Renewable Heat in Scotland, 2010

A report by the Energy Saving Trust for the Scottish Government
Final report

March 2011

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 Brian Horne and Elaine Waterson.

With thanks to:
Brian Horne, Energy Saving Trust
Elaine Waterson, Energy Saving Trust
Rebecca Carr, Forestry Commission
Carbon Trust Scotland
Charlie Blair, Carbon Trust

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

In June 2009 the Sustainable Development Commission Scotland (SDC) produced a report for the Scottish Government entitled Renewable Heat in Scotland[1]. SDC estimated that in 2008/09, 845GWh of renewable heat was being generated from a total renewable capacity of 0.23GW. This was equivalent to 1.4% of Scotland's forecast non-electrical heat demand in 2020. As part of this work, SDC also developed a renewable heat database recording the details of known operational and upcoming renewable heat installations in Scotland.

The Energy Saving Trust has now been asked by the Scottish Government to update the SDC's renewable heat database with installations now known to be operating, those currently under construction and those in planning, and to produce a short report of the findings, including an update of the estimates of capacity and heat production based on the data obtained.

The result of this update to the renewable heat database is that in 2010/11, an estimated **0.411GW** of renewable heat capacity was operational in Scotland, producing an estimated **1,696GWh** of renewable heat energy. This equates to **2.8%** of Scotland's forecast non-electrical heat demand in 2020.

2. Study methodology

2.1 Approach taken

Two main outputs were required from this update of the renewable heat database. The first is an estimate of installed capacity. Capacity refers to the maximum instantaneous power output of a renewable heating system such as a biomass boiler, and is measured in kilowatt therms (kWth) or megawatt therms (MWth), depending on the size of the installation. Total heat capacity is reported here in gigawatt therms (GWth). The second is an estimate of useful renewable heat energy produced over a year. This is measured in megawatt hours (MWh), with the totals reported here in gigawatt hours (GWh). Total installed capacity units are sometimes reported as GW, rather than GWth, to avoid confusion with the units of heat output (GWh).

Useful heat output is hard to measure, and few renewable heat installations monitor the heat generated from their systems. Therefore the results presented in this report are largely estimates of heat output, based on what data was available about each installation. Where possible, results are based on data received about fuel inputs to particular installations, so estimating current *actual* heat output during 2010. This figure may be different to estimates of current *potential* output, which are usually based on heat capacity of an installation and an assumed number of operating hours, and which might therefore be higher (see section 3.3).

The information available about each installation varied, depending on the data source. Where it was supplied, estimates of fuel input were used as the preferred basis for estimating annual heat output.

[1] *Renewable Heat in Scotland*, the Sustainable Development Commission Scotland, June 2009. http://www.sd-commission.org.uk/publications/downloads/SDC%20Renewable%20Heat%20Report.pdf

Where capacity for such installations was not supplied, this was estimated based on the calculated heat output and assumptions about typical running hours in each sector. Where capacity was known, but not output, annual energy output has been estimated based on assumptions about typical running hours per year.

Heat output is always described as useful heat output, taking into account boiler efficiencies.

Results are reported for calendar year 2010, rather than financial year 2010/11 (which would be the more usual way to present such figures). The reason for this is that the Forestry Commission Scotland data set on wood fuel use in 2010 provided a large proportion of the data on which total output has been estimated. This data set was for calendar year 2010 (rather than financial year 2010/11), so overall results here have been reported for calendar year 2010.

In keeping with the SDC's report, installations have been classified by capacity, into large (1MWth and above), medium (between 1MWth and 45kWth) and micro (less than or equal to 45kWth).

The Energy Saving Trust gathered information from a number of sources listed below and has also updated information already held in the SDC's renewable heat database; for example a number of installations recorded as 'under construction' by the SDC are now in operation. These have been reclassified as 'existing' and have been included in the figures for current heat output. Others identified by the SDC are still in the planning or construction stages and are included only in estimates of future heat output. Where energy use in existing installations recorded by the SDC has changed since 2008/09, this information has been updated in the database.

In addition we have also sourced data from further sources such as the Community and Renewable Energy Scheme (CARES), administered by Community Energy Scotland, Scottish Renewables, and the Low Carbon Buildings Programme, administered by the Energy Saving Trust.

A number of smaller installations (primarily those funded through the Scottish Biomass Heat Scheme, CARES, and the Energy Saving Scotland home renewables grants) are known to have been installed in the course of 2010. Such installations have not been counted in the 2010 totals reported here, as for many of them there is uncertainty about how much of the year they will have been operational. These installations all fall into the 'micro' (≤ 45kWth) and 'small to medium' categories (45kWth-1MWth). As large installations (1MWth and above) make up the largest proportion of the overall total renewable heat output (around 85% of the total output counted for 2010), excluding a small number of micro or small to medium installations will not have significantly affected the results for total heat output in 2010. Micro and small to medium installations known to have been installed during 2010 have been included in the estimates for future capacity and output. Large installations which became operational during 2010 have been included in the 2010 totals reported here, with estimated output scaled down where necessary to provide a reasonable estimate of output based on when the installation began producing renewable heat.

Wherever possible, information has been updated on the capacity and thermal output of large installations which were operational during 2008/09 to reflect output in 2010.

More information about the assumptions made is given in section *2.4 Assumptions Used*.

2.2 Technologies included

The Energy Saving Trust has included the following technologies as providing renewable heat in its update of the renewable heat database:

- **Biomass primary combustion**
  Biomass is burnt to directly produce space or water heating. Most often the biomass material is wood, in chips, pellets or logs, and in some installations the wood fuel may be supplemented with other non-biomass matter such as coal ('co-firing'). It is also possible (as in the Lerwick district heating scheme in Shetland) for other organic or putrescible matter, such as food waste, to be burnt to produce heat. In such circumstances the heat produced could be considered as 'energy from waste' (EfW).
- **Biomass 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/water heating. Again, this biomass could either be wood products, or waste material with an organic component, such as municipal waste, in which case the installation could be considered energy from waste.
- **Solar thermal panels**
  Panels normally fixed to roofs, which produce hot water using the sun's heat. Occasionally these system are designed so that the hot water produced also contributes to space heating demand ('solar space heating').
- **Heat pumps**
  Technology to extract low-grade heat from the external environment (the ground, air or a water source) and through a compression system produce heat for space 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. Some heat pumps can also be run 'in reverse' during hot weather to provide cooling, but this use has not been included in this report.
- **Anaerobic digestion (AD)**
  Organic matter is broken down in the absence of oxygen to produce methane gas. This is then burnt to produce heat, or used in a combined heat and power unit to generate both electricity and heat. However in some applications, the heat produced can be used solely to maintain the process of anaerobic digestion itself, which often requires heat input. Therefore anaerobic digestion installations need to be carefully examined on a case by case basis to decide whether they provide useful renewable heat. Useful renewable heat has been classed as heat produced (and used) beyond that fed back into the anaerobic digestion process itself.
- **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.

- **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.

Other technologies which could have been included were:

- **Fuel cell biomass**
  Fuel cells running on biomass could be used to produce useful heat. However none were identified in Scotland for this report.

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

- **Non-biomass 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.
- **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 successfully help a building meet its heat demand, however they have not been included in this report or database, as the heat resource is virtually impossible to measure.

2.3 Data sources used

Multiple sources were used to update the renewable heat database. The main sources used, and the organisations which supplied them, are noted in table 1.

The data sets from Forestry Commission Scotland and Hudson Consulting (which included projects funded by the Scottish Biomass Heat Scheme) contained provisional results for year 2010. The full report 'Annual woodfuel demand and usage in Scotland' is expected to be published in summer 2011.

In addition other organisations such as the Carbon Trust, Scottish Renewables, and individuals connected with specific installations, were also consulted and provided useful information.

Table 1. Main datasets used

Organisation	Dataset
Forestry Commission Scotland	Small woodfuel spreadsheet[2]
Hudson Consulting	Annual woodfuel demand and usage in Scotland (*provisional results for 2010*)
Community Energy Scotland (CES), on behalf of the Scottish Government	Community and Renewable Energy Scheme (CARES)
Energy Saving Trust, on behalf of the Scottish Government.	Energy Saving Scotland small business loans; Energy Saving Scotland home renewables grants/SCHRI household stream
Energy Saving Trust, on behalf of the Department for Energy and Climate Change (DECC)	Low Carbon Buildings Programme (LCBP), Householder; Low Carbon Buildings Programme (LCBP) stream 2a (communities)[3]
Scottish Environment Protection Agency (SEPA)	List of thermal waste applications

2.4 Assumptions used

For the majority of large and medium sized installations burning biomass as primary combustion, the main source of information available was estimates of wood fuel use from the Forestry Commission's annual survey of woodfuel use in 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 is assumed to contain 4.92MWh of energy[4].

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

Installation size	Boiler efficiency assumed	MWh 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

[2] Including information on projects funded under the Scottish Biomass Heat Scheme, on behalf of the Scottish Government.
[3] No installations were recorded in Scotland for LCBP stream 1 Communities or stream 2b Communities.
[4] Mitchell, Hudson, Gardner, Storry and Gray, 1990. Wood Fuel Supply Strategies Vol 1. The Report: ETSU B 1176-P1.

Small or domestic biomass installations are assumed to be split into 10% sealed room heaters or boilers, and 90% open fires. Using SAP2009[5] values for typical efficiencies for such installations gives a weighted average efficiency for a domestic installation of 35%.

For a few installations, estimates of yearly wood fuel were given in units of tonnes of wood with 50% moisture content. Such wood was assumed to contain 2.11MWh of energy[6].

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 1 below.

Figure 1. Formula for estimating 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. Assumptions used to derive capacity or output where one or other was not provided in the dataset used.

Sector and size of installation	Peak running hours/year
Large (1MW+) biomass, and large or small to medium (45kw-1MW) biomass CHP	8,000
Commercial small to medium biomass	5,000
Space heating biomass (including district heating)	2,500
Heat pumps providing space heating	2,500
Heat pumps or biomass providing space heating for community buildings	250

[5] 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.
[6] Mitchell et al.,1990.

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:

- Capacity per m^2: 0.7kW, from the solar trade association
- Useful heat output per m^2: 0.34MWh, derived from SAP 2009 calculations

3 Renewable heat capacity and renewable heat output in 2010

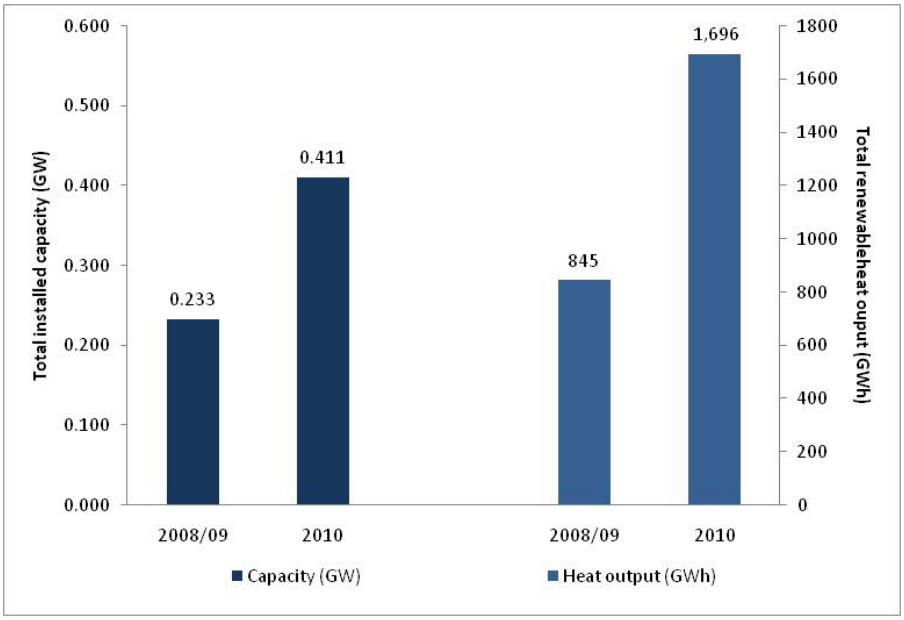
3.1 Results for 2010

In 2010, **1.696TWh** (1,696GWh) of heat was produced from renewable sources, from an installed capacity of **0.411GW**. 1.696TWh is equivalent to **2.8%** of the non-electrical heat demand of 60.1TWh it is estimated Scotland will require in 2020[7].

This represents an increase of 0.178GW of capacity compared to 2008/09, and an increase of 851GWh of output, doubling heat output since 2008/09 (figure 2).

These large increases have mostly come from increases in installed capacity and output at a small number of large (1MW+) wood processing installations, which use biomass primary combustion or biomass combined heat and power, often to supply process heat.

Figure 2. Renewable heat capacity and renewable heat output in 2008/09 and 2010



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

The majority of renewable heat output in 2010 continued to come from large (1MW+) installations (table 4), as in 2008/09. Large installations had a higher %-age output than their installed capacity, 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.

Table 4. Renewable heat output and capacity in Scotland, 2010, by size of installation

	2010 TOTAL CAPACITY		% of existing renewable heat capacity	2010 TOTAL OUTPUT		% of existing renewable heat output
Large (1MW+)	320	MW	78%	1,437,000	MWh	85%
Small to medium (45kW to 1MW)	39	MW	9%	107,000	MWh	6%
Micro (equal to or less than 45kW)	53	MW	13%	151,000	MWh	9%
TOTAL	**411**	**MW**	**100%**	**1,696,000**	**MWh**	**100%**
	0.411	**GW**		**1,696**	**GWh**	

Note: totals may not equal sums due to rounding

3.2 Results by technology

The majority of both output and capacity came from biomass primary combustion and biomass combined heat and power (table 5, and figures 3 and 4). In 2010 83% of renewable heat capacity, and 91% of renewable heat output, came from installations which used biomass primary combustion or biomass combined heat and power.

Table 5. Renewable heat output and capacity in Scotland, 2010, by technology

	2010 TOTAL CAPACITY		% of existing renewable heat capacity	2010 TOTAL OUTPUT		% of existing renewable heat output
Biomass primary combustion	203	MW	49%	941,000	MWh	55%
Biomass CHP	138	MW	34%	601,000	MWh	35%
Waste treatment (energy from waste, landfill gas & anaerobic digestion)	23	MW	6%	74,000	MWh	4%
Solar thermal	17	MW	4%	9,000	MWh	1%
GSHP	24	MW	6%	60,000	MWh	4%
ASHP	5	MW	1%	11,000	MWh	1%
WSHP	0.1	MW	0%	100	MWh	0%
TOTAL	**411**	**MW**	**100%**	**1,696,000**	**MWh**	**100%**
	0.411	**GW**		**1,696**	**GWh**	

Note: totals may not equal sums due to rounding

Figure 3. Renewable heat capacity in Scotland in 2010, by technology

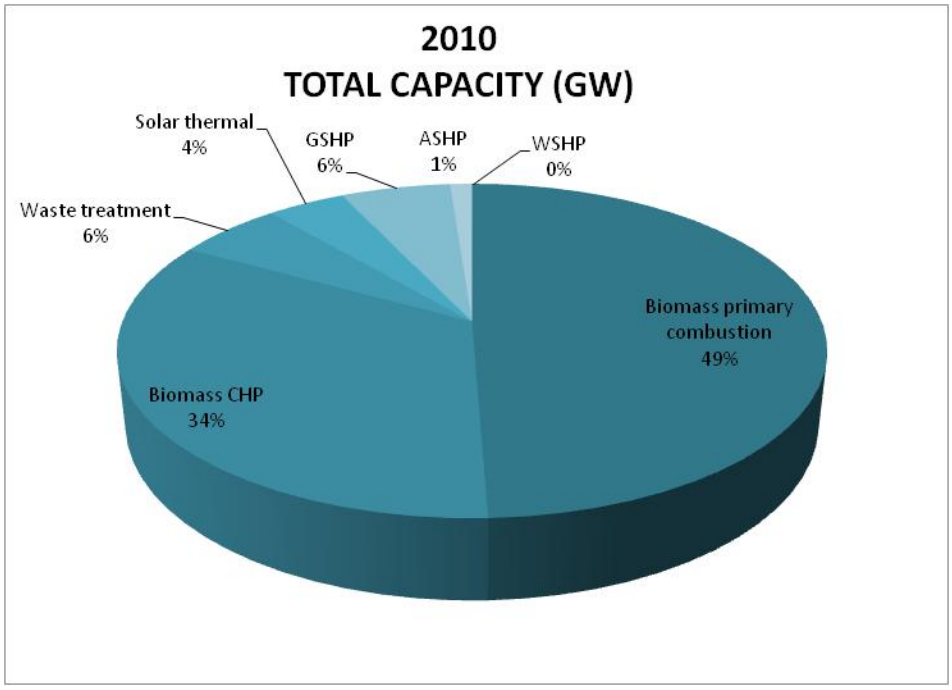
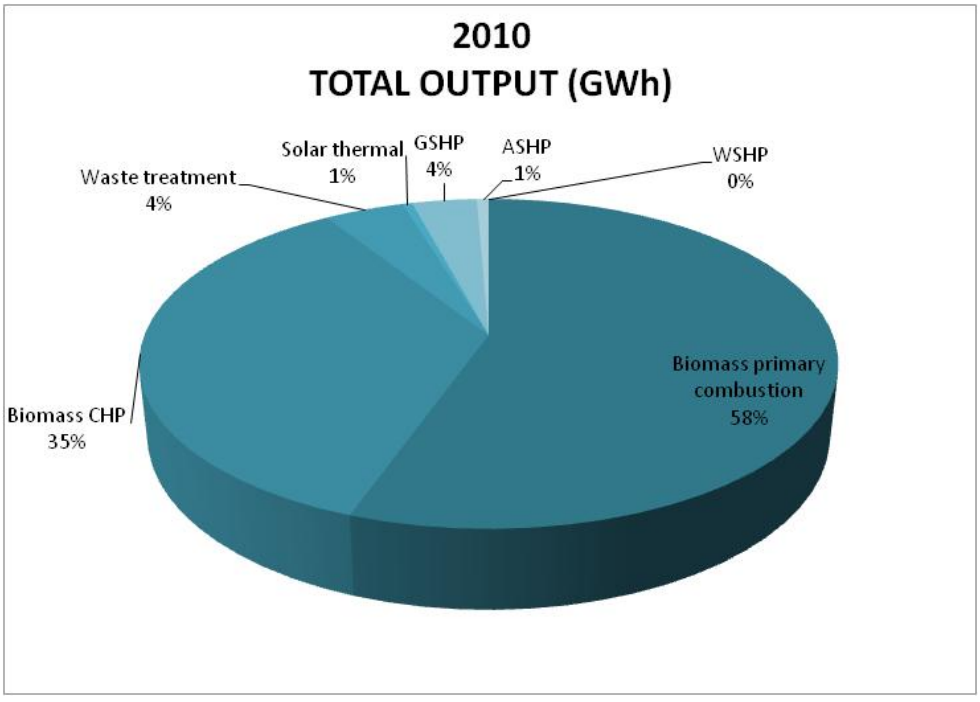


Figure 4. Renewable heat output in Scotland in 2010, by technology



3.3 Estimate of total potential heat deliverable with 2010 capacity

Where possible, results have been based on data received about fuel inputs to particular installations. Only when this was not available has heat output been estimated using capacity multiplied by peak running hours. As heat output from the majority of large and small to medium installations using biomass or biomass CHP has been estimated from data on fuel used in 2010, the results given here for current renewable heat output are mostly based on current *actual* heat output during 2010.

This figure may be different to estimates of *potential* output, which can be calculated based on the heat capacity of an installation multiplied by an assumed number of peak operating hours, depending on size and sector.

Using the known or derived capacity factor for all large (1MW+) and small to medium (45kW-1MW) installations in the renewable heat database, and multiplying by an appropriate number of peak operating hours for each installation (table 3), the total amount of heat which could potentially be delivered by current capacity is estimated to be around 2,588GWh. This is significantly more than the actual output estimated above and is equivalent to 4% of Scotland's forecast non-electrical heat demand in 2020.

4. Further renewable heat capacity under construction and in planning

4.1 Further capacity under construction and in planning

The renewable heat database has also been updated to include information (where known) on renewable heat installations which are under construction or in planning. 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.

At the micro and small to medium scale, based on data for the Scottish Biomass Heat Scheme, CARES and the Energy Saving Scotland home renewables grants, a further **19MW** of capacity and **41,000MWh** of heat output are expected. This covers micro installations which began operating in 2010, and those which are expected to become operational during 2011 or 2012.

A further **69MW** of installed capacity and **487,000MWh** are estimated from large projects which are currently under construction, and around **198MW** of installed capacity and **1,017,000MWh** from large projects in planning.

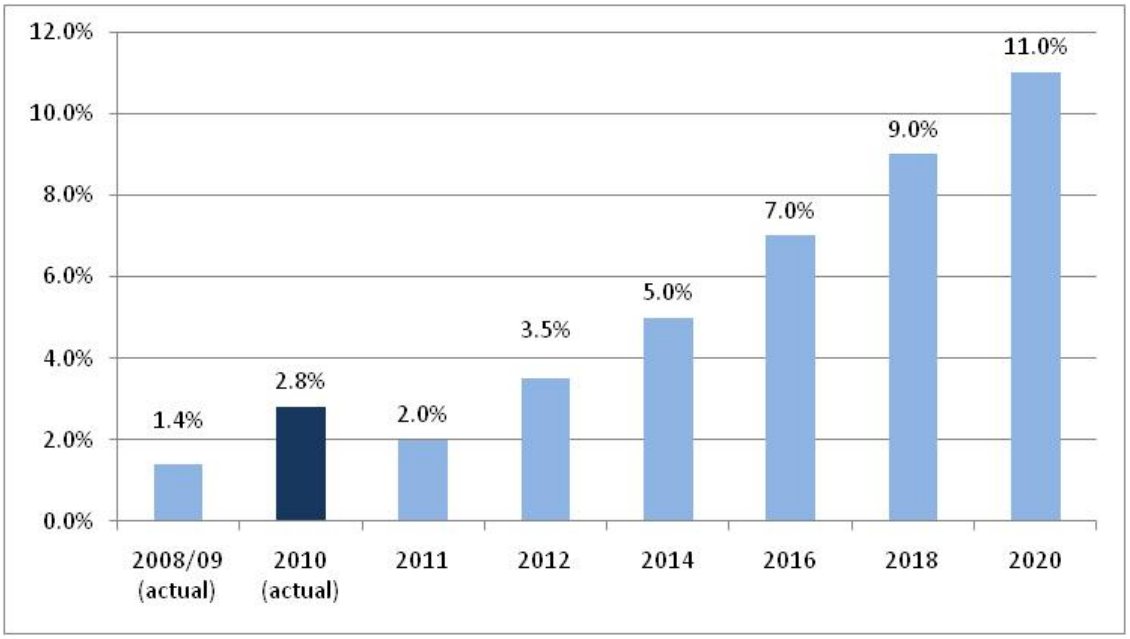
Were all the projects currently under construction, and 50% of those in planning to come to fruition, in addition to the known micro and small to medium installations, this could bring total renewable heat output in Scotland to an estimated **2,733GWh** a year, or around **4.5%** of forecast Scottish 2020 non-electrical heat demand.

4.2 Comparing the findings with progress towards the 2020 target

This update of the renewable heat database indicates that renewable heat output in Scotland approximately doubled between 2008/09 and 2010, from 845GWh to 1,696GWh. Large projects under construction or in planning, plus micro and small to medium projects known to have been installed during 2010, could potentially bring total heat output to around 2,733GWh over the next few years (section 4.1).

Based on the rate of increase from 2008/09 to 2010, Scotland appears to be on track to meet its renewable heat target for 2020 (figure 5).

Figure 5. Indicative interim milestones towards the 2020 target for renewable heat[8], compared with actual heat output in 2010.



5. Uncertainty levels associated with the methodology used

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. Areas for concern in estimates for particular technologies or sectors are discussed in this section.

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

In addition to problems with incomplete data on particular installations, 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. Estimates of future output and capacity from installations still under construction or in planning should also be treated with caution, as projects currently planned may not come to fruition for a variety of reasons. Actual heat output from future installations may also not equal predictions of future output based on installed capacity and peak running hours.

The opposite problem (double-counting installations) is also a potential issue, although efforts have been made to de-duplicate the renewable heat database as necessary. Due to the large number of data sources and the varying level of detail in the data received from different organisations there remains a risk that some double-counting of capacity or output may have occurred. This is most likely in the micro and small to medium categories, so should not significantly affect the 2010 totals.

5.1 Waste treatment; capacity and output

Estimating capacity and output from the waste sector proved particularly challenging, as concerns around commercial confidentiality frequently made it difficult to find information on capacity, and the wide variety of technologies used made estimating useful heat output challenging.

Since 2008/09 at least six large (1MW+) plants have become operational which use some form of waste material to generate heat, sometimes via use of a combined heat and power unit. These plants use various technologies for treating their waste, and make use of very different waste materials as fuel. Estimating heat output from these plants has therefore been challenging. In 2010, 4% of renewable heat output in Scotland is estimated to come from some form of waste treatment, but, for the reasons outlined above, this figure should be treated with caution. For future updates of the renewable heat database, more detailed information on fuel inputs, finished products and processes used at each waste treatment installation would help to make estimates of renewable heat from this technology more reliable.

Three waste treatment plants (two using incineration, one using anaerobic digestion) were found which could in theory supply excess useful heat to other users, but were not currently doing so. The heat capacity from these installations has not been included in total capacity for 2010, but the installations have been recorded in the renewable heat database as potential sources of useful renewable heat output.

Two plants which were included in the 2008/09 renewable heat database have had their estimates of output reduced. Both the Lerwick district heating network (which uses incineration of municipal solid waste) and the Dunfermline landfill gas plant (which uses a CHP plant running off landfill gas) supply heat for space and water heating through district heating networks. For both, peak running hours had previously been assumed to be similar to those of a large industrial plant (around 8,000hours per year). However this would seem to be an overestimate for installations whose main function is to provide space and water heating to (mostly) domestic properties. Therefore the peak running hours assumed for both installations have been reduced to 2,500, in line with the assumption for peak running hours for biomass installations providing district heating. Total heat output from waste treatment has nonetheless increased from 2008/09 to 2010, due to the new plants which have since become operational.

5.2 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 based on SCHRI data 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% to estimate output.

For this 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. This update assumes 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, captured in the SCHRI and Energy Saving Scotland home renewables grants. 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 be captured in the grant information.

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.

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