard error and so are less likely to be statistically significant. The least important reason for installing a biomass boiler was to replace an existing system; with a value of 4.7.

Even though the two most important reasons for installing a biomass boiler were similar in theme (both were linked to income either through savings or the RHI), there appears to be no clear correlation between the two (Figure 5), though more data would be required for this to be tested statistically.

19 (83%) of the 23 survey respondents had systems with thermal stores.

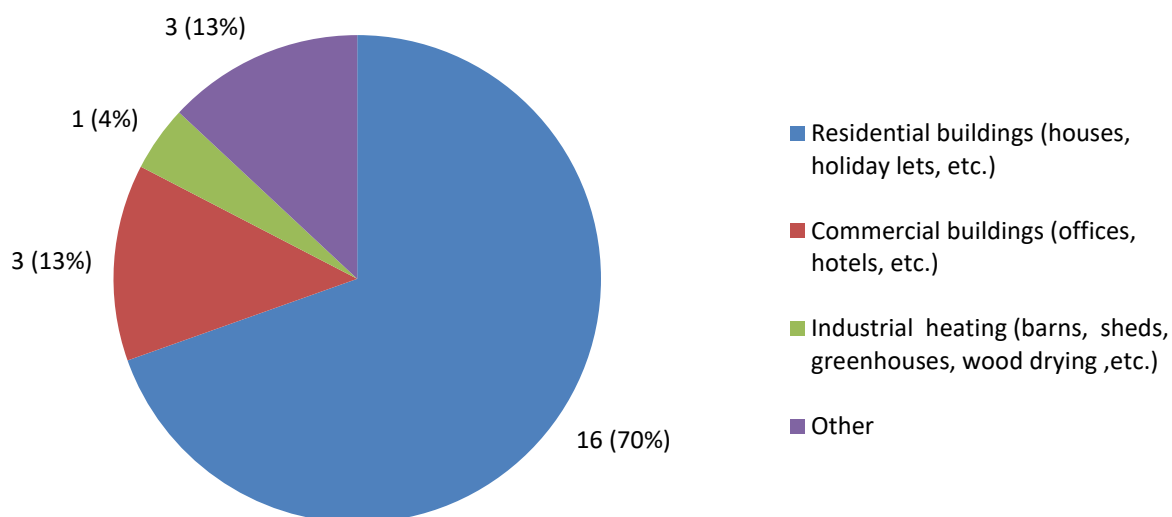


Figure 3 “What do you use the biomass boiler for?” (n=23) (Appendix 4, Question 4)

Table 1 “What specific activities is the biomass boiler used for?” (n=23) (Appendix 4, Question 4A)

Answer Category	Proportion of Responses (n=23)	Percentage of Responses
Heating buildings or spaces	23	100%
Heating water	20	87%
Wood drying	0	0%
Disposal of waste (e.g. scrap wood, etc.)	0	0%
Other (please specify)	2	9%

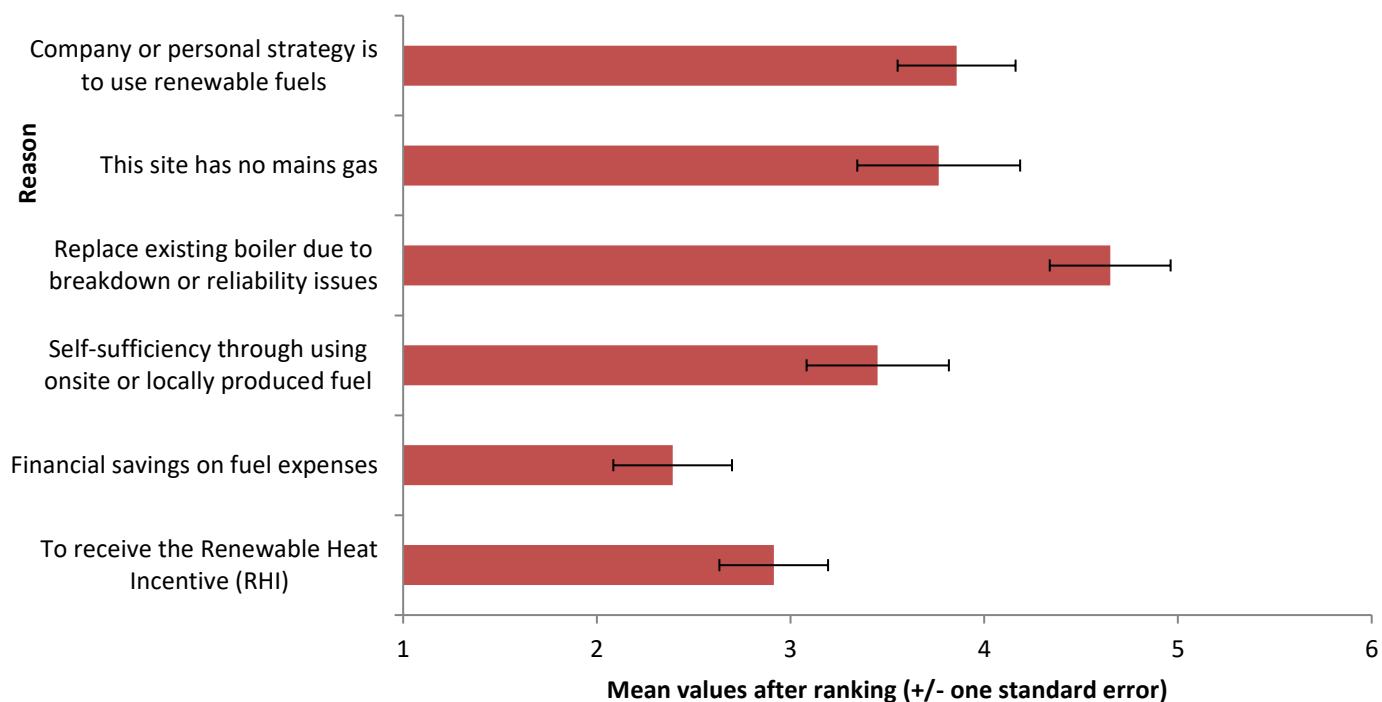


Figure 4 “Why was a biomass boiler chosen for this purpose? Please rank on a scale 1-6 where 1= most important, 6= least important” (n=23) (Appendix 4 Question 4B)

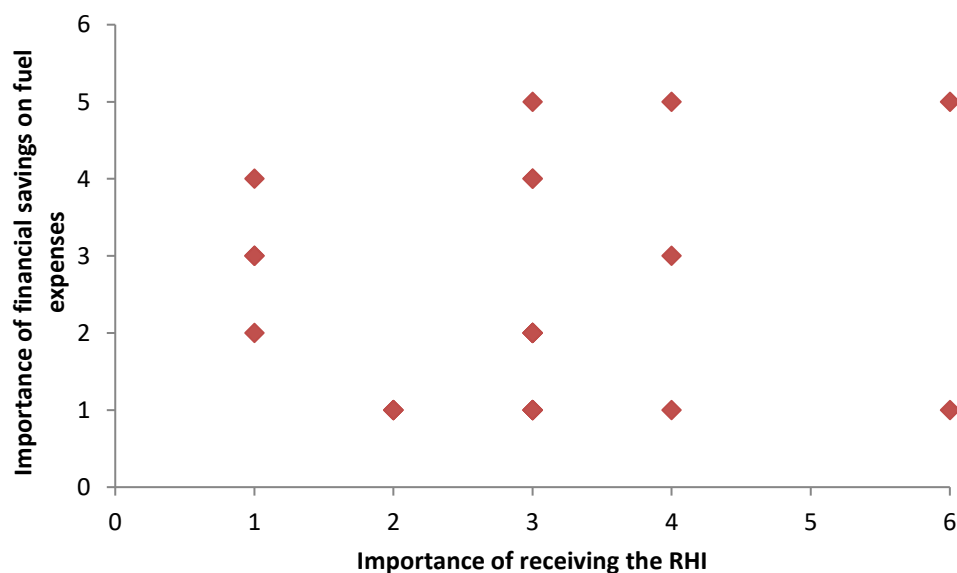


Figure 5 The relationship between the two most important reasons for installing a biomass boiler. 1 = most important, 6 = least important. Data points on the scatter plot may represent multiple respondents who stated the same level of importance. (n=23) (Appendix 4 Question 4B)

4.3 Induction

Several of the survey questions refer to an induction or training which would take place close to the time of boiler installation, this section highlights the results from these questions.

Some survey respondents received some form of training from more than one source (Figure 6). Twenty (87%) out of 23 respondents received an induction/ training from the boiler installer. Two (9%) out of 23 respondents didn't receive an induction at all and stated that they obtained information from learning on the job, speaking to the boiler service company and their own pre-existing knowledge.

Some survey respondents received more than one kind of material listed with twenty (87%) out of 23 respondents receiving a complete manual on installation (Figure 7). 17 (74%) out of 23 respondents received non-written general advice. The survey respondent that received information from a predecessor indicated that they received all options listed in the answer categories except a booklet.

12 (52%) out of 23 respondents didn't think anything else was necessary in addition to that which they already received as part of the handover process (Figure 8). However, six (26%) out of 23 respondents would have liked to have received a service contractor list and five (22%) out of 23 requested more general advice and ongoing professional support.

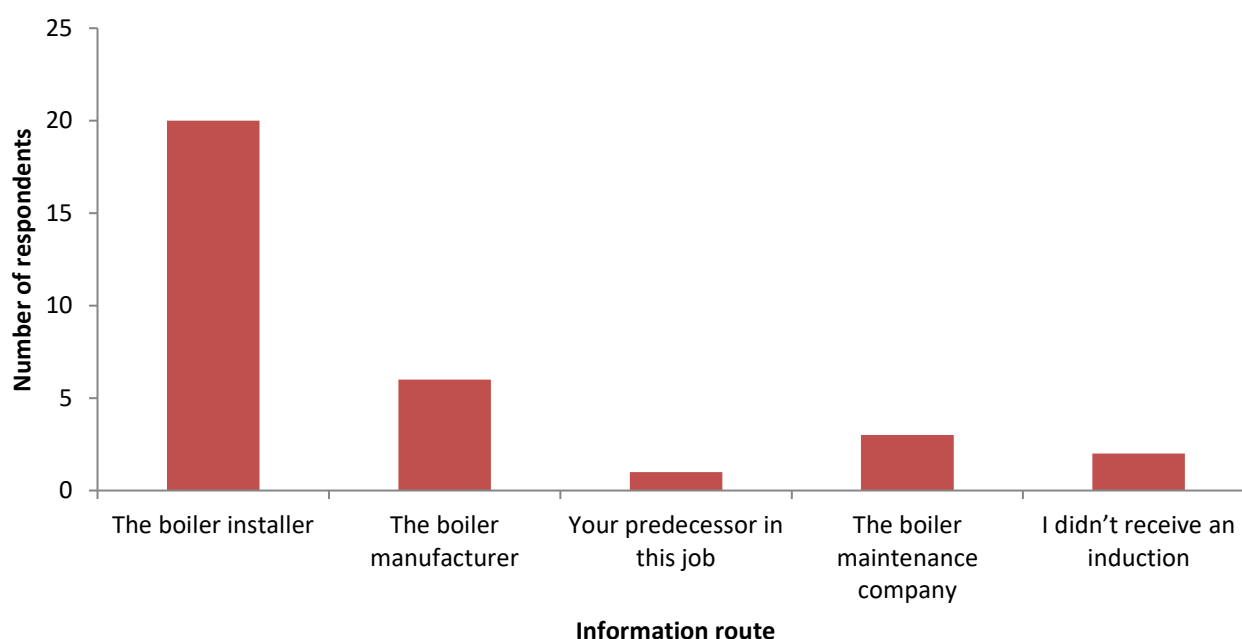


Figure 6 “[who] Did you receive an induction/training about the boiler from [?]” (n=23) (Appendix 4 Question 6)

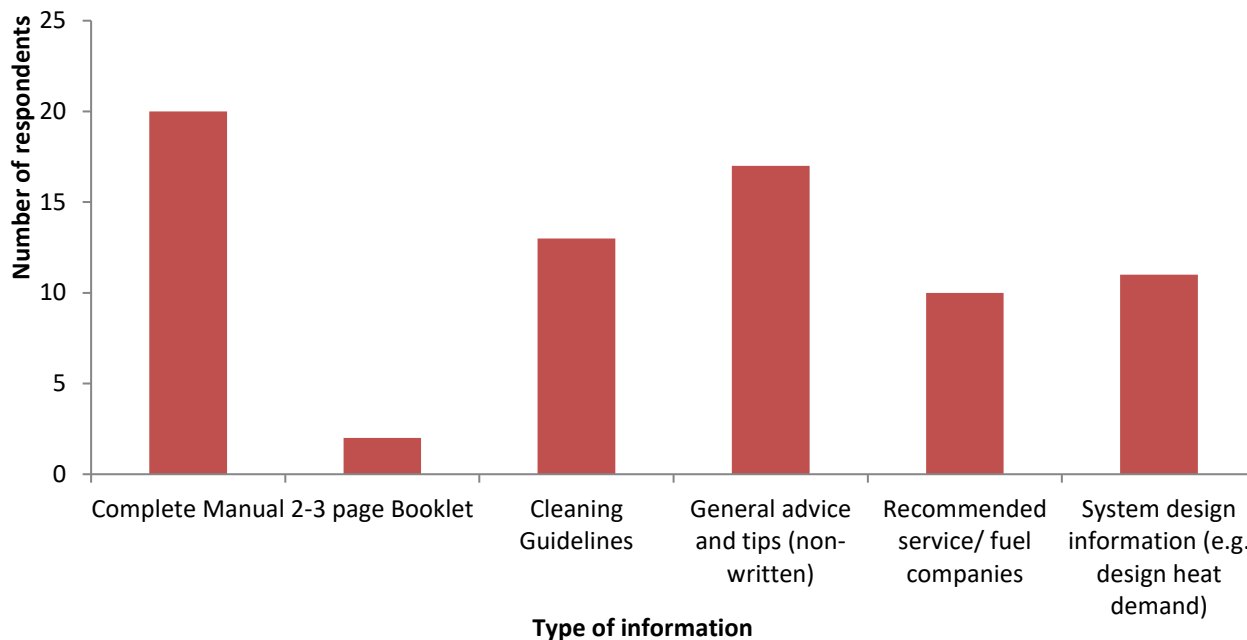


Figure 7 “Did you receive any of the following from the installer/ manufacturer?” (n=23) (Appendix 4 Question 6A)

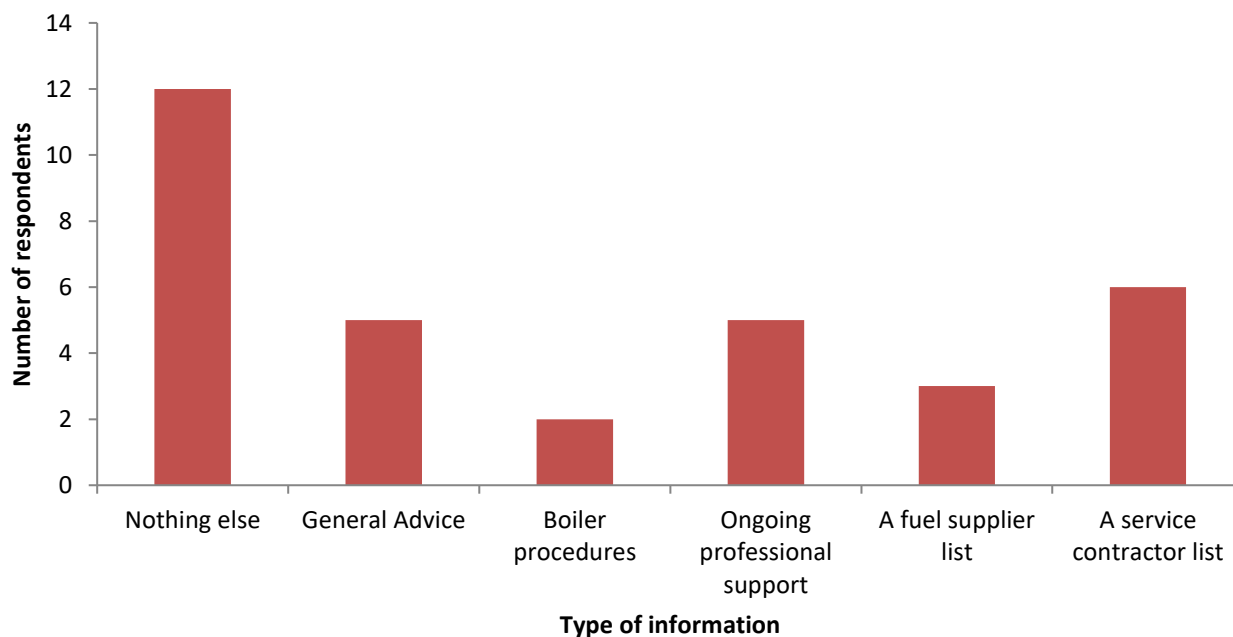


Figure 8 “What would you like more of in the handover?” (n=23) (Appendix 4 Question 6D)

4.4 Maintenance, cleaning and servicing

Maintenance and cleaning are important to ensure smooth operation of the biomass system and the perceptions and challenges to this were explored during the survey.

4.4.1 Perceptions of maintenance, cleaning and servicing

12 (52%) out of 23 respondents were positive to some extent about the quickness of their boiler’s maintenance; this suggests that boiler maintenance activities were not excessively time-consuming (Figure 9). 13 (57%) out of 23 respondents were positive to some extent about both the simplicity and the ease of their boiler’s maintenance; this suggests that respondents felt the boiler maintenance was not excessively complex or difficult to do.

15 (65%) out of 23 respondents have had breakdown or reliability issues with their biomass boiler. The respondents who have had reliability issues were asked to explain in more detail. 28 (62%) out of 45 breakdown issues were not covered by warranty (Figure 10). Augers had the most reliability issues of all parts (eight out of 45 reported issues) however they were covered by warranty on five (63%) out of 8 occasions.

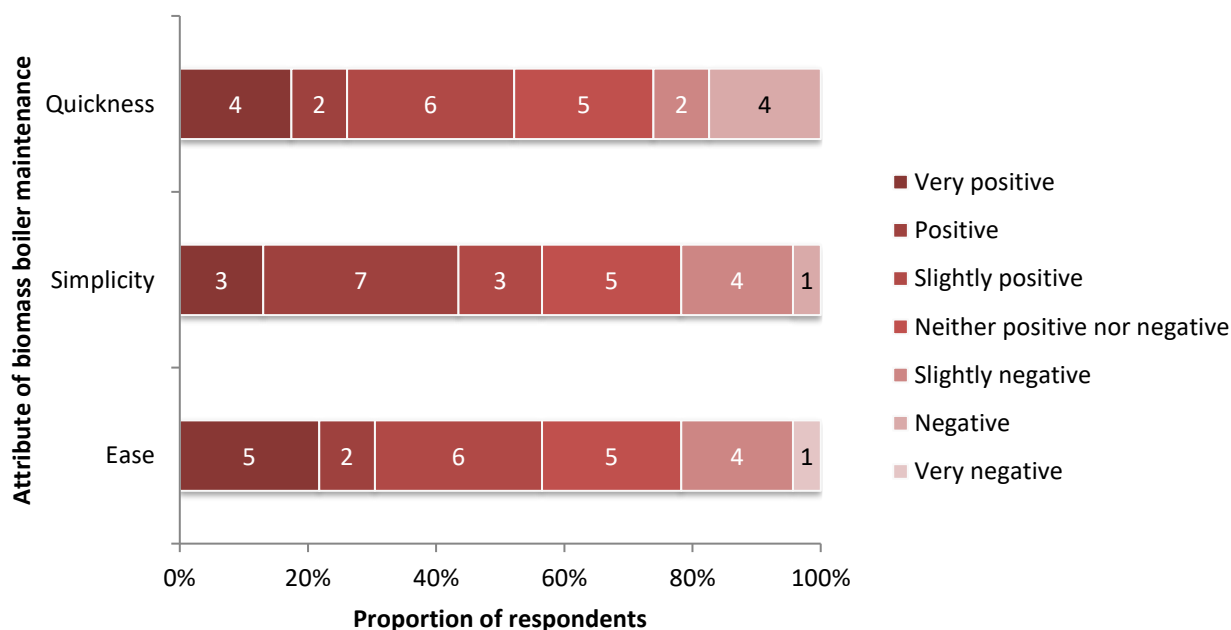


Figure 9: Responses of biomass boiler operators to how they found maintaining the boiler in terms of the quickness, simplicity and ease of the process (n=23). Numbers of individuals responding in each category are shown as data labels. (Appendix 4, Question 7B)

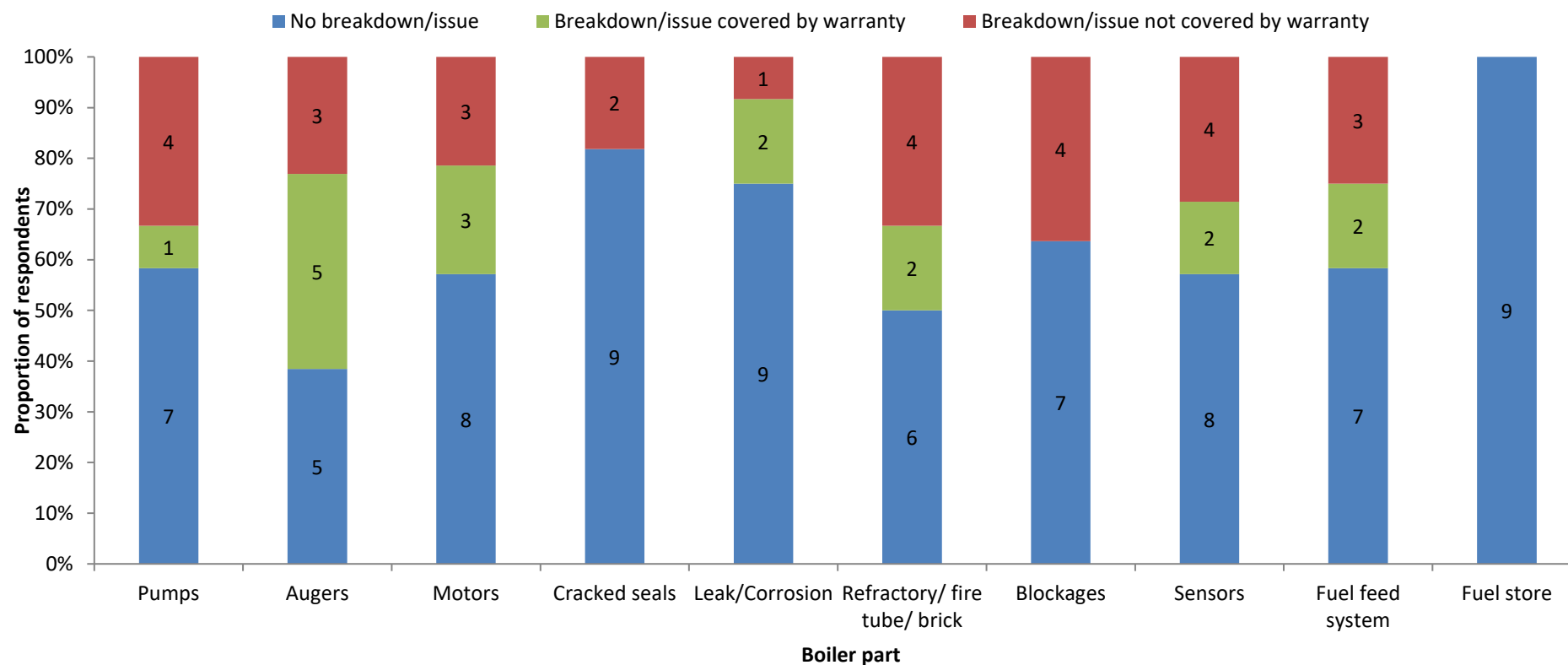


Figure 10 “Which part and was it covered by warranty?” Asked to respondents who reported having had breakdown issues in the past (n=15) (Appendix 4 Question 7A)

4.4.2 Maintenance behaviours

17 (74%) out of 23 respondents get a full service on their boiler every 12 months (Table 2). Only one (4%) out of 23 respondents gets their boiler serviced more than every 12 months. No respondents get a full service on their boiler more regularly than every 6 months.

Four (18%) out of 23 respondents are carrying out maintenance to the boiler, separate to a full service, on a weekly basis (Table 3). Ten (45%) out of 23 respondents carried out additional maintenance less than once a month. Three (14%) out of 22 respondents provided alternative answers to the survey and stated that the “control board prompts for greasing, ash removal etc.”, additional maintenance is required “every quarter” and that a “6 monthly [flue clean]” takes place at these specific sites.

Table 2 “How often do you get a full service?” (n=23) (Appendix 4, Question 8)

Answer category	Proportion of Responses (n=23)	Percentage of Responses
Every 3 months	0	0%
Every 6 months	5	22%
Every 12 months	17	74%
More than every 12 months	1	4%
Other (please specify)	0	0%

Table 3 How often does your boiler require additional maintenance, separate to the main full service?” (n=22) (Appendix 4, Question 8A)

Answer category	Proportion of Responses (n=22)	Percentage of Responses
Less than once a month	10	45%
Every month	5	23%
Every fortnight	0	0%
Every week	4	18%
Other (please specify)	3	14%

4.4.3 Cleaning behaviours

13 (57%) out of 23 survey respondents carried out the majority of boiler cleaning duties (Table 4). Ten (44%) out of 23 respondents stated that the majority of cleaning duties are performed by someone other than themselves.

12 (55%) out of 22 respondents have the smoke tubes cleaned as part of the yearly service (Figure 11).

The survey asked respondents to state their considerations when cleaning with a multiple choice question. The prevailing advice route for cleaning information came from installers, with 13 (59%) out of 22 respondents stating they considered installer advice (Table 5). 10 (45%) out of 22 respondents considered advice from manufacturer and Nine (41%) out of 22 respondents considered advice from the service company. Six (27%) out of 23 respondents carry out cleaning activities as and when required rather than having a strict schedule.

Nine (39%) out of 23 respondents don't have a contract with a boiler maintenance company according to the survey results. Of those who have a service contract, five (36%) out of 14 respondents, use a different company to that which installed the boiler; nine (64%) out of 14 respondents kept the same company.

Table 4 Who performs the majority of boiler cleaning duties?" (n=23) (Appendix 4 Question 9)

Answer category	Proportion of Responses (n=23)	Percentage of Responses
Myself	13	57%
A member of my team	8	35%
Professional contractors	2	9%
Other (please specify)	0	0%

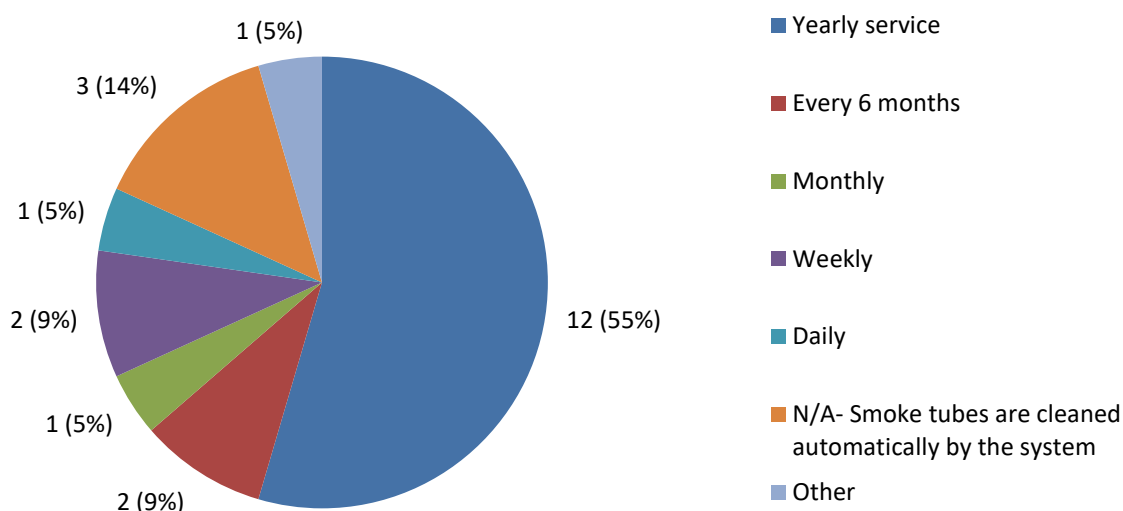


Figure 11 "How often do you clean the smoke tubes of your boiler?" (n=22) (Appendix 4 Question 10)

Table 5 "What sorts of considerations do you take in to account when deciding how and when to clean your boiler?" (n=22) (Appendix 4 Question 11)

Answer category	Proportion of Responses (n=22)	Percentage of Responses
Advice from the manufacturer	10	45%
Advice from the installer	13	59%
Advice from service company	9	41%
Carried out sporadically as required	6	27%
Carried out at the discretion of the service/ cleaning contractor	2	9%
Other (please specify)	1	5%

4.5 Operations

Apart from maintenance and cleaning, other operational activities were explored in the survey, including the presence of bi-products such as soot and smoke, as well as other issues the operator may have had with the system.

10 (43%) out of 23 respondents were aware of soot, smoke or smells from the biomass boiler; but they are generally not noticeable and often there is little smell or smoke emitted (Table 6). In the survey (Appendix 4 Question 13A) no distinction was made between normal operational smells and unexpected or abnormal smells from the boiler.

12 (52%) out of 23 respondents didn't report any additional issues with the boiler except parts and maintenance (Figure 12). However, three (13%) out of 23 respondents did state that they had issues with the computer controls and programmes.

Three (43%) out of 7 respondents called engineers to help with operational solutions. However, Four (57%) out of 7 reported that they had not found any solutions to reducing operational challenges they experienced.

16 (70%) out of 23 respondents did not comment on any solutions they had found to make boiler operation easier.

Table 6 “Can you describe the smoke/soot/smells on a scale of 1-7?” (n=10) (Appendix 4 Question 13A)

Noticeable	Proportion of Responses	Percentages of Responses	Burning smell	Proportion of Responses	Percentages of Responses	Smoke	Proportion of Responses	Percentages of Responses
1 Never notice them	0	0%	1 No burning smell	4	40%	1 No smoke	0	0%
2	8	80%	2	4	40%	2	7	70%
3	1	10%	3	2	20%	3	1	10%
4	1	10%	4	0	0%	4	2	20%
5	0	0%	5	0	0%	5	0	0%
6	0	0%	6	0	0%	6	0	0%
7 Notice them all the time	0	0%	7 Extremely strong burning smell	0	0%	7 Thick black smoke	0	0%

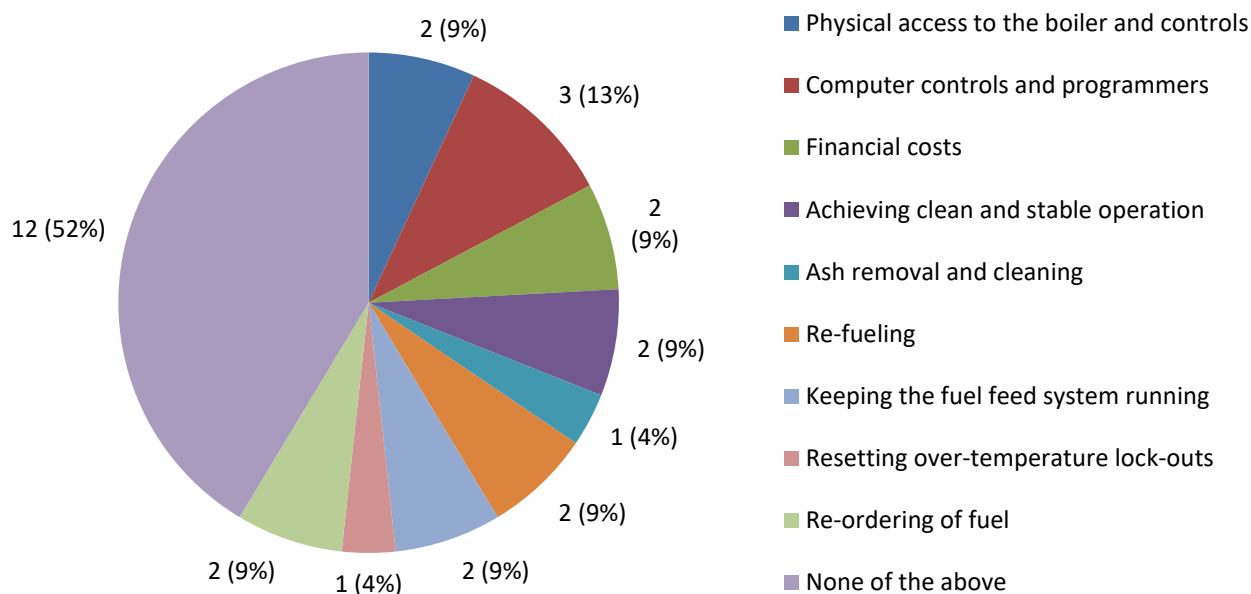


Figure 12 “Except maintenance and replacing parts, what sorts of things do you have trouble with when operating your boiler?” (n=23) (Appendix 4 Question 15)

4.6 Ash

Ash is one of the main outputs from the biomass systems and ash removal and disposal is a regular activity that the main operator is likely to be involved in.

Ash removal was one of the main operational activities of the biomass systems. Nine (41%) out of 22 respondents remove ash by changing bins/pans. Six (27%) out of 22 respondents remove ash through manual removal with a shovel/rake and five (23%) out of 22 use a vacuum cleaner. Two (9%) out of 22 respondents suggested they used another method for ash removal not included in the answer categories and highlighted that ash removal takes place when the boiler is serviced.

17 (77%) out of 23 respondents dispose of ash on site, whereas five (23%) out of 23 dispose of ash off-site. 13 (62%) out of 21 of respondents use ash as fertilizer and only three (14%) out of 21 add to their municipal waste collection (Table 7).

The frequency with which ash is removed from the boiler is varied; eight (36%) out of 22 respondents remove ash weekly, five (23%) out of 22 monthly and four out of 22 (18%) every few days (Figure 13). No respondents removed ash from their system on a daily basis. Four (18%) out of 22 selected the “other” response option and these respondents said they remove ash: “every 3 months”, “[after] every 600 hours of usage” and “when the control panel asks me to”.

There was a variety of responses to the colour characteristic but 12 (52%) out of 23 of respondents considered the ash to be more white than black in colour. 22 (96%) out of 23 respondents stated that ash tended to be more fine than coarse and 21 (91%) out of 23 respondents stated that the ash didn’t contain unburnt material very often (Table 8).

Table 7 “How is the ash disposed of?” (n=21) (Appendix 4 Question 14B)

Answer category	Proportion of Responses (n=21)	Percentage of Responses
Used directly on land as fertilizer	13	62%
Added to compost	5	24%
Municipal waste collection	3	14%
Professional waste disposal	0	0%

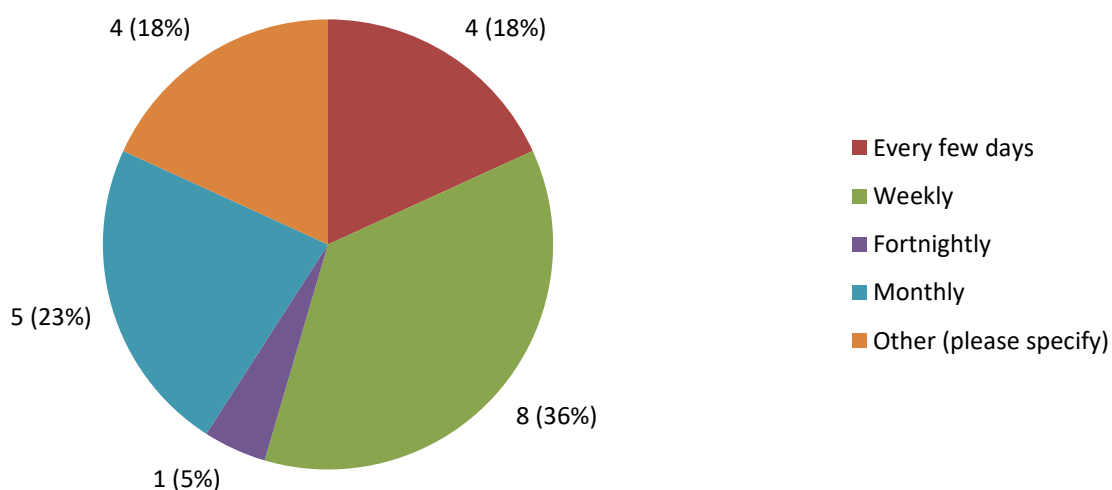


Figure 13 “How often do you remove ash from your boiler?” (n=22) (Appendix 4 Question 14C)

Table 8 “On a scale of 1-7 please can you identify the characteristics of the ash” (n=23) (Appendix 4 Question 14D)

Colour	Proportion of Responses		Texture	Proportion of Responses		Unburnt material	Proportion of Responses	
1 White	1	4%	1 Mostly Very Fine (Dust like)	8	35%	1 Never Contains Unburnt Material	8	35%
2	3	13%	2	8	35%	2	11	48%
3	8	35%	3	6	26%	3	2	9%
4	2	9%	4	1	4%	4	2	9%
5	4	17%	5	0	0%	5	0	0%
6	2	9%	6	0	0%	6	0	0%
7 Black	3	13%	7 Mostly Very Coarse (gravel or larger)	0	0%	7 Always Contains Unburnt Material	0	0%

4.7 Controls

Biomass boilers have a range of adjustable controls which allow the user to tailor the heating system to their needs; some boilers even allow the boiler settings to be adjusted remotely. This section gives the results showing how aware respondents are of these controls.

19 (83%) out of 23 respondents knew how to adjust the hot water tank thermostat, 18 (78%) out of 23 knew how to adjust the building thermostat and 16 (70%) out of 23 of respondents knew how to change the flow temperature set point (Figure 14). Respondents were least likely to know how to change oxygen/ excess air levels as only seven (30%) out of 23 respondents know how to do this.

17 (74%) out of 23 respondents run their boilers at a reduced output during the summer months, with only three (13%) out of 23 switching the boiler off completely.

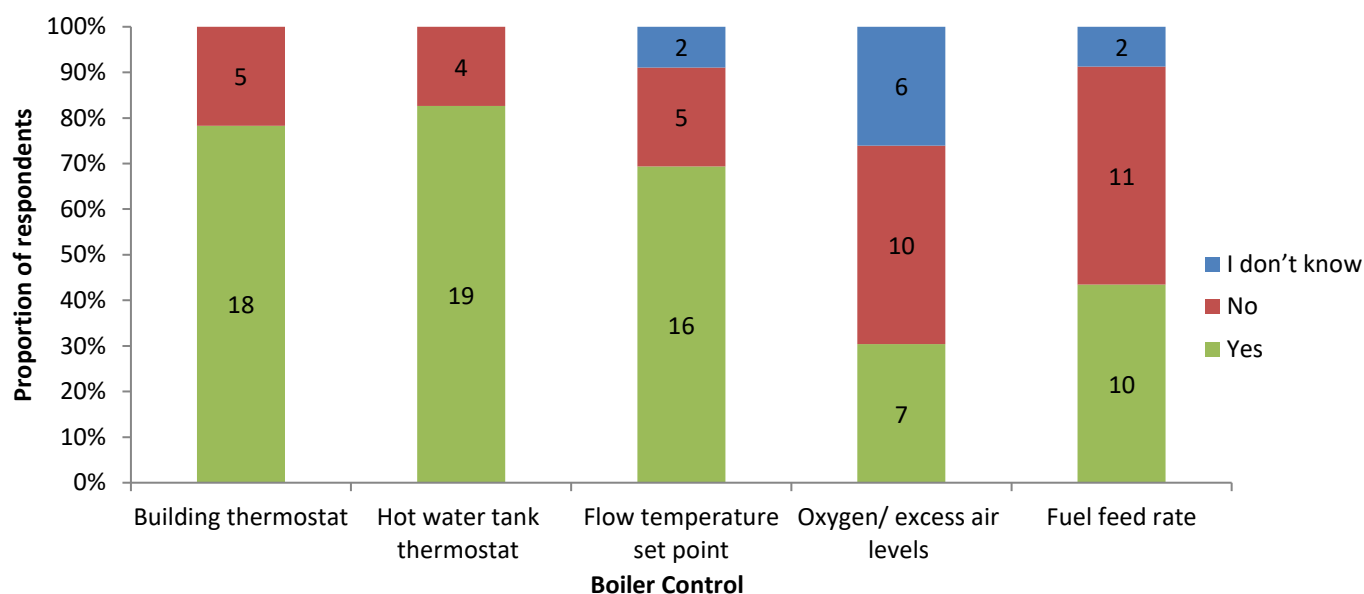


Figure 14 “What sorts of options and controls on the boiler do you know how to change?” (n=23) (Appendix 4 Question 16)

4.8 Fuel

Biomass boilers can utilise a range of fuel and field trial participants may choose to self-supply or purchase fuel depending on their needs and abilities. This section explores the main operators’ behaviours related to fuel including the type of fuel used and how it is stored.

14 (64%) out of 22 respondents purchase their fuel from a supplier, six (27%) out of 22 respondents self-supply and two (9%) out of 22 respondents use a combination of the two. This shows that some survey respondents don’t just use one method of fuel supply. They also don’t all use only one type of fuel as one out of 23 respondents used more than one fuel type as there were 24 responses from 23 respondents. Some boilers have the potential to burn two types of fuel, if set up by the manufacturer this way. However, in this case the respondent that used more than one type of fuel is more likely to have been using small amounts of pellets as kindling. 14 (61%) out of 23 respondents use wood pellets as fuel for the biomass boiler.

Of the 16 respondents who do not self-supply, five (31%) believed the most significant criteria when choosing a fuel supplier is that the supplier is a recommended source by BEIS or an installer or service company. Four (25%) out of 16 respondents felt that the quality of the fuel and cost were the most important criteria (Table 10). The fuel type, whether it is locally sourced, and lead times for delivery were not concerns for these respondents.

Of the 16 respondents who purchase fuel, 14 (88%) out of 16 respondents get their fuel delivered as and when required – meaning there is no strict ordering schedule. Only two (12%) out of 16 respondents scheduled their deliveries to be regular; one (6%) out of 16 received them fortnightly, the other one (6%) out of 16 received them monthly. Eight (50%) out of 16 get their fuel directly blown into their fuel store and five (31%) out of 16 received fuel on a pallet (Table 11). No respondents received fuel from bulk bags or from individual small bags.

Five (36%) out of 14 respondents reordered stock when it is 1 week from empty (Figure 15). However, the rest of the respondents varied how often they reordered fuel stock. Two (14%) out of 14 respondents wait until their fuel stores are empty. Whilst it's likely that several sites had back-up boilers such as LPG or natural gas, and so could run the biomass boiler until empty, it's assumed that respondents meant "very little fuel left" rather than "absolutely empty". Two (14%) out of 14 reorder when stock is one month from empty and 3/14 (21%) reorder fuel when stock is 2 weeks from empty. Two (14%) out of 14 selected the "other" category and stated that reordering fuel "is run in conjunction with other sites" and "[the respondent] buys seasoned logs usually one year in advance".

Table 9 "What sort of fuel do you use in your boiler?" This was a multiple choice question; 24 responses were recorded from 23 respondents (n=23) (Appendix 4 Question 18A)

Answer category	Proportion of Responses (n=23)	Percentage of Responses
Wood chip	7	30%
Wood pellets	14	61%
Wood logs	3	13%

Table 10 "What sort of considerations do you take in to account when deciding upon a fuel supplier?" (n=16) (Appendix 4 Question 18b)

Answer category	Proportion of Responses (n=16)	Percentage of Responses
Fuel availability	3	19%
Recommended source	5	31%
Cost	3	19%
Delivery lead times	0	0%
Local	0	0%
Type of fuel	0	0%
Fuel quality	4	25%
Moisture content	0	0%
None of the above	1	6%

Table 11 How is the fuel for your boiler delivered?" (n=16) (Appendix 4 Question 18e)

Answer category	Proportion of Responses (n=16)	Percentage of Responses
Small bags (e.g. 10-20kg) delivered individually	0	0%
Small bags (e.g. 10-20kg) delivered on a pallet	5	31%
Bulk bags (e.g. 1 tonne)	0	0%
Bulk loose delivered by lorry/tipper truck	2	13%
Bulk loose delivered by lorry and blown in	8	50%
Other (please specify)	1	6%

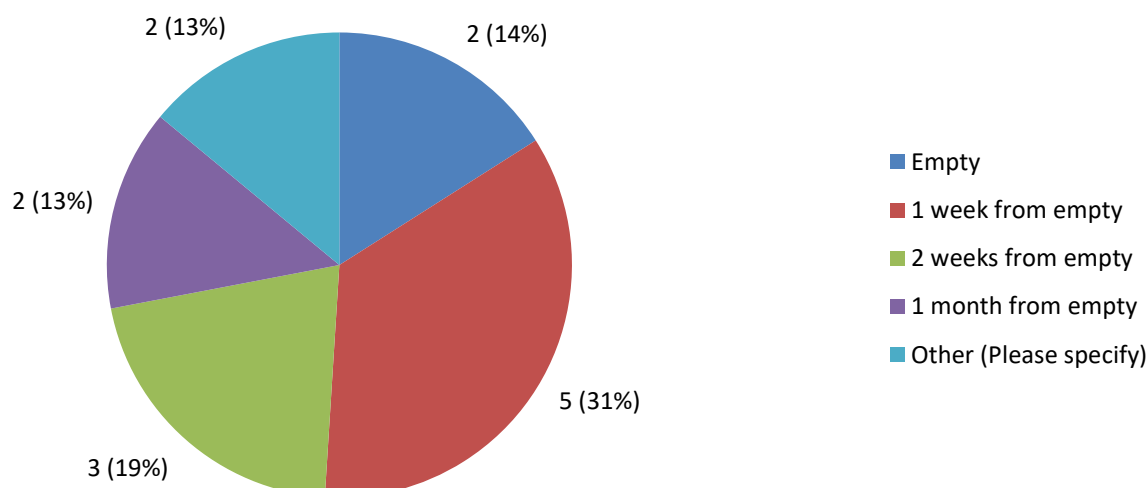


Figure 15 "How low does your stock get before you reorder?" (n=14) (Appendix 4 Question 18d)

4.8.1 Fuel Storage

11 (48%) out of 23 survey respondents immediately store fuel in an enclosed store e.g. a hopper (Table 12). Five (22%) out of 23 respondents kept immediately kept fuel loose in a building such as a barn. Two (9%) out of 23 selected the "other" category and stated they stored fuel in a "silo" and a "garage".

Seven (30%) out of 23 respondents considered their ability to access the fuel as an issue when deciding where to store fuel six (26%) out of 23 respondents stated the storage area's proximity to the boiler was a consideration five (22%) out of 23 respondents reported that maintaining the moisture content was a consideration (Table 13)

Eight (36%) out of 22 respondents check the moisture content of their fuel deliveries whereas fourteen (64%) do not. Four (18%) out of 22 respondents believe there are factors that stop them maintaining the moisture content of their fuel. Those respondents highlighted key barriers to keeping fuel at the desired

moisture content as; rain, lack of appropriate facilities, drying time and inability to change moisture content of delivered fuel. One respondent did not answer questions related to moisture content.

Table 12 “When the fuel is delivered, where do you immediately store it?” (n=23) (Appendix 4 Question 19)

Answer category	Proportion of responses (n=23)	Percentage of Responses
Left out in the open	2	9%
Kept outside under a roof shelter (e.g. lean-to)	1	4%
Kept loose inside a building (e.g. barn)	5	22%
Kept in an open store in a building (e.g. a container)	0	0%
Kept in an enclosed store	11	48%
Other (please specify)	4	17%

Table 13 “What sorts of considerations are taken in to account when deciding where or how to store your fuel?” (n=23) (Appendix 4 Question 20)

Answer category	Proportion of Responses (n=23)	Percentage of Responses
Environmental conditions	4	17%
Access (including delivery)	7	30%
Proximity to boiler	6	26%
Building restrictions	0	0%
Moisture Content	5	22%
Other (Please specify)	1	4%

4.9 Satisfaction

Satisfaction is a valuable determinant of the success or failing of a programme; this section presents results from the survey questions which sought to explore the respondents’ expectations, thermal comfort and general satisfaction.

17 (74%) out of 23 respondents use the amount of fuel they expected and 18/23 (78%) respondents spend the amount of money on the boiler that they expected. Five (21%) out of 23 respondents use more fuel than expected (Table 14). One respondent stated in the further comments section of the survey that:

“We were totally misinformed and misguided about the level of reimbursement we would receive in RHI compared to the cost of the fuel and installation. If we had known the true cost of the system and the fuel, we would not have installed this.”

Survey Respondent

Most respondents feel that the boilers provide good warmth, the building as having a comfortable temperature overall and the building to have an acceptable temperature (Figure 16a-c). Only one (5%)

out of 19 respondents found the overall temperature of the building uncomfortable and only one (5%) found the building temperature very unacceptable.

A mean value of 6.1 out of 7 was calculated for two statements which sought to explore the respondents perception of whether the decision to install a biomass boiler was “a wise decision” and if they “did the right thing” in doing so (Figure 17). This shows good satisfaction among respondents. There was also considerable impetus to recommend the biomass system to a friend or colleague, as this statement returned a value of 5.8 out of 7.

4.0 out of 7 was the mean value calculated for the statement which explored if respondents would have installed the boiler if the RHI had not existed. This was the lowest satisfaction calculated and even though has a neutral value it is significantly lower than others which suggests the RHI was important in the decision making process to install a biomass boiler at the sites involved in the trial. All respondents to the survey claim the Renewable Heat Incentive (RHI) for their biomass boiler.

Table 14 “Does the amount of fuel/ money you use differ from that which you expected?” (n=23) (Appendix 4 Question 20)

Fuel	Proportion of Responses	Percentage of Responses	Money	Proportion of Responses	Percentage of Responses
1 A lot less	0	0%	1 A lot less	0	0%
2	0	0%	2	0	0%
3	1	4%	3	2	9%
4 Expected amount	17	74%	4 Expected amount	18	78%
5	3	13%	5	3	13%
6	1	4%	6	0	0%
7 A lot more	1	4%	7 A lot more	0	0%

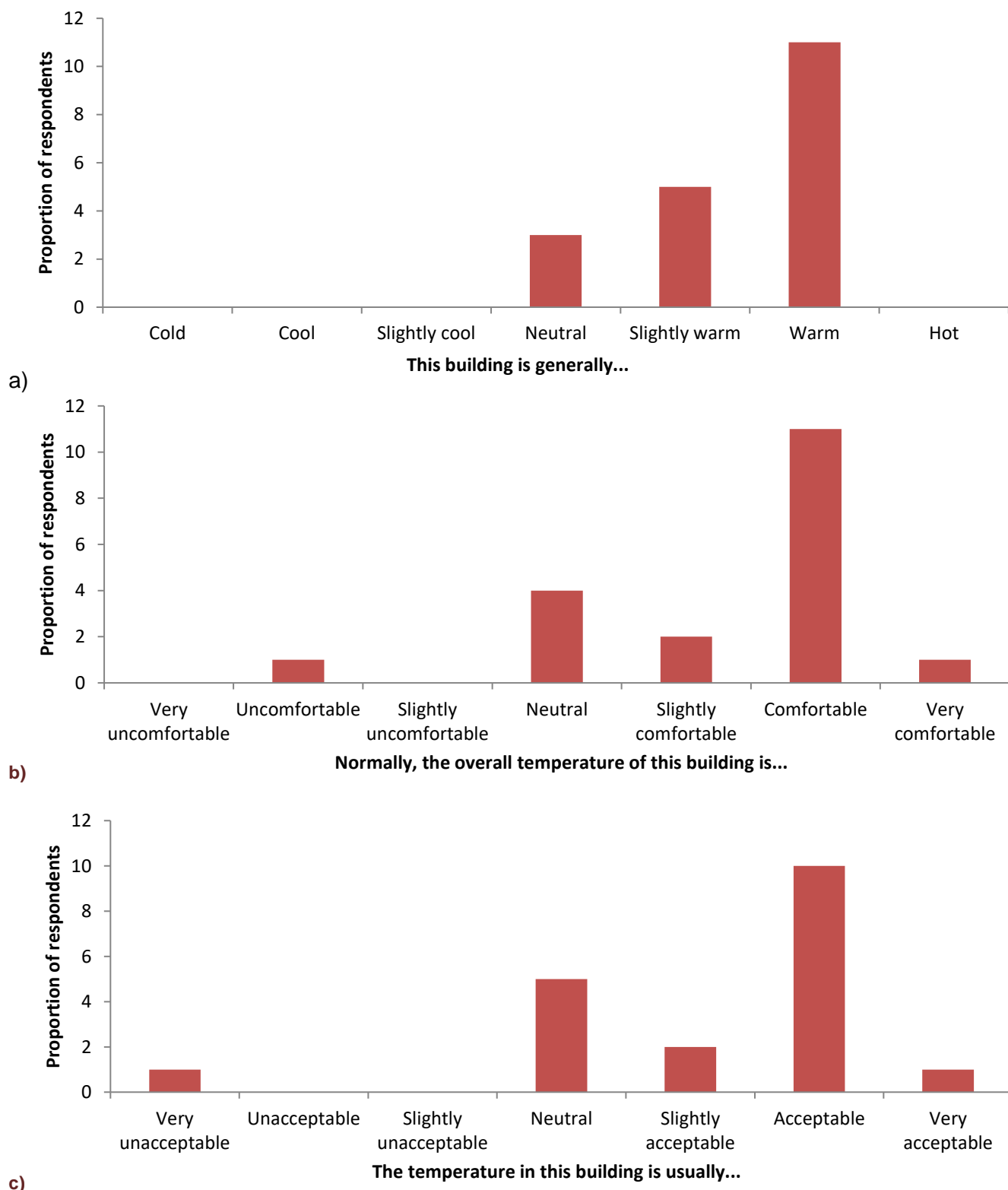


Figure 16 Reported perceptions of private biomass boiler operators of the general building temperature (n =19). a) “This building is generally...” b) “normally, the overall temperature of this building is...” c) “The temperature in this building is usually...” (Appendix 4 Questions 23, 23a, 23b)

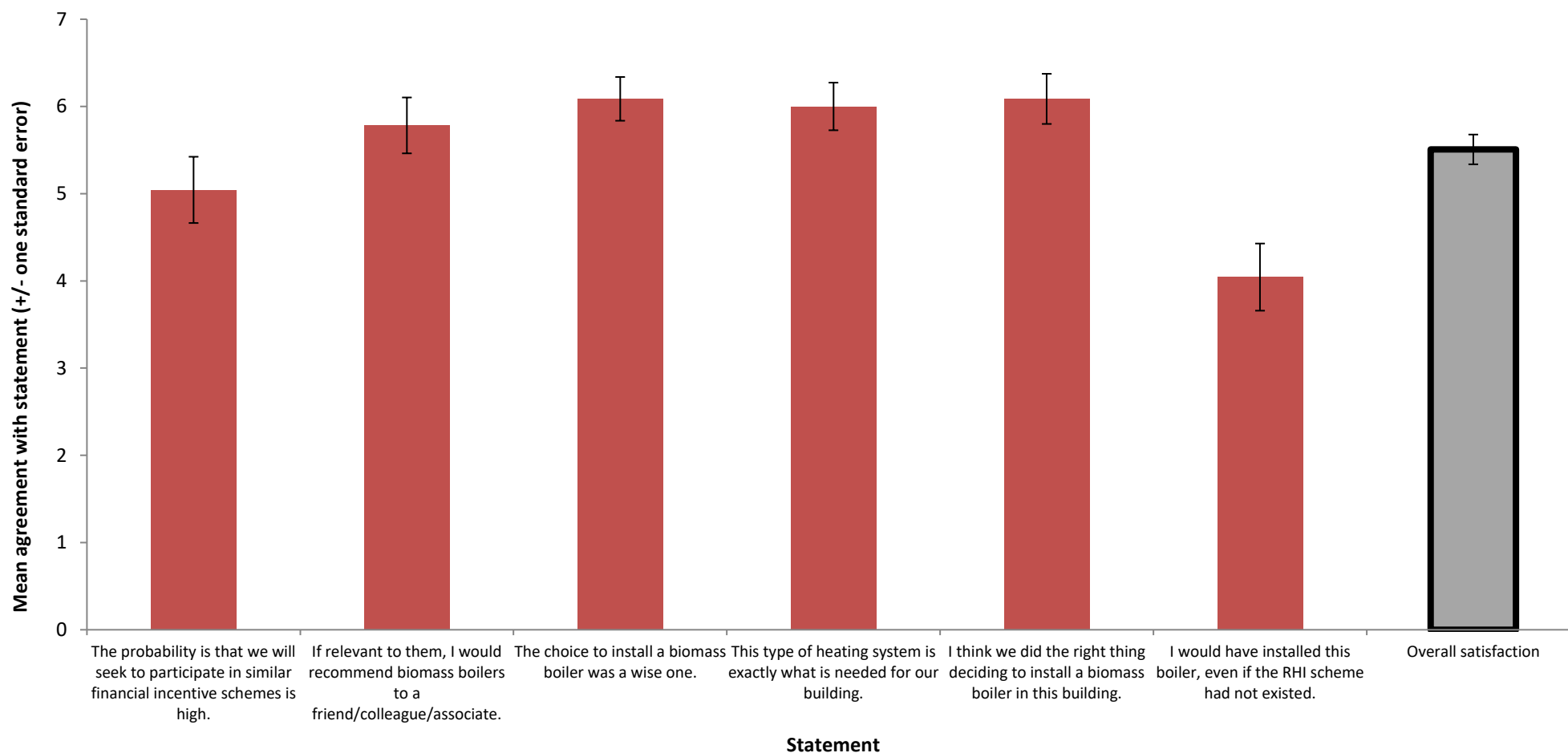


Figure 17 Mean satisfaction values based on a Likert scale question where respondents were asked to rate on a scale 1-7 where 7 is strongly agree and 1 is strongly disagree (n=23) (Appendix 4 Question 24 a-g)

5 Discussion

This section critically evaluates the results which have been presented in Section 4 and provides recommendations based on the findings.

5.1 Main operator information

The industry and profession of the main operator of the biomass boilers is considerably varied. Although most are located in rural locations this does not mean the technology is only used by those in traditionally rural professions. Teachers, hoteliers, planners and energy experts involved in this field trial consider themselves to be the main operator.

The frequency in which the main operators spend time on activities related to the boiler is varied, although 13 (65%) out of 23 respondents spend at least some time on it every few days. This variation might be due to the range and size of each individual system. Some systems serve housing estates and others serve small bed and breakfast accommodation so there is also considerable variation in the scale of systems within among sites in the trial.

5.2 Purpose

All respondents stated they were using their boiler to heat buildings. 16 (70%) out of 23 of the boilers are used to heat residential buildings and 20 (87%) out of 23 boilers are used to heat water. These results suggest that predominantly boilers have multiple end uses for the heat they produce.

This research also explored the rationale behind installing a biomass boiler. According to these results, the most important reason for installed a biomass system is to realise financial savings on fuel expenses (Figure 4). The RHI was the second most important reason given by respondents. This suggests that in reality the biggest single driver for installing a biomass boiler is the financial aspects of its operation. However, there was no clear relationship between these two options (Figure 5), which is a surprising result. Self-sufficiency, company strategy and lack of mains gas access are of moderate importance to decision to install the biomass system. Future investigations into the rationale could be expanded to consider if the RHI is more of a draw for domestic or commercial clients; all respondents claim the RHI even if they stated it wasn't the main reason for installing.

Even though the least important reason for installing a biomass system was to replace a faulty or existing heating system; habit discontinuity theory states when habits are disturbed individuals are more receptive to new information and adopting new behaviours (Verplanken and Roy 2016). It is recommended that this theory could be investigated to understand when biomass boilers are installed based on the life course of the recipient i.e. if they have recently moved house or not, as they may provide additional rationale for why people install a boiler.

An explanation was attached the thermal store question in the survey to negate any lack of technical knowledge in answering Question 5 (Appendix 4). Even after this explanation, four (17%) out of 23 respondents stated they didn't have a thermal store, as stated in the text in Section 4.2.

5.3 Induction

The data shows that inductions are being carried out by the boiler installers in 87% (20 out of 23) of installations, however this is not the only route for information to be received by the operator. The manufacturer and boiler maintenance company also provide training in some circumstances.

A curated set of recommendations and best practice to improve boiler performance (both from the point of view of the operator and from the point of view of efficiency and pollutant emissions), would help ensure a consistent message reached operators. A potential route for sharing this best practice would be to go through this network of trusted messengers comprising of installers, manufacturers and service contractors. Short-term post-installation support should also be provided to ensure any immediate operational challenges are tackled; this would limit the potential for poor operational behaviours to become entrenched.

In terms of the information received, 20 (87%) out of 23 survey respondents received a full manual and general advice was also provided to the main operator (Figure 7). Non-written advice was also provided by the installer, which is a potentially unreliable and inconsistent information route; especially if the main operator leaves the site. Despite this, non-written advice was still one of the most common information routes. A codified central list of frequently asked questions or common solutions to operational challenges would reduce dependency on inconsistent verbal advice for optimum operational behaviours. In order to understand what kind of verbal advice is given by the installers more investigation is required.

The majority of respondents did not think any further information was required in the induction they received (Figure 8). However, 11 (48%) out of 23 respondents indicated that they would like to have received more information which included: general advice, a service contractor list and ongoing professional support. This suggests that among the respondents there was variation in the kinds of and degrees to which specific information was provided to the main operators.

5.4 Maintenance, cleaning and servicing

These results show that the majority of respondents have positive perceptions about the quickness, ease and simplicity of their boiler's maintenance (Figure 9). No respondent was "Very negative" regarding the criteria but there was variation within respondent's individual experiences, which was highlighted by one respondent:

"We've just been unlucky with breakdown issues but very easy to maintain"
B&B owner

Notably three out of 16 interview respondents from phase one of the research mentioned prolonged maintenance challenges, which in some cases raised potential safety issues:

"We've had various faults and no one seems to know what it is such as when it was cold the whole boiler room would fill with smoke"
Facilities manager

"We've had issues with delivery equipment...agitators, refractory etc. [It's] Difficult without full time team going in."
Commercial Heating Manager

*“When first installed we had it working 1 week out of 3 but the day to day is usually fine just the maintenance of it is difficult; sensors [and] the coupling on auger kept breaking. So needed parts from [abroad].”
General Maintenance Manager*

28 (62%) out of 45 boiler breakdown issues were not covered by warranty. More investigation is needed to understand if this is due to warranty expiration or not meeting the warranty criteria. However, this does lead to considerable maintenance costs for the operator or their employer. Eight (18%) out of 45 of breakdowns were caused by broken augers with the refractory, sensors and motors also being reported as also having considerable issues among survey respondents (Figure 10). Augers are the main moving part which can be affected by poor fuel quality which may be the cause.

22 (96%) out of 23 survey respondents ensure regular maintenance takes place either every six months or 12 months. Despite this, five out of 22 (23%) survey respondents have boilers which require additional maintenance as often as once a month and four (18%) out of 22 carrying out additional maintenance every week. The reasons for this could be numerous and were not explored in this survey but might be due to a low quality of parts, poor design or incorrect operational behaviours.

A surprising result from the survey is nine (39%) out of 23 respondents don't have a contract with a maintenance/ service company. Six (27%) out of 23 respondents carry out cleaning activities as and when required rather than having a strict schedule (Table 5). This is a surprising result as the manufacturer's instructions should say how often cleaning should be performed and any negative impact on performance should this not be carried out. Trusted messengers (the manufacturer, installer, service company) help inform a significant amount of survey respondents about when and how they should clean their boiler.

5.5 Operations

Only 10 (43%) out of 23 of survey respondents were aware of soot or smoke coming from the boiler which is not the norm as most respondents see little evidence of either, according to the data. Noticing smoke is more common than any burning smell. It is noted that when smoke is visible, the pollutant emissions of dust are like to be increasing to near 150mg/Nm³ (Ricardo Energy & Environment 2016) which would usually result in the dust emission being greater than 30g/GJ (the limit assumed by the RHI). It would appear that operators may not be aware that smoke should only be visible briefly during startup and shutdown and should not be prolonged.

Except maintenance, there was no singular operational issue that stood out, with 12 (52%) out of 23 respondents stating they did not have any other issues. However, this does not necessarily signify that there are no other operational challenges but more that additional challenges are varied from boiler to boiler with no 'one size fits all' action being possible to solve them. Four (57%) out of 7 reported that they had not found any solutions to reducing operational challenges they experienced. One potential reason for this could be system design which was alluded to in the original interview responses:

“We had a lot of problems with system design... designers don’t understand the operations; they need to see the design challenges to operation. It should be specified, when we got this type of boiler, that we need advice from a professional/ manufacturer about how to maintain and operate it so we can get the full life cycle of 30 years out of it”
Commercial Heating Manager

“If you want to increase uptake then put more thought into [system] design. If I had to call someone out every time I would be very unhappy. Check quality”.
Energy Efficiency Consultant

18 (86%) out of 21 survey respondents use ash as an additional resource as fertilizer or by adding it to compost which shows some behavioural consistency. Although there is variation in the frequency of ash removal and the method in which it is carried out. This may also be due to the variety in boiler design, previously mentioned.

The results highlights that there is variation in the colour characteristics of ash which is likely due to the wide range of fuel which is used by respondents and the combustion performance of the boiler. However, the texture is generally more fine than coarse, and unburnt material isn’t very common.

The majority of respondents know how to change the building thermostat, the hot water tank thermostat and the flow temperature set point. Fewer respondents were aware of how to adjust the oxygen levels and the fuel feed rate. Among the respondents, running the boiler at reduced output during the summer months is very common with 17 (74%) out of 23 of respondents doing this, as mentioned in the text in Section 4.7.

Wood pellets are the most common fuel with 14 (61%) out of 23 of respondents reporting using them as a source of fuel. One respondent used a combination of fuel types which is unusual, although some boilers can burn more than one type of fuel if the boiler settings are changed.

A trusted source, fuel quality, availability and cost are the fundamental considerations that respondents deliberate when choosing a fuel supplier, which were relevant for the 16 (73%) out of 23 respondents who don’t solely rely on self-supply. As with many aspects of the biomass boiler systems, fuel and its delivery is dependent on the system requirements. For example, a small boiler used for domestic purpose is unlikely to have bulk loose fuel delivered and blown into a storage container. 11 (48%) out of 23 respondents store fuel immediately after delivery in an enclosed store such as a hopper which would help them to maintain its moisture content but the decision to do this is dependent on the site’s storage capacity. Three (13%) out of 23 respondents are storing fuel in places which are more likely to be exposed to bad weather which in turn affects the performance of the fuel by altering the moisture content. Access and proximity to boiler are the two most common considerations regarding where and how to store fuel and it may not be possible for the main boiler operator to alter these aspects.

5.6 Satisfaction

Survey respondents are positive about the boiler using the expected amount of fuel. 16 (74%) out of 19 respondents agreeing that it was comfortable to some extent and 13 (69%) out of 19 respondents

agreeing the temperature was acceptable to some extent. The majority of respondents stated that their building is warm as well as acceptable and comfortable. This includes six (26%) out of 23 respondents who work in agriculture and use the boiler for heating buildings, such as poultry sheds, which are often kept above 30°C (Hulzebosch 2006).

This is an interesting finding – it is postulated that the cost saving achieved through the use of biomass rather than more expensive fuels (such as oil or LPG) allows some buildings to be heated to higher and more comfortable temperatures than could have previously been achieved cost-effectively. This means the energy use actually increases and this reduces the potential carbon savings – a phenomenon is known as ‘comfort taking’.

The level of potential recommendation among field trial participants was high according to the survey results; with a mean value of 5.8 out of seven. There were high levels of satisfaction about whether or not the installation was a good decision, with a value of 6.1 (Figure 17). Considering the number of maintenance issues, this is a surprising result, however one that is a testament to the systems perceived ease of use and how appropriate the technology is to the sites involved.

The lowest satisfaction value of 4.0 was calculated based on ratings given to the statement which explored the willingness to install a biomass boiler if the RHI had not existed. This suggests that the RHI was an important factor in the decision to install the boilers at field trial sites which conflicts with previous findings where only 7/23 respondents highlighted this as a reason. It seems that respondents did not see the RHI as the single most important reason to install the system, but would have been less likely to install the system without the RHI. This is illustrated by one respondent from the “other comments” section:

*“Happy with boiler. I couldn't afford to install without the heat incentive.”
IT Business Relationship Manager*

The high level of satisfaction was also alluded to in the stage one interviews with respondents remarking:

*“Mega impressed with the whole system, so good we've encouraged our neighbours to get one as well”
Livestock Farmer*

But this high level of satisfaction is not uniform across all respondents:

*“We have issues finding a supplier that can access our property to a point where we may have to revert back to using an oil boiler. We were totally misinformed and misguided about the level of reimbursement we would receive in RHI compared to the cost of the fuel and installation. If we had known the true cost of the system and the fuel, we would not have installed this.”
Transport Planner*

5.7 Challenges for the evaluation

When participants are recruited for the field trial contact information is collected. However, often this contact information was insufficient for the purposes of this social research as it was outdated or not a

preferred method of contact from the participant's point of view. A particular barrier became apparent when the management and/or service of the boiler was handled by a property or facilities management agent. Often it was the agent's contact information which had been recorded and on several occasions this meant contacting the main boiler operator did not occur despite requesting further contact through the agent. Availability of the contacts due to irregular working patterns, particularly in rural areas, was also a time-consuming challenge.

Several contacts were non-responsive to either email or telephone communication regarding taking part in the social research during either phase. From the non-interviewees only three respondents fully completed the survey which suggests a bias in favour of those who had been interviewed in stage one. All 13 interviewee respondents fully completed the survey. It is assumed, as the stage one sample was self-selecting, that these results are biased towards those who are more engaged in the programme.

Some respondents, although willing to participate in the interview process, had expected to receive data from BEIS regarding the boiler's performance at an earlier stage in the field trial. One participant suggested it would be advantageous to provide a report which compared their boiler performance to the others involved in the field trial.

6 Conclusion

This research was conducted to understand behaviours of the main boiler operators. There are a wide range of behaviours being used across all day to day operations of the boiler within ash removal activities, type of fuel and its use, as well as cleaning regimen. This is most likely due to the diversity in sites and industry in which the boiler is being used.

There are some consistent operational trends across sites. Normally installers, manufacturers or maintenance companies provide information relating to the boiler's operation; therefore, it is important to ensure they are sharing consistent best practice advice with boiler operators. Respondents suggested that more information could have been provided to help ensure the smooth operation of the boilers, such as a BEIS-recommended list of maintenance companies, which would be effective if disseminated via the boiler installers. A short-term support service could be implemented by manufacturers or installers to ensure poor operational behaviours do not become ingrained.

Generally, there was a positive perception of the boiler performance and positive satisfaction with its operation, however there are examples of where individuals have been unhappy with their system and its operation.

There are many issues raised in this research which should be investigated further such as what the favourable conditions are for having a biomass boiler installed, why the majority of repairs haven't been claimed on warranty and if there are actions which operators could take to reduce breakdowns, particularly of moving parts. The creation of a set of design guidelines would be beneficial to help standardise manufacturing, installation and distribution practices across the market as well as operator guides to disseminate best practice. The collation of additional reference material for manufacturers, installers, distributors and operators would also help provide further detail on the biomass boiler systems.

7 Appendices

7.1 Appendix 1 Telephone interviews

#	Purpose	Question	Response Options
1	Intro	Hello, my name is [name] and I am a researcher calling on behalf of [project name]. Is [contact name] about?	Yes; No
2	Intro	IF 1 = NO, when can I call back/where can I reach them?	Open text
3A	Check relevance	Are you the main operator of the boiler, either solely or jointly?	Yes; No
3B	Check relevance	IF 3A = NO Who is the main operator and how can I contact them? END INTERVIEW	Open text
4	Data protection and ethics	The aim of this interview is to document how you currently use your biomass boiler, and your motivations and reasons for doing so. This is to provide us with more information when we analyse the performance of your biomass boiler at the end of the field trial. It should take about 20 to 30 minutes to complete. Your answers will be kept confidential, and will be shared with a joint Kiwa, Energy Saving Trust, and Department for Business, Energy and Industrial Strategy (formerly DECC) research team for the specific purpose of research. Your answers may also be provided in an anonymised form in the final report of the field trial or in a selection of case studies. The anonymised answers will be provided alongside details of the type of technology you have installed at your site and the	Yes; No Extra box for if they say no to sharing the feedback.

		<p>performance data, however no information that can identify you, your site, or the make/model of the boiler installed at your site will be published.</p> <p>If we conduct further research interviews and if at the end of the trial we have recommendations for improvement relating to your site, then we may share some of your responses with you or with other appropriate people within your business or household. If you would prefer that we do not do this, please let us know.</p> <p>Finally, the interview is entirely optional and you can choose to withdraw from it at any time.</p> <p>Are you happy to proceed?</p>	
5		What is your position/role?	Open text
6		<p>ASK IF BUSINESS CUSTOMER (NON-DOMESTIC)</p> <p>How does the operation of the boiler fit into your role?</p>	Open text
7		Which of the following best describes how often you spend time on activities related to the biomass boiler?	<p>More than once a day</p> <p>Daily</p> <p>Every few days</p> <p>Weekly</p> <p>Monthly</p> <p>Every few months</p> <p>Every six months</p> <p>Once a year or more</p>
8A	Check existing knowledge	What do you use the biomass boiler for?	Open text

8B		Why was a biomass boiler chosen for this purpose?	Open text
9	Check existing data	Does your system have a thermal store, which is a place for storing and managing renewable heat until it is needed, for example, a large well-insulated cylinder usually besides the boiler that is often called a buffer or accumulator tank? This should not be confused with a regular hot water tank.	Yes; No
10A		Were you working there when the boiler was installed?	Yes; No
10B		IF 10A = YES Can you please describe the handover process you got from the installer? I.e. what advice, training, manuals, etc did you get?	Open text
10C		IF 10A = NO Can you please describe the handover process you got from your predecessor? I.e. what advice, training, manuals, etc did you get?	Open text
10D		What would you have like more of in the handover?	Open text
10E		What sorts of things do you have trouble with when operating your boiler?	Open text
10F		What sorts of solutions have you come up with to make it easier to operate your boiler?	Open text
11A		What sorts of options and controls does your boiler have that allows you to adjust how it works?	Open text
11B		Does your boiler behave in the way you'd expect? If not, please explain.	
11C		Do you mothball your boiler (i.e. switch it off completely) for the warmer months?	Yes; No
11D		If boiler mothballed: how do you mothball the boiler and do you use alternate sources of heat during this period?	Open text

12A	Check existing knowledge	What sort of fuel do you use in your boiler?	Drop down menu: wood pellet, wood chip, wood log
12B		How do you store the fuel for your boiler?	Open text
12C		What sorts of considerations are taken in to account when deciding where or how to store your fuel?	Open text
12D	Gather information on each contact	How much fuel do you currently have? (Please describe your current fuel level in as much detail as possible, e.g. half-way up the sides of the bunker, approx. 1m below filling hatch)	Open text
12E		Do you buy fuel from a supplier or do you self-supply?	Drop down menu: purchase fuel, self-supply fuel
12F		IF 12E = SELF SUPPLY Where do you source your fuel from?	Open text
12G		IF 12E = SELF SUPPLY Why do you get your fuel from there?	Open text
12H		IF 12E = PURCHASE: Which supplier do you use?	Open text
12I		What sort of considerations do you take in to account when deciding upon a fuel supplier?	Open text
12J		How is the fuel for your boiler delivered?	Open text
12K	Gather information on each contact	Have you changed fuel supplier this calendar year (2016)?	Yes; No
12L		IF 12K = Yes	

		Why did you change fuel supplier?	
12M		How do you decide when to reorder more fuel stock?	Open text
12N		IF 12M IS NOT FOLLOWING SOME AUTOMATIC PROCESS. How low does your stock get before you reorder?	Open text
12O		Your fuel should have an ideal moisture content. Is there anything that prevents you from keeping your fuel at the ideal moisture content?	Open text
13A		What regular maintenance does your boiler require? (Gather as much detail as possible, from regular cleaning to annual servicing, who by, etc.)	Open text
13B		How do you remove the ash from your boiler? (Do you empty an ash bin or manually clean?)	Open text
13C		How often do you remove ash from your boiler?	Open text
13D		What does the ash look like? (Fine/Coarse, Colour, Glassy lumps, etc.)	Open text
13E		How often do you clean the smoke tubes of your boiler? (the smoke tubes are the pipes above the combustion chamber – they may be cleaned automatically by pneumatics)	Open text
13F		What sorts of considerations do you take in to account when deciding how and when to clean your boiler?	Open text
13G		Do you have a service contract with a boiler maintenance company?	Open text
13H		Have you ever noticed any smoke/soot/smells coming from the boiler or flue or chimney? Can you describe them?	Open text
13I		Has the boiler had any breakdown or reliability issues?	Yes; No
13J		If so, what part, how much did it cost to repair and was it covered by warranty?	Open text

13K		How easy is it to maintain the boiler? If difficult, please explain in what way.	Open text (N.B. maintenance work may involve ordering of replacement parts)
14A		Does your boiler behave in the way you'd expect? If not, please explain.	Open text
14B		Do you have any other interactions with your boiler that we haven't discussed already?	Open text
14C		Do you have any comments that you would like to make about your boiler?	Open text

7.2 Appendix 2 A selection of results- verbatim

#	Question	Response Options	R1	R2	R3	R4	R5
3A	Are you the main operator of the boiler, either solely or jointly?	Yes; No	Yes	Yes	Yes	Yes	Yes
5	What is your position/role?	Open text	Commercial Heating Manager	Site supervisor	Facilities manager	Farm Manager	poultry farmer
6	How does the operation of the boiler fit into your role?	Open text	Manages 8 biomass schemes and oversees full time teams	Put all meter readings on RHI. Fill every 3 weeks in winter. Maintenance	Come under environmental performance. Big targets to reduce use reduce 20%	Fine. Keep it running. I put the wood in it	wood on farm to tidy up - need to do something with waste wood and need to heat his house and fathers, also use it for breeding chickens - they have underfloor heating, and processing chickens ie hot water
7	Which of the following best describes how often you spend time on activities related to the biomass boiler?	More than once a day; Daily; Every few days; Weekly; Monthly; Every few months; Every six months; Once a year or more	More than once a day- de-ashing service, Heat services team. Fuel, once every 4 days/2 weeks depending on time of year. Automatic meter readings weekly. As and when to monitor problems	Weekly	Daily	More than once a day	weekly
8A	What do you use the biomass boiler for?	Open text	To provide 100% demand of heat for 80 bungalows.	Two buildings hot water and heating	Provide hot water and comfort heating (underfloor and radiator system) at visitor centre	Heating the two houses and drying grain	See Q6

8B	Why was a biomass boiler chosen for this purpose?	Open text	Part of two schemes at the time- 166 flats converted to biomass as part of funding and council energy strategy.	Two biomass boilers installed two weeks short of RHI so we decided to replace	To provide that kind of energy would be expensive but also we want to achieve 50% renewable by 2020.	Because it's a very good use of wood we already have on the farm.	in to renewable energy so a good match to him
9A	Does your system have a thermal store, which is a place for storing and managing renewable heat until it is needed, for example, a large well-insulated cylinder usually besides the boiler that is often called a buffer or accumulator tank? This should not be confused with a regular hot water tank.	Yes; No	Yes	Yes	Yes	Yes	yes
10A	Were you working there when the boiler was installed?	Yes; No	No	Yes	No	Yes	yes
10B	Can you please describe the handover process you got from the installer? I.e. what advice, training, manuals, etc did you get?	Open text		Manual from manufacturing with cleaning methods, helpline, breakdown		We got booklet for it, but actually running it, we just got the booklet.	just a manual and a brief chat
10C	Can you please describe the handover process you got from your predecessor? I.e. what advice, training, manuals, etc did you get?	Open text	Predecessor passed away on job. Not much, only from previous work		Manual from Royal Energy and Hertz. Training guides for staff which do weekly clean. List of fault codes		
10D	What would you have like more of in the handover?	Open text	Need information from manufacturer about operations and maintenance. Which companies are experts etc	Nothing else needed	Where the heat meter was. Not claiming RHI initially. Risk assessments- unsure if that was covered in installation	Bit more advice on the use of it. I would've liked an easier start up procedure.	yes a bit more of a run through

10E	What sorts of things do you have trouble with when operating your boiler?	Open text	Delivery equipment.	Heat ring cracked, and one pump broke. Day to day is fine	Majority of problems are with the hopper- in a historic building so is limited in how is made, listed building consent. Ply line hopper not extraction or earthing point. Angle of pellets was wrong and steel was heating up. Dust collections causes issues. About 1 ton in the hopper- carbon monoxide risk with going in to clean it out. Field glue around roof line setting off fire alarm	Don't really have a lot of trouble at all. It's a good boiler.	computer controlled and knowing how to put adjustments through the screen - occsasionally flashes up an error,
10F	What sorts of solutions have you come up with to make it easier to operate your boiler?	Open text	Requires engineers. Twin pumps.	When we had original boilers we changed suppliers of fuel because the melamine was causing pellets to congeal	Shape change of hopper and change lining. Lots of discussions about pressure for blowing in pellets- no definite ans wre on pressure to blow in pellets.	Good question. Not sure.	normally press confirm and it seems to be happy
11A	What sorts of options and controls does your boiler have that allows you to adjust how it works?	Open text	Adjust temps lower during summer and higher during winter. On a trend system but its not that good. Boiler is never off as it is the primary fuel source for 80 bungalows.	Temperature adjustment	Get contractors to adjust. We change temp on manifold for heating and heating times. Everything is on weather optimiser. Lack of awarness about controls (wo) in early days	Thermostats on the tank. Thermostats on the store in the house. I can adjust the temperature that the boiler runs at.	don't need adjust
11B	Does your boiler behave in the way you'd expect?	Yes; No	Yes	Yes	No	Yes	yes
11C	What is different to what you'd expected?	Open text			Various issues with overheating. Min temp and max temp close together- shaker spring broke because of this. Design fault with model-		

					ignited compost heat. On really cold days it doesn't cope with the demand.		
11D	Do you mothball your boiler (i.e. switch it off completely) for the warmer months?	Yes; No	No	Yes	Yes	non domestic RHI	no
11E	How do you mothball the boiler and do you use alternate sources of heat during this period?	Open text		Turn off all the radiators and air handling units. But leave hot water for sports	Only when we have to empty hopper- Heating in may and aim to get hopper empty by september		
12A	What sort of fuel do you use in your boiler?	Open text	Wood chip	Wood pellets	6mm wood pellet em+	Solid wood	wood chips
12B	How do you store the fuel for your boiler?	Open text	Just in bunkers- purpose built with agitators to feed into boilers	In a hopper in the plant room, all in the energy centre	All stored in hopper	In a big pile in a shed with three walls.	some stored in chip form, mainly log form and chip it down
12C	What sorts of considerations are taken in to account when deciding where or how to store your fuel?	Open text	Boiler house has to be taken into consideration. Have to make sure we have access 40m3 of space to we can tip. Tip at eye level- quickly	We didn't make that call	Damp	Want to keep it dry and suitable to go in to the boiler. Mentioned the ideal moisture content.	would like a drier place, convenient to loading and loading, near to the boiler
12D	Roughly, how much fuel do you currently have? You might be able to estimate this by thinking about the size of your storage space and how full it is currently.	Open text	80% full	11 tonnes. Fortnightly after checks with a rough guess. Takes 2 weeks to arrive	approx 10 tonnes	About three or four years supply. 75-100 tonnes.	pile of wood - will last through to middle of the summer
12E	Do you buy fuel from a supplier or do you self-supply?	Purchase; self-supply	Purchase	Purchase	Purchase	Self-supply	both - supply willow himself and also tops up with waste slab wood

12F	Where do you source your fuel from?	Open text				Out of woodlands and hedges	local fencing manufacturer
12G	Why do you get your fuel from there?	Open text				Because we've got it there already. We've planted three hectares of woodland under a woodlands scheme and now we're harvesting it. It was a no brainer.	local, need some wood and they deliver - convenient
12H	Which supplier do you use?	Open text	Forest Fuels- went through YPO for tender	Belcas Brites	Tried to buy from Belcas as indigenous wood. But not happy with delivery time. Billingtons as national supplier	N/A	Weavor Fencing
12I	What sort of considerations do you take in to account when deciding upon a fuel supplier?	Open text	Made sure that deliveries could be guaranteed. Made sure no downtime as RHI for a constant flow of fuel. Sometimes same day delivery is required and needed a supplier that could guarantee that.	Pure wood not melamine mixed so pellets don't glue together. Consider moisture content as well	10 days in advance up to christmas but 5 days warmers		See 12G
12J	How is the fuel for your boiler delivered?	Open text	Tractor trailer 20m3	By wagon	Comes on a 6 wheeler truck 14 tonnes. Asked about dust extraction as it's extra weight but they didn't want to use it as more labour intensive.	Mechanically on a trailer	drop it off in a lorry - order it occasionally
12K	Have you changed fuel supplier this calendar year (2016)?	Yes; No	No	No	No	Haven't changed since we put the boiler in.	no
12L	Why did you change fuel supplier?	Open text					
12M	How do you decide when to reorder more fuel stock?	Open text	Based on estimate from heat services team who look in boiler team.	Visual check to see levels	Visual check of pellet levels and think about time of year/ demand. We have another boiler onsite for conservation	We just regularly collect more each year.	decide when need more then can self supply, then plan ahead as needs time to dry

					which is priority and we split loads.		
12N	How low does your stock get before you reorder?	Open text	By eye from daily checks	Estimate based on fortnightly turn around.	Tends to fluctuate try to keep dust levels low. Below 2 tonnes. Different price ranges based on size		
12O	Your fuel should have an ideal moisture content. Is there anything that prevents you from keeping your fuel at the ideal moisture content?	Open text	No, as purpose built bunkers so made sure all ventilation was adequate. Up to fuel provider to ensure this as we pay by kwh	Encased/ sealed hopper so maintains moisture content	Not for the piggery and no problems with damp. But other boiler has external hopper	Nope	rain
13A	What regular maintenance does your boiler require?	Open text	Interim check 6months. Full service yearly. Weekly cleaning	5 year maintenance plan with manufacturer every six. Empty ash bins weekly. Offered in price	Dunster from royal energy. Twice a year for standard services, one combustion check and other is full service. Sweep the flumes. Westford mechanical do monthly check	Clean the fans, clean the ash out, clean the flu, mostly cleaning.	empty ashes once a week, give a clean once a month
13B	How do you remove the ash from your boiler?	Open text	Normally just shovelled out, sometimes a cyclone	Comes into a bin and just replace the bin	Removed by hand from wheelie bins transported to compost heap	Manually, with a rake.	comes in to the box and then empty it
13C	How often do you remove ash from your boiler?	Open text	daily	Weekly	Every two weeks	As often as it needs it. Anything between twice a week and onth a month during the summer	once a week
13D	What does the ash look like? (texture, Colour, etc.)	Open text	Soft grey	Black dust, very fine	Super fine, dark grey, sometimes tiny bits of unburnt	grey wood ash, nothing to it. Burns right down, no chunks	depends on wood - slab wood = dark and black - willow = dusty and grey and lots more of it

13E	How often do you clean the smoke tubes of your boiler? (the smoke tubes are the pipes above the combustion chamber)	Open text	Check at certain points usually every six months	Once a year by manufacturer	Every 6 months-previous every year but had a mini fire.	Every day	self cleaning - couple times a day
13F	What sorts of considerations do you take in to account when deciding how and when to clean your boiler?	Open text	Daily checks from full time team.	Not much really, empty ash bins when full. Once hopper is empty we Hoover dust out- 3-6 months	No because all contracted.	It's just a regular task. We do it regularly otherwise it'll break.	when I feel like it needs doing - when ashes are built up
13G	Do you have a service contract with a boiler maintenance company?	Open text	Service level agreement with NPS. Asked to go to manufacture for maintenance contracts.	Yes with the manufacturer we have a 5 year contract	Dunster do significant problems	No	no
13H	Have you ever noticed any smoke/soot/smells coming from the boiler or flue or chimney? Can you describe them?	Open text	All the time. Normal burning smells if the flue hasn't warmed up we get some back smoke	Some of the teachers say they can smell it when the winds blow. Only black smoke once furnace is starts but not continuous	Problem from cold smoke will fill the room with smoke.	Just regular wood smoke	no - nothing out of the ordinary
13I	Has the boiler had any breakdown or reliability issues?	Yes; No	Yes		Yes	No	broke down - fairly reliable - twice, over 4-5 years
13J	If so, what part, how much did it cost to repair and was it covered by warranty?	Open text	Delivery equipment, worms, agitators, refractory. Not covered as fitted in 2010.	Yes	Various faults and no one seems to know what it is. Was covered by warranty after 2 years		blocked up - did self unblocke it. Other time it needed a probe (lambar) - had to get somebody to do it. Cost a few hundred pounds
13K	How easy is it to maintain the boiler? If difficult, please explain in what way.	Open text	Difficult without full time team going in. Not a monthly check the bigger you the more maintenance required.	Yes all simple design once a month when we have to open door	Regular maintenance so national trust staff not so involved with it	fairly easy to maintain. If the smoke tubes get blocked they are very difficult to unblock. That's why we clean them out regularly to avoid them getting blocked. The lever on the side makes it very easy to clean out.	easy

14B	Do you have any other interactions with your boiler that we haven't discussed already?	Open text	No	No	We designed our boiler and plant room so it is observable with visitors. People want to come and look at it organisation.	I don't think so.	very pleased with it - gives them a lovely warm house.
14C	Do you have any comments that you would like to make about your boiler?	Open text	Been involved in a lot of different fuel poverty schemes. Changeworks were doing something for joseph rowntree foundation- we had a lot of problems with design- we need a longer guarantee period due to massive cost after 5 years etc as they don't understand the operations they need to see design challenges to operation. Should be specifying when we got this type of boiler we need advice from professional/ manufacture about how to maintain and operate it so we can get the full life cycle of 30 years out of it		Despite all negative, what are the other options? everything else was so expensive so we would still we would just design out the flaws and make more automated.	No	no

7.3 Appendix 3 Stage One Thematic analysis

7.3.1 Main operator information

Table 15 Thematic analysis of responses to the question “What is your position/ role?” (n=16)

Main industry of operator	Frequency
Arts, entertainment and recreation	5
Agriculture	4
Real estate	2
Accommodation	1
Manufacturing	1
Education	1
Professional, scientific and technical activities	1
Domestic boiler only	1

Table 16 Thematic analysis of responses to the question “Which of the following best describes how often you spend time on activities related to the biomass boiler?” (n=16)

Theme	Frequency
More than once a day	2
Daily	5
Every few days	2
Weekly	6
Monthly	1

Table 17 Thematic analysis of responses to the question “What do you use the biomass boiler for?” Responses were attributed to more than one theme if appropriate (n=16)

Theme	Frequency
Heating buildings (for commercial purposes)	13
Hot water (for commercial purposes)	9
Heating buildings (for domestic purposes)	8
Hot water (for domestic purposes)	6
Waste Wood	1

Table 18 Thematic analysis of responses to the question “Why was a biomass boiler chosen for this purpose?” Responses were attributed to more than one theme if appropriate (n=16)

Theme	Frequency
Financial reasons	12
Sustainability	9
No mains access	3
Company strategy	2
Other	3

7.3.2 Induction

Table 19 Thematic analysis of responses to the question “Can you please describe the handover process you received from the installer/ predecessor?” Responses were attributed to more than one theme if appropriate (n= 14 for installer induction, 2 for predecessor handover)

Theme	Installer Frequency	Predecessor Frequency
Manual/Booklet	7	1
Training	4	1
Cleaning information	2	1
Only limited information	2	1
Attended installation	1	0
Not needed	1	0
Nothing	1	0
Other	1	0

Table 20 Thematic analysis of responses to the question “What would you have like more of in the handover?” Responses were attributed to more than one theme if appropriate (n=16)

Theme	Frequency
Nothing else	6
General advice	5
Procedures	4
Ongoing professional support	3

7.3.3 Maintenance, cleaning and servicing

Table 21 Thematic analysis of responses to the question “What regular maintenance does your boiler require?” Responses were attributed to more than one theme if appropriate (n=16)

Theme	Frequency
Yearly service	10
Weekly cleaning (including ash removal)	6
Monthly cleaning	3
6 monthly interim-service	2
6 monthly full- service	2

Table 22 Thematic analysis of responses to the question “How often do you clean the smoke tubes of your boiler?” (n=14)

Theme	Frequency
Yearly service	7
Every 6 months	3
Daily	2

Weekly 2

Table 23 Thematic analysis of responses to the question “What sorts of considerations do you take in to account when deciding how and when to clean your boiler?” (n=13)

Theme	Frequency
Manufacturer/ installer advice	6
Regular checks help decide	3
Just as operations require	3
Everything is contracted	1

Table 24 Thematic analysis of responses to the question “Do you have a service contract with a boiler maintenance company?” (n=14)

Theme	Frequency
No	7
Reactionary	3
Currently looking (due to bankruptcy)	2
Yes	7
Manufacturer	3
Different to manufacturer	1
Unknown	1

Table 25 Thematic analysis of responses to the question “Have you ever noticed any smoke/ soot/ smells coming from the boiler or flue or chimney? Can you describe them?” (n=14)

Theme	Frequency
No	4
Yes	10
When warming up/ starting	5
Occasionally	3
Normal burning smells	2
All the time	1
Black smoke	1

Table 26 Thematic analysis of responses to the question “Has the boiler had any breakdown or reliability issues?” (n=16)

Theme	Frequency
Yes	9
No	4
Answer given in operation question	3

Table 27 Thematic analysis of responses to the question “If so, what part [was the cause of the issue]” (n=16)

Theme	Frequency
Moving parts	8
Leak/Corrosion/Cracked seals	4
Refractory/ fire tube/ brick	3
Blockages	3
Sensors	3
Pellet Delivery	2
Hopper	2
Other (system trips, ignition)	3

Table 28 Thematic analysis of responses to the question “How easy is it to maintain the boiler? If difficult, please explain in what way” (n=12)

Theme	Frequency
Simple/ easy	10
Regular maintenance required(external	4
Regular maintenance required(internal)	3
Difficult	2
Needs a lot of attention	1
Problems with part delivery lead time	1

7.3.4 Operations

Table 29 Thematic analysis of responses to the question What sorts of things do you have trouble with when operating your boiler?

Theme	Frequency
Maintenance issues	14
Nothing	2
Building restrictions	1
Computer controls	1
Hidden maintenance costs	1
Fuel choice affecting operating	1
Bad installation	1
Delivery times (for equipment)	1

Table 30 Thematic analysis of responses to the question “What sorts of solutions have you come up with to make it easier to operate your boiler?”

Theme	Frequency
Changing parts	5
Calling engineers	3
Changing fuel	2
None/ Unsure	2
N/A	3
Other	3

Table 31 Thematic analysis of responses to the question “Does your boiler behave in the way you’d expect?”

Theme	Frequency
Yes	13
No	2

Table 38 Thematic analysis of responses to the question “Do you mothball your boiler (i.e. switch it off completely) for the warmer months?”

Theme	Frequency
Yes	5
No	9

Several participants run at reduced capacity during the summer even if the boiler is not switched off completely.

7.3.5 Ash

Table 39 Thematic analysis of responses to the question “How do you remove the ash from your boiler?”

Theme	Frequency
Changing bin/ pans	8
Manually (shovel/rake)	3
vacuum cleaner	2
composting/ put on land	1

Table 40 Thematic analysis of responses to the question “How often do you remove ash from your boiler?”

Theme	Frequency
Daily	1
Every few days	2
Weekly	7
Fortnightly	1
Monthly	3
As required	1

Table 41 Thematic analysis of responses to the question “What does the ash look like? (texture, colour, etc.)”

Theme	Frequency
Grey-Dark Grey	6
Fine	5
Black	4
Dust	3
Crust	1
Soft	1
Unburnt material	1
No unburnt material	1

7.3.6 Controls

Table 42 Thematic analysis of responses to the question “What sorts of options and controls does your boiler have that allows you to adjust how it works?”

Theme	Frequency
Temperature adjustment	13
Remote control	8
Computer screen on boiler	5
Gas levels (Oxygen, CO)	3
Buffer tank/ ignition controls	3
Pellet Feed	2
Professionally managed	2

7.3.7 Fuel

Table 43 Thematic analysis of responses to the question “What sort of fuel do you use in your boiler?”

Fuel Type	Frequency
Wood chip	6
Wood pellets	8
Solid wood	2

Table 44 Thematic analysis of responses to the question “How do you store the fuel for your boiler?”

Theme	Frequency
Hopper	5
Shed/ Barn/ Farm Building	5
Garage	3
Purpose Built Structure	2
Silo	1
Other building	1

Table 45 Thematic analysis of responses to the question “What sorts of considerations are taken in to account when deciding where or how to store your fuel?”

Theme	Frequency
Environmental conditions	6
Access (including delivery)	4
Proximity to boiler	4
Building restrictions	4
Moisture Content	3

Table 46 Thematic analysis of responses to the question “Do you buy fuel from a supplier or do you self-supply?”

Type	Frequency
Purchase	10
Self-supply	5
Combination	1

Table 47 Thematic analysis of responses to the question “What sort of considerations do you take in to account when deciding upon a fuel?”

Theme	Frequency
Fuel availability	4
Recommended source	3
Cost	3
Delivery lead times	3
Local	2
Type of fuel	2
Moisture content	1

Table 48 Thematic analysis of responses to the question “How low does your stock get before you reorder?”

Theme	Frequency
Weight 500kg- 2 tonnes	4
Visual check	3

Table 49 Thematic analysis of responses to the question “Your fuel should have an ideal moisture content. Is there anything that prevents you from keeping your fuel at the ideal moisture content?”

Theme	Frequency
No	13
Sealed store	5
Purpose built structure	2
Sealed bags	2
Yes	2
Rain	1
Lack of appropriate facilities	1

Table 48 Thematic analysis of responses to the question “Do you have any comments that you would like to make about your boiler?”

Theme	Frequency
[Needs]Better design	3
DECC Data requested	3
More information who to go to about reliability/ usability issues	3
More training	2
Has recommended system to others	1
Longer warranty	1

7.4 Appendix 4 Online survey

#	Purpose	Logic	Question	Response Options
####	Introduction text	Those who took part in the telephone interviews	<p>Thank you for taking the time to fill out this survey.</p> <p>Its aim is to document how you currently use your biomass boiler, and your motivations and reasons for doing so. This is to provide us with more information when we analyse the performance of your biomass boiler at the end of the field trial.</p> <p>You may be familiar with some of these questions, as we previously conducted telephone interviews, but it's important to the research to ensure the information obtained is consistent across all participants in the trial.</p> <p>The survey should take about 10-15 minutes to complete.</p> <p>Your answers will be kept confidential, and will be shared with a joint Kiwa, Energy Saving Trust, and Department for Business, Energy and Industrial Strategy (formerly DECC) research team for the specific purpose of research.</p> <p>All data collected is anonymous. If you leave your details, your results will never be used in conjunction with personal information unless you request it.</p> <p>You're free to withdraw from the survey at any time.</p> <p>For more information please contact: tom.woolnough@est.org.uk</p>	

	Introduction text	Those who did not take part in the telephone interviews	<p>Thank you for taking the time to fill out this survey.</p> <p>Its aim is to document how you currently use your biomass boiler, and your motivations and reasons for doing so. This is to provide us with more information when we analyse the performance of your biomass boiler at the end of the field trial.</p> <p>The survey should take about 10-15 minutes to complete.</p> <p>Your answers will be kept confidential, and will be shared with a joint Kiwa, Energy Saving Trust, and Department for Business, Energy and Industrial Strategy (formerly DECC) research team for the specific purpose of research.</p> <p>All data collected is anonymous. If you leave your details, your results will never be used in conjunction with personal information unless you request it.</p> <p>You're free to withdraw from the survey at any time.</p> <p>For more information please contact: tom.woolnough@est.org.uk</p>

1	Data protection	All		Check box
2	Demographic information	All	Please tell us which industry you work in:	Check all that apply: Arts, entertainment and recreation Agriculture Real estate (letting, real estate management etc.) Accommodation and hospitality (Hotels, Bed and breakfast etc.) Manufacturing Education Professional, scientific and technical activities Other (please specify)
2A	Demographic information	All	Please state your occupation	Open text box
3	Survey relevance	All	Are you the main operator of the Biomass Boiler?	Yes/ No

3A	Survey relevance	If "No" to q3	Please can you provide a contact for the main operator so they are able to fill out this survey.	Text box: Contact: END SURVEY
3B	Frequency of interaction	All	How often you spend time on activities related to the biomass boiler?	Drop down menu: More than once a day Daily Every few days Weekly Monthly
System design and documentation				
4	Check existing knowledge	All	What do you use the Biomass Boiler for?	Single selection Residential buildings (houses, holiday lets, etc.) Commercial buildings (offices, hotels, etc.) Process heating (poultry sheds, greenhouses, wood drying ,etc.) Other

4A	Check existing knowledge	All-	What specific activities is the Biomass Boiler used for?	<p>Please tick all that apply:</p> <p>Heating buildings or spaces</p> <p>Heating water for taps, sinks, showers, etc.</p> <p>Wood drying</p> <p>Disposal of waste</p> <p>Other (Please specify)</p>
4B	Understand installation motivation	All	Why was a biomass boiler chosen for this purpose?	<p>Please rank in order of importance 1= most important, 6= least important:</p> <p>To receive the Renewable Heat Incentive (RHI)</p> <p>Financial savings on fuel expenses</p> <p>Self-sufficiency through using onsite or locally produced fuel</p> <p>Replace existing boiler due to breakdown or reliability issues</p> <p>This site has no mains gas</p> <p>Company or personal strategy is to use renewable fuels</p> <p>(optional) If other please specify:</p>
5	Check existing data	All	Does your system have a thermal store, which is a place for storing and managing renewable heat until it is needed, for example, a large well-insulated cylinder usually besides the boiler that is often called a buffer or accumulator tank? This should not be confused with a regular hot water tank.	Yes/ No

Training and Handover				
6	Induction training	If selected any commercial use in Q4	Did you a receive an induction or training about the boiler from:	Please tick all that apply: The boiler installer The boiler manufacturer Your predecessor in this job The boiler maintenance company I didn't receive an induction Other (please specify)
6A	Information routes	If Installer or manufacturer to Q6	Did you receive any of the following from the installer/ manufacturer?	Please tick all that apply Complete Manual 2-3 page Booklet Cleaning Guidelines General advice and tips (non-written) Recommended service/ fuel companies System design information (e.g. design heat demand) None of the above Other (please specify)
6B	Information routes	If predecessor to Q6	Did you receive any of the following from your predecessor?	Please tick all that apply Complete Manual

				<p>2-3 page Booklet</p> <p>Cleaning Guidelines</p> <p>General advice and tips (non-written)</p> <p>Recommended service/ fuel companies</p> <p>System design information (e.g. design heat demand)</p> <p>None of the above</p> <p>Other (please specify)</p>
6C	Information routes	If "None of the above" to 6A/6B	You selected "none of the above", where did you obtain information related to the operations of the boiler?	<p>Please tick all that apply:</p> <p>Learning on the job</p> <p>The internet</p> <p>Speaking to boiler service company</p> <p>Making contact with the manufacturer</p> <p>Existing knowledge and experience</p> <p>Other (please specify)</p>
6D	More information required	All	What would you have like more of in the handover?	<p>Please tick all that apply</p> <p>Nothing else</p> <p>General Advice</p> <p>Boiler procedures</p> <p>RHI and administrative procedures</p> <p>Ongoing professional support</p>

				A fuel supplier list A service contractor list Other (Please specify)													
Maintenance																	
7		All	Has the boiler had any breakdown or reliability issues?	Yes/No													
7A		If 7= Yes	If yes, which part and was it covered by warranty?	Multiple drop down <table border="1"> <thead> <tr> <th><i>Part</i></th> <th><i>Select from drop down</i></th> </tr> </thead> <tbody> <tr> <td rowspan="3">Pumps</td> <td>no breakdown/issue (default option)</td> </tr> <tr> <td>breakdown/issue covered by warranty</td> </tr> <tr> <td>breakdown/issue not covered by warranty</td> </tr> <tr> <td rowspan="3">Augers</td> <td>no breakdown/issue (default option)</td> </tr> <tr> <td>breakdown/issue covered by warranty</td> </tr> <tr> <td>breakdown/issue not covered by warranty</td> </tr> <tr> <td rowspan="2">Motors</td> <td>no breakdown/issue (default option)</td> </tr> <tr> <td>breakdown/issue covered by warranty</td> </tr> </tbody> </table>	<i>Part</i>	<i>Select from drop down</i>	Pumps	no breakdown/issue (default option)	breakdown/issue covered by warranty	breakdown/issue not covered by warranty	Augers	no breakdown/issue (default option)	breakdown/issue covered by warranty	breakdown/issue not covered by warranty	Motors	no breakdown/issue (default option)	breakdown/issue covered by warranty
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				Leak/Corrosion no breakdown/issue (default option) breakdown/issue covered by warranty breakdown/issue not covered by warranty
				Refractory/ fire tube/ brick no breakdown/issue (default option) breakdown/issue covered by warranty breakdown/issue not covered by warranty
				Blockages no breakdown/issue (default option) breakdown/issue covered by warranty breakdown/issue not covered by warranty
				Sensors no breakdown/issue (default option)

				<p>breakdown/issue covered by warranty</p> <p>breakdown/issue not covered by warranty</p> <p>Fuel feed system no breakdown/issue (default option)</p> <p>breakdown/issue covered by warranty</p> <p>breakdown/issue not covered by warranty</p> <p>Fuel store no breakdown/issue (default option)</p> <p>breakdown/issue covered by warranty</p> <p>breakdown/issue not covered by warranty</p> <p>Other</p>
		All	Do you have a backup heating source, should the biomass system breakdown?	Yes/No
7B		All	On a scale of 1-7, how easy is it to maintain the boiler?	<p>7 point select radio button select</p> <p>1= easy, 7=difficult</p> <p>1= simple, 7= complicated</p> <p>1= quick, 7= time consuming</p>

8		All	How often do you get a full service?	Every 3 months Every 6 months Every 12 months More than every 12 months Other (please specify)
8A		All	How often does your boiler require additional maintenance, separate to the main full service?	Less than once a month Every month Every fortnight Every week Other (please specify)
9		All	Who performs the majority of boiler cleaning duties?	Drop down select Myself A member of my team Professional contractors Other please specify
10		All	How often do you clean the smoke tubes of your boiler? (the smoke tubes are the pipes above the combustion chamber)	Drop down select: Yearly service Every 6 months Monthly Weekly Daily

				Smoke tubes are cleaned automatically Other
11			What sorts of considerations do you take in to account when deciding how and when to clean your boiler?	Please tick all that apply: Advice from the manufacturer Advice from the installer Advice from service company Carried out sporadically as required Carried out at the discretion of the service/cleaning contractor. Other (please specify):
12		All	Do you have a service contract with a boiler maintenance company?	Yes/ No
12A		If "Yes" to Q12	Is this a different contractor to that which installed the boiler?	Yes/ No/ Unknown
13		All	Have you ever noticed any smoke/soot/smells coming from the boiler or flue or chimney?	Yes/ No
13A		If yes to Q13	Can you describe them on a scale of 1-7?	Drop down select per row Single select radio buttons: 1= Never notice them 7= Notice them all the time 1= No burning smell 7= Extremely strong burning smell 1= No Smoke 7= Thick black smoke

Operations				
14	Understand operational behaviours	All	How do you remove the (undergrate) ash from your boiler?	Drop down select: Changing bin/ pans Manually (shovel/rake) Vacuum cleaner Other (please specify)
14A	Understand operational behaviours	All	Where do you dispose of the ash?	Drop down menu On site Off site
14B	Understand operational behaviours	All	How is the ash disposed of?	Drop down Used directly on land as fertilizer Added to compost Municipal waste collection Profession waste disposal Other
14	Understand operational behaviours	All	How often do you remove ash from your boiler?	Drop down select: Daily Every few days Weekly Fortnightly Monthly As required

14	Understand operational behaviours	All	On a scale of 1-7 please can you identify the characteristics of the ash	<p>Single select radio buttons:</p> <p>1= White 7=Black</p> <p>1= Mostly Very Fine (Dust like) Texture 7= Mostly Very Coarse (gravel or larger) Texture</p> <p>1= Never Contains Unburnt Material 7= Always Contains Unburnt Material</p>
15	Understand operational behaviours	All	Except maintenance and replacing parts, what sorts of things do you have trouble with when operating your boiler?	<p>Please tick all that apply:</p> <p>Physical access to the boiler and controls</p> <p>Computer controls and programmers</p> <p>Achieving clean and stable operation</p> <p>Ash removal and cleaning</p> <p>Re-fueling</p> <p>Keeping the fuel feed system running</p> <p>Resetting over-temperature lock-outs</p> <p>Re-ordering of fuel</p> <p>None of the above</p> <p>Other (Please specify)</p>
15A	Understand operational behaviours	If answered anything except "none of the above" to Q15	What sorts of solutions have you come up with to make it easier to operate your boiler?	<p>Please tick all that apply:</p> <p>Clean more frequently</p> <p>Calling engineers</p> <p>Changing fuel</p> <p>None</p>

				Other (please specify):
16	Understand operational behaviours	All	What sorts of options and controls on the boiler do you know how to change?	Please tick all that apply: Building thermostat Hot water tank thermostat Flow temperature set point Oxygen/excess air Fuel feed rate Boiler output Boiler moderation Fuel-air ratio Other (please specify):
17		All	Please tick the statement which applies to your boiler	Drop down During the summer months the boiler is switched off completelyruns at reduced outputruns as normal
		If boiler is switched off in Q17	Do you use an alternate source of heating during the summer months?	Yes/No
18		All	Do you buy fuel from a supplier or do you self-supply?	Drop down menu Purchase

				Self-supply Combination
18A		All	What sort of fuel do you use in your boiler?	Please tick all that apply: Wood chip Wood pellets Wood logs Other
18b		If purchase or combination from question Q18	What sort of considerations do you take in to account when deciding upon a fuel supplier?	Please tick all that apply: Fuel availability Recommended source Cost Delivery lead times Local Type of fuel Fuel quality Moisture content None of the above Other (please specify)
18c		If purchase or combination from question Q18	How often is your fuel delivered?	Drop down menu Scheduled weekly deliveries Scheduled fortnightly deliveries Scheduled monthly deliveries

				As and when required Other
18d		If "as and when required" from 18c	How low does your stock get before you reorder?	Please tick one: Empty 1 week from empty 2 weeks from empty 1 month from empty Other (Please specify)
18e		If purchase or combination from question Q18	How is the fuel for your boiler delivered?	Small bags (e.g. 10-20kg) delivered individually Small bags (e.g. 10-20kg) delivered on a pallet Bulk bags (e.g. 1 tonne) Bulk loose delivered by lorry/tipper truck Bulk loose delivered by lorry and blown in Other
18f		If Self-supply Q18	How do you obtain more fuel when you run out?	Please tick all that apply: Fell trees on-site Dead wood on-site Use a back-up wood store Order from local supplier Other
19		All	When the fuel is the delivered, where do you immediately store it? (even if you later move it into the boiler hopper)	Please tick one: Left out in the open

				<p>Kept outside under a roof shelter (e.g. lean-to)</p> <p>Kept loose inside a building (e.g. barn)</p> <p>Kept in an open store in a building</p> <p>Kept in an enclosed store</p> <p>Other (Please specify)</p>
20		All	What sorts of considerations are taken in to account when deciding where or how to store your fuel?	<p>Please tick all that apply:</p> <p>Environmental conditions</p> <p>Access (including delivery)</p> <p>Proximity to boiler</p> <p>Building restrictions</p> <p>Moisture Content</p> <p>Other (Please specify)</p>
21		All	Your fuel should have an ideal moisture content. Do you check the moisture content of your fuel?	Yes/No/ I didn't know it had an ideal moisture content
		All	Is there anything that prevents you from keeping your fuel at the ideal moisture content?	Yes/No
21a		If yes Q22	If yes, please indicate what prevents you from keeping your fuel at the ideal moisture content:	<p>Please tick all that apply:</p> <p>Rain</p> <p>Humidity</p> <p>Lack of appropriate fuel storage facilities</p> <p>Damage to fuel storage facilities</p> <p>Bad batch of fuel from supplier</p>

				Damaged fuel packaging Other (please specify)
22a		All	Does the boiler use more or less fuel than you expected it to, or about what you expected?	7 point scale
22b		All	Do you spend more or less money on fuel than you expected to, or about what you expected?	7 point scale
Thermal Comfort				
23	Thermal comfort	All	This building is generally:	7 point scale select one Cold, cool, slightly cool, neutral, slightly warm, warm, hot
23a	Thermal comfort	All	Normally, the overall temperature of this building is:	7 point scale select one Very uncomfortable, uncomfortable, slightly uncomfortable, neutral, slightly comfortable, comfortable, very comfortable
23b	Thermal comfort	All	The temperature in this building is usually:	7 point scale select one Very unacceptable, unacceptable, slightly unacceptable, neutral, slightly acceptable, acceptable, very acceptable
24		All	Do you claim the Renewable Heat Incentive (RHI) for your biomass boiler?	Yes/No
24a	Intention to recommend programme	If Yes to Q24	The probability is that we will seek to participate in similar financial incentive schemes is high.	7 point scale 1= Strongly disagree 7= Strongly agree

24b	Intention to recommend programme	All	If relevant to them, I would recommend biomass boilers to a friend/colleague/associate.	7 point scale 1= Strongly disagree 7= Strongly agree
24c	Intention to recommend programme	All	If I had to install a heating system over again, I would still choose a biomass boiler.	7 point scale 1= Strongly disagree 7= Strongly agree
24d	Satisfaction with programme	All	The choice to install a biomass boiler was a wise one.	7 point scale 1= Strongly disagree 7= Strongly agree
24e	Satisfaction with programme	All	This type of heating system is exactly what is needed for our building.	7 point scale 1= Strongly disagree 7= Strongly agree
24f	Satisfaction with programme	All	I think we did the right thing deciding to install a biomass boiler in this building.	7 point scale 1= Strongly disagree 7= Strongly agree
24g		All	I would have installed this boiler, even if the RHI scheme had not existed.	7 point scale 1= Strongly disagree 7= Strongly agree
25		All	Do you have any comments you'd like to make which have not been discussed earlier in the survey?	Open text
26		All	We appreciate you taking the time to fill out this survey.	Email:

			Please leave your email below to ensure we don't accidentally contact you again about completing this survey:"	
###			Thank you	

7.5 Appendix 5 References

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