energy saving trust

Wood Fuel Demand and Usage in Scotland

2021 report

4 May 2023

Report produced on behalf of Scottish Forestry

energy saving trust

Executive Summary

1. This report on existing and potential wood fuel use in Scotland covers the 2021 calendar year, as well as providing revised results for some previous reporting years.
2. At the end of 2021, there were an estimated 8,362 biomass installations in Scotland, an increase of 64 (1%) over the revised count of 8,298 for 2020. This is the slowest annual growth seen since 2011 which was when the non-domestic Renewable Heat Incentive (RHI) scheme began.
3. The total amount of wood fuel used in Scotland in 2021 for energy purposes was estimated to be 1,491,000 oven dry tonnes (odt). For 2020, the revised consumption was estimated to be 1,426,000 odt, which means there was a 5% increase in wood fuel usage in 2021.
4. All the installation size categories reported on show increased wood fuel consumption in 2021. For the domestic, small non-domestic (<200 kWth) and medium non-domestic (200 – 999 kWth) size categories, the increase in wood fuel consumption is in line with the number of new installations found within each category. The increase in wood fuel consumption by large size installations (>1,000 kWth) mostly reflects increased consumption at sites already in operation prior to 2021 rather than from the five installations newly commissioned within this size category in 2021. The large installation size category contains the installations which are most likely to show considerable variation in their annual wood fuel consumption owing to their sheer size and the large amounts of wood fuel they can consume. For anti-disclosure purposes, we do not comment on why the wood fuel consumption of individual sites may be changing.
5. In 2021, the number of large sized installations represented 1% of all installations in Scotland which use wood fuel whilst accounting for 74% of total wood fuel consumption. This is the same share of total wood fuel consumption as the revised estimate for 2020. The share of wood fuel consumption by large sized installations has been declining since 2016 when it was estimated to be 84%.
6. The greatest numbers of non-domestic wood fuel biomass installations were found in rural local authority areas, with Dumfries and Galloway, Aberdeenshire, Highland, Perth and Kinross and Scottish Borders accounting for 56% of all non-domestic installations (unchanged from 2020).
7. The same rural local authorities also host the highest numbers of domestic wood fuel boiler installations. Highland, Aberdeenshire, Scottish Borders, Dumfries and Galloway and Perth and Kinross accounted for 56% of all domestic installations (unchanged from 2020), the same percentage as they have of non-domestic installations.
8. The greatest proportion of wood fuel type used in Scotland continued to be virgin fibre (44%). This is followed by co-products and residue, which accounted for 30% of wood fuel consumption, and recycled wood at 19%. Wood pellets accounted for 7% of the total wood fuel consumption for energy purposes.
9. In 2021, biomass installations in Scotland contributed 3,730 gigawatt hours (GWh) of useful heat output[1] to the Scottish Government's renewable heat targets,[2] a 14% increase on the revised figure of 3,280 GWh for 2020.
10. Wood fuelled biomass systems in Scotland are estimated to have saved 1,624,000 tonnes of carbon dioxide equivalent (tCO_2e) in 2021. This is an increase of 86,000 tCO_2e (6%) upon the revised 2020 figure of 1,538,000 tCO_2e. The increase in CO_2e savings can be attributed to the 5% increase in overall wood fuel consumption as well as a 2% decrease to the carbon intensity of wood fuel in 2021 relative to 2020.[3]

[1] Useful heat output is defined as heat used by an eligible end user or process and does not include heat used solely to produce electricity or heat produced but not used.
[2] See the Scottish Government's updated Heat Policy Statement, published June 2015, for more information: http://www.gov.scot/Publications/2015/06/6679
[3] The carbon factors for wood and non-wood fuels used in our analysis are sourced from the annually published UK Government's greenhouse gas conversion factors: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

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1. Introduction

This report is part of an annual series of Wood Fuel Demand and Usage in Scotland reports produced by Energy Saving Trust on behalf of Scottish Forestry and the Scottish Government. In this iteration of the report, we provide data for the 2021 calendar year (1 January 2021 to 31 December 2021) as well as revised figures for some historical reporting years.

Energy Saving Trust would like to thank all individuals and organisations who provided data, with particular thanks to the Department for Business, Energy and Industrial Strategy (BEIS), MCS – who are responsible for the Microgeneration Certification Scheme,[4] the numerous biomass users who took part in the annual wood fuel survey and other individuals who provided useful information or discussion.

The use of wood fuel for energy purposes is presented in this report using four installation size categories:

- Domestic installations: systems which are MCS certified but not found in the non-domestic RHI scheme.[5] These installations will typically have a thermal capacity of less than or equal to 45 kWth.
- Small non-domestic installations: systems accredited under the non-domestic RHI with a thermal capacity of less than 200 kWth.
- Medium non-domestic installations: systems accredited under the non-domestic RHI with a thermal capacity of greater than or equal to 200 kWth and less than 1,000 kWth.
- Large non-domestic installations: systems accredited under the non-domestic RHI or known to us from the wood fuel survey or other site-specific datasets. These installations have a thermal capacity of greater than or equal to 1,000 kWth.

The installations are defined by their thermal output capacity which for combined heat and power (CHP) systems do not include their electrical capacity; a small number of CHP systems are included in the analysis of wood fuel demand and usage in Scotland.

[4] https://mcscertified.com/

[5] For the purposes of this analysis, any installations accredited by MCS but found not to be accredited under the non-domestic RHI scheme are assumed to be domestic because the vast majority of MCS installations are in domestic properties. See section 6.1.3 in appendix A for more information on how the MCS data was used.

2. Results

In 2021, it is estimated that an additional 64 installations were commissioned, bringing the total to 8,362. The number of biomass systems installed in Scotland each year from 2013 onwards is shown in Figure 1 and detailed in Table 1. [6]

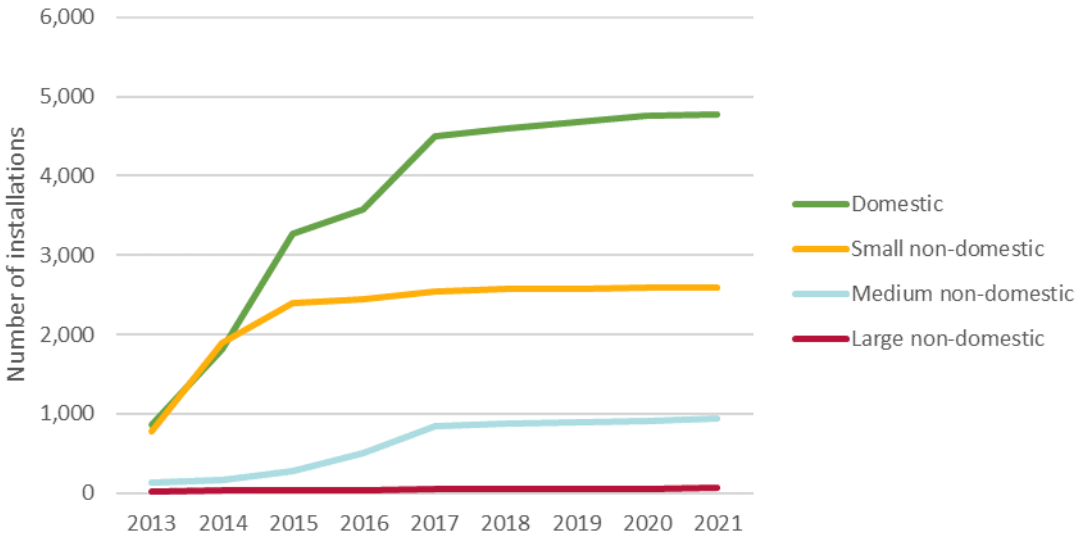

Figure 1. Number of biomass installations by installation size category, 2013 to 2021

All the installations in operation at the end of 2021 were estimated to consume 1,491,000 odt of wood fuel in the 2021 reporting year, an increase of 66,000 odt (5%) compared with 2020. Figure 2 and Table 1 show the estimated wood fuel consumption by installation size category from 2013 onwards.[7]

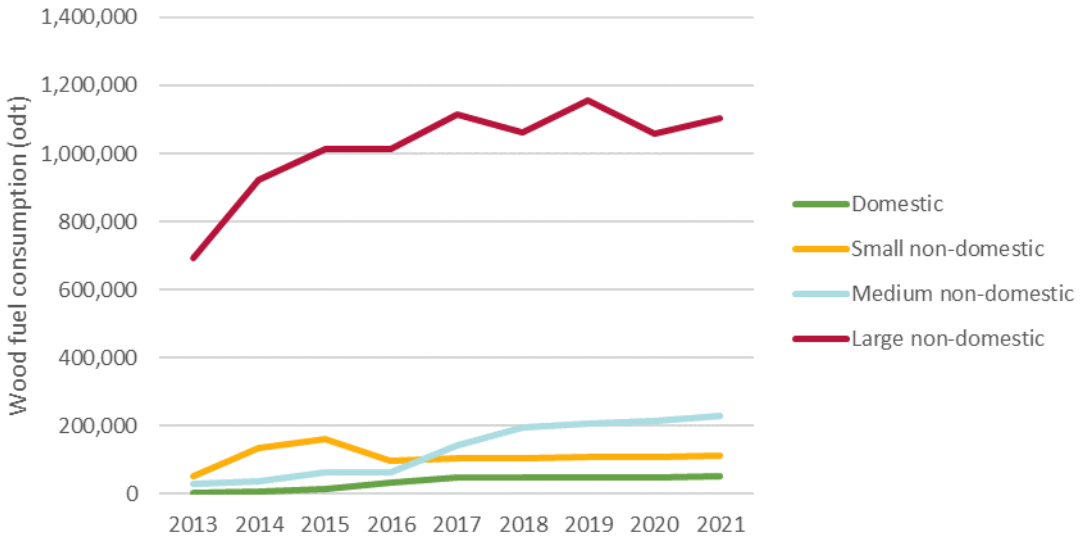

Figure 2. Estimated wood fuel consumption (odt) by installation size category, 2013 to 2021

[6] The decreased uptake of new domestic installations seen in 2016 is methodological rather than actual. The domestic totals for pre-2016 are sourced from domestic RHI data and the totals for after 2016 from the MCS dataset, the latter of which is comprised of the former plus additional installations which were never accredited under the domestic RHI. As the 2016 domestic total does not include the MCS figures, it is therefore showing a much lower growth rate relative to 2017.

[7] Due to methodological changes over the reporting series, the wood fuel consumption by small non-domestic installations between 2013 and 2015 is not directly comparable with the consumption values for 2016 onwards. We would expect that wood fuel consumption by small non-domestic installations to have grown slowly across the time series presented and in line with the growth in consumption seen for domestic and medium non-domestic installations.

Table 1. Total number of biomass installations and wood fuel consumption by installation size category in 2021

Installation size category	Number of installations	Percentage of installations	Wood fuel consumption (odt)	Percentage of wood fuel consumption
Domestic	4,771	57%	50,000	3%
Small non-domestic	2,598	31%	110,000	7%
Medium non-domestic	935	11%	229,000	15%
Large non-domestic	58	1%	1,103,000	74%
Total	**8,362**	**100%**	**1,491,000**	**100%**

2.1.1. Wood fuel use by non-domestic installations with capacities ≥1,000 kWth

At the end of 2021, there was a total of 58 installations included within this size category, eleven of which are confirmed to be CHP installations. During 2021, the 58 large sized installations used a total of 1,103,000 odt of wood fuel, an increase of 45,000 odt (4%) over the 2020 figure of 1,058,000 odt. Wood fuel consumption in 2021 by large size installations can be further broken down into a consumption of 791,000 odt by the eleven CHP installations, and 311,000 odt by the 47 heat-only installations.

Most of the increased wood fuel consumption seen in 2021 can be attributed to installations already in operation prior to 2021 rather than the five installations newly commissioned in 2021 within this size category. The large installation size category contains the installations which are most likely to show considerable variation in their annual wood fuel consumption owing to their sheer size and the large amounts of wood fuel they can consume. For anti-disclosure purposes, we do not comment on why the wood fuel consumption of individual sites may be changing.

Comparing Figures 1 and 2, while large biomass systems make up 1% of the total number of installations, they consume 74% of the total wood fuel usage for energy purposes in Scotland.

2.1.2. Wood fuel use by non-domestic installations with capacities ≥200 kWth and <1,000 kWth

At the end of 2021, there were 935 installations operating in this size category, which is a 3% increase from 2020. Between 2015 and 2017, the growth in uptake of medium sized biomass boilers increased significantly with a 71% increase in 2015, 79% increase 2016 and 66% increase in 2017. This led to a comparable increase in wood fuel consumption for this size category. However, since then the annual increase in the number of new medium sized RHI accreditations has largely plateaued. Although the 31 new biomass installations within this size category commissioned in 2021 is a larger increase than the 13 medium installations seen commissioned in 2020, it remains below the five-year average of 86. This highlights that the installation rate of medium sized installations continues to be consistently lower relative to the significant growth in numbers seen in historical reporting years. The uptick in number of installations in 2021 may reflect applicants making use of the non-domestic RHI scheme before it closed to applications in April 2021.

The amount of wood fuel used in 2021 by the 935 installations is estimated to be 229,000 odt. This is an increase of 8% on the 212,000 odt estimated to have been used by this size category in 2020.

2.1.3. Wood fuel use by non-domestic installations with capacities <200 kWth

The number of installations within this size category was calculated to be 2,598 at the end of 2021. The uptake of smaller sized biomass systems in non-domestic settings has been slowing since the peak uptake of systems of this size in 2014 when there were 1,124 installations newly accredited under the non-domestic

RHI scheme. The uptake of small biomass boilers in 2021, with 12 new accreditations under the non-domestic RHI scheme, is consistent with the trends seen in recent years, with the five-year average annual increase in systems of this size being 31.

The 2,598 operational biomass installations within this size category were estimated to have consumed 110,000 odt of wood fuel in 2021, an increase of 3% over the revised 107,000 odt estimate for 2020.

2.1.4. Wood fuel used by domestic installations

There were 4,771 installations accredited certified under the MCS scheme without also being accredited under the non-domestic RHI scheme.[8] This is 16 installations more than the revised domestic installation count of 4,755 for 2020. This continues the downwards trend seen for the number of new domestic installations, with 2021 being the lowest count recorded since the domestic RHI scheme began.

The 4,771 domestic installations are estimated to have consumed 50,000 odt of wood fuel in 2021, an increase of less than 1,000 odt (1%) on the revised 2020 estimate of 49,000 odt.

2.1.5. Number of installations by local authority

The total number of known non-domestic installations up to the end of 2021 by local authority is shown in Figure 3. The local authority with the greatest number of non-domestic installations is Dumfries and Galloway with 565. This is followed by the Aberdeenshire (498), Highland (490), Perth and Kinross (243) and Scottish Borders (200) local authority areas. The local authority areas with the fewest non-domestic installations are Dundee City and Orkney Islands.[9]

The total number of domestic installations up to the end of 2021 by local authority is shown in Figure 4. The local authority with the greatest number of domestic installations is Highland at 1,264. This is followed by the Aberdeenshire (419), Scottish Borders (378), Dumfries and Galloway (329) and Perth and Kinross (291) local authority areas. The local authority areas with the fewest domestic installations are Glasgow City and Dundee City, both of which have fewer than ten installations.[9]

The distributions of non-domestic and domestic installations by local authority are generally consistent with one another when comparing the two datasets. The same five rural local authorities are responsible for the majority of both non-domestic and domestic installations.

[8] Domestic installations have been defined for this report as those certified under MCS and not accredited under the non-domestic RHI scheme. The MCS cohort is likely to include a small number of non-domestic installations but as they cannot be identified, the MCS dataset has been treated as solely domestic for ease of analysis. The impact of the small number of non-domestic installations within this category is deemed to be minimal.

[9] The exact figures cannot be shared due to the risk of potentially identifying individual installations.

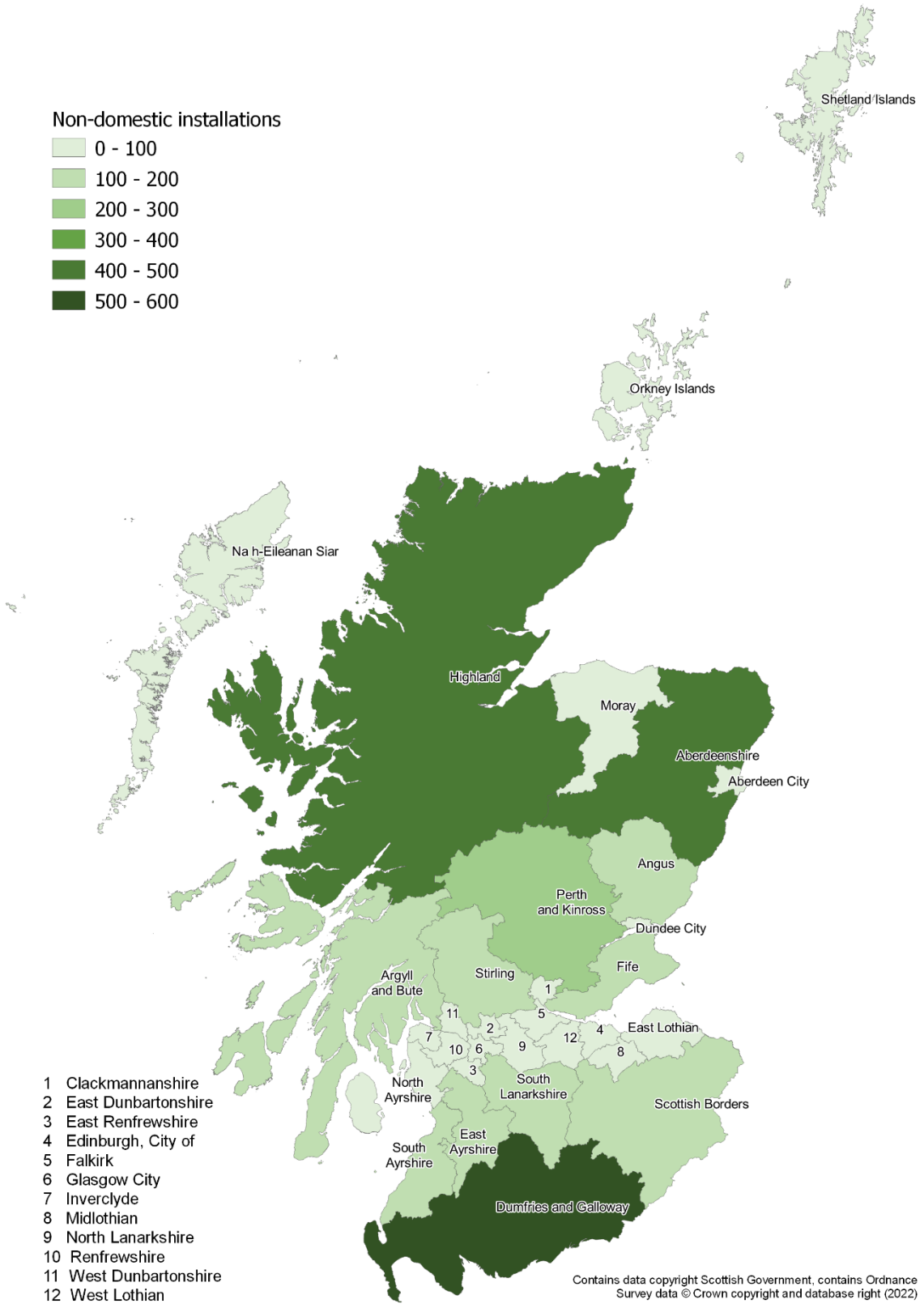

Figure 3. Non-domestic installations by local authority, 2021

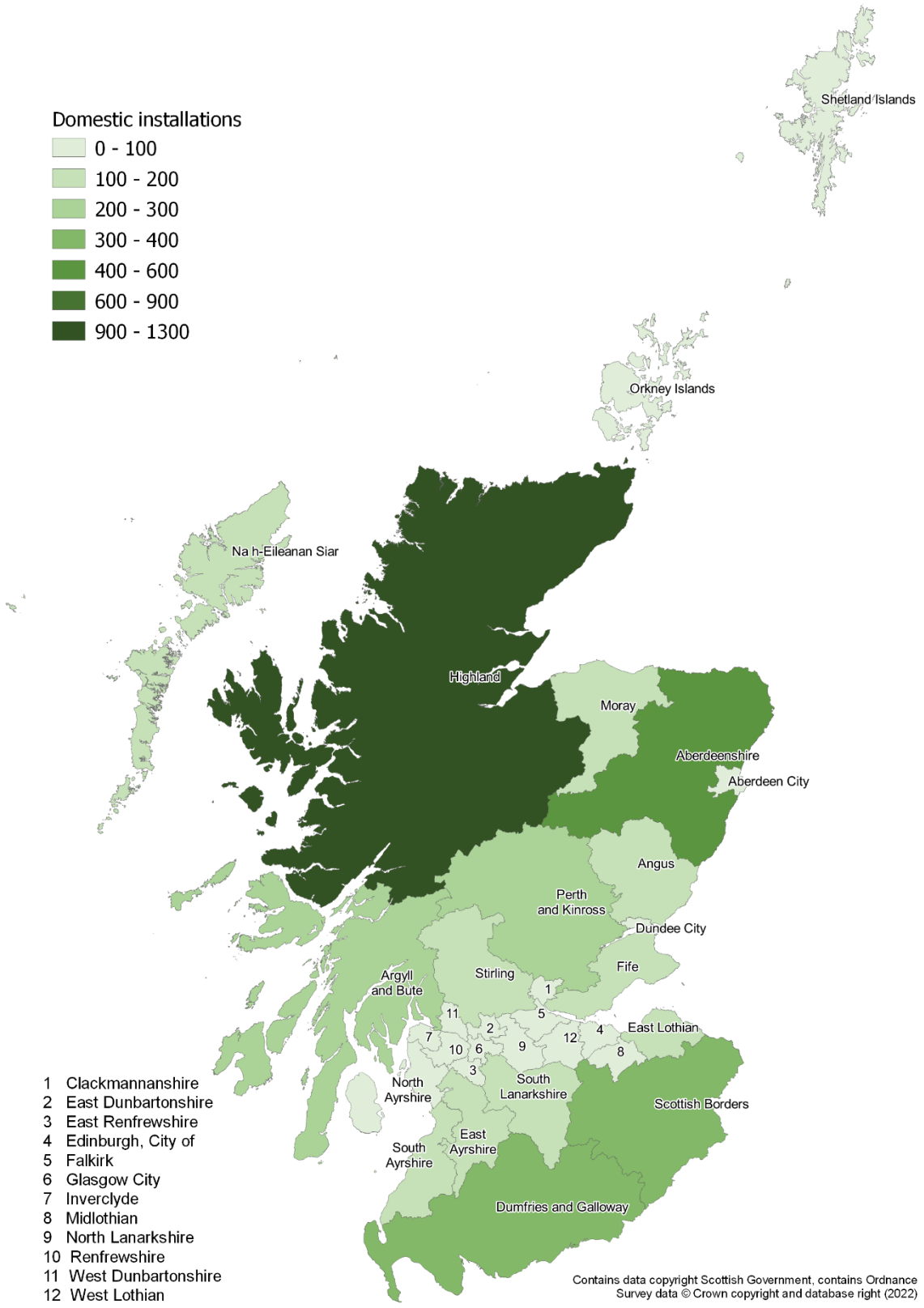

Figure 4. Domestic installations by local authority, 2021[10]

[10] Please note the non-linear scale of the legend

2.2. Wood fuel use by fuel category

Based on survey information and the wood fuel type assumptions and calculations set out in the methodology of Appendix A, the total wood fuel used in 2021 by category is given in Figure 5. Compared with 2020, the use of virgin fibre wood fuel as a percentage of total wood fuel consumption has remained broadly consistent, dropping from 45% in 2021 to 44% in 2020.

There was a three-percentage point increase in the amount of total wood fuel consumption coming from co-products and residue, increasing from a share of 27% in 2020 to 30% in 2021.The amount of recycled wood fuel in use has dropped across the same period from 21% in 2020 to 19% in 2021. The use of the remaining two wood fuel categories has remained consistent between the two reporting years, with the use of wood pellets remaining unchanged at 7% and the use of 'Other' remaining unchanged at less than 1%.

Biomass installations installed for generating heat in the larger wood processing plants will normally be fuelled with as much on-site process residue as possible, such as bark, offcuts and sander dust. Where necessary, companies can supplement their on-site supplies by diverting some of their existing roundwood or sawmill co-product purchases to make up quantities rather than separately buying-in virgin material such as logs, wood chips or recycled timber to fuel their biomass installations. Similarly, large sized biomass CHP installations aim to utilise as much of co-products from the wood processing industries as possible. As we assume in this report that none of the RHI accredited biomass installations are using any co-products and residue or recycled fibre as wood fuel, any change in the consumption figures for these wood fuel types is attributable to just the large surveyed sites, whereas the totals for virgin fibre, wood pellets and other materials is split between the different installation size categories. Most of the changes in the wood fuel types being consumed between 2020 and 2021 can therefore be attributed to large sized installations.

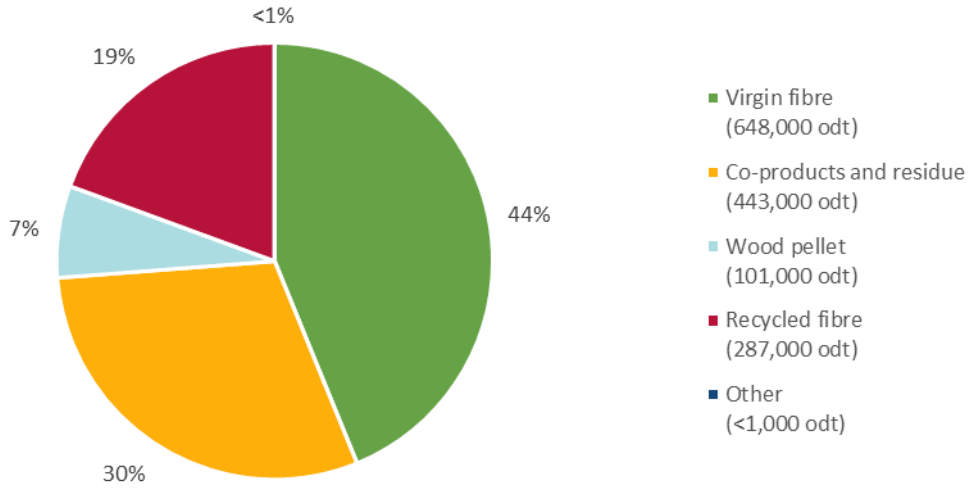

Figure 5. Wood fuel usage by wood fuel type in 2021

Figure 6 shows total wood fuel use since 2004-05 by wood fuel type. Please note that reporting on consumption by wood fuel type has changed throughout the report series. Reporting on the split in wood fuel consumption first commenced in the 2007-08 reporting year but it was not until 2016 that 'Wood pellet' usage was split from the 'Other' wood fuel category. In that same year 'Virgin fibre' was also divided into 'Virgin fibre' and 'Co-products and residue' to better comment on the provenance of the wood fuel being consumed; with the latter being a by-product which can be fed into biomass installations which would otherwise require a greater amount of other wood fuel to meet the site's energy demand. However, there is some degree of subjectivity between the two wood fuel categories, with some virgin fibre potentially being reported to us as co-products and residue, and vice versa.

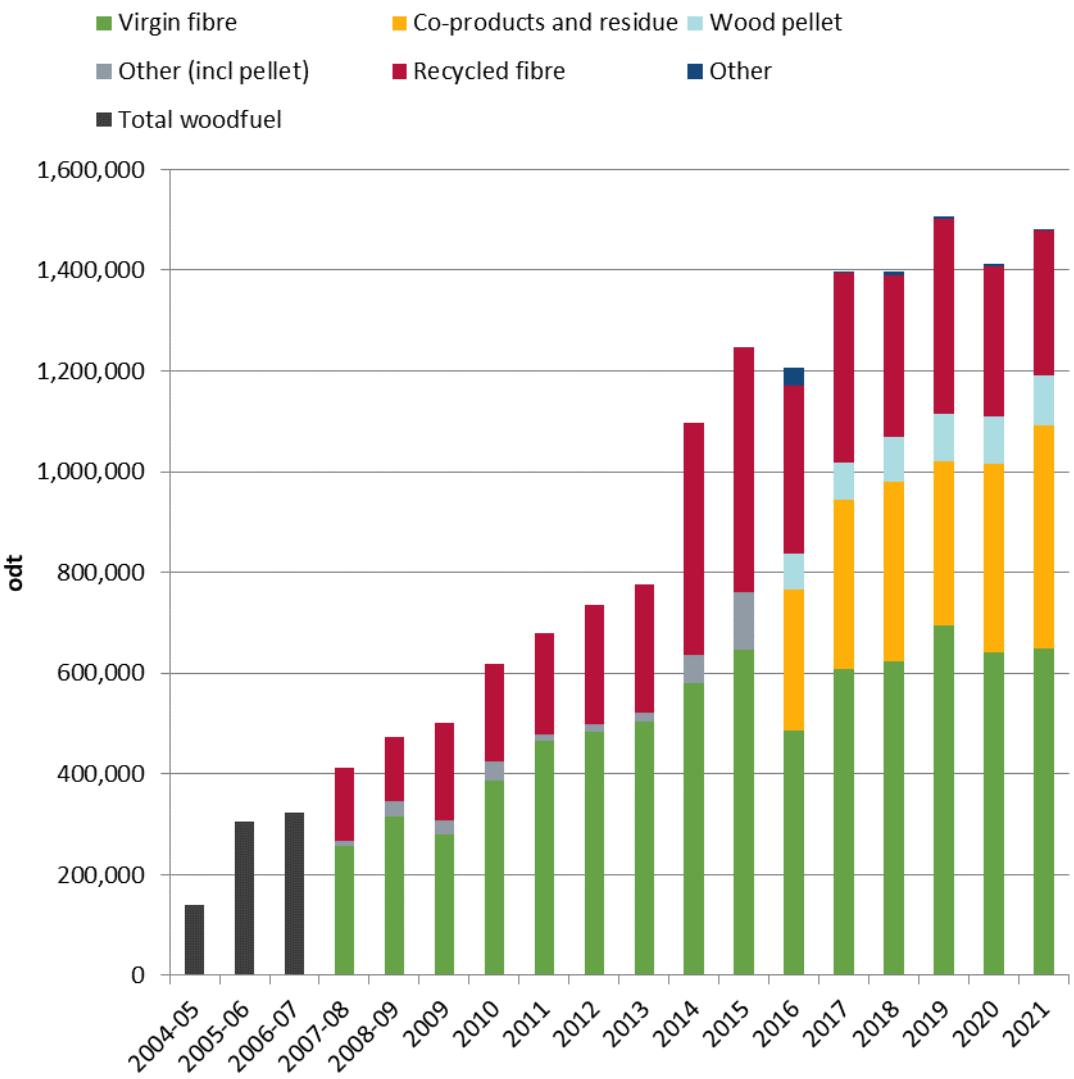

Figure 6. Annual wood fuel consumption (odt) split by wood fuel type from 2004-05 to 2021

2.3. Contributions to the Scottish Government's renewable heat targets

The Scottish Government had a target of meeting 11% of non-electrical heat demand with renewables by 2020.[11] The majority of renewable heat reported to date in Scotland (70%) is produced by biomass installations.[12] Please note that the Renewable Heat in Scotland, 2020 report and this report series do present differing useful heat output totals for biomass. This is largely because of differences in the datasets used to produce each report. However, both reports agree on the significant contribution of biomass to the Scottish Government's renewable heat targets.[13]

The total useful heat output figure for 2021 from this year's Wood fuel Demand and Usage analysis is 3,730 GWh (Table 2). This is an increase of 450 GWh (14%) over the revised 2020 Wood Fuel Demand and Usage reported figure of 3,280 GWh. The significant increase in useful heat output from 2020 to 2021 can mostly be attributed to more reported heat usage at the large biomass sites surveyed, with a smaller share of the increase also due to the small number of new installations recorded for all installation size categories.

[11] See the Scottish Government's updated Heat Policy Statement, published June 2015, for more information: http://www.gov.scot/Publications/2015/06/6679
[12] https://energysavingtrust.org.uk/report/renewable-heat-in-scotland-2020/
[13] Please note that there is no Renewable Heat in Scotland, 2021 report to compare the most up to date Wood Fuel Demand and Usage report figures against because the Renewable Heat reporting figures are not due to be updated again until for the 2022 calendar year.

This increase in useful heat output (14%) might appear to conflict with the much smaller gain in wood fuel consumption (5%) from 2020 to 2021. However, a significant amount of the gain in useful heat output occurred at CHP sites. At such sites, wood fuel consumption is primarily connected to the generation of electricity. Useful heat output can therefore increase at CHP sites, reflecting increased usage of heat that would have otherwise gone unused, without showing a matching increase in wood fuel consumption.

Table 2. Estimated contribution of biomass installations to the Scottish Government's renewable heat target in 2021

Installation size category	Number of installations	Average annual hours of operation[14]	Average boiler capacity (kWth)	Estimated useful heat output (GWh)
Domestic	4,771	1,611	25	196
Small non-domestic	2,598	1,446	115	434
Medium non-domestic	935	1,784	542	904
Large non-domestic	58	Not disclosed	Not disclosed	2,197
Total	**8,362**	**--**	**--**	**3,730**

2.4. Carbon savings

Table 3 shows the estimated CO_2e savings for wood fuel biomass installations in 2021.

Table 3. Estimated CO_2e savings per annum from wood fuel consumption by biomass installations in 2021

Installation size category	Wood fuel consumption (odt)	GCV of wood fuel consumed (GWh)	CO_2e savings (tonnes/annum)
Domestic	50,000	280	65,000
Small non-domestic	110,000	620	144,000
Medium non-domestic	229,000	1,291	299,000
Large non-domestic	1,103,000	6,219	1,117,000
Total	**1,491,000**	**8,410**	**1,624,000**

Wood fuel using biomass installations operating across Scotland are estimated to have saved 1,624,000 tonnes of CO_2e (tCO_2e) over the course of 2021. This is an increase of 86,000 tCO_2e (6%) compared with the revised 2020 estimate of 1,538,000 tCO_2e. This carbon saving increase comes from the increase in total wood fuel consumption and a better carbon factor for wood fuel in 2021 relative to the woodfuel carbon factor used for 2020.

Figure 7 shows annual CO_2e savings from 2006-07 to the current reporting year. Due to differences in methodology, the values for 2017 onwards are not directly comparable to those of preceding years but the

[14] For all non-surveyed installations, this was estimated by dividing the total output by the total capacity of each installation size category.

broad relationship between increasing wood fuel consumption and CO_2e savings can still be distinguished despite said methodological differences.

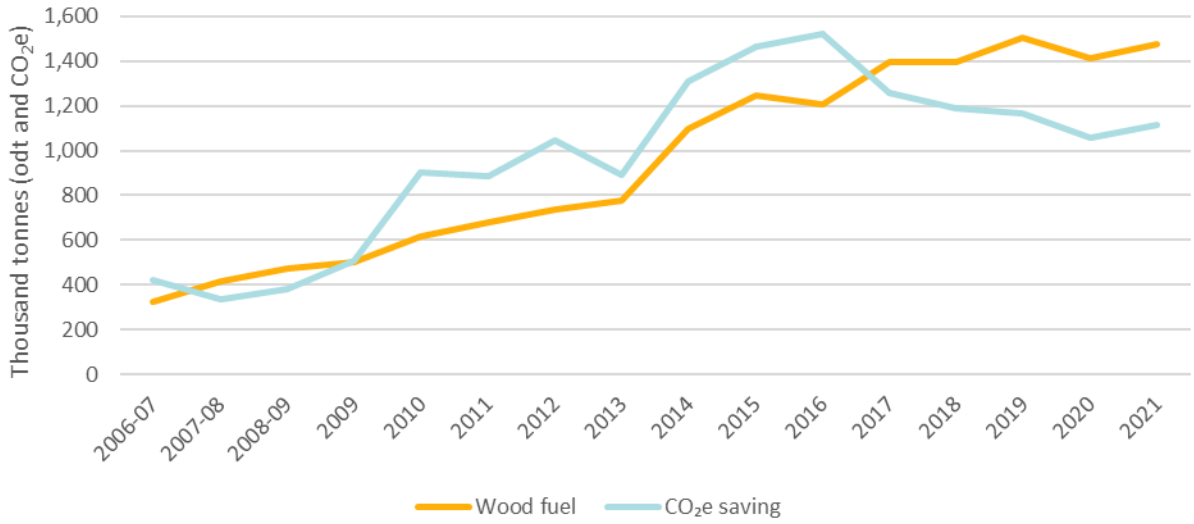

Figure 7. Annual CO_2e savings and wood fuel consumption (thousand tonnes/annum) from 2006-07 to 2021

One particular methodological change which has had a considerable impact upon figure 7 was the inclusion of scope 1 CO_2e emission factors for wood fuel from 2017 onwards. Since 2017, the scope 1 emissions for wood fuel have largely become more CO_2e intensive, increasing by 25% between 2017 and 2020; however, there was a slight reduction of 2% between 2020 and 2021. Had the scope 1 wood fuel CO_2e emission factors not been applied, as per the methodology prior to 2017, the corresponding savings for 2021 would have been 127,000 tCO_2e greater (8%). The CO_2e emission factors for the fuels used in the analysis are given in Table 4.

Table 4. UK Government Greenhouse Gas reporting factors for 2020 and 2021 used in the analysis

Fuel type	$kgCO_2e$ per kWh 2020 (GCV)	$kgCO_2e$ per kWh 2021 (GCV)	Percentage change
Coal (electricity generation)	0.31666	0.32020	1%
Fuel oil	0.26775	0.26815	<1%
Gas oil	0.25672	0.25679	<1%
Natural gas	0.18387	0.18316	>-1%
Oil (kerosene)	0.24666	0.24677	<1%
Wood fuel (logs, chips and pellets)	0.01545	0.01513	-2%

3. Future biomass developments

3.1. Renewable heat incentive and other financial support

The number of new installations recorded in the non-domestic and MCS datasets for 2021 is consistent with the low number of biomass installations happening in recent years (see Figure 8). The most significant cause for the slow installation rate in recent years has been attributed to the reduced payments from the RHI tariffs available during those years. The reduced rates were implemented in order to manage the budget for the RHI; BEIS used a 'degression' mechanism to alter tariff rates for technologies which are using more or less budget than anticipated. Alterations to these tariffs tended to be reflected in the installation numbers, with a drop in installations when tariffs are low.

With the non-domestic RHI scheme closed to new applicants in April 2021, and the domestic RHI scheme closed to new applicants in April 2022, it remains to be seen what effect this will have on the biomass installation rate, although we expect the rate of biomass installation to stay low. These low rates of installation are also anticipated because the Scottish Government stated in their 2021 Heat in Buildings Strategy[15] that biomass heating systems in buildings will have a more limited role compared to zero direct emissions heating systems such as heat pumps with the intention that biomass is an option where zero direct emissions systems are not suitable.

There are other financial incentives available to install biomass boilers. In Scotland, interest free loan funding is currently available from the Scottish Government through the Home Energy Scotland advice service, which can help cover the cost of installing a domestic biomass boiler. Some funding is also available for non-domestic organisations through the Scottish Government's Business Energy Scotland advice service, Community and Renewable Energy Scheme (CARES) and Scottish Government loan and grant schemes supporting heat networks.[16]

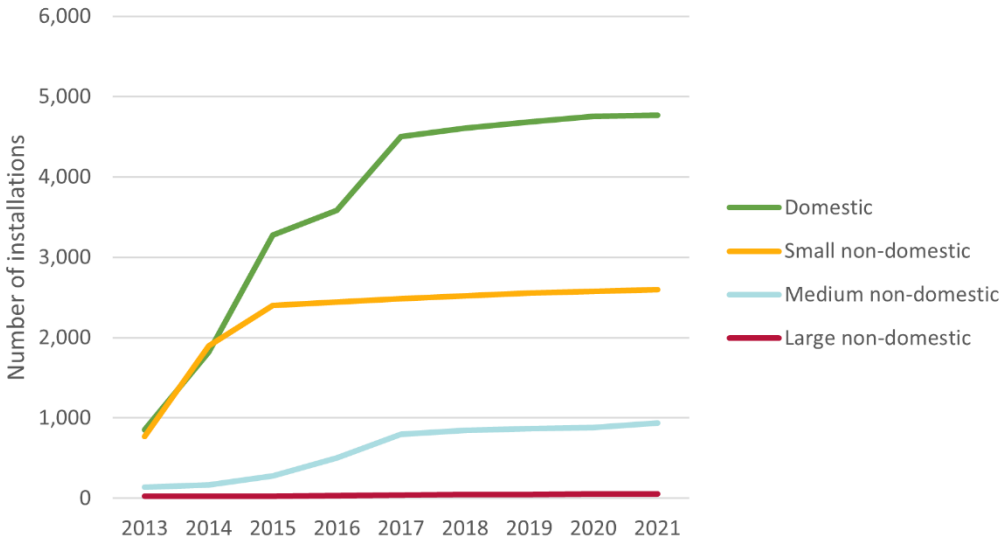

Figure 8. Number of biomass installations by installation size category, 2013 to 2021[17]

[15] https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings/
[16] https://www.gov.scot/publications/heat-in-buildings-strategy-2022-update/pages/progress/
[17] The decreased uptake of new domestic installations seen in 2016 is methodological rather than actual. The domestic totals for pre-2016 are sourced from domestic RHI data and the totals for after 2016 from the MCS dataset, the latter of which is comprised of the former plus additional installations which were never accredited under the domestic RHI. As the 2016 domestic total does not include the MCS figures, it is therefore showing a much lower growth rate relative to 2017.

4. Discussion

4.1. Methodological reflections

There remain a number of uncertainties in the reporting series that it is important to be aware of when interpreting the results, or that could potentially benefit from further improvements to the methodology in order to present our wood fuel consumption estimates in the best context.

1. The inclusion of scope 1 CO_2e emission factors for wood fuel has reduced the annual rate of growth in CO_2e savings relative to the annual rate of growth of the number of biomass installations for 2017 onwards. It has been discussed whether scope 3 (distribution) emission factors should also be applied to all the fuels considered as part of this analysis. This would further worsen the CO_2e savings as wood fuels typically have greater scope 3 emission factors than fossil fuels. On the other hand, the scope 3 emission factors for wood fuel, as given in the UK Government's GHG emission factors, may not be applicable to the specific use cases where the majority of wood in Scotland is consumed; namely, on site by organisations involved in wood processing industries or making use of co-products produced by them. We have therefore chosen not to include scope 3 emissions for any fuels at this time and until evidence is found which proves the suitability of the UK Government's scope 3 emission factors for the particular use cases of this report.
2. The assumed wood fuel type consumed by RHI installations continues to utilise the Wood Heat Association (WHA) analysis from 2015 which has the risk of becoming increasingly out of date as annual reporting continues. The in-situ performance of biomass installations report, referenced earlier, includes a breakdown of wood fuel type consumption by different sizes of biomass systems on a UK wide basis. It was decided that this would not be used here because Scotland is likely to have a noticeably different wood fuel type consumption owing to the greater availability of local woodchip than there is in the rest of the UK. The data used to produce this UK wide analysis was provided by Ofgem who receive voluntary declarations of wood fuel consumption as part of RHI monitoring.
3. In some cases, it was not feasible to allocate the wood fuel being consumed to a specific wood fuel type. The WHA analysis suggests that 73% of wood fuel consumption by biomass boilers accredited under the non-domestic RHI would be comprised of woodchip and sawmill co-products but, with no further information to establish the exact split between the two components, all the wood fuel consumption was assumed to be virgin fibre. Similarly, some of the site survey information received did not distinguish the wood fuel type in use and, in such cases, it was also assumed to be virgin fibre. It is likely that an unknown percentage of this virgin fibre consumption would be co-product and residue use and there may be some degree of interchangeability between the two wood fuel categories.
4. Similar to the above, it is assumed that all of the biomass output being reported in the RHI data set is being provided by wood fuel. However, it is also likely to contain energy sourced from other materials. An examination of a selection of planning applications for biomass installations by Energy Saving Trust suggests that straw is the most common non-wood fuel mentioned in said planning applications, with other grasses and energy crops also being noted on occasion. As such, the derived wood fuel estimates are likely to be overestimated by an as of yet unknown proportion although it is currently not considered to have an overly significant effect on the overall results of this report because wood fuel is by far the dominant biomass fuel consumed.
5. The RHI data will also not include open fires and ineligible biomass stoves and therefore the wood fuel estimates derived are likely to be underestimated as a result but by an unknown amount.
6. As the number of biomass installations of an age greater than ten and fifteen years increases, it is expected that some of these installations will be decommissioned. However, it may not be easy to track how often and when this occurs. Non-domestic RHI payments are made for twenty years which is likely to cover the majority, if not all, of an installation's lifetime but once these payments stop, there may not be any indication of which installations continue to operate. Domestic RHI payments are for the first seven years of operation of the installation and are therefore not likely to capture the end of the installation's lifetime. Similarly, the MCS dataset captures information on the installation at the time of certification (i.e. commissioning) but is not updated should an installation become no longer operational. To properly assess the true count of operational biomass installations, and to

estimate their corresponding wood fuel consumption, an assessment of decommissioning rates may be necessary in order to apply a reduction factor to operational biomass output. Energy Saving Trust will consider the issue and assess what data would be required to introduce such an approach, and how feasible it would be to carry this out as part of the Wood Fuel Demand and Usage analysis.

7. It is known that there is a degree of cross-border movement and consumption of wood fuel between England and Scotland. It is assumed that most of this movement will be small in scale and primarily from Scotland to England. The RO data suggests that there are at least two large biomass users in England reporting that a proportion of their consumed wood fuel is sourced from Scotland. This consumption cannot be counted towards to Scottish CO_2e savings or renewable heat targets, but further information on it could help better inform total wood fuel production and consumption figures. Unfortunately, we have so far been unable to obtain data on wood fuel exports for these projects, and so have not been able to include this in our analysis.

5. Key findings

The total amount of wood fuel used in Scotland in 2021 increased by 66,000 odt to 1,491,000 odt, a 5% increase on the amount used in 2020 (1,426,000 odt).

Large scale installations with a capacity of ≥1000 kWth was the category to have consumed the most wood fuel in 2021, consuming 1,103,000 odt or 74% of all reported consumption. This is the same percentage of total wood fuel consumed by this category in 2020, when consumption was estimated to be 1,058,000 odt. There were an additional five large sized installations newly reported to us in 2021, bringing the total to 58 in 2021, from 53 in 2020 (an increase of 9%). The increase in wood fuel consumption for this size bracket in 2021 can be attributed to the increased consumption at large sites already in operation prior to 2021, with a smaller share of the increase coming from the five installations newly commissioned in 2021.

Wood fuel consumption by the installations sized between 200 and 1,000 kWth increased by 17,000 (8%) from 212,000 odt in 2020 to 229,000 odt in 2021. This increase is largely in line with the 31 medium sized installations newly reported to be in operation in 2021, increasing by 3% from 904 in 2020 to 935 in 2021.

Small sized non-domestic installations (≤200 kWth) had an increase in wood fuel consumption in 2021 of 3,000 odt (3%). The wood fuel consumption by this category thereby increased from 107,000 odt in 2020 to 110,000 odt in 2021. There were 12 new small sized installations commissioned in 2021, an increase of <1% from 2,586 in 2020 to 2,598 in 2021.

Wood fuel consumption by domestic installations increased by less than 1,000 odt (<1%) between 2020 and 2021, increasing from 49,000 odt to 50,000 odt. The number of domestic installations reported in 2021 increased by 16 (<1%) from 4,755 in 2020 to 4,771 in 2021.

The 2021 calendar year continues to see a low uptake of biomass systems across all the size categories reported on. There was an increase of just 64 installations since the end of 2020, bringing the total number of known operational systems to 8,362. In comparison, there were 96 new installations in 2020, 103 in 2019 and 174 in 2018; highlighting the slowing of new installations since 2017. This slowing rate of installation has largely been attributed to the degression of biomass RHI tariff payments which decreased the financial returns from installing and accrediting new biomass installations under the RHI schemes. This trend is likely to continue with the closure of both the non-domestic and domestic RHI schemes and with the Scottish Government's focus for heat in buildings to be largely provided by zero direct emission heating systems. There was a slight uptick in the number of medium sized non-domestic installations in 2021, with 31 newly reported installations compared to 13 in 2020 and 17 in 2019. This likely reflects organisations wishing to make use of the non-domestic RHI scheme before it closed to new applicants in April 2021.

The most widely used type of wood fuel in Scotland in 2021 was virgin wood fibre at 648,000 odt or 44% of the total wood fuel used. Co-products and residue made up an additional 443,000 odt of fuel used or 30%, recycled fibres made up 287,000 odt, or 19%, of wood fuel used; wood pellets made up 7% of wood fuel used, whilst other fuels made up less than 1%.

The rural local authority areas in Scotland account for the majority of all non-domestic and domestic wood fuel installations. The highest numbers of non-domestic and domestic installs can be found in the Dumfries and Galloway and Highland local authority areas respectively.

The contribution of wood fuel-using biomass installations to the Scottish Government's renewable heat target in 2021 has been estimated at 3,730 GWh, a 14% increase over the 2020 contribution of 3,280 GWh. The large increase in useful heat output relative to the smaller increase in wood fuel consumption is largely due to increased useful heat output at CHP sites. As such sites primarily generate electricity with excess heat often produced as a by-product of this process, there can be an increase in the use of previously unused heat without there being a matching increase in wood fuel consumption. The Renewable Heat in Scotland 2020 report states that the useful heat output from biomass accounts for 70% of all renewable heat output currently reported in Scotland.[18]

Carbon dioxide equivalent savings from wood fuel installations in 2021 were estimated at 1,624,000 tCO_2e, which is an increase of 86,000 tCO_2e compared to the 2020 figure of 1,538,000 tCO_2e. The increase in tCO_2e savings can be attributed to the increased total wood fuel consumption as well as better carbon factors for wood fuel relative to what they were in 2020.

[18] https://energysavingtrust.org.uk/report/renewable-heat-in-scotland-2020/

Appendix A Methodology

6.1. Data collection

Each year Energy Saving Trust undertakes a survey of large biomass users who are using wood fuel to produce heat or, in the cases of CHP installations, heat and electricity. This data is collected from the operators of said sites. All the sites included in the 2021 survey, conducted in the 2020 calendar year, were either known to us from previous surveys or identified through Energy Saving Trust research into the renewable energy sector in Scotland.

This report has made extensive use of published and unpublished data collected by BEIS on RHI accredited installations under the domestic and non-domestic schemes.

This report has also made use of unpublished data provided by MCS covering biomass installations accredited under the Microgeneration Certification Scheme (MCS) in Scotland.

Other site-specific data is provided by Scottish Forestry and Forest Research,[19] or extracted from the Ofgem biomass sustainability dataset which includes information on CHP installations accredited under the Renewables Obligation (RO) scheme.

Information on the sources of data and assumptions used are presented below.

6.1.1. Wood fuel survey and other site-specific data

The wood fuel survey asks each respondent for information on:

- The name and location of each large sized system operated by the organisation and when each installation first started operating.
- Whether each installation provides just heat or is CHP.
- Whether each installation receives any subsidy from the RHI or RO schemes, asked to help identify potential double counting between a surveyed site and other datasets.
- The thermal and, where applicable for CHP installations, the electrical capacities and output of each installation.
- The approximate operating hours per year for each installation.
- Whether each installation has a fossil fuel back up and what fossil fuel the biomass system has displaced.
- The amount of wood fuel, in oven dried tonnes (odt), consumed by each installation broken down by wood fuel type into virgin fibre, co-products and residue, recycled wood, wood pellets or other.
- Whether the installations provide any form of district heating and, if so, to how many domestic and non-domestic properties.
- Any other information which could be relevant to our understanding of their wood fuel consumption such as whether an installation only operated for part of the year due to maintenance.

The wood fuel survey data is complemented by data collected by Forest Research as part of their annual survey of the UK timber industry. This survey collects data on the amount of wood fuel consumed for energy purposes on site but does not collect information on the capacities or output of specific installations as how the wood fuel survey does. Figures provided by wood fuel users through our survey and the data provided by Forest Research were used on strict conditions of confidentiality and are therefore only reported on an aggregated basis.

Our understanding of the sites surveyed by either Energy Saving Trust or Forest Research is further improved by cross-referencing the collective survey data against Ofgem's biomass sustainability dataset.[20]

[19] https://www.forestresearch.gov.uk/

[20] The latest Ofgem biomass sustainability dataset can be accessed at https://www.ofgem.gov.uk/publications/biomass-sustainability-dataset-2020-21

This dataset contains information on the fuels used by systems accredited under the RO scheme. The RO scheme subsidises electricity generated by renewables and will therefore only contain information on CHP installations. The most recent information available from the RO dataset is always the financial year prior to the calendar year covered by the latest iteration of the Wood Fuel Demand and Usage report. This means that the RO fuel data cannot be used to provide figures on wood fuel consumption in 2021 but it can help improve historical estimates.

The resulting combined dataset of site-specific information on large biomass installations in Scotland covers wood fuel consumption and/or heat and electricity output between 2016 and 2021 for 25 organisations and 34 large biomass installations. However, some of this data is not recent depending on when the organisation last responded to the wood fuel survey and if the installations are covered by any of the other datasets used.

Where the data for a particular site has not been updated for this reporting year, we have applied the following logic to how the data for the site was sourced for 2021:

- For CHP sites we have rolled over the most recent data available to 2021, whether that is from the wood fuel survey, provided by Forest Research or from the RO dataset.
- For heat only sites that we know to be non-RHI accredited, or only partially RHI accredited, we have rolled over the most recent data available to 2021, whether that is from the wood fuel survey or provided by Forest Research.
- For heat only sites that we know to be RHI accredited, we have excluded previous wood fuel survey or Forest Research data from our analysis. These installations are instead included in the aggregated non-domestic RHI values for 2021, the heat output values from which can be used to estimate wood fuel consumption.

Of the 34 installations covered by the site-specific data collected, 20 have been included within our analysis. The other fourteen were excluded because they are either no longer in operation or have been included within the non-domestic RHI totals. Of the 20 installations covered by the site-specific data used in the analysis, 75% have data for the 2021 calendar year with the other 25% rolling over historical values from the 2020 calendar year. We are no longer using any site-specific data older than 2020 in our analysis.

6.1.2. Non-domestic RHI data

A dataset covering all non-domestic RHI accreditations in Scotland is provided by BEIS to the Scottish Government for use in the Wood Fuel Demand and Usage report analysis. This dataset includes the address of each accreditation as well as their capacity and useful heat output values for the duration of the non-domestic RHI scheme.

A cross-checking exercise is carried out to ensure that none of the installations in the site-specific data are being double counted in the RHI dataset. For those that do exist in both datasets, they are excluded from the RHI totals if the site-specific data is more up to date or if the installation is only partially RHI accredited (because the RHI capacity and output values will be only a proportion of the renewable heat use on site).

Further information on the use of the non-domestic RHI dataset which is relevant to the presentation of the results is:

- The RHI statistics published here will differ from publicly available RHI statistics because we have used the commissioning date to allocate an accreditation to a reporting year, whereas statistics released by BEIS use the accreditation date which can occur considerably later than the commissioning date.
- We have assumed that the number of accreditations under the scheme equates to the number of installations, however, multiple biomass installations can be one accreditation under the non-domestic RHI scheme if they form one overall system.
- The RHI scheme for non-domestic buildings was introduced in November 2011, although it is assumed in this study that no new installations were commissioned until January 2012.
- Biomass installations installed after July 2009 were eligible to be subsequently accredited onto the RHI scheme (‘RHI backdating’).

- Forestry Commission (FC) survey data covers non-domestic installations installed between 2005 and 2012 and is used only for those reporting years which predate the opening of the non-domestic RHI (2005 to 2011).
- The 'heat paid for' figure included in the non-domestic RHI dataset has been used as an estimate for useful heat output because the RHI can only support heat that is used for an 'eligible purpose'. We have defined useful heat output as heat produced for an end process or user and excluding heat used solely to produce electricity or any heat that goes unused.
- Some of the heat output figures are not actual metered values and are instead estimates based on the amount of heat expected to be produced by the installation as well as how much heat the installation had produced in previous years.
- A very small number of CHP installations are included within the medium and large sized installation category totals of the non-domestic RHI scheme. As the RHI scheme only measures heat output and not electrical output, converting the RHI outputs into an estimate of wood fuel consumption will result in an underestimate because the fuel required to produce the electricity will not be included. We expect the impact of this on the overall analysis to be minimal because there are only a small number of CHP installations included within the non-domestic RHI dataset and they will be much smaller than the very large biomass CHP sites already captured as part of the wood fuel survey. Any missing wood fuel consumption will be overshadowed by the wood fuel consumption of the surveyed CHP sites.

6.1.3. MCS data

We also make use of an extract of MCS certified installations provided to the Scottish Government by MCS. The MCS dataset includes the MCS certificate number for the majority of installations within the dataset. This allows easy cross-checking against the non-domestic RHI dataset which also includes the MCS certificate numbers for any non-domestic RHI accreditation that is MCS certified. Any records found to be in both the MCS and non-domestic RHI datasets are removed from the MCS dataset because the non-domestic RHI heat output values are metered values and therefore likely to be more up to date than the MCS output values which are calculated near the time of installation.

A small proportion of MCS records did not have their MCS certificate numbers (covering approximately the latter half of the 2021 calendar year) and thus cannot be easily cross-checked against the non-domestic RHI dataset. These records are therefore likely to include a small number of non-domestic installations. Similarly, there are likely to be more non-domestic MCS installations in all historical reporting years if they were never accredited under the non-domestic RHI scheme and therefore cannot be easily identified as non-domestic installations.

For the purposes of our analysis, we have treated all the MCS records that do not match a non-domestic RHI accreditation as domestic because the vast majority of MCS installations are for domestic properties. We consider the impact of having a small number of non-domestic installations included within the domestic installations category to be insignificant on the overall results presented in this report.

Further information on the use of the MCS dataset which is relevant to the presentation of the results is:

- The MCS standards began in 2008 and MCS certification is an eligibility requirement of many renewable energy schemes, including the domestic RHI and the Home Energy Scotland loan.[21]
- MCS certification occurs at the time of installation and decommissioned installations may not be removed from the certification database. It is therefore assumed that some of the biomass installations included from the MCS dataset may no longer be operational but there is currently no evidence to suggest how many; see the discussion section for more information.
- We now use the MCS dataset in place of data for domestic RHI data for the 2016 to 2021 reporting years.

[21] https://www.homeenergyscotland.org/find-funding-grants-and-loans/interest-free-loans/

6.1.4. Domestic RHI data

In previous reporting years, our domestic installation figures were entirely sourced from data provided by BEIS covering all Scottish biomass accreditations under the domestic RHI scheme. However, with access to the MCS dataset we are no longer using the domestic RHI data for the reporting years we were able to backdate the MCS data to (2016 to 2021). We have chosen to use the MCS data over that of the domestic RHI because MCS certification was a requirement of the scheme, and so every domestic RHI accreditation will be included within the MCS dataset. The MCS dataset will also include data on installations that were never accredited under the domestic RHI scheme and is therefore considered more complete.

6.2. Data assumptions

The following assumptions and assumption-based formula have been applied throughout the analysis:

- One odt of wood has a gross calorific value (GCV) of 5.639 MWh.[22]
- The green to oven dry timber ratio can be calculated using the following formula:

$$R = \frac{(100 - oven\ dried\ moisture\ content\ \%)}{(100 - green\ weight\ moisture\ content\ \%)}$$

  Where R = the ratio to apply
  e.g.

$$R = \frac{(100 - 0\%)}{(100 - 50\%)}$$

$$R = 2$$

  So for every one odt (0% mc) wood produced, two tonnes at 50% mc will need to be harvested.

- Wood fuel consumption was requested in odt as part of the wood fuel survey but where the green weight had been supplied without any indication of moisture content, moisture content was assumed to be 50% for the purposes of converting the green weight of virgin fibre to oven dried. If we had known moisture contents for sites, or historical moisture contents from previous reporting years, these were used in place of our 50% assumption.
- A biomass installation providing just heat, as opposed to a CHP system, is assumed to have a gross efficiency of 70%. This is the average gross efficiency identified by in-situ performance testing of biomass systems as of 2018.[23]
- A biomass CHP system is assumed to have a gross efficiency of 69.1% with a heat to power ratio of 1.86. This is the average gross efficiency and heat to power ratio for all CHP engines and fuel types in 2021 according to chapter 7 of the Digest of UK energy statistics (DUKES). Note that only a small proportion of CHP output is estimated using these assumptions because the majority of CHP output is reported to us directly by sites as part of the surveys.
- For all installations accredited under the non-domestic RHI scheme the wood fuel consumed is assumed to be comprised of 73% virgin fibre, 25% pellets and 2% other material. For domestic installations the wood fuel consumed is assumed to be 90% pellets and 10% logs. All the assumed percentages for the different wood fuel types consumed are sourced from Wood Heat Association (WHA) analysis of declared RHI fuel usage pre-dating 2015. For wood fuel survey responses and other site-specific data which did not indicate the wood fuel type in use, this was assumed to be virgin fibre.
- For the CO_2e saving calculations, the assumed scope 1 UK Government greenhouse gas (GHG) conversion factors for 2021 for each of the relevant fuel types used in the analysis are given in Table 1.

[22] GCV calculated by converting to MWh per tonne the GJ per tonne value for 'Industrial wood' from section A.1 'Estimated average calorific values of fuels 2020' of the Digest of UK energy Statistics (DUKES). https://www.gov.uk/government/statistics/dukes-calorific-values. The value presented here has been rounded to three decimal places for ease of reading although the unrounded values have been used in the analysis.
[23] https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance

- All domestic biomass installations were assumed to be replacing oil (kerosene) burning boilers.
- All small, medium and large sized biomass installations accredited under the non-domestic RHI scheme were assumed to be replacing boilers burning gas oil.
- Most wood fuel survey respondents would include the fuel being displaced but where this was not done, the biomass installations were assumed to be replacing mains gas in on-gas grid areas and replacing fuel oil in off-gas grid areas.

Table 5. Scope 1 UK Government GHG conversion factors for 2021, rounded to five significant figures

Fuel type	$kgCO_2e$ per kWh, 2021 (GCV)
Coal (electricity generation)	0.32020
Fuel oil	0.26815
Gas oil	0.25679
Natural gas	0.18316
Oil (kerosene)	0.24677
Wood fuel (logs, chips and pellets)	0.01513

6.3. Calculations

6.3.1. Converting energy output into wood fuel consumption

The heat paid for totals of the non-domestic RHI scheme and the heat output totals from the MCS data were converted into an estimate of wood fuel consumption by using Equation 1. To summarise, the heat output values from both datasets were divided by the assumed average gross biomass boiler efficiency to calculate the GCV of the fuel consumed to produce said heat. This value was then divided by the GCV of wood fuel to estimate the amount, in odt, of wood fuel used to produce the required heat output.

Equation 1. Converting useful heat output into an estimate of wood fuel consumption for heat-only biomass installations

$$\text{Step 1: } \frac{Useful\ heat\ output}{Gross\ biomass\ boiler\ efficiency} = GCV\ of\ fuel\ consumed$$

$$\text{Step 2: } \frac{GCV\ of\ fuel\ consumed}{GCV\ of\ wood\ fuel} = amount\ of\ wood\ fuel\ consumed\ (odt)$$

The resulting woodfuel estimates were then multiplied by the assumed split in woodfuel consumption by woodfuel type for either domestic or non-domestic installations.

This approach was not required for any of the installations included from the wood fuel survey because they all provided wood fuel consumption values.

6.3.2. Converting wood fuel consumption into energy output

For a small number of installations, it was required to convert a wood fuel amount into energy output because no heat or electrical outputs had been given. For heat-only systems; this meant reversing Equation 1 described in section 6.3.1 as set out in Equation 2. The wood fuel amount was multiplied by the GCV of the wood fuel, then multiplied by the average gross biomass boiler efficiency to obtain an estimate of heat output. There were three heat-only installations that required this approach to estimate their heat outputs.

Equation 2. Converting wood fuel consumption into an estimate of useful heat and electrical output for heat-only biomass installations

Step 1: $Amount\ of\ wood\ fuel\ consumed\ (odt) \times GCV\ of\ wood\ fuel = GCV\ of\ fuel\ consumed$

Step 2: $GCV\ of\ fuel\ consumed \times gross\ biomass\ boiler\ efficiency = useful\ heat\ output$

For CHP installations, the same approach can be followed but using the gross CHP efficiency. However, extra steps are required because the above calculation would provide the total output energy of the installation including electrical and thermal output. We have then split this total output into an estimate of electrical and thermal output by using the assumed heat to power ratio as seen in Equation 3. There were three CHP installations that required an estimation of their energy outputs to be calculated from known wood fuel inputs.

Equation 3. Converting wood fuel consumption into an estimate of useful heat and electrical output for CHP biomass installations

Step 1: $Amount\ of\ wood\ fuel\ consumed\ (odt) \times GCV\ of\ wood\ fuel = GCV\ of\ fuel\ consumed$

Step 2: $GCV\ of\ fuel\ consumed \times gross\ biomass\ CHP\ efficiency = useful\ energy\ output$

Step 3: $Useful\ energy\ output \times \left(\frac{heat\ to\ power\ ratio}{(1+heat\ to\ power\ ratio)}\right) = useful\ heat\ output$

Step 4: $Useful\ energy\ output \times \left(\frac{1}{(1+heat\ to\ power\ ratio)}\right) = electrical\ output$

The useful heat output estimates for CHP derived in this way may be overestimates because CHP sites are often designed and operated to maximise electricity production rather than heat, with heat being a by-product of this process. In this report we refer to useful heat output which is the heat used for an eligible purpose such as space heating, hot water or industrial processes, either on site or by another user to which the heat is exported for their use. This definition does not include heat solely used to produce electricity or the heat that goes unused at CHP operating sites.

Of the three CHP installations that we have estimated the heat output for, two are relatively small and it is not unfeasible that our heat estimates are close to their actual usage. Due to the size of these installations, any overestimation will not have a considerable impact on the total useful heat outputs reported. However, the other CHP installation is significantly larger and consumes more than 100,000 odt per annum. So as to ensure our heat outputs are more conservative, and in line with our knowledge of the site in question, we have further reduced the estimated useful heat output of this site by 99% to represent just a small fraction of the CHP heat produced being used for an eligible purpose.

6.3.3. Calculating CO_2e savings

For all biomass installations, CO_2e savings were calculated by multiplying the total calorific value of the wood fuel consumed by the scope 1 UK government's GHG conversion factors for the fossil fuel replaced. The assumed calorific value of the wood fuel was used rather than the heat outputs because for the CHP installations, the heat outputs were often reported as the heat output consumed, i.e. useful heat output, and therefore did not include the thermal energy required to generate large amounts of electricity at low efficiencies. Only including useful heat would therefore result in an underestimation of fuel consumed and thereby any associated carbon emissions and carbon savings.

Since we report on CO_2e, and not CO_2, we have included a scope 1 conversion factor for biomass. A scope 1 factor for biomass is applicable because, although the conversion factors consider biomass to be scope 1 CO_2 neutral, the CO_2e conversion factor takes into account the emission of other GHGs including nitrous oxide. We have only been reporting on CO_2e, rather than CO_2, since 2019. We have produced revised figures for 2017 and 2018 to include this methodological change but any comparison between the CO_2e savings from 2017 onwards against the CO_2 savings for 2016 or earlier are therefore limited to some extent.

Please note that none of the calculations used in the analysis consider the potential scope 3 emissions associated with the transportation and distribution of the various fuels.