Sustainable Development Commission Scotland

Renewable Heat in Scotland

Report to the Scottish Government

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This report was prepared by Charlie Blair and Maf Smith

Sustainable Development Commission Scotland
Osborne House
Osborne Terrace
Haymarket
Edinburgh
EH12 5HG
0131 625 1880

Scotland@sd-commission.org.uk
www.sd-commission.org.uk/scotland

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Abbreviations

AD	Anaerobic Digestion
ASHP	Air Source Heat Pump
CARES	Community and Renewable Energy Scheme
CEP	Community Energy Programme
CES	Community Energy Scotland
CHP	Combined Heat and Power
EST	Energy Saving Trust
GSHP	Ground Source Heat Pump
GW	See Watt
GWh	See Watt Hour
kW	See Watt
kWh	See Watt Hour
MW	See Watt
MWh	See Watt Hour
ODT	Oven Dried Tonne (woodfuel)
SBHS	Scottish Biomass Heat Scheme
SCHRI	Scottish Community and Householder Renewables Initiative
SEPA	Scottish Environment Protection Agency
SDC	Sustainable Development Commission (Scotland)
W	Watt – a unit of *capacity*. 1,000W = 1kW. 1,000kW = 1MW. 1,000MW = 1GW. 1,000GW = 1TW. In this report we have sought to display figures using the most appropriate form to avoid large number strings
Wh	Watt Hour – a unit of energy. 1,000Wh = 1kWh. 1,000kWh = 1MWh. 1,000MWh = 1GWh. 1,000GWh = 1TWh. In this report we have sought to display figures using the most appropriate form to avoid large number strings
WSHP	Water Source Heat Pump

1. Executive Summary

1.1 Project Summary

The Sustainable Development Commission Scotland, on behalf of the Scottish Government, has been investigating the delivery of **renewable heat** in Scotland. Non-fossil fuel heat markets are not regulated, meaning that renewable heat levels have been based on estimates.

Scotland's target is for 11% of all heat used to come from renewable sources by 2020. Government is actively considering what steps need to be taken to deliver on this target, including discussing with the UK Government how financial support can be provided through a proposed Renewable Heat Incentive.

To help inform the level of any future support and intervention required to deliver its target, it is important that Government obtains an accurate benchmark of the level of renewable heat currently in use in Scotland. There are significant differences in previous estimates made by Government, industry and other commentators, giving low confidence in our current understanding of the figure.

The Sustainable Development Commission Scotland (SDC) was asked by the Scottish Government to research this issue and report back on findings. Separately SDC was also asked to provide policy advice to Government on renewable heat that builds on these findings. This advice is included as Appendix A of this report.

Only 'active' renewable heat delivery mechanisms have been considered in this study. These include **biomass combustion** (including useful heat off-take from biomass CHP), **ground-, air- and water-source heat pumps**, and **solar thermal panels**. Included in the biomass category is the organic component of any waste streams used to raise heat. Passive heat technologies (e.g. solar gain from glass facades) have not been included.

As part of this study SDC was asked to develop a database with information on all significant renewable heat installations in Scotland. We have drawn on a range of sources to populate this database, and cross referenced with information from site operators, developers and trade bodies. This provides a rounded and, we hope, comprehensive picture of renewable heat in Scotland today.

While data about larger scale installations is viewed as robust, assumptions have had to be made, particularly for smaller scale installations. The Forestry Commission Scotland provided high quality data from a range of sources. We are very grateful for their assistance in this project.

Included within the database are plants that generate heat for their own industrial processes (e.g. using heat for drying of wood), and plants which generate heat for export (for example to a district heating scheme). The bulk of renewable heat is currently generated for on-site use within industrial locations. This has made getting a clear picture of the level of renewable heat use in Scotland more difficult than measuring renewable electricity and transport fuels.

A number of other technologies can be classified as renewable heat sources, but our study has not found any plans yet to use them in Scotland. These technologies would include fuel cell CHP units using biofuels to generate electricity and heat, and deep geothermal installations to access geothermal heat directly. Our study has also highlighted a number of installations using renewable electricity (primarily small wind turbines, but also potentially hydro) for heating. These installations have been excluded from totals presented here, to avoid double counting of this generation towards both renewable electricity targets and renewable heat targets, though further work is needed by Government in assessing how to measure heat generated from renewable electricity while avoiding double counting.

The work measures renewable heat *delivered to a point of use*. Inefficiencies in fuel combustion and/or boilers are taken into account and this proportion of fuel energy content is not included. Heat is counted as that delivered either for **process heat** at large industrial sites, or for **space heating and building hot water**.

All installations have been classified as **micro** (equal to or less than 45kW capacity), **small to medium** (45kW to 1MW capacity), or **large** (capacity of 1MW and above).

1.2 Summary of Key Findings

The total figures for financial year 2008/09 are shown in Table 1 and Figure 1 below. **Total renewable heat output over the year was around 0.845TWh**, from a total renewable heat **capacity of 233MW**. 0.845TWh equates to **1.4% of Scotland's forecast annual non electrical heat demand in 2020 of 60.1TWh**.

Biomass boilers, predominantly burning virgin wood fibres and some wood waste, provide 86% of the existing renewable heat. Three large industrial sites engaged in wood processing provide over 50% between them.

Identified future projects suggest a near doubling of renewable heat output can be expected from plant currently under construction (see Table 6). The major new plants under construction are biomass CHP units; again burning wood (only the thermal output of CHP plants is counted here). Assuming that these plants are completed and commence operation, a further 0.774TWh of renewable heat (or 1.3% of the 2020 total) can be expected online in the next two to three years.

Scotland's target for renewable heat use in 2020 is that 11% of all heat used should come from renewable sources. Given that renewable heat is currently at 1.4% of the forecast non electrical heat demand in 2020, this appears challenging. We believe it is possible using existing technologies and supply chains.

Key issues highlighted by the Renewable Heat Database include:

- The bulk of renewable heat capacity and output comes from biomass. Of this, the majority of renewable heat comes from large scale plants using forestry derived biomass
- 68% of Scotland's renewable heat capacity and 74% of its renewable heat output comes from 15 plants of 1MW+ size. All but one of these plants uses forestry derived biomass
- Eight out of these 15 plants provide heat to the wood processing industry. These eight large installations contributed almost 520GWh in 2008/09 – around 62% of all renewable heat output
- There is poor data available on the level of micro renewable heat in Scotland, but notwithstanding this we have estimated that micro-generation makes up 16.5% of current renewable heat output
- While approximately 14% of renewable heat capacity comes from solar thermal panels and heat pump installations, only 8% of output comes from these sources
- Our estimate is that approximately 10% of renewable heat output comes from domestic biomass use. However, we are of the view that the overall capacity of domestic biomass is a much higher percentage; which highlights both low levels of use and high inefficiency.

Our conclusion is therefore that **other large projects either in construction or with consent** (but not yet under construction) could take output per year to 0.811TWh, or 2.8% of 2008/09 heat use.

Beyond this, **known projects currently in various stages of development could add up to 1.124TWh** taking the renewable heat output to 4.7% of the 2020 total. There is high uncertainty associated with the percentage of this potential that will move from planned to operational.

Looking at the potential for waste – particularly commercial and industrial wastes – to contribute to future energy needs through anaerobic digestion and thermal treatment; **we estimate that there is potential for waste sources to contribute at least 4.8% of Scottish heating needs**. This is based on the assumption that 25% of Scotland's municipal waste is used for heat generation, along with 25% of currently unrecovered waste wood (through energy recovery), and 25% of other biological sources such as sewage and food wastes (through treatment by anaerobic digestion).

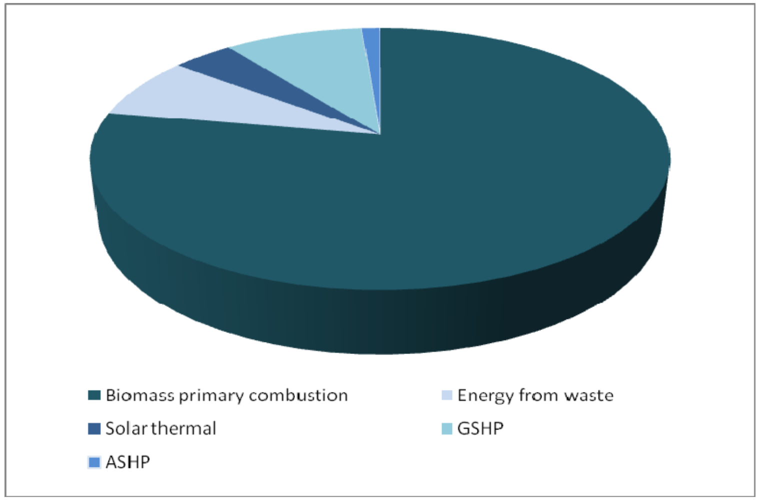
We have not made any attempt to quantify the likely future renewable heat output from micro-scale installations. These currently contribute some 130MWh[1] and there is certainly potential for a considerable increase in all micro-heat technology types.

Table 1: Scottish Renewable Heat Capacity & Output as at 31st March 2009

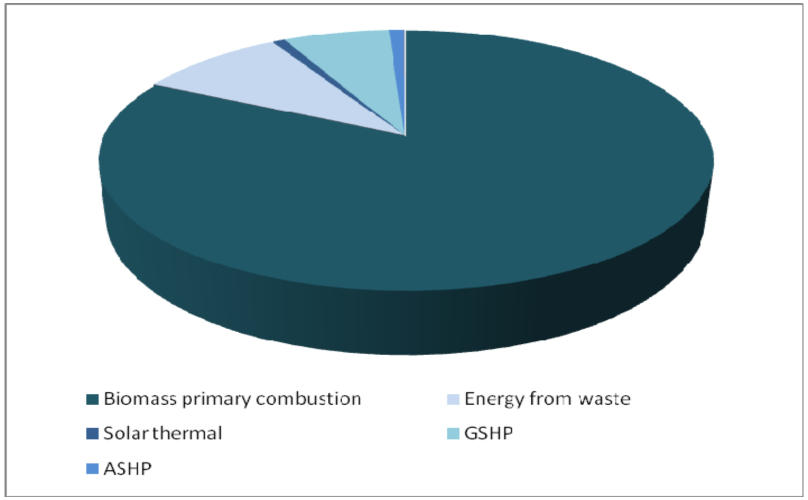
	2008/09 CAPACITY		2008/09 OUTPUT	
	MW	% of existing renewable heat	MWh	% of existing renewable heat
Biomass, including virgin fibre and wood waste (primary combustion & CHP)	192.73	83%	722,609	86%
Waste treatment (energy from waste, landfill gas & anaerobic digestion)	6.56	3%	52,074	6%
Solar thermal	9.37	4%	6,666	1%
GSHP	21.33	9%	55,454	7%
ASHP	2.8	1%	8,022	1%
WSHP	0.05	0%	123	0%
TOTAL	232.84		844,948	

Figure 1: Scottish Renewable Heat Capacity & Output as at 31st March 2009

Heat Capacity



Heat Output



(WHSP contribution not shown in Figure due to low contribution)

Based on our findings, we are confident that Scotland will be able to meet the 11% renewable heat target set by Government. This confidence comes from the fact that there are a significant number of schemes in operation or development. However it is dependent on (a) Government maintaining its stated commitment to introduce support funding (e.g. the Renewable Heat Incentive), and (b) the fact that changes in waste policy are likely to further discourage land filling of commercial and municipal wastes in favour of reduction, reuse, recycling, composting and thermal treatment.

Furthermore, our projections exclude figures for micro-heat devices (wood stoves, solar thermal panels and heat pumps) which could make a significant contribution, dependent on incentives available and relative cost.

2. Study Methodology

SDC's approach has been to assess the existing and forthcoming supply of renewable heat in Scotland. The primary aim has been to produce reliable estimates of (a) the thermal output *capacity* (capacity is the instantaneous heat output capability of a boiler, heat pump or solar panel, measured in Megawatts) and (b) the thermal *energy output* (in Megawatt hours), based on the known installations in Scotland operational as at the end of March 2009.

SDC has also tracked known upcoming renewable heat installations, under the categories 'under construction', 'consented but not built', and 'planned'. The data for these categories is less complete, but gives an indication of expected investment in renewable heat if there is no change to government policy or underlying energy costs.

The Renewable Heat Database contains details of renewable heat installations. For small, medium and large scale plants (over 45kW) these are generally included in the primary 'existing' installations spreadsheet; micro installations (equal to or less than 45kW) are aggregated in the primary spreadsheet.

2.1 Technologies

The following technologies are considered renewable heat. 'Passive' renewable heating – primarily solar gain to buildings through windows and glass facades – has not been included.

- **Biomass primary combustion** - biomass boilers, stoves and fireplaces designed to burn wood and other organic matter (sometimes mixed with non-biomass matter); for space heating, water heating and process heat
- **Biomass CHP** – combustion of biomass to raise electricity and heat; the thermal component is counted as renewable heat (NB the thermal output of fossil-fuelled CHP plants is *not* counted as renewable heat in this study)
- **Solar thermal** – 'active' solar panels for water and/or space heating – primarily flat plate collectors and evacuated tube collectors. Installations are generally classified by collector area in m^2, sometimes by thermal output
- **Heat pumps** – ground source heat pumps (GSHP), air source heat pumps (ASHP) and water source heat pumps (WSHP) used for space or water heating. (Cooling using heat pumps is noted where possible but is not counted as a form of renewable heat)
- **Wind or Hydro electricity used for heat** – at present all renewable electricity generated is eligible for ROC payments regardless of end use, so to avoid double counting wind-to-heat and hydro-to-heat installations are not included in the database
- **Fuel Cell Biomass** – useful thermal output from fuel cells running on biomass would be included but none have been identified. The same is true for direct use of **geothermal heat**.

Installations are classified by capacity as micro (equal to or less than 45kW), small to medium (between 45kW and 1MW) or large (1MW and above).

It is worth noting that by "biomass" we mean all organic matter that might be used in generation of renewable, including wood fuel, waste wood, food wastes and agricultural materials. We have recorded different types of biomass feedstock within the database, and within this report separate out biomass that comes from virgin sources (e.g. using forestry materials) from those using waste materials. The database provides this information in greater detail.

2.2 Information Sources

Data lines for installations came from a number of sources, cross checked wherever possible with other datasets or by phone interviews with individuals at the installation site. Where datasets refer to individual installations, these have been used as primary information sources. Other information sources (for example estimates from various individuals on total installations of each micro technology) have been used to cross check these primary information sources.

The main challenge for data collection has been to avoid double counting of installations. To aid future use of the database, any alternate names for installations have been included, as well as information on location and site type.

The complete list of organisations that provided information on installations is included in Table 2 (right). Key primary datasets are highlighted.

More detail on information sources and issues with the different technologies is also provided in Section 4 ('Technologies – Methodological Issues'). A number of individuals have also provided lists of relevant installations, as well as information on individual sites.

There were significant differences in the quality of the data received. While data quality from the Forestry Commission Scotland, Hudson Consulting and Scottish Renewables was high and consistent, this could not be said of all sources. This is something that Government needs to address if it is going to be able to track renewable heat going forward.

Table2: Origin of Datasets

Source Organisation	Dataset (if applicable)
Forestry Commission Scotland	Small woodfuel spreadsheet
Hudson Consulting	Woodfuel Use in Scotland
Energy Saving Trust	SCHRI Communities spreadsheet SCHRI Household spreadsheet
Community Energy Scotland	SCHRI Communities spreadsheet
Scottish Renewables	Heat Database
Scottish Government	Scottish Biomass Heat Scheme Project Summaries Community Energy Programme Project list
Scottish Enterprise	Various Internal
Scottish Environment Protection Agency	List of Thermal waste applications

2.3 Capacity

For most large installations capacity is known - for biomass boilers and heat pumps this is the rated capacity of the unit, which is the standard means of describing the size of an installation. For solar installations m^2 of collector area is often used to describe an installation. Where collector area is known we have taken an assumption of **0.7kW of capacity per m² of panel area**.

For biomass CHP installations, only the thermal capacity is included (for example, a large CHP might have total capacity of 60MW – 40MW thermal and 20MW electric). Generally the breakdown of thermal and electrical capacity is known; occasionally it has been estimated (noted in the database).

In the few cases where the capacity of an installation is not known we have calculated capacity from a known energy output figure and known (or estimated) running hours figure.

2.4 Energy

For the majority of larger installations (primarily biomass) the amount of fuel used is known.[2] Where total fuel burn is known, useful energy output is estimated using assumptions on:

- Combustion and boiler efficiency (**90% for large plant, 85% for other plant**, 30% average for woodstoves and open fires (see below))
- The energy content of the fuel burned (**assumed 4.92MWh per ODT for wood**).

In some cases where fuel burn is not known, or not applicable, the designed energy output from the system is known (this is the case for *some* installations receiving SCHRI funding). This is used as a best estimate for actual energy output. Where there is no design output, energy output is estimated using one of the following methods:

- Rated capacity x expected running hours (using assumed running hours where necessary)

- Panel surface area **x 0.42MWh** (equivalent to 1500MJ/m^2).

Where alternate methods suggest alternate totals for capacity or energy output the lower number is used unless there is greater confidence in the higher number.

2.5 Fuel and Heat Use

Each installation is also characterised according to the following types of fuel:

- Logs
- Chips
- Pellet
- Waste wood
- Biogas
- Biofuel (liquid)
- Other waste (biomass proportion of waste where energy is recovered, including incineration)
- Not applicable - NA (solar gain).

And, where known, installations have been characterised by end user of the heat (in addition to the primary categorisation of 'process heat' or 'space heating and building hot water', as follows:

- Distillery
- Food
- Wood processing
- Other industry
- Public Sector (NB includes community buildings)
- Commercial space heating
- Domestic space heating and water.

2.6 Micro-Installations

There are separate lines on the database for all known installations over 350kW and many below that size. We have received information from EST and CES regarding these installations; this information is included within a separate sheet of the database. We have calculated average capacity and energy figures for each technology under each funder, and where gaps are present in the datasets we have increased the totals accordingly.

One issue in our work is the fact that we expect there to be a significant number of micro renewable installations that either pre date the current grant programmes or have been installed without grant support, so will be unrecorded. We have not found reliable sources of data to map these installations, so have made an adjustment to the total micro-installation figures for solar thermal and heat pumps to account for this. We have discussed this issue with EST - deliverers of the SCHRI household funding – and CES, and our estimate is that for all technologies half as many installations again (with equivalent capacity and energy) have been installed in addition to SCHRI funded installs.

This data has also been cross checked with a number of additional sources, including individual installation companies, trade associations (solar thermal and heat pump), government officials and other informed individuals.

Domestic biomass installations present a significant difficulty. A total of 291 biomass installations have been funded through SCHRI's household funding stream, with total capacity of 3.5MW (all automated pellet or chip boilers). The total number and capacity of domestic biomass fittings, however, is certainly much higher. There are probably several hundred thousand domestic chimneys in Scotland (out of 2.3 million dwellings), though a large proportion of these are rarely used.

Forestry Commission has estimated that some 52,000 ODT of woodfuel (logs, pellets and chips) are burned in Scotland each year.[3] (This estimate is based on an Omnibus Survey which identified a small subset of woodfuel users). Taking an assumed **average efficiency of 30%** (a mixture of open fires with efficiency of 20% or so and modern stoves and boilers with efficiency of 70% or more), this suggests 77GWh of delivered biomass heat to households each year. As expected this figure of 77GWh is significantly higher than the 6MWh delivered through SCHRI funded biomass installations – so the 77GWh figure has been included in the total.

Estimating capacity from domestic biomass fittings is more problematic. 250,000 chimneys with average unit capacity of 2kW might equate to a theoretical capacity of 500MW (a lot more than the total renewable heat capacity identified in this study). It is very clear, however, that only a tiny proportion of this is used. Through discussions with Forestry Commission Scotland we have estimated that some 13-19MW of capacity is in regular use. An 'active capacity' number of 15MW has been used in section 3 and in the database.

2.7 Confidence

It should be noted that all the numbers in the database (and, therefore, in this report) are subject to uncertainty. The degree of uncertainty varies considerably,[4] although we have concentrated on confirming the information on the major installations, given that these installations account for the bulk of renewable heat use in Scotland at present. There is also a high probability that we have missed some existing installations. However, we expect these to be in the micro or small to medium scale, and have confidence that omissions will not undermine the overall results of this study. Again, we have concentrated on accuracy and coverage of our data on major installations.

The varying degrees of uncertainty around all of the input numbers have meant that a range for the output numbers (energy and capacity) would be inappropriate.

There is particular danger of inaccuracy from our aggregated data for micro-heat installations of all technologies. We are also concerned that there may be biogas (AD) CHP installations providing renewable heat that we do not know about (AD plants that have been identified are generating electricity only).

Information within the three sheets on the database referring to future projects is necessarily incomplete. This is meant as an *indicator* of potential, and no weight should be put on the totals. All information sources report considerable interest in renewable heat installations, but real difficulties getting heat projects off the ground as there is currently no support for renewable heat (unlike electricity).

However, changes to the Renewables Obligation – which should see 2 ROCs being payable to support biomass CHP – coupled with discussions about a Renewable Heat Incentive – are likely to bring increased market confidence and support the development of projects.

Both the energy and capacity figures for micro-scale biomass involve very significant uncertainties. Given that the total domestic biomass energy is a significant proportion of the total useful heat output (approximately 10%), this represents an important weakness of this study.

3. Renewable Heat Capacity and Delivered Output

Table 3 shows our calculated figures for renewable heat capacity and output.

Table 3: Scottish Renewable Heat Capacity and Output (as at 31 March 2009)

	2008/09 CAPACITY		2008/09 OUTPUT	
	MW	% *	MWh	% *
Biomass primary combustion & CHP	192.73	82.8	722,609	85.5
Waste combustion (Energy from waste and landfill gas)	6.56	2.8	52,074	6.2
Solar thermal	9.37	4.0	6,666	0.8
GSHP	21.33	9.2	55,454	6.6
ASHP	2.80	1.2	8,022	1.0
WSHP	0.05	0.02	123	0.01
TOTAL	**232.84**		**844,948**	

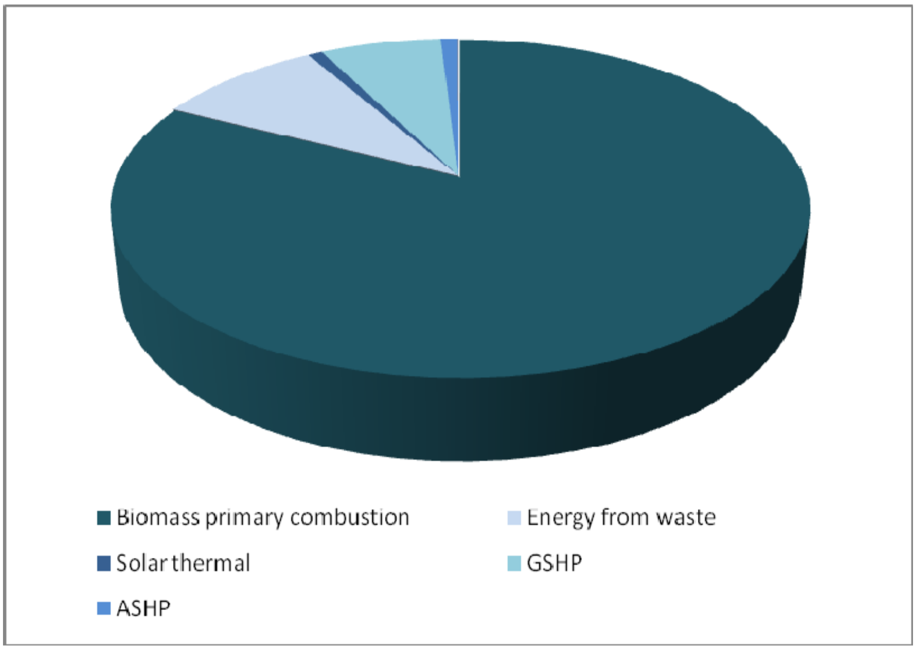
- * Percentage of existing renewable heat

3.1 Delivered Renewable Heat (Output)

Total renewable heat used in 2008/09 is estimated at 0.845TWh. This amounts to 1.4% of Scotland's total heat consumption.[5] This is broken down into relevant technologies in Figure 2.

The total renewable heat output is at the lower end of expectation – previous estimates (which did not include actual counting of individual installations) have included Scottish Renewables' estimate of 3TWh in 2006/07[6] and FREDS' derived 4% renewable heat estimate.[7]

Figure 2: Renewable Heat Database: 2008/09 Total Output



The vast majority of renewable heat in Scotland (637GWh, 164MW) comes from large installations. As expected, large biomass installations at industrial sites (many in the wood processing industry) were responsible for much of the total: the 15 existing 'large' biomass installations delivered 75% of renewable heat used in Scotland in 2008/09. The single biggest installation – biomass burners at a wood processing plant – provided over 30% of the current level of renewable heat.[8]

Ground Source Heat Pumps, the majority supported by the SCRHI funding scheme, provided around 7% of renewable heat. Solar thermal and ASHPs each provided a little less than 1% of the current level of renewable heat output[9]. The Shetland energy from waste plant, delivering heat to the Lerwick District Heating Scheme, was responsible for a little over 4%.

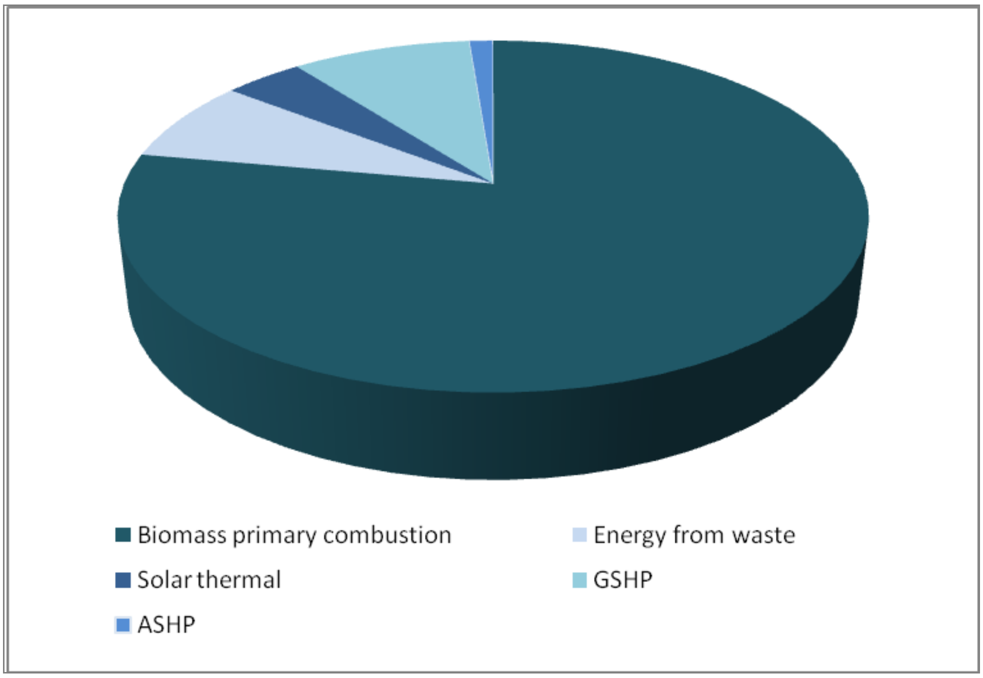
In total 637GWh of renewable heat were outputted from 'large' sources of over 1MW capacity; 68GWh from 'small to medium' sources of between 45kW and 1MW; and 139GWh from 'micro' sources of less than or equal to 45kW.

3.2 Renewable Heat Capacity

Total renewable heat delivery capacity in Scotland is currently around 233MW. This is broken down into respective technologies in Figure 3.

Thermal output capacity gives an indication of the amount of renewable heat theoretically available from existing installations in Scotland. A total heat capacity of 233MW could *theoretically* correspond to energy output per year of over 20TWh,[10] at least for biomass and heat pumps. However an installation's actual heat output will depend on when heat is required at site, because heat can neither be stored nor transported easily.

Figure 3: Renewable Heat Database: 2008/09 Total Capacity



Capacity figures for solar thermal and micro-biomass are problematic because the 'capacity factor' for both these technologies is likely to be both low and variable. The total of 233MW includes figures for solar thermal (9.4MW) and micro-biomass (15MW). The solar figure has been calculated from the surface area of panels known to have been installed. The micro-biomass figure is an estimate of the number of domestic biomass burners (stoves, fireplaces, boilers) that are actually used on a regular basis. The domestic biomass figure, particularly, demonstrates the difficulty with capacity as a measure of successful renewable heat policy. As mentioned in Section 2.6, the total capacity of open fires in Scotland could be as high as 500MW (250,000 open fires x 2kW capacity per fire), but this capacity is irrelevant if never used.

3.3 Renewable Heat Users

It is clear that the majority of heat is being generated in larger installations: as is shown in Table 4 and Figure 4. The bulk of which is using biomass as a heat source.

It is also clear that in these larger installations, the majority are generating renewable heat for on-site use. This is shown in Table 5 and Figure 5.

In total around 583GWh was used in the commercial sector. The majority was in wood processing but the figure also includes commercial space heating and hot water use, and use of heat in the food industry. Eight out of twelve of the large renewable heat installations in the database provide heat to the wood processing industry. These eight large installations contributed almost 520GWh in 2008/09 – around 62% of all renewable heat. In total the wood processing industry used some 526GWh of renewable heat, in biomass boilers fuelled by a mixture of wood-wastes (off-cuts) and virgin wood fibres.

Public sector installations - including community buildings offices, universities, hospitals, schools and leisure centres - used some 79GWh of renewable heat.[11] Public sector installations have a total capacity of 18MW. Public sector renewable heat installations tend to have relatively low running times. This is because a high number of installations in the public sector have been for community buildings which are heated for only a few hundred hours per year.

29.6GWh of renewable heat was delivered to commercial premises for space heating, and a similar quantity to other industries (including food processing and distilleries).

183GWh of renewable heat were used for space heating and hot water in domestic homes. This includes 35GWh from SCHRI grant funded non-biomass installations, as well as an estimated 17 GWh from additional non-biomass installations and 76.7GWh of domestic woodfuel use (as estimated by Forestry Commission Scotland: see Section 2.6).

Table 4: Renewable Heat Output by size of installation (2008/09)

	TOTAL CAPACITY 2008/09		TOTAL OUTPUT 2008/09	
	MW	% *	MWh	% *
Large (1MW+)	163.7	70.3	637,420	75.4
Small to Medium (45kW to 1MW)	23.8	10.2	68,431	8.1
Micro (equal to or less than 45kW)	45.4	19.5	139,096	16.5
TOTAL	232.8		844,947	

* Percentage of existing renewable heat

Figure 4: Renewable Heat Output by size of installation (2008/09)

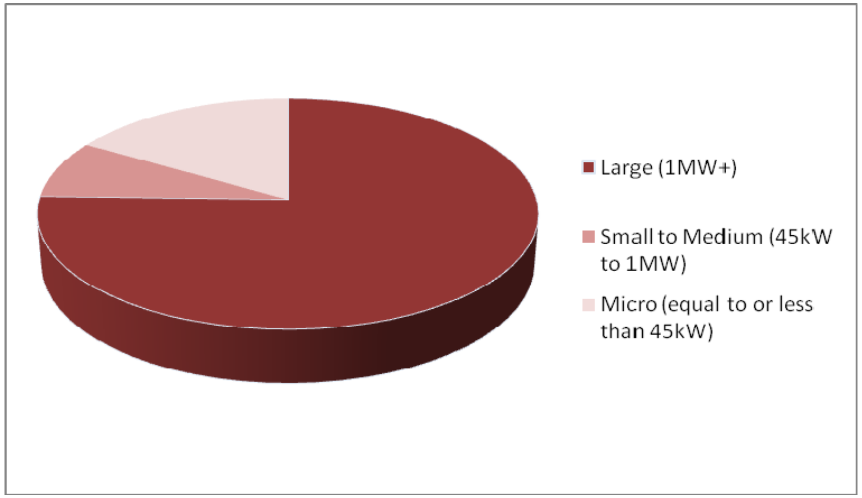
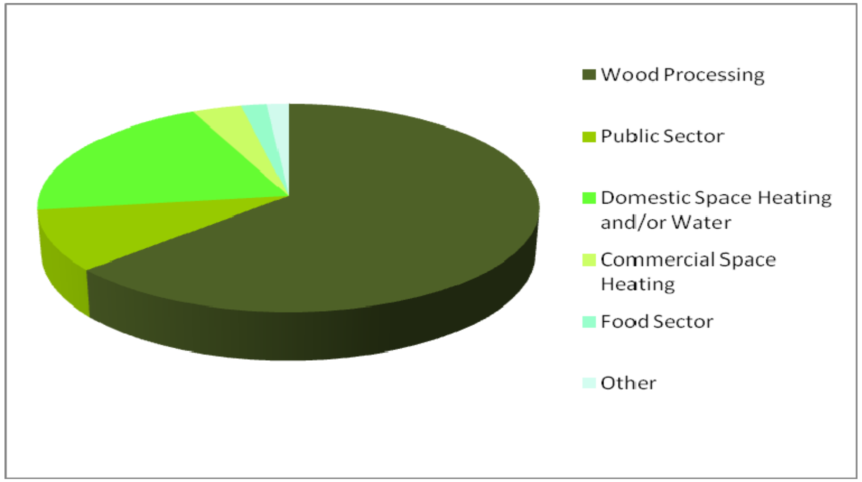


Table 5: Renewable Heat Output by use (2008/09)

	TOTAL CAPACITY 2008/09		TOTAL OUTPUT 2008/09	
	MW	% *	MWh	%*
Wood Processing	146.0	62.7	525,554	62.2
Public Sector	18.6	8.0	78,555	9.3
Domestic Space Heating and/or Water	52.4	22.5	183,007	21.7
Commercial Space Heating	10.2	4.4	29,642	3.5
Food Sector	2.5	1.1	15,498	1.8
Other	3.1	1.3	12,691	1.5
TOTAL	232.8		844,947	

* Percentage of existing renewable heat

Figure 5: Renewable Heat Output by use (2008/09)



4. Renewable Heat Projections

4.1 Introduction

The renewable heat database includes separate sheets under the headings 'under construction', 'consented not built', and 'planned'. These categories are necessarily loose, but a total of 39 plants are included as separate lines, with a further 44 aggregated (with particular care to avoid double counting). These are nearly all large or small to medium biomass plants (including waste to energy); we have not made assumptions about future domestic or community installations funded by the SCHRI or an equivalent. In addition to these, there is a number of proposed energy from waste plants logged by SEPA, which we have added without MW or MWh contributions, due to lack of accurate data.

Our conclusion is therefore that other large projects either in construction or with consent should increase the total output per year to 1.6TWh (2.8% of the total heat demand in 2020). Beyond this, known projects currently in various stages of development could add up to 2.7TWh (1.9% of the total heat demand in 2020), though there is high uncertainty associated with this figure.

We estimate that there is potential for waste sources to contribute at least 4.8% of Scottish heating needs. This is based on the potential for waste – particularly commercial and industrial wastes – to contribute to future energy needs through anaerobic digestion and thermal treatment.

This estimate has high uncertainty, and is for illustrative purposes only. This estimate is based on the following assumptions:

- **That 25% of Scotland's municipal waste is used for heat generation**. The Scottish Government has committed to set a cap on the amount of municipal waste that can be treated by energy from waste at 25%. Furthermore, such plant will need to be of high thermal efficiency, making it likely that all if not the majority will be CHP or heat only plant, rather than electricity only. However, this estimate assumes that the 25% cap is reached, and that the type of plant developed then provides usable heat.
- **That 25% of waste wood which is currently unrecovered, is used for energy recovery**. This estimate assumes that there is sufficient market pull (e.g. the Renewable Heat Incentive) and/or regulatory pressure (e.g. further tightening of landfill regulations) to support private sector investment in energy generation and infrastructure for waste wood collection.
- **That 25% of other biological sources such as sewage and food wastes are collected and treated by anaerobic digestion**. This estimate assumes, as above, that there is sufficient market pull and/or regulatory pressure to support private sector investment in energy generation and infrastructure for waste collection. It also assumes that biogas generated by anaerobic digestion is then used for provision of heat.

We have not made any attempt to quantify the likely future renewable heat output from micro-scale installations. These currently contribute some 130MWh.[12]

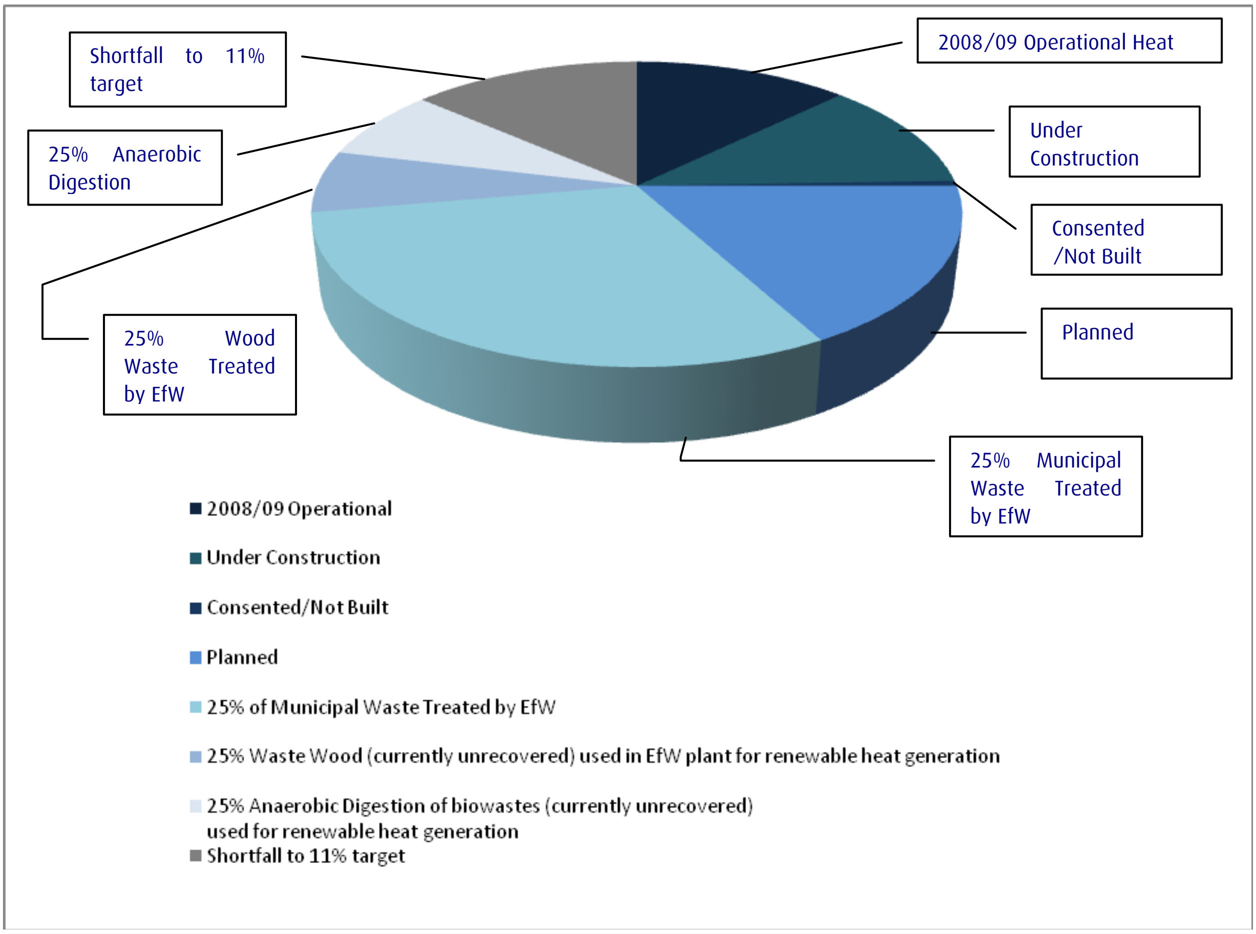
Table 6: Renewable Heat Projections

	2008/09 Operational Total Output (MWh)	Under Construction Total Output (MWh)	Consented/Not Built Total Output (MWh)	Planned Total Output (MWh)	25% of Municipal Waste Treated by EfW Total Output (MWh)	25% Waste Wood (currently unrecovered) used for renewable heat generation Total Output (MWh)	25% Anaerobic Digestion of biowastes (currently unrecovered) used for renewable heat generation Total Output (MWh)
Biomass primary combustion & CHP	722,609	689,200	36,822	384,314			
Waste treatment*	52,074	85,200		740,000	2,000,000	436,400	603,000
Solar thermal	6,666						
Ground source heat pumps	55,454						
Air source heat pumps	8,022						
Water source heat pumps	123						
Total	844,948	774,400	36,822	1,124,314	2,000,000	436,400	603.000
Cumulative Total	844,948	1,619,348	1,656,170	2,780,484	4,780,484	5,216,884	5,819,884
Percentage of Scottish Heat **	1.4%	1.3%	0.1%	1.9%	3.3%	0.7%	1.0%
Cumulative Percentage of Scottish Heat **	1.4%	2.7%	2.8%	4.7%	8.0%	8.7%	9.7%

* energy from waste, landfill gas and anaerobic digestion

** based on forecast non electrical heat demand in 2020

Figure 6: Renewable Heat Projections



4.2 Illustrating future renewable heat development

We have taken data on projects identified as either under construction, consented but not built or planned, and to these have added the potential for projects based on available waste resources.

Setting out these potential sources of renewable heat is **for illustration only**, to help the Scottish Government see how its renewable heat target could be delivered. Our illustrative projections are set out above in Table 6 and Figure 6.

However, there are other development paths available. For example, our estimates exclude the contribution of micro heat sources such as solar thermal panels, household scale biomass boilers and heat pumps. This exclusion is not because we have discounted the possibility that such technologies could play a significant role, but because we wanted to investigate what options exist for development of renewable heat from resources that are limited in nature (e.g. waste sources).

Solar thermal and heat pumps installations have significant potential, and rely on a renewable resource with a supply (solar energy) far beyond our heat needs.

Growth in capacity and output from these technologies is likely to be influenced by changes in fossil fuel prices and how future support mechanisms develop (such as the successor schemes to SCHRI - CARES and Home Renewables grants - as well as the planned Renewable Heat Incentive). In addition, the Government's Energy Assistance packages offer air source heat pumps as a renewable generation source to eligible fuel poor households in off-gas grid areas.

Their actual contribution will depend strongly on the level of support given, both through building regulations, planning (e.g. deemed permission) and through financial support (e.g. deemed generation through the Renewable Heat Incentive. We know that the Scottish Government is committed to or working on all of these issues.

It is however clear that if Scotland wishes to develop micro heat, it could learn from the experience in other European countries.

For example, in 2008 Germany installed 1,920,000m^2 (1.3GW) of solar thermal panels, and now has some 11,317,000m^2 (7.9GW) of solar thermal panels in use.[13] Scotland has a population approximately 5% that of Germany but only 0.11% of the level of solar thermal installations.[14]

Germany is by far the biggest solar thermal market in Europe. Many of the other strongly performing countries are from the Mediterranean. However, countries with a similar climate to the UK, such as the Netherlands, Denmark and Sweden, all have stronger solar thermal markets.

In Sweden for example, a total of 388,000m^2 (equivalent of 272MW) of solar thermal panels have been installed.[15] Sweden has a population of approximately 9m people, so an equivalent installation level for Scotland would be 150MW capacity,[16] approximately 15 times larger than the estimated Scottish capacity.

However, it is worth noting, that even at these higher installation rates, Scotland would only be meeting a small percentage of its renewable heat from solar thermal. If Scotland has installed a proportionate number of panels[17] to that of Germany, it would still only be getting approximately 0.6% of its total heat needs from solar thermal.

4.3 Known future developments

Biomass CHP

Two new large biomass CHP plants currently under construction are expected to add another 80MW of heat capacity and around 640TWh of thermal output. These are both expected to come on line in 2009. Another two CHP units, using waste streams as fuel, could add a further 90GWh (although there is uncertainty about whether all of this heat will be used, and whether it would qualify as renewable).

We know of at least another 57MW of planned biomass CHP capacity (either 'consented not built' or 'planned') that will burn wood or wood waste. These could add another 400GWh of output potential; meaning that wood biomass CHP plants currently under construction and planned could more than double Scotland's renewable heat output to approximately 2.5% of heat needs.

Energy from Waste

Generating heat from waste materials is likely to be a key future source of renewable heat in Scotland. This could include energy from waste, as well as use of landfill gas and biogas from anaerobic digestion. At present the Shetland energy from waste plant, which feeds 36GWh of renewable heat (no electricity generation) into the Lerwick district heating main, is the only energy from waste installation in the database. We know of several local authorities that are at various stages of considering energy from waste schemes. Both SEPA and Scottish Enterprise report several new planned projects since March 2009.

Scottish Enterprise is also involved in a number of projects that we have included in aggregate in the 'planned' spreadsheet. These include 44 plants with a total biomass heat capacity of 148MW,[18] and potential thermal output of 740GWh. The majority of these plants are waste-to-energy plants, using AD or other energy recovery technologies, many of which will be using technology which is not common in the UK. We do not necessarily expect all of these plants to be built, but the thermal output from these plants alone would add up to the total 2008/09 renewable heat output in Scotland. If added to the additional biomass CHP being planned, this could increase renewable heat output to approximately 4% of heat needs.

The emerging waste policy for Scotland is in line with EU hierarchy (prevention; re-use; recycling; recovery; landfill) but does recognise there is a role for Energy from Waste. In support of this, SEPA's Thermal Treatment Guidelines should ensure installation of high efficiency energy from waste plant utilising CHP or heat only generation.

Future Biomass Development

We know of at least another 13MW of additional non-CHP biomass ('Biomass Primary Combustion'), with potential output of 75GWh. This includes one 5MWth woodchip boiler and a number of smaller boilers due to receive funding from the Scottish Biomass Heat Scheme. We assume there are other small to medium biomass plants planned that we do not know about.

There is also undeniable potential for significant increases in woodfuel use for domestic heating in Scotland. One of the major CHP plants under construction is a wood pellet plant being built by Balcas. It will have a pellet output of some 100,000 ODT (equivalent to 490GWh of potential biomass *input*, which if burned in 85% efficient stoves could add some 400GWh of renewable heat output). Balcas expects a small proportion of this total (perhaps 5,000 ODT, equivalent to 21GWh) to be sold in Scotland in the short term. If the pellet and stove market develops in Scotland this source alone (other smaller plants are under construction) has the potential to nearly double Scotland's renewable heat output.

The Forestry Commission Scotland also agrees that there is good potential for increases in the use of local firewood (logs and woodchip) for space heating and domestic hot water. The 77GWh currently in the database for domestic biomass use (including pellets) is a very rough estimate, but there is little doubt that this could increase. Improving the average efficiency with which this resource is burned (by replacing open fires with stoves or boilers) would have a particularly significant effect.

5. Technologies – methodological issues

This section includes a more detailed discussion of data collection and other methodological issues regarding the individual technologies, and some observations on the potential for these technologies to contribute to Scotland's renewable heat output.

5.1 Non-household biomass (and district heating biomass)

Primary combustion of woody biomass contributes the majority of delivered renewable heat in Scotland. 'Large' and 'Small to medium' plants are relatively well understood.– The majority of non-domestic installations are either counted by the Forestry Commission's annual roundup of Woodfuel Use in Scotland and/or have received funding from the SCHRI community grant scheme. There is overlap between these two data sources, so the Forestry Commission's annual roundup of woodfuel use has been used in preference.

We have confidence in the primary data for existing large biomass plants, which consists of data on ODT burned, collected by the Forestry Commission. To get to actual renewable heat output, however, we need to make assumptions on boiler efficiency, assumed to be 90% for large plant, and 85% for smaller plant. Given that those biomass installations with Forestry Commission data make up the majority of all renewable heat in the database, these efficiency assumptions are very important.[19] Visiting each large site to check thermal efficiency, or – better – measuring actual heat output, would be a significant improvement.

We do know of at least one AD plant producing biogas which fuels a generator, with waste heat used for heating the digester and pasteurising the AD slurry. Because the heat is not measured this has not been included, but as AD becomes more common consideration should be given to whether this counts as renewable heat and if so how to measure the contribution.

It is also worth noting that the Scottish Government is currently funding a pilot scheme in Aberdeenshire to look at the use of heat from energy from waste. Gray Composting Services Ltd are running this pilot at an existing organic waste treatment site, and are testing the efficient energy recovery of heat from maturing compost. [20]

5.2 Household Biomass

Various estimates have been made for total woodfuel use in single homes in Scotland. The estimate we use is from a paper submitted in 2006 to *Biomass and Bioenergy*, and uses the results of an Omnibus Survey (2002) to estimate a total of 52,000 ODT of wood burned in open fires, wood stoves, and boilers. The authors stress that this estimate is subject to a very high margin of error due to the small sample size of biomass users in the Omnibus survey. Nevertheless, it does correspond relatively well to an estimated total of 100,000 wet tonnes/annum, which comes from extrapolating UK domestic woodfuel use figures.[21]

We have assumed average efficiency of fireplaces, stoves and boilers burning this woodfuel to be 30%. (Open fires are almost certainly less than 20% efficient, while stoves and pellet boilers may be over 70%). This is based on a very basic knowledge of the Scottish Housing stock, and limited information from the Omnibus Survey.

Better data on the amount of domestic woodfuel used, and the appliances it is used in, would allow a far greater degree of certainty about the amount of domestic renewable heat used. This could be achieved through an extension of the Forestry Commission's annual roundup of woodfuel use to include assessment of domestic woodfuel sold through log, pellet and chip suppliers (although this would still be an estimate and would miss informal woodfuel use), or a survey aimed specifically at assessing renewable heat use in domestic heating.

5.3 Solar Thermal

At the current time non biomass renewable heat makes a much less significant contribution to Scottish heating needs than biomass based sources, but it is also more difficult to get reliable data about.

SCHRI data from EST and CES suggest that solar installations that have received funding from the household and community streams of the SCHRI contribute some 4.7GWh per year. As described in Section 2.6, to account for non-grant funded installations, we have used a 50% multiplier to increase the capacity and output figure for solar panels and heat pumps. This number is based on discussions with EST, CES and solar and heat pump trade associations, but is only an estimate.

There could be considerably more solar thermal panels installed than we know about (both installed before the SCHRI funding began, and installed without any grant). There is also certainly potential for a massive increase in the use of solar thermal hot water – well over half of all detached homes in Scotland are theoretically suitable for panels.

5.4 Heat Pumps (and geothermal)

SCHRI information is also available for heat pump installations, suggesting a total of 15MW capacity installed to date, equating to a yearly output of 39GWh (assuming running times of **2,500 hours** where SCHRI applicants have not estimated MWh output directly). GSHPs make up nearly 90% of this total, with ASHPs on around 10% and a minimal contribution from WSHPs.

We have used the same 50% multiplier to account for estimated domestic heat pumps installed without SCHRI household stream funding. We have not included a multiplier for non-domestic installations. GSHPs are increasingly seen as a cost-effective alternative to oil boilers and the total figure of 21.3MW GSHP capacity may be a significant underestimate.[22] One additional large installation – at Vale of Leven CHC – is included in the database. Others may be missing.

As part of this study we also identified a small number of housing developments using heat pumps to tap heat within abandoned coal mines. These sites are often referred to as "geothermal" because they tap heat in water within flooded abandoned coal mines. This water is being heated to a level of approximately 12-14°C by geothermal action, but heat pump technology is needed to then raise the temperature of this water to a usable 55°C.[23]

It was also difficult to gain data from developers on actual renewable heat output in larger schemes. We were unable to find any clear data on the number of heat pump installations for single buildings using water from old mine workings.

Perhaps the most well known scheme in Scotland is the Glenalmond Street development in Shettleston, which was designed by John Gilbert Architects for Shettleston Housing Association. In this development 16 homes used water, which had flooded an abandoned coal mine under the site, to heat the homes. The water in the coalmine was some 100m below the ground and was tapped via a well hole and pumped to two heat pumps at the surface, before storage in a thermal storage tank. This system is also supplemented by solar thermal panels.[24]

Given (a) the small number of known installations, (b) the fact that this geothermal source needs to utilise heat pump technologies and (c) the difficulty of getting output data for these installations, we have classified these developments as heat pump installations. We are confident that their contribution to Scottish renewable heat targets is satisfactorily captured within the 50% multiplier used.

Finally, during the data collection process for the database a number of waste heat recovery units have come to our attention. These bear certain resemblances to ASHPs, but we have not included heat recovered from ventilation or other low grade building heat sources as renewable.

5.5 Heat from Renewable electricity

In addition to the 53% of Scottish energy use is for heating needs, it is estimated that one quarter of Scotland's electricity is used to generate heat. This represents five percent of Scotland's total energy needs.[25]

This five percent is usually classified within electricity figures to avoid double counting. However, it is worth being aware of the fact that if Scotland reaches its target to generate 50% of its electricity needs from renewables by 2020, half of all electrical heating will be renewable/low carbon.

It is also worth highlighting that there is already a number of wind-to-heat projects operating in Scotland, particularly in the outer Isles through SCHRI support. Most use 6kW Proven wind turbines feeding power directly into heat storage radiators at community buildings.

The electricity providing this heat is certainly renewable, and the installations will therefore be eligible for ROCs. We are aware that for many such installations ROCs are not claimed because of metering and regulatory issues surrounding ROC accreditation. However, to avoid double counting by Government we do not include any installation where renewable electricity is used for heating.

SCHRI figures from CES suggest there are 57 wind-to-heat installations totalling 0.342MWh, outputting some 855MWh to storage heaters. This assumes an output of 15MWh for each 6kW wind turbine in the Western Isles.

This is an issue that the Scottish Government may wish to look at more closely during discussions with the UK Government about the design of the Renewable Heat Incentive. While Government will need to avoid any double-counting or paying both ROCs and the RHI for any single unit of energy, Government must also avoid the situation where such projects are not being counted, because of exclusion from the RHI coupled with an inability to claim for ROCs.

Appendix A: Recommendations and Policy Discussion

A1. Maintaining & Updating the Renewable Heat Database

We recommend that the Scottish Government maintains this database, at least until the introduction of the Renewable Heat Incentive, as the primary source of data on renewable heat in Scotland.

Maintaining this database should be done at least on an annual basis. One individual with a good understanding of renewable heat terminology should be able to access the primary information sources (Table 2) and update the database within a week's work. **We recommend that an individual within Scottish Government takes responsibility for updating the renewable heat database and maintaining contact with the primary information sources.**

To assist this work, **we recommend that the Government insist on better and more consistent compilation of data sources** from organisations currently collecting information on renewable heat as part of delivery of grant schemes, and/or in support of Government policy.

These organisations include Community Energy Scotland, the Energy Saving Trust Scotland, the Forestry Commission Scotland, Scottish Enterprise and the Scottish Environment Protection Agency. At a minimum these organisations should collect data on capacity of installations, estimated annual output, fuel being replaced, expected carbon savings, as well as fuel type, location and date of installation. The Forestry Commission Scotland already collects this level of data for its own work and for Government bioenergy grant schemes. This needs to extend to other support schemes which support or track renewable heat installations, including waste plants.

The introduction of CARES to replace the SCHRI community stream represents a particularly good opportunity for the Government to ensure that CES collects more comprehensive data on projects being supported. This would enable CARES to report more accurately to Government on how community installations are contributing to renewable targets (both electric and heat).

When updating the database the Scottish Government needs to pay particular attention to the issue of double counting. We recommend that the Scottish Government considers applying a unique reference number to each renewable heat installation over 45kW, as well as maintaining the practise of listing alternate names and locations for installations.

Linking the Database with the Renewable Heat Incentive

We understand that a renewable heat incentive (RHI) of some sort is likely to be introduced in Scotland and the UK over the coming 2-3 years. Based on our database work, **we recommend that consideration is given to how this incentive can be structured to facilitate the collection of *energy* and *capacity* data on an *installation by installation* basis.**

In particular the RHI should be able to collect the following information on all installations claiming support:

- Renewable Thermal Capacity
- Renewable Thermal Output
- Fuel Source (e.g. municipal energy from waste)
- Technology (e.g. solar thermal) and type (e.g. evacuated tubes)
- Location/Address
- Installation Date.

We believe that a central renewable heat database, which includes characteristic information on an installation by installation basis, will be of great use to Government (and other organisations). We believe this to be the case even if the RHI in future enables a total capacity and output figure to be obtained more easily.

In addition, the Renewable Heat Incentive will need to consider how to support projects that use renewable electricity to generate heat, if those projects are either unable or choose not to claim ROCs because of technical or regulatory barriers.

Making data publicly available

We recommend that a summary version of the updated database should be made available publicly. This database will then become a definitive reference for renewable heat in Scotland. For logistical or confidentiality reasons this is likely to not include all columns and rows of the database. (This is something that needs to be treated carefully, given that there are commercial sensitivities. This would apply to sharing the data with the organisations below).

Publishing of this data would be particularly beneficial to other organisations working towards Scotland's renewable heat targets. Doing this will assist in collecting data that can be added to the master copy of this database. It will also help to give a clearer view of renewable heat development in Scotland. These organisations are likely to include:

- Community Energy Scotland
- Energy Saving Trust Scotland
- Scottish Renewables
- Sustainable Development Commission Scotland.

A2. Policy Recommendations for 2020

Woodfuel, including CHP

It is clear that there is a significant amount of large scale renewable heat plant in development. The identified large planned plants are, as with existing plant, primarily biomass using wood fuel. Of the 77GWh worth of plant currently under construction, 64GWh comes from biomass CHP plants being built at two wood processing sites: UPM Caledonian Paper at Irvine, and Balcas' pellet plant at Invergordon. Another 390GWh worth of woodchip CHP is either consented but not built, or in planning, including 200GWh from the Tullis Russell CHP plant in Fife.

All these plants will have identified, and possibly forward-purchased, an available wood fuel supply. There seems, therefore, to be potential to at least double heat delivery from forestry-derived fuels in Scotland.

From discussions with The Forestry Commission Scotland, however, we understand there are limits to the supply of domestic woodchip for large plants. Future large scale plants may therefore find it more challenging to establish bulk woodfuel contracts (using domestic supply), as has been the case for plants in operation or under construction. There is a projected increase over the next few years in the potential supply from the private sector forestry but accessing this volume is dependent on market conditions and coordination of the supply chain. Further bulk woodfuel contracts are likely to require a mix of materials including diversion of wood from established non energy markets (including export of low value wood), greater use of treated wood waste and or import of woodfuel.

FCS believes there is considerable scope for growth in– 'small to medium' and 'micro' biomass installations. These would, by and large, access more locally based wood supply chains, where there is potential to divert significant quantities of wood products to energy uses. Approximately 32GWh worth of small to medium heat-only biomass plant has received funding through the Scottish Biomass Heating Scheme (SBHS). It is clear that **there is very significant potential for a substantial increase in small to medium heat only biomass**. Experience in Austria has shown that significant penetration of woodfuel heating is possible using localised fuel supplies. Meeting a further 2-3% of heat from small to medium scale installations by 2020 seems feasible.

Scotland's Waste Strategy

Currently 36GWh of renewable heat are delivered from energy from waste (EfW) plant in Scotland – all from one thermal treatment plant on Shetland. This single plant currently provides over 4% of Scotland's renewable heat, taking as feedstock municipal solid waste, and some industrial waste, from Shetland and Orkney. Projects like the Shetland one are common in other parts of Europe, so there are no substantial technical barriers to replication in other towns and cities across Scotland.

The Scottish Government has set a cap of 25% on the amount of level of municipal waste[26] that can be used for the generation of energy. SEPA's New Thermal Treatment Guidelines[27] should ensure high thermal efficiency thresholds for energy from waste plants which will favour CHP or heat only installations. Our estimates show that based on 2008/09 levels of waste, and with similar performance to the Shetland scheme, using 25% of Scotland's municipal waste for heat generation, show that a further 2TWh of heat output could be delivered. This is equivalent to just over 3% of Scottish heating needs.[28]

As highlighted in our report *A Burning Issue*, SDC is supportive of a cap on the level of municipal waste being treated through energy from waste. We recommend against any action to increase this cap level. Instead, priority needs to be looking at options for better treatment of commercial, agricultural and industrial wastes.

A recent report published by Remade Scotland highlights that only 35% of waste wood is currently being recovered, and that 492,793 tonnes of wood waste are "unrecovered" (444,265 tonnes of this is from commercial and industrial sources, while the remainder is from municipal sources).[29] Based on a 20% moisture content in the "green wood", the report estimates that this would be equivalent to 394,234 oven dried tonnes of wood. If all this waste wood could be recovered and used for renewable heat it could generate up to 1.75TWh per year, which is the equivalent of 3% of Scottish heating needs.

Our research has identified one scheme in Dunfermline using landfill gas to provide electricity and heating through CHP use, but as the proportion of waste being sent to landfill declines, so the opportunity to tap and use landfill gas for generation will also decline. However, with the introduction of a Renewable Heat Incentive, it may be that other landfill gas generators consider CHP rather than electricity only combustion.

Of waste wood currently recovered, 73% goes into board manufacture, while 16% goes to the EON facility at Lockerbie for electricity generation. Remade Scotland note that there is potential for further development of waste wood recovery for energy recovery, but also highlights concerns about competition for the resource from board manufacture. To compete with the board manufacturing industry the energy sector would need to match or improve on the present average board mill prices of £31/tonne.

Beyond increasing use of waste wood for thermal treatment, there are also opportunities for treatment of waste biomass - particularly garden waste, food waste, sewage sludge and agricultural wastes – through anaerobic digestion. Reliable figures on the amount of such wastes theoretically available are hard to come by. The Scottish Government has estimated that up to 1,005,000 tonnes of waste produced annually in Scotland would be suitable for anaerobic digestion.[30] We calculate that this could produce between 0.4TWh and 2.4TWh of heat, depending on the thermal efficiency of the process and whether electricity only or CHP generation technology is used.[31] If 25% of this theoretical maximum was utilised, this would equate to 1% of Scottish heat needs.

For comparison, a recent National Grid paper estimated that "renewable gas" from anaerobic digestion or thermal gasification, could provide between 5% and 18% of UK gas demand. This would be the equivalent of up to 10% of total UK energy demand. [32]

There is already significant interest in the development of plant treating waste biomass. Scottish Enterprise reports that it is seeing increasing interest from the food and waste sectors in the use of energy from waste for waste treatment and energy generation. Its data indicates that schemes in development would provide approximately 70GWh worth of thermal output. This information has cross checked with data held by SEPA on applications for thermal energy treatment. It is clear from the SEPA information that there is significant interest in development of energy from waste to treat a range of waste sources. However, data held by SEPA does not provide reliable estimates of planned heat capacity or output. Data from neither source makes clear whether proposed developments would accord with SEPA's Thermal Treatment Guidelines. Data held by SEPA indicates that some 92MW of heat could be generated by the proposed schemes, which could provide approximately 300GWh of heat. However, only 9 of the 24 schemes that SEPA list on its database provide any information on expected energy generation. This total figure therefore cannot be judged as being reliable. Because of this, the information from SEPA has not been included in estimates of the contribution of planned energy schemes to Scottish renewable heat figures.

Given the close links between waste and energy policy, and the need to ensure that Thermal Treatment Guidelines are being followed, **it will be important that SEPA addresses the issue of how to better record energy data from proposed waste treatment plants**.

Despite uncertainty surrounding current data, it is clear that the Scottish Government's waste policy will have a role in achieving Scotland's renewable heat target. How waste policy encourages high efficiency schemes that utilise CHP or heat technologies will be of critical importance.

Government must pay particular attention to how it encourages treatment of agricultural, commercial and industrial wastes, as well as municipal waste. In delivery of waste and energy policies, further thought and attention is needed on the following:

- How to encourage heat users such as district heating alongside any energy from waste plants
- How to stimulate use of anaerobic digestion technologies in Scotland.

Government also needs to have clarity about how it expects a GB biogas market to develop. The interplay between support schemes such as the Renewable Obligation Certificates and the Renewable Heat

Incentive will be an important influence on how this market evolves. Biogas from anaerobic digestion can be utilised either locally on site through electricity generation, local CHP generation or local heat only generation. It could also be used as an input fuel for generation plant and in commercial and industrial heating at a national scale through injection into the mains gas grid.

Thermal treatment of waste has an important role to play in providing a sustainable means of waste treatment and energy generation. However, given that in waste policy the priority will remain action to reduce, reuse and recycle waste, the amounts of waste being available for thermal treatment will remain limited. Our assumption is that if 25% of suitable wastes (including municipal waste and commercial sources such as waste wood and other biological wastes suitable for anaerobic digestion) are used to generation of renewable heat, this will provide just below 5% of Scotland's heating needs.

District heating

There are several wood-fuelled heating networks on the database heating tens of buildings, but the Lerwick district heating scheme is the only significant renewable heat plant feeding heat into a district heating scheme at present.

We believe that district heating – whether using heat from a CHP or thermal only plant – is the most efficient way to heat closely grouped buildings using fuel. It certainly makes the conversion from fossil heating to renewable heating much simpler. Considerable moves towards district heating are probably necessary to achieve Scotland's interim and long term heat targets.

District heating already exists in locations throughout Scotland, and we understand that there is growing interest in the development of schemes in many parts of Scotland.

While it is likely that smaller scale district heating schemes could develop using wood fuel or energy from waste, in the short term any large scale urban district heating schemes will likely be fuelled by fossil fuel, particularly gas. This is due to the easy availability and the cost effectiveness of gas. Changing a small number of boilers or CHP units to burn biomass or accept solar thermal heat, however, is simple compared to changing thousands of domestic boilers. Supplying biomass fuel to district heating boilers is also considerably simpler than supplying thousands of individual boilers.

This means that **action to support district heating should be taken forwards as part of Government work to stimulate low carbon heat sources.** Renewable district heating is likely to be developed at a smaller scale and in more rural and semi rural locations initially, or alongside energy from waste developments. It should be supported as part of any overall action on low carbon heat. In the future, probably post 2020, switching of large district heating schemes to renewable heat sources will likely occur.

Micro-heat

Micro-scale installations currently provide around 15% of renewable heat delivered in Scotland, but there are big uncertainties around this figure.

We think it is likely that to achieve the 2020 target the majority of heat will come from large and medium scale installations; because it is easier for Government to influence change at a few large projects. As shown, our research identifies that larger scale plants in operation or under development could provide approximately 4% of Scotland's heating needs.

We have not added into our projected figures a contribution from micro heat sources. However, we are confident that they will make a more substantial contribution than they have to date, and so help to close the gap and contribute to the 11% target.

This shift will inevitably take time – a typical boiler is replaced every 15 years. It is important that the country starts to normalise non-fossil domestic heating soon. At some point within the next 10 years the expectation that new and refurbished homes are heated using fossil fuels will need to change. We see biomass heating of individual buildings becoming dominant in rural and some suburban areas, with waste or gas (supplemented by biomass) district heating dominant in urban areas, and solar thermal providing additional hot water in all situations. Heat pumps and electric heating will be a logical choice in very well insulated homes with minimal heat demand.

Support for micro and small scale renewable heat has to date been via grant payments for individual installations or associated infrastructure and wood supply. This is understandable as the industry develops, and reflects the higher capital cost of most renewable technologies compared to gas boilers. Capital grant schemes will not create a mass market for domestic renewable heat equipment. Other options, which are better suited to supporting tens of thousands rather than hundreds of installations per year, might include:

- Low interest loans
- A payment for renewable heat used (this would almost certainly have to be estimated)
- Carbon taxes on non-renewable heat, at the point of fuel delivery or import (this would have significant effects on fuel poverty).

Any scheme to encourage domestic renewable heat will have to be extremely simple. Hassle is a very significant non-financial barrier to micro-renewable installations, and a new scheme for micro-heat should need to be as low-threshold as possible.

A simple zero-cost intervention to avoid hassle in the future would be to oblige, through building controls, all new hot water tank installations to be dual coiled. This would enable solar, biomass or heat pump heat sources to be added at a later date.[33]

Domestic woodfuel use currently contributes 77GWh on the database – equivalent to the third largest single installation. Yet biomass installations that received money from the SCHRI only contribute around 9GWh of this. This indicates that most domestic woodfuel is used in low efficiency open fires or older stoves. **There is very clear scope for improving the efficiency of domestic woodfuel use by promoting the installation of efficient pellet stoves and/or wood boilers to replace open fires currently in use.**

The potential for individual biomass installations in urban areas is likely to be limited by updates to the Clean Air Act. In rural or semi-urban areas this action could focus on two particular interventions:

- Promoting the installation of domestic log stoves would provide a step change efficiency improvement in the burning of local woodfuel, if it leads to the replacement of open hearths. Increasing average domestic woodfuel efficiency from 30% to 50% would increase the total of renewable heat being produced from 77GWh to 128GWh, without increasing wood fuel use
- Domestic pellet boilers, and log stoves with back boilers, are common in parts of Continental Europe. Their installation would support local woodfuel supply chains, providing a step change in the amount of local woodfuel used.[34] The Forestry Commission is of the view that there is the capacity amongst local informal suppliers to increase firewood production and pellet plants currently operation or under construction have a capacity in Scotland of over 140,000 Oven Dried Tonnes (ODT) – equivalent to 419GWh if burned in 85% efficient boilers.

A3. Policy Recommendations for 2050

We welcome the Government's commitment to publish a 'Renewable Heat Action Plan', as recognition of the importance of renewable heat, and action on the ground to achieve the 2020 target. In the long run, though, we think that separation of renewable heat and non-renewable heat is counterproductive. The focus will need to be on low carbon heat and how this is delivered through a national heat policy.

An 11% target is achievable with no fundamental changes to the way heat is currently used, or the way renewable fuels (in particular wood and waste streams) are produced and delivered. However, to deliver the Scottish Government's target that greenhouse gas emissions are reduced to 80% of the 1990 level by 2050, will require much more significant changes in how we generate and use heat. Indeed, to reach the interim target of the Scottish Climate Change Act that emissions are reduced by 42% by 2020, it may be necessary to go beyond the 11% target before 2020.

Achieving the 80% target will necessitate a heat system where renewable heat is the dominant type. Delivering this will mean more of the same (considerable biomass and EfW) as well as some serious technical changes. Which, if any, of these changes happen will depend to some extent on changes to Scottish energy policy, but also on technical advances.

Step Change Technologies

We expect electricity generation to make use of 'waste' heat from generation as a matter of course. This is likely to mean more localised forms of generation more suited to CHP, and to making use of heat generated. Such plants could be fed from feedstock's including waste streams and wood, but also energy crops. A significant proportion of industry and homes will likely be connected to city-wide heat mains, with heat a metered commodity like electricity or water. New heat sources might also include deep geothermal mines.

Fuel cells may well become the dominant type of generation for biomass CHP units, possibly running on biogas (with internal reformation) that is fed into the existing gas network in concentrations near 100% from anaerobic digestion and other gasification plants. Domestic fuel cell CHP units will be common in cities with no district heating and where solid biomass combustion is problematic. In rural areas combustion is likely to remain the norm. For large heat loads advanced combustion of biomass, including biogas from the mains, will become the dominant heat-raising technology. Solar thermal technology will become widespread, with panels on all suitable roofs (alongside PV) and seasonal heat storage[35] common.

Achieving a majority renewable heat system will involve a close matching of heat demand from homes, industrial sites and commercial sites with heat sources. Heat planning is likely to become an important role of local government, or possibly utilities. The current situation in which householders and industrial sites are able to choose their heat source will become less common. Connection to district heating schemes will be required where these are present in cities. Where connection is impossible local electricity demand and renewable fuel availability will dictate whether biomass combustion, fuel cell CHP, or heat pumps are used for building heating.

In 2050 each unit of heat delivered to a building will certainly go further. Insulation will be such that heating demand in new homes will be less than ten percent of the current average. Energy used is likely to be a more significant cost in goods and services. This can lead to heat or fuel availability again becoming an important factor in firm's location decisions.

There are significant challenges for Scotland in moving to low carbon heat. Many of the changes will come about because of technical innovation, or regulatory changes that sit outside of devolved powers. However, given this **we have identified a number of areas that we would recommend the Scottish Government pay further attention to. These are longer term issues but will require Government support and planning in the short term, if the longer term potential is to be realised:**

Energy from waste: A key issue will be how to make effective use of the waste biomass coming from commercial and industrial sources. While some of this waste could be avoided (through reduction and reuse) or recycled, much will need some kind of treatment. Of particular relevance for Scotland is how to develop anaerobic digestion as a technology to treat agricultural and food wastes.

District heating: The priority for Scotland will be to encourage district heating, irrespective of fuel source. These installations can then be supplemented with renewable heat sources, and ultimately replaced, e.g. replacing gas fuelled boilers with biomass or biogas fuelled boilers. Government attention must therefore be on what mechanisms can best support installation of district heating both in new build, but in particular in existing building stock.

Heat Planning: To support the use of renewable technologies alongside the roll out of district heating, attention must be paid to heat planning within Scottish local authorities. Making use of heat mapping, local authorities will need to plan for heat as part of their wider structure planning. The Scottish Government should consider carefully how it can support local authorities in taking on this work, and how planning policy can guide this development.

Appendix B: Assumptions

The database includes a separate sheet with all important assumptions. These assumptions can therefore be changed, and the corresponding calculations throughout the database will be updated. We recommend that any users of the database check the assumptions made.

The assumptions sheet on the database includes a brief description and justification of each assumption made. These are detailed below:

Energy Content of Fuel

1 ODT equates to 4.92MWh thermal input; and 1 wet tonne at 50% MC equates to 1.899MWh thermal input.[36]

Energy Output from Fuel (combustion)

Taking the energy input from the assumptions above (in many cases known input of ODT) we have made the following assumptions on efficiency of thermal conversion.

- 90% assumed efficiency for 'large' plants (1MW or over)
- 85% assumed efficiency for 'small to medium' plants (45kW to 1MW)
- 30% assumed aggregate efficiency for 'micro' installations (<45kW).

The assumptions for large and small to medium plant are typical of nameplate boiler efficiency for large plant. The slightly lower number for small to medium plant reflects the expectation that these are likely to be run intermittently, with an associated efficiency penalty. Both these efficiency numbers may be higher than actual measured field output from plant, and it should be noted that small changes to these efficiencies will have a large effect on the total.

The 'micro' efficiency of 30% is designed to be an aggregate of the mixture of open fires (efficiency of 20% or below); wood burning stoves (efficiency 60 – 80%); and pellet boilers (efficiency 80% or more). Ideally the 30% reflects the composition of the 13-19MW of domestic biomass combustion capacity. It has been developed after discussion with The Forestry Commission Scotland and biomass boiler installers.

Plant Running Times

Where fuel usage is not known, plant has been assumed to run at full capacity for **8,000 hours per year** for large biomass (including CHP) and **5,000 hours** for small to medium industrial/commercial plant (unless actual running hours are known, or installation site suggests the heat is purely for heating and hot water). Where biomass energy is used for space heating and building hot water - including all micro installations - a running time of **2,500 hours** per year has been assumed. 2,500 hours has also been used for all heat pumps in domestic installations (assumed to be running for space heating and hot water). Finally, community buildings are assumed to require heat for just **250 hours** per year.

The 8,000 hours per year and 5,000 hours per year assumptions are relatively standard assumptions for industrial and commercial sites that require year-round heat or hot water. Irregularities are more likely to emerge from errors in allocating boilers to each category than with the assumption itself.

The 2,500 hours for heating is also relatively standard for heating / hot water run times in the UK (although arguably on the high side). It has been checked as reasonable with the EST, CES and the UK Ground Source Heat Pump Association.

All running time assumptions have also been reverse checked against installations where fuel use is known (energy output per year divided by capacity). This suggests that the running times assumptions above are at least in the right ballpark. This reverse checking also led us to introduce the very low 250 hours per year running time assumption for community buildings (where running time is not known).

Solar Output and Capacity

Solar capacity per m^2 is assumed to be 0.7kW and energy output per m^2 per year 0.42MWh (equivalent to 1500MJ). These appear to be standard assumptions, and are used by the Solar Trade Association to estimate total UK solar thermal capacity.

Both flat plate and evacuated tubes have been assumed to have the same capacity and output per m^2. This is clearly not the case (evacuated tubes are capture considerably more heat per unit area) but the data supplied by CES and EST did not enable us to separate the two technologies. In 2008/09 solar contributes a relatively low proportion of total renewable heat, so this is not considered problematic, but in future a separate assumption for the two technologies would be desirable.

Multiplier for micro-technologies installed without grant funding

Working out how many solar panels and heat pumps have been installed without SCHRI funding is seriously problematic.

We have discussed this matter with CES and EST, and some individuals from heat pump and solar trade associations. None feel qualified to suggest a multiplier, but none think that the decision to use a 50% multiplier is unreasonable.

This weak assumption will not have a significant effect on the total output or capacity figures, because the solar and heat pump component of the renewable heat total is under 10% of the total. However micro-heat installations (including biomass) are likely to make a significant contribution to renewable heat totals in the future. Better assumptions for this multiplier and the micro-biomass totals would improve confidence in the final total.

References & Endnotes

[1] Note there is considerable uncertainty regarding all totals, but particularly for micro-installations. Over half the micro-heat total is an estimate from Forestry Commission on domestic woodfuel use, which was based on a survey which identified a small subset of woodfuel users.

[2] Forestry Commission Scotland gathers data on woodfuel use, which is a key source for this renewable heat work (www.forestry.gov.uk/forestry/infd-6b2jgq).

[3] McKay, H. M., Hudson, B., Carr, R., Beck, C., Ward, S., Snowling, H. and Pendlebury, J. (submitted). Woodfuel Consumption in Scotland 2005-8. Biomass and Bioenergy. The total of 52,000 ODT corresponds well to extrapolations of 100,000 wet tonnes of woodfuel used in Scotland from Forestry Commission figures for UK woodfuel use.

[4] In the database, numbers with significant uncertainty are highlighted in light green; problematic numbers are highlighted in orange or pink.

[5] Total heat consumption is 60.089 TWh (figure supplied by Scottish Government).

[6] Scottish Renewables (2005) Scottish Renewables: *Delivering the New Generation*

[7] This 4% derived figure was 4% of 91TWh – so 4% of a higher number.

[8] Note some sites have more than one boiler or renewable heat source on site.

[9] Note that there is uncertainty around the proportion of domestic installations installed without SCHRI funding (see Section 2.6 – 'Micro Installations').

[10] 20 TWh derived from 230MW multiplied by 8,760 hours per year.

[11] This number includes 3,083MWh from SCHRI funded non-biomass installations, and 62,555MWh from biomass installations.

[12] Note there is considerable uncertainty regarding all totals, but particularly for micro-installations. Over half the micro-heat total is an estimate from Forestry Commission on domestic woodfuel use, which was based on a survey which identified a small subset of woodfuel users.

[13] EurObserv'ER (2009) Solar Thermal Barometer, June 2009. See http://eurobserv-er.org

[14] If Scottish estimated solar thermal capacity is 9.37 MW, an equivalent capacity to that installed in Germany would be 475MW. This is calculated as follows: 7,922 MW (German installed capacity) x 6% (percentage population difference). 475MW would produce an estimated 337,924 MWh heat. This would be 0.56% of Scotland's heat needs.

[15] EurObserv'ER (2009)

[16] If Scottish estimated solar thermal capacity is 9.37 MW, an equivalent capacity to that installed in Sweden would be 151MW. This is calculated as follows: 272 MW (Swedish installed capacity) x 55% (percentage population difference). 272MW would produce an estimated 107,424 MWh heat. This would be 0.18% of Scotland's heat needs.

[17] A proportionate number is taken as 6% of the level of panels installed in Germany to date.

[18] Note there is a concern that this capacity number includes heat from combustion of non-organic matter. The strictly renewable number is likely to be lower. There are also concerns that many of these projects currently have no heat user lined up (so the thermal output would not qualify as renewable heat).

[19] For example, changing these assumptions to 80% for large plants and 70% for small plants would decrease the total renewable heat output to 760,000 MWh.

[20] Funding pilot managed by Caledonian Environment Centre on behalf of the Scottish Government. See www.remade.org.uk.

[21] As referred to within the Scottish Government's Project Specification (20 Feb 2009) covering this work.

[22] We have been in touch with heat pump installers via the Ground Source Heat Pump Associations (whose members also install ASHPs). Responses received from a limited number of members suggest at least 8.5 MW of installed GSHP and ASHP capacity in Scotland for space heating (including a single installation at Vale of Leven CLC of 3.6MW). Using the assumed 2,500 hour running time this suggests around 22,000 MWh of heat output from heat pumps in Scotland – the domestic installations have not been included in the spreadsheet or the totals in Section 2 but provide a useful cross check.

[23] Communication with John Gilbert Architects, architects of the Glenalmond Street, Shettleston (16 homes) and Ochilview, Lumpfinnans (18 homes) housing schemes. Both schemes utilise heat from water in flooded disused coal mines to provide heating and hot water via heat pump technology.

[24] John Gilbert Architects (1999) Sustainable Housing Glenalmond Street: Technical paper describing development.

[25] Scottish Renewables (2005)

[26] For further discussion on energy from waste see the SDC Scotland 2007 Report *A Burning Issue.*

[27] SEPA (2009) Thermal treatment of waste guidelines 2009.

[28] This estimate is calculated as follows: Total Scottish MSW arisings (2007/08) = 3,380,771 tonnes. 25% of this is 845,193 tonnes. According to the Scottish Waste Statistics, the Shetland plant receives 15,207 tonnes of waste, from which 4.56 MW / 36,074 MWh of renewable heat are produced (note this is not the total heat produced but the calculated renewable fraction). If scaled up across Scotland this level of heat would be 253.34 MW / 2,004,964 MWh.

[29] Remade Scotland (2009) Arisings of Waste Wood from the Scottish Waste Management Industry for the Development of the Biomass Industry. Report to Scottish Government.

[30] Communication with Simon Stockwell, Scottish Government Waste Division

[31] This range of MWh/tonne comes from experience in the EU, where the conversion efficiency of energy from waste varies between 0.4MWh/tonne and 2.4MWh/tonne. Source: Energy from Waste. State of the Art Report. Statistics 5th Edition August 2006. ISWA Working Group on Thermal Treatment of Waste.

[32] National Grid (2009) The Potential for Renewable Gas in the UK.

[33] We understand some big heating installation companies are already doing this future proofing as standard.

[34] Increasing cell 'Existing N184' of the Renewable Heat Database.

[35] For an example of heat storage see case studies of the Drake Landing Solar Community in Canada (www.dlsc.ca).

[36] Mitchell, Hudson, Gardner, Storry and Gray (1990) Wood Fuel Supply Strategies Vol 1. The Report ETSU B 1176-P.1 (after discussion with Barrie Hudson).

Sustainable Development Commission

www.sd-commission.org.uk

England
(Main office)
55 Whitehall
London SW1A 2HH
020 7270 8498
enquiries@sd-commission.org.uk

Scotland
Osborne House
1 Osbourne Terrace, Haymarket
Edinburgh EH12 5HG
0131 625 1880
Scotland@sd-commission.org.uk
www.sd-commission.org.uk/scotland

Wales
Room 1, University of Wales,
University Registry, King Edward VII Avenue,
Cardiff, CF10 3NS
029 2037 6956
Wales@sd-commission.org.uk
www.sd-commission.org.uk/wales

Northern Ireland
Room E5 11, OFMDFM
Castle Buildings, Stormont Estate,
Belfast BT4 3SR
028 9052 0196
N.Ireland@sd-commission.org.uk
www.sd-commission.org.uk/northern_ireland