Published November 2021

Renewable Heat in Scotland

2020 Appendices

Appendices produced by Energy Saving Trust on behalf of the Scottish Government

Contents

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Appendix summary

A1.1 Changes to the report

Version two of the Renewable Heat in Scotland, 2020 report corrects an error with the estimated heat output at some large biomass sites.

For 2020, biomass output was reduced from 3,578GWh to 3,512GWh; total output was reduced from 5,074GWh to 5,008GWh and the Scottish Government's progress towards their target remains unchanged at 6.4% due to rounding and is now an increase, rather than a decrease, compared to the corrected 2019 values.

For 2019, biomass output was reduced from 3,816GWh to 3,531GWh; total output was reduced from 5,209GWh to 4,925GWh and progress towards the target was reduced from 6.6% to 6.2%. This change results in an increase to overall progress against the target between 2019 and 2020, rather than the decrease previously reported.

For 2018, biomass output was reduced from 3,878GWh to 3,663GWh; total output was reduced from 5,028GWh to 4,813GWh and progress towards the target was reduced from 6.2% to 6.0%.

Some percentages contained in the local authority analysis section of this report have also been changed as a result of corrections in the overall contribution of different technology classes.

The corrected figures have been used throughout this report. **Previously published figures are no longer applicable.**

A1.2 Background

These appendices were created for use with the Renewable Heat in Scotland 2020 report published by Energy Saving Trust on behalf of the Scottish Government.

All information contained within this document relates only to the 2020 iteration of the Renewable Heat Report, published in 2021, because many of the calculations, sources and assumptions used in the analysis are reviewed and updated on an annual basis.

Throughout this file all output values are shown in gigawatt hours (GWh)[1] and capacities are shown in gigawatts (GW).[2] For ease of reading, the report and appendices utilise the following rounding conventions:

- All output values have been rounded to the nearest whole number except those which are less than 1GWh which are shown as <1.

[1] 1GWh = 1,000MWh = 1,000,000kWh.
[2] 1GW = 1,000MW = 1,000,000kW.

- All capacity values have been rounded to two decimal places except those which are less than 0.01GW which are shown as <0.01.
- All number of installation figures have been rounded to the nearest ten except those which are less than ten which are shown as <10.

Due to rounding, some figures may not be precisely consistent with summed totals or percentage changes.

For any questions or comments relating to the Renewable Heat Database or accompanying analysis and report please contact RenewableReporting@est.org.uk.

Appendix 1. Data tables for Renewable Heat in Scotland, 2020 report

Table A1. Renewable heat and renewable heat as a percentage of non-electrical heat demand in Scotland, 2010 to 2020[3]

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Renewable heat output (GWh)	1,667	1,709	1,883	2,103	2,661	3,906	3,542	4,346	4,813	4,925	5,008
Non-electrical heat demand (GWh)	88,180	85,310	84,767	82,256	80,153	78,024	79,274	81,989	80,864	78,844	*78,844*[4]
% of non-electrical heat demand met by renewables	1.9%	2.0%	2.2%	2.6%	3.3%	5.0%	4.5%	5.3%	6.0%	6.2%	6.4%

[3] The 2018, 2019 and 2020 overall output values and the progress towards the target in each year have been revised due to a correction to output from some large biomass installations. See Section 0 “Changes to this report” for more information. These corrections have been applied throughout the appendices.

[4] To calculate the percentage of non-electrical demand met by renewables, the 2019 non-electrical heat demand value has been rolled over to 2020 because the final sub-national fuel estimates for a given calendar year are not available until the publication of the subsequent Renewable Heat in Scotland report.

Table A2. Renewable heat output (GWh) by technology class, 2010 to 2020

Technology class	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biogas	39	42	42	72	73	117	173	240	272	303	322
Bioliquid	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Biomass	1,529	1,565	1,720	1,882	2,419	3,459	2,722	3,287	3,663	3,531	3,512
Biomethane	0	0	0	0	<1	126	409	552	578	716	716
Heat pump	78	79	97	125	143	179	200	229	262	307	390
Solar thermal	9	9	11	12	12	13	14	14	14	14	15
Waste	12	12	12	12	12	12	23	23	23	52	52
Total	1,667	1,709	1,883	2,103	2,661	3,906	3,542	4,346	4,813	4,925	5,008

Table A3. Renewable heat output (GWh) by installation size category, 2010 to 2020[5]

Installation size category	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Large	1,440	1,463	1,595	1,700	2,083	2,799	1,868	2,102	2,219	2,117	2,105
Medium	14	24	32	51	81	161	325	675	942	981	1,029
Small	9	18	28	80	165	377	459	506	534	536	543
Micro	204	204	229	272	332	442	480	511	541	575	615
Biomethane	0	0	0	0	<1	126	409	552	578	716	716
Total	1,667	1,709	1,883	2,103	2,661	3,906	3,542	4,346	4,813	4,925	5,008

[5] Biomethane is presented as a distinct installation size category because biomethane installations do not have a capacity as no fuel is combusted on site but is instead injected into the gas grid.

Table A4. Number of renewable heat installations by technology, 2010 to 2020

Technology	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Air source heat pump	600	600	1,510	3,680	4,860	7,120	8,460	9,750	11,520	13,790	16,280
Biogas combustion	<10	<10	<10	<10	<10	20	90	140	160	160	160
Bioliquid combustion	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Biomass combustion	1,710	1,810	2,270	3,260	5,690	8,070	8,760	9,360	9,640	9,730	9,820
Biomethane injection to the gas grid	0	0	0	0	<10	<10	10	10	10	20	20
Ground or water source heat pump	2,250	2,260	2,510	2,720	2,880	3,100	3,270	3,490	3,670	3,870	4,390
Solar thermal	5,500	5,500	6,350	6,920	7,260	7,590	7,760	7,930	8,020	8,150	8,240
Waste combustion	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total	10,060	10,180	12,650	16,610	20,710	25,900	28,350	30,680	33,030	35,730	38,920

Table A5. Biomass heat output (GWh) by installation size category, 2010 to 2020

Biomass installation size category	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Large	1,389	1,409	1,541	1,618	1,999	2,678	1,708	1,937	2,065	1,906	1,854
Medium	14	23	30	49	78	151	296	615	847	875	907
Small	6	13	21	73	157	365	436	447	459	457	456
Micro	120	120	128	145	186	265	282	288	292	293	294
Total	1,529	1,565	1,720	1,882	2,419	3,459	2,722	3,287	3,663	3,531	3,512

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Table A6. Renewable heat capacity (GW) by technology class, 2010 to 2020

Technology Class	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biogas	0.01	0.01	0.01	0.03	0.03	0.03	0.05	0.08	0.09	0.09	0.09
Bioliquid	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Biomass	0.37	0.39	0.46	0.56	0.84	1.20	1.34	1.55	1.70	1.71	1.73
Biomethane[6]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Heat pump	0.03	0.03	0.05	0.07	0.08	0.11	0.12	0.14	0.17	0.22	0.27
Solar thermal	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Waste	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Total	0.44	0.46	0.55	0.68	0.98	1.37	1.55	1.81	1.99	2.06	2.14

[6] Biomethane installations do not have a capacity because no fuel is combusted on site and is instead injected into the gas grid.

Table A7. Renewable heat output (GWh) by technology class and installation size category, 2019 and 2020

Technology class	Size category	2019	2020
Biogas	Large	148	152
Biogas	Medium	94	102
Biogas	Small	62	68
Biogas	Micro	<1	<1
Bioliquid	Large	0	0
Bioliquid	Medium	0	0
Bioliquid	Small	<1	<1
Bioliquid	Micro	0	0
Biomass	Large	1,906	1,854
Biomass	Medium	875	907
Biomass	Small	457	456
Biomass	Micro	293	294
Biomethane	Biomethane	716	716
Heat pump	Large	11	46
Heat pump	Medium	12	19
Heat pump	Small	17	18
Heat pump	Micro	268	306
Solar thermal	Large	<1	<1
Solar thermal	Medium	<1	<1
Solar thermal	Small	<1	<1
Solar thermal	Micro	13	14
Waste	Large	52	52
Waste	Medium	0	0
Waste	Small	0	0
Waste	Micro	0	0
Total		4,925	5,008

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Table A8. Renewable heat capacity (GW) by technology class and installation size category, 2019 and 2020

Technology class	Size category	2019	2020
Biogas	Large	0.05	0.06
Biogas	Medium	0.02	0.02
Biogas	Small	0.01	0.01
Biogas	Micro	<0.01	<0.01
Bioliquid	Large	0.00	0.00
Bioliquid	Medium	0.00	0.00
Bioliquid	Small	<0.01	<0.01
Bioliquid	Micro	0.00	0.00
Biomass	Large	0.73	0.74
Biomass	Medium	0.50	0.51
Biomass	Small	0.31	0.31
Biomass	Micro	0.16	0.17
Biomethane	Biomethane	N/A	N/A
Heat pump	Large	0.03	0.04
Heat pump	Medium	0.01	0.02
Heat pump	Small	0.01	0.02
Heat pump	Micro	0.17	0.19
Solar thermal	Large	<0.01	<0.01
Solar thermal	Medium	<0.01	<0.01
Solar thermal	Small	<0.01	<0.01
Solar thermal	Micro	0.03	0.03
Waste	Large	0.01	0.01
Waste	Medium	0.00	0.00
Waste	Small	0.00	0.00
Waste	Micro	0.00	0.00
Total		2.06	2.14

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Appendix 2. Extended methodology

A2.1 Variables required

The Renewable Heat Database records installations known to be operating and those currently in various stages of development. It contains data on the capacity and yearly heat output of those installations and is updated annually.

Two main variables are required from the Renewable Heat Database to monitor progress towards the Scottish Government's target of 11% of non-electrical heat demand being met by renewable sources.

The first is an estimate of operational renewable heat capacity. Capacity refers to the maximum instantaneous power output of a renewable heating system such as a biomass boiler and is usually measured in kilowatt-thermal (kWth) or megawatt-thermal (MWth), depending upon the size of the installation. Total heat capacity is presented in this report as gigawatts (GW) rather than as GWth, to avoid confusion with the units of heat output (GWh).

The second variable required from the database is an estimate of useful renewable heat energy produced over the reported year (1 January 2020 to 31 December 2020). Useful heat is the heat delivered to the end user or process, taking into account the technology efficiency and losses. This is referred to throughout the report as renewable heat output, heat output, or useful heat output, and is recorded in megawatt hours (MWh) for each installation in the database, with the totals in the report given in gigawatt hours (GWh). In some cases, the useful heat production of an installation is not known. Where this occurs, actual heat output is used instead, which is the known or estimated total heat production of an installation of which useful heat makes up an unknown proportion.

The following terms have been used in the report when talking about heat output from heat generating installations:

- **Heat output**

Where used in this report 'heat output' refers to the heat output from a site. This may be potential, actual or useful heat output.

- **Useful heat output**

Heat delivered to an end user or process, taking into account losses.

- **Actual heat output**

The predicted amount of heat produced by a site, accounting for losses and efficiency. Actual heat output includes heat that is not delivered to an end user or process and is often estimated using assumed values for running hours and capacity.

- **Potential heat output**

The total amount of heat that could potentially be generated by the site if it operated all year round.

- **Renewable heat output**

Refers to the renewable heat output from a site. This term is used for clarity where it may not be clear if the heat output being discussed is renewable, for example with waste combustion sites where only a proportion of the total output is considered renewable.

A2.2 Available data

With some exceptions,[7] the data held within the Renewable Heat Database is collated from sources where heat output (either 'actual' or 'useful') for the site is not necessarily known and, in these situations, heat output needs to be estimated. Where possible, heat output estimates are based on the quantity, type and energy content of fuels used in the relevant year at the site along with known or assumed operating efficiencies. This information is used to estimate actual heat output during 2020 which may be greater than the useful heat output.

Where information on capacity is not available, this is estimated by dividing a known heat output by the operational running hours. Where the actual running hours of the system are not reported by the source, assumptions about typical running hours are made instead based on installation size and technology.

Where capacity and running hours are both known, but not output, annual heat output is estimated by multiplying the capacity by the running hours. Output can also be calculated by multiplying a known capacity by assumed typical running hours per year where the latter has not been provided by the source.

Further information about the assumptions used is provided in Appendix 3.

Aside from the Renewable Heat Database, other externally held, unpublished datasets[8] have also been used to produce the Renewable Heat in Scotland, 2020 report, namely:

- An extract of Scottish accreditations under the non-domestic and domestic RHI schemes provided by BEIS. The methodology used to analyse and include these datasets within our reporting is detailed in Appendix 4.
- An extract of Scottish accreditations under the MCS scheme provided by MCS. The methodology used to process this data and include it within the wider Renewable Heat in Scotland analysis is detailed in Appendix 5.

[7] For example, where we have a known contact at the site who can provide the precise information required.
[8] An extract of Scottish accreditations under the CHPQA scheme from BEIS was not available at the of publication of this report.

Taken together, the capacity and ‘heat paid for’ data from the non-domestic RHI scheme, the heat demand and capacity figures from the domestic RHI scheme, the installation data from MCS and those calculated from the Energy Saving Trust dataset, provide the most accurate measure of renewable heat capacity and useful heat output in Scotland available to date.

In all cases, only the renewable portion of the heat output has been included in the figures reported.

A2.3 Renewable heat technologies included

The following technologies are considered to produce heat from renewable sources, and are included in the database:

- **Biogas combustion**
    - **Biogas produced by anaerobic digestion (AD)**

      Organic matter is broken down in the absence of oxygen to produce a mixture of combustible gases. The biogas is then burnt to produce heat or burnt in a combined heat and power unit to generate both heat and electricity. In some applications, the heat produced is used solely to maintain the anaerobic digestion process which requires some heat input. The feedstock is typically some form of waste such as food and garden waste or agricultural waste.

      Biogas that is produced by AD and then processed into biomethane for injection into the gas grid is not included under biogas combustion as no fuel is consumed on site. Any renewable heat output produced in this way is found under the biomethane technology class.

    - **Biogas produced by landfill**

      Landfill gas (methane from rotting organic matter in landfill) is captured and burnt to produce heat or used in a combined heat and power unit.

    - **Biogas produced by pyrolysis or other advanced conversion methods**

      Treatment of waste at high temperatures either in the complete absence of oxygen (pyrolysis) or a limited amount of oxygen (gasification) to produce gases which can be burnt to generate heat or heat and electricity.

- **Biomass combustion**
    - **Biomass heat only**

      Solid biomass is burnt to directly produce heat for space or water heating, or to provide heat for an industrial process. Woodfuel is the most common type of solid biomass used to produce heat in Scotland, usually in the form of woodchip, pellets, or logs. Large biomass boilers installed for generating heat in the wood processing industries will normally be fuelled with as much on-site produced co-products as possible such as bark, offcuts and saw dust, supplemented by virgin fibre or woodfuel when required. A small proportion of biomass installations may be using other solid biomass fuels instead of or in addition to woodfuel, such as straw or energy crops.

- **Biomass combined heat and power (CHP)**

Solid biomass is burnt to generate electricity. Heat is produced as a co-product, which can then be used for process heat, supplying space or water heating or exported to another user. Biomass CHP installations tend to be very large in capacity and will predominantly use a variety of woodfuel types including any wood co-products produced on site, recycled wood and virgin fibre.

- **Biomethane**

Biomethane follows the same process as anaerobic digestion up to the point of having a biogas product produced on site, however, this is 'upgraded' to allow it to be injected into the gas grid by ensuring it has similar properties to fossil natural gas. As no biomethane is used on site, the renewable heat output for this technology class is the calorific value of the biomethane injected into the gas grid.

- **Solar thermal panels**

Panels which produce hot water using the sun's heat. The systems can be designed so that the hot water produced also contributes to space heating demand ('solar space heating') but it is more commonly used to provide hot water only.

- **Heat pumps**

Technologies to extract low-grade heat from the external environment through a compression system. Typically used to produce heat for space heating, water heating or both and are therefore most common in domestic properties although specific heat pump set ups may also be capable of meeting industrial process heat demands. Although heat pumps rely on electricity to operate, their high co-efficient of performance (COP) means they extract more heat energy from the environment than they use in electricity.

Heat pumps can be used with air or water distribution systems but only heat pumps using a wet distribution system are eligible for RHI payments. For this reason the vast majority of heat pumps installed use wet distribution systems.

'Exhaust air heat pumps' (which, in addition to extracting heat from the external air, also draw warmth from warm stale air leaving a building) have been included under the air source heat pump technology. Units which are purely exhaust air heat recovery, without also extracting heat from the air outside, have not been included as these do not include any element of renewable heating. Cooling provided by heat pumps has also not been recorded in the database.

- **Air source heat pump (ASHP)**

Heat from outside air is absorbed at low temperature into a fluid. This fluid passes through a compressor, increasing the temperature, and transfers that higher temperature heat to the heating circuits.

- **Ground source heat pump (GSHP)**

Ground source heat pumps circulate a mixture of water and antifreeze through pipework buried in the ground. Heat from the ground is absorbed into the fluid, the fluid is compressed, and then the heat passes through a heat exchanger into the heat pump. The pipework can be buried horizontally, referred to as a ground loop, or vertically in a borehole. The length of buried pipework is dependent on the amount of heat required.

- **Water source heat pump (WSHP)**

Water source heat pumps function the same as ground source heat pumps except the pipework is submerged in a body of water such as a river or lake, or a water filled borehole rather than the ground. Due to needing a substantial body of water available, the number of installed water source heat pumps is considerably lower than the number of installed air or ground source heat pumps.

- **Waste combustion**

Heat energy produced from burning waste not considered as solid biomass or bioliquids, such as municipal solid waste. For installations burning municipal solid waste, a proportion of the heat capacity and output is estimated to be renewable based on the biodegradable proportion of the waste burnt.[9]

Had operational examples been found, fuel cell biomass and deep geothermal could also have been included:

- **Deep geothermal**

Heat from deep underground is extracted by pumping water into a deep well, allowing it to heat up using the heat of the rocks, then abstracting the water via another well.

[9] The percentage of municipal waste assumed to be renewable is 50% in line with the latest BEIS RESTATS methodology. https://www.gov.uk/government/collections/renewables-statistics

- **Fuel cell biomass**

Fuel cells running on biomass could be used to produce useful heat.

A2.3 Heat technologies not included

Technologies which are not included in the database, as they do not produce renewable heat, are:

- **Non-biomass combined heat and power (CHP)**

Combined heat and power units running on gas (or other fossil fuels) to produce electricity and heat. Because the heat from such units comes from fossil fuel sources, it has not been counted towards ‘renewable heat’ targets in this report.

- **Exhaust air heat recovery (EAHR)**

Systems for recovering the heat from warm stale air leaving a building, which is used to warm incoming air. This can help to reduce space heating requirements. However, because the heat being recovered for the building will normally have come from fossil fuels in the first instance, rather than being drawn from a renewable source, these systems have not been included as providing renewable heat unless they are associated with a known renewable heat installation.

- **Waste combustion installations where the only fuel is hospital waste**

The Digest of UK Energy Statistics (DUKES)[10] considers hospital waste as non-biodegradable, therefore, installations burning only hospital waste are not counted as producing renewable heat. However, installations which burn other wastes that are considered biodegradable such as municipal waste, in addition to hospital waste, have been included in the database but only the heat output proportioned to the percentage of waste consumed that is biodegradable has been counted.

The following renewable heat technologies are not included in the Renewable Heat Database:

- **Passive renewable heating**

This is where building design is used to ensure buildings benefit from features such as solar gain through large areas of south-facing glazing. Such design features can help a building meet its heat demand; however, they have not been included in this report or database, as the heat resource provided is very hard to assess.

[10] Renewable Energy Statistics: Data Sources and Methodologies, Department for Business, Energy and Industrial Strategy: https://www.gov.uk/government/collections/renewables-statistics

- **Wind or hydro to heat (electricity)**

Wind to heat installations (where wind turbines produce electricity which is used to directly charge electric storage heaters for space heating) can be an important source of low-carbon heating in remote rural locations in Scotland. However, the electricity produced by these systems is already counted towards renewable electricity targets for Scotland. Estimates of heat from these systems have therefore not been included in the renewable heat figures reported here to avoid double counting.

A2.4 Data collection for district and communal heating schemes

For district or 'communal' heating schemes, the number of non-domestic buildings or domestic dwellings connected to each scheme is recorded where known. Information on any known extensions which are planned are also included in the database. Information on whether or not an installation is providing district heating was not available from all sources used to update the database. The Renewable Heat Database heat network information is supplemented by extracts of Scottish Heat Network data provided by the Scottish Government. The collated information is not yet regarded as complete enough to use the dataset to estimate the extent of district heating in Scotland fuelled by renewable sources.

A2.5 Local authority identifiers

The majority of Renewable Heat Database records have a local authority identifier affixed but for a small proportion this is not currently possible. Some of oldest records held in the database are aggregated and anonymised installation counts for schemes which ran across Scotland and where the breakdown of installations by local authority is unknown.

All of the external datasets used to produce the Renewable Heat Report analysis (non-domestic RHI, domestic RHI and MCS) include address level information which allows the identification of local authority.

97% of renewable heat output and 96% of renewable heat capacity has now been identified to local authority level.

A2.6 Potential useful heat output that is not currently utilised

In previous reports the potential for unused heat from industrial sites currently using less heat than they produce has not been quantified. It is still beyond the current scope of this report to cover this subject as the detailed data required and the agreed methodology are not yet available. Data required would include: energy consumed on site; detailed heat and electrical output; unused 'useful heat' including the form of heat available, for example warm or hot water, steam, hot air. There is also a methodology required for quantifying the size and value of nearby potential heat loads in relation to the type and scale of heat available.

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Appendix 3. Renewable heat database assumptions

A3.1 Combined heat and power (CHP)

Calculating useful heat output for CHP is difficult without detailed metered data for each specific site. Even with data on fuel input, energy content of the fuel, system efficiency and running hours, the realised useful heat output might vary considerably. One factor for this is that CHP produces both electricity and heat and estimating the output for each energy type depends on how the CHP is operated by the end user. This then poses a problem for sites where the main purpose is generating electricity as it is unknown how much of the heat generated goes unused.

Where known, useful heat output has been recorded for CHP sites based on information from the sites themselves provided via woodfuel surveys or other direct contact.

Where the output of a CHP plant was unknown, the assumptions detailed in following chapters were used to estimate the plant's efficiency, capacity, running hours and woodfuel calorific values, where applicable, in line with the CHP statistics found in chapter 7 of the DUKES 2019 publication.[11]

A3.2 Converting biomass woodfuel use to heat output

For the majority of large installations burning wood biomass for heat or CHP, the main woodfuel usage estimates available were from the Scottish Forestry's annual woodfuel survey. Where metered data was not available, woodfuel usage figures were converted into estimates of heat output based on assumptions about combustion efficiency. Table A9 lists the gross efficiencies used for calculating heat output of biomass boilers from known amounts of woodfuel combusted.

The biomass CHP efficiency reflects the efficiency of converting the wood fuel into usable energy and not the efficiency by which the CHP system generates electricity which will be considerably lower. Heat is often a waste by-product of CHP electricity production, so to account for this a heat wastage factor has been applied to estimate the proportion of heat which is released by the CHP system when there is no demand for it. This heat wastage factor is based on analysis of the ratio of heat to electricity output of CHP sites in the UK relative to their stated capacities as found in the CHP chapter of the DUKES publication.[12]

[11] DUKES 2020 has since been published but was not available at the time of the Renewable Heat in Scotland, 2020 analysis

[12] https://www.gov.uk/government/statistics/combined-heat-and-power-chapter-7-digest-of-united-kingdom-energy-statistics-dukes

Table A9. Boiler efficiencies assumed for converting oven-dried tonnes (ODT) of wood burnt to heat output

Biomass technology	Assumed gross system efficiency	Woodfuel gross calorific value MWh per ODT burnt	MWh heat output per ODT burnt	MWh useful heat output per ODT burnt
Biomass heat-only	70.0%	5.64	3.95	3.95
Biomass CHP	70.4%	5.64	3.97	1.79

A3.2 Running hour assumptions

Assumed annual running hours are used to estimate capacity from a known output, or an output from a known capacity, where those values are unknown. We have used the non-domestic RHI analysis to provide average running hours for the biogas, biomass, heat pump and solar thermal technology classes to be used for systems where the running hours are unknown in the Renewable Heat Database. The average running hours were calculated for each calendar year and have been applied throughout the historical time series. The assumed running hours used for 2010 to 2020 are given in Table A10.

Table A10. The assumed running hours for each technology for 2010 to 2020 derived from non-domestic RHI analysis

Technology	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Air source heat pump	1,336	1,336	1,336	1,336	1,336	1,336	1,357	1,533	1,722	1,429	1,540
Biogas	3,993	3,993	3,993	3,993	1,046	6,140	3,367	3,757	4,366	4,507	4,771
Biomethane	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Biomass (large)	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,238	2,200
Biomass (medium)	1,419	1,419	1,419	1,023	1,002	1,405	1,460	1,579	1,592	1,628	1,664
Biomass (small)	791	791	791	1,106	665	1,368	1,424	1,435	1,423	1,419	1,407
Biomass (micro)	1,149	1,149	1,149	1,061	7,06	1,254	1,264	1,216	1,262	1,239	1,190
Biomass CHP	2,757	2,757	2,757	2,757	2,757	2,757	2,757	1,352	2,881	3,385	3,409
Ground source heat pump	2,314	2,314	2,314	2,176	1,873	2,155	1,981	1,984	2,098	2,092	1,816
Solar thermal	270	270	270	279	202	300	294	274	265	266	282
Water source heat pump	2,256	2,256	2,256	1,342	3,228	2,854	2,430	2,519	1,897	2,102	1,676

A3.3 Capacity assumptions

For installations where values for neither capacity nor output were provided, an estimate was made for likely installed capacity based on technology, ownership category and building type (where appropriate). This was derived from similar installations where capacity was known in the Renewable Heat Database.

Table A11 below shows the assumed capacities that are used in the Renewable Heat Database where information on capacity was not available. Only 10% of the reported total renewable heat capacity is estimated either using the capacity assumptions below or the running hours assumptions discussed in section A3.2.

For solar thermal panels, information was sometimes only provided in m^2 of panel area. This is converted to a capacity value with an assumed capacity per m^2 of 0.7 kW, taken from the Solar Trade Association.

Table A11. Assumptions used for capacity where not known, 2020

Technology	Ownership category	Build type	Assumed capacity (kW)	Derived from
ASHP	Community	All non-domestic	16	Average of known community ASHP capacities held in the database
ASHP	Local authority	Schools	62	Average of known school ASHP capacities held in the database
ASHP	Local authority	All other non-domestic	10	Average of known local authority non-domestic ASHP capacities held in the database
ASHP	Local business	All non-domestic	19	Average of known local business capacities held in the database
Biomass	Community	All non-domestic	60	Average of known community biomass capacities held in the database
Biomass	Community	District heating	175	Average of known community biomass heat network capacities held in the database

Biomass	Farm and estate	All non-domestic	233	Average of known farm and estate biomass capacities held in the database
Biomass	Local authority	Schools	239	Average of known local authority school biomass capacities held in the database
Biomass	Local authority	All other non-domestic	168	Average of known local authority non-domestic biomass capacities held in the database
Biomass	Local business	All non-domestic	190	Average of known local business biomass capacities held in the database
Biomass	Public sector and other charities	Large hospitals	1,400	Average of known large hospital biomass capacities held in the database
Biomass	Public sector and other charities	Small hospitals and medical centres	200	Average of known small hospital and medical centre biomass capacities held in the database
Biomass	Public sector and other charities	All other non-domestic	140	Average of known public sector and charity biomass capacities held in the database
GSHP	Local business	All non-domestic	30	Average of known local business GSHP capacities held in the database
GSHP	Various	Public buildings	30	Average of known public building GSHP capacities held in the database
Solar thermal	Community	All non-domestic	6	Average of known community solar thermal capacities held in the database
Solar thermal	Local authority	Schools	7	Average of known school solar thermal capacities held in the database

Waste combustion installations

Only a proportion of heat output and capacity from installations combusting municipal solid waste is considered to be renewable. Since 2015, the assumed renewable heat component is 50% and before 2015 it was assumed to be 63.5%. The values used in this reporting series are in line with the assumptions of BEIS's RESTATS methodology.[13] The percentages represent the proportion of municipal solid waste considered to be biodegradable with the fall from 63.5% to 50% in 2015 accounted for by increased recycling rates leading to less biodegradable material in general or landfill waste.

[13] Renewable Energy Statistics: Data Sources and Methodologies, BEIS: https://www.gov.uk/government/collections/renewables-statistics

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Appendix 4. Analysing the RHI dataset

A4.1 Background to the RHI schemes

The non-domestic Renewable Heat Incentive (RHI) is a scheme that opened to applicants in November 2011 (with scope for legacy applicants to apply for accreditation). The non-domestic scheme is designed to incentivise uptake of renewable heat technologies in mainly non-domestic applications but does include district heating for residential schemes.[14]

The domestic RHI scheme was launched in April 2014 (also with scope for legacy applications to apply for accreditation). The domestic scheme incentivised the uptake of renewable heating systems to provide space heating and/or hot water in domestic properties, particularly properties in off-gas grid areas. Both schemes are administered by Ofgem on behalf of BEIS.

A4.2 Analysis of the non-domestic RHI dataset

Since 2018, BEIS have provided an address level extract of all installations accredited under the non-domestic RHI scheme in Scotland. This includes information on the accredited renewable heat capacity and the amount of heat paid for under the scheme for each year that the installation was accredited. BEIS does not collect data on useful heat output directly in the non-domestic RHI dataset; rather, they collect data on the 'heat paid for' per site under the scheme. We used this 'heat paid for' figure as an estimate for useful heat output, as the RHI can only support heat that is used for an 'eligible purpose'.

It is a requirement under the scheme that installations be metered but due to a lag in collecting the data, the amount of heat paid for is not always available for every installation within the RHI dataset for the most recent reporting year. In these cases, the 'imputed heat' values were used instead, which is an estimate of the heat likely to be generated based on details of the site and the amount of heat generated in preceding periods. Only the metered non-domestic RHI values were treated as known and the 'imputed' heat values have been counted as estimates.

To avoid double counting between the non-domestic RHI dataset and the Renewable Heat Database, a cross-checking exercise was carried out to identify the overlap between the two, and the methodology used is as follows:

All RHI accreditations with a capacity of 1MW or greater were manually cross checked against with the Renewable Heat Database to ensure the most accurate matching of the installations with the greatest output and therefore greatest potential impact on the Renewable Heat in Scotland results.

All non-domestic RHI accreditations with a capacity of less than 1MW were then cross referenced with the Renewable Heat Database using a combination of excel formulae and

[14] Communal and district heating include systems that link more than one property to the heat network. These may still be domestic applications, but they are not eligible for support under the Domestic RHI scheme.

VBA code to compare key pieces of information shared between the two datasets. This was supported by manual checks of individual installations where required.

The key variables used to identify matches between the datasets were:

- Project/installation name
- Owner name
- Full address
- Postcode
- Technology
- Capacity
- Commissioning date

A scoring hierarchy was established to easily reference the variables used to match records between the two sets. Records with very weak matches (partial matches on owner name and postcode district for example) were manually checked to verify whether individual records should be removed from the analysis. Any records which matched on a combination of technology, postcode district and any of the following: capacity, commissioning date or owner name were assumed to be good matches and not requiring any further manual checks to confirm their validity. For this reason, the matching between the two datasets is conservative i.e. we have assumed matches to be correct, to reduce the risk of double counting renewable heat.

For any records that were found to be a match, the Renewable Heat Database values were removed from our analysis because the metered (or imputed) heat values of the non-domestic RHI dataset will be more precise than our own estimates which often rely on assumptions. The only exception to this were any installations known to us to be partially RHI accredited in which case we retained the Renewable Heat Database values in place of those of the non-domestic RHI dataset.

A4.2 Analysis of the domestic RHI dataset

The majority of installations accredited under the domestic RHI are not metered and instead receive deemed payments which are based on the heat demand of the property from the property’s Energy Performance Certificate (EPC); or the generation of the system taken from the installation’s MCS certificate. The domestic RHI accreditations which were flagged as being metered were counted as known values and all other installations were treated as estimates.

There was a risk of double counting between the domestic RHI dataset and the Renewable Heat Database. To avoid this, any micro-sized installations held within the Renewable Heat Database were removed from our analysis excepting those which pre-dated the end of the 2011 calendar year. This distinction was made because the very earliest records held within the Renewable Heat Database, which cover renewable heat systems installed between 2008 and 2011, contain aggregated and anonymised data from:

- A number of Scottish Government programmes delivered by Energy Saving Trust to fund renewable measures, such as the Scottish Community and Householder Renewables Initiative (SCHRI).
- The number of renewable heat technologies listed on EPCs for properties in those years, taken from an extract of the Scottish domestic EPC register.
- Estimates of the number of renewable heating systems installed in Scotland from various industry sources.

The Renewable Heat Database records for these years are therefore considered more representative of renewable heat developments because the number of systems accredited as legacy installations under the domestic RHI are far fewer than the total number of renewable heat installations suggested by the Renewable Heat Database records.

Appendix 5. Analysing the MCS dataset

The MCS dataset is an extract of renewable heat installations accredited under the Microgeneration Certification Scheme taken from the MCS Installation Database (MID). The database is installer facing where accreditations are lodged by installers through an online portal. The extract includes address level information as well as renewable heat capacity, generation (renewable heat output), commissioning date and MCS certificate number. The extract covers all installations accredited under MCS in Scotland going back until 2008 when the MCS standards began. The dataset is therefore the best source of information on micro-sized installations in Scotland available.

The MCS dataset needed to be handled in various ways in order to accommodate its inclusion within the wider Renewable Heat in Scotland analysis as outlined below.

Firstly, there were a number of MCS records which had incomplete data or atypical data assumed to be unsuitable for our analysis due to the potential inclusion of errors. For the latter, any record with a capacity of 0kW or greater than 100kW, or a load factor[15] of 0% or greater than or equal to 100%, were deemed unsuitable. These records were altered to become more representative of the overall dataset. Capacity values were adjusted by replacing them with the average capacity for that particular technology. Load factors were corrected by replacing the original output with a new estimation of output calculated by multiplying the capacity (either the original or the altered capacity if an adjustment was required) by the average running hours for that particular technology as derived from the MCS dataset.

Although the MCS values are modelled at or before the time of installation, for the purposes of our analysis they have been treated as known values because they are derived from on-site measurements of the property using accredited MCS methodologies and are therefore both robust and tailored to the specific installation. MCS values were treated as estimates only where Energy Saving Trust had altered the values we deemed unsuitable for the analysis.

Secondly, there was known to be a considerable overlap between the MCS dataset and the other datasets included within the Renewable Heat in Scotland analysis.

An MCS certificate was an eligibility requirement of the domestic RHI and both the domestic RHI and MCS datasets included the MCS certificate numbers for their respective accreditations. The MCS certificate numbers were used to identify duplicate entries and any identified were removed from the MCS dataset and preserved in the domestic RHI dataset. Approximately 55% of MCS accreditations by number and 65% of MCS accredited renewable heat output can be found under the domestic RHI scheme.

The non-domestic RHI data also included an MCS certificate where an installation was known to have one which allowed easy cross-checking against the MCS dataset. As an MCS certificate was not an eligibility requirement of the non-domestic RHI scheme, and a

[15] Load factor is an estimation of the amount of time an installation is in operation each year. It is calculated by dividing the total output by the total capacity by the number of hours within a year.

significant number of non-domestic RHI accredited installations have capacities greater than those typically accredited under the MCS scheme, there were very few confirmed matches between the MCS and non-domestic RHI datasets. Approximately 2% of MCS accreditations by number and 4% of MCS accredited renewable heat output were found under the non-domestic RHI scheme.

There was also a risk of double counting between the MCS dataset and the Renewable Heat Database. To avoid this, and as per the approach taken for the domestic RHI dataset, any micro-sized installations held within the Renewable Heat Database were removed from our analysis excepting those which pre-dated the end of the 2011 calendar year.

The Renewable Heat Database records for these years were kept because the number of renewable heat installations accredited under MCS between 2008 and 2011 is less than the number of installations suggested by the Renewable Heat Database entries for these years. This may be due to the MCS standards being relatively new during this period and that there were few programmes requiring MCS accreditation as an eligibility requirement to promote use of the MCS scheme. On the other hand, we cannot use both sources because a degree of overlap is known to be happening because one such scheme to require MCS accreditation during that time frame was the Scottish Government’s SCHRI scheme, the installations from which are included in the Renewable Heat Database 2008-11 records.

Appendix 6. Measurement of heat demand in Scotland

This Appendix sets out:

- How the Scottish Government derived the original 11% renewable heat target.
- An explanation of how improved data and an updated methodology is being used to monitor renewable heat as a percentage of annual non-electrical heat demand in Scotland.

A6.1 Background

Heat has been estimated to account for more than half of Scotland's total energy use.[16] Switching from fossil fuel to renewable heat sources has the potential to reduce greenhouse gas emissions and make a significant contribution to Scotland's overall renewable energy target. The 2009 Renewable Heat Action Plan[17] sets a target of delivering 11% of Scotland's projected 2020 (non-electrical)[18] heat demand from renewable sources.

In 2006, the Scottish Energy Study described Scotland's current energy supply,[19] energy consumption and energy-related CO_2 emissions during 2002. This was the first major study of energy supply and demand to be conducted in Scotland for more than a decade. At that time, the discrete study provided the most robust data source available for estimates of energy consumption in Scotland. This study produced estimates for 2002 and subsequently a figure for 2020 heat demand was derived from these estimates. This heat demand figure was subsequently used to derive the 11% heat target (detailed in section 6.2). Due to improved availability of heat demand data for Scotland, the heat demand figure derived in 2006 is no longer used to monitor progress towards the 2020 target.

A6.2 Derivation of the 11% heat target

The target figure of 11% for renewable heat by 2020 was derived using the estimated contributions that renewable electricity and renewable transport would make to the overall 2020 renewable energy target. Based on the requirements of total non-electrical heat demand in Scotland at the time, it was estimated that renewable heat must contribute

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16 Energy Statistics Database, September 2019, Scottish Government, https://www.webarchive.org.uk/wayback/archive/20150218203820/http://www.gov.scot/Topics/Statistics/Browse/Business/Energy/Database

17 Renewable Heat Action Plan (2009). https://www.webarchive.org.uk/wayback/archive/20150218203601/http://www.gov.scot/Publications/2009/11/04154534/0

18 To avoid double counting the non-electrical heat component is measured against the heat target, acknowledging that the demand for heating delivered by electricity will be included as part of the renewable electricity target. The Scottish House Condition Survey (2019) estimates that around 11% of households in Scotland use electricity as their primary heating fuel.

19 Scottish Energy Study, Vol 1 (2006). https://www.webarchive.org.uk/wayback/archive/3000/https://www.gov.scot/Publications/2006/01/19092748/0

6,420GWh of output in order for Scotland to meet its 2020 Renewable Energy Target. Total heat energy demand in Scotland in 2020 was estimated to be 60,089GWh using data from the 2006 Scottish Energy Study. Therefore, the target was set at 11% (See Table A12).

Table A12. Description of the derivation of the renewable heat target (estimated 2020 figures)

Step	Step description	Output (GWh)
1	Total energy demand	160,307
2	Renewable energy target (20%)	32,061
3	Estimated renewable electricity contribution (50% target)	22,244
4	Estimated renewable transport contribution (10% target)	3,397
5	**Renewable heat output required (remainder)**	**6,420**
6	Total energy consumed within domestic, industrial and service sectors	95,276
7	Less: electricity consumption in these sectors	35,187
8	**Derived heat energy demand**	**60,089**
9	**Therefore, renewable heat required**	**c. 11%**

A6.3 Improving data on heat demand in Scotland

In the years following the publication of the Scottish Energy Study, BEIS began publishing more detailed sub-UK estimates of energy consumption which has enabled the development of a systematic and robust method of monitoring (non-electrical) heat demand in Scotland on an annual basis.[20] The Scottish Government has worked with colleagues in BEIS to derive a heat demand methodology for Scotland which will allow more accurate annual measurement of progress towards the renewable heat target.

BEIS data shows a breakdown of final energy consumption by end use for Scotland down to local authority level. By subtracting electricity and transport consumption from the final energy consumption figure, this results in an estimate for non-electrical heat demand in Scotland (see the flow chart in Figure A1 below for more detail).

[20] Total final energy consumption at sub-national level, BEIS. https://www.gov.uk/government/collections/total-final-energy-consumption-at-sub-national-level

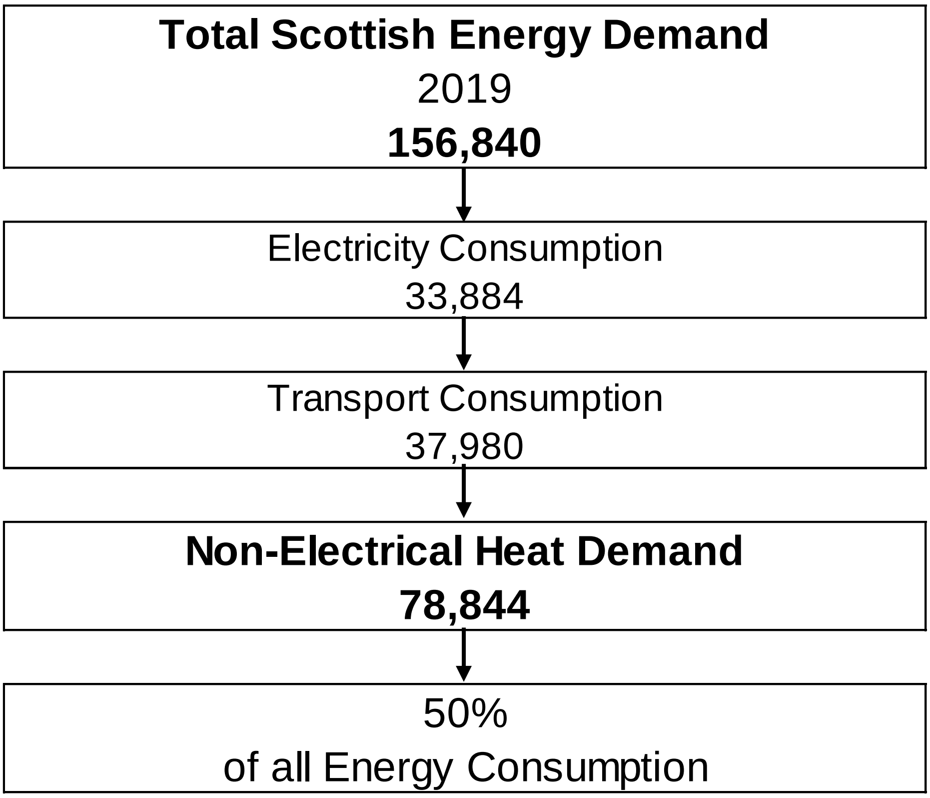

Figure A1. Heat demand methodology

It is important to note that BEIS's estimates of final energy consumption (from 2005 onwards) are subject to annual revision. This can impact on the Scottish Government's time series of non-electrical heat demand, and hence the renewable heat target progress figures.

In 2019 BEIS adjusted their methodology to calculate sub-national energy consumption; now including petroleum use in the public sector and agriculture. In September 2019, BEIS published a revised time series back to 2005. Previously, heat demand was assumed to be all gas and residual fuels not used for transport, but end use of these are not definitively known from the sub-national statistics. BEIS's Energy Consumption in the UK (ECUK) publication breaks down end use for heat by sector and fuel, but this data applies to Great Britain as a whole. To estimate use for heat in Scotland, the proportion used for heat for each fuel and sector was applied to the Scottish consumption figures to calculate a more realistic representation of Scottish heat demand. The ECUK data shows that approximately 96% of non-transport consumption from coal, petroleum, manufactured fuels and bioenergy and wastes is used for heat.

It should also be noted that this methodology is not directly estimating non-electrical heat demand in Scotland, but the energy content of the fuels consumed to meet the estimated non-electrical heat demand. This distinction is important because we are comparing this value, which does not take into account the efficiencies or losses of the heating systems involved, against our estimates of renewable heat output which do take into account system efficiencies, losses and the amount of heat used rather than what is generated.

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The impact of this is that we are knowingly underestimating the percentage of non-electrical heat demand being met by renewables, however, we consider this the best possible estimate of progress towards the 2020 target with the information currently available. The terminology used to describe non-electrical heat demand was changed in the Renewable Heat in Scotland, 2019 report to better clarify this issue.

A6.4 Summary of the changes as a result of the new methodology

Advantages

- The target can now be measured annually against the heat demand in a particular year, allowing more accurate monitoring of target progress.
- Improves the comparability and consistency with other energy target measures.

Issues

- There is a lag in the availability of BEIS sub-UK consumption data – 2019 data will not be available until September 2021.
- An adjustment is made to the electricity consumption data to account for discrepancies within BEIS datasets.
- The adjustment of figures for heat end use is based on the proportion used for heat in GB as a whole. There may be reasons to believe that Scotland's proportion used for heat may be different. A greater proportion of buildings being off the gas grid and higher heating demand may be reasons why Scotland may differ to the rest of GB.

For any queries or feedback on the new measure, or on the measurement of heat demand in Scotland in general, please contact energystatistics@scotland.gsi.gov.uk.