Renewable Heat in Scotland, 2011

A report by the Energy Saving Trust for the Scottish Government

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About the Energy Saving Trust

The Energy Saving Trust is Scotland and the UK's leading impartial organisation helping people save energy and reduce carbon emissions. We do this by directly supporting consumers to take action, helping local authorities and communities to save energy, using our expert insight and knowledge and providing quality assurance for goods and services.

This work was carried out by the Energy Saving Trust on behalf of the Scottish Government. The report draws on various sources of data from the Energy Saving Trust and other organisations working in Scotland, and was written by Cate Lyon with input from Elaine Waterson.

With thanks to all individuals and organisations who provided data, and with particular thanks to the Forestry Commission Scotland and Hudson Consulting.

Please note that the methodology used in this report to calculate renewable heat capacity and output for Scotland may not necessarily be in line with that required by the EU Renewable Energy Directive and as such the figures should not be used for any reporting purposes associated with this Directive.

Contents

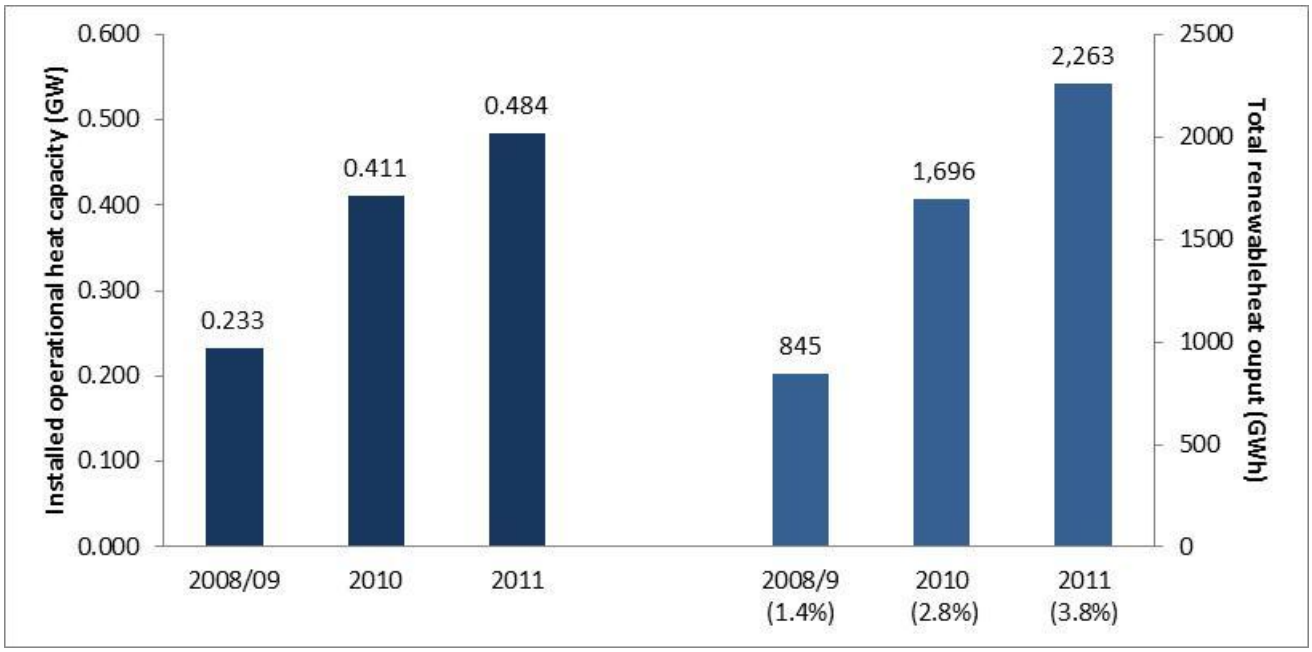
1. Summary of key findings

The Scottish Government has set a target for 11% of non-electrical heat demand in Scotland to come from renewable sources by 2020[1].

In order to help measure progress towards this target, the Energy Saving Trust maintains a database of renewable heat installations on behalf of the Scottish Government. The database records installations known to be operating and those currently in various stages of development, and contains data on the capacity and yearly heat output of those installations. In March 2011, we estimated that during calendar year 2010 Scotland had 0.411GW of renewable heat capacity in operation, producing an estimated 1,696GWh of useful renewable heat energy, equating to 2.8% of Scotland's forecast non-electrical heat demand in 2020[2].

The database has now been updated with new information on heat generated from renewable sources during 2011, and new installations which are in development. As a result, we estimate that in calendar year 2011, around **0.484GW** of renewable heat capacity was operational in Scotland, producing an estimated **2,263GWh** of useful renewable heat. This equates to **3.8% of Scotland's total forecast non-electrical heat demand in 2020**.This represents an increase of 0.07GW of capacity from 2010, and an increase of 567GWh of heat generated from renewable sources compared to that in 2010.

Figure 1. Estimated renewable heat capacity and output, in 2008/09, 2010 and 2011 *(note: data were not gathered for calendar year 2009).*



[1] Renewable Heat Action Plan for Scotland, Scottish Government, November 2009. http://www.scotland.gov.uk/Publications/2009/11/04154534/0

[2] Renewable Heat in Scotland, 2010. A report by the Energy Saving Trust for the Scottish Government, March 2011. http://www.scotland.gov.uk/Resource/Doc/917/0115248.pdf

2. Methodology

2.1 Approach taken

Two main outputs are required from the renewable heat database which the Energy Saving Trust maintains on behalf of the Scottish Government. 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 therms (kWth) or megawatt therms (MWth), depending on the size of the installation. Total heat capacity is presented in this report as gigawatts (GW)[3] or megawatts (MW), rather than as GWth or MWth, to avoid confusion with the units of heat output (GWh). Installations are classified by their capacity, into large (1MW and above), medium (between 1MW and 45kW) and micro (less than or equal to 45kW).

The second main output required from the database is an estimate of useful[4] renewable heat energy produced over a year. This is referred to throughout the report as useful heat output and is recorded in megawatt hours (MWh) for each installation in the database, with the totals in this report given in gigawatt hours (GWh)[5].

Useful heat output is hard to measure, and few renewable heat installations monitor the heat generated from their systems[6]. Therefore the results presented in this report are mainly estimates of heat output, based on what data are available for each installation. Where possible, results are based on data received about fuel inputs to particular installations and assumptions about their efficiency, which are used to estimate *actual* heat output during 2011. This figure may be different to estimates of *potential* output, which are usually based on the heat capacity of an installation and an assumed number of operating hours, and which might therefore be higher. However where data on fuel inputs were not available, the figure for potential output has been used.

The information available about each installation varies, depending on the data sources used. Where it is supplied, estimates of fuel input are used as the preferred basis for estimating annual heat output. Where information on capacity is not available, this is estimated based on information about heat output and assumptions about typical running hours, based on installation size and the heat use (space heating or process heat). Where capacity is known, but not output, annual heat output is estimated based on assumptions about typical running hours per year. Further information about the assumptions used is provided in section 2.4, *Assumptions used*.

Where possible, data have been checked against estimates provided by industry figures and/or trade bodies for the different sectors and technologies.

Results are reported here for calendar year 2011, rather than financial year 2011/12. This is because the Forestry Commission Scotland data set on wood fuel use, which provides a large portion of the data on which total output has been estimated, is currently updated on a calendar year basis.

[3] 1GW = 1,000MW = 1,000,000kW
[4] Useful heat is the heat delivered to the end user or process, taking into account the technology efficiency.
[5] 1GWh = 1,000MWh = 1,000,000kWh
[6] Although non-domestic installations claiming the renewable heat incentive (RHI) are required to submit regular heat meter readings to Ofgem, data from individual Scottish installations registered for the RHI were not available from Ofgem for this update of the renewable heat database.

2.2 Technologies included

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

- **Biomass (wood) primary combustion**
- **Biomass (wood) combined heat and power (CHP)**
- **Solar thermal panels**
- **Heat pumps: water source, air source and ground source**
- **Energy from waste (EfW), including:**
    - Anaerobic digestion (AD)[7]
    - Landfill gas capture
    - Biomass primary combustion of biodegradable material (other than wood)
    - Advanced thermal treatment (ATT), using pyrolysis and/or gasification

Had an example been found, the following technology could also have been included:

- Fuel cell biomass

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

- Non-biomass combined heat and power (CHP) running on mains gas or other fossil fuel
- Exhaust air heat recovery (EAHR) where the initial heat is not provided from a renewable source
- Energy from waste: installations where the only fuel is clinical (hospital) waste[8]

The following technologies can be considered sources of renewable heat, but are not currently captured in the renewable heat database:

- Passive renewable heating, for example solar gain. This is excluded due to the difficulty of assessing its contribution to heating demand.
- Wind- or hydro-produced electricity which is used to provide heat. These technologies are excluded to avoid double counting of progress towards renewables targets, as the energy produced counts towards the Scottish Government's target for renewable electricity generation.

Descriptions of all these technologies are provided in Appendix 1.

2.3 Data sources used

The Energy Saving Trust updated the renewable heat database for the Scottish Government in March 2011 to give an estimate of renewable heat capacity and output in 2010. The new estimate for renewable heat output in 2011 has been generated by updating the information held in the database. Effort has focussed on updating information from the installations with the largest capacities, which also produce the largest amounts of heat.

Multiple sources of data were used to update the renewable heat database. The main sources used, and the organisations which supplied them, are listed in table 1. In addition, other organisations such as the

[7] Excluding the parasitic heat used to maintain the anaerobic digestion process.

[8] In line with assumptions used in the Department of Energy and Climate Change (DECC) RESTATS methodology, clinical waste is considered non-biodegradable and therefore non-renewable. Renewable Energy Statistics: Data Sources and Methodologies, Department of Energy and Climate Change.
http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/renewables/renewables.aspx

Carbon Trust, and individuals connected with specific installations, were also contacted and provided useful information.
The data sets from the Forestry Commission Scotland and Hudson Consulting contain estimates of wood fuel usage for the year 2011. The full Forestry Commission Scotland report 'Annual woodfuel demand and usage in Scotland 2012' (covering wood fuel used in 2011) is expected to be published in autumn 2012.

Table 1. Main datasets used

Organisation	**Dataset**
Forestry Commission Scotland / Hudson Consulting	Annual woodfuel demand and usage in Scotland (*estimate for 2011*)
AEA, on behalf of the Department of Energy and Climate Change (DECC)	The Renewable Energy Planning Database (REPD)[9]
Energy Saving Trust, on behalf of the Scottish Government	Energy Saving Scotland small business loans; Energy Saving Scotland home loans and home renewables loans; Energy Saving Scotland home renewables grants[10]; Applications to the district heating loan fund; Community and locally owned renewable energy database[11]
Energy Saving Trust, on behalf of the Department of Energy and Climate Change (DECC)	Renewable heat premium payment applications
Scottish Environment Protection Agency (SEPA)	Information on installations covered by the Pollution Prevention and Control license in Scotland

In addition, information on installations in development was sourced from local planning authority planning departments via online searches.

A number of smaller installations (such as those funded by the Energy Saving Scotland home loans and home renewables loans) are known to have been installed during 2011. However, such installations have not been counted in the 2011 totals reported here. The reason for this is that, for many of them,

[9] https://restats.decc.gov.uk/cms/welcome-to-the-restats-web-site/
[10] Energy Saving Scotland home renewables grants ended in June 2010.
[11] http://www.energysavingtrust.org.uk/scotland/Publications2/Communities/Community-and-locally-owned-renewable-energy-PDF

there is uncertainty about how much of the year they will have been operational for. These installations all fall into the 'micro' (≤ 45kW) and 'small to medium' categories (45kW-1MW). As large installations (1MW and above) make up the largest proportion of the overall total renewable heat output, excluding output from a small number of micro or small to medium sized installations will not have significantly affected the results for total heat output in 2011. Micro and small to medium sized installations known to have been installed during 2011 have been included in the estimates for future capacity and output. Large installations (1MW and above) which became operational during 2011 have been included in the 2011 totals reported here, with estimated output scaled down where necessary to provide an estimate of output based on when the installation began producing renewable heat.

2.4 Assumptions used

For the majority of large and medium sized installations burning biomass wood for primary combustion or CHP, the main source of information available was estimates of wood fuel use from Hudson Consulting's annual survey of wood fuel use in Scotland for the Forestry Commission Scotland. These data were then converted into estimates of heat output, based on the assumptions about combustion efficiency given in table 2. One oven-dried tonne (ODT) of wood at 30% moisture content is assumed to contain 4.92MWh of energy[12].

Table 2. Boiler efficiencies assumed for converting oven-dried tonnes of wood burnt to heat output

Installation size	Boiler efficiency assumed	MWh heat output per ODT burnt
Large installations (>1MW, or >10,000 ODT)	90%	4.43
Medium installations (45kW – 1MW, or <10,000 ODT)	85%	4.18
Small (≤45kW) non-domestic	80%	3.94
Domestic	35%	1.74

Small or domestic biomass installations are assumed to be split into 10% sealed room heaters or boilers, and 90% open fires. Using SAP2009[13] values for typical efficiencies for such installations gives a weighted average efficiency for a domestic installation of 35%.

For biomass combined heat and power, a calculation was used to work out the estimate of heat energy produced from oven dried tonnes of wood, based on the values given for electrical power (MWe) and heat output (MWth). An example is given in figure 2 below.

[12] Mitchell, Hudson, Gardner, Storry and Gray, 1990. Wood Fuel Supply Strategies Vol 1. The Report: ETSU B 1176-P1.

[13] The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2009 edition version 9.90, BRE. http://www.bre.co.uk/filelibrary/SAP/2009/SAP-2009_9-90.pdf. Solid fuel room heater, open fire in grate, non-HETAS installed = 32% seasonal efficiency. Manual feed independent boiler in heated space, HETAS installed = 65% seasonal efficiency.

Figure 2. Formula used to estimate efficiency of heat production from burning biomass, in a biomass CHP plant.

Example calculation: a 20MWe and 80MWth biomass CHP unit.
Total efficiency = 90% (as for large biomass combustion plant)
Total output (electricity + heat) = 10 + 80 = 100MW
Total thermal input = output / total efficiency = 100 / 0.9 = 111MW
Electrical efficiency = electrical output / thermal input = 20 / 111 = 18%
Thermal efficiency = heat output / thermal input = 80 / 111 = 72%

For installations where an estimate of annual heat output was provided (or derived from ODT of wood burnt) but information on capacity was not given, capacity has been estimated based on typical running hours per year by size of installation or sector. These hours are given in table 3. The same running hours were used to derive an estimate of output for those installations where information on capacity was provided but an estimate of heat per year was not.

Table 3. Peak running hours assumed by technology, size and heat use

Sector and size of installation	Peak running hours/year
Large (1MW+) biomass providing process heat, and large biomass CHP	8,000
Energy from waste installations providing process heat or running as CHP	8,000
Commercial small to medium (45kw-1MW) biomass[14]	5,000
Space heating biomass, all sizes (including district heating)	2,500
Heat pumps providing space heating	2,500
Heat pumps or biomass providing space heating for community buildings	250

For installations where values for neither capacity nor output were provided, an estimate was made for likely installed capacity, based on technology type, ownership category and building type (where appropriate). This was derived from similar installations where capacity was known. The values assumed for capacity in those instances are given in Appendix 2. Yearly heat output was then estimated using the assumptions in table 3.

For solar thermal panels, information was sometimes only provided in m^2 of panel area. The following assumptions were used to derive capacity and/or output, where this was not provided:

[14] DECC uses an estimate of 1,314 peak load hours per year (equivalent to a 15% load factor) as the tier-break point between tier 1 and tier 2 prices paid for heat from small and medium sized non-domestic biomass under the Renewable Heat Incentive. However this is noted by DECC as being a reasonable estimate of a minimum level of usage that could be expected. Therefore 2,500 peak load hours has been used here, in keeping with estimates of renewable heat in Scotland, as an estimate of total peak load hours for space heating in Scotland. http://www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/incentive/incentive.aspx

- Capacity per m^2: 0.7kW, from the Solar Trade Association
- Useful heat output per m^2: 0.34MWh, derived from SAP 2009 calculations

In line with assumptions used in DECC's RESTATS methodology[15], municipal solid waste is considered to contain 63.5% biodegradable waste. Therefore an installation producing heat from burning municipal solid waste will have 63.5% of its capacity and output recorded as renewable heat in the database.

For anaerobic digestion facilities, 4% of the renewable heat output has been removed from the total figure for useful renewable heat production, as this is estimated to be the parasitic heat requirement of the AD process[16].

Scotland's total forecast non-electrical heat demand in 2020 is taken to be around 60,089GWh (60.1TWh)[17].

3 Renewable heat capacity and renewable heat output in 2011

3.1 Results for 2011

In 2011, **2,263GWh** (2.263TWh) of heat was produced from renewable sources, from an installed capacity of **0.484GW**. 2,263GWh is equivalent to **3.8%** of the non-electrical heat demand of 60.1TWh it is estimated that Scotland will require in 2020[18]. It can be assumed that all the installations currently in operation will still be operating by 2020.

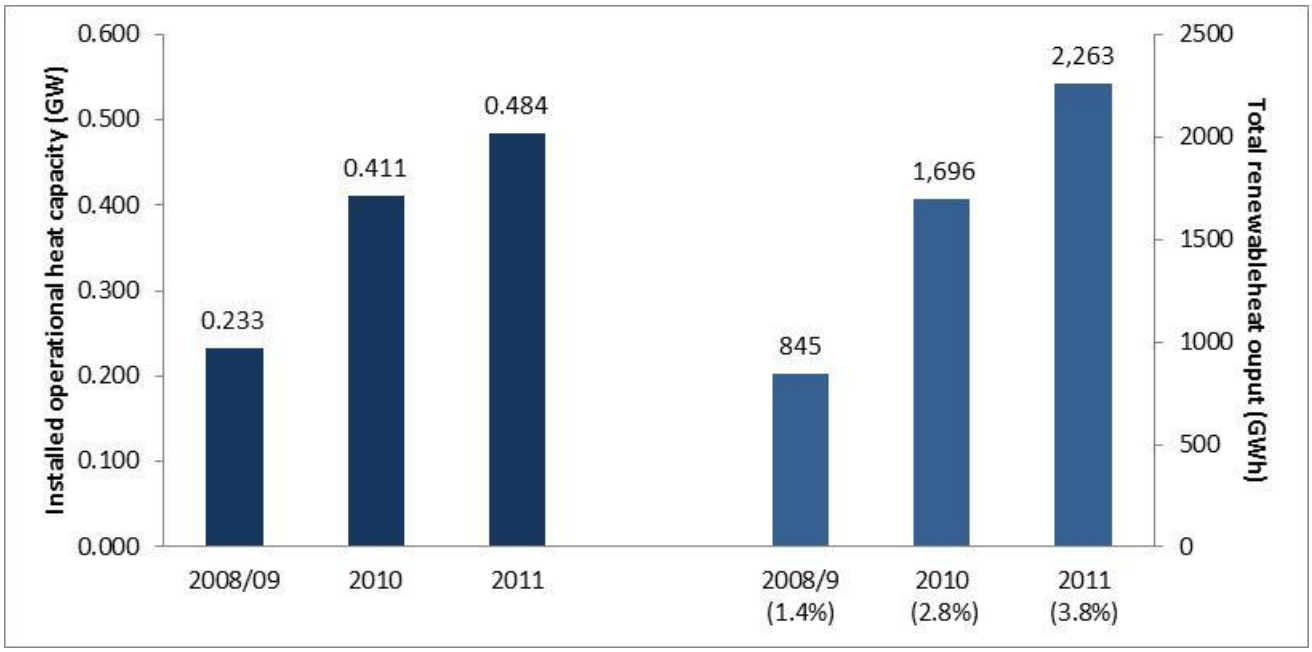
0.484GW of capacity and 2,263GWh of output represent an increase of 0.07GW in capacity compared to 2010, and an increase of 567GWh of output since 2010. Since the Sustainable Development Commission Scotland's[19] estimate of renewable heat output in Scotland during 2008/9, renewable heat capacity has increased by 0.25GW and output by 1,418GWh a year.

Table 4. Estimated renewable heat capacity and output, in 2008/09, 2010 and 2011 *(note: data were not gathered for calendar year 2009).*

	2008/9	2009	2010	2011
Capacity (GW)	0.233	-	0.411	0.484
Heat output (GWh)	845	-	1,696	2,263
% of Scotland's non-electrical heat demand in 2020	1.4%	-	2.8%	3.8%

[15] Renewable Energy Statistics: Data Sources and Methodologies, Department of Energy and Climate Change. http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/renewables/renewables.aspx
[16] Based on discussions with the Carbon Trust.
[17] Renewable Heat Action Plan for Scotland, Scottish Government, November 2009. http://www.scotland.gov.uk/Publications/2009/11/04154534/0
[18] Renewable Heat Action Plan for Scotland, Scottish Government, November 2009. http://www.scotland.gov.uk/Publications/2009/11/04154534/0
[19] Renewable Heat in Scotland. A report to the Scottish Government from the Sustainable Development Commission Scotland, June 2009. http://www.sd-commission.org.uk/publications.php?id=1015

Figure 3. Estimated renewable heat capacity and output, in 2008/09, 2010 and 2011 *(note: data were not gathered for calendar year 2009).*



The majority of renewable heat output in 2011 continues to come from large (1MW+) installations (table 5), as in previous years. Large installations contribute a larger percentage of heat output (85%) than of installed capacity (68%), compared with small to medium (45kW-1MW) and micro (≤45kW) installations. This reflects the longer running hours and (in some cases) higher efficiencies seen in large installations. In addition, the large installation category includes installations which are primarily using renewable heat to provide process heat, as a product of combined heat and power, or for waste disposal, which are activities which continue year round. Small to medium, and micro installations, are more likely to be used to provide space heating and/or building hot water, whose demands are more seasonal.

Table 5. Renewable heat output and capacity in Scotland, 2011, by size of installation

	2011 TOTAL CAPACITY	% of operating renewable heat	2011 TOTAL OUTPUT	% of operating renewable heat
Large (1MW+)	329 MW	68%	1,912,000 MWh	85%
Small to Medium (45kW to 1MW)	57 MW	12%	143,000 MWh	6%
Micro (equal to or less than 45kW)	98 MW	20%	198,000 MWh	9%
TOTAL	**484 MW**	**100%**	**2,263,000 MWh**	**100%**
	0.484 GW		**2,263 GWh**	

Note: totals may not equal sums due to rounding

3.2 Results by technology

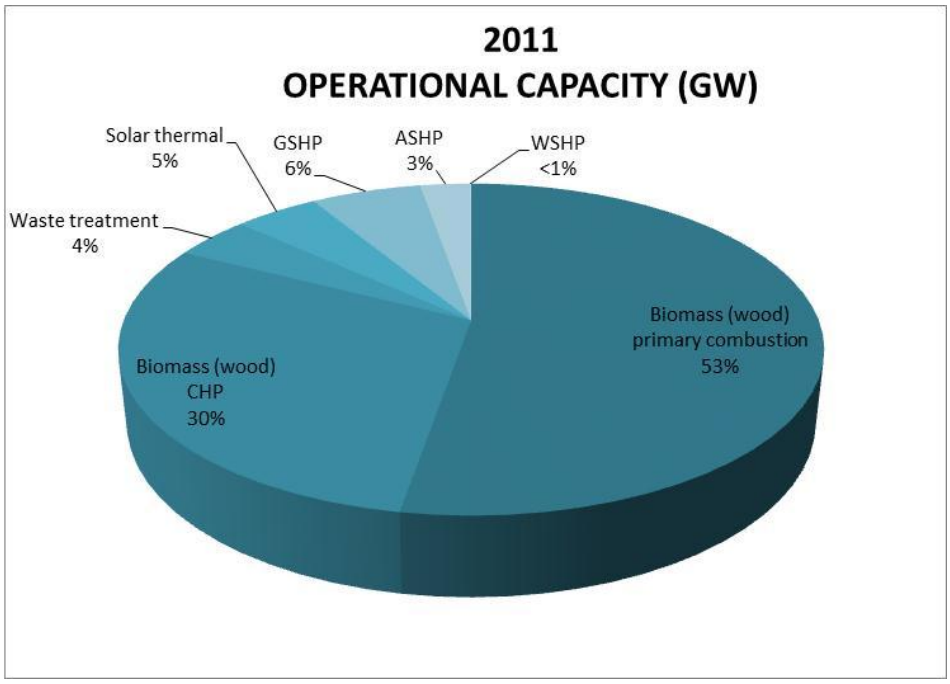
The majority of both output and capacity in 2011 came from biomass primary combustion and biomass combined heat and power (table 6, and figures 4 and 5). 82% of renewable heat capacity, and 89% of renewable heat output came from installations which used biomass primary combustion or biomass combined heat and power.

Table 6. Renewable heat output and capacity in Scotland, 2011, by technology

	2011 TOTAL CAPACITY	% of operating renewable heat	2011 TOTAL OUTPUT	% of operating renewable heat
Biomass primary combustion	255 MW	53%	1,045,000 MWh	46%
Biomass CHP	144 MW	30%	978,000 MWh	43%
Waste treatment (energy from waste, landfill gas & anaerobic digestion)	20 MW	4%	128,000 MWh	6%
Solar thermal	22 MW	5%	11,000 MWh	<1%
GSHP	29 MW	6%	70,000 MWh	3%
ASHP	13 MW	3%	31,000 MWh	1%
WSHP	0.2 MW	<1%	600 MWh	<1%
TOTAL	**484 MW**	**100%**	**2,263,000 MWh**	**100%**
	0.484 GW		**2,263 GWh**	

Note: totals may not equal sums due to rounding

Figure 4. Renewable heat capacity in Scotland, 2011, by technology



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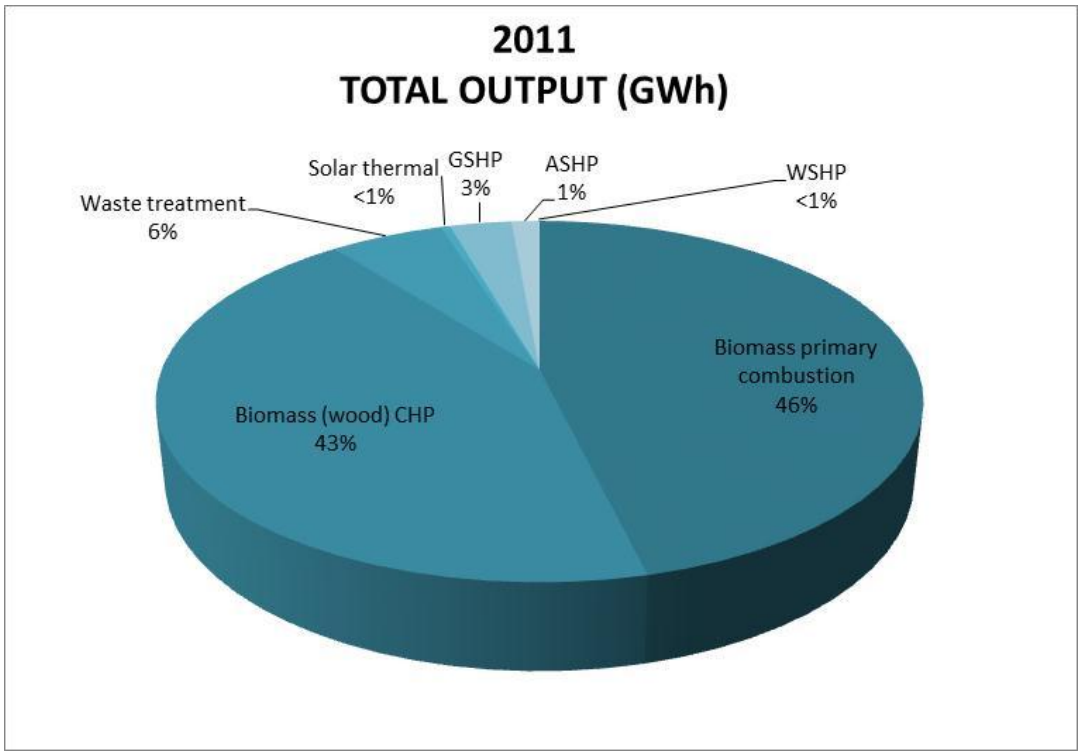


3.3 Change in output and capacity by technology since 2010

The largest increase in renewable heat output in real terms between 2010 and 2011 has come from increased wood use in biomass combined heat and power installations. The estimated amount of wood fuel used for combined heat and power in Scotland was significantly greater in 2011 than it was in 2010.

The largest increase in capacity was in biomass (wood) primary combustion installations. However around 26MW of the 52MW increase in capacity from biomass primary combustion is due to a change in the assumptions used to calculate capacity in domestic installations (see section 5.1, *Estimating domestic installations: capacity and output*).

The estimated capacity of renewable heat in energy from waste installations is lower for 2011 than that reported for 2010. This is due to:

- improved information about some installations, which has led to a downwards revision of their total installed capacity from 15MW to 6MW;
- advice received from SEPA that one energy from waste installation (capacity 2MW) which was operating in 2010 was not in operation during 2011.

This decrease in capacity was partly, but not entirely, countered by other new energy from waste installations which produce heat becoming operational during late 2010 or early 2011, adding a total capacity of 8MW. These new energy from waste installations have large heat outputs and are responsible for the fact that heat output from energy from waste has increased from 2010 to 2011, despite the decrease in renewable heat capacity.

The capacity of any installations which were not operating during 2011 has not been included in the figures reported here for operational capacity. However, they are included in the renewable heat database as an indication of potential renewable heat capacity.

Table 7.Changes in renewable heat output and capacity in Scotland from 2010 to 2011, by technology

	2011 TOTAL CAPACITY	Increase since 2010	2011 TOTAL OUTPUT	Increase since 2010
Biomass primary combustion	255 MW	52 MW	1,045,000 MWh	104,000 MWh
Biomass CHP	144 MW	6 MW	978,000 MWh	377,000 MWh
Waste treatment (energy from waste, landfill gas & anaerobic digestion)	20 MW	-3 MW	128,000 MWh	54,000 MWh
Solar thermal	22 MW	5 MW	11,000 MWh	2,000 MWh
GSHP	29 MW	5 MW	70,000 MWh	10,000 MWh
ASHP	13 MW	8 MW	31,000 MWh	20,000 MWh
WSHP	0.2 MW	0.2 MW	600 MWh	500 MWh
TOTAL	**484 MW**	**73 MW**	**2,263,000 MWh**	**567,000 MWh**
	0.484 GW	**0.07 GW**	**2,263 GWh**	**567 GWh**

Note: totals may not equal sums due to rounding

4. Further renewable heat capacity in development

4.1 Further capacity under construction and in planning

The renewable heat database has also been updated to include information (where available) on renewable heat installations which are in development: under construction, consented but not yet built, in planning or in scoping. These can be used to provide an estimate of future renewable heat output in Scotland, although there is necessarily a large degree of uncertainty around such figures.

An estimated **0.153GW** of installed capacity from (mostly large) projects is currently under construction in Scotland, which could provide a further **1,104GWh** of renewable heat. Adding these figures to current operational installations will provide a total of **0.637GW** of renewable heat capacity and **3,367GWh** of renewable heat output, equivalent to **5.6%** of non-electrical heat in 2020.

In addition, an estimated 0.448GW of capacity is either consented but not built, or submitted to local planning authorities for planning permission. These installations could provide around 2,850GWh of renewable heat. Assuming that 50% of these projects come to fruition before 2020 (providing a further 0.224GW and 1,425GWh of heat), and added to those installations currently under construction and operating, this would give a total capacity of **0.860GW** and **4,792GWh** of renewable heat, equivalent to **8.0%** of non-electrical heat in 2020.

A further 0.151GW of heat capacity is estimated from projects which are still at the 'scoping' phase i.e. they have not yet submitted an application for planning permission. These could provide a further 847GWh of heat. However these numbers should be treated with caution as:

- It is unknown how many of these projects will ultimately become operational;
- Numbers are likely to be an underestimate as not all projects in scoping will have been captured in the renewable heat database.

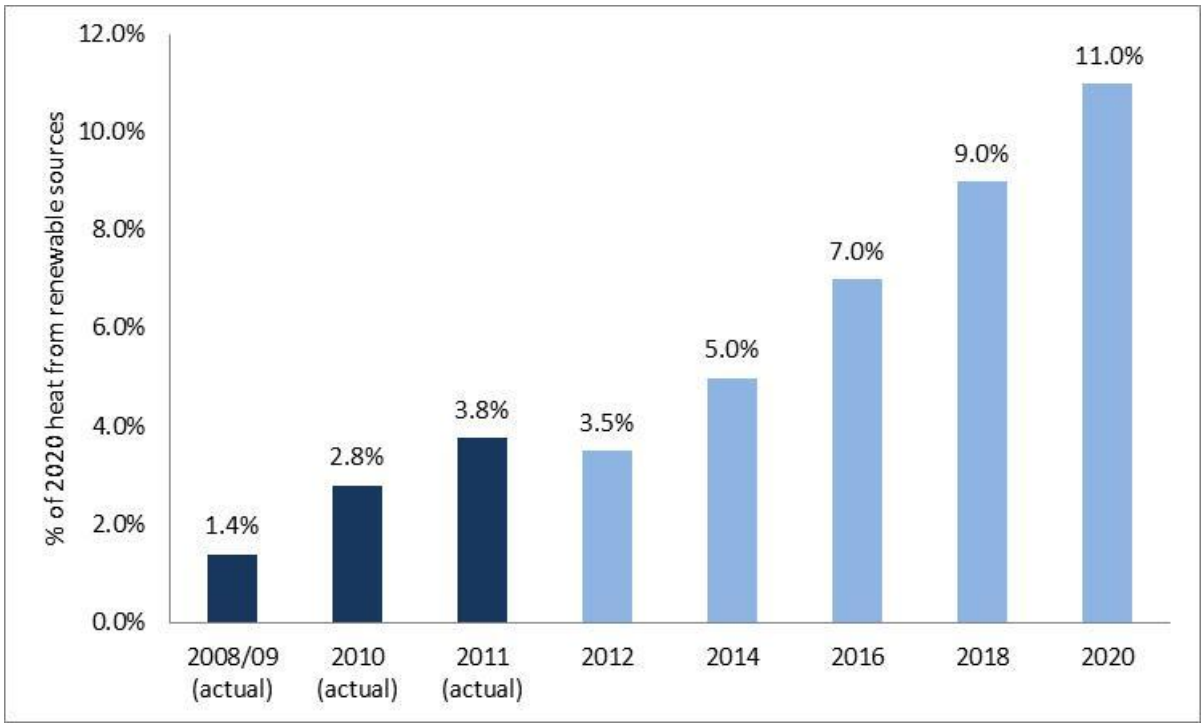
Over half of the capacity and output currently under construction and in development continues to come from large (1MW+) installations which propose to use biomass (wood), usually in CHP installations. Over half of all capacity and output under construction or in development is from biomass (wood) CHP installations. Between a third and quarter of capacity and output under construction and in development is from installations which will use energy from waste technologies.

4.2 Comparing the findings with progress towards the 2020 target

Between 2010 and 2011, renewable heat capacity in Scotland has increased by 0.073GW, and output has increased by 567GWh, from 2.8% of 2020 forecast non-electrical heat demand to 3.8%. Projects under construction, consented but not yet built, or in planning, could potentially bring total heat output to around 4,792GWh a year, or 8.0% of 2020 heat demand (section 4.1).

Scotland is currently still ahead of the projections provided in the Renewable Heat Action Plan (2009) for meeting the 2020 target (figure 6).

Figure 6. Indicative interim milestones towards the 2020 target for renewable heat[20], compared with actual heat output in 2008/9, 2010 and 2011 *(note data were not collected for calendar year 2009).*



5. Uncertainty levels associated with the methodology used, and recommendations for future updates

In any analysis of this kind where incomplete data are gathered from a variety of sources, certain assumptions have to be made to fill in gaps in the data. Assumptions made for particular technologies or sectors are discussed in this section, as well as general advice on the robustness of these figures.

Given the number of sectors and technologies this report covers, there is a chance that installations may have been missed which should be included in the database. However, large capacity installations are typically higher profile projects, and more likely to require planning permission (and planning records are a very good source of reliable information). Issues with data collection are therefore more likely for smaller capacity installations and should therefore have less effect on the totals presented.

The opposite problem (double-counting of installations) is also a possible issue, although efforts have been made to de-duplicate the renewable heat database as far as possible. Due to the large number of

[20] Renewable Heat Action Plan for Scotland, Scottish Government, November 2009. http://www.scotland.gov.uk/Publications/2009/11/04154534/0

data sources and the varying level of detail in the data received from different organisations there remains a risk that some double-counting may have occurred. This is most likely in the micro and small to medium categories, so should not significantly affect the 2011 totals.

Estimates of future output and capacity from installations still in development should also be treated with caution, as these projects may not come to fruition for a variety of reasons, and the stated capacity and heat output for projects still in development may be subject to change. Actual heat output from future installations may also not equal predictions of future output based on installed capacity and peak running hours. It is worth noting that many heat installations currently in development propose to export heat to nearby heat users; however the heat networks necessary to transport this heat have yet to be constructed, and in some cases there is not yet a heat user located nearby. Therefore use of the renewable heat will depend firstly on a suitable heat user being agreed or established nearby; and secondly how much heat that user requires, either for process heat or space heating.

5.1 Estimating domestic installations: capacity and output

Domestic renewable heat capacity and renewable heat output are particularly hard to estimate. In 2008/09, the SDC estimated capacity and output from domestic installations based on the number of installations of air source and ground source heat pumps, and solar thermal panels using data from the Scottish Community and Householder Renewables Initiative (SCHRI) received from the Energy Saving Trust. An additional uplift factor of 50% was then added to account for additional installations not using grant funding, or installed before grants were available. Domestic wood fuel use was estimated based on a figure of 52,000 ODT wood used per year in the domestic sector, multiplied by an average domestic appliance efficiency of 30%[21] to estimate output.

For the 2010 update, the increase in total output from domestic installations was estimated using the known increase in output between 2008/09 and 2010 from domestic GSHPs (based on Energy Saving Scotland home renewables grants data) as a basis. It assumed that the proportion of domestic heat output from each technology in 2010 was the same as in 2008/09. In 2008/09, the proportions of output from domestic renewables were approximately 60% biomass, 30% GSHP, 5% ASHP and 5% solar thermal. The increase in heat output from domestic GSHP's was calculated based on known installations between 2008/09 and 2010, receiving a SCHRI grant or an Energy Saving Scotland home renewables grant. The new total heat output in 2010 from GSHPs (SDC figure plus grants since) was then used to estimate heat output from the other three technologies, assuming the proportion of heat output from each has remained the same.

GSHP was chosen as the basis for increase across all domestic technologies because the high capital cost of purchasing and installing a GSHP compared to the other technologies means that we would expect most GSHPs to have been installed with the help of an Energy Saving Scotland home renewables grant. This is unlike the other technologies, where due to lower installation costs (solar thermal panels) or grants not being available (for example wood burning room heaters) there may have been many installations not captured by grant data. Therefore the majority of increase in heat output from GSHPs between 2008/09 and 2010 should have been captured in the grant information.

[21] This assumption has since been updated to 35%. Section 2.4, Assumptions used.

Heat output from each technology type was then used to work out estimates of installed capacity by technology type, based on the running hours for heat pumps in table 3, and the assumptions for solar thermal panels given on page 6.

For 2011, the same methodology was followed, i.e. the known increase in capacity from GSHP's has been used as the basis for estimating the increase across all renewable technologies. This may therefore underestimate the amount of renewable heat from other technologies.

The figure given for installed capacity of domestic biomass primary combustion in the 2008/9 SDC report was an estimated 15MW of 'active capacity', based on an estimate of between 13-19MW of capacity in regular use. Total heat output in 2008/9 from domestic biomass was estimated at around 72,00MWh a year, based on figures from the Forestry Commission Scotland. This would indicate a number of peak running hours of around 4,800 hours a year, far above the estimate used for space heating for other installations in the database (section 2.4, *Assumptions used*). For 2011 an estimate of 2,500 peak running hours a year for domestic biomass has been used, in line with other installations providing space heating. This has led to an increase of around 26MW in the capacity of domestic biomass assumed from 2010 to 2011.

To check the estimates of renewable heat from domestic installations in Scotland, the figures for output and capacity for each technology have been compared to:

- estimates of Scottish installations derived from UK-wide figures on domestic renewables, received from the Heat Pump Association, the Heating and Hot Water Industry Council, and the Stove Industry Alliance;
- an analysis of heating data from the Scottish Energy Performance Certificate register, which the Energy Saving Trust runs on behalf of the Scottish Government.

The estimates of renewable heat capacity estimated from these sources are broadly equivalent to the figures in the renewable heat database; however the final figures should still be treated with caution. In addition, the estimate of total domestic wood fuel use for space and water heating in Scotland remains a source of considerable uncertainty.

5.2 Energy from waste installations

Energy from waste technologies (primary combustion of non-wood biomass, anaerobic digestion, and combustion of landfill gas) currently provide only 4% of renewable heat capacity and 6% of renewable heat output (table 6). However, between a third and quarter of renewable heat capacity and output now under construction or in development in Scotland is from installations which will use energy from waste technologies. These technologies are expected to make use of a wide variety of feedstocks, including food and garden waste, by-products from whisky production, and derivatives of municipal solid waste. Some developments propose to make use of more than one technology and/or feedstock at the same site. Care will need to be taken in future updates to ascertain the biodegradable content of the feedstock for each plant, especially where the fuel used is a derivative of municipal solid waste.

5.3 Recommendations for future updates

The Renewable Heat Incentive (RHI) is expected to be one of the main drivers of future increases of renewable heat production in Scotland and the rest of Great Britain. Non-domestic installations claiming

payments under the RHI are required to submit regular meter readings on actual heat production to Ofgem, who are the administrators of the scheme. We recommend that the Scottish Government work closely with DECC and Ofgem to ensure this data can be used by the Scottish Government to help monitor progress towards its renewable heat target.

Appendix 1. Individual technology descriptions

Renewable energy technologies:

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

- **Biomass (wood) primary combustion**
  Wood is burnt to directly produce heat for space or water heating, and/or to provide heat for an industrial process. The wood burnt may be chips, pellets or logs, or waste wood, sawdust or offcuts. In some installations the wood fuel may be supplemented by, or be a supplement to, other non-renewable fuels such as coal. These cases are referred to as 'co-firing', and the renewable heat capacity and renewable heat output of installations when co-firing occurs are estimated to be a proportion of the total capacity and heat, based on the mix of different renewable and non-renewable fuels used.

- **Biomass (wood) combined heat and power (CHP)**
  Biomass is burnt in order to generate electricity. Heat is produced as a by-product, which can then be used for process heat, or supplying space or water heating.

- **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 only hot water.

- **Heat pumps: water source, air source and ground source**
  Technologies to extract low-grade heat from the external environment (the ground, air or a water body) and through a compression system produce heat for space and/or water heating. 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. '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 within the category air source heat pumps. However units which are purely exhaust air heat recovery, without also extracting heat from the air outside, have not. Cooling provided by heat pumps has not been included in the database.

- **Energy from waste (EfW)**
  Heat energy produced from the treatment of organic biodegradable waste other than wood. This category includes the following technologies:
    - **Anaerobic digestion (AD):**
      Organic matter is broken down in the absence of oxygen to produce methane gas. The methane 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. Useful renewable heat has been classed as heat produced (and used) beyond that fed back into the anaerobic digestion process to maintain it, which is sometimes called the parasitic heat load.

- **Landfill gas capture:**
  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. Only one example of this was found which is currently providing useful heat for buildings, and this is the Dunfermline landfill gas plant in Fife.
- **Biomass primary combustion:**
  This category covers installations where materials other than wood, such as municipal solid waste and animal carcasses, are burnt directly to produce heat. 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.
- **Advanced thermal treatment (ATT), using pyrolysis and/or gasification**
  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.

Had an example been found, the following technology could also have been included:

- **Fuel cell biomass**
  Fuel cells running on biomass could be used to produce useful heat. However none have yet been identified in Scotland.

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.

- **Energy from waste: installations where the only fuel is hospital waste**
  The Digest of UK Energy Statistics (DECC)[22] considers hospital waste as non-biodegradable, so 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**.**

The following renewable heat technologies are not included in the renewable heat database:

- **Passive renewable heating**

[22] Renewable Energy Statistics: Data Sources and Methodologies, Department of Energy and Climate Change. http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/renewables/renewables.aspx

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 successfully 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.

- **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, so estimates of heat from these systems have not been included in the renewable heat figures reported here.

Appendix 2. Capacities assumed for individual installations where information was not available

The following assumed capacities were used in the renewable heat database where information on capacity was not available.

Ownership category[23]	Building type	Technology	Estimate of likely installed capacity	Derived from:
Community	Community buildings	Heat pumps (ASHP and GSHP)	16kWth	Average for other heat pumps in public sector, LA non-domestic and community buildings recorded in the database
	All	Biomass	45kWth	Average for other community biomass installations recorded in the database
	All	Biomass district heating	250kWth	Average for other community biomass district heating installations recorded in the database
Other public sector and charity	All	Solar thermal	13kWth	Average for other public sector and charity solar thermal installations recorded in the database
	All	Heat pumps (ASHP and GSHP)	16kWth	Average for other heat pumps in public sector, LA non-domestic and

[23] Ownership categories are those used in the community and locally owned renewable energy database, maintained by the Energy Saving Trust for the Scottish Government.

				community buildings recorded in the database
	All except hospitals	Biomass	150kWth	Average for other public sector and charity biomass installations, excluding hospital installations, recorded in the database
	Hospitals	Biomass	1.7MWth (1,700kWth)	Average for other hospital biomass installations recorded in the database.
Farms and Estates	All	Biomass	150kWth	Average for other farm and estate biomass installations recorded in the database
	All	Biomass district heating	150kWth	Average for other farm and estate biomass district heating installations recorded in the database
Local businesses	All	ASHP	16kWth	Average for other local business ASHP's recorded in the database
	All	GSHP	30kWth	Average for other local business GSHP's recorded in the database
	All	Biomass	200kWth	Average for other local business biomass recorded in the database
	All	Biomass district heating	150kWth	Average for other local business biomass district heating recorded in the database
Local authority	Domestic properties	Solar thermal	3.4m^2	Analysis of Energy Saving Scotland home renewables grants[24]
	Domestic properties	Heat pumps (ASHP and GSHP)	7kWth	Average for other LA- and HA-owned heat pumps in domestic properties recorded in the database
	Schools	Solar thermal	7kWth	Average for other school solar thermal installations recorded in the database
	Schools	ASHP	10kWth	Average for school ASHP installations recorded in the database
	Schools	Biomass	200kWth	Average for other school biomass boiler installations

[24] Energy Saving Scotland home renewables grants (no longer available) were grants for domestic renewables, administered by the Energy Saving Trust on behalf of the Scottish Government.

				recorded in the database
	Other buildings	Heat pumps (ASHP and GSHP)	16kWth	Average for other heat pumps in public sector, LA and community buildings, recorded in the database
Housing Association	Domestic properties	Solar thermal	3.4m^2	Analysis of Energy Saving Scotland home renewables grants[25]
	Domestic properties	Heat pumps (ASHP and GSHP)	7kWth	Average for other LA- and HA-owned heat pumps in domestic properties, recorded in the database
	Domestic properties	ASHP - EAHR[26]	4kWth	Average for other LA- and HA-owned ASHP-EAHR's in domestic properties, recorded in the database

[25] Energy Saving Scotland home renewables grants (no longer available) were grants for domestic renewables, administered by the Energy Saving Trust on behalf of the Scottish Government.
[26] ASHP - EAHR = air source heat pump with exhaust air heat recovery. Such heat pumps draw heat from both air outside a building, and heat from stale air leaving the building or extracted from rooms such as kitchens and bathrooms within the building, to provide space and water heating to the building.

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