sweett

Department of Energy and Climate Change (DECC)

Research on the costs and performance of heating and cooling technologies

Final report

21st February 2013

contents

Executive Summary

A consortium led by Sweett Group, together with Buro Happold and the Association for Conservation of Energy (ACE), was commissioned by DECC to undertake a study looking at the costs and performance of a range of Low and Zero Carbon (LZC) heating and cooling technologies.

The work involved the collection and analysis of empirical, disaggregated data from a range of industry practitioners across the supply chain (i.e. manufacturers / suppliers / installers).

Over 3,000 industry practitioners were contacted as part of the engagement exercise. Organisations responded by providing cost data from actual installations within the past 12 – 18 months. This data was loaded into a repository and cleansed to appraise the overall quality of and confidence in, the data. Where any queries with the data were identified, those who provided it were contacted and the data sample was discussed. This helped ascertain whether the costs provided were realistic (e.g. no errors were made when populating the data) and transferrable (e.g. the cost was attributable to a genuine item that would be likely to be experienced on other projects of a similar nature).

This report provides a breakdown of the data received for different technologies based on different capacity sizes. It appraises the data against other sources and provides commentary regarding its overall robustness and any assumptions applied. The table below sets out a summary of cost per kW for the different technologies investigated as part of the study (numbers of samples obtained in parentheses).

Technology	**Capacity (kW)**					
	0 - 5	**5 - 10**	**10 - 20**	**20 - 50**	**50 – 100**	**>100**
Air to Air Heat Pump	▨	£1,138 (2)	£584 (2)	£1,415 (1)	▨	▨
Air to Water Heat Pump	£1,380 (2)	£1,187 (12)	£556 (16)	£1,963 (2)	£1,240 (2)	£513 (1)
Biomass	▨	▨	£945 (20)	£568 (52)	£383 (12)	£208 (9)
Ground Source Heat Pump		£2,403 (11)	£1,980 (9)	£1,652 (23)	£1,172 (17)	£1,719 (19)
Solar Thermal	£2,060 (41)	£1,199 (3)	£1,025 (1)	▨	▨	▨

Data has been grouped into the above bandwidths in order to enable quick comparison of the costs of the different technologies. In addition to this data, scatter plots showing the distribution of the costs obtained have been provided throughout the report.

The costs presented include equipment and installation costs but not operational costs. VAT is excluded to enable easier cross-comparison of technologies.

A full explanation of the methodology and assumptions applied is provided in the main body of the report and its appendices.

This work has been subjected to peer review by stakeholders from across academia and industry.

The overall conclusions drawn from the study were as follows:

1. The engagement process involved liaison with a diverse range of practitioners. Industry was supportive of the initiative and in the majority of cases was responsive to the request for data.
2. The attainment of extensive datasets of robust, transparent data takes time and requires close dialogue with specialists from across the supply chain. Often those with the most pertinent data are the most difficult to access (e.g. the installers). This is due to the time pressures they face. This should be taken into consideration on all future studies.
3. The data obtained from this study has on the whole shown consistency with previous sets of data. However there are instances where variances have occurred. In many of these instances there is a logical explanation for the observed differences. Moving forward it is important to maintain accurate records of all cost data to facilitate other exercises in data interrogation.
4. Collating and storing data in a consistent, transparent format is critical. The use of a central data repository should be upheld moving forwards. Sharing data and pooling it from other resources is an effective way of developing a comprehensive dataset.
5. Derivation of load factors and the calculation of implied heat output are critical areas that need to be accurately appraised. Monitoring of actual performance data will help ensure that the anticipated performance of low / zero carbon technologies is readily understood.

1.0 Introduction

Background

A consortium led by Sweett Group, together with Buro Happold and the Association for Conservation of Energy (ACE), was commissioned by DECC to undertake a study looking at the costs and performance of a range of Low and Zero Carbon (LZC) heating and cooling technologies.

The work involved the collection and analysis of empirical, disaggregated data from a range of industry practitioners across the supply chain (i.e. manufacturers / suppliers / installers). This data has been captured within a cost and performance database which accompanies this report. This report provides a summary of the cost data for a range of scenarios. It should be noted that the cost database provided enables the user to interrogate the data in more depth than the level of detail provided within this report.

LZC technologies

The brief for the project required that a wide range of technologies be addressed. The figure below sets out the original target list and those where (and how much) data was successfully collated. Where comprehensive datasets were not obtained the reasons why are explained.

Figure 1.1: List of technologies reviewed

Technology type	Data quality
Air to Air Heat Pumps	Empirical data collected from a range of projects
Air to Water Heat Pumps	Empirical data collected from a range of projects
Biomass (Boilers / CHP / direct air)	Empirical data collected from a range of projects
Cooling technologies	Cooling performance data collected for heat pumps
District Heating Systems	Limited data samples (albeit from actual projects)
Fuel cells	Limited data samples (albeit from actual projects)
Ground Source Heat Pumps	Empirical data collected from a range of projects
Solar thermal	Empirical data collected from a range of projects
Ultra low carbon technologies	Limited data samples (albeit from actual projects)

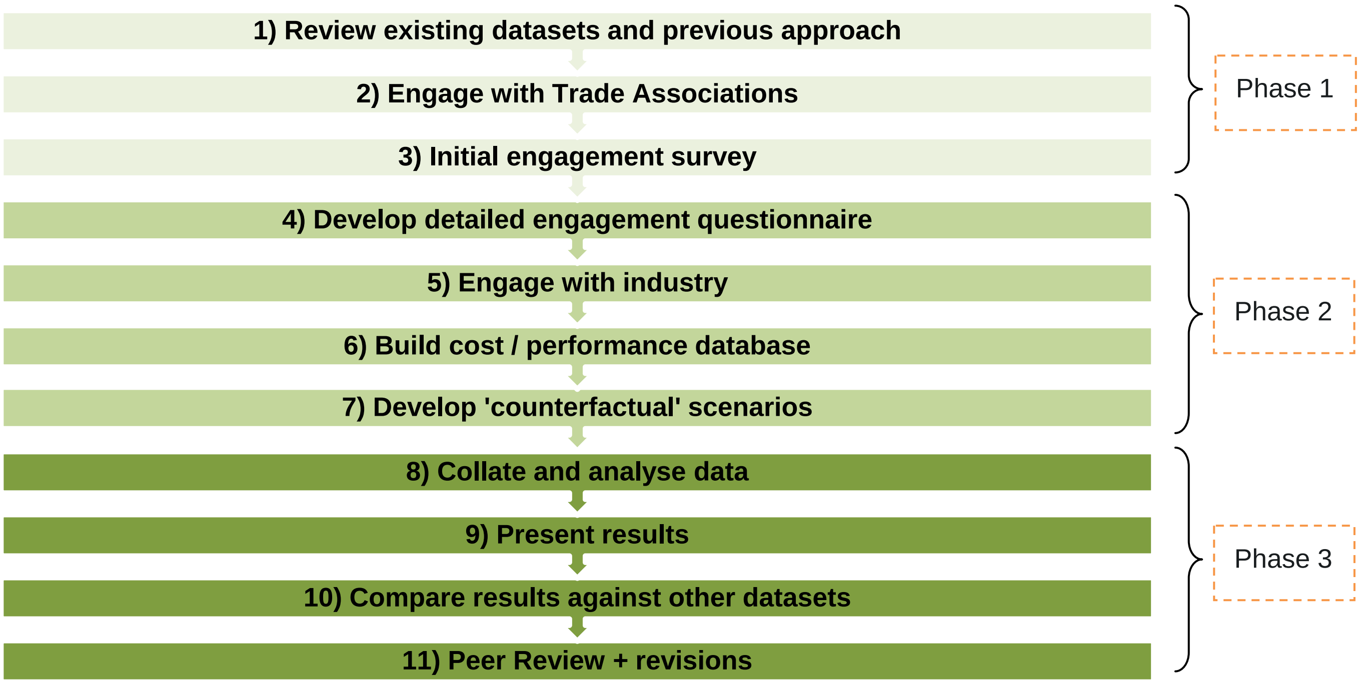
The detailed methodology and assumptions applied can be found in Appendices 1 – 3. The survey templates used to engage with the industry and capture data can be found in Appendices 4 – 5.

2.0 Methodology

Introduction

The project was addressed in three phases as shown in the diagram below:

Figure 2.1: Overview of methodology



Description of process

The following section explains each step of the process in more detail.

1) Review existing datasets and previous approach

Existing databases produced for the analysis of the Renewable Heat Incentive (RHI) were reviewed to understand the layout and required data fields.

Existing datasets investigated include:

- Renewable Heat Premium Payment (RHPP) data (Domestic and Social Landlord)
- RHI Phase II – Technology assumptions (AEA Technology)

2) Engage with Trade Associations

To ensure a successful engagement process it was vital to obtain the support and assistance of relevant Trade Associations and Membership bodies.

The following organisations provided support to the study:

Figure 2.2: List of Trade Associations engaged with

3) Initial engagement survey

An online questionnaire was developed as a way of rapidly ascertaining practitioners' interest and appetite for providing data. A copy of the survey can be found in Appendix 4. This survey provided a rapid means of accessing the very extensive and diverse supply chain within the UK and although it creates a self selecting sample, this drawback is outweighed by the benefits of increased data quantity and quality.

4) Develop detailed engagement questionnaire

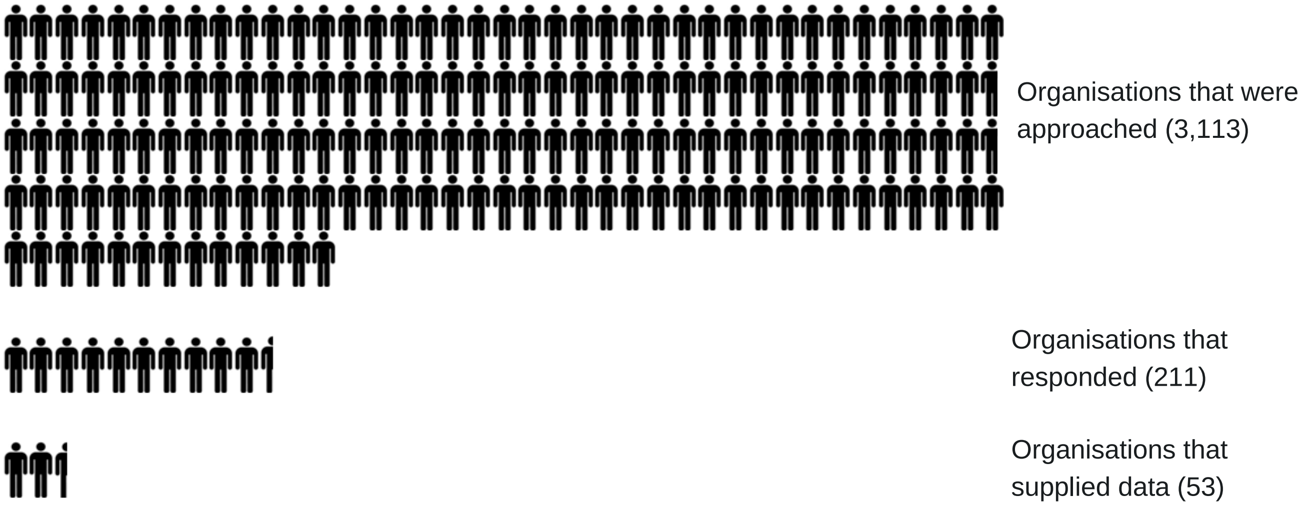
A detailed engagement questionnaire was developed. The role of this questionnaire was to collate the disaggregated data required as part of the project. A copy of the engagement questionnaire can be found in Appendix 5.

5) Engage with industry

The detailed questionnaire was issued to contacts provided by the Trade Associations, and those provided by DECC (and the consortium's own contacts).

The following diagram illustrates the extent of coverage:

Figure 2.3: Extent of engagement with industry.



6) Build cost and performance database

A dedicated excel based cost and performance database was built as part of the project. This has been provided as a separate output.

The cost and performance database serves as a repository for the data collected. It provides graphical representations of the data which enables the visualisation of the costs for the different technology types.

The data can be interrogated in more detail based on a range of filters. One key filter is 'level of confidence'. A confidence rating was applied to the data collected, defined as follows:

High: empirical data, clear audit trail of data, detailed breakdown of data

Medium: empirical data, clear audit trail of data, less detailed breakdown of data

Low: empirical data (albeit through a third party), limited audit trail of data, limited breakdown of data

The costs are broken down into the following three categories / descriptions:

Technology: costs for main and associated equipment

Add-on: costs for labour and commissioning

Hassle / abnormal: or the purpose of this study this relates to abnormal, non-transferable costs (e.g. the need to remove and rebuild a wall in order to fit kit in place as opposed to the 'hassle' of disruption).

A detailed explanation of how the database has been constructed and its functionality can be found in Appendix 3.

7) Develop baseline / counterfactual scenarios

Baseline and counterfactual scenarios were developed for the domestic and non-domestic building types. The methodology used can be found in Appendix 1 and 2 respectively.

8) Collate and analyse data

The completed data questionnaires were imported into the cost and performance database. The data was then cleansed. This process involved reviewing the quality of the data and checking that it had been inputted correctly. The data was then plotted and interrogated. Where there were obvious outliers the person who supplied the data was contacted in order to confirm that the figures provided were correct and to find out further information relating to the project. In the majority of instances there were legitimate reasons for the variations in the data received.

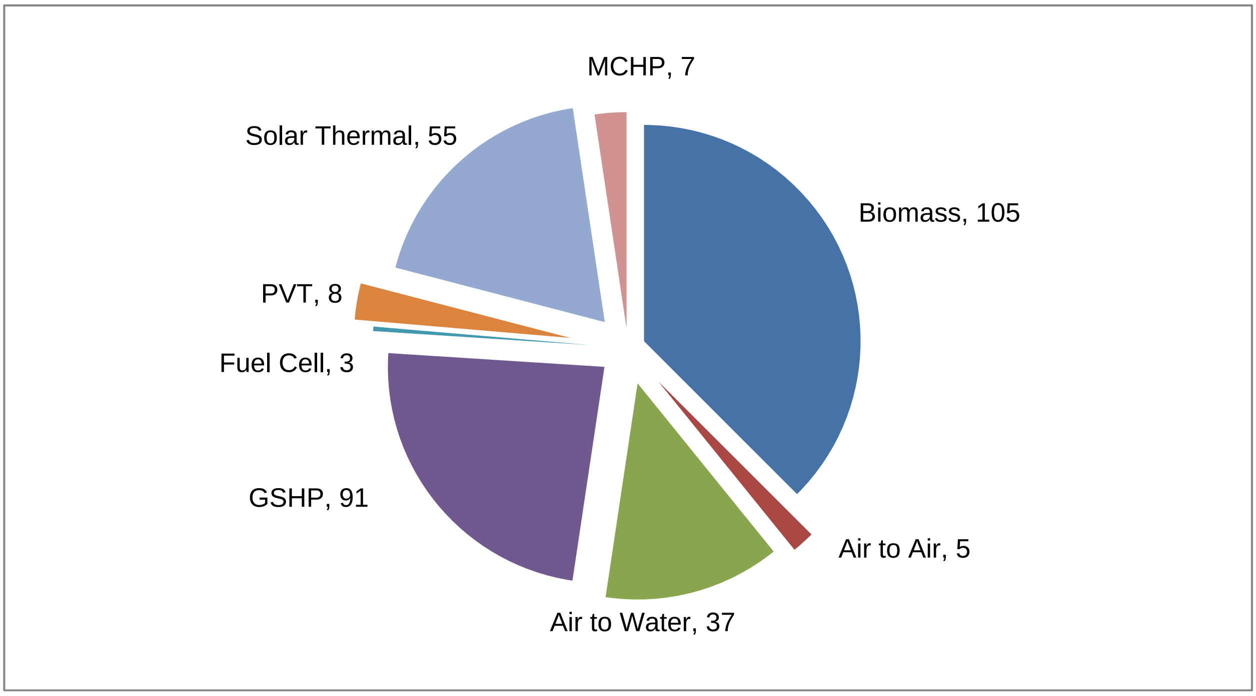
9) Present results

A breakdown of the headline results can be found the following section. The extent and quality of the data obtained is set out below.

311 complete Data Sets were received broken down as follows:

- 259 'High' quality Data Sets
- 26 'Med' quality Data Sets
- 26 'Low' quality Data Sets

Figure 2.4 Breakdown of datasets



10) Compare results against other datasets

The installer data collated through this study was reviewed against other datasets such as the information collated through the Renewable Heat Premium Payment (RHPP) scheme and from previous studies (AEA Technology – RHI Phase II assumptions report). This is explained in more information in Section 5.

11) Peer review + revisions

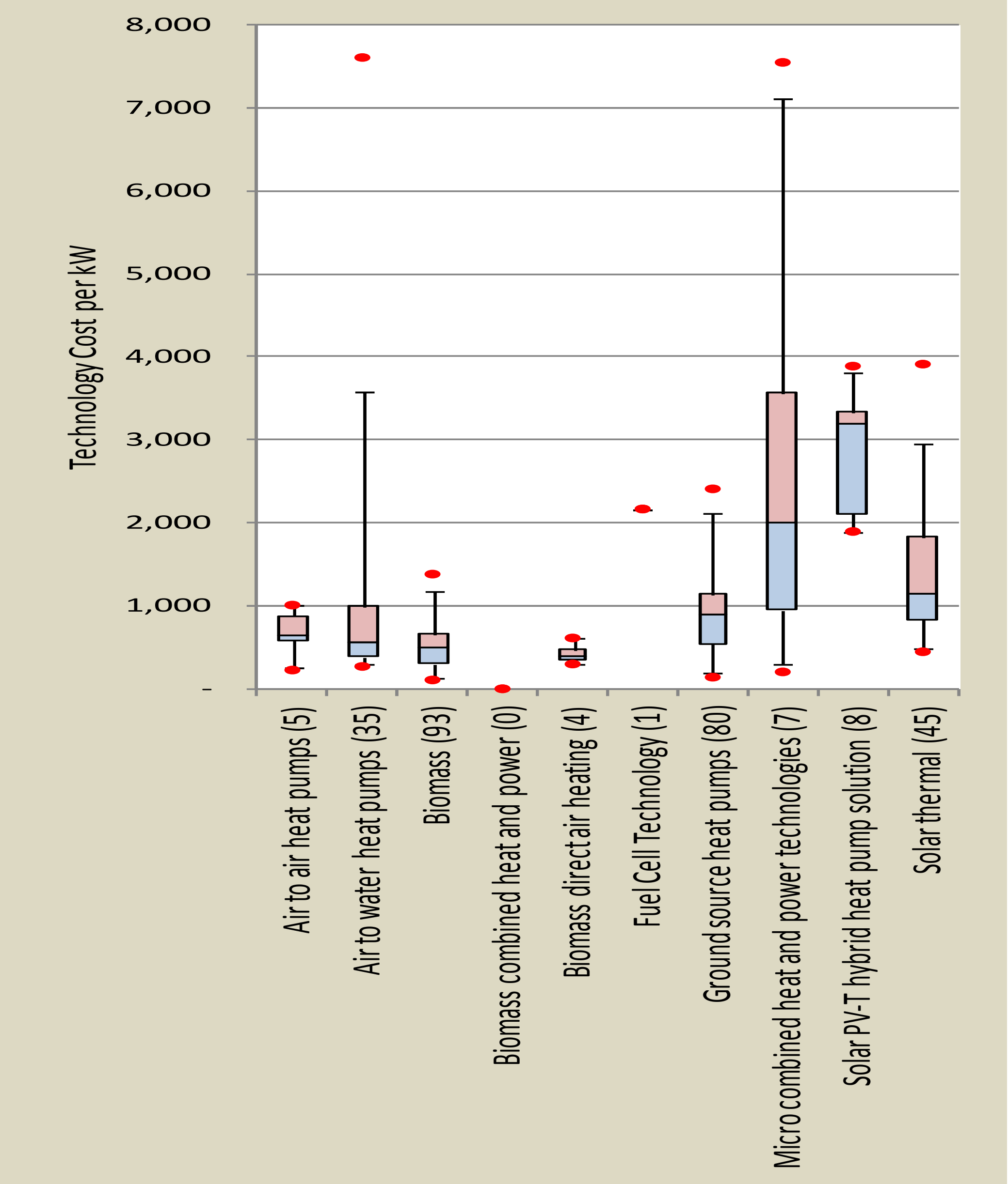
The data provided and the methodology applied was subject to peer review from academic and industry specialists. This report addresses any comments obtained.

3.0 Headline results

Overall summary of data

Figure 3.1 sets out a box and whisker plot of all the project data obtained[1]:

Figure 3.1



The box and whisker plot shown is an example of some of the output options the cost and performance database enables the user to populate. The above graph illustrates how the distribution of technology cost per kW for the different technology options. The blue section of the box represents the second quartile and the pink section the third quartile.

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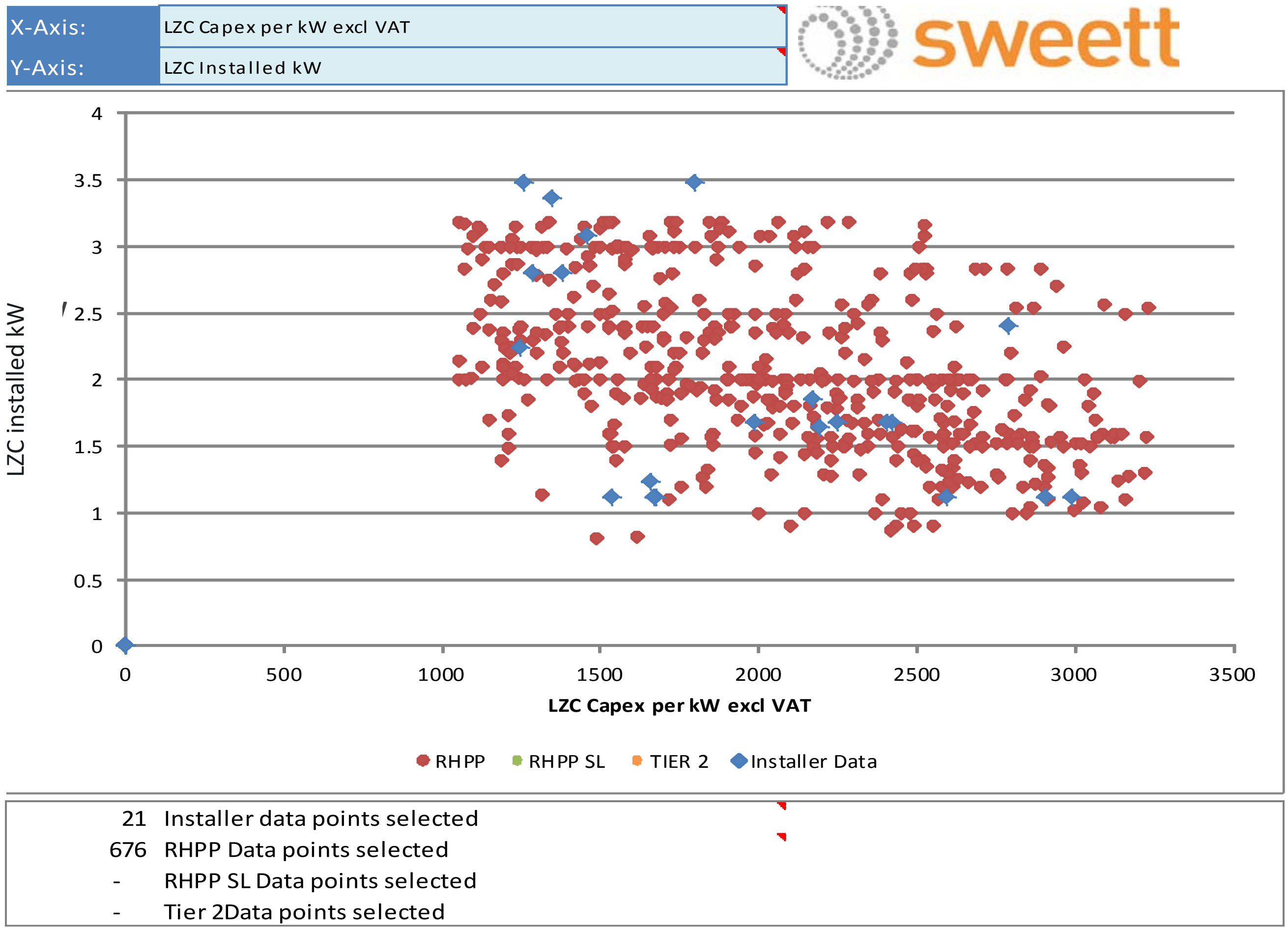
[1] Sample sizes are for medium and high quality data (hence do not represent the complete data set)

The whiskers extend to the 98% percentile and 2nd percentile. Red dots indicate the range of higher and lower values.

Other output options that the cost and performance database enables the user to populate are scatter plots for a range of scenarios (for example; cost or efficiency per kW versus installed system size). Figure 3.2 below sets out an example of how the scatter plot looks for capex per kW versus installed system size for solar thermal. The plot includes both installer and RHPP data.

Figure 3.2: Example scatter plot (installer and RHPP data)



X-Axis:	LZC Capex per kW excl VAT
Y-Axis:	LZC Installed kW

21	Installer data points selected
676	RHPP Data points selected
-	RHPP SL Data points selected
-	Tier 2Data points selected

Within this report the cost information has been grouped (for ease of presentation) into capacity bandwidths (e.g. 0 – 5kW, 5 – 10kW, and so forth) and the median data for each bandwidth has been presented. It should be noted that this approach is for illustrative purposes only and that any output datasheets populated by the cost and performance database use the nearest approximate data set. For example if populating the cost of a 2kW system, the data would be derived from cost information specifically for that size (i.e. the median of the 0 – 5kW bandwidth would not be used).

Breakdown of costs and performance of individual technologies

The following section addresses each of the technologies and provides a range of headline data. For each technology, scatter plots, bandwidth graphs and summary data tables are provided. The data provided is explored in more detail throughout the report. For comparative purposes RHPP data has been plotted on the bandwidth graphs (denoted by green dots).

Fundamental information / assumptions

Cost data

The costs provided were broken down under the three categories:

Equipment: the cost of the main and associated equipment

Installation: the cost of installation and commissioning

Abnormal: any abnormal costs specifically associated with the project in question. These were considered exclusive to the project hence non-representative of typical projects.

The costs presented in this report are for equipment and installation costs. They exclude the abnormal costs; this is on the basis that those observed were project specific hence not reflective of ‘average’ costs. All cost data presented exclude VAT (to enable ease of comparison). All prices quoted are in 2012 equivalent and represent the costs to the final customer.

Efficiency

All efficiency data provided relates to manufacturers assumed performance not to actual measured performance.

Operational data

The Opex (Operational Expenditure) data presented below is a combination of fixed and variable operation costs, defined as follows:

Fixed: the cost of servicing / maintenance

Variable: fuel costs

Reversible systems

Where systems are reversible (i.e. can be used for cooling as well) the costs provided are based on the heating capacity / efficiency of the system). This was following confirmation from the practitioners (which provided the data) that the vast majority of their cost data was based on the heat load of the building (not the cooling requirement).

Air to air heat pumps

Number of samples collected (high and medium data)	5
Size range (kW)	8 – 25
Cost range (total cost)	£6,653 - £35,363
Manufacturer's claimed performance range (coefficient of performance)	3 – 3.76
Approximate labour costs as a percentage of total cost	32%

Figure 3.3ii: Overall distribution of cost data

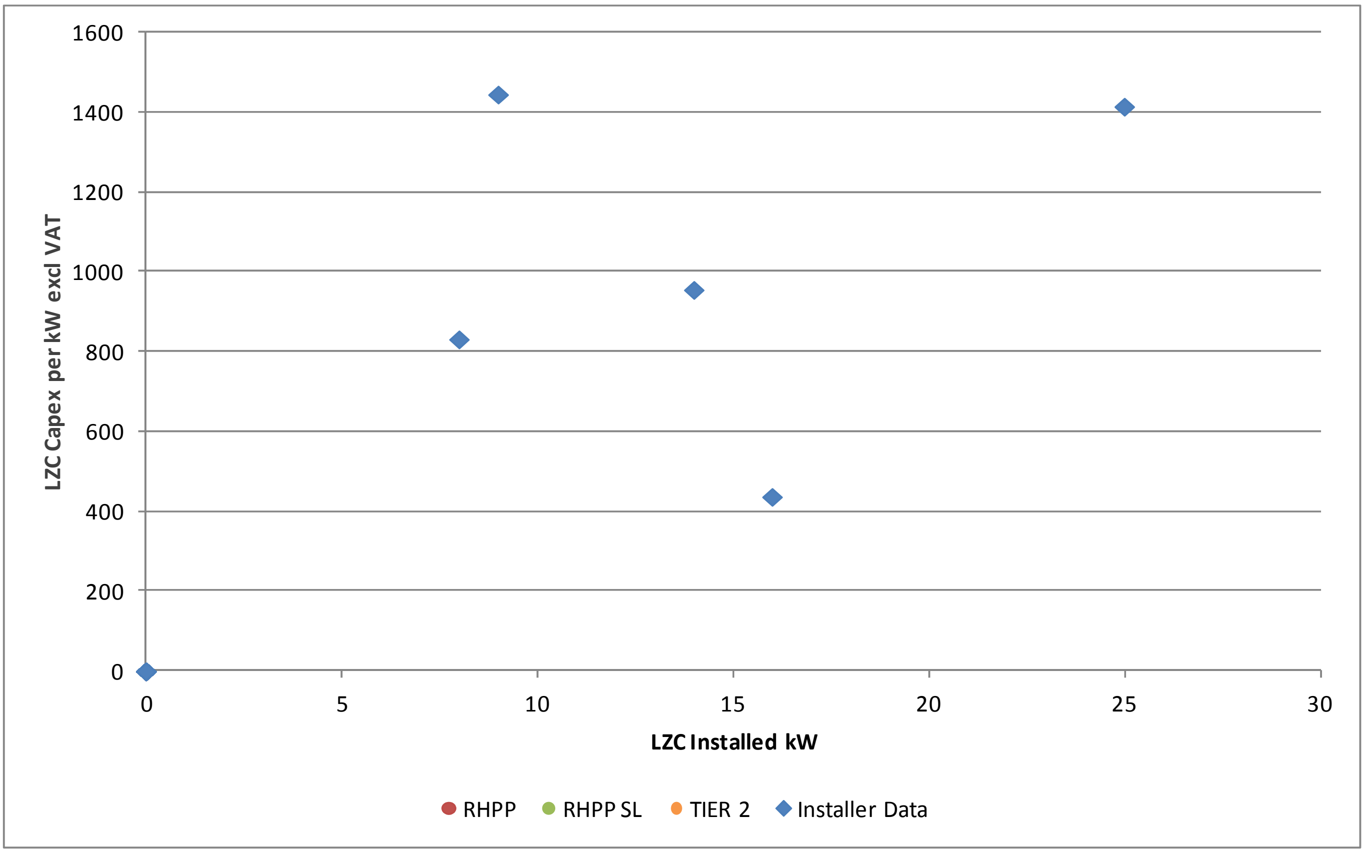
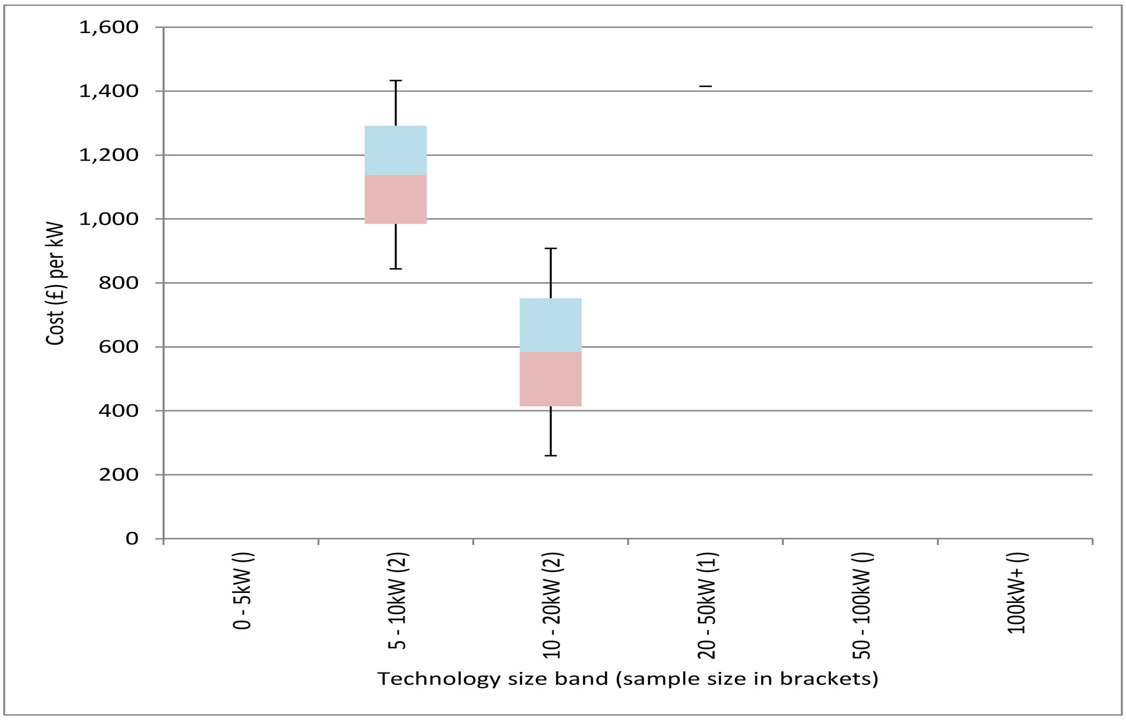


Figure 3.3ii: Distribution of equipment and add-on costs (high and medium confidence data) per bandwidth



⁎ Note: data not collected for Air to Air Heat Pumps within the RHPP dataset

Figure 3.3iii: Cost summary

SUMMARY	5 - 10kW	10 - 20kW	20 - 50kW
No. of samples	2	2	1
Max Capex (£/kW)	£1,445	£921	£1,415
Median Capex (£/kW)	£1,138	£584	£1,415
Min Capex (£/kW)	£832	£246	£1,415
Average Opex (£/kWh including fuel cost @ 2012)	£0.09	£0.08	£0.08
Max CoP	-	-	-
Median CoP	3.35	3.38	3.56
Min CoP	-	-	-

Interrogation of data

It is difficult to infer a trend in the data given the low sample size. The data shows that above the 5 – 20kW the costs notably increase. The increase in cost at this threshold was also experienced with the Air to Water Heat Pump data (shown below). Above the 20kW size range the heat pump systems are likely to be more bespoke hence the system costs in this size range are likely to demonstrate greater variation. As systems increase in size, the boundaries defining air to air heat pumps and large-scale Variable Refrigerant Flow/Volume (VRF/VRV) systems become less defined. As a result, scope of design and therefore installation and supply similarly become less distinct, such that the scope of an air to air heat pump may involve connection of multiple internal units to a single heat pump, with the number of internal units potentially increasing if a heat recovery system is incorporated.

Air to water heat pumps

Number of samples collected (high and medium data)	35
Size range (kW)	2 – 126
Cost range (total cost)	£6,300 - £78,435
Manufacturer’s claimed performance range (Coefficient of performance)	2.5 – 4.0
Approximate labour costs as a percentage of total cost	25%

Figure 3.4i: Overall distribution of cost data

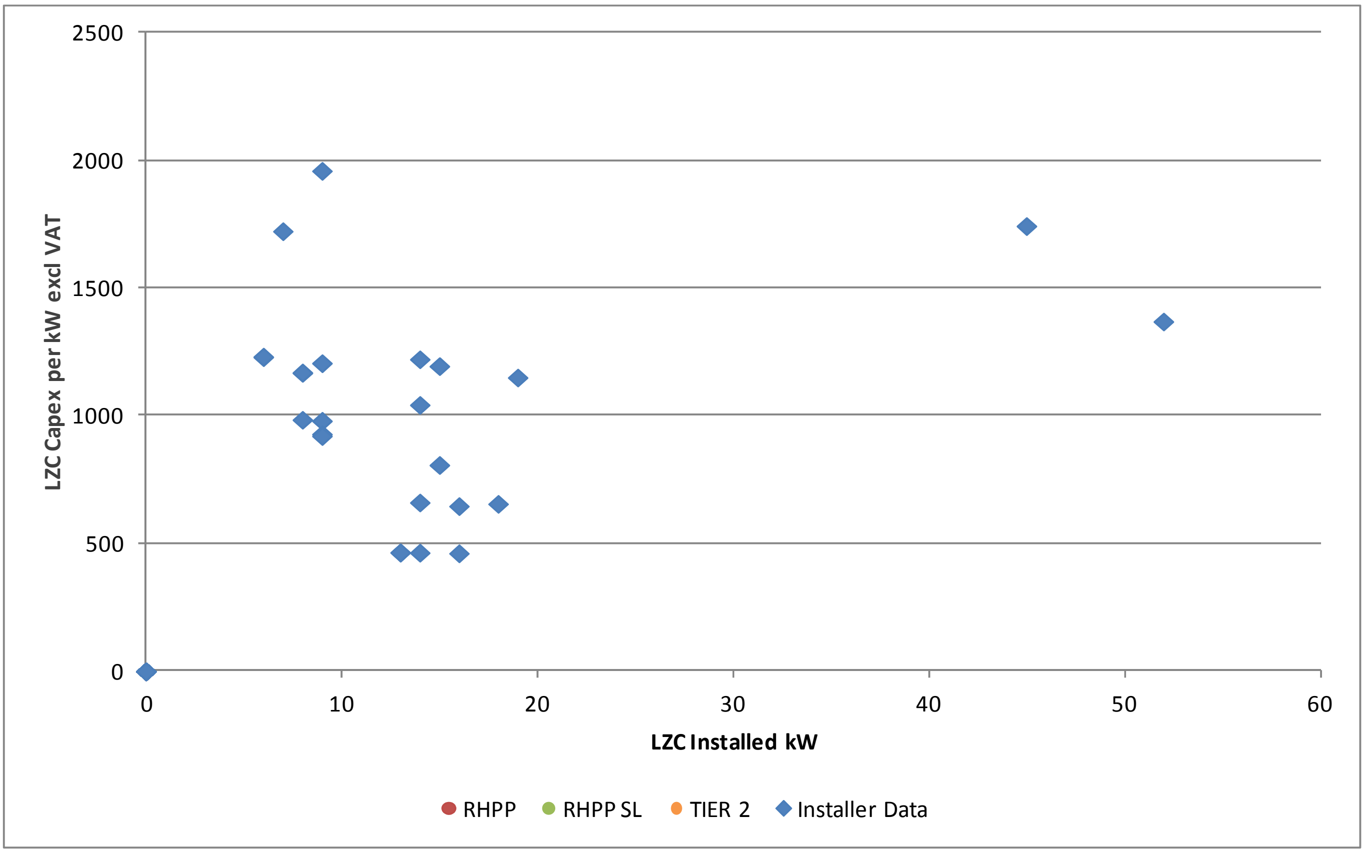


Figure 3.4ii: Distribution of equipment and add-on costs (high and medium confidence data)

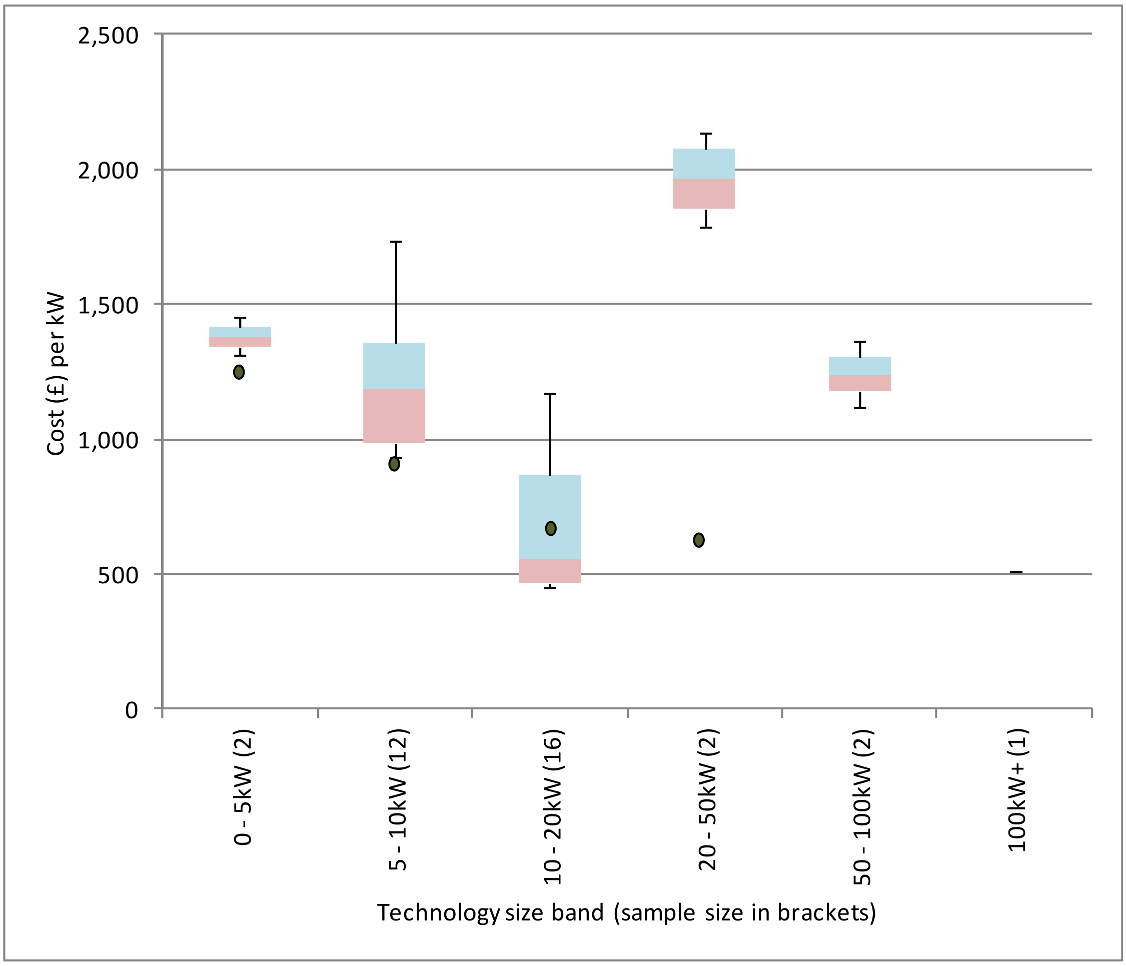


Figure 3.4iii: Cost summary

SUMMARY	0 - 5kW	5 - 10kW	10 - 20kW	20 - 50kW	50 - 100kW	100kW+
No. of samples	2	12	16	2	2	1
90th percentile (£/kW)	£1,450	£1,734	£1,172	£2,159	£1,364	£513
Median Capex (£/kW)	£1,380	£1,187	£556	£1,963	£1,240	£513
10th percentile (£/kW)	£1,309	£933	£454	£1,787	£1,116	£513
Average Opex (£/kWh including fuel cost @ 2012)	£0.08	£0.07	£0.07	-	£0.001	-
Max CoP	-	3.9	3.6	-	-	-
Median CoP	2.5	3.1	3.2	3.9	3.7	4.0
Min CoP	-	2.5	2.5	-	-	-

Interrogation of data

For systems between 0 – 20kW there is a consistent pattern. For systems above this size the correlation is less regular. Interrogation of the data reveals that at larger system sizes more factors are introduced that influence the range of costs (as experienced with the Air-to-Air Heat pumps). Furthermore, statistical confidence in the data at this scale is reduced due to the limited number of completed surveys returned for larger system sizes.

More data is required to properly investigate the shape of the trajectory between 0-20kW and 20-50kW and identify the factors causing the two separate cost ranges. There should be less cause for variation with size for this technology compared to other technologies (e.g. biomass boiler systems). Factors that may have caused the data pattern shown include:

- preliminaries, administrative burden, tender requirements – larger systems tend to be procured via a formal tender process with tender packages produced by cost consultants and specifications produced by building services engineers
- design, health and safety and contract requirements are much more onerous than would be experienced for typical small scale domestic systems, which will add cost to the installation
- the cost of the compressor increases notably at larger sizes of output
- the power supply needs to be more robust at larger sizes of output hence introduces more complexity / cost

Biomass

Number of samples collected (high and medium data)	93
Size range (kW)	12 – 995
Cost range (total cost)	£7,529 - £627,396
Manufacturer’s claimed performance range (Efficiency)	80% - 95.4%
Approximate labour costs as a percentage of total cost	22%

Figure 3.5i: Overall distribution of cost data

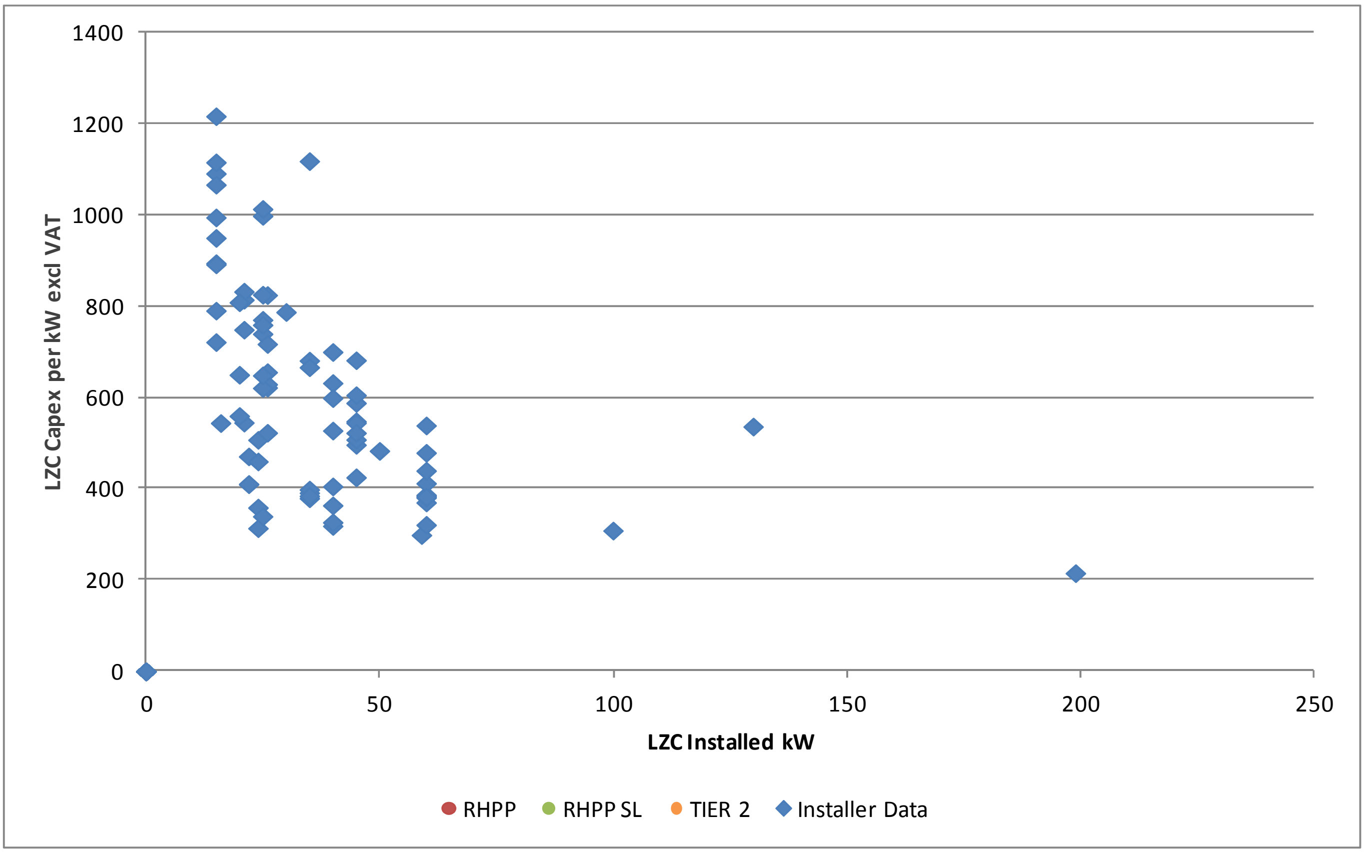


Figure 3.5ii: **Distribution of equipment and add-on costs (high and medium confidence data)**

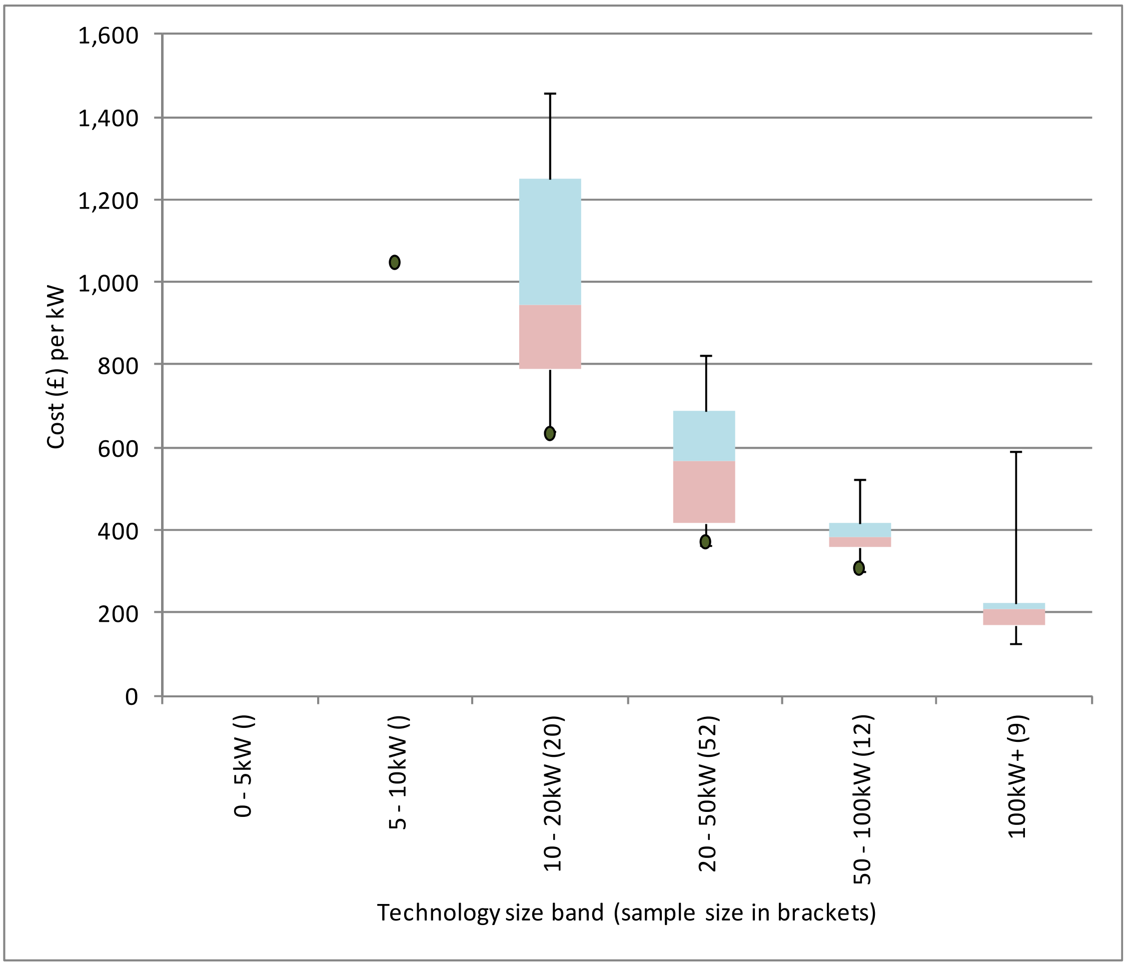


Figure 3.5iii: **Cost summary**

SUMMARY	10 - 20kW	20 - 50kW	50 - 100kW	100kW+
No. of samples	20	52	12	9
90th percentile (£/kW)	£1,460	£824	£526	£590
Median Capex (£/kW)	£945	£568	£383	£208
10th percentile (£/kW)	£641	£365	£301	£127
Average Opex (£/kWh including fuel cost @ 2012)	£0.05	£0.05	£0.04	£0.04
Max efficiency	0.95	0.95	0.95	0.91
Median efficiency	0.92	0.92	0.92	0.91
Min efficiency	0.85	0.85	0.85	0.85

Investigating the influence of the cost of the fuel store

Figures 3.5iv and 3.5v below demonstrate the influence the fuel store has on the overall cost. At both smaller (<20kW) and larger (>100kW) capacities, the presence of a fuel store has a marked impact, whilst for intermediate capacities the impact is less noticeable. The cost range for >100kW systems is much wider when a fuel store is included, this is a reflection of the bespoke nature of these larger systems.

Fig 3.5iv: Costs with fuel store

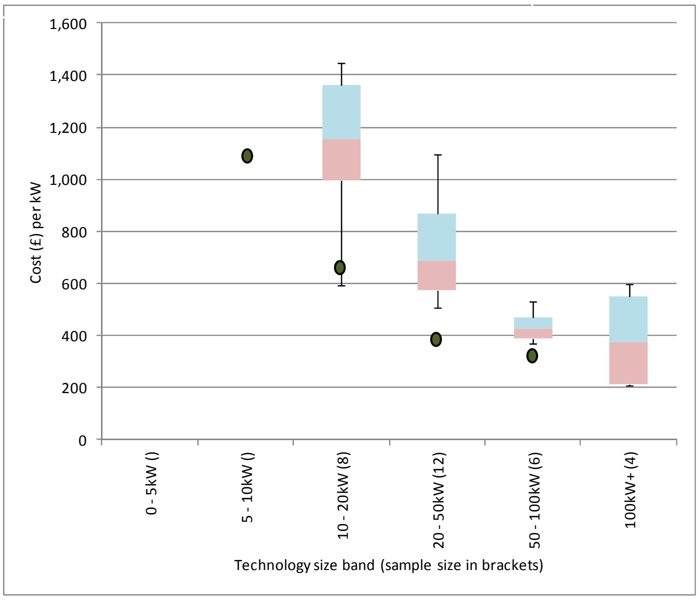
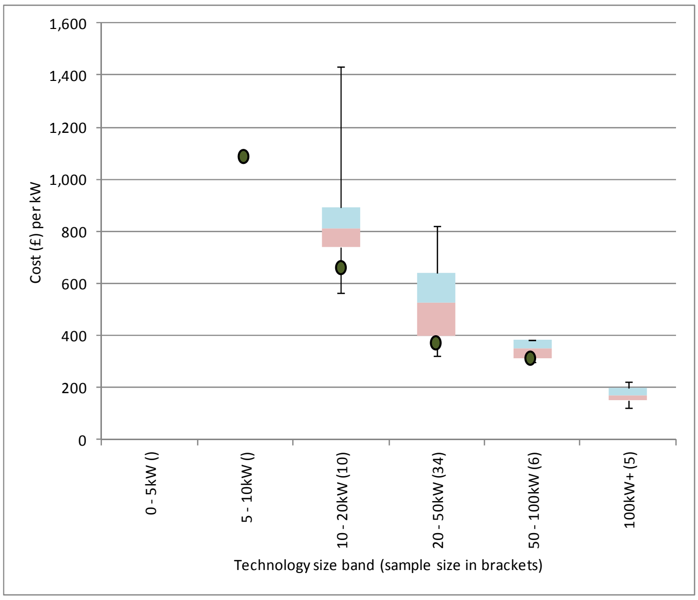


Fig 3.5v: Costs without fuel store



Interrogation of data

The cost data (for with and without the fuel store) shows a consistent downward trend with increasing capacity. This trend reflects that equipment costs tend to reduce when normalised for rated output. Labour emerged as a cost item that did not show a direct correlation between cost and installed capacity. This is supported by anecdotal data collected during the survey process that indicated many installers of small scale systems will quote a similar labour price for different size boilers as many of the tasks are similar (e.g. pipework, flue installation, rationalisation of existing heating systems, removal of old boilers, etc.). In these instances, the major cost difference is the size of the equipment used, which does not in itself require more time/effort to be expended.

The overall system efficiency obtained is dependent on the fuel type used with pellet based systems offering higher efficiency levels.

Other observations include:

1. Heat metering costs – some installers chose to include costs for heat meters and inspection reports (i.e. those requirements specifically needed to support a RHI application) which added between 1 and 10% onto the value of the project (depending on scale, system configuration etc.).

2. Civil engineering costs – civil engineering works associated with excavating trenches was a cause of significant variation between quotations. Survey data for biomass boilers that included for district heating systems (relatively prevalent with small to medium scale rural biomass projects) showed an uplift in total project cost of between 10 and 20%. This cost item is very site specific and not related to the kW rating of the boiler itself.

3. Fuel store - a strong relationship was identified between boiler types and sizes. This relationship was heavily influenced by the requirement for a fuel store as shown in Figures 3.5iv and 3.5v. As a result, log fired boilers were less costly than pellet and wood chip boilers which require more expensive dedicated fuel stores, particularly at the larger end of the size spectrum where integral pellet bins are not available. The greater fuel storage volume required by wood chip boilers in comparison to equivalently sized pellet boilers, results in wood chip boilers tending to attract the highest total installed cost. A potential exception is for wood chip

boilers installed in agricultural settings. This is typically because farmers are able to utilise existing loading equipment to feed their boiler systems, removing the requirement for expensive below ground wood chip stores. Larger systems often require more complex fuel transfer mechanisms to ensure they are fully automated and can receive full deliveries and thus costs increase. The requirement for larger more bespoke fuel stores (especially below ground stores) is a significant contributor to the slight upturn in trajectory for systems above 200kW$_{th}$.

4. Preliminaries and overheads – preliminary costs associated with contractor design, health and safety and other contractual requirements (including system commissioning etc.) are typically avoided for the large part for domestic or smaller scale installations as they are simply not required or are accounted for in standard terms and conditions/generic method statements. Although these costs are not a major contribution to overall project cost, they are nevertheless a project consideration.

Biomass direct air heating

Number of samples collected (high and medium data)	4
Size range (kW)	13 – 45
Cost range (total cost)	£9,839 - £47,230
Manufacturer's claimed performance range (efficiency)	78% - 93.5%
Approximate labour costs as a percentage of total cost	31%

Figure 3.6i: **Overall distribution of cost data**

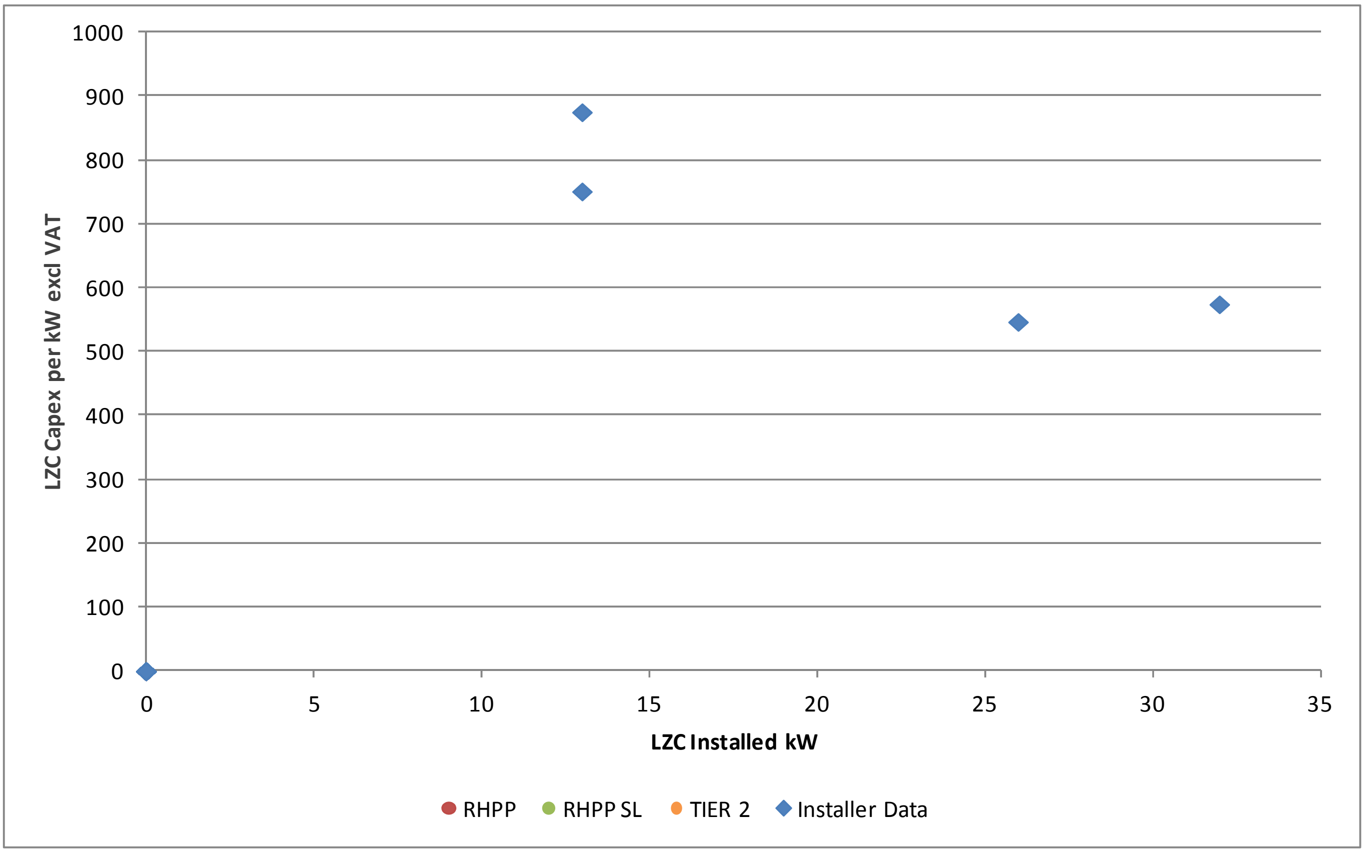


Figure 3.6ii: Distribution of equipment and add-on costs (High and Medium confidence data)

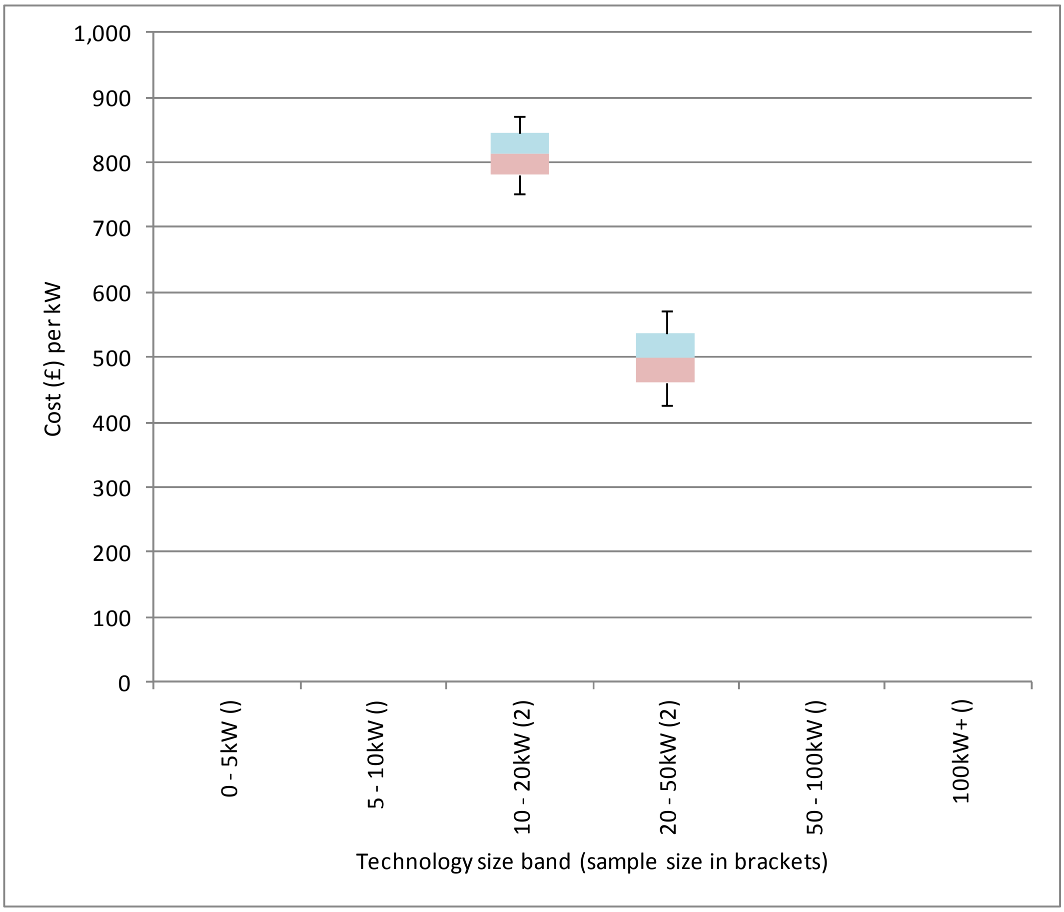


Figure 3.6iii: Cost summary

SUMMARY	10 - 20kW	20 - 50kW
No. of samples	2	2
90th percentile (£/kW)	£863	£559
Median Capex (£/kW)	£813	£500
10th percentile (£/kW)	£763	£440
Average Opex (£/kWh including fuel cost @ 2012)	£0.01	£0.01
Max efficiency	-	-
Median efficiency	0.80	0.84
Min efficiency	-	-

Interrogation of data

A limited number of data sets were collected for this technology. Those entered show a consistent trend downwards in cost as size increases.

It should be noted that costs of more common biomass direct air heating units were not included (i.e. wood burning stoves below 5kW). Had this data been included, the trend line would have looked more parabolic as costs per kW for wood stoves are lower than mechanical biomass direct air heaters.

Generally installed costs per kW were lower than equivalently sized biomass boilers. This can be attributed to the following reasons:

1. Direct air heaters are a simpler technology and therefore have a correspondingly lower associated cost.
2. Direct air heaters can be installed relatively easily with no wet system plumbing required to connect the system to existing or new heating/hot water systems. There is potential that heat can be distributed via a ducted air system, however although equipment costs can be higher, associated installation costs tend to be lower.
3. None of the cost information received for this category included any allowance for fuel storage.

Ground source heat pumps

Number of samples collected (high and medium data)	91
Size range (kW)	5 – 760
Cost range (total cost)	£7,700 - £2,145,121
Manufacturer's claimed performance range (coefficient of performance)	3 – 4.9
Approximate labour costs as a percentage of total cost	42%

Figure 3.7i: Overall distribution of cost data

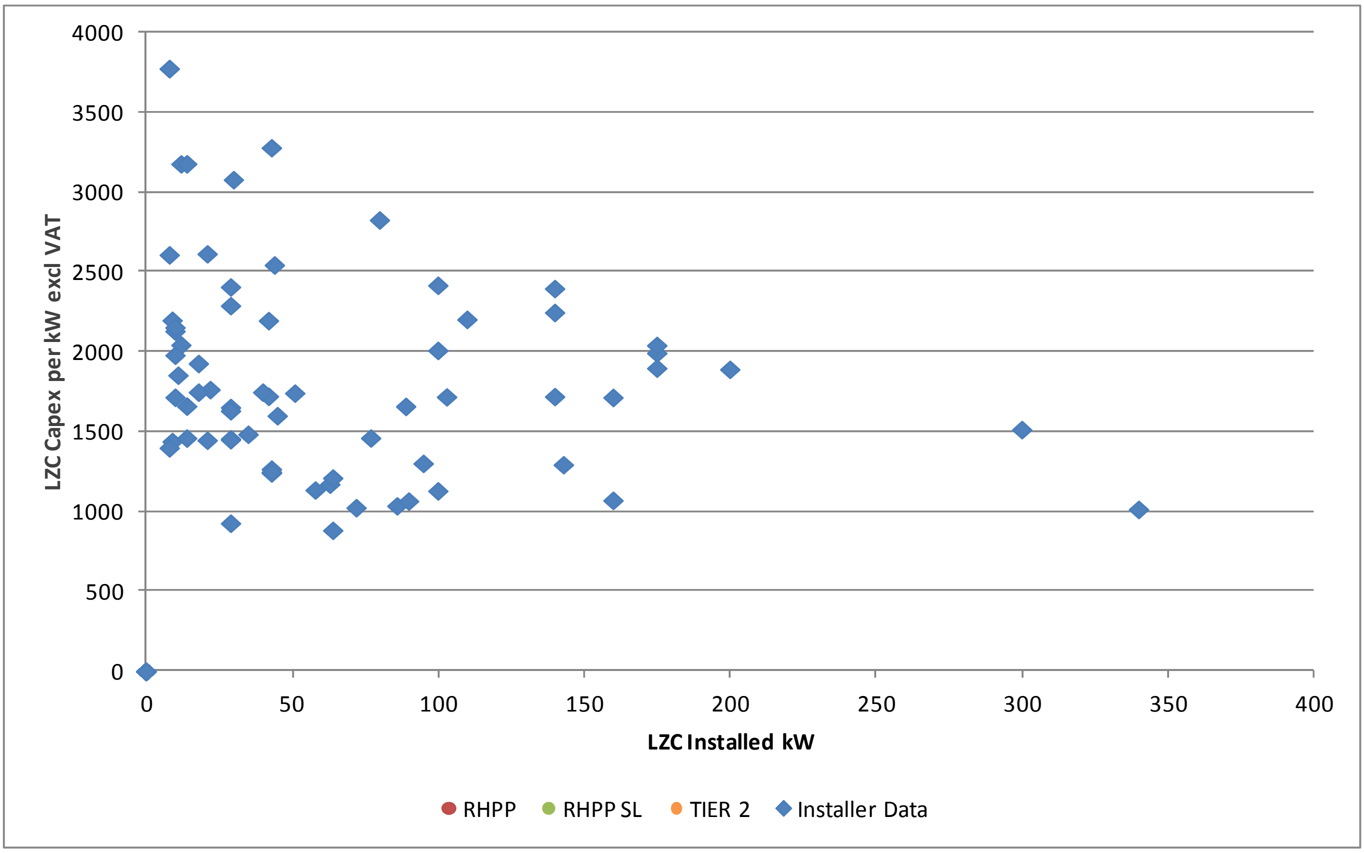


Figure 3.7ii: Distribution of equipment and add-on costs (high and medium confidence data)

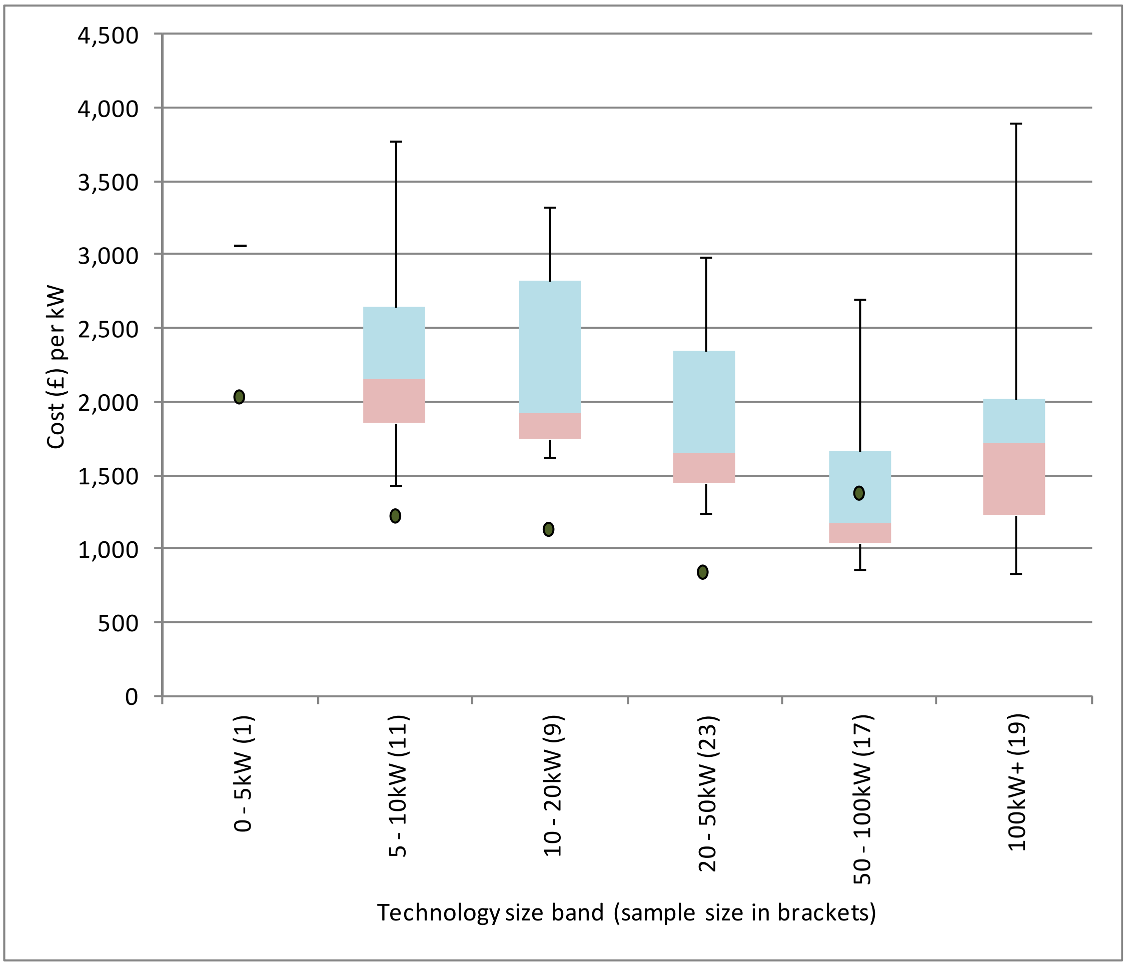


Figure 3.7iii: Cost summary

SUMMARY	5 - 10kW	10 - 20kW	20 - 50kW	50 - 100kW	100kW+
No. of samples	10	11	23	17	19
90th percentile (£/kW)	£3,775	£3,320	£2,986	£2,696	£3,896
Median Capex (£/kW)	£2,154	£1,928	£1,652	£1,172	£1,719
10th percentile (£/kW)	£1,439	£1,621	£1,244	£855	£834
Average Opex (£/kWh including fuel cost @ 2012)	£0.05	£0.05	£0.03	£0.05	-
Max CoP	3.2	3.5	3.0	3.0	3.0
Median CoP	4.0	4.0	4.6	4.0	4.0
Min CoP	4.1	4.9	4.9	4.8	5.0

Interrogation of data

The data shows a consistent trend of decreasing cost with increasing size with good availability of cost data for ground source heat pumps for systems up to 100kW in size. Above this range a limited amount of data was received and because the technology size range increased significantly (up to 760kW) the confidence in this data set becomes less certain.

The type of ground heat exchanger is an important factor influencing both total installed cost and variability of cost for each of the categories. Figures 3.7iv and 3.7v below set out how the costs vary depending on whether the systems are vertical or horizontal respectively. Total installed costs per kW for horizontal systems are generally lower than costs received for similarly sized systems using vertical boreholes. Similarly, cost variability within the size categories is greater for vertical systems.

Key reasons for this include:

1. Project specific design – heat only commercial scale ground source heat pump systems typically require more boreholes than a reversible system (heating and cooling) to avoid over abstraction of heat from the system and a long term reduction in system performance; the number and costs of boreholes is very project specific. The significant variance shown for the 100kW vertical system was due to one system requiring 91 boreholes (77 number 200m boreholes and 14 number 135m boreholes).
2. Ground conditions – local geology will influence the type of drill rig used as well as time etc. taken to drill the borehole field and therefore cost. (Issues with contaminated land will also influence cost).
3. Preliminaries, contractual and health and safety requirements – data returns for vertical borehole systems indicate they were purchased as part of a wider construction programme and the contractor would have had to include for up-front design, health and safety costs and other items to demonstrate compliance with contractual requirements.
4. Figure 3.7iv shows that for the large vertical system there is a considerable cost variation. This may be because closed loop systems with the ground loop installed within the building piles are commonplace, especially for commercial buildings on tight sites. The effect of this is that the cost of the bore is in the ground workers or civils package, not with the ground source specialist.

Figure 3.7iv: Costs of vertical systems

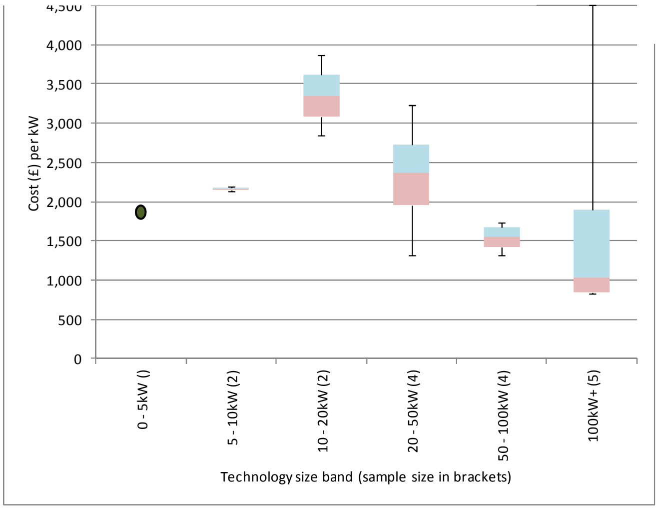
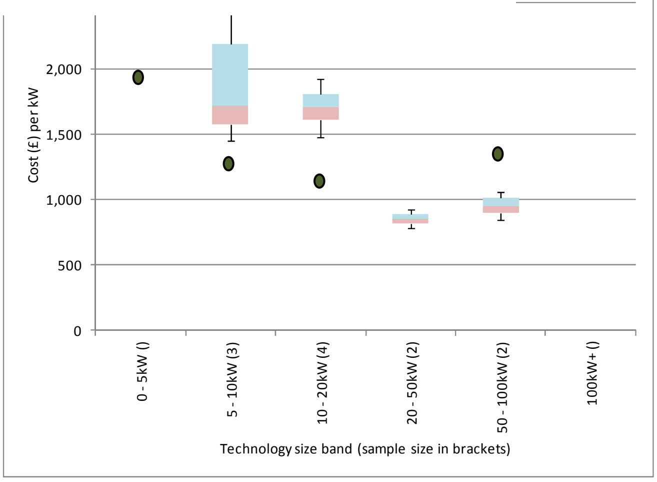


Figure 3.7v: Costs of horizontal systems



Micro Combined Heat and Power

Number of samples collected (high and medium data)	7
Size range (kW)	15.5 – 24
Cost range (total cost)	£7,675 - £119,000
Manufacturer’s claimed performance range (Thermal efficiency)	84%%
Approximate labour costs as a percentage of total cost	25%

Figure 3.8i: Overall distribution of cost data

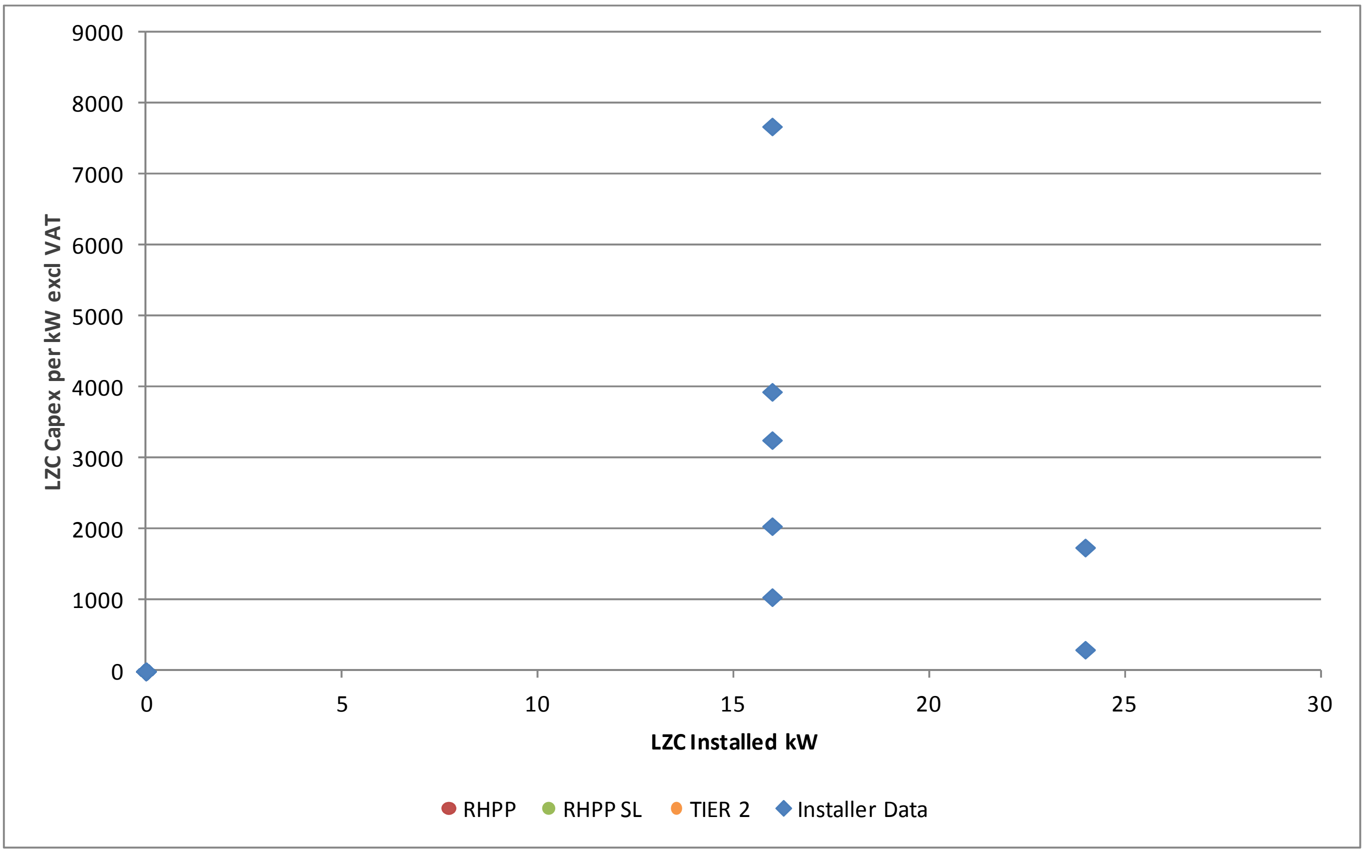


Figure 3.8ii: Distribution of equipment and add-on costs (High and Medium confidence data)

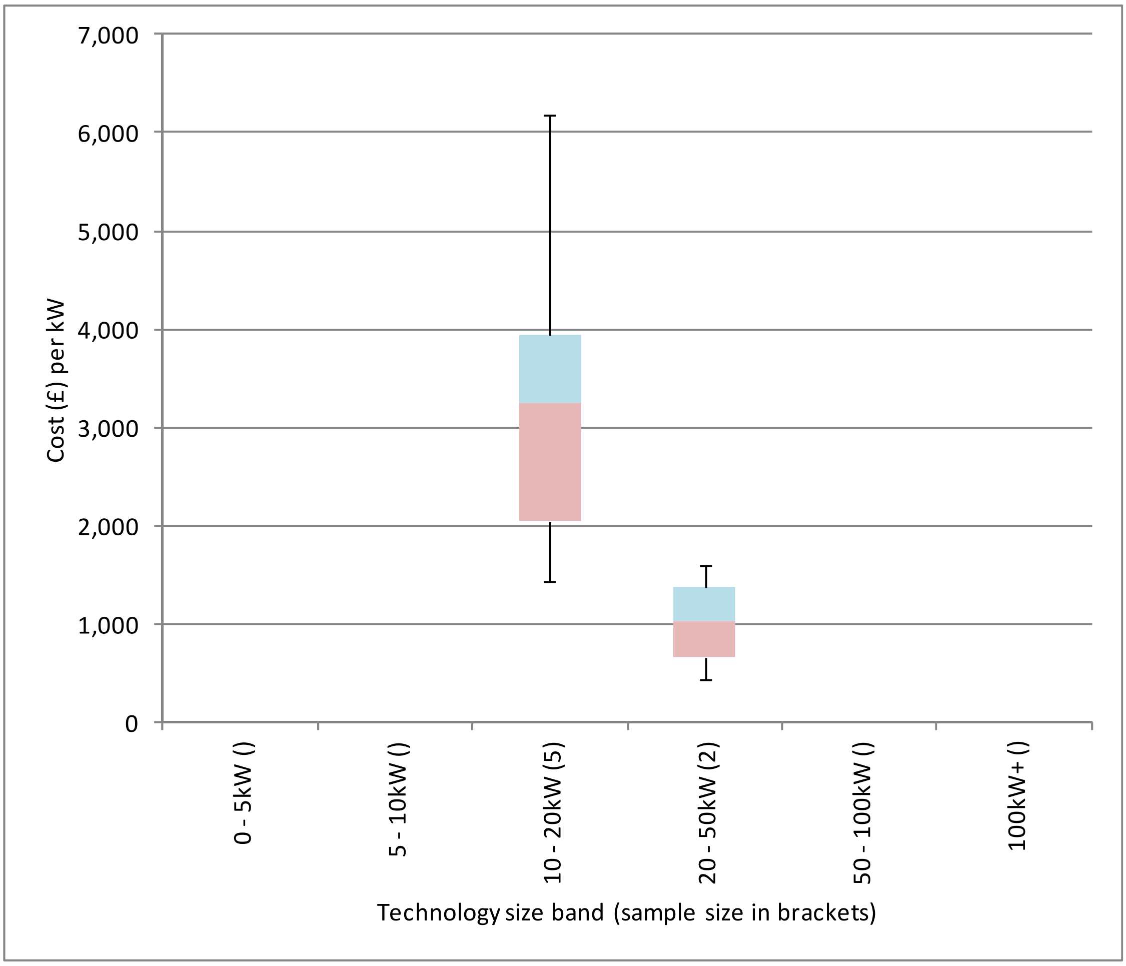


Figure 3.8iii: Cost summary

SUMMARY	10 - 20kW	20 - 50kW
No. of samples	5	2
90th percentile (£/kW)	£6,182	£1,601
Median Capex (£/kW)	£3,258	£1,025
10th percentile (£/kW)	£1,445	£449
Average Opex (£/kWh including fuel cost @ 2012)	£0.01	£0.07
Max efficiency	0.84	-
Median efficiency	0.84	0.84
Min efficiency	0.84	-

Interrogation of data

The data set for this technology is limited and although a downward trend was observed the variability of data within the two categories does not provide sufficient confidence to draw an accurate conclusion regarding relationships between size of plant and cost of equipment. Some of the variation may be attributable to the scope of the data returned, in particular supply only or supply and install, however due to the limited number of datasets received and the emerging nature of this technology type in the UK, it is too early to draw meaningful conclusions.

Solar PV-T hybrid heat pump solution

Number of samples collected (High and medium data)	8
Size range (kW)	4.5 – 18
Cost range (total cost)	£22,150 - £61,000
Manufacturer's claimed performance range (Coefficient of performance)	N/A
Approximate labour costs as a percentage of total cost	17%

Figure 3.9i: Overall distribution of cost data

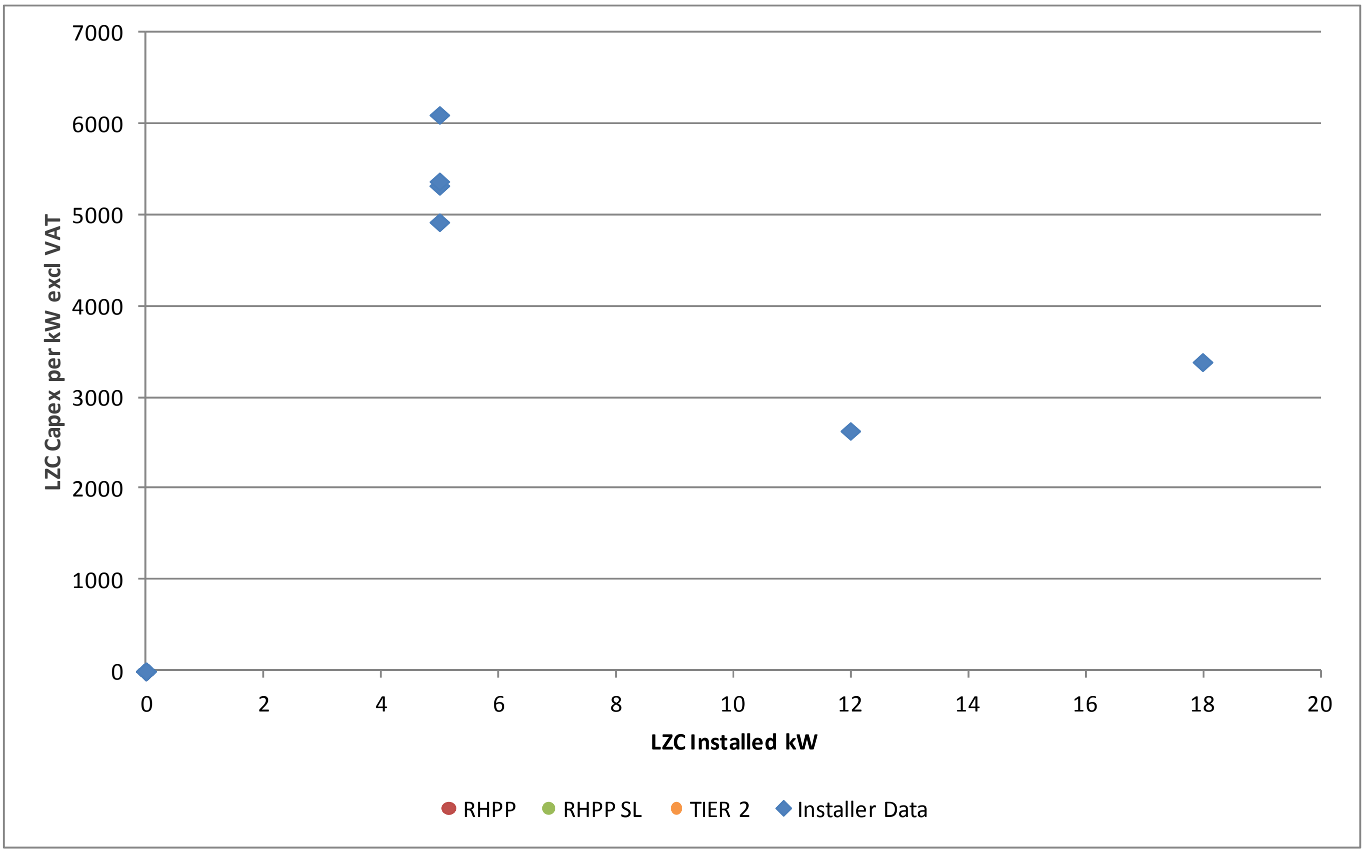


Figure 3.9ii: Distribution of equipment and add-on costs (High and Medium confidence data)

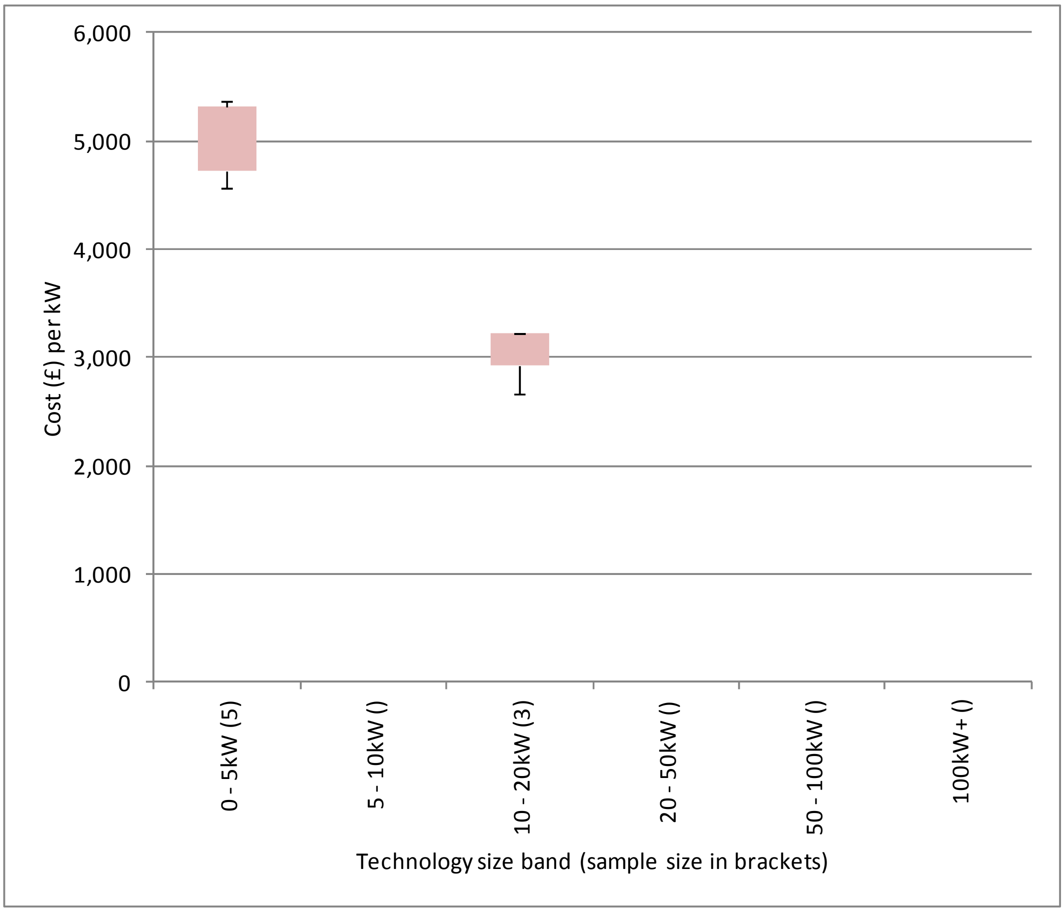


Figure 3.9iii: Cost summary

SUMMARY	0 - 5kW	10 - 20kW
No. of samples	5	3
90th percentile (£/kW)	£5,365	£3,222
Median Capex (£/kW)	£5,322	£3,222
10th percentile (£/kW)	£4,569	£2,752
Average Opex (£/kWh including fuel cost @ 2012)	£0.01	£0.01
Max CoP	-	-
Median CoP	4.20	4.85
Min CoP	-	-

Interrogation of data

The data set for this technology is limited but again shows a downward trend within the limited data set available. This is very much an emerging technology that combines solar thermal and in some cases ground thermal storage to improve the annual efficiency of the heat pump itself. The variability in cost can be attributed to the different designs used, in particular the inclusion/exclusion of a borehole to store heat produced during the summer for abstraction to improve heat pump performance during winter months.

Due to the photovoltaic component of the array, the system also includes a number of costs for items that would not normally be included within heat technologies. These include inverters, cabling, export metering etc, however these are offset by the financial benefits accrued through the generation of renewable electricity, attracting the feed in tariff and sale of electricity. .

Solar thermal

Number of samples collected (High and medium data)	55
Size range (kW)	0.74 – 12.32
Cost range (total cost)	£1,700 – £85,000
Performance range (Efficiency)	N/A
Approximate labour costs as a percentage of total cost	30%

Figure 3.10i: Overall distribution of cost data

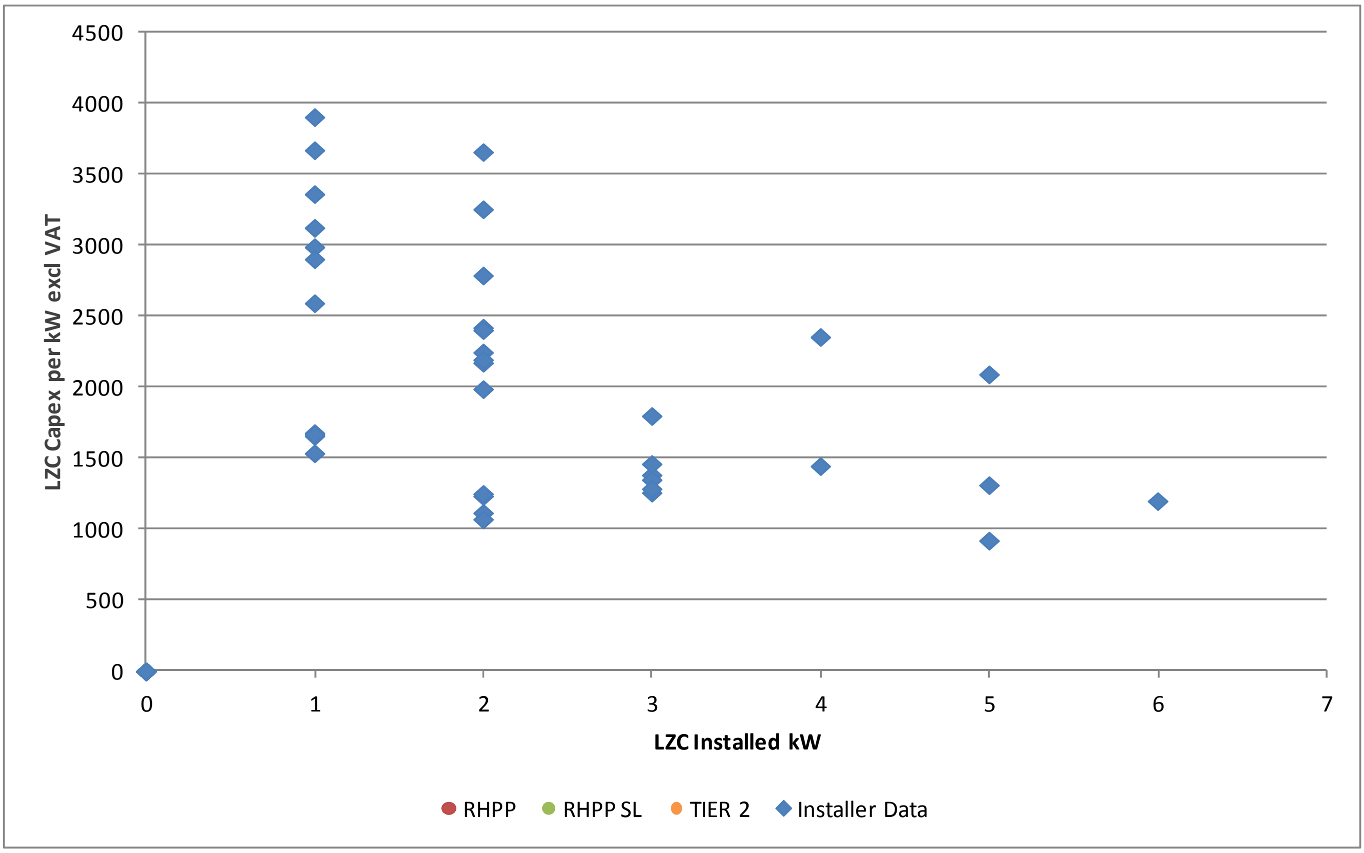


Figure 3.10ii: Distribution of equipment and add-on costs (High and Medium confidence data)

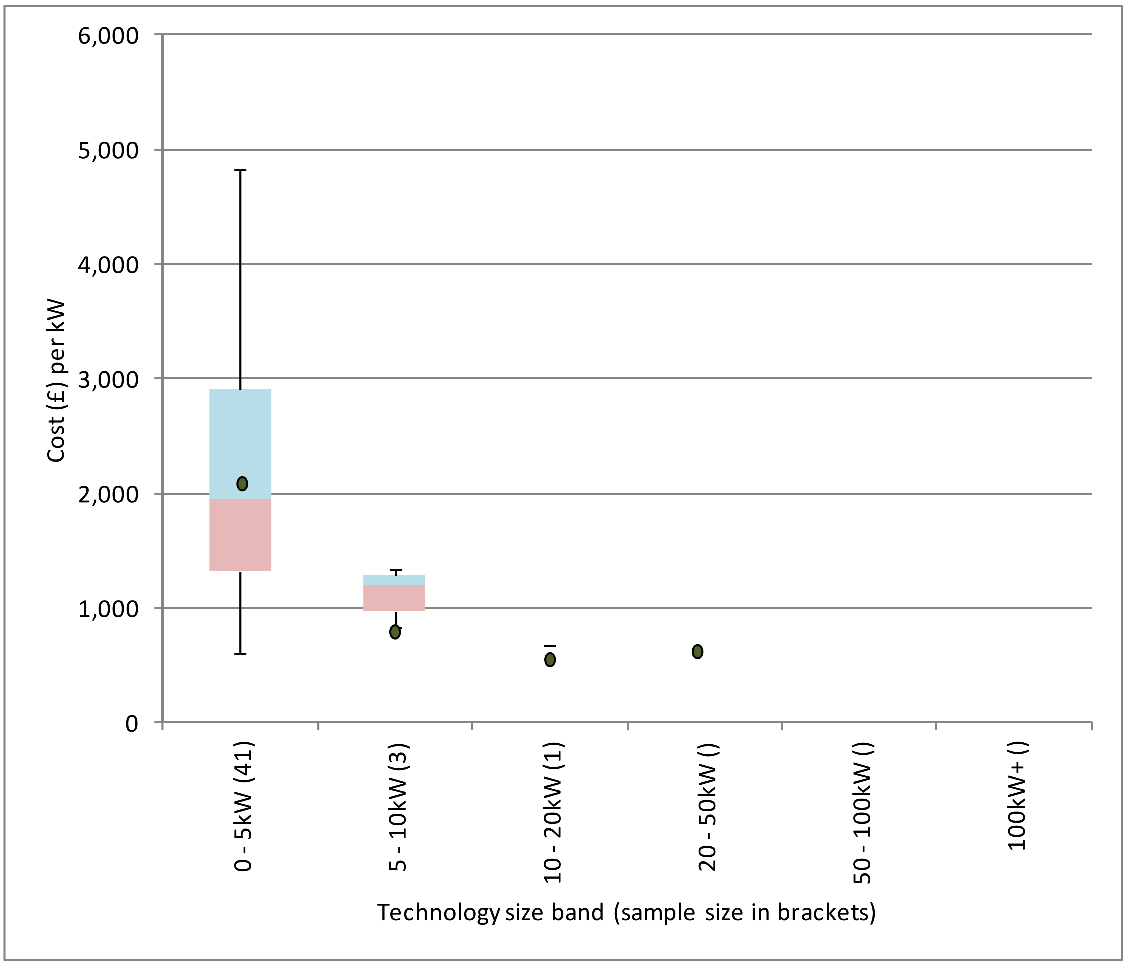


Figure 3.10iii: Cost summary

SUMMARY	0 - 5kW	5 - 10kW	10 - 20kW
No. of samples	41	3	1
90th percentile (£/kW)	£4,826	£1,335	£681
Median Capex (£/kW)	£2,060	£1,199	£681
10th percentile (£/kW)	£597	£825	£681
Average Opex (£/kWh including fuel cost @ 2012)	£0.14	£0.13	£0.13

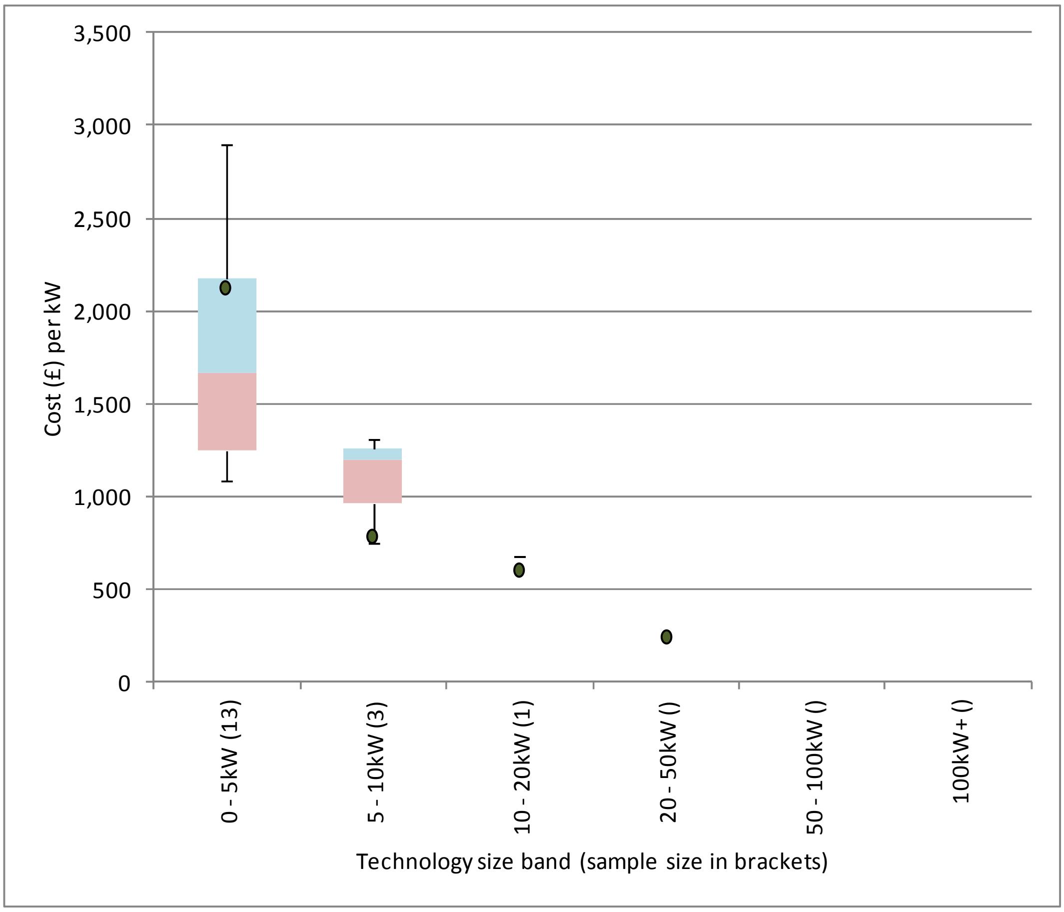
Interrogation of data

The majority of cost information was received for small scale domestic solar thermal systems, for which considerable variation was observed. A downward trend is observed with increasing capacity.

Solar thermal systems are usually designed and priced based on the percentage contribution to the domestic hot water demand of the associated building and are therefore designed on m^2 of absorber area, rather than a kW output. This study has required costs to be normalised using kW heat output to demonstrate consistency with previous studies and enable comparison between different technology types. However, it should be noted that actual kW output from solar thermal systems is a function of the relationship between ambient air temperature and mean internal fluid temperature (therefore heat loss from the array) and that useful kW output from the array is a function of actual kW output and the temperature of domestic hot water cylinder. Thus, designers and installers will tend to benchmark pricing and associated performance based on the number of tubes (which can be converted into m^2 absorber area) for evacuated tube systems and quantity and/or area of flat plate collector for solar thermal systems.

A significant cause for cost variation, particularly at the domestic scale was the inclusion/exclusion of the cost of the domestic hot water cylinder. Unless a retro-fit solar coil is used (often deployed in lieu of an immersion heater) a new cylinder is required to enable heat exchange between domestic hot water and the solar thermal heat exchange fluid (typically a glycol/water mixture). The figure below shows that by removing the cylinder from the overall scope of works, the cost variation becomes less extreme.

Figure 3.10iv: Distribution of equipment and add-on costs (High and Medium confidence data) – excluding solar cylinder



District Heating Systems

District heating systems can provide a cost effective means of distributing heat to a network of users. For the purposes of this study it has been requested that capex and opex data be provided per kW of heat demand. Figure 3.11 below provides a summary of data for domestic, commercial and industrial scenarios respectively. The numbers should be treated for indicative purposes only as in practice the cost per kW will be influenced by the scale and type of development accordingly.

Figure 3.11: Summary of costs for biomass district heating

Description	Domestic	Commercial		Industrial	
		Small	Large	Small	Large
Size (kW)	1,200	1,000	2,000	1,000	2,000
i) Cost of Plant (per kW)					
Urban	£575	£575	£525	£575	£525
Rural	£560	£560	£515	£560	£515
ii) Cost of Distribution (per kW)					
Urban	£190	£100	£95	£110	£105
Rural	£220	£150	£145	£160	£155
iii) Cost Connection to building (per kW at point of connection on peak demand)					
Urban	£45 (based on peak demand of 40kW for DHW)	£14 (less than 250kW HEX)	£11 (greater than 250kW HEX)	£16 (less than 250kW HEX)	£13 (greater than 250kW HEX)
Rural	£45 (based on peak demand of 40kW for DHW)	£15 (less than 250kW HEX)	£12 (greater than 250kW HEX)	£17 (less than 250kW HEX)	£14 (greater than 250kW HEX)
Total cost (i + ii + iii)					
Urban	£810	£689	£631	£701	£643
Rural	£825	£725	£672	£737	£684

DHW = Domestic Hot Water

HEX = Heat Exchanger

Assumptions

1. Cost of plant includes biomass boiler, gas boiler, thermal store, flues, controls, fuel storage and balance of plant.
2. Cost of energy centre enclosure and associated works is excluded.
3. Commercial and Industrial scenarios based on multiple buildings linked to a single network.
4. Cost of connection includes heat exchanger, pipework connection from network into building and associated civils.
5. Domestic scenario based on 500 dwellings. Urban assumes a greater density of dwellings than rural.
6. Domestic cost of connection is based on a heat interface unit with 40kW peak capacity for domestic hot water generation.
7. Commercial and industrial scenarios assume buildings are in closer proximity in urban areas.

8. Opex assumed to be 2% of capex as per AEA / NERA assumptions[2].

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[2] NERA Economic Consulting and AEA Technology, 2009. The UK Supply Curve for Renewable Heat.

Fuel Cells

A number of quotes were obtained for Fuel Cell CHP products. These have been excluded from the main bulk of the analysis due to many of the products not currently being fully commercially available.

A summary of cost and performance data is set out below:

Model: Fuel Cell CHP

Warranty: 2 years

Description: 24kW - auxiliary condensing burner max; 1.2kW - fuel cell heat max; 0.8kW - fuel cell electricity max.

Cost of main equipment: £2,600

Installation cost: £1,800

Additional ancillaries: £100

Ultra low carbon technologies

The data received in this category related to Passive Flue Gas Heat Recovery Devices (PFGHRD). The cost breakdown is shown below. These costs were confirmed as being consistent regardless of property / boiler size.

Model: Zenex Gas Saver GS1

Warranty: 5 years

Description: No power supply (passive system). Saves around 1,200 kWh per annum.

Equipment cost: £650

Install cost: £80

Maintenance cost: £80 annual service cost

4.0 Population of RHI model input sheet

Introduction

One of the outputs of the cost and performance database is a worksheet specifically formatted by DECC in order to align with the input data for their RHI model. This section of the report explains the information provided and the assumptions applied.

Figure 4.1: Assumptions applied when populating RHI model input sheet

DECC Column heading	Descriptions / assumptions
Technology	Range of LZC technologies
Customer segment	Commercial / public / domestic / industrial
Fuel counterfactual	Electricity / gas / non net-bound
Sub segment	Non-domestic : Private or public (large or small) – Large space heating wet / dry – Small space heating wet / dry – Large / small, high temperature process heat dry / wet – Large, low temperature process wet Domestic: Detached / Flat / Semi-detached / Terraced
Location	Rural / Urban / Semi-urban
Building age	Non domestic: Insulated pre 1990 / post 1990 Domestic: – New build – Insulated post 1990 – Non-insulated post 1990 – Insulated pre 1990 – Solid wall (insulated and non-insulated)
Space restriction	Not assessed as part of study
Heat grade match to application	Not assessed as part of study
Environmental and other impacts	Not assessed as part of study
RH Capex	The database uses a look-up based on the size of the system to populate the Capex data
RH fixed Opex	The database uses a look-up based on the size of the system to populate the Opex data. The Opex data is for fixed costs i.e. maintenance / servicing. In the absence of actual data (for some size bands) the average Opex cost is used. This is deemed acceptable as the maintenance costs do not have a

DECC Column heading	Descriptions / assumptions
	proportional relationship to system size hence are widely transposable
RH efficiency	Non domestic data based on AEA assumptions* Domestic data based on SAP assumptions
RH load factor	Non-domestic – calculated based on the building type for each installation scenario Domestic – based on SAP assumptions (See Appendix 1 for more detail)
RH size	Non-domestic – calculated based on the building type for each installation scenario Domestic – Derived from the required peak heat demand
RH lifetime	Not presented (data was collected relating to this but typically the data received related to manufacturer's warranties hence not actual lifetime figures)
Implied RH Heat output	Non domestic – Calculated based on the counterfactual building type Domestic – Calculated using SAP (See Appendix 1 for more detail)

⁎ DECC RHI Assumptions Phase II report – AEA Technology February 2012

Key assumptions / considerations

Gaps in data

Non-domestic

- There are gaps within the non-domestic data set where the counterfactual energy use scenario (e.g. a 100% electrically heated large office building) was considered to be unrepresentative of the building type. This is explained further in Appendix 2.

Domestic

- In some scenarios no data has been provided for certain technologies or dwelling types. This is because the nature of the dwelling and / or technology makes the scenario unviable. An example of this is the use of biomass in flats – in order to meet the heat demand of a flat then the boiler size needs to be <5kW, in practice this size biomass system is not available hence no data has been provided. The costs of shared systems are described in Section 3.

Non-domestic building performance

This is a fundamental area. At present the approach used in the RHI model applies the following approach:

Heat output = Load factor x capacity x number of hours in a year

The above approach should be used carefully. The reason being is that, particularly for non-domestic buildings, the capacity of system and load factor are influenced by a multitude of factors that are highly variable and are not directly linked to a generic building type.

For example:

- availability of space (to install a system)
- heat demand / profile (of the building) (e.g. in some instances the system will be sized based on the heat demand or hot water demand or both or a percentage of either / both, etc)
- availability of budget (to spend on systems)

Therefore assigning a particular load factor or capacity based on building type or size should be used for indicative purposes only. The results generated will need to be appraised before reaching any firm conclusions.

Impact of location on cost

The data obtained did not demonstrate a trend between the different sub segments e.g. urban / semi-urban / rural hence this variable has not been applied to the data.

Impact of specific technology attributes on cost

The model provided alongside this report enables the user to interrogate costs based on the following variables:

- **Air Source Heat Pumps**
  - Split system / single unit
- **Biomass**
  - Fuel type (Logs / wood chip / pellet / hybrid)
  - Presence of fuel store
- **GSHP**
  - Vertical / Horizontal
  - Drilling included in pricing / drilling not included
- **Solar Thermal**
  - Cylinder / no cylinder

5.0 Comparison against other datasets

Introduction

This section reviews other sources of cost data provided by DECC to evaluate how the data collated through this project compared with the data that DECC has collated to date.

Figure 5.1 below sets out the cost data obtained from the following sources:

Installer data: data collated through direct engagement

RHPP data: data provided by DECC

AEA data (as referenced earlier): Data used within RHI model

Figure 5.1: Comparison of data sets

Technology	Capacity (kW)	Cost and variance (ex VAT)		
		Installer data	RHPP data	AEA data
Air to Air Heat Pump	0 – 5	▨	▨	£418
	5 – 10	£1,138	▨	£386
	10 – 20	£584	▨	£405
	20 – 50	£1,415	▨	£391
	50 – 100	▨	▨	£446
	>100	▨	▨	£452
Air to Water Heat Pump	0 – 5	£1,380	£1,260	▨
	5 – 10	£1,187	£882	£1,301
	10 – 20	£556	£641	£1,108
	20 – 50	£1,963	£583	£929
	50 – 100	£1,240	▨	£783
	>100	£513	▨	£557
Biomass	0 – 5	▨	▨	▨
	5 – 10	▨	£1,078	£773
	10 – 20	£945	£625	£770
	20 – 50	£568	£391	£718
	50 – 100	£383	£333	▨

Technology	Capacity (kW)	Cost and variance (ex VAT)		
		Installer data	RHPP data	AEA data
	>100	£208	▨	£455
Ground Source Heat Pump	0 – 5	▨	£2,015	▨
	5 – 10	£2,403	£1,222	£1,760
	10 – 20	£1,980	£1,070	£1,545
	20 – 50	£1,652	£816	▨
	50 – 100	£1,172	£1,417	£1,397
	>100	£1,719	▨	£900
Solar Thermal	0 – 5	£2,060	£2,015	£1,603
	5 – 10	£1,199	£733	▨
	10 – 20	£1,025	£555	▨
	20 – 50	▨	£200	£1,363
	50 – 100	▨	▨	▨
	>100	▨	▨	▨

Explanation of observed cost differences

Comparison between installer data and RHPP data

From Figure 5.1 it can be seen that the installer data collected is on the whole higher than that for the RHPP data. On discussion with practitioners involved with the RHPP it was identified that some of the RHPP installations were carried out at a special rate in order to sell the first installation and get accredited as an MCS installer.

In addition, it has been raised that the invoices submitted to EST were not required to cover the full cost of the installation and for some boilers there will have been additional work covered on a subsequent invoice. For that reason the invoices may need some further investigation if the tariff will be mainly based on this previous pricing.

It can be seen that there is significant variance between the GSHP costs. It should be noted that the figures presented for the installer data include both vertical and horizontal systems. It is unclear whether this is the case for the RHPP data hence a potential fundamental reason for the variance. If just the installer data for horizontal systems are presented then these costs are in closer alignment with the RHPP data.

Comparison between installer data and AEA data

It should be noted that the installer costs presented are the median data for the bandwidths presented, whereas the AEA numbers represent specifically sized systems within those bandwidths. In general it can be seen that the data collated through the engagement exercise are higher than that presented within the AEA dataset. From a review of the source of AEA's data it appears that a large proportion of the data came from a limited number of manufacturers / suppliers. The data collated for this study came predominantly from installers who provided evidence of the cost of actual installations. These costs included the mark-up / profit applied by the installers hence increased the overall figure. Furthermore, the data came from a wider range of sources which meant a greater variation in the product used (i.e. some products used were more expensive, but offered higher outputs or levels of assurance, but as a result cost more than less effective alternatives).

Notable exclusions from datasets

i) Emerging data for low cost options

During the engagement work it was brought to the attention that some technologies could be sourced from Asia at a much lower rate than European counterparts. A specific example relating to Air Source Heat Pumps was provided. Whilst it is recognised that these lower cost options are available (and likely to become increasingly available) none of the costs provided by industry practitioners reflected these lower cost options hence they have not been included in this study. It is recommended that a review is undertaken at periodic intervals to understand the breakdown of the technology supply market in order to ensure that the cost data is kept up to date. Furthermore, it will be important for DECC to liaise with the Microgeneration Certification Scheme (MCS) in order to gauge their view on whether the lower cost technologies meet their required levels of robustness. This will allow a more accurate appraisal of the potential impact on the future market.

ii) Older data sets

For some technologies quotations were provided which were older than 3 years. The data within this study focuses on quotes from within the last 12 – 18 months, anything older than this has been excluded. This has reduced the overall sample size but should provide more representative figures.

6.0 Cost projections

Introduction

The costs and performance of heating and cooling technologies are expected to change over time as their markets expand. Industry learning and economies of scale in supply are expected to result in reductions in the cost per unit of performance output. The extent and scale of cost changes will be influenced by several factors including:

1. Projected growth in the market for a technology – more rapid growth in the market resulting in greater potential learning and economies of scale.
2. Potential for learning and economies – this is typically captured using a 'learning rate' the amount of cost reduction that could be expected for a given increase in market size. The learning rate will vary according to the type of technology / activity and may also change over time for a technology. Numerous studies have established learning rates for different technologies, although it is important to remember that learning rates are only suitable for assessing medium to long-term impacts on cost and do not take into account market dynamics or changes in external factors (see below). Many studies on learning rates have identified rates in the range of 20% (i.e. each time the market for a product group doubles the cost reduces by around 20%) while others have claimed that underlying learning rates (after adjusting for other factors such as competition and raw material prices) are lower, in the range of 5-10%.
3. Market forces – the cost of a technology on the market is influenced by a complex array of pricing factors which the cost of supply is only one. Market dynamics can be influenced by a wide range of factors and may result in short term fluctuations in pricing particularly in relatively immature markets. In the longer term it would be expected that prices would stabilise although they would be periodically disrupted by step changes in supply, demand or competitive behaviour.
4. External factors – including exchange rates, commodity and energy prices, etc. As well as competition from overseas manufacturers, which have the potential to significantly undermine the domestic market and exploit the elevated RHI tariffs.

Medium / long term projections

Learning rates

Figure 6.1 shows the learning rates used in this study, they are based on those applied in previous work and where originally collated in 2005 by Element Energy[3].

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[3] The Potential for Microgeneration, 2005. Element Energy. Report for the Energy Saving Trust available at http://www.berr.gov.uk/files/file27558.pdf.

Figure 6.1: Learning Rates for different technology groups

	Learning Rate (%)		
Technology	**High**	**Medium**	**Low**
Air to Air Heat Pumps	15%	9%	5%
Air to Water Heat Pumps	15%	9%	5%
Biomass boilers	20%	15%	15%
Biomass Combined Heat and Power (CHP)*	20%	15%	15%
Biomass direct air heating*	20%	15%	15%
District Heating Systems**	20%	15%	15%
Ground Source Heat Pumps***	15%	9%	5%
Solar thermal	18%	10%	10%

* based on the rates for biomass heating systems
** based on the rates for medium CHP systems
*** based on the rates for heat pumps in general

Market projections

Market projections have been developed for both global markets, as these are the primary drivers of underlying technology learning. However, it is also relevant to consider the projected scale of expansion in the UK along to get an indication as the likely impact of projected growth on the maturity and efficiency of the market.

The global market projections used in this study are based on the IEA's Blue Plan or 2DS scenarios as described in their Technology Roadmap publications[4], while UK projections are based on the DECC Renewable Energy Action Plan for the UK[5]. Figure 6.2 shows the global market projections used to project future costs, these are developed using IEA analysis using a trend line between projected market size in 2050 together and the installed capacity.

Figure 6.2: Global market projections

		Year								
Technology	**Unit***	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Air to Water Heat Pumps	ktoe	96	118	150	194	342	456	604	996	1,301
Biomass boilers	ktoe	444	551	697	904	1,161	1,548	2,052	2,765	3,612
District Heating Systems	ktoe	62	77	97	126	102	136	181	176	230
Ground Source Heat Pumps	ktoe	174	216	273	354	433	578	766	730	953
Solar thermal	ktoe	34	34	34	34	34	34	34	34	34

** Kilo-tons of oil equivalent*

To some extent the use of market projections to estimate future costs is a circular exercise as the projections used in the study already include assumptions about the speed of cost changes. Nonetheless using global projections

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[4] Specifically the Technology Roadmaps for: Energy Efficient Buildings Heating and Cooling Equipment, and Bioenergy for Heat and Power. Both publications are available from www.iea.org.

[5] DECC, 2009. Available at: http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/25-nat-ren-energy-action-plan.pdf

does provide an indication as to the potential direction of future costs given the wide range of international and other national policies and socio-economic factors and can therefore be a useful baseline to assess the implications of additional policy measures. The use of UK market projections is more complex, given that these projections already incorporate to a greater or lesser extent the planned implications of national energy efficiency and renewable heat policies.

Figure 6.3 shows the UK market projections to 2020 taken from the Renewable Energy Action Plan. These projections have not been used for quantitative cost projections but they do illustrate the scale of development envisaged for the UK market. One impact of this growth in market size and maturity will be greater price transparency and a progressive reduction in any UK 'premium' arising from inefficiencies or higher profit taking. This may result in additional cost reductions being seen in the UK for technologies where the UK market is currently less developed than those in other countries.

Figure 6.3: UK market projections

		Year								
Technology	**Unit**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Air to Air Heat Pumps	installed units	600	624	648	674	701	729	757	787	819
Air to Water Heat Pumps	GWth	739	776	816	857	901	947	995	1,046	1,099
Biomass boilers	ExJ	3.00	3.06	3.11	3.17	3.23	3.29	3.35	3.41	3.47
Biomass Combined Heat and Power (CHP)	GWe	50	53	57	61	64	69	73	78	83
Ground Source Heat Pumps		739	776	816	857	901	947	995	1,046	1,099
Solar thermal	GWth	152	165	180	196	213	232	252	274	298

	Year									
Technology	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Air to Air Heat Pumps	851	885	920	956	994	1,033	1,074	1,117	1,161	1,207
Air to Water Heat Pumps	1,155	1,214	1,276	1,341	1,409	1,481	1,556	1,635	1,719	1,806
Biomass boilers	3.54	3.60	3.67	3.73	3.80	3.87	3.94	4.02	4.09	4.17
Biomass Combined Heat and Power (CHP)	89	94	101	107	114	122	130	138	147	157
Ground Source Heat Pumps	1,155	1,214	1,276	1,341	1,409	1,481	1,556	1,635	1,719	1,806
Solar thermal	325	353	384	418	455	495	538	586	637	693

Cost projections

Figures 6.4 to 6.6 show the projected reductions in costs of each technology group between 2012 and 2030 based on projected growth in global markets. The analysis indicates cost reductions of between 2 and 18% will be seen by 2020 with further reductions of up to 35% of the 2012 cost by 2030. Over this period to 2020, the UK market for heating and cooling technologies is projected to increase by up to 8 times (see Figure 6.7) indicating a significant growth in the level and maturity of the market. This may result in further UK specific cost reductions and a narrowing in the range of costs experienced as market prices become more established.

Figure 6.4: ‘High’ learning rate applied

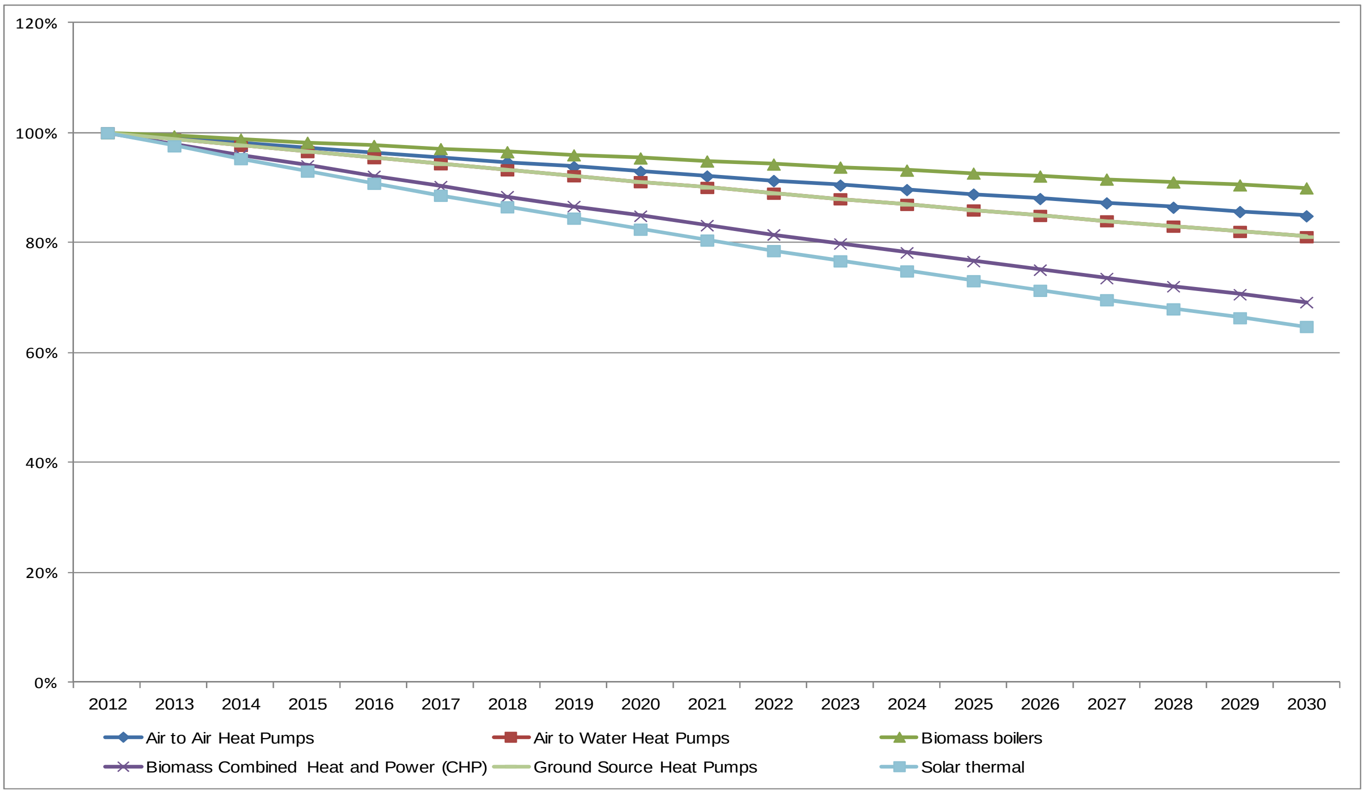


Figure 6.5: ‘Medium’ learning rate applied

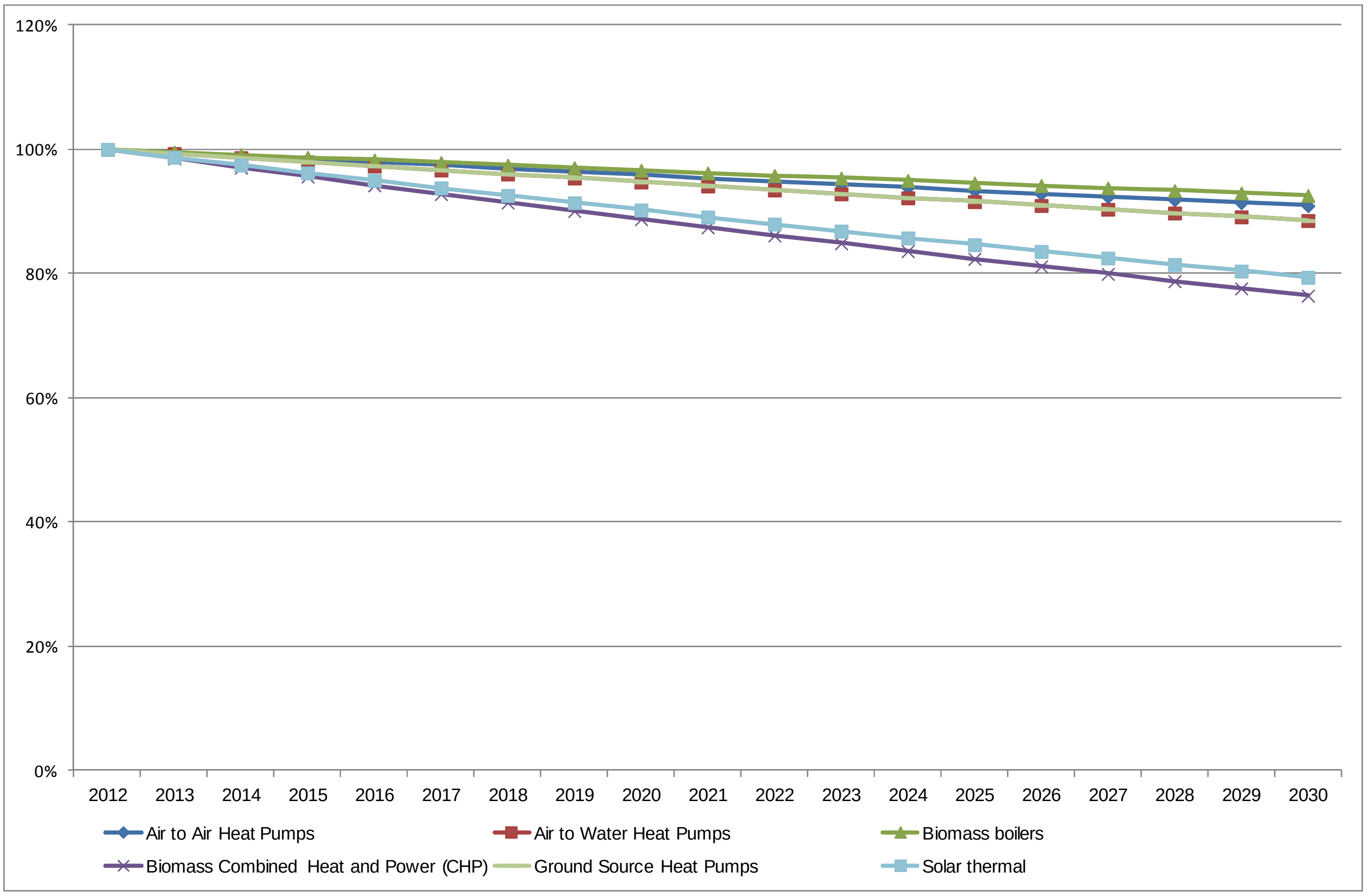
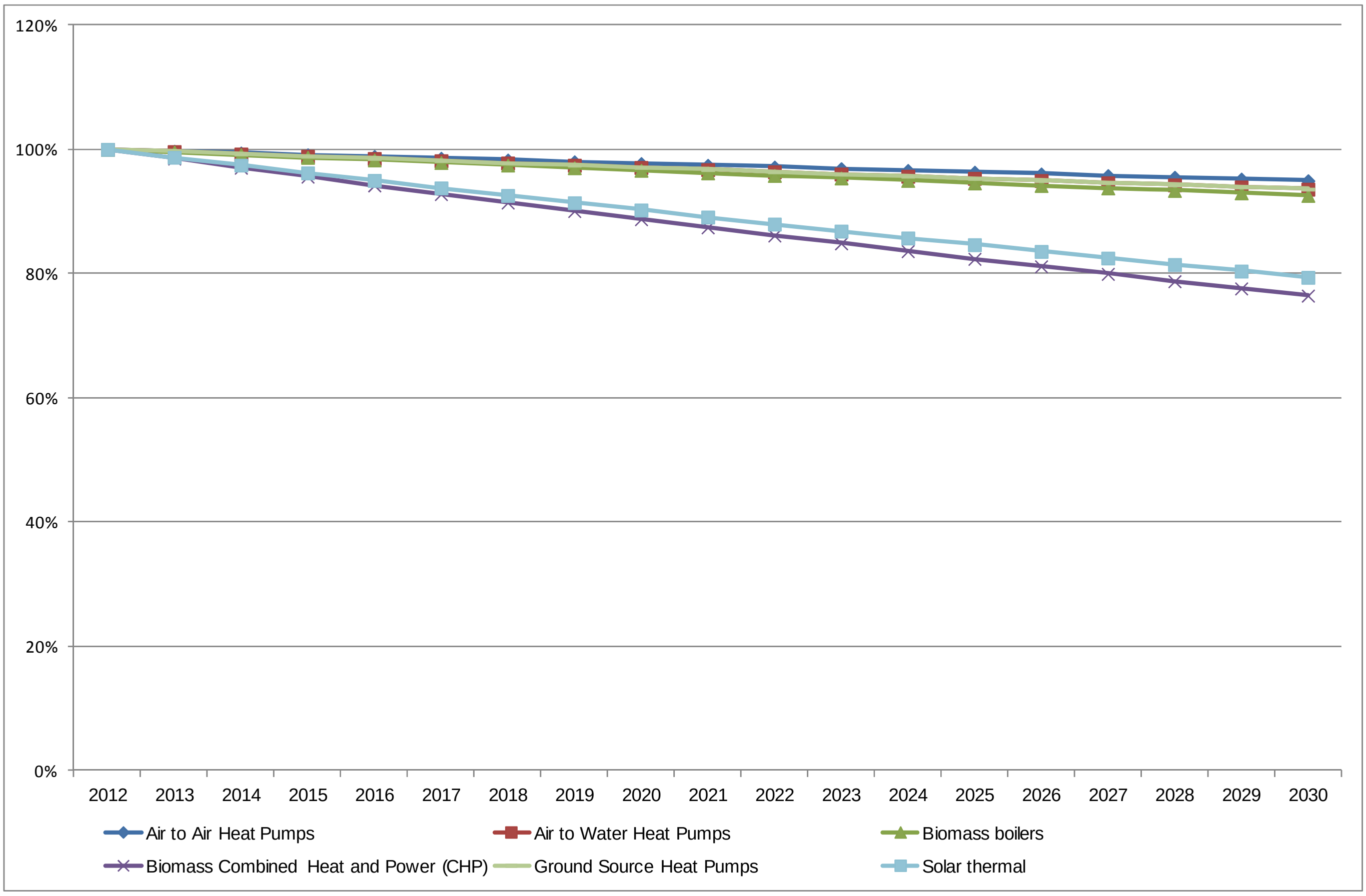


Figure 6.6: ‘Low’ learning rate applied


120%
100%
80%
60%
40%
20%
0%
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
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2025
2026
2027
2028
2029
2030
Air to Air Heat Pumps
Air to Water Heat Pumps
Biomass boilers
Biomass Combined Heat and Power (CHP)
Ground Source Heat Pumps
Solar thermal

Figure 6.7: **Calculation table for the renewable energy contribution of each sector to final energy consumption (ktoe)**

Scenario	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Expected gross consumption of RES for Heating and Cooling	475	518	621	756	937	1,186	1,537	2,039	2,719	3,604	4,746	6,199
Expected gross final consumption of RES for electricity	1,506	2,720	3,195	3,613	4,061	4,582	5,189	6,077	7,053	8,052	9,008	10,059
Expected final consumption of energy from RES from Transport	69	1,066	1,383	1,663	1,859	2,223	2,581	2,927	3,265	3,596	3,925	4,251
Total	2,050	4,304	5,200	6,032	6,856	7,992	9,307	11,043	13,037	15,252	17,679	20,510

Notes for Figure 6.7:

1) *Source: DECC analysis based on Redpoint/Trilemma (2009), Element/Pöyry and Nera (2009) and DfT*
2) *According to Art.5(1) of Directive 2009/28/EC gas, electricty and hydrogen from renewable energy sources shall only be considered once. No double counting is allowed.*
3) *Containing all RES used in transport including electricity, hydrogen and gas from renewable energy sources and excluding biofuels that do not comply with the sustainabilty criteria (cf Article 5(1) last subparagraph).*

7.0 Further information

Introduction

This section sets out some of the anecdotal evidence received from industry during the engagement process.

General observations

Installation costs do not increase linearly with size of equipment. One of the overriding factors influencing installation cost is space. For example, when there is limited space, the installation activity becomes considerably more complex and time consuming hence costs increase accordingly.

Installers vary how they price their jobs, for example in some instances they will discount the cost of the equipment but then increase their labour costs. This makes the differentiation between equipment and labour costs more complicated.

Some installers will include the costs of other work within their scope. This is prevalent when the installer is a more general tradesman as opposed to a specialist installer. Examples include, fixing floor boards or laying insulation in the loft. The cost of this additional work often gets incorporated in the overall cost hence skewing the cost of the installation work slightly.

Significant variation also exists with respect to the quality of the technology installed (note, this is not always reflected accurately in the accompanying manufacturer's warranties). Different brands are recognised across the industry as offering differing levels of efficiency, longevity and aesthetic quality. Client specification/ supplier endorsement therefore can result in a distinctive impact upon the cost of an installation.

It will be important to work with industry to test assumptions around the applied modelling methodology. This is a key area of contention – particularly with respect to performance calculations.

Appendices

Appendix 1.0: Modelling methodology - Domestic

Overview

The domestic modelling consisted firstly of creating 84 dwelling variations; one for each of the 'age/insulation', 'rurality' and 'dwelling type' combinations (details given in Figure A1.1). Each of the 84 standard dwellings was then modelled with the renewable and counterfactual heating systems that were deemed appropriate for that dwelling type (details given in Table A1.1 and Table A1.2). Where a renewable heating system is commonly installed to provide space heating only or to provide both space heating and domestic hot water (DHW), both potential options were modelled (further details are included below). A total of 2268 SAP 2009[6] models were thus undertaken. Details of how the standard dwellings were created and the performance assumptions used for each of the renewable and counterfactual heating systems are given below.

Creation of the standard dwellings

The dimensions, construction types and other data required to undertake a SAP model, for each of the standard dwellings, were ascertained from the English Housing Survey (EHS) 2009[7] as follows:

1. The **average dimensions** were calculated using the EHS 2009 for each rurality-age-dwelling type combination, including: volume; total floor area; and external wall, roof, floor, window and door areas. There are 48 different sets of dimensions corresponding to these combinations, or 'standard dwellings'. A summary of the dimensions used for each standard dwelling is presented in Table A1.3.
2. **Other SAP data requirements** such as the SAP age band of the property, living area fraction, total number of light fittings and percentage of those which have compact fluorescents lamps (CFLs) were ascertained for each dwelling in the EHS. The average was then found for each dwelling-type sample subset.
3. The **construction specifications** assigned to each 'age/insulation' group of dwellings are given in Table A1.4.
4. A few assumptions were made to simplify the variations between the dwellings: all floor areas were assumed to be solid and all roofs were assumed to be pitched. The construction features assigned to each 'age/insulation' group were chosen based on an analysis of the typical construction types in the EHS. For the pre-1990 group, however, the wall construction assigned to a particular standard dwelling also depended on whether the average age of that type of dwelling was before or after 1950; with narrow cavity walls (filled or unfilled) being typical before and 'conventional' cavity walls being typical after that date (again, filled or unfilled).

Within the EHS, no rural, solid-walled flats were identified. This dwelling type is still included in the model, but it is assumed to have the same dimensions as a suburban solid-walled flat.

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[6] Building Research Establishment (BRE) on behalf of Department of Energy and Climate Change (DECC), 2010, *The Government's Standard Assessment Procedure for Energy Rating of Dwellings (SAP) 2009 edition*, accessible from: http://www.bre.co.uk/sap2009/page.jsp?id=1642

[7] Department for Communities and Local Government (DCLG), *English Housing Survey (EHS) 2010*, data accessible from: http://www.ccsr.ac.uk/esds/variables/ehs/

Assumptions for the performance of the renewable and counterfactual heating systems

Energy demands and fuel/electricity consumption modelling

The assumptions for modelling the annual energy demands and fuel/electricity consumption for the renewable and counterfactual heating systems are given in Table A1.6 and Table A1.7. In addition, common to all systems modelled, we have assumed there to be no secondary heating; 100% of the heating demand is provided by the counterfactual or renewable heating system.

For the RH systems, models were undertaken both when:

- DHW is provided by the RH system (where this is a technical possibility); and
- when DHW is not provided by the RH system.

The latter case might be likely to occur when, for example, a heat pump or biomass boiler is installed in a previously electrically heated property which has an existing immersion heater hot water system that is not connected to a wet central heating system.

Renewable heating and counterfactual system sizing methodology

The methods used to size the heating systems are as follows:

- For all systems except for heat pumps and CHP, the methodology used is that described in the Energy Saving Trust publication *CE54: Domestic heating sizing method*[8], using the design temperature difference (or temperature factor) stipulated for the Midlands (30K).
- For heat pumps and CHP, the design temperature difference used to size the systems is 24.2K, as recommended in Appendix N of SAP 2009. The methodology used is in-line with that described in the *Microgeneration Installation Standard: MIS 3005*[9], i.e. that heat pumps should be designed to meet the temperature difference arising at an external temperatures that is equalled or exceeded for 99% of occupied hours, with the internal design temperatures referenced in the MIS 3005 document. No further capacity is included for the provision of DHW, regardless of whether it is to be provided.

Sizing methodologies were agreed through consultation with the RHI team at DECC.

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[8] Energy Saving Trust (EST), 2010, *CE54: Domestic heating sizing method,* accessed from http://www.energysavingtrust.org.uk/Publications2/Housing-professionals/Heating-systems/Domestic-heating-sizing-method-2010-edition

[9] Department of Energy and Climate Change (DECC), 2008, *Microgeneration Installation Standard: MIS 3005: Requirements for contractors undertaking the supply, design, installation, set to work commisioning and handover of microgeneration heat pump systems*, accessible from: http://www.microgenerationcertification.org/images/MIS_3005_Issue_3.1a_Heat_Pump_Systems_2012_02_20.pdf

Figure A1.1: Age/insulation, dwelling type and ruralities modelled

Age/insulation:

1 New build
2 Post-1990
3 Post-1990 uninsulated
4 Pre-1990
5 Pre-1990 uninsulated
6 Solid-wall
7 Solid-wall uninsulated

Dwelling type:

1 Detached
2 Flat
3 Other (semi-, end of terrace)
4 Mid-terrace

Rurality:

1 Urban
2 Suburban
3 Rural

7 x 4 x 3 = **84** combinations

Table A1.1: Counterfactual heating systems and their applicability

System type		Applicable dwelling type	Applicable dwelling age
1	Electric storage	all	all*
2	Gas non-condensing standard	houses	all
3	Gas non-condensing combi	flats	all
4	Non-net-bound (oil) non-condensing standard	houses	all
5	Non-net-bound (oil) non-condensing combi	flats	all
6	Gas condensing standard	houses	all
7	Gas condensing combi	flats	all
8	Non-net-bound (oil) condensing standard	houses	all
9	Non-net-bound (oil) condensing combi	flats	all

** Different assumptions for new build and non-new build*

Table A1.2: Renewable heating systems and their applicability

System type		Applicable dwelling type	Applicable dwelling age	System might provide heating only (H) or heating and domestic hot water (H & DHW)
1	Air to air heatpump	all	all	H only
2	Air to water heat pumps (radiators)	all	all	H or H & DHW
3	Air to water heat pumps (underfloor)	all	all	H or H & DHW
4	Ground source heat pumps (radiators)	all	all	H or H & DHW
5	Ground source heat pumps (underfloor)	all	all	H or H & DHW
6	Biomass	all	all	H or H & DHW
7	District heating systems	all	all	H or H & DHW
8	Liquid biofuels	all*	all	H & DHW
9	Micro combined heat and power technologies	all	all	H or H & DHW
10	Gas condensing standard, Gas Saver	houses	all	H & DHW
11	Gas condensing combi, Raven Heat	flats	all	H & DHW
12	Non-net-bound (oil) condensing standard, Gas Saver	houses	all	H & DHW
13	Non-net-bound (oil) condensing combi, Raven Heat	flats	all	H & DHW
14	Gas condensing standard, SHW	houses	all	H & DHW
15	Non-net-bound (oil) condensing standard, SHW	houses	all	H & DHW
16	Gas non-condensing standard, SHW	houses	all	H & DHW
17	Non-net-bound (oil) non-condensing standard, SHW	houses	all	H & DHW

*** *Different assumptions for houses and flats***

Table A1.3: Average dimensions and other SAP inputs for the standard dwellings

Standard dwelling description			Dwelling dimensions and other SAP parameters										
Rurality	Dwelling type	Age band	Dwelling volume	Floor area	Wall area	Roof area	Floor area	Window area	Door area	SAP age band	Light fittings	Living area fraction	CFLs
Urban	Detached	New build	369.9	149.2	140.5	94.4	77.9	30.2	7.3	2003-2006	13.0	0.18	32%
Urban	Detached	Post-1990	331.7	133.8	132.5	89.2	73.9	28.3	6.0	1996-2002	12.7	0.18	30%
Urban	Detached	Pre-1990	327.2	130.6	122.9	97.2	80.8	29.7	5.5	1950-1966	11.5	0.20	30%
Urban	Detached	Solid-wall	400.6	149.8	142.6	103.2	87.3	36.5	6.0	1900-1929	12.1	0.20	29%
Urban	Semi-/end of terrace	New build	235.4	94.4	87.5	53.2	42.1	17.3	5.1	2003-2006	9.7	0.23	38%
Urban	Semi-/end of terrace	Post-1990	198.2	77.9	77.1	50.0	40.3	15.7	4.0	1996-2002	8.6	0.25	35%
Urban	Semi-/end of terrace	Pre-1990	230.8	89.8	79.7	60.7	49.1	21.7	4.5	1950-1966	9.5	0.23	35%
Urban	Semi-/end of terrace	Solid-wall	280.3	104.3	94.8	65.6	53.9	24.4	4.8	1900-1929	10.4	0.21	34%
Urban	Mid-terrace	New build	248.5	98.4	55.5	50.0	40.1	16.7	5.3	2007-2012	9.4	0.24	37%
Urban	Mid-terrace	Post-1990	184.1	74.0	39.1	44.0	36.0	13.5	4.2	1996-2002	8.0	0.26	40%
Urban	Mid-terrace	Pre-1990	208.6	80.2	49.6	51.0	41.2	17.2	4.1	1950-1966	8.7	0.25	38%
Urban	Mid-terrace	Solid-wall	241.7	89.9	53.3	54.0	44.6	18.8	4.3	1900-1929	9.5	0.23	37%
Urban	Flat	New build	155.3	61.6	43.7	61.5	61.5	8.2	1.9	2003-2006	5.6	0.36	47%
Urban	Flat	Post-1990	139.9	56.1	44.0	55.7	55.4	8.0	1.9	1996-2002	5.5	0.38	40%
Urban	Flat	Pre-1990	149.4	58.3	44.7	57.9	57.1	10.0	1.9	1967-1975	5.5	0.38	47%
Urban	Flat	Solid-wall	165.9	61.9	42.6	61.3	54.4	10.7	1.9	1930-1949	6.0	0.36	46%
Suburban	Detached	New build	391.9	151.9	144.5	98.6	81.6	31.3	6.2	2003-2006	12.4	0.18	29%
Suburban	Detached	Post-1990	310.1	125.4	129.0	91.0	74.1	25.5	6.0	1996-2002	12.0	0.19	38%
Suburban	Detached	Pre-1990	328.4	127.9	120.5	103.0	86.0	28.4	5.3	1950-1966	11.2	0.20	34%

Standard dwelling description			Dwelling dimensions and other SAP parameters										
Rurality	Dwelling type	Age band	Dwelling volume	Floor area	Wall area	Roof area	Floor area	Window area	Door area	SAP age band	Light fittings	Living area fraction	CFLs
Suburban	Detached	Solid-wall	397.3	148.3	142.1	101.3	89.5	33.2	5.4	1900-1929	12.0	0.21	30%
Suburban	Semi-/end of terrace	New build	217.3	87.4	81.2	51.2	40.4	17.4	5.0	2003-2006	8.5	0.24	39%
Suburban	Semi-/end of terrace	Post-1990	194.4	78.7	71.6	53.9	42.9	15.5	3.7	1996-2002	8.1	0.27	44%
Suburban	Semi-/end of terrace	Pre-1990	221.6	88.6	76.1	64.5	52.6	20.1	4.5	1950-1966	9.3	0.23	37%
Suburban	Semi-/end of terrace	Solid-wall	285.8	111.7	93.1	71.0	59.1	23.5	4.7	1900-1929	10.3	0.21	39%
Suburban	Mid-terrace	New build	224.5	91.7	51.2	47.2	36.5	18.5	5.2	2003-2006	10.6	0.21	51%
Suburban	Mid-terrace	Post-1990	160.1	65.5	36.5	44.8	36.3	12.0	3.8	1991-1995	7.4	0.27	33%
Suburban	Mid-terrace	Pre-1990	201.9	80.6	51.2	55.2	43.8	15.7	4.2	1950-1966	8.5	0.25	38%
Suburban	Mid-terrace	Solid-wall	231.3	90.9	54.2	55.3	44.4	16.4	4.0	1900-1929	9.0	0.24	31%
Suburban	Flat	New build	171.8	68.9	52.3	68.9	68.9	6.9	1.9	2003-2006	6.0	0.33	43%
Suburban	Flat	Post-1990	130.7	53.0	45.2	53.0	53.0	10.7	1.9	1996-2002	6.0	0.30	21%
Suburban	Flat	Pre-1990	154.1	61.5	50.7	61.5	61.5	8.8	1.9	1976-1982	7.2	0.28	16%
Suburban	Flat	Solid-wall	184.9	70.3	49.1	70.3	70.3	7.2	1.9	1900-1929	5.7	0.33	42%
Rural	Detached	New build	409.4	161.3	140.2	117.0	100.6	33.7	7.1	2003-2006	12.1	0.19	37%
Rural	Detached	Post-1990	405.2	163.4	139.1	118.3	100.4	32.6	6.9	1996-2002	13.5	0.17	34%
Rural	Detached	Pre-1990	386.4	154.5	125.6	123.1	104.8	32.9	6.0	1950-1966	12.1	0.19	30%
Rural	Detached	Solid-wall	496.6	193.2	161.2	129.3	109.6	38.5	6.6	1900-1929	13.7	0.19	29%
Rural	Semi-/end of terrace	New build	273.1	106.9	89.6	64.3	51.5	20.3	5.9	2003-2006	9.8	0.22	30%
Rural	Semi-/end of terrace	Post-1990	221.8	90.6	81.2	62.0	49.5	16.9	4.1	1996-2002	9.3	0.23	38%
Rural	Semi-/end of terrace	Pre-1990	235.7	95.3	79.8	68.9	56.9	20.7	4.4	1930-1949	9.5	0.23	39%

Standard dwelling description			Dwelling dimensions and other SAP parameters										
Rurality	**Dwelling type**	**Age band**	**Dwelling volume**	**Floor area**	**Wall area**	**Roof area**	**Floor area**	**Window area**	**Door area**	**SAP age band**	**Light fittings**	**Living area fraction**	**CFLs**
Rural	Semi-/end of terrace	Solid-wall	312.4	123.7	103.2	83.0	68.5	23.0	5.1	1900-1929	10.3	0.22	32%
Rural	Mid-terrace	New build	261.3	103.7	56.6	49.5	42.8	20.0	6.2	2007-2012	10.1	0.21	39%
Rural	Mid-terrace	Post-1990	145.7	58.2	37.9	38.4	30.6	10.8	2.8	1996-2002	6.7	0.30	58%
Rural	Mid-terrace	Pre-1990	208.9	83.9	48.9	57.5	46.9	16.8	4.0	1930-1949	9.1	0.24	33%
Rural	Mid-terrace	Solid-wall	307.8	115.2	61.9	71.7	59.4	21.7	4.4	1900-1929	10.0	0.22	31%
Rural	Flat	New build	147.6	59.9	54.2	59.9	59.9	4.0	1.9	2007-2012	6.0	0.30	80%
Rural	Flat	Post-1990	125.4	50.9	35.5	50.9	50.9	6.0	1.9	1996-2002	6.0	0.30	0%
Rural	Flat	Pre-1990	188.1	70.6	42.8	70.6	70.6	9.3	1.9	1950-1966	8.0	0.25	20%
Rural	Flat	Solid-wall	184.9	70.3	49.1	70.3	70.3	7.2	1.9	1900-1929	5.7	0.33	42%

Table A1.4: Construction types assumed for each of the 48 standard dwellings

Age/insulation	Wall	Roof	Floor	Window	Door
New build	Cavity, modern, filled	loft, 300+ mm	solid, 100 mm	Double-glazed- UPVC	uPVC
Post-1990	Cavity, part filled, filled	loft, 200-249 mm	solid, 25 mm	Double-glazed- UPVC	uPVC
Post-1990 uninsulated	Cavity, part filled, unfilled	loft, 1-59 mm	solid, 0 mm	Single-glazed- UPVC	uPVC
Pre-1990	*1950-1990:* Cavity, conventional, filled. *Pre-1950:* Cavity, narrow, filled	loft, 200-249 mm	solid, 25 mm	Double-glazed- UPVC	Wood
Pre-1990 uninsulated	*1950-1990:* Cavity, conventional, unfilled. *Pre-1950:* Cavity, narrow, unfilled	loft, 1-59 mm	solid, 0 mm	Single-glazed- wood casement	Wood
Solid-wall	External insulation	loft, 200-249 mm	solid, 25 mm	Double-glazed- wood	Wood
Solid-wall uninsulated	Solid	loft, 1-59 mm	solid, 0 mm	Single-glazed- wood sash	Wood
Special case for flats	-	below heated	above heated	-	internal

Figure A1.5: Wall construction types present in each 'age/insulation' group in the EHS

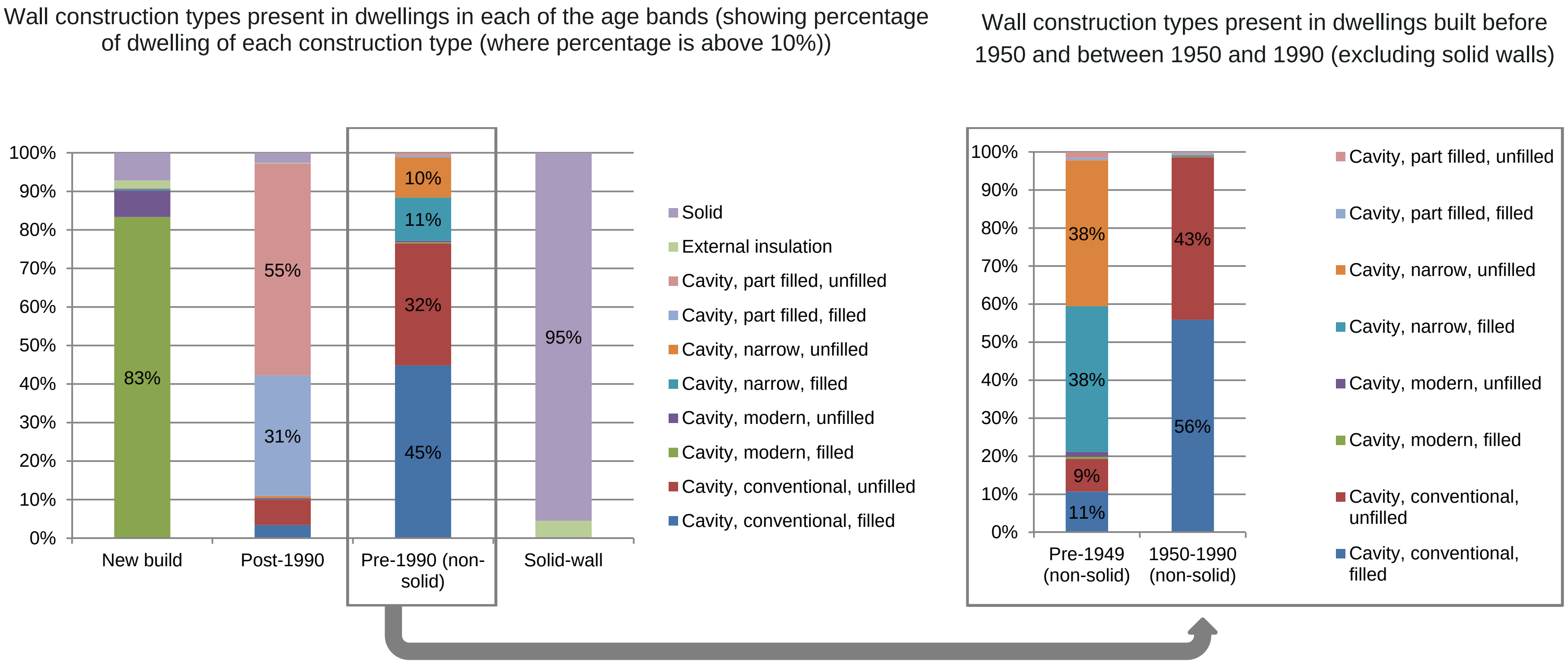


Table A1.6: Performance assumptions for counterfactual heating systems

Heating system	Main heat fuel	Hot water	Hot water fuel	Heat distribution	Heat controls[1]	Gains from pumps and fans (W)	Electricity consumption (kWh/yr)	Flue fan & Electric keep hot consumption (kWh/yr)	Primary circuit losses (kWh/yr)	Efficiency of space heater	Efficiency of space heater with under floor heating	Efficiency of water heater
Electric storage (non new build)	electricity (7 hr. off peak)	electric immersion heater, factory insulated tank	electricity (7 hr. off peak)	room heaters	Basic	0	0	0	0	100%	100%	100%
Electric storage (new build)	electricity (7 hr. off peak)	electric immersion heater, factory insulated tank	electricity (7 hr. off peak)	room heaters	Advanced	0	0	0	0	100%	100%	100%
Gas non-condensing standard	gas (mains)	from main, factory insulated tank	gas (mains)	radiators	basic	10	130	0	610	74%	77%	64%
Gas non-condensing combi	gas (mains)	from main, combi	gas (mains)	radiators	basic	10	130	0	0	74%	77%	65%
Non-net-bound (oil) non-condensing standard	heating oil	from main, factory insulated tank	heating oil	radiators	basic	10	230	0	610	80%	83%	68%
Non-net-bound (oil) non-condensing combi	heating oil	from main, combi	heating oil	radiators	basic	10	230	0	0	77%	80%	68%
Gas condensing standard	gas (mains)	from main, factory insulated tank	gas (mains)	radiators	basic	10	130	45	610	90%	93%	80%
Gas condensing combi	gas (mains)	from main, combi	gas (mains)	radiators	basic	10	130	45	0	90%	93%	80%
Non-net-bound (oil) condensing standard	heating oil	from main, factory insulated tank	heating oil	radiators	basic	10	230	0	610	90%	93%	74%
Non-net-bound (oil) condensing combi	heating oil	from main, combi	heating oil	radiators	basic	10	230	0	0	90%	93%	85%

“Basic” heating controls corresponds to SAP heating control code 2 and no DHW cylinder thermostat is assumed. “Advanced” heating controls corresponds to SAP heating control code 3 with DHW cylinder thermostat with separate time control. The specification of heating controls that meets codes 2 and 3 is dependent on heating system type, as specified in Table 4e, SAP 2009.

Table A1.7: Performance assumptions for renewable heating systems

Heating system	Main heat fuel	Hot water	Hot water fuel	Heat distribution	Heat controls[1]	Gains from pumps and fans (W)	Electricity consumption (kWh/yr)	Flue fan & Electric keep hot consumption (kWh/yr)	Primary circuit losses (kWh/yr)	Efficiency of space heater	Efficiency of space heater with under floor heating	Efficiency of water heater
Air to air heatpump (all)	electricity (standard tariff)	electric immersion heater, factory insulated tank	electricity (standard tariff)	warm air system	advanced	0	0	0	0	250%	250%	100%
Air to water heat pumps (all)	electricity (standard tariff)	from main, factory insulated tank	electricity (standard tariff)	radiators	advanced	10	130	0	0	250%	250%	100%
Air to water heat pumps (all)	electricity (standard tariff)	from main, factory insulated tank	electricity (standard tariff)	underfloor	advanced	10	130	0	0	250%	250%	100%
Ground source heat pumps (all)	electricity (standard tariff)	from main, factory insulated tank	electricity (standard tariff)	radiators	advanced	10	130	0	0	320%	320%	100%
Ground source heat pumps (all)	electricity (standard tariff)	from main, factory insulated tank	electricity (standard tariff)	underfloor	advanced	10	130	0	0	320%	320%	100%
Biomass (all)	wood	electric immersion heater, factory insulated tank	electricity (standard tariff)	radiators	advanced	10	130	0	610	70%	73%	100%
District heating systems (all)	community heating from CHP/waste heat	communal, factory insulated tank	community heating from boilers	radiators	advanced	10	130	0	360	75%	75%	75%
Liquid biofuels (houses)	liquid biofuel	from main, factory insulated tank	liquid biofuel	radiators	advanced	10	230	0	610	90%	93%	74%
Liquid biofuels	liquid biofuel	from main, combi	liquid biofuel	radiators	advanced	10	230	0	0	90%	93%	85%

Heating system	Main heat fuel	Hot water	Hot water fuel	Heat distribution	Heat controls[1]	Gains from pumps and fans (W)	Electricity consumption (kWh/yr)	Flue fan & Electric keep hot consumption (kWh/yr)	Primary circuit losses (kWh/yr)	Efficiency of space heater	Efficiency of space heater with under floor heating	Efficiency of water heater
(flats)												
Micro combined heat and power technologies (all)	gas (mains)	from main, factory insulated tank	gas (mains)	radiators	advanced	10	130	45	610	69%	72%	48%
Gas condensing standard (with gas saver)	gas (mains)	from main, factory insulated tank	gas (mains)	radiators	Basic	10	130	45	610	90%	93%	80%
Gas condensing combi (with raven heat)	gas (mains)	from main, combi	gas (mains)	radiators	Basic	10	130	45	0	90%	93%	80%
Non-net-bound (oil) condensing standard (with gas saver)	heating oil	from main, factory insulated tank	heating oil	radiators	Basic	10	230	0	610	90%	93%	74%
Non-net-bound (oil) condensing combi (with raven heat)	heating oil	from main, combi	heating oil	radiators	Basic	10	230	0	0	90%	93%	85%
Gas condensing standard (with 4m^2 SHW)	gas (mains)	from main, factory insulated tank	gas (mains)	radiators	Basic	10	130	45	610	90%	93%	80%
Non-net-bound (oil) condensing standard (with 4m^2 SHW)	heating oil	from main, factory insulated tank	heating oil	radiators	Basic	10	230	0	610	90%	93%	74%
Gas non-condensing	gas (mains)	from main, factory	gas (mains)	radiators	Basic	10	130	0	610	74%	77%	64%

Heating system	Main heat fuel	Hot water	Hot water fuel	Heat distribution	Heat controls[1]	Gains from pumps and fans (W)	Electricity consumption (kWh/yr)	Flue fan & Electric keep hot consumption (kWh/yr)	Primary circuit losses (kWh/yr)	Efficiency of space heater	Efficiency of space heater with under floor heating	Efficiency of water heater
standard (with $4m^2$ SHW)		insulated tank										
Non-net-bound (oil) condensing standard (with $4m^2$ SHW)	heating oil	from main, factory insulated tank	heating oil	radiators	Basic	10	230	0	610	90%	93%	74%
Electric storage (non new build) (with $4m^2$ SHW)	electricity (7 hr. off peak)	electric immersion heater, factory insulated tank	electricity (7 hr. off peak)	none	Basic	0	0	0	0	100%	100%	100%
Electric storage (new build) (with $4m^2$ SHW)	electricity (7 hr. off peak)	electric immersion heater, factory insulated tank	electricity (7 hr. off peak)	none	Advanced	0	0	0	0	100%	100%	100%

[1] “Basic” heating controls corresponds to SAP heating control code 2 and no DHW cylinder thermostat is assumed. “Advanced” heating controls corresponds to SAP heating control code 3 with DHW cylinder thermostat with separate time control. The specification of heating controls that meets codes 2 and 3 is dependent on heating system type, as specified in Table 4e, SAP 2009.

Appendix 2.0: Modelling methodology – Non domestic

Introduction

The cost and performance database provided as part of this study enables the performance of the technologies to be assessed for the domestic, non-domestic and industrial sectors segmented in a consistent format with existing and planned DECC heat models. To this end, the performance of the technologies has been assessed using annual heating demands and peak load data for typical buildings within these sectors. Heat consumption for the domestic sector is relatively well understood, with occupancy profiles well monitored and demands generally varying as a function of occupancy (number of persons), size of house and building fabric. Heat demand in non-domestic buildings (including public sector, commercial and industrial buildings) is less understood. There are many more sub-categories of building usage under these headings with different occupancy profiles and building typologies. Furthermore, measured data is less widely available. Industrial buildings in particular show variance as in addition to the factors already discussed, heat demands can often be a function of process heat load, i.e. the type of manufacturing being undertaken within the building itself.

The following sections set out the non-domestic energy heating demands used to develop the non-domestic counterfactual scenarios and provides supporting information, references and justifications for their selection and use.

Building Selection

Unlike domestic buildings, non-domestic buildings cover a wide range of different uses, sizes and design (i.e. fabric build-up/air tightness). Counterfactual scenarios have been provided for the public, private (commercial) and industrial sectors, it should be noted that these scenarios are subject to considerable variation and the numbers provided should be treated as illustrative only.

Public sector

Public sector building typologies comprise a wide range of uses including schools, offices, prisons, hospitals and other more specialised building uses. Data has not provided counterfactual scenario data for all public sector building types for the following reasons:

- counterfactual scenarios are required to compare performance of different technology types, not compare different building uses;
- benchmark data for some of the less common building types is less likely to be statistically valid as the data will be sourced from a smaller sample number;
- renewable heat technologies are unlikely to be deployed on buildings where mains gas is available. A large number of different public sector buildings are located in urban areas (e.g. hospitals) and are therefore less applicable to this study;
- office space is covered under the commercial building heading.

Experience of the renewable heat market suggests that schools represent the most suitable building type for use in developing a counterfactual scenario for public sector buildings for the following reasons:

- schools have a high heating demand and a large number are still heated by oil (and coal in some areas), especially those located in rural areas as well as schools constructed pre- 1980's in urban areas;
- a significant programme of Post Occupancy Evaluation (POE) has been undertaken on modern schools to compare actual heating bill data with benchmark data;
- benchmark data is readily available and considered reliable due to size of sample population used to develop databases (e.g. CIBSE Guide F and CIBSE TM46);
- public and private sector schools and academies are known to be actively targeted by renewable heating companies (e.g. biomass/GSHP/solar thermal) and a significant number have already been converted.

The table below presents the benchmark data and counter-factual heat consumption estimates provided for schools.

Table A2.1 Proposed counter-factual data - schools

Building	Heating benchmark	DHW benchmark	Heating energy	DHW energy	Heat load	Source
Unit	KWh/m^2/yr	KWh/m^2/yr	MWh/yr	MWh/yr	KW	
Pre 2000 school	127	18	1,339	187	1,296	ECG073 (typical)
Post 2000 school	66.5	9.18	700	96	916	POE data

It should be noted that some schools, particularly those with boarding houses are likely to have higher heat demands per kW boiler installed due to the longer operational hours expected of the boiler plant.

Commercial Buildings

As with the public sector, there are a wide range of buildings that comprise the commercial sector. Two building types have been chosen to provide counterfactual scenarios against which the cost benefits of different technologies can be assessed. These are hotels and commercial office space. These particular building types were chosen for the following reasons:

1. Offices represent a relatively common building typology for which heating energy consumption data is relatively readily available and are found in both urban and rural locations;
2. Hotel heating demands are also relatively well understood for hotel buildings. A relatively high heating demand that incorporates a high year round domestic hot water demand as well as process load associated with swimming pools and often rural locations make hotels a suitable target for the renewable heat industry. They have consequently been included within this study.

Data for buildings constructed pre and post 1995 has been provided. Data has been taken from reliable sources and compared where possible with actual data taken from POE data/other private sources of information to ensure validity and relevance of benchmark data within the context of this study. Counter-factual data, benchmarks are sources of data are provided in Table A2.2.

Table A2.2 – Commercial building heat demands

School age	Heating benchmark	DHW benchmark	Heating energy	DHW energy	Heat load	Source
Unit	KWh/m^2/yr	KWh/m^2/yr	MWh/yr	MWh/yr	KW	
Office - typical	144	8	718	37	500	ECG 019 Type 3
Office – good	78	4	391	20	350	ECG 019 Type 3
Hotel – Typical	196	77	1,129	442	578	CIBSE GF Type 2
Hotel - good	136	51	785	295	347	CIBSE GF Type 2

NB: – Type 3 office type comprises an air conditioned office of standard specification

Type 2 hotel type comprises standard business/holiday hotel

Industrial

Industrial building heat use is arguably most difficult to benchmark due to the influence on the particular building industry/usage on heating energy consumption. Counterfactual scenarios have been provided for two different types of building:

- industrial non process – e.g. standard industrial units with no industrial process heat load. Examples might include distribution depots, light manufacturing etc.
- industrial process – industrial buildings with a high process heat load.

Industrial building users likely to utilise renewable sources of heat include:

1. Industrial non process users located in rural environments (i.e. off mains gas);
2. Industrial process heat users located in rural environments (off mains gas) - these might typically include agricultural industry such as mushroom cultivation or large greenhouses growing salad crops etc., food processing/production industries e.g. dairies, breweries or timber production and processing industries.
3. Industrial process heat users that produce timber waste products – e.g. sawmills, furniture/pallet makers.

For industrial process heat loads the relationship between peak boiler size and annual heat demand tends to be specific to the nature of heat use and the system configuration. For example where steam is required to sterilise packaging (e.g. bottles) or compost (e.g. mushrooms) a large amount of steam is required over a relatively short period. The system may be designed to meet this instantaneous load using the boiler in isolation or an accumulator vessel, or a combination of the two. Effectively this means the size of boiler required to serve a demand can vary significantly and the numbers presented here-in are based upon a set of industry benchmarks that have been verified through data received informally from industry sources.

Similarly industrial buildings (non process) will also demonstrate a significant variation in heat demands. Heat demands in these types of buildings, although not related to process heat demands are more related to building fabric but also usage of building. For example large logistics centres may choose to only heat a small proportion of the overall building envelope as doors etc. are constantly opening and shutting to allow goods to be delivered/picked up or more commonly they may choose to heat to a lower setpoint.

Table A2.3 presents the benchmarks and consumption figures used within this study. It should be noted however that the potential for variation within this category in particular is considerable; therefore the data presented needs to be treated as indicative only.

Table A2.3: Industrial building heat demands

Building	Heating benchmark	DHW benchmark	Heating energy	DHW energy	Heat load (peak)	Source
Unit	KWh/m^2/yr	KWh/m^2/yr	MWh/yr	MWh/yr	KW	
Industrial non-process **Post 1995**	73.4	8.16	88	9	96	CIBSE GF Industrial <5000m^2
Industrial non-process **Pre 1995**	81.855	9.095	98	11	120	CIBSE GF Industrial <5000m^2
Industrial process	N/A	N/A	2,945	N/A	1600	See note

The counter-factual heat demand for the industrial process building type has been developed for a 'typical' mushroom farm. The assumptions used to develop this scenario are presented in Table A2.4. The estimates shown in Tables A2.3 and A2.4 have been checked against actual recorded data to ensure it is representative and realistic.

Table A2.4: Industrial building (process) heat demand assumptions

Item	Value	Unit	Source
Heat consumption	2,500	KWh oil per tonne compost used	Farm Energy Centre, 2008
Annual compost usage	91,320	Tonnes/year	DEFRA mushroom production area study, 2010, England)
Number of growers	31	Growers	DEFRA mushroom production area study, 2010, England)
Number of farms/grower	2	Farms/growers	Based on observations
Annual energy demand/farm	3,682	MWh/year	calculation
Boiler efficiency	80%		Assumption
Annual heat demand	2,945	MWh/year	calculation
Boiler size	1.6	MW	Observation
Industrial process	N/A	N/A	-

Other examples of industrial process heat users located in rural areas include dairies and cheese producers. Dairy Crest recently installed 2 no. 6MW biomass steam boilers to generate c. 80% of the annual steam required for cheese making at their Davidstow plant in North Cornwall. Prior to the installation of the biomass boilers, the steam was produced using conventional oil fired boilers and was costing the business £3 million/year in fuel costs. Due to price volatility in the heating oil market it was also considered a significant risk to future business viability therefore the decision was taken to construct a 6MW wood pellet system. Capital costs were estimated at £4.2m and payback was anticipated in Year 4 of operation (http://www.boilerguide.co.uk/dairy-crests-4-2m-biomass-boiler-given-the-royal-treatment)

Development of load factors

DECC has requested that the database enables the performance of the technologies to be assessed for the domestic, non-domestic and industrial sectors segmented in a consistent format with existing and planned DECC heat models. Previously AEA Technologies assigned a range of load factors for different technologies under different building types and scenarios. The load factors are in turn used to determine the annual hours of operation of a particular renewable heating technology as follows:

Renewable heat (RH) technology KW_{th} output x 8,760 hours x load factor = RH technology annual heat production

This number has then been used to derive the RHI tariff levels using the following factors to complete the cost benefit analysis:

1. Operational cost savings – technology efficiencies are used to estimate input energy costs (e.g. biomass fuel, electricity for heat) and fuel savings against conventional heating systems;
2. Capital costs – previous capital cost estimates have been used;
3. Investment period – payback must be achieved in a 20 year period

The factors outlined above have been used to calculate the level of tariff required to provide the 12% return on investment.

This makes the tariff calculation process sensitive to the underlying assumptions and variables as outlined below:

1. Load factor – load factors are often building/load specific and relate to the client and therefore engineers brief. Load factors for residential properties are relatively well understood, however the potential for variation in the non-domestic sector is significant hence the approach needs to be handled in a sensitive manner;
2. Operational costs – system efficiencies drive the calculation of operational cost savings. Perversely under the current model, inefficient systems that require more input fuel (biomass, electricity etc.) per unit heat produced will result in a higher tariff level. These calculations should therefore be considered alongside the ultimate goal of this support mechanism in terms of £/Kg CO_2 saved.
3. Capital costs – capital costs vary according to building specific requirements as scopes for different technologies can vary significantly.

The focus of the study undertaken has been to develop a reliable database of system costs and associated technology performance. Industry groups, suppliers, installers and engineers have all responded and their data has been used as appropriate. This study was not commissioned to undertake a detailed review on individual system efficiencies and in particular developing load factors for the different technologies, particularly for the non-domestic sector. It should be noted that renewable heat technologies are sized with specific aims depending on the particular situation and therefore applying a standardised approach to load factor and efficiency criteria has limitations when assessing system cost benefits and therefore supporting the calculations used to derive the RHI tariffs.

DECC has requested that commentary is provided on the load factors developed by AEA Technologies and where possible derive alternatives. This section sets out the rationale behind the numbers provided, however the overarching caveat is that these numbers are variable and dependent on site specific system and environmental factors and therefore can only provide an indication of technology performance.

Non-domestic Buildings

Non domestic buildings include a wide variety of different structures of different sizes, ages, constructions, systems designs and uses. Therefore any benchmark data for each non-domestic building type will also need suitable caveats attached. Acknowledging this, Buro Happold has provided benchmark data for a range of different building types that are more likely to be fitted with renewable heat technology in different capacities. These include:

- Public sector – schools (pre and post 1990)
- Commercial sector – hotels (pre and post 1990)
- Commercial sector – offices (pre and post 1990)
- Industrial – non process (pre and post 1990)
- Industrial – process batch production
- Industrial – process continuous production
-

It is appreciated that there are a wide range of other building types, however it is also envisaged that other building types will have similar peak load, load profiles and annual heat demands as those outlined above (allowing for variation in building footprint) and therefore similar ‘down-stream’ relationships can be inferred (e.g. residential care homes and hotels).

As outlined in the introduction, the potential for variation in load factors between different buildings and even different buildings within the same type (e.g. schools) is significant as it can depend on (but not be limited to):

- Local environmental conditions (ground/air temperature);
- Building fabric and permeability;
- Occupancy and use;
- Servicing strategy (e.g. natural ventilation vs. mechanical ventilation systems);
- Location

The other variable in developing load factors for renewable heat technologies is the purpose behind the installation itself. There is a multitude of differing factors, but broadly for the non-domestic sector these can split into two different categories:

1. Sizing system to replace oil/electric heating system to reduce fuel bills (most common reason for existing buildings but also valid for new build off-gas grid buildings);
2. Sizing system to achieve a specific renewable energy target (most common for new buildings with connections to the gas-grid required to meet a local authority target or BREEAM or equivalent target).

These two different rationale result in different design and sizing strategies with the aim of option 1 to size to meet as much of the demand as economically as possible and the aim of option 2 to do the opposite, i.e. meet the minimum demand required to achieve the target for the least cost possible on the understanding gas fired boilers represent the most cost effective means to heat a building within the physical constraints of new buildings (limited space availability).

Taking these factors into account, Buro Happold has developed a series of load factors by applying simple first principle design principles typically used to determine cost benefits at an early stage in the design process prior to the development of bespoke building energy models or equivalent at the later stages of design. The data used to develop these load factors have been derived using published guidance where possible, our own design experience as well as first principles (in the instance of developing a load factor for an industrial process heat load). The basic formula used to develop a load factor for use by RHI is:

- Peak heat demand (kWth) x % load served by RH technology = RH Technology capacity (kW$_{th}$)
- Annual heat demand (kWh/yr) x % demand met by RH technology = RH Technology annual heat production kW$_{th}$
- RH Load factor = RH Technology annual heat production/ (RH Technology capacity x number of hours in a year)

Estimating peak heat loads and annual heat demands

Peak loads and annual heat demands for each building type are presented in Table A2.5.

Table A2.5: Heat demands and peak heat loads

Category	type	Age	Floor area m^2	Heating kWh/m^2	hot water kWh/m^2	Total heat demand kWh/yr	Process heat demand kWh/yr	Peak load W/m^2	Peak load kW	Peak DHW load kW
Public Sector	School	pre 1990	10,529	127	18	1,339,226		123	1,295	170
	School	modern	10,529	62	15	654,016		70	737	150
Commercial sector	Hotel	pre 1990	5,778	196	77	1,129,599		100	578	350
	Hotel	modern	5,778	136	51	785,808		60	347	350
	Office	pre 1990	5,000	144	8	718,675		90	450	55
	Office	modern	5,000	78	4	391,638		70	350	55
Industrial	No process	Pre 1990	1,200	73	8	88,128		100	120	N/A
	No process	modern	1,200	82	9	98,226		80	96	N/A
	Process	Batch	N/A				2,945,806		1,600	
	Process	Continuous					8,750,000		2,000	

Table A2.6 summarises the benchmark information used to calculate these estimates.

Table A2.6: Benchmark information

Category	Type	Age / function	Source	Sub-source	Peak heat demand W/m^2	Source
Public	School	pre 1990	ECG 073	Typical school	100	Rule of thumb
	School	modern	Published POE data - buro Happold		87	Modelled
Commercial	Hotel	modern	CIBSE Guide F	Type 2 good practice	100	Rule of thumb
	Hotel	pre 1990	CIBSE Guide F	Type 2 typical practice	60	BSRIA handbook 4th ed
	Office		ECG 019	Type 3 air conditioned office	90	Rule of thumb
	Office		ECG 019	Type 3 air conditioned office	70	BSRIA handbook 4th ed
Industrial	non process		CIBSE Guide F	Post-1995 <5000m^2	80	Rule of thumb
	non process		CIBSE Guide F	Pre-1995 <5000m^2	100	Rule of thumb
	process	batch	See comment 1		See comment 1	
	process	continuous	See comment 2		See comment 2	

Comment 1 – Estimates were calculated using the following data sources for a typical agri-industrial batch sterilisation process:

1. Energy consumption of mushroom farms – Farm Energy Centre, 2008;
2. DEFRA mushroom production area 2010, England.

Comment 2 – Estimate derived for an example of a commercial horticultural plant grower taken from Carbon Trust Guide 012 – Biomass Heating – Guide for Practical Users P.12

Due to the very specific nature of process heat load, it is virtually impossible to create a rule of thumb. Instead these numbers have been estimated to provide an indication of performance and demonstrate the extreme caution that should be applied when seeking to develop generic load factors for different buildings.

Load factors

Tables A2.7, A2.8 and A2.9 show the load factors calculated for the different building uses and different technology types. Once again it is important to stress that there is potential for variation on the numbers presented, sizing strategy is often influenced by sizing factors and within the retrofit market, sizing is often skewed to ensure the best value for money for the client by sizing generation plant to qualify for the maximum tariff, hence the proliferation of 199 kW rated biomass boilers.

The method by which the load factors has been calculated does show that the relationship between peak load and annual demand and the associated load profile has an influence on load factor that creates significant site specific variation. Thus hotels have a relatively high base heat load (due to a high proportion of domestic hot water demand) which returns a relatively high corresponding load factor, whereas a like for like comparison with offices shows a lower load factor due to a more sporadic peak load profile.

Table A2.7: Biomass Load Factors

Biomass	Building	Age	CF fuel	% peak load	% annual load	Boiler size	Annual heat produced	RHI Load Factors	Comment
Public sector	school	pre 1990	oil/gas	50%	80%	648	1,071,381	18.9%	Sizing ratio based on optimum sizing with thermal storage - CTG012
	school	modern	oil	50%	80%	369	523,213	16%	Majority of modern schools constructed with gas boilers, however new build schools in rural locations (e.g. Scotland) will specifiy 100% biomass over oil
	school	modern	gas	20%	50%	147	327,008	25%	Majority of modern schools constructed with gas boilers. Biomass typically used to meet planning/BREEAM target. % targets presented are based upon designs actually installed to meet these criteria
	school	pre 1990	electric	50%	80%	648	1,071,381	19%	Electric only schools v. Unlikely. Therefore if these were encountered, would warrant a 100% replacement
	school	modern	electric	100%	100%	737	654,016	10%	Electric only schools v. Unlikely. Therefore if these were encountered, would warrant a 100% replacement
Commercial sector	hotel	pre 1990	oil	100%	100%	578	1,129,599	22%	No scenario provided for gas as counterfactual fuel as gas boilers cheaper to replace and operate. Unlikely to be replaced with renewable heat technologies
	hotel	modern	oil	100%	100%	347	785,808	26%	new build hotels located in off-grid locations may specify 100% biomass biomass as part of a new build design
	hotel	modern	gas	27%	31%	94	243,600	30%	A renewable heating technology is likely to be only deployed in lieu of a gas fired boiler if a planning/BREEAM target requires it.
	office	post 1990	electric	100%	100%	350	391,638	13%	Note electric wet heating system v. Unlikely to occur
		pre 1990	electric	100%	100%	450	718,675	18%	Note electric wet heating system v. Unlikely. If it did occur, benefits of replacing with biomass would likely mean 100% replacement
	office	pre 1990	oil	50%	70%	225	503,073	26%	Optimum sizing criteria
	office	post 1990	oil	50%	80%	175	313,310	20%	Optimum sizing critier
	office	pre 1990	gas	60%	70%	270	503,073	21%	Note - More suitable to replace aging gas fired boiler with newer one. If not we have assumed similar sizing princpals, i.e. Optimising as per oil fired boiler scenario
	office	modern	gas	60%	70%	210	274,146	15%	A renewable heating technology is likely to be only deployed in lieu of a gas fired boiler if a planning/BREEAM target requires it
Industrial	no process	pre 1990	oil/electric	100%	100%	120	88,128	8%	No scenario provided for gas as counterfactual fuel as gas boilers cheaper to replace and operate. Unlikely to be replaced with renewable heat technologies. Note perverse incentive possible through replacement of radiant tubes
	no process	modern	oil/electric	100%	100%	96	98,226	12%	No scenario provided for gas as counterfactual fuel as gas boilers cheaper to replace and operate. Unlikely to be replaced with renewable heat technologies. Note perverse incentive possible through replacement of radiant tubes
	no process	pre 1990	gas	50%	70%	60	61,690	12%	Sizing ratio based on optimum sizing with thermal storage - CTG012. Note perverse incentive possible through replacement of radiant tubes
	no process	modern	gas	35%	50%	34	49,113	17%	Sizing ratio likely to be proportionate to planning requirement with respect to targets for planning etc. Note perverse incentive possible through replacement of radiant tubes
	no process	modern	electric	100%	100%	96	98,226	12%	If replacing a 100% electric system 100% of the heating system will also require replacement - less of an issue in an industrial environment
	Process (batch production)		oil/electric/gas	100%	100%	1,600	2,945,806	21%	Industrial process loads likely to be suitable for biomass heating systems only due to higher temperatures (e.g. Steam), industrial price of gas etc. Peak/baseload ratio means system will likely be sized for 100% demand with suitable heat/steam accumulation required. **PLEASE NOTE THAT REPLACEMENT OF GAS BOILERS V.UNLIKELY DUE TO COST OF SYSTEM AND FUEL COST**
	Process (continuous production)		oil/electric/gas	100%	100%	2,000	8,750,000	50%	Based on example of a commercial scale greenhouse provided on page 10 of Carbon Trust Guide 012 - Biomass Heating - A Guide for Practical Users **HOWEVER THIS IS SITE DEPENDENT AND SEPERATE STUDY REQUIRED TO DEFINE FIGURES. PLEASE NOTE SYSTEM UNLIKELY TO REPLACE GAS FIRED BOILERS**

Table A2.8: Heat pump load factors

GSHP/ASHP	Building	Age	CF fuel	% peak heat load	% annual heat load	Boiler size	Annual heat produced	RHI Load Factors	Comment
Public sector	school	pre 1990	oil	20%	30%	259	401,768	18%	heat pump technology unlikely to be suitable for retro-fit to old oil fired systems. Significant cost expenditure required to upgrade heating system and servicing systems make it very impractical.
		post 1990	oil	9%	20%	69	128,841	21%	New builid school with counterfactual of oil v.unlikely. Servicing strategy would comprise GSHP for baseload and top-up using oil. This would depend on buiilding, but in difference to new build gas, cost benefit of providing larger GSHP to replace oil boilers likely to be justified
		modern	Electric	100%	100%	737	654,016	10%	Electric only schools very unlikely servicing strategy. Difficult to determine sizing rationale for a heat pump (particularly Air to air) therefore default 100% 100% chosen - additional work is required.
		pre 1991	Electric	50%	80%	648	1,071,381	19%	Electric only schools very unlikely servicing strategy. Difficult to determine sizing rationale for a heat pump (particularly Air to air) therefore default 100% 100% chosen - additional work is required.
		pre 1990	gas	9%	20%	117	267,845	26%	Heat pump v. Unlikely to be suitable for straightforward retro-fit of existing gas fired boiler due to operating temperatures of existing heating systems. Potential for bivalent system design (i.e. Creation of hybrid system) however determining load factor for this is a detailed exercise. This should be an element of the work recommended on load factors. Load factor based on sizing rationale for post 1990 buildings
	school	post 1990	gas	9%	20%	69	128,841	21%	A renewable heating technology is likely to be only deployed in lieu of a gas fired boiler if a planning/Part L /BREEAM target requires it. % load factors provided from actual school example where heating is supplied to specific areas in accordance with servicing strategy, however these are building specific **therefore no rule of thumb**
	school	modern	oil	50%	80%	369	523,213	16%	Heat pump technology only likely to be specified in a new build school that would otherwise be on oil to ensure heat emitters etc. are appropriately sized. Note requirement for cooling v. Dependent on school design. Majority of new schools on oil likely to be small primary schools in rural locations that will not have cooling demand (i.e. naturally ventilated)
Commercial sector	hotel	pre 1990	oil	N/A	N/A	N/A	N/A	N/A	heat pump technology unlikely to be suitable for retro-fit to old oil fired systems therefore no counterfactual performance data has been developed for this scenario
	hotel	modern	oil	50%	80%	173	628,646	41%	Heat pump technology only likely to be specified in a new build hotel that would otherwise be on oil to ensure heat emitters etc. are appropriately sized
	hotel	modern	gas	27%	31%	94	243,600	30%	A renewable heating technology is likely to be only deployed in lieu of a gas fired boiler if a planning/BREEAM target requires it. % load factors based previous projects, however will vary accordingly to project, i.e. **No rule of thumb**
	office	pre 1990	electric	100%	100%	450	718,675	18%	Please note that electric only offices v. Unlikely. No sizing rationale as will depend heavily on services strategy within the building. Therefore assumed 100%/100% as a default - more work required to confirm
		post 1990	electric	100%	100%	350	391,638	13%	Please note that electric only modern offices v.v.unlikely. No sizing rationale as will depend heavily on services strategy within the building (i.e. Perimter heating vs. air load heating (mech vent vs. nat vent). Therefore assumed 100%/100% as a default - more work required to confirm
		pre 1990	oil	50%	60%	225	431,205	22%	Heat pump technology unsuitable for retro-fit into existing office with wet central heating on oil due to significant costs associated with upgrading heating and servicing systems - not suitable for retro-fit
		post 1990	oil	100%	100%	350	391,638	13%	Heat pump technology likely to be used for 100% replacement in oil fired boiler locations
		pre 1990	gas	60%	60%	270	431,205	18%	Heat pump technology unsuitable for retro-fit to existing gas fired boiler due to servicing strategy and temperature requirements of heating system, unless entire heating system is being replaced. Therefore very unlikely application
	office	modern	gas	77%	90%	270	352,474	15%	A renewable heating technology is likely to be only deployed in lieu of a gas fired boiler if a planning/BREEAM target requires it. % load factors based previous projects, however will vary accordingly to project, i.e. **No rule of thumb**
Industrial	no process	pre 1990	oil	25%	50%	30	44,064	17%	Note dry air systems in industrial units tend to be radiant tubes as they are more fficient means of heating. Replacing with ATA ASHP or other heating devices and systems will result in lower overall efficiency and should not therefore be specified (or at least detailed calculation and analysis undertaken)
		modern	oil	25%	50%	24	49,113	23%	A renewable heating technology is likely to be only deployed in lieu of a gas fired boiler if a planning/BREEAM target requires it. % load factors based previous projects, however will vary accordingly to project, i.e. **No rule of thumb**
		modern	electric/ gas	100%	100%	96	98,226	12%	Note dry air systems in industrial units tend to be radiant tubes as they are more fficient means of heating. Replacing with ATA ASHP or other heating devices and systems will result in lower overall efficiency and should not therefore be specified (or at least a full comparison should be made)
		pre 1990	electric/gas	100%	100%	120	88,128	8%	Note dry air systems in industrial units tend to be radiant tubes as they are more fficient means of heating. Replacing with ATA ASHP or other heating devices and systems will result in lower overall efficiency and should not therefore be specified (or at least a full comparison should be made)
	process batch		oil	N/A	N/A	N/A	N/A	N/A	Process heat loads tend to have higher temperature requirements therefore unsuitable for heat pump technology
	process continuous		oil	N/A	N/A	N/A	N/A	N/A	Process heat loads tend to have higher temperature requirements therefore unsuitable for heat pump technology

Table A2.9: Solar thermal load factors

Solar thermal	Building	Age	CF fuel	% peak heat	% annual heat load	Boiler size	Annual heat produced	RHI Load Factors	Comment
Public sector	school	pre 1990	oil	80%	40%	136	74,747	6%	Sizing solar thermal systems for non-domestic buildings is site specific and related to DHW demands, occupancy (summertime particularly), plant location and spacing, availability of roof top space amongst other factors and so is very site specific. Estimates have been provided based on good practice rule of thumb sizing for all building types, however it should be noted that these cannot replicate building specific sizing and so there is likelihood for a considerable margin of error
	school	modern	gas	80%	40%	120	61,489	6%	
Commercial sector	hotel	pre 1990	oil	80%	40%	280	176,807	7%	
	hotel	modern	oil	80%	40%	280	117,871	5%	
	hotel	modern	gas	80%	40%	280	117,871	5%	
	office	pre 1990	electric	80%	40%	44	15,130	4%	
		pre 1990	oil	80%	40%	44	15,130	4%	
	office	modern	gas	80%	40%				
Industrial	no process	pre 1990	oil	80%	40%				
	no process	modern	oil	80%	40%				
		modern	electric	80%	40%				
	process batch		oil	N/A	N/A				
	Process continuous			N/A	N/A	N/A	N/A	N/A	Very dependent on heat load

Appendix 3.0: Cost and Performance database - user guide

Introduction

This document provides an overview of the DECC RHI Cost and Performance database structure and operation. The database is contained within a single MS excel macro-enabled workbook. The contents of each worksheet are described below:

Data Analysis

Function

This sheet provides an interactive interface for the analysis of installer returns and supplementary data contained within the database.

Selections of filtering criteria (click on/off or drop-down lists) are reflected on the scatter chart. The X and Y-axes of this chart may be varied using the drop-downs above the chart. The status of each filter setting is carried to [Working Sheet] and [Supplementary Working Sheet] where the filtering actions are performed. (See detail on the Working Sheets later in this document).

Filters

The operation of filters is described below:

Group	Influence
Technologies to include	Click on/off to include/exclude specific technology groups from the scatter chart
Property Type to include	Click on/off to include/exclude specific property type from the scatter chart
Region to include	Click on/off to include/exclude specific geographic region from the scatter chart
Location to include	Click on/off to include/exclude specific location, or context, from the scatter chart
Plant size to include	Click on/off to include/exclude specific plant size groups from the scatter chart
Counterfactual Fuel	Select from the drop-down from the fuel types available, and the price trend to consider
Data clipping	Enter upper and lower percentile ranges at which data will be included into the scatter chart. This allows filtration of outliers from the analysis. Click on/off to include supplementary data into the scatter chart.
Biomass Fuel type	Select from the drop-down to set the biomass fuel price applied to lifecycle cost calculations
Level of confidence	The data within the model has been assigned a confidence rating of low / medium /high, defined as follows: **High:** Empirical data, clear audit trail of data, detailed breakdown of data **Medium:** Empirical data, clear audit trail of data, less detailed breakdown of data

	Low: Empirical data (albeit through a third party), limited audit trail of data, limited breakdown of data The user may select the levels of confidence to be included into the analysis.

Overview Charts

A number of overview charts and tables are contained below the data filters. These provide a selection of graphical interpretations of the data selected by the filtering constraints this sheet.

Technology Charts

Function

This sheet provides a graphical representation, by technology type, of the data selected by the filtering constraints on the [Data Analysis] sheet. Results can be further modified using the drop-down to select Technology to chart, and the component of installation costs to be included.

Filters

The operation of filters is described below:

Group	Influence
Technology to include	Use the dropdown to select a specific technology
Level of confidence	The data within the model has been assigned a confidence rating of low / medium /high, defined as follows: **High:** Empirical data, clear audit trail of data, detailed breakdown of data **Medium:** Empirical data, clear audit trail of data, less detailed breakdown of data **Low:** Empirical data (albeit through a third party), limited audit trail of data, limited breakdown of data The user may select the levels of confidence to be included into the analysis.
Filter 1 and 2	This is a free-format field which may be used to select data points using specific values, or ranges of values required. The user may enter a single number or a range such as <2

All Data

Function

The All Data sheet is used to load installer returns into the database. The installed heating and cooling capacities for each entry are manually entered on this sheet as a part of the data cleansing operation.

Supplementary Data

Function

This sheet contains supplementary data within the database. All entries are manually captured into the appropriate columns.

Reference Data

Function

All static reference data used in the operation of the database and calculations is housed within this sheet. See Appendix A for a description of these reference tables.

LZC Performance Table

Function

This sheet contains default heating energy performance values for the various property types, contexts and technology groups.

Field Descriptors

The following provides a brief description of the contents and function of each column in the table:

Ref	Field Name	Contents / Function
1	BuildingType	Type of building from standard reference list – See Appendix A
2	Context	Location / Context of the property – Urban, Semi-Urban or Rural
3	HeatingSystem	Technology from the standard reference list – See Appendix A
4	SpaceHeatingAnnualKWH	Space heating requirement in kWh / annum
5	WaterHeatingAnnualKWH	Water heating requirement in kWh / annum
6	SpaceHeatingKW	Space heating demand in kWh / annum
7	WaterHeatingKW	Water heating demand in kWh / annum
8	HeatingCapacityKW	Total heating demand in kWh / annum
9	SpaceHeatingFuel	Space heating fuel type
10	SpaceHeatingFuelKWH	Space heating fuel consumption per annum
11	WaterHeatingFuel	Water heating fuel type
12	WaterHeatingFuelKWH	Water heating fuel consumption per annum
13	HeatingElectricityKWH	Supplementary electrical heating requirement in kWh per annum

Ref	Field Name	Contents / Function
14	ParasiticElectricityKWH	Parasitic electrical load (eg: pumping) per annum
15	Electricity	CALCULATED: Electrical consumption per annum
16	Gas	CALCULATED: Gas consumption per annum
17	Non net-bound	CALCULATED: Non net-bound (heating oil) consumption per annum
18	Biomass	CALCULATED: Biomass consumption per annum
19	District heat	CALCULATED: Heat consumption per annum supplied from a district heating system

Counterfactual Performance Table

Function

This sheet contains default heating energy performance values for the various property types, contexts and technology groups.

Field Descriptors

This table layout is identical to [LZC Performance Table] described above.

Export Sheet

Function

This sheet provides the user with a facility to export selected data from the model, into csv files.

The export sheet lists fields which are available for export, from both the installer data and supplementary data.

Fields listed in the blue columns are the source fields from within the model and may not be changed, but the corresponding fields in the adjacent red columns are user definable. The user should enter a field name into all fields which are required in the export. Where a data field is not required, the red column field should be cleared / left blank.

Click the ‘Export Data’ button to initiate the export, then select the destination folder, and click OK. Data is exported in comma-delimited csv format, into a file named using “yyymmdd hhmmss” as a filename to identify the file export date and time.

Field Descriptors

The following provides a brief description of the contents and function of each column in the database:

Ref	Field Name	Contents / Function
1	BuildingType	Type of building from standard reference list – See Annex A
2	Building Group	Provides a sub-division of Building Type into Domestic, Public and Industrial

Re f	Field Name	Contents / Function
3	Region	Geographic region from reference list – See Annex A
4	Location	Context of the property – Urban, Semi-Urban or Rural
5	ProcureDate	Date of procurement of the installation service
6	constraintScaffold	Indicates whether scaffolding was required for the installation
7	constraintAccess	Indicates whether access to the installation site was constrained
8	constraintNoise	Indicates whether installation environment required noise to be limited
9	constraintGround	Indicates abnormal ground conditions
10	constraintOther	Indicates any other abnormal installation constraints
11	constraintOthertext	Text describing other constraints
12	Scope	Freeform text describing the scope of the installation
13	Technology	Technology from the standard reference list – See Appendix A
14	Make	Equipment manufacturer
15	Model	Equipment model reference
16	Warranty	Equipment warrantee period in years
17	COP	Coefficient of performance of the equipment (where appropriate)
18	Capacity KW	Installed capacity of the equipment – this is a freeform text field, which is interpreted and manually translated into the following two columns:
19	Heating Capacity KW	Installed heating capacity in kW
20	Cooling Capacity KW	Installed cooling capacity in kW
21	Life	Service life estimation in years
22	Supplier	Equipment supplier
23	costEquipment	Cost of the heating/cooling technology components
24	costHeatStore	Cost of any heat storage installed
25	costHeatExchanger	Cost of heat exchanger/s installed

Re f	Field Name	Contents / Function
26	costFuelStore	Cost of any fuel storage installed
27	costFuelTransport	Cost of any fuel transportation equipment installed
28	costheatDistribution	Cost of any heat distribution installation
29	costBuildersWork	Cost of any builders work associated with the installation
30	costBuildings	Cost of any shelters / buildings erected as an integral part of the installation
31	costExternalWorks	Cost of any site works / external works associated with this installation
32	costutilityUpgrade	Costs of upgrading any statutory service supplies feeding the installation
33	costOtherEnabling	Cost of any other enabling works not yet listed above, such as preparation works, access roads, fencing removals and re-erection, etc
34	costCommissioning	Cost of commissioning of the plant
35	Commissioning Supplier	Yes/No – commissioning was carried out by the Equipment Supplier
36	commissioningInstaller	Yes/No – commissioning was carried out by the Installation Engineer
37	commissioningOthers	Yes/No – commissioning was carried out by others
38 40 42 44 46 48	Hassle01 to Hassle06	Description of any 'hassle' or ancillary costs incurred during this service – eg: replacement of building elements, site works, etc which were carried out at the same time, but had no bearing on the actual installation, operation or performance of the installation.
39 41 43 45 47 49	costHassle01 to costHassle06	Cost of these 'hassle works (note these are referred to as abnormal costs in the main report)

Ref	Field Name	Contents / Function
50 52 54 56 58	Add01 to Add05	Text describing additional costs, such as preliminaries, insurances, site establishment costs, storage facilities, guarding, offices, etc. required by the installation contractor to perform this service.
51 53 55 57 59	costAdd01 to costAdd05	Costs of these additional requirements.
60	VATInc	Indicated if VAT is INCLUDED in the above costs
61	VATExcl	Indicated if VAT is EXCLUDED in the above costs
62	TotalCost	Total final out-turn cost of the installation described above.
63	Total Technology cost	CALCULATED: VAT Exclusive cost of technology components only
64	Total Add-On cost	CALCULATED: VAT exclusive cost of add-on costs only
65	Total Hassle cost	CALCULATED: VAT exclusive cost of ‘hassle’ costs only
66	serviceArrangement	Indication of servicing responsibility for the equipment installed: Equipment supplier service agreement; or User to make own arrangements; or Installer service agreement
67	serviceFrquency	Frequency of servicing recommended by the equipment manufacturer. Frequency may be stated in years, months, operating hours, operating kWhrs
68	serviceUnit	Unit of servicing frequency. Frequency may be stated in years, months, operating hours, operating kWhrs
69	costService	Cost of one servicing event at the intervals described above
70	installationDate	Date of actual installation
71	Annual Fixed Opex	CALCULATED: Annual servicing cost based on the servicing frequency and costs above

Ref	Field Name	Contents / Function
72	KWh Heat / Cool Demand per annum	CALCULATED: Average annual space + water heating requirement for the specific property type in the specific context (urban, rural, etc) from the [LZC Performance] table. Where this property type and context does not exist in the [LZC Performance] table, the calculation check for the same space+water heating requirements in the [Counterfactual Performance] table. Where no values are found in either table, the calculation returns a zero.
73	Technology cost per heating kW	CALCULATED: [Ref 63] above divided by installed heating capacity [Ref 19]
74	Add-On cost per heating kW	CALCULATED: [Ref 64] above divided by installed heating capacity [Ref 19]
75	Hassle cost per heating kW	CALCULATED: [Ref 65] above divided by installed heating capacity [Ref 19]
76	LZC Capex per kW excl VAT	CALCULATED: [Ref 73] + [Ref 74] + [Ref 75]
77	LZC Fixed Opex per kW	CALCULATED: [Ref 71] above divided by installed heating capacity [Ref 19]
78	LZC Fuel demand kWh / annum	CALCULATED: Total of [Ref 91] to [Ref 95] inclusive in kWh
79	LZC NPV per kW	CALCULATED: Total LZC NPV divided by installed heating capacity [Ref 19]
80	LZC Installed kW	TRANSFERRED from [ref 19] into the area used for selection of X and Y Axes values on [Data Analysis] sheet
81	Installer Data Quality	CALCULATED: Based on a total count of incomplete key fields (costs, dates, VAT details and installed capacity) on a scale 0 – 10.
82	CF Installed heating capacity kW	CALCULATED: Average installed capacity for the specific property type and context from the [Counterfactual Performance] table.
83	CF Capital Life Expect	LOOK-UP: From Reference table for specific property type – See Appendix A.
84	CF Capex per kW	LOOK-UP: From Reference table for specific property type – See Appendix A.
85	CF Fixed Opex per kW / annum	LOOK-UP: From Reference table for specific property type – See Appendix A.

Annex A: Standard Reference Lists

Ref	Field Name	Contents / Function
86	CF Fuel demand KWh / annum	CALCULATED: Average fuel consumption for the specific property type, context nd counterfactual fuel type (counterfactual fuel type filter is selected on [Data Analysis] sheet from the [Counterfactual Performance] table.
87	CF NPV per heating kW	CALCULATED: Total Counterfactual NPV [Ref 119]divided by installed heating capacity [Ref 92]
88	CF Electricity kWh / annum	CALCULATED: Average mains electricity consumption per annum for the specified property type and context from the [Counterfactual Performance] table
89	CF Gas kWh / annum	CALCULATED: Average mains gas consumption per annum for the specified property type and context from the [Counterfactual Performance] table
90	CF Non net-bound kWh / annum	CALCULATED: Average non net-bound (heating oil) consumption per annum for the specified property type and context from the [Counterfactual Performance] table
91	**LZC Electricity kWh / annum**	**CALCULATED: Average mains electricity consumption per annum for the specified property type, context and technology group from the [LZC Performance] table**
92	LZC Gas kWh / annum	CALCULATED: Average mains gas consumption per annum for the specified property type, context and technology group from the [LZC Performance] table
93	LZC Non net-bound kWh / annum	CALCULATED: Average non net-bound (heating oil) consumption per annum for the specified property type, context and technology group from the [LZC Performance] table
94	LZC Biomass kWh / annum	CALCULATED: Average biomass consumption per annum for the specified property type, context and technology group from the [LZC Performance] table
95	LZC District heat kWh / annum	CALCULATED: Average district heating supplied heat consumption per annum for the specified property type, context and technology group from the [LZC Performance] table

Version Control

Function

Changes made to the database are recorded on this sheet.

The Database refers to a number of standard reference lists. The contents of these lists are described below:

Property Type

Property Type
Domestic - Detached - New Build
Domestic - Detached - Insulated post 1990
Domestic - Detached - Insulated pre 1990
Domestic - Detached - Non-insulated post 1990
Domestic - Detached - Non-insulated pre 1990
Domestic - Detached - Solid wall
Domestic - Flat - New Build
Domestic - Flat - Insulated post 1990
Domestic - Flat - Insulated pre 1990
Domestic - Flat - Non-insulated post 1990
Domestic - Flat - Non-insulated pre 1990
Domestic - Flat - Solid wall
Domestic - Other (Semi / Terraced) - New Build
Domestic - Other (Semi / Terraced) - Insulated post 1990
Domestic - Other (Semi / Terraced) - Insulated pre 1990
Domestic - Other (Semi / Terraced) - Non-insulated post 1990
Domestic - Other (Semi / Terraced) - Non-insulated pre 1990
Domestic - Other (Semi / Terraced) - Solid wall
Public - Pre 1990
Public - Post 1990
Commercial - Pre 1990
Commercial - Post 1990
Industrial - Pre 1990
Industrial - Post 1990

Geographic Region

Region
East Midlands Region
Eastern Region
London Region
North East Region
North West Region
Northern Ireland Region
Scotland Region
South East Region
South West Region
Wales Region
West Midlands Region
Yorkshire and the Humber Region

Technology Group

Technology
Air to air heat pumps
Air to water heat pumps
Biomass
Biomass combined heat and power
Biomass direct air heating
Fuel Cell Technology
Ground source heat pumps
Micro combined heat and power technologies
Solar PV-T hybrid heat pump solution
Solar thermal

Retail Fuel Price Projections

Retail price projections have been extracted from the DECC Updated Energy & Emissions Projections - October 2011 found at http://www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3121-annex-f-fossil-fuel-wholesale-and-retail-prices.xls

Biomass prices have been based upon the report entitled “Biomass prices in the heat and electricity sectors in the UK for the Department of Energy and Climate Change: January 2010” prepared by E4tech, downloaded from http://www.decc.gov.uk/assets/decc/consultations/rhi/132-biomass-price-heat-elec-e4tech.pdf

Fuel type	**Price trend**	**Application**
Biomass Bagged Pellets	Low	Residential
Biomass Bulk Pellets	Central	Services
Biomass Wood chips	High	Industrial
District heat		
Electricity		
Gas		
Liquid biofuel		

Counterfactual Energy Performance

Capital and Operating costs of counterfactual technologies within each property type have been developed as shown in the below table.

Property type	**CF Capex per kW (based on AEA Report)**			**CF Fixed Opex per kW per annum (based on AEA Report)**			**CF Capital life**		
	Elect.	Gas	Non net-bound	Elect.	Gas	Non net-bound	Elect.	Gas	Non net-bound
Domestic - Detached - New Build	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Detached - Insulated post 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Detached - Insulated pre 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00

Property type	CF Capex per kW (based on AEA Report)			CF Fixed Opex per kW per annum (based on AEA Report)			CF Capital life		
Domestic - Detached - Non-insulated post 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Detached - Non-insulated pre 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Detached - Solid wall	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Flat - New Build	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Flat - Insulated post 1990	£175.00	£137.50	£137.50	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Flat - Insulated pre 1990	£175.00	£137.50	£137.50	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Flat - Non-insulated post 1990	£175.00	£137.50	£137.50	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Flat - Non-insulated pre 1990	£175.00	£137.50	£137.50	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Flat - Solid wall	£175.00	£137.50	£137.50	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Other (Semi / Terraced) - New Build	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Other (Semi / Terraced) - Insulated post 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Other (Semi /	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00

Property type	**CF Capex per kW (based on AEA Report)**			**CF Fixed Opex per kW per annum (based on AEA Report)**			**CF Capital life**		
Terraced) - Insulated pre 1990									
Domestic - Other (Semi / Terraced) - Non-insulated post 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Other (Semi / Terraced) - Non-insulated pre 1990	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Domestic - Other (Semi / Terraced) - Solid wall	£187.50	£175.00	£175.00	£-	£9.00	£9.00	15.00	15.00	15.00
Public - Pre 1990	£221.00	£65.00	£70.00	£1.00	£2.00	£2.00	15.00	15.00	15.00
Public - Post 1990	£221.00	£65.00	£70.00	£1.00	£2.00	£2.00	15.00	15.00	15.00
Commercial - Pre 1990	£221.00	£65.00	£70.00	£1.00	£2.00	£2.00	15.00	15.00	15.00
Commercial - Post 1990	£221.00	£65.00	£70.00	£1.00	£2.00	£2.00	15.00	15.00	15.00
Industrial - Pre 1990	£147.00	£55.00	£60.00	£0.20	£0.20	£0.20	15.00	15.00	15.00
Industrial - Post 1990	£147.00	£55.00	£60.00	£0.20	£0.20	£0.20	15.00	15.00	15.00

In the majority of instances data size assumptions from previous studies (namely NERA-AEA supply curve) have been used. For the domestic scenario it was assumed that flats would have a 12kW system and all other domestic properties a 20kW system. Additional counterfactual cost data was presented to DECC as part of separate submission alongside this report.

Appendix 4.0: Initial engagement questionnaire

Department of Energy and Climate Change (DECC) 'Heating & Cooling Technology' Survey

Dear Sir/ Madam

You are being contacted in relation to research being conducted on behalf of the Department of Energy and Climate Change (DECC). Please see below a brief explanation from DECC.

"The 'Renewable Heat Incentive' (RHI) and 'Heat Strategy' are important Government projects, expected to bring about significant improvements to the nation's heating. Considerable expenditure is foreseen and to ensure that any subsidies are set at the appropriate level DECC has commissioned Sweett Group to carry out a review of cost and performance assumptions used in DECC's calculations.

Your organisation has been selected to take part in the review and your cooperation would be very much appreciated. Sweett Group is compiling a comprehensive cost database for heating and cooling technologies. We would be grateful if you could provide cost breakdowns for the technologies you are involved with. Where possible empirical, project related data is desired."

If you would like to provide a response please complete this short questionnaire. Following this you will be contacted by a member of Sweett Group's team via telephone.

Thank you in advance for your time.
Sweett Group (on behalf of DECC)

Personal Information

Your name:

Preferred contact phone number:

Preferred contact email address:

Organisation Information

Organisation Name:

Address of your organisation:

Please state the number of employees in your company	Large >£250K	☐		
	Medium 50-250	☐		
	Small 10-50	☐		
	Micro <10	☐		
Industry sector	Manufacturer	☐	Installer	☐
	Supplier	☐	Client	☐
	If other please state:			

Technology Information

Cooling technologies you deal with directly:	Absorption chillers	☐	Trigeneration	☐
	Chilled beams	☐	Air to air heat pumps	☐
	Ground to air heat pumps	☐	Passive cooling technologies	☐
	Automated	☐	Other	☐

ventilation ☐ ☐

Location Information

In what regions do you operate? (you can select multiple choices)

East Midlands	☐	North West England	☐
East of England	☐	South East England	☐
Greater London	☐	South West England	☐
West Midlands	☐	Yorkshire and the Humber	☐
North East England	☐	All the above	☐
Scotland	☐	Wales	☐

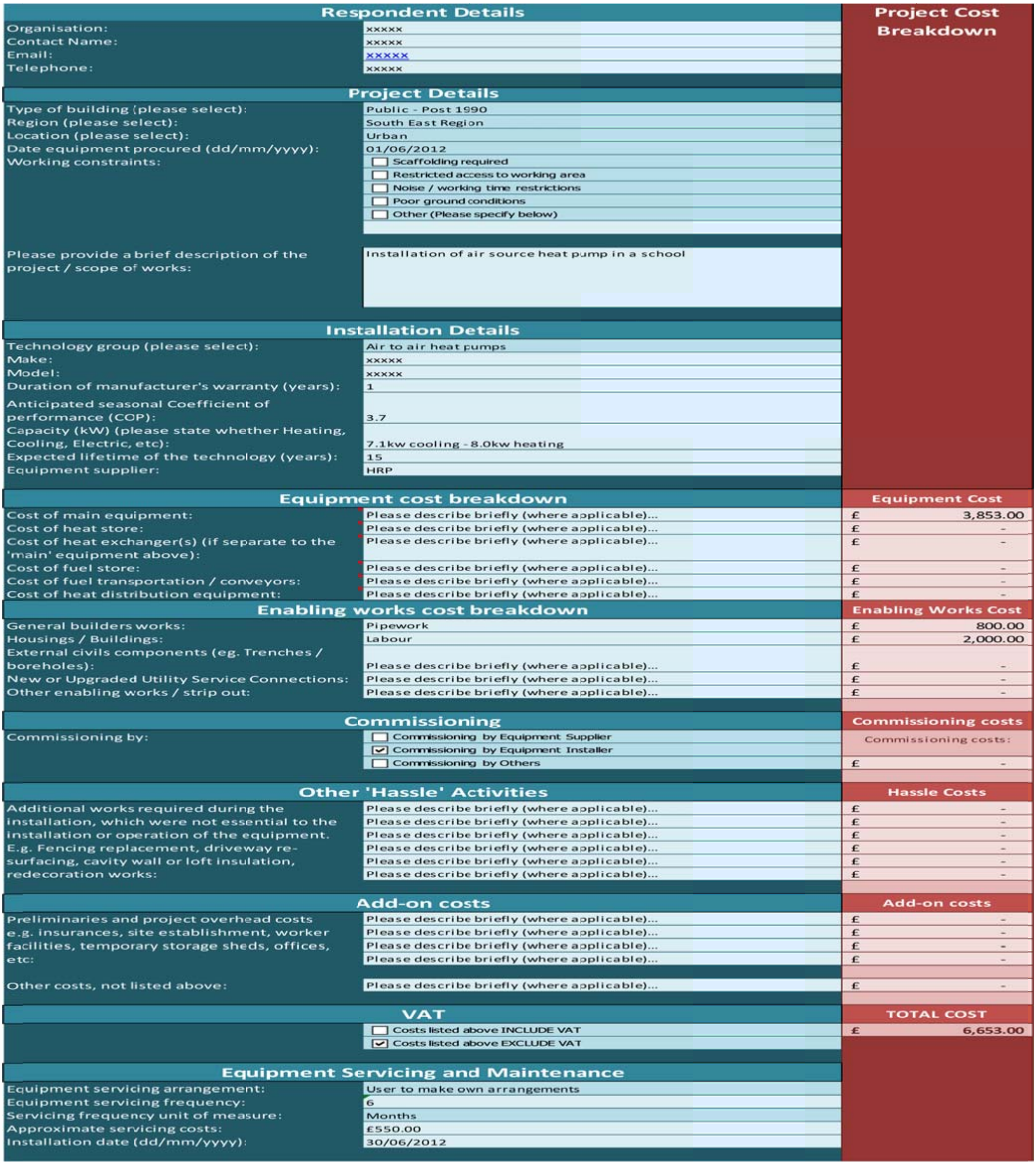
Key factors influencing price

In your opinion of the listed cost-influencing factors, please outline their significance in affecting the price of your products/ services.

	N/A	Low	Medium	High
Geographical Location				
Scale/ Quantity				
Associated/ remedial works				
Product Selection				

Other, (please specify):

Appendix 5.0: Detailed engagement questionnaire



Respondent Details		**Project Cost Breakdown**	
Organisation:	xxxxx		
Contact Name:	xxxxx		
Email:	xxxxx		
Telephone:	xxxxx		
Project Details			
Type of building (please select):	Public - Post 1990		
Region (please select):	South East Region		
Location (please select):	Urban		
Date equipment procured (dd/mm/yyyy):	01/06/2012		
Working constraints:	☐ Scaffolding required		
	☐ Restricted access to working area		
	☐ Noise / working time restrictions		
	☐ Poor ground conditions		
	☐ Other (Please specify below)		
Please provide a brief description of the project / scope of works:	Installation of air source heat pump in a school		
Installation Details			
Technology group (please select):	Air to air heat pumps		
Make:	xxxxx		
Model:	xxxxx		
Duration of manufacturer's warranty (years):	1		
Anticipated seasonal Coefficient of performance (COP):	3.7		
Capacity (kW) (please state whether Heating, Cooling, Electric, etc):	7.1kw cooling - 8.0kw heating		
Expected lifetime of the technology (years):	15		
Equipment supplier:	HRP		
Equipment cost breakdown		**Equipment Cost**	
Cost of main equipment:	Please describe briefly (where applicable)...	£	3,853.00
Cost of heat store:	Please describe briefly (where applicable)...	£	-
Cost of heat exchanger(s) (if separate to the 'main' equipment above):	Please describe briefly (where applicable)...	£	-
Cost of fuel store:	Please describe briefly (where applicable)...	£	-
Cost of fuel transportation / conveyors:	Please describe briefly (where applicable)...	£	-
Cost of heat distribution equipment:	Please describe briefly (where applicable)...	£	-
Enabling works cost breakdown		**Enabling Works Cost**	
General builders works:	Pipework	£	800.00
Housings / Buildings:	Labour	£	2,000.00
External civils components (eg. Trenches / boreholes):	Please describe briefly (where applicable)...	£	-
New or Upgraded Utility Service Connections:	Please describe briefly (where applicable)...	£	-
Other enabling works / strip out:	Please describe briefly (where applicable)...	£	-
Commissioning		**Commissioning costs**	
Commissioning by:	☐ Commissioning by Equipment Supplier	Commissioning costs:	
	☑ Commissioning by Equipment Installer		
	☐ Commissioning by Others	£	-
Other 'Hassle' Activities		**Hassle Costs**	
Additional works required during the installation, which were not essential to the installation or operation of the equipment. E.g. Fencing replacement, driveway re-surfacing, cavity wall or loft insulation, redecoration works:	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
Add-on costs		**Add-on costs**	
Preliminaries and project overhead costs e.g. insurances, site establishment, worker facilities, temporary storage sheds, offices, etc:	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
	Please describe briefly (where applicable)...	£	-
Other costs, not listed above:	Please describe briefly (where applicable)...	£	-
VAT		**TOTAL COST**	
	☐ Costs listed above INCLUDE VAT	£	6,653.00
	☑ Costs listed above EXCLUDE VAT		
Equipment Servicing and Maintenance			
Equipment servicing arrangement:	User to make own arrangements		
Equipment servicing frequency:	6		
Servicing frequency unit of measure:	Months		
Approximate servicing costs:	£550.00		
Installation date (dd/mm/yyyy):	30/06/2012		

Africa

Americas

Asia

Australia

Europe

Middle East

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