Following a request from Angus MacDonald MSP during the evidence session on 23rd May 2012, I am happy to enclose further details of the draft report by Element Energy and the Energy Savings Trust for WWF – “Scotland’s Renewable Heat Future”.

As we stated in our written evidence to the Committee, this draft report studies the potential impact of an RHI on the domestic heating market in Scotland and how policy can best be shaped to achieve the Scottish Government’s renewable heat target.

Initial findings indicate that:

- Uptake of renewable heat in Scottish dwellings falls well short of the levels required to meet ambitions for decarbonising heat supply.

- Continued intervention and significant transformation of the Scottish heating market over the next two decades is required to support renewable heating technologies to beyond 2030.

- High ambitions for renewable heat are unlikely to be met without a substantial contribution from district heating. However, there are significant barriers to delivering schemes under current market conditions.

- Given a sustained growth in demand for renewable heat technologies, supply chain expansion will also be crucial to meet renewable heat targets. A knowledge and skills gap also exists that could continue to restrict the development of district heating in Scotland.

I would like to emphasise that this is a draft report for WWF Scotland and has not yet been formally launched. It will undergo further development and revision before final publication by WWF Scotland later this year.

I trust the initial findings of this report are helpful to the Committee.

Best wishes

Andrew Watson
ScottishPower
# Contents

1 Summary ........................................................................................................................ 1  
   1.1 Overview .................................................................................................................... 1  
   1.2 Methodology .............................................................................................................. 2  
   1.3 Results ....................................................................................................................... 4  
   1.4 Conclusions ............................................................................................................. 14  
   1.5 Policy recommendations ......................................................................................... 17  

2 Introduction ................................................................................................................... 21  
   2.1 Context .................................................................................................................... 21  
   2.2 Definition of renewable heat .................................................................................... 22  
   2.3 Previous work on renewable heat ........................................................................... 24  
   2.4 Scope ...................................................................................................................... 25  
   2.5 Aims ......................................................................................................................... 25  
   2.6 Renewable heat ambition scenarios ....................................................................... 25  

3 Methodology ................................................................................................................. 27  
   3.1 Introduction .............................................................................................................. 27  
   3.2 Uptake of renewable heat in individual dwellings .................................................... 27  
   3.3 Renewable heat from district heating ...................................................................... 30  
   3.4 Stakeholder consultation ......................................................................................... 31  

4 Results and analysis..................................................................................................... 32  
   4.1 Introduction .............................................................................................................. 32  
   4.2 District heating ......................................................................................................... 32  
   4.3 Dwelling-scale technologies: baseline .................................................................... 37  
   4.4 Uptake in line with the CCC’s Medium abatement scenario ................................... 40  
   4.5 Renewable heat meeting 50% of domestic demands by 2030 ............................... 46  
   4.6 Sensitivity and policy analysis ................................................................................. 51  
   4.7 Wider energy system impacts ................................................................................. 54  
   4.8 Fuel poverty impacts ............................................................................................... 57  

5 Conclusions and policy recommendations ................................................................. 64  
   5.1 Meeting ambitions for renewable heat ................................................................. 64  
   5.2 Renewable heating technology mix ................................................................. 66
| AD       | Anaerobic digestion          |
| AQMA    | Air quality management area  |
| ARR     | Additional renewable resource|
| ASHP ATW| Air source heat pump (air-to-water) |
| BM      | Biomass                      |
| CBA     | Cost benefit analysis        |
| CCC     | Committee on Climate Change  |
| CHP     | Combined heat and power      |
| COP     | Coefficient of performance   |
| DECC    | Department for energy and climate change |
| DF      | Discount factor              |
| DH      | District heating             |
| ECO     | Energy Company Obligation    |
| EU      | European Union               |
| ESCO    | Energy services company      |
| FIT     | Feed-in tariff               |
| FREDS   | Forum for Renewable Energy Development in Scotland |
| GD      | Green Deal                   |
| GHG     | Greenhouse gas               |
| GSHP    | Ground source heat pump      |
| GWh     | Gigawatt hour (1GWh = 1,000MWh) |
| HA      | Housing association          |
| HP      | Heat pump                    |
| IAG     | Inter-departmental Analysts Group |
| IGZ     | Intermediate geography zone  |
| IRR     | Internal rate of return      |
| kW      | Kilowatt (unit of power)     |
| kWh     | Kilowatt hour (unit of energy) |
| LA      | Local authority              |
| LCOE    | Levelised cost of energy     |
| MW      | Megawatt (1MW = 1,000kW)     |
| MWh     | Megawatt hour (1MWh = 1,000kWh) |
| Odt     | Oven dry tonne               |
| ORC     | Organic Rankine Cycle        |
| RD&D    | Research, development and demonstration |
| RH      | Renewable heat               |
| RHI     | Renewable Heat Incentive     |
| RES-H   | Heat from renewable energy sources |
| RO      | Renewables Obligation        |
| SG      | Scottish Government          |
| SHCS    | Scottish House Condition Survey |
| SPF     | Seasonal performance factor  |
| SWI     | Solid wall insulation        |
| TWh     | Terawatt hour (1TWh = 1,000GWh) |
1 Summary

1.1 Overview

1.1.1 Context

With Scotland committed to achieving greenhouse gas emission reductions of 80% by 2050 (42% by 2020), transformations across all sectors of energy use will be required in the coming years. Decarbonising heat supply is one of the key aims of the Scottish Government, which seeks a largely decarbonised heat sector by 2050, with significant progress by 2030.

The Scottish Government has set a target to meet 11% of total heat demand with renewable heat by 2020. This is broadly consistent with the recommendations of the Committee on Climate Change (CCC), which include a 12% target for renewable heat supply in the UK by 2020.

Uptake of renewable heating technologies in Scotland and across the UK has been low to date, primarily due to the strong position of incumbent (fossil fuel) heating systems and the relatively high capital costs of alternative options. The introduction of the Renewable Heat Incentive (RHI) is expected to shift the balance, creating an economic case for installing renewable heating technologies and thus stimulating new markets. Phase 1 of the RHI (from autumn 2011) will provide support for non-domestic renewable heat installations; the second phase, which will be expanded to include the domestic sector, is expected to commence in autumn 2012. This study, which explores the potential impact of an RHI on the domestic Scottish heating market, is therefore timely.

1.1.2 Scope

The focus of this study is on the potential uptake of renewable heat in dwellings in Scotland, the barriers to adoption that householders face, and the additional policies that will be required to maximise the impact of an RHI in the domestic sector. The main technologies of interest at the individual dwelling scale are:

- Air source heat pumps (air-to-water) (for individual dwellings).
- Ground source heat pumps (for individual dwellings and medium scale systems serving tenement blocks / blocks of flats).
- Biomass boilers (individual boilers serving a single dwelling and medium size boilers sized to meet the demands of blocks of tenements / flats).

The potential contribution of renewable heat from district heating has also been considered. District heating could be fed with heat from any of the above sources in addition to other technologies including heat from biogas (from anaerobic digestion), heat from power stations / industrial processes, biomass-fired CHP etc.

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1 Reductions relative to 1990 emission levels.
Solar thermal technologies are also expected to be supported by the RHI. However, solar thermal installations are not replacements for heating systems (they supplement a primary heat source by typically meeting a portion of the annual hot water demands). Since this study’s uptake modelling is based on heating system replacement decisions, solar thermal (a discretionary choice) is not included in the main results.

1.1.3 Aims of study

This study sets out to address three primary questions:

- What could the renewable heat generation mix in Scottish households be in 2020 and 2030 under different scenarios of overall renewable heat ambition?
- What are the resulting upstream demands of renewable heating technologies (biomass fuel supply and electricity generation)?
- What are the barriers to delivering the levels of renewable heat deployment required to meet the ambitions, and what additional policies are needed to address them?

1.1.4 Renewable heat ambition scenarios

The research questions above are considered in the context of two over-arching ambitions for renewable heat uptake:

- Uptake in line with the Medium abatement scenario described by the Committee on Climate Change in the Fourth Budget report. This equates to a renewable heat contribution to total domestic heat demands in Scotland of around 2.5% and 30% by 2020 and 2030 respectively.
- Uptake in line with Scottish Government’s ambition to decarbonise the heat sector in Scotland by 2050. This is interpreted as 50% penetration of renewable heat in the domestic sector by 2030.

Note that both scenarios are consistent with longer term ambitions to decarbonise heat supply. The main difference is that the second (as described above) requires more rapid ramp-up of renewable heat deployment over the next two decades, whereas the CCC’s scenario includes more back-loading (i.e. higher penetration of renewable heat in the domestic sector in the period post 2030).

1.2 Methodology

Our approach to addressing the study’s research questions is based on a model of the uptake of renewable heating technologies in Scottish dwellings. Broadly speaking, dwellings’ thermal demands can either be met by individual (dwelling-scale) technologies, or via a community energy system, where one or more heat sources supplies multiple dwellings (i.e. district heating). Developing a district heating network requires coordination of multiple consumers, since the technical and economic viability of such schemes depends on achieving sufficient heat density and diversity of demand. District heating therefore represents a rather different proposition from the standard system in the UK, where individual consumers decide on a heating system for their building (typically at the end of the existing boiler’s useful life).

Given these fundamental differences in heating system decision-making, we need different approaches to estimate the contribution of renewable heat from installations in individual dwellings and from larger systems connected to district heating schemes. Our overall
modelling methodology is designed to deal with this issue and is summarised in the diagram below.

The uptake model of dwelling-scale technologies included a representation of the Scottish housing stock, the choice faced by consumers buying heating systems, and how consumers respond to the available options. The principal inputs are summarised below.

![Diagram showing District heating and Dwelling-scale technologies]

**Figure 1: Uptake model input assumptions**

The quantitative modelling was supplemented by a consultation exercise, which served to verify modelling assumptions and to gain input on barriers to renewable heat and potential policy mechanisms to support this emerging sector in Scotland. The consultation consisted of telephone discussions with around twenty stakeholders (conducted over summer 2011), covering representatives from Scottish Government, energy companies, consumer groups, charities, academia, and equipment suppliers and installers.
1.3 Results

1.3.1 District heating

Scenario-based uptake

As mentioned above, a scenario-based approach to estimating the potential for district heating in Scottish dwellings was employed. Assessment of key metrics (deemed important for district heating viability) was undertaken at the Intermediate Geography Zone (IGZ) level. IGZs with potential were filtered into those suitable for district heating (or not) according to the following criteria: average heat density, proportion of total gas demand from non-domestic consumers, and proportion of dwellings in the social renting sector.

Table 1: IGZ filtering criteria for assessing the potential for district heating

<table>
<thead>
<tr>
<th>IGZ filtering scenario</th>
<th>Minimum heat density (MW/km²)</th>
<th>Minimum proportion of total gas demand from non-domestic consumers</th>
<th>Minimum proportion of dwellings in the social renting sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower constraints</td>
<td>1</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Central constraints</td>
<td>2</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Upper constraints</td>
<td>3</td>
<td>50%</td>
<td>50%</td>
</tr>
</tbody>
</table>

We imposed different penetration levels of district heating uptake on to the reduced list of IGZs for each filtering scenario, using Low, Medium, and High levels, reflecting DH uptake in an increasing proportion of dwellings. Results from this assessment are summarised in the figure below, with three different scenarios in terms of the filtering criteria, each with Low, Medium and High DH penetration (representing potential uptake depending on the extent to which barriers are overcome).

Figure 2: Renewable heat delivered by DH in 2030 under each scenario

The large range in renewable heat delivered by district heating in 2030 under the different scenarios highlights the sensitivity of key inputs (heat density, non-domestic heat load as a

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4 There are 1,235 IGZs in Scotland and an IGZ contains between 900 and 5,400 households.
proportion of total demand etc.). The ‘High’ scenarios are extreme cases in which half of all dwellings in feasible areas connect to district heating by 2030. These results suggest that while district heating has a role in meeting Scotland’s renewable heat ambitions, renewable heat delivered via district heating is unlikely to meet the targets alone. Individual dwelling-scale technologies will also be important and we consider their role below.

1.3.2 Baseline results and impact of RHI duration

The baseline defined in this study is set by current and announced policy commitments (as of summer 2011) and includes ‘central’ case assumptions regarding the main variables that affect uptake of renewable heat (such as supply chain growth rates, fuel prices etc.). At the time of writing no budget for RHI support for new installations beyond 2015 has been confirmed. The baseline therefore includes support for new installations up to and including 2015 only.

The results below show projected uptake of renewable heat in Scottish dwellings under the baseline. We also consider the impact of alternative RHI duration levels by extending the period under which new installations are eligible to receive RHI support. In the RHI to 2030 scenario the contribution of renewable heat from district heating is based on the Central constraints_Medium scenario. With no or short-term RHI support we assume that the contribution of renewable heat from district heating will be negligible.

Note that throughout the study we assume that all installations that are initially eligible continue to receive RHI support for their full lifetime.
Figure 3: Renewable heat delivered in 2020 and 2030: baseline and RHI duration scenarios

The results above reveal:

- Without continued RHI support beyond 2015, uptake of renewable heat in dwellings is likely to fall well short of the level needed to meet the Scottish Government’s 2020 target.
- Of the renewable heating technologies considered, ASHPs are the primary contributor to renewable heating targets in the domestic sector. This is largely due to the lower capital cost of this technology (relative to the other renewable heating options) and more restrictive suitability constraints on biomass boilers and GSHPs.
Without significant cost reductions in renewable heating technologies (not expected), or unforeseen technology development, continued intervention (to at least 2030) is likely to be required for renewable heat to compete with the incumbent options. This is in contrast to the philosophy of the feed-in tariff for PV for example, which aims to drive a technology down a cost curve over the next decade to a point where it competes without additional support.

1.3.3 Meeting the CCC’s Medium abatement scenario

The Committee on Climate Change has set out an ambition for around 35% of the UK’s total heat demands in 2030 to be met by renewable heat. Analysis by the CCC suggests that the contribution from different sectors may vary (e.g. domestic (dwellings), commercial, industrial), and RES-H delivered in Scottish dwellings should equate to around 30% of 2030 heat demands.

We have developed various scenarios under which this level of ambition could be met:

- **High fuel prices** – all fuel prices rise in line with DECC’s High projections.
- **High supply-side growth** – lower supply-side restrictions (equivalent to maximum year-on-year growth of 61% to 2020 compared to 46% in the baseline).
- **Reduced hassle barriers** – time to research new technologies is included for renewable heating options in the baseline (c.£250 per installation). This scenario represents this barrier being removed, e.g. through increased familiarity with the technologies (effective marketing / awareness campaigns etc.).
- **Reduced renewable heating technology costs** – capital costs of renewable heating technologies can vary substantially with installation site. The baseline cost assumptions are relatively conservative and this scenario explores the impact of reducing costs for GSHPs by 15% and biomass boilers by 10% (with no change in the RHI support levels from the baseline).
- **High fossil fuel boiler costs** – in this scenario the RHI is continued to 2020 only, and from 2021 fossil fuel boiler costs are increased (initially by a factor of 2.5 (in 2021), rising to 4.3 by 2030 (linear increase)). This represents a future where renewable heating technologies are supported by increasing the costs of alternative options (rather than subsidising renewable heat).
Figure 4: Scenarios with overall RH uptake in Scottish dwellings in line with the CCC Medium abatement scenario

The different mix of technologies between the CCC’s and this study’s results is largely a result of differences between the modelling approaches:

- The CCC’s Medium abatement scenario results are based on considering uptake using the social cost of carbon abatement, which includes the use of a ‘social’ (i.e. low) discount rate. This is distinct from approaches (such as that used in this study) that consider potential uptake by modelling consumer behaviour. The approach used here is more robust given that it considers what consumers might actually purchase, rather than what is optimal from a social perspective.

- Other distinctions include differences in capital cost assumptions for renewable heating technologies (validated in this study against grant scheme cost data) and fuel (particularly electricity) price projections.

Heat pumps play a major role in the domestic sector by 2030. The high reliance on heat pumps (particularly ASHPs) in meeting RES-H ambitions has a number of implications:

- Upgrading the insulation levels of Scottish dwellings will be important to ensure that the seasonal performance factors assumed are achieved in practice (i.e. SPF of 2.5 for ASHPs installed in 2011, rising to 3.5 for installations by the middle of the 2020s).

- Additional demands arising from heat pump uptake will need to be considered and factored in to investment decisions on new generation capacity and grid upgrades.

The scenarios presented above represent a significant transformation of the Scottish heating market, and delivering this level of renewable heat will require a combination of:

- Providing a sufficient financial case for consumers to consider installing a renewable heating technology.

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6 “Social” cost of carbon is a term used by governments in economic evaluations and refers to attempts to ensure that societal impacts of carbon emissions are included in economic evaluations of policy impacts.
- Raising awareness of renewable heat amongst consumers; and inspiring confidence in consumers regarding renewable heating technologies to a level where they will consider switching from the incumbent systems.
- Developing and sustaining supply chains to meet growing demand and delivering sufficient after-sales service.

Next we consider scenarios under which a stretch ambition (50% of all domestic heat from RES-H by 2030) could be met.

### 1.3.4 Renewable heat meeting 50% of domestic demands by 2030

Given the relatively slow turnover rate of building heating systems, a 50% renewable heat target for 2030 is highly ambitious. We have developed a number of alternative scenarios that could meet the ambition, as summarised in the following table.

#### Table 2: Scenarios to achieve 50% renewable heat in Scottish dwellings by 2030

<table>
<thead>
<tr>
<th>Scenario</th>
<th>District heating scenario</th>
<th>Dwelling-scale technology uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier removal</td>
<td>Central constraints_High</td>
<td>RHI to 2030&lt;br&gt;Time to research technology barrier removed&lt;br&gt;High supply side growth rates&lt;br&gt;High fuel price projections</td>
</tr>
<tr>
<td>Increased RHI (all)</td>
<td>Central constraints_High</td>
<td>RHI to 2030&lt;br&gt;RHI levels increased by 4% (all technologies)&lt;br&gt;Time to research technology barrier removed&lt;br&gt;High supply side growth rates</td>
</tr>
<tr>
<td>Increased RHI (GSHP, BM boilers)</td>
<td>Central constraints_High</td>
<td>RHI to 2030&lt;br&gt;RHI levels increased by 30% (GSHPs and biomass boilers only)&lt;br&gt;Time to research technology barrier removed&lt;br&gt;High supply side growth rates</td>
</tr>
<tr>
<td>FF boiler tax</td>
<td>Central constraints_High</td>
<td>RHI to 2020&lt;br&gt;Time to research technology barrier removed&lt;br&gt;Capital costs of fossil fuel boilers increased from 2021: 2.5x baseline values in 2021 up to 4.3x baseline values in 2030 (linear increase)</td>
</tr>
<tr>
<td>High gas, High oil prices</td>
<td>Central constraints_High</td>
<td>RHI to 2030&lt;br&gt;Time to research technology barrier removed&lt;br&gt;High supply side growth rates&lt;br&gt;Gas and oil price projections from 'high' scenario</td>
</tr>
<tr>
<td>DH-led</td>
<td>Lower constraints_High⁷</td>
<td>RHI to 2030&lt;br&gt;Time to research technology barrier removed&lt;br&gt;Increased confidence⁸</td>
</tr>
</tbody>
</table>

⁷ The 1MW/km² figure is based on experience from Scandinavia. However, the economic analysis undertaken suggests that DH uptake based on this assumption represents a very optimistic scenario.
⁸ This was modelled by reducing the discount factor used in the RHI coefficient to 16% (from the baseline value of 20%).
With the exception of the *DH-led* scenario, achieving ‘high’ supply side growth rates is a prerequisite to meeting the 2030 50% renewable heat ambition, as is the need to provide some form of financial support for renewable heating technologies. Note also that in each of the scenarios, the ‘High’ scenario for district heating uptake is applied; which equates to half of all dwellings in areas with favourable characteristics connecting to district heating. The renewable heat mix in Scottish dwellings under these scenarios is presented below.

**Figure 5: Heat delivered in Scottish dwellings in the decarbonised heat sector scenarios**

In each scenario we assume rapid rollout of insulation measures (additional insulation being applied to around 200,000 dwellings per year) to reduce demand for heat (by c.25% relative to today’s levels) and increase the suitability of the building stock for renewable heat.\(^9\) A summary of the implications of these results is:

- Improving the efficiency of the stock will be crucial to meeting such targets.
- Strong financial support for renewable heat (e.g. through subsidy or making alternatives more costly) to 2030 and beyond will also be required.
- Confidence in the long-term future of renewable heating markets is needed to attract investment in supply chains to deliver the necessary growth rates.
- Given the high reliance on heat pumps (primarily ASHPs), efficiency improvements for this technology will be critical (such that average SPF values for new installations reach at least 3.5 by the middle of the next decade).
- Each scenario requires a combination of ‘high’ input assumptions (e.g. on supply side growth rates and fossil fuel prices), and removal of barriers associated with unfamiliarity with renewable heating technologies.

\(^9\) Rollout of energy efficiency measures assumed is consistent with the Scottish Government’s *Report on Proposals and Policies* (p.53), which includes a 2020 milestone for every home to have loft and cavity wall insulation (where cost-effective and technically feasible), and solid wall insulation in *many of Scotland’s homes by 2020*. 
• It is highly unlikely that this ambition will be met without the rollout of renewables-fed district heating. This presents a challenge given the economics of district heating in the current market (even with an RHI) – see above.

• In the DH-led scenario renewable heat from district heating provides 30% of the total renewable heat delivered in 2030, equivalent to c.350,000 Scottish dwellings connected to (renewables-fed) district heating by 2030. This is equivalent to 50% of all households in Aberdeen, Dundee, Edinburgh and Glasgow being connected to district heating systems. This level of uptake would demand strong leadership from the public sector and firm commitments to develop large scale schemes connecting a mix of domestic and non-domestic building types.

1.3.5 Sensitivity analysis

The model developed to assess uptake of renewable heating technologies at the individual dwelling scale contains a wide variety of inputs. There are of course many uncertainties when looking twenty years into the future and we have stress-tested the results against numerous sensitivities. Highlights from this analysis are presented below.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

Figure 6: Renewable heat delivered in Scottish dwellings in 2030 under a selection of sensitivity scenarios (all include RHI to 2030)

From the results above we conclude:

• There is limited scope to reduce subsidy levels if uptake is to be sufficient to realise CCC and Scottish Government renewable heat ambitions (all RHI support is reduced by 20% in the RHI_80% scenario).\(^{10}\)

• Soft (low interest rate) loans for the full amount of additional capital cost consumers face when buying a renewable heating technology (Loan 3.5% scenario) could increase uptake. However, loans at commercial rates (Loan 15% scenario) are unlikely to be effective in facilitating greater levels of RES-H delivery.

\(^{10}\) Assumed initial RHI support levels for individual domestic installations: £75/MWh (ASHPs), £70/MWh (GSHPs), £90/MWh (biomass boilers).
- Provided an RHI is in place, heat pumps continue to appear attractive to many consumers under the High high gas and oil scenario, but their uptake is severely restricted under the High high elec. prices scenario.¹¹
- Restricted supply side growth rates (equivalent to 36% average year-on-year growth to 2020 (Low) as opposed to 46% (Central)) would pose a threat to meeting RES-H ambitions.

The following scenarios show the impact of less optimistic assumptions on heat pump efficiency values (SPFs), and cost reduction forecasts. The results of two of the suitability scenarios are also presented: HPs_50% (half of all dwellings assumed to be suitable, compared to c.70% in the baseline), and HPs – off-gas only (a scenario with restricted heat pump uptake, for example as a result of a lack of permitted development rights).¹² The confidence scenarios involve varying the discount factor used to calculate a key coefficient in the uptake modelling. The baseline value of 20% is varied between 8% (low rate reflecting high confidence) and 32% (high rate reflecting pessimistic attitudes to the RHI).

![Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

Figure 7: Renewable heat delivered in Scottish dwellings in 2030 under a selection of confidence and heat pump performance and suitability scenarios (all include RHI to 2030)

From the results above the following is clear:

- Failure of heat pumps to achieve SPF levels assumed in the baseline is likely to have a significant impact on renewable heat delivered, reducing it by 25% relative to the base case.¹³

¹¹ Note however that high electricity prices improve the economic case for CHP.
¹² The main concerns relating to ASHPs (and reasons why they are not currently permitted development in Scotland) are noise (from fan and compressor of the external unit), vibration and visual impact. These issues tend to be more difficult to mitigate in areas of higher housing density, hence the choice of allowing heat pumps in off-gas areas only for the lack of permitted development rights scenario.
¹³ Baseline SPF values in retrofit applications are 2.5 (2011), rising to 3.5 (2030) for ASHPs and 3.3 (2011), rising to 4.3 (2030) for GSHPs.
• Equally, RES-H ambitions will be undermined if technology cost reductions do not come about (while the RHI is degressed over time).

• The suitability of heat pumps in Scottish dwellings is a key factor and also an uncertain parameter. Failure of heat pumps to penetrate the heating market across the full range of dwelling types will lead to RES-H ambitions being missed, or necessitate alternative solutions to make up the shortfall.

• There is a wide range of potential outcomes depending on consumers’ attitudes towards the RHI. Renewable heat uptake will be maximised by providing long-term certainty on the policy landscape and instilling confidence in consumers in relation to the ability of technologies to meet their needs.

### 1.3.6 Wider energy system impacts

The results above suggest that decarbonising heat supply will involve a significant shift in the heating market, with greater reliance on electricity for heating via heat pumps in the future. This section considers the wider impacts of renewable heating technology uptake by assessing the impacts on the electricity grid for selected scenarios.

**Figure 8: Electricity demands due to heat pump uptake in the domestic sector in Scotland under a selection of scenarios**

- **Baseline (RHI to 2015)**
- **RHI to 2030, high fuel prices**
- **Barrier removal**
- **DH-led**

% values show electricity demands due to heat pumps relative to total forecast electricity demands in Scotland.
This analysis suggests that:

- Uptake in line with the CCC Medium abatement scenario leads to additional average annual electricity demand from heat pumps by 2030 which is less than 7% of total forecast electricity demands in Scotland. This represents a 20% increase on 2008 domestic sector electricity demands.

- The overall increase in electricity demands (including average over the year and peak demands) due to heat pump uptake is expected to be manageable within upgrade plans over the next two decades.

However, local issues (on distribution networks) could arise where clusters of heat pumps are connected. Identifying where such clustering might occur and the associated impacts is beyond the scope of this study. High reliance on heat pumps could also lead to upward pressure on electricity prices (as additional investments will be required in generation plant and distribution networks). The impact of high electricity prices on renewable heat uptake is shown in the sensitivity analysis above, and the results show that although total renewable heat delivered could fall significantly, heat pumps still dominate the overall mix in the domestic sector.

### 1.4 Conclusions

#### 1.4.1 Meeting ambitions for renewable heat

1) Based on current policy commitments (i.e. RHI funding to 2015 only), uptake of renewable heat in Scottish dwellings falls well short of the levels required to meet ambitions for decarbonising heat supply.

2) There are numerous pathways to achieving renewable heat uptake in line with the CCC’s Medium abatement scenario; however all require continued intervention to support renewable heating technologies to beyond 2030 and significant transformation of the Scottish heating market over the next two decades.
3) Meeting a stretch ambition of renewable heat contributing 50% of domestic heat demand by 2030 would require a greater reliance on renewable heat from district heating combined with very rapid ramp up in dwelling-scale renewable heat technology sales.

4) The results are based on a very aggressive insulation rollout programme to upgrade the energy efficiency of Scotland’s dwelling stock. Failure to adequately insulate homes could lead to heat pump efficiency values not being achieved and undermine medium to long term renewable heat targets.

5) The Renewable Heat Incentive is a novel policy and consumer reaction to the RHI is highly uncertain. Modelling results are therefore indicative only and further work to understand consumer attitudes to such support mechanisms is advisable.

6) High ambitions for RES-H are unlikely to be met without a substantial contribution from district heating. However, there are significant barriers to delivering schemes under current market conditions.

7) The costs of meeting renewable heat ambitions are likely to be substantial and need to be balanced against the benefits an RHI could deliver.

1.4.2 Renewable heating technology mix

8) In each scenario considered, uptake of dwelling-scale technologies is dominated by ASHPs. However, the penetration of this technology into Scotland’s domestic heating market will depend on improving insulation standards of the dwelling stock.

9) A greater contribution from ground source heat pumps and biomass boilers may be expected if the additional capital cost of renewable heating technologies could be reduced, for example through low interest loans.

10) The development of district heating networks will provide an opportunity for increased diversity of heat supply. The precise mix of heat supplied via such networks will be dictated by local conditions and the policy framework.

11) Residential-led retrofit district heating schemes are unlikely to be economically competitive against gas or oil boilers, but could provide heat at a competitive price against direct electric heating.

12) A combination of reasonably high heat density and high heat consumption per connection (which necessitates non-domestic connections) is required for district heating to deliver renewable heat at a cost competitive with oil or gas boilers.

1.4.3 Barriers and risks to meeting renewable heat ambitions

13) The single largest barrier to renewable heat uptake has to date been the lack of an economic case. The RHI is expected to provide sufficient incentive to stimulate the renewable heating market but may not be accessible to all consumers. Without a breakthrough in technology costs, the renewable heat sector is likely to be dependent on financial support through to 2030.

14) Given the fundamental importance of heat generation to people’s everyday lives, financial incentives alone are unlikely to be sufficient to drive significant uptake. High consumer confidence in the technologies will also be required.
15) Given sustained growth in demand for renewable heat technologies, supply chain expansion will also be crucial to meet RES-H targets. Failure of supply chains to develop is a key risk to be managed.

16) To play a full role in meeting RES-H ambitions, the average seasonal performance factors of heat pumps must increase relative to values observed in UK field trial data.

17) With an RHI of £90/MWh, biomass boiler uptake in the domestic sector is relatively insensitive to biomass price. However, high electricity prices could severely restrict the uptake of heat pumps.

18) The high capital cost of renewable heating technologies could prove a significant barrier for many consumers, even with ongoing RHI support.

19) The provision of loans could help overcome the capital cost barrier. However, increased renewable heat uptake is only expected with medium to low cost finance.

20) Furthermore, loans will have to be sufficiently large to cover a high portion of the additional capital cost of renewable heating technologies.

21) A major barrier to the development of district heating is the lack of a robust financial case (and high risks), especially for retrofit schemes.

22) A knowledge and skills gap also exists that could continue to restrict the development of district heating in Scotland.

23) There are multiple other barriers to district heating deployment and although some are reducing, the consensus from stakeholders was that there is insufficient progress for district heating to make a substantial contribution in the short to medium term.

1.4.4 Wider impacts of renewable heat uptake

Energy system impacts

24) The additional demands for electricity (in terms of average annual demands and national peak demands) due to heat pump uptake in the domestic sector under the RHI are expected to be manageable in the period to 2030.

25) However, local clusters of high heat pump penetration would be likely to strain local distribution networks and further research is required to understand the scale of the challenge.

Fuel poverty implications

26) Opportunities for the RHI to benefit those in fuel poverty are likely to be very limited unless low to zero cost finance can be provided to such consumers.

27) Policies to reduce fuel poverty should focus on reducing demand for energy, increasing the efficiency of heating systems, and increasing household income.
1.5 Policy recommendations

This study's results highlight the scale of the challenge in meeting ambitious renewable heat targets on the path towards decarbonising heat by 2050. Further actions (to supplement the RHI) will be required and we propose a number of key priorities below.

1.5.1 District heating

- The Scottish Government should continue to make low interest loans available for capital spend on district heating projects under the District Heating Loans Scheme until at least 2020.
- The Scottish Government should introduce loans for development work on district heating projects, to initially cover the 19 local authority areas not covered under the JESSICA programme.
- The Scottish Government should ensure their discussions and analysis of options relating to implementing Section 64 of the Climate Change (Scotland) Act 2009 include consideration of district heating.
- Local authorities should be required to develop a strategy and implementation plan for district heating in their area.
- Local authorities should be trained in using and interpreting the information generated from existing heat mapping work.
- The Scottish Government should provide local authorities with powers to require that heat users, including householders at the point of heating system change, connect to a district heating system in all or part of their areas.
- The Scottish Government should consider encouraging local authorities to develop a zoned approach to district heating.
- Local authorities should be required to commit to connect their public buildings to district heating networks where possible.
- Local authorities and housing associations should be compelled to consider district heating when planning housing stock upgrades.
- Planning authorities should require consideration of district heating in new developments (including the potential to connect to existing district heating systems).

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15 Joint European Support for Sustainable Investment in City Areas (JESSICA) is a programme of urban development funds. The Scottish Government and European Investment Bank have recently announced the selection of a preferred bidder to manage a new £50 million investment fund which will offer loans and equity investment to revenue generating projects in 13 local authority areas in Scotland. See: [http://www.scotland.gov.uk/Topics/Built-Environment/regeneration/jessica/FundManagerAnnouncement](http://www.scotland.gov.uk/Topics/Built-Environment/regeneration/jessica/FundManagerAnnouncement).

16 This was another recommendation from the Heat and the City workshop (September 2011).

17 In Denmark local authorities have the power to require that all or part of a local authority area connect either to a natural gas supply or district heating (Executive Order no. 581 of 22 June 2000 on connection etc., to public heat supply installations). The degree to which this power is exercised varies considerably from area to area. For further information see: [http://193.88.185.141/Graphics/Publikationer/Forsyning_UK/Heat_supply_in_Denmark/html/full_publication.htm](http://193.88.185.141/Graphics/Publikationer/Forsyning_UK/Heat_supply_in_Denmark/html/full_publication.htm).
schemes) through their Development Plans and development management policies.

- Information sharing networks should be created to facilitate information exchange between local authorities and, ideally, loan funding should be able to cover the procurement of expertise to aid scheme development.\textsuperscript{18}

- The Scottish Government should develop, or fund the development of a) ‘off the peg’ legal and business models for district heating schemes in Scotland based on UK-wide best practice, b) guidance on the development of ESCOs, c) best practice and d) generic models for the ongoing operational aspects of a community energy scheme, including cost transparency around maintenance and billing costs.

- A single ‘portal’ of advice, signposting, and new and existing case studies of district heating in Scotland should be developed.

- Local authorities should improve the training of planning officers by increasing the resources available for practical training on district heating and renewable heat sources.

- The Scottish Government and other stakeholders (including Ofgem and the National Grid) should work together to provide more resources to simplify and speed up the grid connection process and provide district heating developers with guidance on transmission charges and grid connection charges.

1.5.2 Microgeneration

- The UK and Scottish Governments should provide clear indications of the long-term support framework for renewable heat (i.e. to at least 2030), to support both dwelling scale technologies and renewables-fed district heating.

- The UK Government should extend the RHI (or an equivalent support mechanism) beyond the current commitment period (2015) to at least 2030.

- The UK Government should include minimum energy efficiency measures as an eligibility criterion for the domestic RHI.

- The Scottish Government should consider regulation as a potential part of the policy mix to drive the uptake of renewable heat technologies at the individual dwelling scale.

- The Scottish Government should continue to make loans available to households for renewable heating technologies.

- The Scottish Government should work closely with the UK Government to investigate and implement additional ways of removing the capital cost barriers faced by those considering installing renewable heating technology.

- The Scottish Government should continue to support a single point of contact for households looking to install renewable heating technologies through the Energy Saving Scotland advice network.

\textsuperscript{18} The Heat and the City project is proposing to host further focus groups / workshops, and develop information and expertise exchange for energy practitioners and local authorities in the UK. See: http://www.heatandthecity.org.uk/__data/assets/pdf_file/0007/71926/Heat_and_the_City_-_September_2011_Workshop_report.pdf, p. 5, Presentation Seven – Heat and the City Project, Next steps for action and conclusions.
• In order to help meet targets for renewable heat, and help to ensure heat pump SPFs are realised, the Scottish Government needs to continue to focus on achieving the fastest possible uptake of insulation in Scotland’s homes.

• The Scottish Government should work with Ofgem and other stakeholders to explore how those with heat pumps can minimise their electricity bills through appropriate tariffs.

• Further work is required to understand better the characteristics of Scottish dwellings and to establish more robust estimations of the suitability of Scottish dwellings for renewable heat.

• Further opportunities to raise consumer awareness of the renewable heating technologies are required. In order to deliver this the Scottish Government should:
  - Further develop the existing Green Homes Network provided by the Energy Saving Trust.
  - Continue to fund Community Energy Scotland to provide free advice and financial support for eligible community groups and other not-for-profit community-focused organisations.
  - Work to ensure provision of information about renewable heating options (including district heating) at, or soon after, annual boiler checks.\(^{19}\)
  - Work to ensure that information about renewable heating options is also provided at all refurbishment trigger points, for example, building approvals processes or alongside home moving.\(^{20}\)
  - Provide business development support for the existing heating installer industry and small builder trade.

• Local authorities should improve the training of planning officers by increasing the resources available for practical training in renewable heating technologies and district heating.

• The Scottish Government must use the information gathered during the 2010 consultation on permitted development rights for air source heat pumps to decide whether to widen existing permitted development rights for this technology.

• The Scottish Government should ensure that a) microgeneration (and district heating) technologies are given adequate consideration within discussions on the next SHQS\(^{21}\), b) guidance on the 2015 SHQS provides sufficient detail on renewable heat technologies, and c) all social landlords take full advantage of the domestic RHI.

• Where and when appropriate, standards set under the Microgeneration Certification Scheme for renewables installers and products should be amended by the UK Government to include findings from independent field trials and / or any subsequent research.

\(^{19}\) This would build on the work that the Scottish Government previously undertook in relation to the dissemination of boiler advice leaflets with Home Energy Checks as part of work to comply with Article 8 of the EU Energy performance of buildings directive (EPBD).

\(^{20}\) Evidence suggests that, at least for energy efficiency action, people are willing to consider investment at refurbishment trigger points. See: http://www.energysavingtrust.org.uk/Publications2/Corporate/Research-and-insights/Trigger-Points-a-convenient-truth.

\(^{21}\) SHQS = Scottish Housing Quality Standard.
• To provide confidence to consumers, the Energy Saving Trust should explore how best to raise the awareness of the REAL Deposit and Advanced Payment Insurance Scheme, and the REAL Insurance Backed Guarantee when providing advice to consumers.\textsuperscript{22}

• Trade Associations should work to raise awareness among their installers of the Microgeneration Certification Scheme and how renewables can benefit their business, encourage their members to undertake additional training to become MCS qualified and provide assistance to those seeking certification.

\textsuperscript{22} See https://www.real.qanw.co.uk/consumer-faqs.php (REAL Deposit and Advanced Payment Insurance Scheme) and https://www.real.qanw.co.uk/consumer-IBG-faqs.php (REAL Insurance Backed Guarantee). The former policy is available for free to consumers awaiting installation of a microgeneration technology by a REAL scheme member and covers the consumer’s Deposit and Advance Payments in the event that the REAL Assurance Scheme Member Company ceases to trade and is therefore unable to supply the Goods. The purpose of the \textbf{REAL Insurance Backed Guarantee} is to cover the \textbf{Installer’s Written Workmanship Guarantee}, and honour the terms of that Guarantee for the duration of same, in the event that the Installer has \textbf{Ceased to Trade}, and is therefore unable to honour the terms of their \textbf{Written Workmanship Guarantee} and rectify any defective workmanship.
2 Introduction

2.1 Context

The passing of The Climate Change (Scotland) Act 2009 demonstrates the Scottish Parliament’s commitment to reducing Scotland’s greenhouse gas emissions and facilitating the shift to a low carbon economy. The Act contains overall ambitions for Scotland, which include a minimum 42% reduction in GHG emission by 2020 on the path to achieving at least an 80% reduction by 2050 (relative to 1990 levels).

Achieving such ambitions will require significant changes across all sectors of energy use. Around half of Scotland’s total energy demand is accounted for by heat, which means that decarbonising heat supply will be crucial to meet emission reduction targets. Recognising this, the Scottish Government has identified the following as one of the transformational outcomes required:

“a largely decarbonised heat sector by 2050, with significant progress by 2030”

To help realise this ambition, the Scottish Government has set a target for 11% of total 2020 heat demand to be supplied by renewable heat, amounting to 6.42TWh of renewable heat supply in 2020. According to the Renewable Heat Action Plan, the bulk of this (45%) is expected to come from the industrial sector, with 33% and 22% from the commercial and domestic sectors respectively.

Renewable heat currently accounts for a small share of the total heating market in Scotland (c.1.7TWh in 2010/11), but the recent introduction of the Renewable Heat Incentive (RHI) is expected to stimulate the renewable heat market throughout Great Britain.

The RHI is designed to provide a guaranteed income to owners of renewable heating technologies, making them economically attractive to a range of investors. The scheme is being introduced in two phases. The first (expected to be open for applications from 30th September 2011) will provide support mainly for non-domestic installations. Up to £15m is also being made available for domestic installations under the Renewable Heat Premium Payment scheme. RHI support will be expanded in the second phase (from October 2012) to include additional technologies and householders’ installations.

RHI tariff levels for non-domestic installations were announced in March 2011, but the levels for domestic consumers are yet to be finalised (and will be informed in part by data collected under the Renewable Heat Premium Payment scheme). Assessing the potential

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23 Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010–2022, www.scotland.gov.uk/Publications/2011/03/21114235/2. The other transformational changes are decarbonising electricity generation, decarbonising road transport and adopting a comprehensive approach to ensure that carbon is fully factored into strategic decisions about rural land use.


uptake of renewable heat in Scotland’s dwellings under currently announced support levels is therefore timely.

2.2 Definition of renewable heat

2.2.1 Renewable heating technologies supported by the RHI

In general ‘renewable’ heat is heat produced by burning renewable fuels (i.e. non fossil fuels), or heat produced from high-efficiency technologies such as heat pumps. The RHI supports the following fuels / technologies:

- Biomass boilers
- Heat pumps (ground, water source)
- Deep geothermal
- Solar thermal
- Heat from biogas combustion

DECC decided not to support air source heat pumps from the outset of the RHI, stating that more work is required to better understand the costs (and due to the fact that no method yet exists for measuring direct air heating (produced by air-to-air heat pumps)). However, air source heat pumps are recognised as able to contribute to renewable heat targets at the EU level, subject to meeting minimum performance criteria.26

2.2.2 Overview of renewable heat supply options

The main characteristics of the technologies of interest for this study are outlined below.

Table 3: Introduction to renewable heat supply options

<table>
<thead>
<tr>
<th>RH supply option</th>
<th>Overview</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| ASHP             | Extract low grade heat from the air and increase the temperature using an electrically powered compression cycle, so that it can be used to meet thermal demands. Multiple units of heat can be delivered for each unit of electricity consumed. | • One of the lower cost renewable heating technology options that can meet a dwelling’s total thermal demands.  
• Fewer restrictions due to space constraints (compared to GSHP).  
• Well suited to new build. | • Efficiency reduced unless heat is distributed at low temperature.  
• Limited opportunity to reduce fuel bills given that they are powered by electricity. |


<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| GSHP                | Extract low grade heat from the earth and increase the temperature using an electrically powered compression cycle, so that it can be used to meet thermal demands. Multiple units of heat can be delivered for each unit of electricity consumed. | • Offer higher efficiency than ASHPs.  
• No visible external components.  
• Long life expectancy of ground loops. | • Relatively high capital costs (due to groundworks to bury pipes).  
• Efficiency reduced unless heat is distributed at low temperature.  
• Limited opportunity to reduce fuel bills given that they are powered by electricity.  
• Suitability restricted by space constraints for ground loops. |
| Biomass boiler      | Boilers designed to burn a biological material for heat, typically woody biomass in chip or pellet form.                                                                                                     | • Potential for high CO₂ reduction.  
• Offer means of reducing reliance on fossil fuels while not putting additional demands on electricity grid. | • High capital cost.  
• High space requirements for boiler & fuel store.  
• Regular fuel deliveries required.  
• Ongoing fuel costs (e.g. pellets are more expensive than gas on £/MWh basis).  
• Fuel availability concerns (until supply chains develop further). |
| Solar thermal       | Solar collectors extract heat from sunlight to meet a portion of a building’s hot water demand.                                                                                                               | • One of the lowest capital cost RH technology options.  
• Minimal running costs (no fuel costs). | • Not viable to meet entire hot water demand over the year.  
• High cost of energy (due to limited output). |
| District heating    | A heat delivery mechanism (rather than heat source). District heating is a broad term and is used in this study to refer to both district-wide schemes (involving transmission and distribution pipework), and smaller scale community energy installations (where pipework may link a collection of buildings rather than whole areas). | • Can be fed by a diverse mix of energy sources, including heat recovery (e.g. from industrial processes).  
• Potential efficiency advantage of CHP.  
• Advanced flue gas cleaning more likely to be justified on larger boilers.  
• Minimal additional space requirements in dwellings.  
• Useful option for hard to treat buildings. | • High capital costs and high disruption in retrofitting.  
• Difficult to finance (high capex at risk) – DH is a long-term investment with no short payback.  
• Viability depends on characteristics of area (not suitable in all locations).  
• Various obstacles to initiating schemes, including financing, coordination, phasing etc. |
2.3 Previous work on renewable heat

The literature on renewable heat in the UK has grown considerably in recent years, in part as a result of UK Government efforts to support this nascent market through introduction of the Renewable Heat Incentive. A summary of selected relevant reports is given below.

Table 4: Summary of existing literature on renewable heat in the UK

<table>
<thead>
<tr>
<th>Report</th>
<th>Author(s)</th>
<th>Date</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieving deployment of renewable heat</td>
<td>Element Energy and NERA for the CCC</td>
<td>April 2011</td>
<td>Study considered uptake of renewable heat in the UK to 2030, with a focus on barriers to uptake and additional policies required. Work formed part of evidence base for the Renewable Energy Review (May 2011).</td>
</tr>
<tr>
<td>Renewable Heat Incentive policy document</td>
<td>DECC</td>
<td>March 2011</td>
<td>Sets out details of how the RHI will be implemented, including eligibility criteria, tariff levels, and payment mechanisms.</td>
</tr>
<tr>
<td>Renewable Heat in Scotland, 2010</td>
<td>EST for Scottish Governm ent</td>
<td>March 2011</td>
<td>This work updated a renewable heat database originally produced by the Sustainable Development Commission Scotland. The study found that an estimated 0.4GW of renewable heat capacity was operating in Scotland in 2010/11, producing c.1.7TWh of renewable heat energy.</td>
</tr>
<tr>
<td>Decarbonising Heat: Low Carbon Heat Scenarios for the 2020s</td>
<td>NERA and AEA for the CCC</td>
<td>June 2010</td>
<td>This study investigated scenarios for decarbonising heat supply through the 2020s. The three high-level paths identified were based on electrification, bioenergy, and district heating, with the best strategy combining elements of each. The work formed part of the evidence base for the Fourth Carbon Budget (2023–2027) report.</td>
</tr>
<tr>
<td>Design of the Renewable Heat Incentive</td>
<td>NERA for DECC</td>
<td>Feb. 2010</td>
<td>Building on RH supply curve work, this study produced updated supply curves, proposed RHI subsidy levels, and modelled renewable heat deployment, along with CBA metrics.</td>
</tr>
<tr>
<td>Renewable Heat Action Plan for Scotland</td>
<td>Scottish Governm ent</td>
<td>Nov. 2009</td>
<td>The document provides a plan for the promotion of the use of heat from renewable sources. It reports progress, sets out targets (11% RES-E by 2020 (6.4TWh/yr)) and delivery actions.</td>
</tr>
<tr>
<td>The UK Supply Curve for Renewable Heat</td>
<td>NERA and AEA for DECC</td>
<td>July 2009</td>
<td>Study into levels of RH available in the UK under various scenarios at what cost. Provided the initial evidence base for developing the RHI.</td>
</tr>
</tbody>
</table>

The 2020 renewable heat targets set by the Scottish Government are relevant for this study, and suggest that to meet a target of 11% across all sectors, around 1.4TWh of renewable heat will be needed in the domestic sector.²⁷

²⁷ Data from the Renewable Heat Action Plan for Scotland, Figure 4, p.17, (2009). Based on the heat demand forecasts used in this study, this level of uptake equates to c.5.5% of heat demands in Scottish dwellings being met by renewable heat by 2020. The contribution from other sectors will need to be higher to meet an overall target of 11%. 

24
This study builds on previous work, with a focus on renewable heat uptake in Scotland’s dwelling stock to 2030, the expected technology mix, and wider impacts on the energy system.

2.4 Scope

To meet ambitions to decarbonise heat supply, it is clear that renewable heat must be adopted across all sectors. However, the main focus of this study is on the potential uptake of renewable heat in dwellings, the barriers to adoption that householders face, and the additional policies that will be required to maximise the impact of the RHI in the domestic sector. The main technologies of interest are:

- Air source heat pumps (air-to-water) (for individual dwellings).
- Ground source heat pumps (for individual dwellings and medium scale systems serving a tenement block / block of flats).
- Biomass boilers (individual boilers serving a single dwelling and medium size boilers sized to meet the demands of a block of tenements / flats).

The potential contribution of renewable heat from district heating has also been considered. District heating could be fed with heat from any of the above sources in addition to other technologies including heat from biogas (from anaerobic digestion), heat from power stations / industrial processes, biomass-fired CHP etc.

Solar thermal technologies are also expected to be supported by the RHI. However, solar thermal installations are not replacements for heating systems (they supplement a primary heat source by typically meeting a portion of the annual hot water demands). Since this study’s uptake modelling is based on heating system replacement decisions, solar thermal (a discretionary choice) is not included in the main results.

2.5 Aims

WWF Scotland commissioned Element Energy and the Energy Saving Trust to undertake this study to understand:

- The renewable heat generation mix in Scottish households in 2020 and 2030 under different scenarios of overall renewable heat ambition (see below).
- The resulting upstream demands of renewable heating technologies (biomass fuel supply and electricity generation).
- The barriers to delivering the levels of renewable heat deployment required to meet the ambitions, and the most effective policy levers available to address them.

The outputs from this work will be used by WWF Scotland to champion the importance of faster progress on renewable heat and to provide an evidence base with which to advocate policy changes designed to support renewable heat.

2.6 Renewable heat ambition scenarios

The research questions above are considered in the context of two over-arching ambitions for renewable heat uptake:

- Uptake in line with the Medium abatement scenario described by the Committee on Climate Change in the Fourth Budget report. This equates to a renewable heat
contribution to total domestic heat demands in Scotland of around 2.5% and 30% by 2020 and 2030 respectively.\textsuperscript{28}

- Uptake in line with Scottish Government’s ambition to decarbonise the heat sector in Scotland by 2050. This is interpreted as needing to achieve 50% penetration of renewable heat in the domestic sector by 2030.

Both scenarios are consistent with longer term ambitions to decarbonise heat supply. However, the second (as described above) requires more rapid ramp-up of renewable heat deployment over the next two decades.

\textsuperscript{28} For further details see section 4.4.
3 Methodology

3.1 Introduction

In broad terms, deployment of renewable heating technologies in Scotland is expected to occur at two levels. The first is uptake in individual dwellings or buildings, where renewable heating technologies are selected as replacements for incumbent heat sources. The second method by which the use of renewable heat may increase is through community energy schemes with district heating. This involves connecting one or more sources of heat (which may be renewable) to a heat distribution network to serve multiple consumers in an area.

Quantitative uptake modelling of renewable heating was required to address the study’s research questions (see section 2.5 above), and the methodology developed reflects these two main mechanisms of deploying renewable heat. An overview of each follows, with further details provided in the appendix, section 6.1.

3.2 Uptake of renewable heat in individual dwellings

3.2.1 Modelling methodology – overview

In general, the quantitative modelling of uptake of new technologies involves representing:

- The choice faced by consumers (i.e. the technologies available, costs and expected performance).
- Consumer behaviour (i.e. what consumers are likely to choose given the available options).

Of the methods available for representing consumer behaviour, we chose a logit-based approach, which allows quantification of the relative importance of different attributes of each technology and allows competition between the various options. This technique is based on an understanding of how consumers respond to the attributes of each technology, and how the attributes determine the overall utility (attractiveness) to consumers. The overall process is summarised in the diagram below.

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29 Logit stands for logarithmic transformation, a mathematical technique commonly used to model consumer choice.
Figure 10: Logit uptake modelling – overview

This method of representing consumer choice and modelling uptake of novel technologies has been used extensively by Element Energy in the past. Indeed, for this study we drew on data from previous consumer surveys (that provide the coefficients that dictate how consumers respond to certain attributes).

Considering the uptake model for dwelling-scale technologies in more detail, we can map out the range of assumptions and data required to represent the choice on offer and how consumers may respond.

Figure 11: Uptake model input assumptions

This diagram shows the range of input assumptions required. There is of course a high degree of uncertainty in attempting to forecast what may happen in the future (especially when looking over a period of twenty years or more). We therefore create a baseline which includes central estimates of the main assumptions and explore the sensitivity of results to varying various factors.

30 No new consumer survey was conducted in this study.
Note that uptake modelling of this sort is an attempt to gain insights into potential futures and the relative importance of different factors in determining outcomes. The results should not be taken as predictions of what will happen; rather they provide a means of understanding the key determinants of the renewable heating market.

3.2.2 Energy efficiency uptake assumptions

The characteristics of dwellings referred to above (Figure 11) include type, size, age etc. For the purpose of this study Scotland's dwelling stock was broken down into 35 dwelling types (see section 6.2), differentiated by a number of metrics, including an indication of the level of insulation applied (and an assumed average thermal demand per dwelling). This metric dictates whether dwellings are “insulated” or “uninsulated” based on the level of loft insulation and presence of external wall insulation (see section 6.3.1 for further details). Uptake of energy efficiency measures was represented by altering the numbers of consumers in each category over time, such that all uninsulated dwellings receive energy efficiency measures over the next decade. The following graph shows the resulting change in thermal demand over time (including additional demands due to new dwellings).

![Forecast thermal demand of Scottish dwelling stock](image)

**Figure 12: Change in thermal demand of Scottish dwellings over time under baseline assumptions**

This level of energy efficiency rollout equates to energy efficiency upgrades to around 200,000 dwellings in Scotland per year over the next decade. For reference, the latest data from the Homes Energy Efficiency Database suggest that current rates of insulation (cavity wall and loft) installation in Scottish dwellings is around 40,000–50,000 per year (excluding DIY loft insulation). This suggests that our energy efficiency uptake assumptions would require a significant ramp up in the rate of insulation rollout in Scottish dwellings.

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31. This is of course a simplification of reality. However, in the interests of restricting the model to a manageable size only two levels of insulation were included.

32. The extent to which thermal demands are reduced through energy efficiency measures is relevant at it affects the amount of renewable heat required to meet the targets (given that targets are set in terms of meeting a proportion of demands by renewable heat), and the technical suitability of dwellings for renewable heating technologies (e.g. in terms of meeting demands and maximising efficiency values in the case of heat pumps).
The need for increased uptake of energy efficiency has been recognised by the Scottish Government. Action being taken, together with further work required, is set out in the Conserve and Save Energy Efficiency Action Plan for Scotland, which states that the Scottish Government will:

- Provide support and financial assistance for energy efficiency in existing housing, exploring all alternative funding sources available. We will work with the Energy Saving Trust and private landlords to improve the uptake of existing incentive programmes.

- Continue to work with DECC to improve deliverability in Scotland of future GB-wide programmes.

- Work with DECC on the post-2012 Energy Company Obligation and the Green Deal to ensure that these policies and the UK Energy Security and Green Economy Bill are developed in a manner that will allow delivery in Scotland to meet Scottish circumstances.

- Work with social landlords and other stakeholders to achieve carbon reductions in social housing, including developing an appropriate energy efficiency standard beyond SHQS.

- Strengthen guidance for local housing strategies by issuing supplementary guidance jointly with COSLA.

3.3 Renewable heat from district heating

The supply of heat from one or more sources to multiple buildings via a heat distribution network (district heating) is a very different proposition from the standard method of supplying buildings’ thermal demands in the UK. Developing a district heating network requires coordination of multiple consumers, since the technical and economic viability of such schemes depends on achieving sufficient heat density and diversity of demand. In particular, the following criteria are relevant when considering the viability of district heating:

- **Heat density** – typically measured as average heat demand (MW/km²), high heat densities increase the economic viability of district heating.

- **Connection density** – installing pipework in the ground is one of the major costs of a district heating system, which means that a smaller number of large consumers is preferable to the same overall demand consisting of a large number of small consumers.

- **Tenure** – coordination can be easier with publicly owned buildings, e.g. connection of council-owned housing and public buildings to initiate schemes.

- **Diversity of demand** – refers to when consumers demand heat. A mix of consumer types (e.g. domestic and non-domestic) produces a smoother load profile (good for district heating), and large users can also act as heat anchors (providing guaranteed heat demand).

Given the different characteristics of district heating, it is not possible to model its uptake via a method similar to that discussed above. Instead, we have identified district heating opportunity areas in Scotland, where certain criteria (based on the metrics outlined above)
are met. We then explore plausible scenarios of district heating uptake in the opportunity areas. The opportunity area analysis has been completed at the Intermediate Geography Zone (IGZ) level, where data on energy consumption, population, number of households etc. are available.\textsuperscript{36} Our overall approach to estimating district heating potential is summarised below.

![Diagram of methodology for assessing potential for district heating in Scotland]

**Figure 13: Overview of methodology for assessing potential for district heating in Scotland**

For further details of the methodology, including a discussion of the limitations of this approach, see section 6.1.

### 3.4 Stakeholder consultation

The quantitative uptake modelling was supplemented by a consultation with some of the key actors in Scotland’s renewable heating market. The consultation provided an opportunity to gather views on the future of renewable heat in Scotland, the additional support policies that may be required and to validate the main input assumptions used in the modelling.

Telephone discussions were held with around twenty stakeholders, covering representatives from Scottish Government, energy companies, consumer groups, charities, academia, and equipment suppliers and installers. A list of individuals contacted is provided in the appendix, section 6.9, and a summary of the main findings from the consultation is given in section 6.8.

\textsuperscript{36} There are 1,235 IGZs in Scotland and an IGZ contains between 900 and 5,400 households.
4 Results and analysis

4.1 Introduction

This section considers the potential uptake of renewable heating technologies in Scotland, as estimated according to the methodology described above. We first explore scenarios for district heating uptake and test the sensitivity of results to key assumptions (section 4.2). Following this, section 4.3 introduces baseline results, including district heating and individual dwelling-scale technologies. The subsequent sections define scenarios for achieving given levels of renewable heat ambition, the sensitivity of results to varying assumptions and the potential impact of new policies.

4.2 District heating

4.2.1 Overview

The criteria for filtering regions (IGZs), leaving only areas with favourable characteristics for district heating include:

- Average heat density (MW/km²).
- Non-domestic gas demand as a proportion of total gas demand.
- Proportion of all dwellings that are social housing.

Given the high degree of uncertainty around appropriate values for these metrics, we use a range to illustrate the impact of these assumptions on the amount of renewable heat that could be delivered by district heating.

Table 5: Criteria for identifying district heating opportunity areas in Scotland

<table>
<thead>
<tr>
<th>Metric</th>
<th>Values</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum heat density (MW/km²)</td>
<td>1, 2, 3</td>
<td>Studies in Scandinavia³⁷ have found DH can be economic from c.1MW/km². High heat density regions defined as those that exceed 3MW/km² in a DH study for DECC.³⁸</td>
</tr>
<tr>
<td>Minimum proportion of total gas demand from non-domestic consumers</td>
<td>25% or 50%</td>
<td>Non-domestic heat consumers are important anchor loads and provide a more favourable demand profile. These illustrative figures capture the requirement for non-domestic loads for scheme viability.³⁹</td>
</tr>
<tr>
<td>Minimum proportion of dwellings in the social renting sector</td>
<td>0%, 25%, 50%</td>
<td>Social landlords can make decisions on energy supply to multiple properties. Social housing could therefore provide a catalyst for DH scheme development.</td>
</tr>
</tbody>
</table>

These criteria are used to filter the 1,235 IGZs in Scotland to a smaller number with potential for district heating. Three main scenarios based on these filtering criteria have been defined, as summarised below.

³⁸ The potential and costs of district heating networks, Pöry and AECOM for DECC, p.120 (2009).
³⁹ In their study for the CCC, NERA / AEA use the following rules of thumb to assess suitability for DH based on the DECC heat map: area deemed suitable for DH if area heat load density >5MW/km² and housing heat load is <50% of total heat load; or at least one load >5MW is present; or area heat density is >50MW/km². NERA / AEA for the CCC (p.53–54) (2010).
Table 6: IGZ filtering criteria for assessing the potential for district heating

<table>
<thead>
<tr>
<th>IGZ filtering scenario</th>
<th>Minimum heat density (MW/km²)</th>
<th>Minimum proportion of total gas demand from non-domestic consumers</th>
<th>Minimum proportion of dwellings in the social renting sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower constraints</td>
<td>1</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Central constraints</td>
<td>2</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Upper constraints</td>
<td>3</td>
<td>50%</td>
<td>50%</td>
</tr>
</tbody>
</table>

We then investigate district heating uptake through ‘High’, ‘Medium’ and ‘Low’ connection scenarios.

Table 7: District heating deployment scenarios

<table>
<thead>
<tr>
<th>DH deployment scenario</th>
<th>Proportion of dwellings connected to DH schemes by 2030 in each opportunity area by tenure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owner-occupier</td>
</tr>
<tr>
<td>Low</td>
<td>5%</td>
</tr>
<tr>
<td>Medium</td>
<td>20%</td>
</tr>
<tr>
<td>High</td>
<td>50%</td>
</tr>
</tbody>
</table>

The High scenario represents a situation with strong incentives to connect to district heating, where for example system costs fall and many of the barriers to connection are removed. Under this scenario half of all dwellings connect to district heating in those IGZs where potential exists. The Low scenario corresponds to the opposite extreme, where district heating remains a niche option, with high initial capital costs and a range of other barriers restricting uptake, even in areas with favourable characteristics for district heating. The Medium scenario falls between these two extremes and sees district heating uptake in around a third of social housing, a fifth of owner-occupier properties and a tenth of privately rented properties in IGZs with potential. We vary the proportion of dwellings assumed to connect by tenure type to reflect the different general characteristics of these consumers:

- **Owner-occupiers** – likely to be interested in minimising fuel bills and may switch if district heating can provide lower cost heat (provided that other concerns (lack of familiarity, disruption associated with connecting, tie-in to single supplier etc.) can be addressed).

- **Private landlords** – in general do not pay fuel bills for let properties and therefore have low interest in heating systems installed.

- **Social landlords** – operate in a more closely regulated environment (e.g. compared to private landlords), leading to opportunities to stipulate that social housing providers will connect to district heating where feasible.

4.2.2 Results

Renewable heat from district heating

The methodology for estimating the potential for district heating described in sections 3.3 and 4.2.1 leads to a list of areas (IGZs) in Scotland with potential, and numbers of
dwellings connected to district heating under Low, Medium and High scenarios. To estimate the level of renewable heat delivered we calculated the average thermal demand per dwelling (based on average gas consumption and a boiler efficiency of 85%), and further assume that on average 65% of total thermal demands (of dwellings connected) are met by renewable heat. In practice the amount of renewable heat delivered will depend on the mix of heat sources connected to the networks, and predicting this with any degree of certainty is impractical. Whilst imperfect, the 65% assumption at least provides us with a reasonable estimate of renewable heat that could be delivered.

The following graph shows the range of renewable heat delivered from district heating under the various scenarios described above.

Figure 14: Renewable heat from district heating under a range of scenarios

The large range in renewable heat delivered by district heating in 2030 under the different scenarios reflects the high level of uncertainty inherent in such estimations. For example, under the Medium and Low scenarios, with restrictive criteria for finding opportunity areas, renewable heat from district heating accounts for no more than about 0.5% of heat demands. At the opposite extreme, around 4TWh/yr of renewable heat is supplied to Scottish dwellings by district heating in a scenario where many of the barriers are removed or overcome and there is deemed to be potential for district heating in c.25% of Scotland’s IGZs.

In interpreting the results above we should remember that achieving any of the High scenarios (with half of all dwellings in areas with potential assumed to connect to district heating) would be extremely challenging (given the current levels of district heating deployment in Scotland). Further implications of these results include:

- One scenario sees district heating delivering renewable heat to meet around half of the CCC’s Medium abatement ambition. This requires all variables to be set to maximise the case for district heating (1MW/km², and no restrictions on tenure, and ‘High’ levels of connection). Note that to achieve this level of district heating penetration would involve substantial investment in systems that would not be

40 Note that “renewable” district heating schemes, e.g. those supplying heat from biomass boilers, often include fossil fuel heat to meet peak loads and as a backup. It is more cost effective to size renewable heating technologies to meet a base load than to supply all thermal demands, and to include supplementary fossil fuel heat sources.
economically viable without a significantly more generous renewable heat incentive or alternative source of public funding.

- District heating has a role in meeting Scotland’s renewable heat ambitions, but in practice it is unlikely to provide a silver bullet solution. For example, under the Medium scenario (with central assumptions on IGZ filtering criteria), we see around 4% of 2030 heat demands being met by renewable heat from district heating. This suggests that individual dwelling-scale technologies will also be important in meeting renewable heat targets.

**Technology mix**

The wide variety of potential heat sources is often cited as a major advantage of district heating, offering diversity of energy supply. From economic analysis of some of the potential heat sources (section 6.4), heat only biomass boilers appear to be one of the more cost-effective options. Other potential heat sources include:

- Biomass CHP
- Gas boilers / gas CHP
- Heat from biogas combustion
- Energy from waste
- ‘Waste’ heat from industrial processes / power generation
- Geothermal heat

Assessing the mix of heat sources feeding potential district heating systems in Scotland is beyond the scope of this study. However, the economic analysis section provides insight into the likely relative costs of different options. A pertinent finding here from the stakeholder consultation was the large technical resource in heat from mine water under Scottish towns and cities. For example, there are extensive coal mine networks under Glasgow and the wider conurbations (including hundreds of mineshafts in Glasgow), now flooded with warm water which could provide a useful source of heat. It is most likely that development of this kind of resource would only be economic at medium to large scales, rather than at the individual building level. The British Geological Survey is undertaking ongoing work, often in partnership with universities, to develop detailed three dimensional sub-surface models in urban areas. This provides an invaluable resource for understanding the technical opportunities in this area, however further work is required to understand the technical and economic feasibility of extracting the heat.\(^{41}\)

Anaerobic digestion refers to the processes through which microorganisms break down biological material (food waste, livestock slurries, sewage sludge etc.) in the absence of oxygen to produce biogas (a mixture of mainly methane and carbon dioxide). Biogas can be combusted directly (in heat only, electricity only, or CHP applications), or upgraded and fed into the gas grid (or used in transport applications). A recent report for DECC analysed the technology costs and characteristics in this area, and included an assessment of the potential growth rates of biogas uptake in Great Britain to 2030.\(^{42}\) Estimates of biogas availability for three different scenarios (low, central and high growth) are provided for

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\(^{41}\) We would like to thank Dr Diarmad Campbell for providing the team with an overview of the work in this area.

\(^{42}\) *Analysis of characteristics and growth assumptions regarding AD biogas combustion for heat, electricity and transport and biomethane production and injection to the grid*, SKM Enviros and CNG Services Ltd for DECC, (May 2011).
Pro-rating these estimates to Scotland (on the basis of population), we calculate that up to 3.2TWh/yr of heat could be delivered via biogas in Scotland in 2030 (based on the high scenario and using the biogas in heat-only mode with boiler and district heating efficiencies of 85% and 90% respectively, consistent with the SKM Enviros assumptions). For context, total heat demands of Scottish dwellings are forecast to be 26.4TWh/yr in 2030 in this study’s baseline. These figures suggest that even if the maximum estimated biogas resource were exploited by 2030 total heat delivered would not exceed c.12% of domestic heat demands in Scotland. In other words, while biogas may make a useful contribution to renewable heating targets, there is insufficient technical potential for renewable biogas to be the dominant source of renewable heat to meet medium to long term ambitions.

Wider implications

It is important to consider the role of district heating in decarbonising heat supply in Scottish dwellings in the context of other options. For example, the CCC’s Medium abatement scenario shows a high reliance on heat pumps (dwelling-scale) in the domestic sector, combined with significant decarbonisation of electricity supply, to meet 2030 renewable heat ambitions. Given that district heating networks are likely to have a less heavy reliance on electrically-driven plant, decarbonisation of the electricity grid will tend to impair the case for district heating in carbon terms.

On the other hand, relying largely on the electricity grid to decarbonise heat supply brings about its own challenges, in particular ensuring sufficient generating capacity is available to meet peak demands, and that transmission and distribution grids are sufficiently robust to cope with such load growth. District heating can make a positive contribution to such issues.

If the electricity grid decarbonises to the extent envisaged by the CCC, then high efficiency electric heating (i.e., based on heat pumps) is likely to be an appropriate strategy to meet renewable heating targets. Renewably-fuelled district heating could play a useful role in decarbonising heat supply in dwellings that are unsuitable for heat pumps, and / or could be developed as a risk mitigation strategy in the event that electricity supply is not decarbonised or heat pumps do not play as large a role (e.g., if efficiency values are not sufficiently high or the grade of heat delivered causes compatibility issues with retrofitting).

In the short to medium term efforts to deploy district heating should be focused in areas with favourable characteristics for developing cost-effective schemes, keeping sight of longer-term expansion options to capitalise on economies of scale. The analysis above suggests that the most economic opportunities will be in areas of high heat density and high average consumption per connection – i.e., high density housing (flats) linked to large commercial / industrial consumers.

43 Analysis of characteristics and growth assumptions regarding AD biogas combustion for heat, electricity and transport and biomethane production and injection to the grid, SKM Enviros and CNG Services Ltd for DECC, Table 14, p.32 (May 2011).
44 Having said this, one of the longer term options under consideration for managing intermittency from an electricity grid with high levels of wind generation is using excess electricity for direct electric heating. At times of high wind generation (if supply exceeds demand), the excess energy could be converted from electricity to heat, for example in thermal stores as part of district heating systems. Under normal circumstances it would not be economically viable to include direct electric heating as a heat source for district heating, but the economic case could be made when electricity prices go negative at times of high supply relative to demand.
45 We consider the potential grid impacts in section 4.7.
In the following sections we explore the uptake of renewable heat in individual dwellings. To gain the full picture of potential levels of renewable heat deployment we combine an estimated contribution from district heating with dwelling-scale technologies. Unless otherwise stated, the contribution from district heating is taken from the Central constraints_Medium scenario.

4.3 Dwelling-scale technologies: baseline

4.3.1 Baseline definition

The baseline includes ‘central’ case assumptions regarding the main variables that affect uptake of renewable heat, and includes policies currently in place or to which the Government is committed. The baseline serves as a useful starting point in forecasting the uptake of renewable heat, from which we explore the effect of various sensitivities. The main baseline assumptions are summarised below.

Table 8: Baseline assumptions

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial support for renewable heat</td>
<td>RHI support (based on latest levels published by DECC) for new installations starting in 2011 and continuing to 2015. 46</td>
</tr>
<tr>
<td>Supply side restriction</td>
<td>Annual industry growth rates defined by the ‘Central’ case, equivalent to a maximum of 46% year-on-year sales growth over the next decade.</td>
</tr>
<tr>
<td>Fuel price projections</td>
<td>‘Central’ fuel price projections from DECC (IAG).</td>
</tr>
<tr>
<td>Technology cost and performance</td>
<td>Capital costs of heat pumps fall over time. Heat pump efficiencies increase over time such that average SPF values for installations by the middle of the next decade are +1 unit relative to today’s values.</td>
</tr>
<tr>
<td>Hassle barriers</td>
<td>Allowance included for consumers’ time to research new technology monetised and added to the capital cost of renewable heating technologies (equivalent to c.£250 per installation).</td>
</tr>
<tr>
<td>Suitability assumptions</td>
<td>‘Central’ case suitability (see section 6.3.6 for further details). Note that only dwellings with a reasonable level of insulation are considered suitable for renewable heat (see section 6.3.1). 47</td>
</tr>
<tr>
<td>Boiler replacement rate</td>
<td>Fundamental limit to the rate of uptake of renewable heat (according to this study’s methodology). A replacement rate based on heating system lifetime of 20 years is assumed.</td>
</tr>
</tbody>
</table>

46 Note that although domestic installations will not receive RHI payments until phase 2 of the RHI (expected from October 2012), DECC has clearly signalled that all eligible systems installed since 15th July 2009 will be able to apply for RHI support.

47 This is consistent with the Renewable Heat Premium Payment Scheme criterion: Property must have loft insulation to 250mm and cavity wall insulation (where practical) (see www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Renewable-Heat-Premium-Payment).
4.3.2 Baseline results

In this section we consider uptake under the baseline assumptions set out above and analyse the impact of alternative RHI durations. Results are presented in terms of renewable heat delivered across the Scottish dwelling stock by 2020 and 2030.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2020](image)

**Figure 15: Renewable heat delivered in Scottish dwellings in 2020: baseline and RHI duration scenarios (renewable heat needs to meet 5.5% of domestic sector demands for consistency with the 11% overall target – see section 2.3)**

The contribution from district heating under the RHI to 2030 scenario is taken from the Central constraints_Medium scenario (see previous section), with 2020 values based on linear interpolation to 2030. Note that in these results (and all that follow), all changes in input assumptions relative to the baseline are indicated by the scenario name (and all other variables remain the same as in the baseline). The results above reveal:

- Without continued RHI support beyond 2015, uptake of renewable heat in dwellings is likely to fall well short of the level needed to meet the Scottish Government’s 2020 target.
- Of the renewable heating technologies considered, ASHPs are the primary contributor to renewable heating targets in the domestic sector. This is largely due to the lower capital cost of this technology (relative to the other renewable heating options) and more restrictive suitability constraints on biomass boilers and GSHPs.
- Uptake of GSHPs and biomass boilers is likely to remain restricted even with an RHI in place. The upfront costs of these technologies make them unattractive to consumers who tend to use high discount rates in evaluating costs. This suggests that there could be a role for loans (or other ways of removing the upfront cost); we explore this in section 6.7.7.

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48 These results include no uptake of renewable district heating with no RHI (or with RHI to 2015 only). DH uptake under the RHI to 2020 scenario is based on half the level of uptake under the RHI to 2030 scenario (on the basis that lack of continued support is expected to restrict uptake).
The following graph shows renewable heat delivered in 2030 under the same scenarios.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

**Figure 16: Renewable heat delivered in 2030: baseline and RHI duration scenarios**

In the absence of any policy to reduce the capital costs of GSHPs and biomass boilers seen by the consumer, these technologies remain niche to 2030. The results above also show that renewable heating technologies are unlikely to gain significant market share without a financial incentive (RHI or equivalent), unless the counterfactual option becomes less attractive.

With central case assumptions for the key variables, and RHI support continuing to 2030, these results suggest that renewable heating installations could deliver around a third of total heat demands by 2030. This is broadly consistent with the uptake required for Scottish dwellings to make a proportionate contribution to meeting the CCC Medium abatement ambition, a scenario we consider in more detail below.

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49 This is consistent with the 2020 results given that no transformative change in cost or performance of these technologies is expected in the period 2020–2030.
4.4 Uptake in line with the CCC’s Medium abatement scenario

4.4.1 Introduction

The Committee on Climate Change provides advice to the UK Government on setting carbon budgets in line with meeting legally binding long-term emission reduction targets. The Fourth Carbon Budget report includes economy-wide scenarios for emission reductions through the 2020s. The scenarios (Low, Medium and High abatement) are based around meeting set criteria to different extents. According to the CCC, the Medium abatement scenario ‘forms the basis of what we should plan for in the 2020s as it prepares sufficiently for 2050 whilst being feasible, sustainable and cost-effective’.

Renewable heat uptake under the Medium abatement scenario corresponds to around 35% of total UK 2030 heat demands being met by renewable heat. Uptake of renewable heat is expected to vary by sector (domestic, commercial, industrial), and the CCC provided a breakdown of uptake in Scottish dwellings in line with the Medium abatement scenario.

![Renewable heat uptake in Scottish dwellings](image)

**Figure 17: Renewable heat uptake in the domestic sector in Scotland under the CCC Medium abatement scenario**

This section considers scenarios under which uptake of renewable heat in Scottish dwellings (from dwelling-scale technologies) is in line with the CCC’s Medium abatement scenario 2030 ambition.

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50 The criteria are: feasibility, sustainability, cost-effectiveness, and consistency with the 2050 target.
52 Personal communication with the CCC.
53 The CCC Medium abatement scenario includes some contribution from renewable heat delivered by district heating. However, no breakdown by sector or region in the UK was supplied for this study. This section therefore focuses on dwelling-scale technologies only.
4.4.2 Results

The following scenarios have been derived such that uptake estimated by the model developed for this study is in line with the CCC’s Medium abatement scenario, i.e. the pathway towards meeting 2050 targets considered by the CCC to be feasible, sustainable and cost-effective.

- **High fuel prices** – with RHI continuing to 2030, this scenario looks at the impact of all fuel prices rising in line with the High projections (see section 6.3.5).
- **High supply-side growth** – RHI continues to 2030, with fewer supply-side restrictions (equivalent to maximum year-on-year growth of 61% to 2020 compared to 46% in the baseline, see section 6.3.7).
- **Reduced hassle barriers** – time to research new technologies is included for renewable heating options in the baseline. The monetised value of this time is c.£250 per installation. This scenario represents this barrier being removed, e.g. through increased familiarity with the technologies (effective marketing/awareness campaigns etc.).
- **Reduced renewable heating technology costs** – the capital costs of certain renewable heating technologies (particularly GSHPs and biomass boilers) can vary substantially with installation site. The baseline cost assumptions are relatively conservative and this scenario explores the impact of reducing costs for GSHPs by 15% and biomass boilers by 10% (with no change in the RHI support levels from the baseline).
- **High fossil fuel boiler costs** – in this scenario the RHI is continued to 2020 only, and from 2021 fossil fuel boiler costs are increased (initially by a factor of 2.5 in 2021, rising to 4.3 by 2030 (with a linear increase)). This represents a future where renewable heating technologies are supported by increasing the costs of the alternatives (rather than subsidising renewable heat).

Renewable heat delivered

Uptake under each of the scenarios described above in terms of renewable heat delivered in 2030 from dwelling-scale technologies is shown in the figure below.

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54 For example, due to variable fuel storage costs in the case of biomass boilers, and differences in groundworks costs for GSHPs depending on location.
Figure 18: Scenarios with overall RH uptake in Scottish dwellings in line with the CCC Medium abatement scenario

The CCC Medium abatement scenario also includes a contribution of renewable heat from district heating at the UK level. In its Fourth Budget Report the CCC took a cautious approach to district heating, estimating a contribution of 10TWh/yr by 2030 (based on 10% of heat demands in ten UK cities with high heat density being served by renewable heat from district heating). As mentioned above, it was not possible to disaggregate this figure to show the contribution of district heating in Scottish dwellings, hence district heating is not included in the results above. This study’s assessment of the potential for district heating shows from around 0.5–2TWh/yr in the Central constraints scenario, a range broadly consistent with the CCC’s estimation.

The results above reveal a stark difference in renewable heating technology mix to achieve the same overall level of ambition by 2030, with the CCC’s results showing a far greater contribution from GSHPs and biomass boilers. The principal reasons for this are differences between the modelling approaches:

- The CCC’s Medium abatement scenario results are calculated using the social cost of carbon abatement, which includes the use of a ‘social’ (i.e. low) discount rate. This is distinct from approaches (such as that used in this study) that consider potential uptake by modelling consumer behaviour. The approach used here is arguably more robust given that it considers what consumers might actually purchase, rather than what is optimal from a social perspective.

- Other distinctions include differences in capital cost assumptions for renewable heating technologies (validated in this study against grant scheme cost data) and in fuel (particularly electricity) price projections.

We would therefore not expect this study’s results to be consistent with those from the CCC. It is clear that in both cases heat pumps play a major role in delivering renewable heat in the domestic sector by 2030. The high reliance on heat pumps (particularly ASHPs) in meeting RES-H ambitions has a number of implications:

55 “Social” cost of carbon is a term used by governments in economic evaluations and refers to attempts to ensure that societal impacts of carbon emissions are included in economic evaluations of policy impacts.
The suitability of this technology in Scottish dwellings will be crucial. Further work is required to investigate the suitability of heat pumps across the building stock and validate the assumptions used here (see sections 6.3.6 and 6.7.4).

Upgrading the insulation levels of Scottish dwellings will be important to ensure that the SPF values assumed are achieved in practice.

The additional electricity demands arising from heat pump uptake will need to be considered and factored in to investment decisions relating to new generation capacity and grid upgrades (see section 4.7).

The scenarios presented above represent a significant transformation of the heating market in Scotland, and delivering this level of renewable heat will require a combination of actions:

- Providing a sufficient financial case for consumers to consider installing a renewable heating technology.
- Raising awareness of renewable heat among consumers who are largely indifferent to heating system choice and are generally accustomed to reliable, (relatively) cheap energy that meets their needs.
- Inspiring confidence in consumers regarding renewable heating technologies to a level where they will consider switching from the incumbent systems.
- Developing and sustaining supply chains to meet growing demand and delivering effective after-sales service.

These are non-trivial challenges, potential solutions to which are presented in section 6.8.

### Annual sales

Considering the change in sales of renewable heating systems over time provides further insight into the scale of the challenge. The results below correspond to the *RHI to 2030, high fuel prices* scenario (which leads to overall uptake in line with the CCC Medium abatement scenario).

Table 9: Modelled change in renewable heating system sales (and market share) over time under the RHI to 2030, high fuel prices scenario

<table>
<thead>
<tr>
<th>Year</th>
<th>ASHP</th>
<th>GSHP</th>
<th>BM boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1,320</td>
<td>0</td>
<td>240</td>
</tr>
<tr>
<td>2015</td>
<td>7,550</td>
<td>170</td>
<td>1,370</td>
</tr>
<tr>
<td>2020</td>
<td>25,580</td>
<td>570</td>
<td>2,420</td>
</tr>
<tr>
<td>2025</td>
<td>63,650</td>
<td>1,420</td>
<td>1,690</td>
</tr>
<tr>
<td>2030</td>
<td>67,170</td>
<td>3,520</td>
<td>1,160</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>ASHP market share</th>
<th>GSHP market share</th>
<th>BM boiler market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1%</td>
<td>0.0%</td>
<td>0.2%</td>
</tr>
<tr>
<td>2015</td>
<td>5%</td>
<td>0.1%</td>
<td>1.0%</td>
</tr>
<tr>
<td>2020</td>
<td>18%</td>
<td>0.4%</td>
<td>1.7%</td>
</tr>
<tr>
<td>2025</td>
<td>47%</td>
<td>1.0%</td>
<td>1.2%</td>
</tr>
<tr>
<td>2030</td>
<td>50%</td>
<td>2.6%</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

For uptake in line with the CCC Medium abatement scenario a significant transformation of the domestic heating system market in Scotland is required. Renewable heating technologies will have to go from close to zero market share today to over 50% market share by 2030. Historical evidence shows that major shifts are possible. For example, changes to the Building Regulations in 2005 (England and Wales) and 2007 (Scotland) stipulated that all new central heating boilers must be high efficiency condensing systems (unless there are exceptional circumstances). This change led to condensing boiler sales
in the UK increasing from around 10% market share in 2002 to >98% market share in the first quarter of 2011.\textsuperscript{56}

**Subsidy spend**

It is instructive to consider the cost implications of providing continued subsidy support to renewable heating installations. The graph below shows the annual payments required in each year to 2030 (note that payments in a year are for all new installations in that year and any systems installed in previous years that are still in operation). The RHI budget figure is based on the total budget allocated for the RHI (for Great Britain) pro-rated to Scotland on the basis of population. Note that this ‘budget’ must cover all sectors (but the subsidy spend results relate to the domestic sector only).

Figure 19: RHI subsidy spend under a scenario that leads to uptake in line with the CCC Medium abatement scenario

For this level of uptake (c.8TWh/yr renewable heat in the domestic sector by 2030), RHI subsidy support reaches in excess of £520m/yr by 2030. For context, this is equivalent to £190 per dwelling in Scotland.\textsuperscript{57} The alternative to providing ongoing RHI support would be to make the incumbent option more expensive (the RHI to 2020, high ff boiler costs scenario). This approach (ending the RHI in 2020 and encouraging renewable heat uptake by making the alternative options more expensive) leads to far lower subsidy costs by 2030 (£88m/yr). However, the cost of meeting RES-H targets would still be significant, albeit distributed in a different way. I.e. raising the costs of fossil fuel boilers beyond 2020 is not likely to lead to significant reductions in the cost of renewable heating options. The effect of a policy such as this would simply be to increase costs for all consumers installing a new system.


\textsuperscript{57} For context, the Electricity Market Reform Impact Assessment suggests that: “the estimated baseline annual domestic electricity bill could increase by just under £200 from now until 2030, whilst for example under the FIT CID packages for reform, this increase could be reduced to around £160”. EMR Impact Assessment, p.113, (2011). www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.a spx.
Sustainable renewable heat generation mix to meet the CCC Medium abatement scenario in 2020 and 2030

Based on the scenarios considered above the RHI to 2030, high fuel prices scenario could lead to uptake in line with the CCC’s Medium abatement scenario. Note that the fuel price projections under the ‘high’ scenario include a starting point (in 2011) closer to today’s values, see section 6.3.5. The renewable heat generation mix under this scenario is given below.

**Table 10: Renewable heat generation mix in Scottish dwellings in line with the CCC Medium abatement scenario (RHI to 2030, high fuel prices)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total RH generation in Scottish dwellings in line with CCC Medium abatement scenario (TWh/yr)</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RH generation from this study’s results (TWh/yr and % of total RH generated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASHP</td>
<td>1.31 (67%)</td>
<td>7.65 (84%)</td>
</tr>
<tr>
<td></td>
<td>GSHP</td>
<td>0.02 (1%)</td>
<td>0.17 (2%)</td>
</tr>
<tr>
<td></td>
<td>Biomass boiler</td>
<td>0.10 (5%)</td>
<td>0.22 (2%)</td>
</tr>
<tr>
<td></td>
<td>Renewable DH</td>
<td>0.53 (27%)</td>
<td>1.06 (12%)</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1.96</td>
<td>9.10</td>
</tr>
</tbody>
</table>

58 Includes renewable heat from district heating from the Central constraints_Medium scenario.
4.5 Renewable heat meeting 50% of domestic demands by 2030

4.5.1 Introduction

In its Climate Change Delivery Plan, the Scottish Government sets out four transformational outcomes required\(^{59}\), one of which is:

**A largely de-carbonised heat sector by 2050 with significant progress by 2030 through a combination of reduced demand and energy efficiency, together with a massive increase in the use of renewable or low carbon heating**\(^{60}\)

An advanced ambition has been considered in which half of Scotland’s domestic heat demand is met by renewable heat by 2030.\(^{61}\) This section considers what the renewable heat mix may look like to meet such an ambition and the required changes in the heating market.

4.5.2 Results

Given the turnover rate of building heating systems, a 50% renewable heat target for 2030 is highly ambitious. Here we consider a number of alternative scenarios that could see the ambition met. An introduction to the scenarios is given in the following table.

---

\(^{59}\) The other transformational outcomes include a largely decarbonised electricity generation sector by 2030, almost complete decarbonisation of road transport by 2050 and a comprehensive approach to ensure that carbon is fully factored into strategic and local decisions about rural land use. The transformational outcomes guided the development of the *Report on Proposals and Policies* (Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010–2022).


\(^{61}\) This is based on the interpretation of ‘significant progress by 2030’ on the path to a ‘largely de-carbonised heat sector by 2050’.
Table 11: Scenarios to achieve 50% renewable heat in Scottish dwellings by 2030

<table>
<thead>
<tr>
<th>Scenario name</th>
<th>District heating scenario</th>
<th>Dwelling-scale technology uptake – input assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier removal</td>
<td><em>Central constraints_High</em></td>
<td>RHI to 2030</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to research technology barrier removed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High supply side growth rates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High fuel price projections</td>
</tr>
<tr>
<td>Increased RHI (all)</td>
<td><em>Central constraints_High</em></td>
<td>RHI to 2030</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RHI levels increased by 4% (all technologies)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to research technology barrier removed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High supply side growth rates</td>
</tr>
<tr>
<td>Increased RHI (GSHP, BM</td>
<td><em>Central constraints_High</em></td>
<td>RHI to 2030</td>
</tr>
<tr>
<td>boilers)</td>
<td></td>
<td>RHI levels increased by 30% (GSHPs and biomass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>boilers only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to research technology barrier removed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High supply side growth rates</td>
</tr>
<tr>
<td>FF boiler tax</td>
<td><em>Central constraints_High</em></td>
<td>RHI to 2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to research technology barrier removed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capital costs of fossil fuel boilers increased</td>
</tr>
<tr>
<td></td>
<td></td>
<td>from 2021: 2.5x baseline values in 2021 up to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3x baseline values in 2030 (linear increase)</td>
</tr>
<tr>
<td>High gas, High oil</td>
<td><em>Central constraints_High</em></td>
<td>RHI to 2030</td>
</tr>
<tr>
<td>prices</td>
<td></td>
<td>Time to research technology barrier removed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High supply side growth rates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas and oil price projections from ‘high’ scenario</td>
</tr>
<tr>
<td>DH-led</td>
<td><em>Lower constraints_High</em> 62</td>
<td>RHI to 2030</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to research technology barrier removed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased confidence 63</td>
</tr>
</tbody>
</table>

With the exception of the DH-led scenario, achieving ‘high’ supply side growth rates is a prerequisite to meeting the 2030 50% renewable heat ambition, as is the need to provide some form of continued financial support for renewable heating technologies. Note also that in each of the scenarios, the ‘High’ scenario for district heating uptake is applied; which equates to half of all dwelling in areas with favourable characteristics connecting to district heating (see section 4.2.1). The renewable heat mix in Scottish dwellings under each of these scenarios is presented below.

---

62 The 1MW/km² figure (in the Lower constraints scenario) is based on experience from Scandinavia (see section 4.2.1). However, the economic analysis presented in section 6.4 suggests that DH uptake based on this assumption represents a very optimistic scenario.

63 This was modelled by reducing the discount factor used in the RHI coefficient to 16% (from the baseline value of 20%).
Figure 20: Heat delivered in Scottish dwellings in the 50% renewable heat by 2030 scenarios

Underpinning each of these scenarios is an assumption that the thermal demands of Scottish dwellings are significantly reduced through insulation rollout over the next decade. Improving the efficiency of the stock will be crucial in meeting such targets to increase the suitability of dwellings for renewable heat and to reduce the absolute amount of renewable heat required. The other important assumption behind the results above is continued strong financial support for renewable heat (e.g. through subsidy or making alternatives more costly) to 2030 and beyond. Confidence in the long-term future of renewable heating markets will be required to attract the necessary investment in supply chains to deliver the growth rates implied.

A high reliance on heat pumps (primarily ASHPs) to meet the 50% 2030 ambition is apparent from the results above. Average SPF values of ASHP installations are assumed to increase from 2.5 for new installations in 2011 to 3.5 by the middle of the next decade. Cost reductions are also included in the baseline such that capital costs of heat pumps in 2030 are 38% below 2010 values. Based on feedback from installers as part of this study’s consultation these cost reductions are aggressive, however the performance improvements are within expected limits.

The impact on heat pump uptake of failure to achieve these projections, in particular the efficiency improvements, is likely to be severe (see section 6.7.5). A significant shortfall between the 50% 2030 target and actual renewable heat delivered is likely if heat pumps

---

64 Total thermal demands of the Scottish housing stock is assumed to decrease from c.35TWh/yr in 2011 to c.26.5TWh/yr by 2030 (including additional demands due to new build). The dwelling stock is forecast to grow by c.400,000 dwellings (16%) from 2011 to 2030 in the baseline.

65 Our baseline cost projections are consistent with previous work for the CCC. One stakeholder suggested that heat pump capital costs could drop by around 10% but that there is limited scope for further reductions. We explore the impact of no cost reduction in the sensitivity testing, section 6.7.5. It was suggested that the main area for SPF improvement is in motor and control system design (e.g. weather compensation). For further discussion of heat pump performance see section 4.3.1 of Decarbonising Heat: Low-Carbon Heat Scenarios for the 2020s, NERA and AEA for the CCC (2010).
fail to perform as projected, or if the proportion of dwellings suitable for this technology is significantly lower than assumed here. In such a situation achieving the target would depend on either another renewable heating technology to fill the gap, or increased rollout of renewables-fed district heating. Further implications of these results are discussed below.

Dwelling-scale technology-led scenarios

Under the first five scenarios presented in Figure 20 above, dwelling-scale technologies provide the largest proportion of renewable heat to meet the 2030 ambition. Note that each scenario requires a combination of ‘high’ input assumptions (e.g. around supply side growth rates and fossil fuel prices), and removal of barriers associated with unfamiliarity with these new technologies. Furthermore, it is likely that meeting this ambition will require the rollout of renewable heat delivery via district heating. The results above correspond to around 6% of domestic heating demand being met by district heating by 2030. We also include a scenario with less reliance on dwelling-scale technologies but even higher district heating rollout, the DH-led scenario.

District heating-led scenario

In this scenario renewable heat from district heating provides 30% of the total renewable heat delivered in 2030, approximately double the level described under the dwelling-scale technology-led scenarios discussed above. This corresponds to around 350,000 Scottish dwellings connected to (renewables-fed) district heating by 2030 (13% of the 2030 dwelling stock). For context, Scotland’s four largest cities together currently have c.676,500 households. To meet this level of district heating uptake therefore is equivalent to 50% of all households in Aberdeen, Dundee, Edinburgh and Glasgow being connected to district heating systems by 2030. This level of uptake is highly unlikely without strong leadership from the public sector and firm commitments to develop large scale schemes connecting a mix of building types in the domestic and non-domestic sector.

Sustainable renewable heat generation mix to meet 50% of domestic demands by 2030

With a focus on removing the barriers to renewable heat uptake (including time to research new technology and supply side restrictions), the Barrier removal scenario could produce renewable heat uptake to meet half of domestic demands by 2030. The renewable heat generation mix under this scenario is given below.

---

66 2010 household estimates for Scotland:
http://www.gro-scotland.gov.uk/files2/stats/household-estimates/he-10/households-dwellings-est-2010.pdf (Table 1, p.31). Household estimates include Aberdeen City (103,677), Dundee City (70,401), Edinburgh City (220,195), and Glasgow City (282,198).
Table 12: Renewable heat generation mix in Scottish dwellings in line with the 50% 2030 scenario (Barrier removal)\textsuperscript{67}

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total RH generation in Scottish dwellings in line with scenario to meet 50% of domestic demands by 2030 (TWh/yr)</strong></td>
<td>1.30</td>
<td>13.2</td>
</tr>
<tr>
<td><strong>RH generation from this study’s results (TWh/yr and % of total RH generated)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASHP</td>
<td>2.35 (64%)</td>
<td>10.4 (78%)</td>
</tr>
<tr>
<td>GSHP</td>
<td>0.05 (1%)</td>
<td>0.32 (2%)</td>
</tr>
<tr>
<td>Biomass boiler</td>
<td>0.15 (4%)</td>
<td>0.30 (2%)</td>
</tr>
<tr>
<td>Renewable DH</td>
<td>1.12 (30%)</td>
<td>2.23 (17%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3.67</td>
<td>13.2</td>
</tr>
</tbody>
</table>

The Barrier removal scenario includes continuation of the RHI to 2030, removal of barriers around unfamiliarity with renewable heating technologies, high supply side growth rates and high fuel price projections. Additional supportive policies to achieve such a scenario are presented in section 5.5.

\textsuperscript{67} Percentage figures may not sum to 100% due to rounding.
4.6 Sensitivity and policy analysis

4.6.1 Introduction

The model developed to assess uptake of renewable heating technologies at the individual dwelling scale contains a wide variety of inputs (see section 3.2). There are of course many uncertainties when looking twenty years into the future and we have stress-tested the results against numerous sensitivities. Highlights from this analysis are presented below; full details of this sensitivity analysis, including introductions to the scenarios, are provided in the appendix, section 6.7.

4.6.2 Economic proposition and supply chain growth rates

The results below present the impact of factors that affect the economic proposition to consumers (fuel prices, RHI support level etc.) and the effect of low supply chain growth rates. We have also considered loan scenarios which reduce the capital cost of renewable heating technologies to parity with the counterfactual options.

It is likely that some mechanism of removing the capital cost barrier, either through loans or via an ESCO-type company (see section 6.7.7), will be required for renewable heating technologies to be made available to all consumers. High capital costs represent a significant barrier to those on low incomes and / or who do not have the capital to pay the relatively high up-front costs.

![Graph: Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

**Figure 21: Renewable heat delivered in Scottish dwellings in 2030 under a selection of sensitivity scenarios (all include RHI to 2030)**

The \textit{RHI\textsubscript{80%}} scenario corresponds to all RHI levels being reduced by 20% relative to baseline values. These results suggest that there is limited scope to reduce subsidy levels if uptake is to be sufficient to realise CCC and Scottish Government renewable heat ambitions. Under the loan scenarios all consumers are offered renewable heating technologies at no additional capital cost; instead they make annual payments on loans that cover the difference between the capital costs of the renewable heat technology and the counterfactual option. The percentage value indicates the interest rate charged on the loan (note that all scenarios also include RHI support for all new installations to 2030). A
rate of 3.5% represents a soft loan and leads to significantly higher uptake as the capital cost barrier is effectively removed. However, these results show that at a commercial interest rate of 15% uptake is reduced relative to the no loan scenario. The impact of providing loans together with an RHI is twofold: removing the capital cost barrier could lead to more renewable heat being delivered; and the provision of loans will make the RHI accessible to a wider group of consumers. We return to this point when considering impacts on fuel poverty in section 4.8.

The results above also indicate the potential impact of alternative fuel price futures. Provided an RHI is in place, heat pumps continue to appear attractive to many consumers under the High high gas and oil scenario, but their uptake is severely restricted under the High high elec. prices scenario.

We saw in the previous section (4.5) the need for supply side growth rates along the lines of the ‘high’ scenario. Uptake under the ‘low’ growth scenario is shown above, which confirms the need for rapid ramp-up in supply capacities for RES-H ambitions to be met.

4.6.3 Technology cost and performance and confidence scenarios

The scenarios below show the impact of less optimistic assumption on heat pump efficiency values (SPFs), and cost reduction forecasts. The results of two of the suitability scenarios are also presented: HPs_50% (half of all dwellings assumed to be suitable, compared to c.70% in the baseline), and HPs – off-gas only (a scenario with restricted heat pump uptake, for example as a result of a lack of permitted development rights). The final two scenarios involve varying the discount factor used in the calculation of one of the key coefficients in the uptake modelling. The baseline value is 20% and this is varied between 8% (low rate reflecting high confidence) and 32% (high rate reflecting pessimistic attitudes to the RHI).

---

68 The impact of loans on uptake is sensitive to consumers’ discounting behaviour – i.e. the perception of capital cost versus ongoing loan repayments. This is represented in the model by a loan coefficient, calculated as an annuity based on a discount factor of 10%. This leads to a loan repayment coefficient that is consistent with other coefficients used in the modelling (e.g. the RHI coefficient – see section 6.7.2).

69 Note that assumptions on renewable heat technology suitability factors are based on the best available analysis of the building stock (see section 6.3.6). However there is uncertainty around these factors, hence we stress test the results to various suitability values.

70 These values are consistent with those reported in the literature. See section 6.7.2 for further details.
Failure of heat pumps to achieve SPF levels assumed in the baseline is likely to have a significant impact on renewable heat delivered and pose a serious threat to meeting medium and long term RES-H targets.

Equally, RES-H ambitions will be undermined if technology cost reductions do not come about (while the RHI is degressed over time).

With high reliance on heat pumps for meeting RES-H targets, the suitability of this technology in Scottish dwellings is a key factor and also an uncertain parameter. Failure of heat pumps to penetrate the heating market across the full range of dwelling types will lead to RES-H ambitions being missed, or necessitate alternative solutions to make up the shortfall.

There is a wide range of potential outcomes depending on consumers’ attitudes towards the RHI. Renewable heat uptake will be maximised by providing long-term certainty on the policy landscape and instilling confidence in consumers in relation to the ability of technologies to meet their needs.

Baseline SPF values in retrofit applications are 2.5 (2011), rising to 3.5 (2030) for ASHPs and 3.3 (2011), rising to 4.3 (2030) for GSHPs.
4.7 Wider energy system impacts

4.7.1 Introduction

Scotland’s energy infrastructure is currently set up to deliver the majority of heat via fossil fuel, primarily natural gas through the gas network and oil in off-grid locations. The results presented above show that decarbonising heat supply will involve a significant shift in the heating market, with far more reliance on electricity for heating via heat pumps in the future. Demand for solid biomass fuel is also expected to increase with the introduction of the RHI, with the majority of demand most likely to arise from the non-domestic sector.

This section considers the wider impacts of renewable heating technology uptake by assessing the impacts on the electricity grid and considering future demands for solid biomass fuel against supply projections.

4.7.2 Impacts on the electricity grid

Understanding the potential impacts of heat pumps on the electricity grid (both in terms of generating capacity required to meet demands and impacts on the transmission and distribution networks) is complicated by several factors. For example, instantaneous electricity demands depend on heat pumps’ COPs (which in practice are not constant values\(^{72}\)), time of day, day of week and time of year. Detailed exploration of the network impacts of heat pumps is beyond the scope of this study and is the subject of ongoing work.\(^{73}\) In this section we estimate the potential impact of heat pumps on the Scottish electricity grid using published benchmark figures. The main assumptions used are summarised below.

Table 13: Grid impacts – assumptions

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional generating capacity per unit of annual heat load served by heat pumps (MW/TWh)</td>
<td>75</td>
<td>NERA &amp; AEA(^{74})</td>
</tr>
<tr>
<td>Forecast electricity demand in Scotland in 2030 (TWh/yr)</td>
<td>35.3</td>
<td>GL Garrad Hassan(^{75})</td>
</tr>
<tr>
<td>Forecast peak electricity demand in Scotland in 2030 (excluding heat pump uptake) (GW)</td>
<td>5.0</td>
<td>National Grid(^{76})</td>
</tr>
</tbody>
</table>

These data are used to put the additional loads due to heat pump uptake into context, as shown in the following figures.

\(^{72}\) In practice COPs will vary by installation and depend on factors such as whether demand is for space heating or hot water and the differential between heat extraction and delivery temperatures.

\(^{73}\) Research on this question is currently being undertaken at UK universities, including Imperial College for example.

\(^{74}\) Decarbonising Heat: Low-Carbon Heat Scenarios for the 2020s, p.40, NERA and AEA for the CCC (2010).

\(^{75}\) The Power of Scotland Secured (summary for policy makers), GL Garrad Hassan for Friends of the Earth Scotland, Demand Reduction scenario, Table 2, p.12 (2010).

Under a scenario with uptake in line with the CCC’s Medium abatement ambition, electricity demands from heat pumps in the domestic sector equate to around 6.5% of total forecast demands in Scotland in 2030. This rises to 9% under the 50% 2030 target scenario. For comparison, total electricity consumption in the domestic sector in Scotland was 11.6TWh in 2008, compared to a total of 28.3TWh across all sectors. The additional demand from heat pumps by 2030 therefore represents a 20% increase on 2008 domestic sector electricity demands (with uptake in line with the CCC scenario). In the graph below we consider heat pumps’ impact on electricity generation capacity required.

Figure 23: Electricity demands due to heat pump uptake in the domestic sector in Scotland under a selection of scenarios

77 Total sub-national final energy consumption, DECC (2011).
The overall increase in electricity demands (including average over the year and peak demands) due to heat pump uptake is expected to be manageable within upgrade plans over the next two decades. However, local issues (on distribution networks) could arise where clusters of heat pumps are connected. Identifying where such clustering might occur and the associated impacts is beyond the scope of this study (and beyond the capabilities of the model used).

High reliance on heat pumps could also lead to upward pressure on electricity prices (as additional investments will be required in generation plant and distribution networks). The impact of high electricity prices on renewable heat uptake is considered in section 6.7.6, and the results show that although total renewable heat delivered could fall significantly, heat pumps still dominate the overall mix in the domestic sector.

### 4.7.3 Impacts on biomass fuel demand

Forecasts of potential biomass fuel supply are available in a report published by the Wood Fuel Task Force, which provides the following data.

**Table 14: Biomass fuel demands in Scotland – assumptions**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value (2017/21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net availability of biomass material (odt/yr)</td>
<td>1,183,700</td>
</tr>
<tr>
<td>Energy available (TWh/yr)</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Demands for biomass fuel in the domestic sector are likely to remain well below these levels. For example, under scenarios that lead to uptake in line with the CCC ambition / 2030 50% target, demand for biomass for domestic installations reaches around 0.3 and 0.4TWh/yr in 2030 respectively. Feedback from stakeholders contacted during this study

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78 **Wood Fuel Task Force 2: The supply of wood for renewable energy production in Scotland,** Table 3, p.31 (2011).

79 Based on a conversion factor of 5.3MWh/odt (from biomassenergycentre.org.uk).
suggests that fuel availability is not currently a barrier for domestic biomass boiler uptake. Demand for biomass in the non-domestic heating sector is likely to be far more significant (given the economies of scale of larger systems). A concern raised during the consultation was that increased use of biomass for electricity generation (either through co-firing or in biomass CHP applications) may put pressure on the supply chain that could impact all sectors.

4.8 Fuel poverty impacts

4.8.1 Introduction

Fuel poverty, generally defined as a situation in which a household cannot afford to heat the home to a satisfactory standard, is a serious issue that affects around 30% of Scottish households.

The Scottish Government has a target to eradicate fuel poverty by 2016 as far as is reasonably practicable. The three main factors that determine whether a household is in fuel poverty are:

- Net household income.
- Total demand for fuel (which depends on thermal efficiency of dwelling, efficiency of heating system, temperature differentials (i.e. the weather) etc.).
- Fuel prices.

In this section we consider the potential impact of an RHI on fuel poverty in Scotland. In the context of the three factors above the RHI will mainly impact the first, net income, by providing an additional source of income due to generation of renewable heat.

If the RHI for the domestic sector takes a similar form to that for the non-domestic sector (i.e. ongoing subsidy payments rather than capital grants), then households in fuel poverty will be less likely to be in a position to take advantage of the RHI. Provided that this barrier could be overcome (e.g. through targeted soft loans), it is instructive to consider the costs of heat delivered from the alternative heating system options to understand the relative costs of heat at the individual dwelling level.

4.8.2 Energy costs in tenements / flats

Taking a typical tenement / flat as an example, we compare the costs of energy delivered from alternative heating system options. The comparison metric used, levelised cost of energy (LCOE), is defined as the net annual cost of running the heating system (£/yr) divided by useful energy delivered (MWh/yr). The table below sets out the data from which LCOE values are calculated.

Table 15: LCOE calculation assumptions: tenement / flat

<table>
<thead>
<tr>
<th></th>
<th>Gas boiler</th>
<th>Electric heating</th>
<th>ASHP</th>
<th>GSHP (communal)</th>
<th>Biomass boiler</th>
</tr>
</thead>
</table>

80 Review of fuel poverty in Scotland, Scottish Government, p.5 (2008). This document also sets out the definition of fuel poverty in Scotland: A household is in fuel poverty if, in order to maintain a satisfactory heating regime, it would be required to spend more than 10% of its income (including Housing Benefit or Income Support for Mortgage Interest) on all household fuel use. A satisfactory heating regime for the main living area for people over 60 (and those who are long-term sick or disabled) is for the room to reach 23°C for 16 hours per day, seven days a week. For non-pensioner households the requirement is 21°C for nine hours per day on weekdays and 16 hours per day on weekends.
Note that in this example no capital cost (or opex) has been included for electric heating. The assumption here is that in the case of ‘electric heating’ the dwelling uses existing storage heaters. The LCOE for electric heating then depends only on fuel price and efficiency (taken as 95% to allow for storage losses). For the other technologies a capital cost is included and annualised (over 15 years at either 3.5% or 15%) in the calculation of LCOE. The resulting costs of energy are presented graphically below.
Figure 25: Levelised cost of energy for a selection of heating system options – tenement / flat

These graphs show the LCOE by component, with the red cross indicating the net LCOE (i.e. including RHI revenues). The upper plot includes capital costs annualised at 3.5%, which is consistent with the soft loan scenario considered in section 6.7.7. By comparing these results to those in the lower plot, which includes a commercial discount rate of 15%, the impact of this figure is clear.

If consumers must pay a commercial rate for capital (or if the capital cost barrier is removed by a company that requires a commercial rate of return), then only the ASHP (with an RHI of £75/MWh) provides energy at a lower cost than the gas boiler option (a 13% reduction). Even relative to heat from direct electric heating, the GSHP and biomass boiler options (based on communal block-scale systems) are unlikely to provide lower overall costs (even when supported by an RHI at these levels).

In the case where consumers are provided with low interest loans (or if a public body with access to very low interest finance could assist), all three of the renewable heating
technologies considered deliver energy at a cost competitive with direct electric heating. However, based on the data set out in Table 15 above, only ASHPs and GSHPs can compete with gas boilers (biomass remains more expensive even with a soft loan and an RHI).

From this we conclude that the renewable heating technology options for reducing fuel bills are limited, and that to provide any saving in ongoing energy costs access to low cost finance will be essential.

### 4.8.3 Energy costs in houses

Having looked at the extent to which renewable heating technologies could reduce ongoing fuel costs in flats, we now consider the case in houses. The data below are consistent with the assumptions used in the uptake model.

**Table 16: LCOE calculation assumptions: other house**

<table>
<thead>
<tr>
<th></th>
<th>Gas boiler</th>
<th>Oil boiler</th>
<th>ASHP</th>
<th>GSHP</th>
<th>Biomass boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex (£/installation)</td>
<td>2,200</td>
<td>2,200</td>
<td>9,600</td>
<td>15,000</td>
<td>11,500</td>
</tr>
<tr>
<td>Opex excluding fuel (£/installation)</td>
<td>65.00</td>
<td>65.00</td>
<td>50.00</td>
<td>50.00</td>
<td>65.00</td>
</tr>
<tr>
<td>Annual output (MWh/yr)</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Efficiency</td>
<td>85%</td>
<td>85%</td>
<td>250%</td>
<td>330%</td>
<td>85%</td>
</tr>
<tr>
<td>Fuel price (£/MWh)</td>
<td>40.00</td>
<td>57.00</td>
<td>90.00</td>
<td>90.00</td>
<td>58.00</td>
</tr>
<tr>
<td>RHI (£/MWh)</td>
<td>N/A</td>
<td>N/A</td>
<td>75.00</td>
<td>70.00</td>
<td>90.00</td>
</tr>
</tbody>
</table>

Levelised cost of energy values, again at low and commercial discount rates, are plotted below.
These results are broadly similar to those discussed above (for flats). The main difference is the higher RHI level for biomass in this case (for an individual rather than a communal system) leads to the LCOE of heat from biomass being competitive against gas at the low discount rate.

The conclusion that renewable heating technologies are unlikely to provide lower net heating system running costs (unless low or zero cost finance is available) is unsurprising given that the RHI is designed around a 12% rate of return\textsuperscript{81}, i.e. the subsidy is not sufficient to provide significant ongoing savings at the same time as paying off capital at a commercial interest rate.\textsuperscript{82} This is also consistent with views from the stakeholders contacted during this study, who in general did not see how the RHI could benefit those in fuel poverty.

\textsuperscript{81} See Design of the Renewable Heat Incentive, NERA for DECC (2010).
\textsuperscript{82} This is also demonstrated by the ESCO scenarios discussed in section 6.7.7.
4.8.4 Renewable heat technology mix in off gas grid homes

The incidence of fuel poverty is higher in households off the gas grid, partly due to the higher cost of fuel in such areas, as shown by the following graph.

**Figure 27: Proportion of households in fuel poverty in Scotland by heating fuel type**

The Scottish housing stock is characterised by a higher proportion of dwellings not connected to the gas grid relative to Great Britain as a whole, as shown below.

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of domestic gas meters (million)</th>
<th>Domestic gas meters relative to number of households</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>19.57</td>
<td>87%</td>
</tr>
<tr>
<td>Scotland</td>
<td>1.88</td>
<td>79%</td>
</tr>
<tr>
<td>Wales</td>
<td>1.09</td>
<td>82%</td>
</tr>
<tr>
<td>Great Britain</td>
<td>22.55</td>
<td>86%</td>
</tr>
</tbody>
</table>

In order to better understand the renewable heat mix in dwellings more likely to be affected by fuel poverty, WWF Scotland requested insight into the expected renewable heating technology mix in off gas grid homes. We therefore consider the renewable heat mix in such dwellings for two of the scenarios presented in the preceding sections:

- **RHI to 2030, high fuel prices** scenario – which leads to uptake in line with the CCC Medium abatement ambition.

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83 Data from *Review of Fuel Poverty in Scotland*, Table 2, p.16, Scottish Government (May 2008).
• **Barrier Removal** – a scenario that gives uptake in line with Scottish Government’s ambition to decarbonise the heat sector in Scotland by 2050 (50% renewable heat by 2030).

![Figure 28: Proportion of renewable heat by technology in dwellings off the gas grid for two example scenarios in 2020 and 2030](image)

This study’s uptake modelling suggests that ASHPs are likely to be the dominant renewable heating technology in off gas grid homes, supplying nearly 90% of the renewable heat in these dwellings in 2020 and 2030 under these scenarios.

We must bear in mind that the high capital cost of renewable heating technologies is a significant barrier likely to restrict uptake in fuel poor households. Assuming that mechanisms are implemented to allow those in fuel poverty to access renewable heating technologies, we can consider how the renewable heat mix may change in the context of other policies designed to address fuel poverty. The Scottish Government’s 2008 review of fuel poverty states: *in the context of its limited powers to address the key contribution of household income and fuel prices to fuel poverty, the Scottish Government has instead focussed on seeking to improve household energy efficiency.*\(^{85}\) The main effect of fuel poverty reduction policies is expected to be to reduce energy demand in fuel poor households. Increasing the energy efficiency of dwellings will tend to increase their suitability for renewable heating technologies; however, there is little evidence to suggest that such policies will have a significant impact on the mix of renewable heat. Considering renewable heat in economic terms, with an RHI in place reducing thermal demands tends to favour less capital intensive technologies (e.g. ASHPs) as lower load factors are more detrimental to the more expensive technologies.

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5 Conclusions and policy recommendations

5.1 Meeting ambitions for renewable heat

Based on current policy commitments (i.e. RHI funding to 2015 only), uptake of renewable heat in Scottish dwellings falls well short of the levels required to meet ambitions for decarbonising heat supply.

- Excluding the potential contribution from renewable district heating, renewable heat uptake by 2020 is around a quarter of the level required for the domestic sector to make a proportionate contribution to the 2020 11% renewable heat target.
- Similarly, with an RHI to 2015 only, RES-H in dwellings is below a fifth of the amount required to meet the CCC’s Medium abatement scenario ambition in 2030.
- Long-term support for renewable heating technologies (to 2030 and beyond) will be essential if renewable heat ambitions are to be met. Options include either providing financial support (e.g. via the RHI or similar mechanism), or making non-renewable alternative options less attractive.

There are numerous pathways to achieving renewable heat uptake in line with the CCC’s Medium abatement scenario. All require continued intervention to support renewable heating technologies to beyond 2030.

- Uptake of heat in the domestic sector is consistent with the CCC’s ambitions under scenarios that include high fossil fuel price projections, or where hassle barriers associated with renewable heating technologies are overcome, or where supply side restrictions are less severe for example.
- In all cases intervention is expected to be required to 2030 and beyond to ensure continued demand for these technologies. Furthermore, these scenarios rely on relatively optimistic assumptions regarding technology performance and the suitability of the Scottish dwelling stock for renewable heat.

Meeting a stretch ambition of renewable heat contributing 50% of domestic heat demand by 2030 would require a greater reliance on renewable heat from district heating combined with very rapid ramp up in dwelling-scale renewable heat technology sales.

- It is highly unlikely that a 50% 2030 renewable heat target will be met by dwelling-scale technologies alone. All scenarios that meet this ambition include a greater contribution from district heating relative to the CCC scenario. This will be extremely challenging given the limited number of economic opportunities for district heating under current market conditions (see below).
- This level of uptake will also require the removal of a combination of barriers, for example, supply side restrictions and research time for consumers to understand and evaluate new technologies.
- There are risks to very rapid industry growth, such as maintaining high quality of installations and after-sales service. Such risks will have to be managed and mitigated in any high growth future. It will also be crucial to first demonstrate the performance and suitability of renewable heating technologies in Scottish dwellings to ensure that renewable heat targets are not pursued to the detriment of consumers’ heating needs.
Meeting the renewable heat ambitions considered in this study will require a significant transformation of the heating market in Scotland.

- For uptake in line with the CCC's Medium abatement scenario sales of renewable heating technologies will have to grow to account for in excess of half of all new heating system sales by 2030.
- Such a transformation will require significant investment in developing supply chains and will only be achieved in the context of strong continued demand (to unlock the investment required).
- Strong demand in turn will depend on continued financial support for renewable heat combined with consumer confidence that products can be supplied and maintained to an adequate level (e.g. rapid response to any breakdowns).

The results presented here are based on a very aggressive insulation rollout programme to upgrade the energy efficiency of Scotland's dwelling stock. Failure to adequately insulate homes could lead to heat pump efficiency values not being achieved and undermine medium to long term renewable heat targets.

- This study’s baseline includes suitability of dwellings for heat pump installation increasing steadily over the next decade (leading to c.70% of dwellings being suitable for heat pumps).
- In a scenario where only 50% of dwellings can accept ASHPs, renewable heat delivered from dwelling-scale technologies in 2030 falls by a third.
- Renewable heat uptake should not be viewed as an alternative to demand reduction through insulation rollout. On the contrary, insulation uptake is likely to be an essential enabler to support the delivery of renewable heat.

The Renewable Heat Incentive is a novel policy and consumer reaction to the RHI is highly uncertain. Modelling results are therefore indicative only and further work to understand consumer attitudes to such support mechanisms is needed.

- The RHI represents a different proposition from other financial support mechanisms (such as the feed-in tariff) given that it relates to heating systems, which are fundamental to the comfort of building occupiers.
- In addition, interactions with the property market are potentially more intricate, for example concerns over impacts on property values.

High ambitions for RES-H are unlikely to be met without a substantial contribution from district heating. However, there are significant barriers to delivering schemes under current market conditions.

- There are numerous barriers to developing district heating (including high capital costs, revenue uncertainty, phasing issues etc.) which have been well-documented elsewhere.\(^\text{86}\)
- The most economic opportunities for district heating are in Scotland's cities, particularly Edinburgh and Glasgow. The economic viability of district heating is enhanced in mixed use schemes (i.e. domestic and non-domestic consumers) in areas of high heat density.

\(^{86}\) See for example, Achieving deployment of renewable heat, Element Energy and NERA for the CCC, section 4.3.6 (2011).
The costs of meeting renewable heat ambitions are likely to be substantial and need to be balanced against the benefits an RHI could deliver.

- For uptake consistent with the CCC’s Medium Abatement scenario, RHI subsidy support reaches in excess of £520m/yr by 2030 for the domestic sector in Scotland. This is equivalent to £190 per dwelling in Scotland.
- These costs should be considered against the benefits that increased renewable heat deployment could bring, including reduced reliance on fossil fuels, greater diversity of energy supply, reduced GHG emissions and development of new businesses in Scotland.

5.2 Renewable heating technology mix

In each scenario considered, uptake of dwelling-scale technologies is dominated by air source heat pumps. However, the penetration of this technology into Scotland’s domestic heating market will depend on improving insulation standards of the dwelling stock.

- Given the relatively low additional capital costs of ASHPs (compared to the other renewable heating technologies considered (and lower disruption during installation compared to GSHPs)), this technology is likely to be preferred by the majority of consumers adopting renewable heating technology in the domestic sector.
- The highest seasonal performance factors will only be achieved in cases where the technology is well installed into suitably insulated properties. Poor installations in unsuitable dwellings will lead to disappointing performance and could damage the reputation of heat pumps.

A greater contribution from ground source heat pumps and biomass boilers may be expected if the additional capital cost of renewable heating technologies could be reduced or removed, for example through low interest loans.

- Consumers’ aversion to upfront capital expenditure results in relatively low uptake of high cost heating systems. Soft loans could provide a mechanism for overcoming this barrier.
- These technologies could also provide a cost-effective solution when deployed in tenements / flats at the building / block level.

Given the more extensive barriers to delivering district heating (relative to dwelling-scale technologies) its contribution to meeting medium term renewable heat targets is highly uncertain. However, it is clear that renewably fired district heating has a key role in fully decarbonising heat in buildings in the longer term.

- The development of renewable district heating schemes should initially be focused on priority areas, i.e. cities with high heat density, particularly Edinburgh and Glasgow (see section 6.5).
- Recommended policies to encourage district heating development are given in section 5.5.

The development of district heating networks will provide an opportunity for increased diversity of heat supply. The precise mix of heat supplied via such networks will be dictated by local conditions and the policy framework.

- District heating is enabling infrastructure that facilitates the delivery of heat from a limited number of sources to multiple consumers. The role of district heating in meeting renewable heat targets depends crucially on the sources of heat supply.
The high-level economic analysis undertaken in this study suggests that heat-only biomass boilers will be one of the more cost-effective renewable heat supply options, particularly when supported by the RHI.

**Residential-led retrofit district heating schemes are unlikely to be economically competitive against gas or oil boilers, but could provide heat at a competitive price compared to direct electric heating.**

- The relatively high costs of heat distribution infrastructure and associated equipment required (heat exchanges, heat meters etc.) must be recouped through the heat sale price for an economically viable scheme. This leads to high heat prices, even with RHI support for the generating plant.
- Larger heat consumers are therefore required to enhance the economic case (lowering the infrastructure cost for a given heat density).

**A combination of reasonably high heat density and high annual heat consumption per connection (which necessitates non-domestic connections) is required for district heating to deliver renewable heat at a cost competitive with oil or gas boilers.**

- Wide-scale uptake of renewably-fired district heating depends on heat prices being competitive with heat from individual gas and oil boilers. This is only likely to be achieved with relatively high local heat densities and high consumption per connection, criteria which will only be met with mixed schemes (a combination of residential and non-residential heat loads).
- Development of district heating schemes should focus on areas with most favourable characteristics, including high heat density combined with low connection density, a mix of building types and sufficient anchor loads.

### 5.3 Barriers and risks to meeting renewable heat ambitions

**The single largest barrier to renewable heat uptake has to date been the lack of an economic case. The RHI is expected to provide sufficient incentive to stimulate the renewable heating market but may not be accessible to all consumers. Without a breakthrough in technology costs, the renewable heat sector is likely to be dependent on financial support through to 2030.**

- High capital cost was identified as the most important barrier to renewable heat technology uptake by those contacted during this study.
- Sufficiently high RHI levels (i.e. those currently proposed by DECC) are expected to stimulate demand for renewable heating technologies but could exclude consumers without access to capital (or finance).
- If the RHI for the domestic sector is structured in a similar way to that for the non-domestic sector (i.e. ongoing subsidy payments rather than capital grants) then the capital cost barrier will have to be addressed by other mechanisms in order to extend accessibility of renewable heat technologies to lower income group consumers. Options include loans, or ESCO-type companies providing finance in return for RHI payments (although commercial opportunities for such companies are likely to be limited).
Given the fundamental importance of heat generation to people’s everyday lives, financial incentives alone are unlikely to be sufficient to drive significant uptake. High consumer confidence in the technologies will also be required.

- In contrast to the renewable electricity market for example, consumers selecting renewable heating technologies will rely on them to meet their everyday comfort needs. Demonstration of successful installations will therefore be crucial to building consumer confidence in technology.

Renewable heating technologies are not direct replacements for fossil fuel boilers, with different space requirements, environmental impacts and heat delivery capabilities. There is considerable uncertainty regarding the suitability of Scottish dwellings for these technologies and this is a key area for further research.

- The baseline suitability assumptions used in this study are relatively optimistic. Greater restrictions on renewable heat deployment could severely limit uptake. For example, overall RES-H delivered in 2030 falls by 50% where heat pump uptake is allowed only in off-gas areas, reflecting a scenario where heat pumps are not permitted development and can only be installed in less built up areas.

Given sustained growth in demand for renewable heat technologies, supply chain expansion will also be crucial to meet RES-H targets. Failure of supply chains to develop is a key risk to be managed.

- Meeting medium and long-term RES-H targets will require supply chain growth at rates towards the upper end of those experienced in more mature European renewable heating markets.

- Significant investment will be required (e.g. in starting new businesses / expanding or retraining in existing companies) to achieve such levels. Such investment will only be forthcoming if the long-term future of the renewable heating market is clear.

To play a full role in meeting RES-H ambitions, the average seasonal performance factors of heat pumps must increase relative to historical values observed in UK field trial data.

- Average SPFs of ASHPs will need to rise to around 3.5 or above for new domestic installations by the middle of the next decade for this technology to play its full role.

- This is significantly higher than empirical values from UK trials to date, but deemed achievable based on experience from other European countries, published data and stakeholder feedback.\(^\text{87}\)

- Good heat pump performance in the initial years will also be important in instilling confidence in the technology. The ongoing EST heat pump trials will provide valuable data and learning, as will data collected through the Renewable Heat Premium Payment Scheme.

With an RHI of £90/MWh, biomass boiler uptake in the domestic sector is relatively insensitive to biomass price. However, high electricity prices could severely restrict the uptake of heat pumps.

- High capital cost and suitability constraints will be the main barriers to biomass boiler uptake in domestic applications (rather than fuel availability or fuel price).

\(^{87}\) See section 6.3.3 for references to heat pump field trial data.
• However, this study’s results suggest that renewable heat delivered by 2030 could fall by a third under a high electricity price future.\(^88\)

• The need to replace retiring power stations, rising fossil fuel prices, investment in upgrading transmission and distribution networks, and support policies for low carbon generation (RO, FT etc.) will place continued upward pressure on electricity prices. Renewable heat delivery will depend on heat pump customers being offered favourable electricity tariffs.

The high capital cost of renewable heating technologies will be a barrier for many consumers (particularly those without access to capital), even with ongoing RHI support.

• Consumers, particularly in the domestic sector, tend to be averse to high upfront costs and discount future revenues heavily.

• Households without access to capital are unlikely to be able to install renewable heating technologies without further support to meet the high capital costs. It remains to be seen whether providers will offer low cost finance or revenue-sharing schemes to take advantage of the RHI, as have emerged for photovoltaics under the feed-in tariff.

The provision of loans could help overcome the capital cost barrier. However, increased renewable heat uptake is only expected with medium to low cost finance.

• For a positive impact on RES-H delivered, loans at or below typical mortgage interest rates (e.g. 8%) will be required.

Furthermore, loans will have to be sufficient to cover a large portion of the additional capital cost of renewable heating technologies.

• The loan scenarios that lead to notable additional renewable heat uptake represent subsidising the entire additional capital costs consumers face.

• The impact of smaller loans (e.g. the current Scottish Government’s £2,000 loan) is likely to be limited given the size of the additional capital costs associated with renewable heating technology installation.

A major barrier to the development of district heating is the lack of a robust economic case (and high risks), especially for retrofit schemes.

• Development of district heating involves relatively high costs in planning, designing and assessing the feasibility of new schemes. These costs are at risk, i.e. they will not be recouped in the event of the scheme not being developed.

• High upfront capital costs, long (and uncertain) payback periods, and low returns on investment currently hamper district heating development.

• Furthermore, there can be a conflict in that installation (particularly groundworks) costs can be highest in locations with favourable characteristics such as high density urban areas.

\(^88\) For reference, in the Central (baseline) case gas prices rise from 4.2p/kWh in 2011 to 5.9p/kWh in 2030, and electricity prices from 12.9–23.5p/kWh over the same period. The high high electricity price scenario includes electricity prices rising from 16.1p/kWh in 2011 to 30.1p/kWh in 2030 (i.e. c.25% higher than baseline values).
A knowledge and skills gap also exists that could continue to restrict the development of district heating in Scotland.

- This includes a lack of independent, impartial advice around the legal and financial details of district heating; and a lack of technical skills in this area in the UK. This is being addressed to some extent (e.g. the expert group on district heating being established by the Scottish Government).

There are multiple other barriers to district heating deployment and although some are reducing, the consensus from stakeholders was that there is insufficient progress for DH to make a substantial contribution in the short to medium term.

- Some of the other barriers include securing sufficient numbers of customers and phasing issues (upfront costs for plant and infrastructure, but demands (and hence revenues) build up over time).
- Local authorities are seen as the right partners to lead on district heating implementation. However, there are challenges regarding coordinating the multiple stakeholders required (planning, housing, financing, legal department etc.).

5.4 Wider impacts of renewable heat uptake

5.4.1 Energy system impacts

The additional demands for electricity (in terms of average annual demands and national peak demands) due to heat pump uptake in the domestic sector under the RHI are expected to be manageable in the period to 2030.

- Additional annual demands are no more than 9% of total forecast electricity demand in 2030 under any of the scenarios considered. Similarly, the maximum increase in generating capacity required due to domestic heat pumps is estimated to be no more than around 800MW (16% of total peak demands) in 2030.

However, clustering of areas with high heat pump penetration is likely to strain local distribution networks and further research is required to understand the scale of the challenge.

- Unless planned for, high heat pump uptake will lead to excessive strains on local distribution networks.
- However, it has not been possible within the current study to analyse local impacts in detail and further investigation in this area will become necessary as uptake increases.

5.4.2 Fuel poverty implications

Opportunities for the RHI to benefit those in fuel poverty are likely to be very limited unless low to zero cost finance can be provided to such consumers.

- Fuel poor households are unlikely to be able to install renewable heat technologies if the domestic RHI is structured so as to be consistent with the non-domestic scheme (i.e. ongoing subsidy rather than capital grant support).
- Removing the capital cost barrier could change this situation, but ongoing fuel costs are unlikely to be reduced (as a result of renewable heat uptake) unless very low or zero cost finance can be provided.
Policies to reduce fuel poverty should focus on reducing demand for energy, increasing the efficiency of heating systems, and increasing household income.

- Alleviating fuel poverty is not one of the aims of the RHI policy. Whilst there may be opportunities to develop lower cost heat delivery systems (e.g. communal systems with RHI support replacing direct electric heating), the RHI should not form a central aspect of fuel poverty reduction strategies.

5.5 Policy recommendations

The results and conclusions above highlight the scale of the challenge in meeting ambitious renewable heat targets in the medium term on the path towards decarbonising heat by 2050. These ambitions will not be met with a single support scheme (i.e. an RHI) alone. Additional actions will be required and we propose a number of key priorities below.

5.5.1 District heating

- The Scottish Government should continue to make low interest loans available for capital spend on district heating projects under the District Heating Loans Scheme until at least 2020, and ideally increase the amount of funding available under this programme.

- The Scottish Government should introduce loans for development work on district heating projects, to initially cover the 19 local authority areas not covered under the JESSICA programme. One option for the introduction of such a scheme would be an extension to the District Heating Loans Scheme which could be ring fenced for development spend. This should include provision to provide funds for ‘in-house’ project management, in part to ensure co-ordination across local authority departments and during the development phase.

- The Scottish Government should ensure their discussions and analysis of options relating to implementing Section 64 of the Climate Change (Scotland) Act 2009 include consideration of district heating. This should include an analysis of the connection requirements in other countries and options to replicate or build on these for Scotland.

- Local authorities should be required to develop a strategy and implementation plan for district heating in their area. This should be based on their understanding of their local area arising from the heat mapping exercise that the Scottish Government has piloted with the Highland and Islands Council, and which is due to be rolled out to other local authorities. Local authorities should also be required to report on progress towards meeting the goals set out in their implementation plans.

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90 Joint European Support for Sustainable Investment in City Areas (JESSICA) is a programme of urban development funds. The Scottish Government and European Investment Bank have recently announced the selection of a preferred bidder to manage a new £50 million investment fund which will offer loans and equity investment to revenue generating projects in 13 local authority areas in Scotland. See: http://www.scotland.gov.uk/Topics/Built-Environment/regeneration/jessica/FundManagerAnnouncement.

• Local authorities should be trained in using and interpreting the information generated from existing heat mapping work. This work should be supported by the Scottish Government as part of the planned rollout of heat mapping work across Scottish local authorities.

• The Scottish Government should provide local authorities with powers to require that heat users, including householders at the point of heating system change, connect to a district heating system in all or part of their areas. Such powers should be set within reasonable limits: for example, local authorities and / or the Scottish Government would need to help with connection costs for vulnerable households, and seek guarantees from the district heating operator that heat would be supplied at the same price or below that of the incumbent local fuel supply.

• The Scottish Government should consider encouraging local authorities to develop a zoned approach to district heating. This approach has been adopted in Denmark and considered for Glasgow. Zones would be areas where district heating is most likely to be cost effective to develop for reasons such as such as high heat density, availability of waste heat, or a mix of commercial and domestic users. Identifying such zones within a local authority area would help potential private developers, and the local authorities, to focus on areas where it would be cost-effective for them to operate a district heating scheme. These zones could become the areas where local authorities use their powers to require connection to district heating schemes.

• Local authorities should be required to commit to connect their public buildings to district heating networks where possible. This would provide some guarantee of heat load to developers and encourage private sector involvement in developing projects. However, there would also need to be guarantees in place for ensuring value for money for the local authority (i.e. developers would need to agree heating rates with the local authority which are equivalent to or lower than prevailing market energy costs etc.).

• Local authorities and housing associations should be compelled to consider district heating when planning housing stock upgrades.

• Planning authorities should require consideration of district heating in new developments (including the potential to connect to existing district heating schemes) through their Development Plans and development management policies. When considering applications for developments in high density areas,

92 This was another recommendation from the Heat and the City workshop (September 2011).

93 In Denmark local authorities have the power to require that all or part of a local authority area connect either to a natural gas supply or district heating (Executive Order no. 581 of 22 June 2000 on connection etc., to public heat supply installations). The degree to which this power is exercised varies considerably from area to area. For further information see: http://193.88.185.141/Graphics/Publikationer/Forsyning_UK/Heat_supply_in_Denmark/htm l/full_publication.htm.


planning authorities should require evidence that the proposed heating, cooling and power systems have been selected to minimise carbon dioxide emissions. Major developments should demonstrate that the proposed heating and cooling systems have been chosen from a hierarchy of choices in the following order of preference:

- Connection to existing CCHP / CHP distribution networks.
- Site-wide CCHP / CHP powered by renewable energy.
- Gas-fired CCHP / CHP or hydrogen fuel cells, both accompanied by renewables.
- Communal heating and cooling fuelled by renewable sources of energy.
- Gas fired communal heating and cooling.

- The provision of expert support, advice and training for local authorities and others on the development of district heating is essential. Much expertise lies within local authorities that have already developed district heating networks in their areas. Information sharing networks should be set up to facilitate information exchange between local authorities and, ideally, financial support should be able to cover the procurement of expertise to aid scheme development. This should include covering expenses and local authority officers’ time, to allow local authorities with in-house expertise to share this knowledge with other practitioners.

- The Scottish Government should develop, or fund the development of a) ‘off the peg’ legal and business models for district heating schemes in Scotland based on UK-wide best practice, b) guidance on the development of ESCOs, c) best practice and d) generic models for the ongoing operational aspects of a community energy scheme, including cost transparency around maintenance and billing costs.

- A single ‘portal’ of advice, signposting, and new and existing case studies of district heating in Scotland should be developed. There are several existing sources of information on district heating development in Scotland and the UK more widely, including the Combined Heat and Power Association (CHPA), the District Energy Association (DEA), the UK Decentralised Energy Knowledge Base, the Energy Saving Trust and Community Energy Scotland.

- Local authorities should improve the training of planning officers by increasing the resources available for practical training on district heating and renewable heat sources.

- The Scottish Government and other stakeholders (including Ofgem and the National Grid) should work together to provide more resources to simplify and speed up the grid connection process and provide district heating developers with guidance on transmission charges and grid connection charges.

96 CCHP = combined cooling, heat and power.
97 The details of this recommendation are taken from the London Plan, the Mayor of London’s planning strategy for London, section 4A.6 Decentralised energy: Heating, cooling and power. http://www.london.gov.uk/thelondonplan/policies/4a-06.jsp.
98 The Heat and the City project is proposing to host further focus groups / workshops, and develop information and expertise exchange for energy practitioners and local authorities in the UK. See: http://www.heatandthecity.org.uk/__data/assets/pdf_file/0007/71926/Heat_and_the_City_-_September_2011_Workshop_report.pdf, p. 5, Presentation Seven – Heat and the City Project, Next steps for action and conclusions.
99 www.dekb.co.uk.
### 5.5.2 Microgeneration

- The UK and Scottish Governments should provide clear indications of the long-term support framework for renewable heat (i.e. to at least 2030), to support both dwelling scale technologies and renewables-fed district heating.
- The UK Government should extend the RHI (or an equivalent support mechanism) beyond the current commitment period (2015) to at least 2030.
- UK Government should include minimum energy efficiency measures as an eligibility criterion for the domestic RHI to ensure heat pump SPFs are realised. The eligibility should be updated if necessary as further information becomes available from Energy Saving Trust field trials or other research (e.g. RHPF findings).
- In order to help meet targets for renewable heat, and help to ensure heat pump SPFs are maximised, the Scottish Government needs to continue to focus on achieving the fastest possible uptake of insulation in Scotland’s homes.
- The Scottish Government should consider regulation as a potential part of the policy mix to drive the uptake of renewable heating technologies at the individual dwelling scale. Regulation may be needed if early indications from the RHI are that tariffs are insufficient to drive the levels of uptake needed. This approach has worked well in the past to drive the uptake of new heating technologies (e.g. condensing boilers).
- The Scottish Government should continue to make loans available to households for renewable heating technologies. For these systems to become mainstream, the value of loans will need to increase to cover the price differential between the cost of a conventional heating system and that of the chosen renewable heating system.
- The Scottish Government should work closely with the UK Government to investigate and implement additional ways of removing capital cost barriers faced by those considering installing renewable heating technology. Options could include designing the RHI for the domestic sector to help cover high upfront costs, and linking the RHI to the Green Deal.
- The Scottish Government should continue to support a single point of contact for households looking to install renewable heating technologies through the Energy Saving Scotland advice network. The provision of a) in-depth and (where appropriate) in-house advice on the appropriateness of different renewable heating systems for different homes, b) recommendations specific to the householder’s situation, c) referral to appropriately accredited installers and products, and d) information about financial support mechanisms such as the RHI, have an important role to play in overcoming hassle barriers. Such services will need to be grown over time if the rate of uptake of these technologies is to significantly increase.
- The Scottish Government should work with Ofgem and other stakeholders to explore how those with heat pumps can minimise their electricity bills through appropriate tariffs.
- The Energy Saving Trust carried out the first detailed study of the effectiveness of heat pumps in real homes in the UK, including a sample in Scotland. Further work is now required to look in greater detail at the specific characteristics of the Scottish building stock and to establish more robust estimations of the suitability of Scottish dwellings for renewable heat. This study should make use of Energy
Performance Certificate data, Scottish House Condition Survey data, and gather additional data where needed.

- The Scottish Government already funds considerable provision of expert, impartial advice on renewable heat technologies in Scotland, primarily through the Energy Saving Trust and the Energy Saving Scotland advice network. However, achieving the targets envisaged by the Scottish Government will require further opportunities to raise consumer awareness of these technologies. This could involve:
  
  o Increased visibility of renewable heating technologies both for householders and the media through further development of the existing Green Homes Network managed by the Energy Saving Trust, which allows those considering microgeneration (including renewable heating technologies) to talk with and visit those who have already installed systems.

  o Publicly-owned and community-owned buildings provide good opportunities for such day-to-day contact with these technologies provided the technology is properly promoted and explained. The Scottish Government should continue to fund Community Energy Scotland to provide free advice and financial support for eligible community groups and other not-for-profit community-focused organisations. Groups benefitting from this advice should be encouraged and supported to make information about their projects publicly available, both on the internet and at the installation site.

  o Provision of information about renewable heating options (including district heating) should be provided at, or soon after, annual boiler checks. This would ensure that people receive information about future heating options before their current system needs to be replaced. The Scottish Government should work with relevant stakeholders (industry bodies and organisations providing consumer advice), to develop a programme of information provision, with an initial focus on off-gas homes.

  o In order to maximise awareness and the potential for action, information about renewable heating options should also be provided at all refurbishment trigger points, for example, building approvals processes or during home moving.

  o Alongside customer awareness, training, awareness and business development support for the existing heating installer industry and small builder trade is vital. These are often micro-SMEs and business development support could encourage these businesses to embrace new opportunities provided by renewable heating.

100 This would build on the work that the Scottish Government previously undertook in relation to the dissemination of boiler advice leaflets with Home Energy Checks as part of work to comply with Article 8 of the EU Energy performance of buildings directive (EPBD).

101 Evidence suggests that, at least for energy efficiency action, people are willing to consider investment at refurbishment trigger points. See: http://www.energysavingtrust.org.uk/Publications2/Corporate/Research-and-insights/Trigger-Points-a-convenient-truth.

102 It is important to note that experience from the transition to condensing boilers suggests that Government, manufacturers and training providers would need to undertake a considerable programme of activity to support a major transition to new heating technologies. It has also been suggested that this is only likely to be successful when the installer industry is convinced that existing technologies will no longer be acceptable or
Local authorities should improve the training of planning officers by increasing the resources available for practical training in renewable heating technologies and district heating.

- The Scottish Government must use the information gathered during the 2010 consultation on permitted development rights for air source heat pumps to decide whether to widen existing permitted development rights for this technology. Currently Scottish householders must seek planning permission if the air source heat pump would be situated less than 100 metres from the curtilage of another dwelling. Recent changes to the permitted development status of air source heat pumps in England means that the equivalent distance under which planning permission would be required is 1 metre. However, we acknowledge the need to balance the benefits of easing the installation process against the risk of negative environmental impacts and resulting reputational issues for the industry.

- Social landlords are seen as an important early market for renewable heating technologies as they are able to make well researched decisions and also take advantage of the knowledge and expertise of a professional community. It is therefore important that a) such technologies are given adequate consideration within discussions on the next SHQS, b) guidance on the 2015 SHQS provides sufficient detail on renewable heating technologies, and c) the Scottish Government works to ensure that all social landlords take full advantage of the domestic RHI.

- Where and when appropriate, standards set under the Microgeneration Certification Scheme for renewables installers and products should be amended by the UK Government to include findings from independent field trials and / or any subsequent research, to ensure installations are appropriately designed and installed in order to maximise carbon and cost savings.

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104 SHQS = Scottish Housing Quality Standard.
To provide confidence to consumers, the Energy Saving Trust should explore how best to raise the awareness of the REAL Deposit and Advanced Payment Insurance Scheme, and the REAL Insurance Backed Guarantee when providing advice to consumers.\textsuperscript{105}

Trade Associations should work to raise awareness among their installers of the Microgeneration Certification Scheme and how renewables can benefit their business, encourage their members to undertake additional training to become MCS qualified and provide assistance to those seeking certification.

\textsuperscript{105} See \url{https://www.real.qanw.co.uk/consumer-faqs.php} (REAL Deposit and Advanced Payment Insurance Scheme) and \url{https://www.real.qanw.co.uk/consumer-IBG-faqs.php} (REAL Insurance Backed Guarantee). The former policy is available for free to consumers awaiting installation of a microgeneration technology by a REAL member company and covers the consumer’s Deposit and Advance Payments in the event that the REAL Assurance Scheme Member Company ceases to trade and is therefore unable to supply the Goods. The purpose of the REAL Insurance Backed Guarantee is to cover the Installer’s Written Workmanship Guarantee, and honour the terms of that Guarantee for the duration of same, in the event that the Installer has Ceased to Trade, and is therefore unable to honour the terms of their Written Workmanship Guarantee and rectify any defective workmanship.
6 Appendix

6.1 Details of uptake modelling methodology

6.1.1 Individual dwelling-scale technologies

A logit-based uptake model was developed for this study to represent consumer choice and estimate the uptake of renewable heating technologies. The overall approach is summarised in section 3.2. Consumer coefficients are central to this approach as they set the value that consumers place on each attribute. The coefficients used were taken from previous consumer survey work in the microgeneration sector conducted by Element Energy, and represent attributes including capital cost, fuel costs, ongoing maintenance, subsidy payments etc. The magnitude of the coefficients relative to the capital cost coefficient provides an indication of the average amount consumers are willing to pay upfront for each unit of ongoing saving.

<table>
<thead>
<tr>
<th>Ongoing cost / revenue source</th>
<th>Fuel bill</th>
<th>Maintenance</th>
<th>RHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront payment for each £ of ongoing cost / revenue</td>
<td>£2.93</td>
<td>£5.91</td>
<td>£4.87</td>
</tr>
</tbody>
</table>

These figures show that, for example, consumers will on average pay around £3 additional capital cost for each pound of ongoing fuel bill saving.

6.1.2 District heating

Identifying opportunity areas

An overview of the methodology used to estimate the potential for district heating is provided in section 3.3, which also lists the criteria that affect district heating scheme viability. In this section we provide further details behind the methodology and the main assumptions used.

This study attempts to assess the potential for district heating at the national level and to achieve this we need to divide the country into discrete areas. The Scottish Government collates and publishes statistics at various levels of geographic resolution, as shown in the following figure.
Heat density is one of the fundamental determinants of district heating viability. To calculate this parameter we require heat (or fossil fuel) demands and a measure of the area in which these demands are concentrated. Data on gas and electricity consumption are available at the Intermediate Geography Zone (IGZ) level from DECC. We therefore calculate the number of district heating opportunity areas at the IGZ level based on the following criteria:

- Heat density (MW/km²).
- Proportion of total gas demand from non-domestic consumers.
- Proportion of dwellings in the social renting sector.

Values for these criteria used in the opportunity area analysis are given in Table 5, section 4.2.1. Filtering the full list of IGZs in Scotland according to these criteria yields a reduced number of areas, each of which is deemed to potentially have favourable characteristics for district heating.

**District heating deployment scenarios**

The other aspect of the methodology for assessing the potential role of district heating involves defining DH deployment scenarios (see Figure 13, section 3.3), which are overlaid on to the opportunity areas from the methodology outlined above. Given the high level of uncertainty regarding uptake of district heating, we define three scenarios, broadly representing the extent to which the barriers to DH are overcome.

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107 [www.decc.gov.uk/en/content/cms/statistics/energy_stats/regional/electricity/mlsoa_llsoa/mlsoa_llsoa.aspx](http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/regional/electricity/mlsoa_llsoa/mlsoa_llsoa.aspx). There are 1,235 IGZs in Scotland, with between 900 and 5,400 households in each. Heat density is calculated on the basis of estimated total energy demand for heating. Domestic gas demands are adjusted according to the proportion of dwellings off the gas grid and added to non-domestic gas demands to find an estimate of heat demands (MWh/yr) in each IGZ.
Table 18: District heating deployment scenarios

<table>
<thead>
<tr>
<th>DH deployment scenario</th>
<th>Proportion of dwellings connected to DH schemes by 2030 in each opportunity area by tenure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owner-occupier</td>
</tr>
<tr>
<td>Low</td>
<td>5%</td>
</tr>
<tr>
<td>Medium</td>
<td>20%</td>
</tr>
<tr>
<td>High</td>
<td>50%</td>
</tr>
</tbody>
</table>

Calculating renewable heat from district heating

In the results presented in section 4, the contribution of renewable heat from district heating is added to the renewable heat from individual dwelling scale technologies. Renewable heat from district heating is calculated on the assumption that on average 65% of the heat demands of dwellings on DH are met by renewables (e.g. large scale biomass boilers). This figure is consistent with typical schemes where fossil fuel boilers are used for redundancy and to meet peak loads.

Limitations of methodology

The methodology for estimating the potential for district heating outlined above is designed to provide insight into the possible role of this heat delivery mechanism in Scotland’s renewable heating future. By its nature, an estimation of the potential at the national level will be approximate only and will never uncover all opportunities. For example, this approach, given the level of geographic resolution, will not identify local pockets of high heat density and other favourable conditions for district heating development. Equally, the viability of district heating schemes depends on more factors than it is possible to represent in this kind of assessment, and developing schemes in the opportunity areas identified will require further detailed study.

A further point to note is that the term district heating gives no indication of the source of heat delivered by the network. Potential sources of heat for district heating include gas boilers, gas CHP, biomass boiler, biomass CHP, ‘waste’ heat from industrial process or power generation, biogas combustion, large scale heat pumps, etc. Medium to large scale district heating networks are typically fed by numerous sources of heat, as evidenced by the schemes in counties with mature district heating markets such as Denmark. The analysis of district heating economics (section 6.4) provides some high-level insights into the potential mix of heat sources but what will be delivered in practice depends on a wide range of factors, which cannot be captured in a study such as this.
6.2 Consumer types

The Scottish dwelling stock was represented by 35 consumer (dwelling) types in the logit uptake modelling. The dwelling types were differentiated by size (flat / tenement, detached house and other house), age (existing or new build), level of insulation and counterfactual heating fuel. We also included a fuel poverty metric for the existing dwellings that allowed us to explore the potential impact of the RHI and other policies on fuel poverty in Scotland.

The consumer types, together with approximate number of dwellings by type, are summarised below.

Table 19: Consumer types

<table>
<thead>
<tr>
<th>ID</th>
<th>Dwelling type</th>
<th>Age</th>
<th>CF fuel</th>
<th>Insulation?</th>
<th>Fuel poverty?</th>
<th>No. of dwellings in Scotland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>0</td>
<td>16,566</td>
</tr>
<tr>
<td>2</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>0</td>
<td>99,831</td>
</tr>
<tr>
<td>3</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>0</td>
<td>110,287</td>
</tr>
<tr>
<td>4</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>0</td>
<td>843</td>
</tr>
<tr>
<td>5</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>0</td>
<td>13,764</td>
</tr>
<tr>
<td>6</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>0</td>
<td>29,208</td>
</tr>
<tr>
<td>7</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>0</td>
<td>2,854</td>
</tr>
<tr>
<td>8</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>0</td>
<td>3,465</td>
</tr>
<tr>
<td>9</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0</td>
<td>234,011</td>
</tr>
<tr>
<td>10</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0</td>
<td>548,401</td>
</tr>
<tr>
<td>11</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0</td>
<td>394,360</td>
</tr>
<tr>
<td>12</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0</td>
<td>13,502</td>
</tr>
<tr>
<td>13</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0</td>
<td>56,109</td>
</tr>
<tr>
<td>14</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0</td>
<td>113,388</td>
</tr>
<tr>
<td>15</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0</td>
<td>47,110</td>
</tr>
<tr>
<td>16</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0</td>
<td>24,277</td>
</tr>
<tr>
<td>17</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>1</td>
<td>5,756</td>
</tr>
<tr>
<td>18</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>1</td>
<td>38,234</td>
</tr>
<tr>
<td>19</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>1</td>
<td>20,943</td>
</tr>
<tr>
<td>20</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>1</td>
<td>653</td>
</tr>
<tr>
<td>21</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>1</td>
<td>11,733</td>
</tr>
<tr>
<td>22</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>1</td>
<td>11,034</td>
</tr>
<tr>
<td>23</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>1</td>
<td>1,994</td>
</tr>
<tr>
<td>24</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>1</td>
<td>454</td>
</tr>
<tr>
<td>25</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>1</td>
<td>87,518</td>
</tr>
<tr>
<td>26</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>1</td>
<td>182,173</td>
</tr>
<tr>
<td>27</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>1</td>
<td>117,443</td>
</tr>
</tbody>
</table>
New build rates were based on Scottish Government household projections, which show the total number of households in Scotland increasing from 2.33m in 2008 to 2.81m in 2033. Based on these projections we assume new build rates of 23,500 dwellings per year to 2020 and 17,070 dwellings per year from 2021 to 2030 (split between detached, other houses and tenements / flats on a 20%-60%-20% basis).

6.3 Modelling assumptions

6.3.1 Thermal demands per dwelling

Overview

The dwellings’ thermal demands are one of the fundamental characteristics that dictate the attractiveness of renewable heat technologies. Average annual thermal demand and heating system size (kWth) together dictate the load factor of a heating system (which can be expressed as a percentage, or number of full-load equivalent run hours per year).

The thermal demands of each of the 35 dwelling types (see section 6.2) were derived from Element Energy’s Housing Energy Model for Scotland, which in turn are based on energy modelling in line with the Standard Assessment Procedure (SAP). Demands per dwelling are summarised in the table below.

Table 20: Average annual thermal demand per dwelling

<table>
<thead>
<tr>
<th>ID</th>
<th>Dwelling type</th>
<th>Age</th>
<th>CF fuel</th>
<th>Insulation?</th>
<th>Thermal demand (MWh/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>11.8</td>
</tr>
<tr>
<td>2</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>11.9</td>
</tr>
<tr>
<td>3</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>6.4</td>
</tr>
<tr>
<td>4</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>22.5</td>
</tr>
<tr>
<td>5</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>12.9</td>
</tr>
<tr>
<td>6</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>6.7</td>
</tr>
<tr>
<td>7</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>17.3</td>
</tr>
<tr>
<td>8</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>11.9</td>
</tr>
<tr>
<td>9</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>23.0</td>
</tr>
<tr>
<td>10</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>16.2</td>
</tr>
<tr>
<td>11</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>8.8</td>
</tr>
<tr>
<td>12</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>26.0</td>
</tr>
<tr>
<td>13</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>17.8</td>
</tr>
<tr>
<td>14</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>10.9</td>
</tr>
<tr>
<td>15</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>36.8</td>
</tr>
<tr>
<td>16</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>16.2</td>
</tr>
<tr>
<td>33</td>
<td>Detached</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>7.3</td>
</tr>
<tr>
<td>34</td>
<td>Other house</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>5.0</td>
</tr>
<tr>
<td>35</td>
<td>Tenement / flat</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Summing the product of thermal demand per dwelling and number of dwellings of each type provides a figure for total thermal demands of all Scottish dwellings. The figure is 35.7TWh/yr in 2011.

Dwellings 17–32 are identical in physical characteristics to 1–16 and therefore have identical thermal demands.
Total thermal demands obtained from the method described above were cross-checked against energy consumption data. For example, thermal demands of all gas heated dwellings came to 26.5TWh/yr, which equates to fuel use of around 33TWh/yr on the basis of an average efficiency of 80%. This is consistent with total gas consumption in the domestic sector in Scotland of 33.3TWh in 2008.\textsuperscript{110}

**Insulation**

The insulation metric used in the dwelling type definition is included as a simple representation of the thermal efficiency of dwellings. Dwellings were assigned to the “insulated” categories where the following criteria were met:

- Loft insulation of >100mm.
- Some form of external wall insulation.

These metrics (from the SHCS) were used to set the initial numbers of dwellings in each category.\textsuperscript{111} The uptake of insulation measures in dwellings is represented in the model by shifting consumers from “uninsulated” categories into the corresponding “insulated” categories over time. The baseline assumption is that all uninsulated dwellings receive some form of insulation upgrade over the next decade.\textsuperscript{112} Although loft and external wall insulation are the metrics used to initially define “insulated” and “uninsulated” dwellings, the insulation uptake assumptions are not intended to imply that all external walls will be insulated by 2020. For example, technical (insulating solid wall homes) or environmental (filling cavity walls in exposed locations is not recommended due to damp concerns) barriers are likely to restrict the potential for insulating external walls.

The baseline insulation uptake assumptions are consistent with (and actually exceed) WWF Scotland’s ambitions to see all F or G rated homes brought up to an E rating (or better) by 2015. They are also consistent with a report on proposals and policies for meeting Scotland’s emission reduction targets, which gives the following milestones in the Homes and Communities section:

- ‘every home to have loft and cavity wall insulation, where this is cost-effective and technically feasible, plus simple measures such as draught-proofing and pipe lagging;
- every home heated with gas central heating to have a highly efficient boiler with appropriate controls; and
- at least 100,000 homes to have adopted some form of individual or community renewable heat technology for space and/or water heating.’\textsuperscript{113}

\textsuperscript{110} From Total Final Energy Consumption at Sub-National Level: www.decc.gov.uk/en/content/cms/statistics/energy_stats/regional/total_final/total_final.asp

\textsuperscript{111} Note that splitting the housing stock into “insulated” and “uninsulated” categories is of course a simplification of reality. The focus of this study is renewable heat uptake, not uptake of energy efficiency measures. We therefore aimed to keep the number of insulation categories to a minimum in order to restrict the number of dwelling (consumer) types to a manageable number.

\textsuperscript{112} This is an ambitious aim and would require a significant ramp up in pace of insulation rollout relative to historical trends.

6.3.2 Consumer decision-making frequency

The rate of heating system replacement is a fundamental limitation to the uptake rate of renewable heating technologies. For the purposes of this study’s modelling consumer decision making frequency is directly linked to heating system turnover rates, which are assumed to be 5%; i.e. each year 5% of consumers make a heating system choice. This is consistent with an average heating system lifetime of 20 years.

6.3.3 Technology cost and performance data

Heating technology costs vary by dwelling type. Similarly, the efficiency of certain heating technologies, in particular heat pumps, can vary depending on the characteristics of the installation. The tables below summarise the cost and performance assumptions for each technology considered, from which offers to consumers are calculated (see section 3.2).

Counterfactual technologies

Within the uptake model each consumer is presented with a choice of heating system, including one counterfactual option (based on the incumbent heating fuel). Dwellings currently heated by electricity represent a different type of consumer as the majority of electrically heated homes use overnight storage heaters. In practice these consumers do not make heating system purchasing decisions in the same way as those with a gas or oil-fired boiler. Householders with gas or oil heating tend to purchase a new boiler when the existing unit has reached the end of its useful life. However, in non-centrally heated homes (e.g. those with storage heaters), there is no single heat source that requires periodic replacement. Storage heaters tend to be replaced one or two at a time as and when they break down. Some households with this kind of system elect to switch to central heating with an electric combi boiler, which is more responsive and therefore offers a greater degree of comfort. For the purposes of modelling uptake of individual dwelling-scale technologies we assume the same decision-making frequency for all consumer types, and the counterfactual option for electrically heated dwellings is an electric combi boiler.

Table 21: Cost and performance data: incumbent technologies

<table>
<thead>
<tr>
<th>Metric</th>
<th>Gas</th>
<th>Oil</th>
<th>Electric</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>System size</td>
<td>15, 20, or 25kW</td>
<td>15, 20, or 25kW</td>
<td>9 or 12kW</td>
<td>Gas &amp; oil: typical domestic boiler sizes Electric: electric combi boiler sizes</td>
</tr>
<tr>
<td>Load factor</td>
<td>5–11%</td>
<td>7–17%</td>
<td>8–25%</td>
<td>Based on system size and dwellings’ thermal demands</td>
</tr>
<tr>
<td>Efficiency</td>
<td>90%</td>
<td>92%</td>
<td>95%</td>
<td>Gas &amp; oil: typical values for new condensing boilers (SAP 2009 rating from SEDBUK) Electric: near 100% efficiency, includes some storage loss</td>
</tr>
<tr>
<td>Capex (£/installation)</td>
<td>£2,200</td>
<td>£2,200</td>
<td>£2,000</td>
<td>Typical values for total installed capital cost</td>
</tr>
<tr>
<td>Annual opex (£/installation)</td>
<td>£65</td>
<td>£65</td>
<td>£15</td>
<td>Gas &amp; oil: typical service charge (one per year) Electric: no annual service required – allowance for infrequent checks</td>
</tr>
</tbody>
</table>

Another common reason for replacing storage heaters with an electric boiler is on aesthetic grounds (storage heaters can be regarded as unattractive in dwellings).
A cost of £1,000 (tenements / flats), £1,500 (other houses) or £2,000 (detached houses) for installing a wet central heating system is also included for dwellings with electricity as the counterfactual fuel.

**Air source heat pumps**

Cost and performance assumptions for domestic air source heat pumps are given below.

**Table 22: Cost and performance data: ASHPs**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Values</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>System size (kWth)</td>
<td>6, 10, 12, 14 or 18kW</td>
<td>Size depends on thermal demands of dwelling</td>
</tr>
<tr>
<td>Load factor</td>
<td>7–23%</td>
<td>Load factor indicates equivalent full load run hours per year and affects the economic attractiveness of the system</td>
</tr>
<tr>
<td>Efficiency (SPF), retrofit (2011)</td>
<td>2.50</td>
<td>Seasonal performance factor refers to ratio between total electricity in and total heat delivered — base case assumption is that this increases by 1.0 by 2026</td>
</tr>
<tr>
<td>Efficiency (SPF), new build (2011)</td>
<td>2.75</td>
<td>Higher value for new build to reflect lower heat delivery temperatures – increase of 1.0 by 2030 also included in base case</td>
</tr>
<tr>
<td>Capex (£/installation)</td>
<td>£6k–£14.4k</td>
<td>Installation costs depend on system size – capex assumed to fall by 40% by 2030 in the base case</td>
</tr>
<tr>
<td>Annual opex (£/installation)</td>
<td>£50</td>
<td>Based on service every five years taking half a day</td>
</tr>
</tbody>
</table>

**Ground source heat pumps**

Cost and performance assumptions for domestic ground source heat pumps are given below.

**Table 23: Cost and performance data: GSHPs**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Values</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>System size (kWth)</td>
<td>6, 10, 12, 14 or 18kW</td>
<td>Size depends on thermal demands of dwelling</td>
</tr>
<tr>
<td>Load factor</td>
<td>7–23%</td>
<td>Load factor indicates equivalent full load run hours per year and affects the economic attractiveness of the system</td>
</tr>
<tr>
<td>Efficiency (SPF), retrofit (2011)</td>
<td>3.30</td>
<td>Seasonal performance factor refers to ratio between total electricity in and total heat delivered — base case assumption is that this increases by 1.0 by 2026</td>
</tr>
<tr>
<td>Efficiency (SPF), new build (2011)</td>
<td>3.80</td>
<td>Higher value for new build to reflect lower heat delivery temperatures – increase of 1.0 by 2030 also included in base case</td>
</tr>
<tr>
<td>Capex (£/installation)</td>
<td>£9.6k–£22.5k</td>
<td>Installation costs depend on system size – capex assumed to fall by 40% by 2030 in the base case</td>
</tr>
<tr>
<td>Annual opex (£/installation)</td>
<td>£50</td>
<td>Based on service every five years taking half a day</td>
</tr>
</tbody>
</table>
Empirical data on heat pump performance are available through a number of trials, including:

- Heat Pump Efficiency (Wärme-pumpen Effizienz) project, Fraunhofer Institute on Solar Energy Systems, a study involving seven heat pump manufacturers and over 100 installations in Europe.\(^{115}\)

- Seasonal Performance factor and monitoring for heat pump systems in the building sector (SEPEMO). A project that began in June 2009 and is due to run until May 2012 which includes developing a universal methodology for measuring SPF values.\(^{116}\)

- Energy Saving Trust heat pump field trials, which began in 2008 and monitored the performance of 83 heat pump installations across the UK. The trial has been extended to gather further results and to understand in more detail the reasons for the wide variation in efficiency values observed.

**Biomass boilers**

Cost and performance assumptions for individual (domestic) biomass boilers are given below.

Table 24: Cost and performance data: GSHPs

<table>
<thead>
<tr>
<th>Metric</th>
<th>Values</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>System size (kWth)</td>
<td>8, 12, 15, 20 or 25kW</td>
<td>Size depends on thermal demands of dwelling</td>
</tr>
<tr>
<td>Load factor</td>
<td>7–17%</td>
<td>Load factor indicates equivalent full load run hours per year and affects the economic attractiveness of the system</td>
</tr>
<tr>
<td>Efficiency</td>
<td>85%</td>
<td>Net combustion efficiency</td>
</tr>
<tr>
<td>Capex (£/installation)</td>
<td>£11.5k</td>
<td>Typical total installed cost of a high quality domestic pellet boiler</td>
</tr>
<tr>
<td>Annual opex (£/installation)</td>
<td>£65</td>
<td>As with gas / oil boiler, annual maintenance check is required</td>
</tr>
</tbody>
</table>
6.3.4 RHI support levels

Initial support levels available through the RHI are based on the latest figures published by DECC. No indication has yet been given regarding how support levels will change over time. However, tariff deflation is likely when subsidy levels are reviewed. In the absence of published deflation rates, it has been assumed that subsidy levels will decrease in line with reductions in LCOE resulting from capital cost reductions. The levels of RHI support used in the baseline for a selection of years are shown below.

Table 25: Baseline RHI support levels

<table>
<thead>
<tr>
<th>Technology</th>
<th>RHI support by installation year (£/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>ASHP (individual)</td>
<td>75.00</td>
</tr>
<tr>
<td>GSHP (individual)</td>
<td>70.00</td>
</tr>
<tr>
<td>GSHP (&lt;100kWth)</td>
<td>43.00</td>
</tr>
<tr>
<td>GSHP (100kWth+)</td>
<td>30.00</td>
</tr>
<tr>
<td>Biomass boiler (individual)</td>
<td>90.00</td>
</tr>
<tr>
<td>Biomass boiler (&lt;200kWth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass boiler (200–1,000kWth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Support for biomass boilers in the non-domestic sector (or serving more than one dwelling) is calculated using a tiered system. The ‘Tier 1’ tariffs apply up to the Tier Break, beyond which output is subsidised at the Tier 2 level. The Tier Break (kWh) is calculated as the installed capacity (kWth) multiplied by 1,314 (which corresponds to a 15% annual load factor).
6.3.5 Fuel prices

Fuel prices, and in particular the relative differences in fuel prices, affect the attractiveness of the alternative heating systems available to consumers. Fuel price projections to 2030 are based on UK Government data (IAG forecasts) and are summarised in the tables below. The biomass prices are taken from a study undertaken for DECC (based on the international biomass price scenarios).\(^\text{117}\)

Table 26: Fuel price projections for domestic consumers in Scotland

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Scenario</th>
<th>Fuel prices including VAT in £/MWh (2010£)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>Electricity</td>
<td>Low</td>
<td>102.38</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>129.36</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>142.07</td>
</tr>
<tr>
<td></td>
<td>High High</td>
<td>160.58</td>
</tr>
<tr>
<td>Natural gas</td>
<td>Low</td>
<td>31.11</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>41.99</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>46.74</td>
</tr>
<tr>
<td></td>
<td>High High</td>
<td>53.57</td>
</tr>
<tr>
<td>Oil</td>
<td>Low</td>
<td>31.63</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>40.26</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>46.84</td>
</tr>
<tr>
<td></td>
<td>High High</td>
<td>56.70</td>
</tr>
<tr>
<td>Biomass (pellets)</td>
<td>Low</td>
<td>49.55</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>58.23</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>64.54</td>
</tr>
<tr>
<td></td>
<td>High High</td>
<td>72.28</td>
</tr>
</tbody>
</table>

\(^\text{117}\) Biomass prices in the heat and electricity sectors, E4Tech for DECC (January 2010).
6.3.6 Suitability assumptions

Introduction

The characteristics of renewable heating technologies mean they are not in general direct replacements for fossil fuel boilers. For example, renewable heating systems have different space requirements, environmental impacts and heat delivery capabilities. This fact is captured in the dwelling scale uptake modelling by restricting the number of consumers who may install a given renewable heating technology. Suitability factors (in terms of percentage of dwellings that are considered suitable for a given technology) were derived from values used in a previous study for the CCC. ¹¹⁸ These in turn were originally produced by NERA / AEA, whose methodology is set out in detail in earlier work for the CCC. ¹¹⁹ In essence, the suitability assessment captures constraints in three categories: physical space, grade of heat, other factors (e.g. air quality, noise in urban environments).

Assumptions on the proportion of the dwelling stock that is suitable for renewable heat are necessary inputs to the modelling. Given the considerable uncertainty associated with the figures (given below) we explore the sensitivity of results to a range of assumptions (see section 6.7.4).

¹¹⁹ Decarbonising Heat: Low Carbon Heat Scenarios for the 2020s, NERA and AEA for the CCC, section 4, p.31 (2010).
### Suitability assumptions

**Table 27: Suitability assumptions: ASHPs**

<table>
<thead>
<tr>
<th>ID</th>
<th>Dwelling type</th>
<th>Age</th>
<th>CF fuel</th>
<th>Insulation?</th>
<th>Suitability factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>72%</td>
</tr>
<tr>
<td>2</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>68%</td>
</tr>
<tr>
<td>3</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>67%</td>
</tr>
<tr>
<td>4</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>94%</td>
</tr>
<tr>
<td>5</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>74%</td>
</tr>
<tr>
<td>6</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>68%</td>
</tr>
<tr>
<td>7</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>98%</td>
</tr>
<tr>
<td>8</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>96%</td>
</tr>
<tr>
<td>9</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>10</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>11</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>12</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>13</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>14</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>15</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>16</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>33</td>
<td>Detached</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>34</td>
<td>Other house</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>35</td>
<td>Tenement / flat</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>ID</td>
<td>Dwelling type</td>
<td>Age</td>
<td>CF fuel</td>
<td>Insulation?</td>
<td>Suitability factor</td>
</tr>
<tr>
<td>----</td>
<td>---------------</td>
<td>-----------</td>
<td>---------</td>
<td>-------------</td>
<td>--------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>72%</td>
</tr>
<tr>
<td>2</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>37%</td>
</tr>
<tr>
<td>3</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>68%</td>
</tr>
<tr>
<td>4</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>81%</td>
</tr>
<tr>
<td>5</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>54%</td>
</tr>
<tr>
<td>6</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>69%</td>
</tr>
<tr>
<td>7</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>8</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>91%</td>
</tr>
<tr>
<td>9</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>10</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>11</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>12</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>13</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>14</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>15</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>16</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>33</td>
<td>Detached</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>14%</td>
</tr>
<tr>
<td>34</td>
<td>Other house</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>35</td>
<td>Tenement / flat</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>ID</td>
<td>Dwelling type</td>
<td>Age</td>
<td>CF fuel</td>
<td>Insulation?</td>
<td>Suitability factor</td>
</tr>
<tr>
<td>----</td>
<td>----------------</td>
<td>---------</td>
<td>---------</td>
<td>-------------</td>
<td>--------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>44%</td>
</tr>
<tr>
<td>2</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>7%</td>
</tr>
<tr>
<td>3</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>1</td>
<td>67%</td>
</tr>
<tr>
<td>4</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>60%</td>
</tr>
<tr>
<td>5</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>28%</td>
</tr>
<tr>
<td>6</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>1</td>
<td>67%</td>
</tr>
<tr>
<td>7</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>98%</td>
</tr>
<tr>
<td>8</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>1</td>
<td>72%</td>
</tr>
<tr>
<td>9</td>
<td>Detached</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>10</td>
<td>Other house</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>11</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Gas</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>12</td>
<td>Detached</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>13</td>
<td>Other house</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>14</td>
<td>Tenement / flat</td>
<td>Existing</td>
<td>Electricity</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>15</td>
<td>Detached</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>16</td>
<td>Other house</td>
<td>Existing</td>
<td>Oil</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>33</td>
<td>Detached</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>44%</td>
</tr>
<tr>
<td>34</td>
<td>Other house</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>7%</td>
</tr>
<tr>
<td>35</td>
<td>Tenement / flat</td>
<td>New build</td>
<td>Gas</td>
<td>1</td>
<td>67%</td>
</tr>
</tbody>
</table>
6.3.7 Industry growth rates

In common with the rest of the UK, the use of renewable heat in Scotland is very limited, which means the supply industry across the whole supply chain is relatively small.\textsuperscript{120}

Supply capacity will typically develop as demand expands, but it cannot do so at an unlimited pace. There is inertia in the rate of training of installers, entry of new companies, or growth of existing companies. Also, expansion requires investment, which will be forthcoming only when there is confidence in sustained demand for the products. Supply side constraints thus are linked to the demand-side, as investment in supply capacity will come forward more readily if demand is seen to be robust, including in the longer term.

We restrict the rate at which annual sales are allowed to grow in the model using a methodology developed in a previous study for the CCC.\textsuperscript{121} Following a one-off doubling of sales allowed between 2010 and 2011 the following growth rates apply.

Table 30: Supply side growth rate assumptions

<table>
<thead>
<tr>
<th>Growth scenario</th>
<th>Emerging</th>
<th>Growth</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>40%</td>
<td>30%</td>
<td>15%</td>
</tr>
<tr>
<td>Central</td>
<td>60%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>High</td>
<td>80%</td>
<td>60%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Each of the three phases (emerging, growth and maturity) are assumed to last for three years following introduction of the RHI.

The high growth scenario corresponds to an upper estimate of feasible growth rates, which will require significant investment by private organisations and will only be realised with high confidence in sustained demand for renewable heating technologies. For example, certainty in continued demand for the products will be required to unlock the finance needed to increase production capacities.

The low growth scenarios represent a more pessimistic outlook, where issues at one or more of the points in the supply chain (design, manufacture, sales, distribution, installation) limit expansion rates. The Central case (used in the baseline) is between these two extremes and represents a reasonably ambitious but achievable level of supply chain expansion.

\textsuperscript{120} This includes manufacturing capacity / import volumes, infrastructure (e.g., for fuel processing and delivery), distribution and sales capacity, qualified personnel for installation and maintenance, etc.

\textsuperscript{121} For further background to and evidence for the choice of growth rates see: Achieving deployment of renewable heat, Element Energy and NERA for the CCC, section 4.1.3 (2011).
6.4 District heating – economic analysis

6.4.1 Introduction

The results presented in section 4.2 relate to district heating uptake as estimated by a scenario-based approach. In this section we explore the economic characteristics of district heating in further detail.

Assessing the potential for district heating uptake across a wide geographic area is challenging, as the viability of district heating is highly dependent on local factors. In particular, the economics will depend on:

- **Heat density** – a high concentration of heat demand provides a good opportunity to sell heat at limited infrastructure costs (shorter pipe distances).
- **Connection density** – a smaller number of large heat users will typically be favourable compared to a larger number of small connections, due to the costs associated with each connection.
- **Anchor heat loads** – the presence of a single or small number of large heat users can support the extension of a district heating system into neighbouring areas.
- **Scale of the system** – a larger heat load leads to economies of scale in the energy centre and a lower cost of heat generation.
- **Social housing or LA-owned housing** – development of a district heating system, particularly when retrofitting to existing properties, requires coordinated action by multiple partners. The presence of social or local authority landlords that can (or are forced to) make firm commitments to connect large numbers of properties can significantly simplify the process and de-risk projects for district heating developers.
- **The alternative fuel** – district heating will be more favourable in areas where the alternative fuel choice is more expensive or unreliable.

An analysis of the impact of these factors on the economics of district heating systems is instructive in terms of understanding the opportunity for uptake of district heating systems and the potential impact of support policies.

6.4.2 Generic area types

As discussed above, the economics of district heating are highly dependent on local factors. Nonetheless, for the purposes of this analysis a number of generic scenarios have been considered, which are characterised by a connection density and the average heat consumed per connection (these two parameters imply a heat density).

A modest density, suburban residential scenario, for example, would be characterised by a relatively low connection density (say around 30 dwellings per hectare) and an average heat consumption of 15–20MWh/yr. A high density urban scenario, with a higher proportion of terraced houses and flats, would be characterised by a higher connection density (e.g. 60–80 per hectare), but a lower heat consumption per connection, consistent with smaller dwellings. An increasing presence of commercial or industrial heat load will tend to increase the average heat consumed per connection.

The relationship between average heat consumption, connection density and heat density is shown in the plot below. Typical development scenarios are mapped onto the plot on the basis of these simple parameters.
6.4.3 Economic model

We developed a simple model to assess the cost of heat supply via district heating systems serving areas of varying heat density and connection density and using various thermal plant technologies. The impact of the capacity of thermal plant on heat supply costs is also assessed. We assume in each case that the scale of the system, i.e. the overall heat load, is sufficient to enable the thermal plant to operate at an appropriate load factor.

The following assumptions have been made in calculating the heat supply price:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value / data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of capital</td>
<td>10%</td>
</tr>
<tr>
<td>Period</td>
<td>15 years</td>
</tr>
<tr>
<td>Fuel prices</td>
<td>Based on DECC Central scenario</td>
</tr>
<tr>
<td>Electricity ROC price</td>
<td>£45/MWh (assumes 1 ROC per MWh for technologies supported by RHI)</td>
</tr>
<tr>
<td>Load phasing</td>
<td>Assumes 100% uptake from year 1</td>
</tr>
</tbody>
</table>
6.4.4 Results

The cost of heat supply is shown in the plots below for a number of development scenarios. The impact of an RHI of £26/MWh, consistent with the level for large solid biomass boilers, on heat supply price is shown. In each case, the cost of heat supplied by various district heating system options is compared with the cost of typical counterfactuals, i.e. domestic gas boilers, oil boilers and electric heating (conventional and ASHP).

![DH heat price - Low density domestic retrofit](image)

Figure 31: District heat supply price for a range of technologies at various scales assuming relatively low density (25 dph) residential heat load characteristics
In the case of primarily residential areas, as considered in the charts above, the cost of heat supplied by district heating systems does not compete with the cost of heat generated by domestic gas and oil boilers. The DH heat price (when supported by the RHI) does become competitive with electric heating, particularly in the higher density scenario. Note that the ASHP provides the lowest cost heat by some margin if an RHI for domestic heat pumps of £75/MWh is included.

An increasing component of non-domestic heat load will tend to increase the average heat consumption per connection (albeit that larger capacity non-domestic connections will have a higher capital cost) and the heat density. This can reduce the DH heat price such that it is favourable to extend the system to serve neighbouring residential areas, particularly if built at high density.

The chart below compares the price of DH heat for systems of various sizes to individual domestic alternatives in the case where the average heat consumption per connection is 40MWh/yr and the heat density is 15MW/km², which is consistent with a mix of commercial and relatively high density residential uses.
District heating supply price in an area of high heat density (15MW/km²) and high average heat load per connection (40MWh/connection) – representative of a mix of uses, with a significant non-domestic component

Under this scenario, DH heat from biomass boilers, assuming RHI support at £26/MWh, becomes competitive with the cost of heat from individual gas and oil boilers. The price of DH heat without the RHI is very close to the unsubsidised cost of heat from a domestic ASHP. Once the widely differing levels of RHI tariff are applied (assuming £75/MWh for domestic RHI), the ASHPs are clearly very favourable.

The variation of heat price with heat density and average heat consumption per connection can be seen more clearly in the contour plot below. In this case, it is assumed that heat is provided by a community-scale biomass boiler system (5MWth).
Figure 34: Variation of DH heat supply price with heat density and average heat load per connection, assuming a 5MW biomass boiler as the heat source (including RHI support at £26/MWh).

This plot emphasises the beneficial effect on district heating economics of larger heat users that increase the average heat consumption per connection. In residential areas, where average heat consumption per connection is typically <25MWh/yr, a high heat density is required for the district heating supply price to compete with the cost of typical dwelling-scale technologies, which implies a high dwelling density. We note from the above that:

- For heat consumption per connection of 15MWh/yr (a typical domestic demand) a heat density of in excess of 20MW/km² is required to provide heat at a cost competitive with gas boilers. This is consistent with very high density dwellings but exceeds typical heat density values for lower density housing.
- Energy efficiency rollout will tend to reduce the average heat consumption per connection. A compensating increase in heat density is therefore required for district heating to compete with dwelling-scale options.
6.5 District heating – opportunity areas

The methodology for estimating the potential contribution from district heating (discussed in section 4.2) involved filtering a list of Intermediate Geography Zones in Scotland according to set criteria. The table below shows the top fifty IGZs in terms of estimated average heat density (MW/km²).

Table 31: List of Scottish IGZs with high heat density

<table>
<thead>
<tr>
<th>LA name</th>
<th>LA code</th>
<th>IGZ code</th>
<th>Households (2008)</th>
<th>Average dph</th>
<th>Average ff demand (MW/km²)</th>
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</thead>
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</tbody>
</table>

According to the 2008 estimate, there are around 138,000 households in these fifty IGZs, all of which exhibit relatively high average heat density.
6.6 Renewable heat mix in 2020

The main results section (specifically sections 4.4 and 4.5 above) focus on renewable heat delivered in 2030. We present the 2020 results for equivalent scenarios below.

6.6.1 Uptake in line with the CCC’s Medium abatement scenario

The CCC’s Medium abatement scenario shows around 12% of total (i.e. cross-sector UK) 2020 heat demands being met by renewable heat. The domestic sector is expected to make a proportionally lower contribution, and CCC data show just 2.5% of 2020 heat demands in Scottish housing being met by renewable heat. The scenarios designed to meet the 2030 CCC ambition in Scottish dwellings (30% of heat demands from dwelling scale renewable heat, see section 4.4.1) significantly exceed the CCC’s indicative 2020 target, as shown below.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2020](image)

Figure 35: Scenarios with overall RH uptake in Scottish dwellings in line with the CCC Medium abatement scenario – 2020 results

6.6.2 Renewable heat meeting 50% of domestic demands by 2030

The 50% 2030 target for renewable heat in Scottish dwellings is based on a simple interpretation of the Scottish Government’s stated ambition to decarbonise the heat sector by 2050 (i.e. this scenario corresponds to this 2050 ambition assuming that an equal contribution is made prior to and after 2030). The levels of renewable heat delivered by 2020 under scenarios that achieve this ambition are given in the graph below.
Figure 36: Heat delivered in 2020 in Scottish dwellings in the 50% renewable heat by 2030 scenarios
6.7 Modelling results: sensitivity and policy analysis

Results in sections 4.4 and 4.5 focus on scenarios for achieving certain levels of renewable heat ambition by 2030. In this section we explore the impact of varying key assumptions on renewable heat delivered by 2030.

6.7.1 Varying RHI support levels

Introduction

At the time of writing RHI levels for the domestic sector are to be confirmed. The Renewable Heat Premium Payment Scheme will provide further evidence for setting appropriate support levels. Given the uncertainty around RHI support in the domestic sector, in this section we consider the impact of alternative RHI levels through the following scenarios:

- **RHI_80%** – RHI levels for all technologies and all consumers reduced by 20% from baseline values.
- **RHI_120%** – RHI levels for all technologies and all consumers increased by 20% from baseline values.
- **Off-grid RHI_70%** – RHI levels for all dwellings off the gas grid reduced by 30% from baseline values (across all technologies).
- **Off-grid RHI_50%** – RHI levels for all dwellings off the gas grid reduced by 50% from baseline values (across all technologies).
- **GSHP_£90/MWh** – the initial RHI level for individual domestic GSHPs is increased from £70/MWh (baseline) to £90/MWh (the same level as the domestic biomass boiler tariff).

In each of these scenarios RHI support is continued to 2030. All other assumptions are as per the baseline.

Results

The following graph shows the range of potential outcomes in terms of renewable heat delivered in Scotland’s dwelling stock by 2030. Note that contribution from district heating is included in these results in line with the Medium scenario and the following IGZ filtering criteria: 2MW/km², 25% non-domestic gas demand and 25% social housing. It should also be noted that in all cases RHI support begins in 2011 and continues to 2030.\(^\text{122}\)

\(^{122}\) Note that although domestic installations will not receive RHI payments until phase 2 of the RHI (expected from October 2012), DECC has clearly signalled that all eligible systems installed since 15th July 2009 will be able to apply for RHI support.
These results suggest that the RHI levels currently proposed for the domestic sector are broadly consistent with what is required for uptake in Scotland’s dwellings to be in line with the CCC’s Medium abatement scenario (provided support is continued to at least 2030). A 20% reduction in tariff levels for all technologies and consumers could lead to a fall in total heat delivered by 2030 of over 40%. The impact of cutting RHI support for off-gas dwellings is less severe since the cost of the counterfactual fuel is typically higher.

We also find that increasing support for GSHPs to levels proposed for domestic biomass boilers leads to relatively little additional uptake. This is a reflection of the fact that the main barrier to this technology is the high capital cost and consumers' discounting behaviour.

The graph below shows the forecast RHI subsidy spend (due to Scottish dwellings only) under a selection of these scenarios. Note that the ‘RHI budget’ figure is based on the total budget allocated for the RHI (for Great Britain) pro-rated to Scotland on the basis of population.

Figure 37: Renewable heat uptake with varying levels of RHI support (all include RHI to 2030)

These results put the subsidy spend to support uptake of renewable heat in Scottish dwellings into context. In the Off-grid RHI\_70\% scenario for example, RHI policy costs in 2030 are reduced by 24\% relative to the RHI to 2030 scenario, while renewable heat delivered only falls by 17\% as a result of reducing the RHI payments to certain consumers.

### 6.7.2 Confidence

#### Introduction

In the uptake model we calculate market shares of renewable heating technologies by multiplying capex, fuel costs, opex, RHI revenue etc. by logit coefficients. In general the coefficients come from consumer surveys (choice experiments). However, there is a higher degree of uncertainty around the RHI coefficient (given that this is a novel policy). The coefficient is calculated as an annuity based on a set discount factor over a twenty year period. We consider the following scenarios:\(^{124}\)

- **High confidence** – 8\% discount factor – all baseline assumptions, apart from discount factor used to calculate the RHI coefficient. A lower discount factor means consumers place a higher value on ongoing income from the RHI. This scenario represents one in which consumers have high confidence in the technology and expect to be able to benefit from the RHI for the full period (20 years) (e.g. no concerns about failure to gain benefit due to moving house etc.).

- **Low confidence** – 32\% discount factor – all baseline assumptions, apart from discount factor used to calculate the RHI coefficient. At the other extreme, a high discount factor corresponds to consumers placing a low value on ongoing RHI revenue. This could be due to one (or a combination) of numerous factors: lack of

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\(^{124}\) These two extremes in discount rates are consistent with the *household discount rates* used by NERA & AEA in developing the UK’s supply curve for renewable heat, who refer to evidence from the literature. See *The UK Supply Curve for Renewable Heat*, NERA and AEA for DECC, July 2009, p.22.
trust in technology, lack of confidence that they will be able to benefit from the scheme for the full technology lifetime etc.

A discount factor of 20% is used in the baseline, this being the (mean) average of these two extremes.

Results

Levels of renewable heat uptake by 2030 under these two scenarios are compared against the baseline assumption (20% discount factor) in the graph below.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

**Figure 39: Impact of consumer confidence on renewable heat uptake (all include RHI to 2030)**

Demand for RH technologies is high under the high confidence scenario, and limited by supply side growth constraints over the next 15 years. The same is not true for the low confidence scenario, where demand is much weaker.

Renewable heat delivered by 2030 varies by a factor of three between the two extremes of consumer discounting behaviour indicated by the literature. This highlights the level of uncertainty associated with the outcome of the RHI, and the need to provide sufficient evidence and support for consumers to trust the technologies and the financial benefits of the RHI.

6.7.3 Industry growth rates

Introduction

Restrictions on the rate of expansion in annual sales of renewable heat technology are implemented to represent the limitation on rates at which supply chains are able to expand to meet growing demand. Being a novel policy, precise growth rates achievable under the RHI are uncertain, so we explore three scenarios: Central, Low and High growth.

Maximum annual sales increases for the initial years of the RHI policy (in emerging, growth and maturity market phases) are summarised below. Note that each phase is assumed to last for three years.
Table 32: Supply side growth rate assumptions

<table>
<thead>
<tr>
<th>Growth scenario</th>
<th>Emerging</th>
<th>Growth</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>40%</td>
<td>30%</td>
<td>15%</td>
</tr>
<tr>
<td>Central</td>
<td>60%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>High</td>
<td>80%</td>
<td>60%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Given unconstrained demand, these growth rates correspond to average annual sales increases between 2011 and 2020 of 36% (low), 46% (central) and 61% (high).

**Results**

The impact of these alternative growth rate assumptions on uptake of renewable heat by 2030 is shown below.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

**Figure 40: Impact of supply side growth rates on renewable heat uptake (all include RHI to 2030)**

With all other assumptions constant between these scenarios, we find that renewable heat delivered by 2030 varies by a factor of two between the Low and High growth rate scenarios. To provide further context we can consider the increase in ASHP sales required to meet the CCC’s RES-H ambition by 2030 (with Central case growth). ASHP sales in Scotland will have to increase from numbers in the high hundreds or low thousands today to c.25,000 by 2020, rising to nearly 70,000 (c. half of all new heating system sales) by 2030. Experience from elsewhere in Europe suggests that this rate of industry growth is achievable. However, it will require significant investment and is only likely to come

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125 See Table 9, section 4.4.2.
126 Industry growth rates assumed here are consistent with those used in a previous study for the CCC. Renewable heating technology sales data for other European countries are presented in that study’s final report. See *Achieving deployment of renewable heat*, Element Energy and NERA for the CCC, section 4.1.3 (2011).
about with high confidence and certainty in the long-term future of the renewable heat market.

6.7.4 Renewable heat suitability

Introduction
One of the factors that will limit the uptake of renewable heat is the fact that not all technologies are suitable in all dwelling types. Suitability assumptions are included in the model to reflect this and are based on data used in previous work for the CCC. However, since it is not possible to define suitability factors with absolute certainty, we stress-test the uptake under different suitability assumptions.

Combined with insulation package rollout, Central (baseline) suitability assumptions equate to 70% of all dwelling types being suitable for an ASHP, 45% for GSHPs and 47% for biomass boilers.

We also explore the following suitability scenarios:

- **HPs – off-gas only** – suitability of heat pumps in all dwellings on the gas grid is set to zero. This scenario represents restricted heat pump uptake, for example to less urban areas, as a result of a lack of permitted development rights.
- **No HPs in flats** – with this scenario we represent an extreme case where heat pumps are not suitable in tenements or flats by setting the suitability values to zero.
- **No RH in elec CF** – a scenario in which no renewable heating technologies are suitable in dwellings where electricity is the counterfactual fuel.
- **HPs_20%, 50%, 80%** – scenarios where the suitability of heat pumps (in insulated dwellings) is set to constant values across the dwelling stock. These scenarios allow us to assess the required compatibility of dwellings and heat pumps to meet renewable heat ambitions.

Results
The impact of the suitability scenarios described above on renewable heat uptake by 2030 is shown below.

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127 Suitability factors were derived taking into account physical constraints (space for fuel storage (biomass boilers) / ground loops (GSHPs) for example), grade of heat required, and other factors (e.g. air quality considerations, noise in urban areas). Suitability factors by consumer and technology in these scenarios are given in section 6.3.6.

128 The rationale for this scenario is that electricity is significantly more expensive than other fossil fuel heating systems, which suggests that there are substantial barriers preventing these consumers from switching from direct electric to other forms of heating.
Figure 41: Impact of alternative suitability assumptions on renewable heat uptake (all include RHI to 2030)

Given the high reliance on heat pumps to meet RES-H targets in the domestic sector any scenario under which suitability is restricted poses a threat to meeting the ambitions. As mentioned above, the precise proportion of the Scottish dwelling stock that is “suitable” for renewable heating technology installation is uncertain. While uptake is likely to be in those dwellings that are suitable in the early years, in the medium to longer term further work is required to understand maximum potential penetration levels of renewable heat in homes. We also note that there is scope for innovation in the heating system market over this period, which could lead to novel products that open up new markets for renewable heat.

6.7.5 Technology cost and performance

Introduction

The baseline includes capital cost reductions for heat pumps, together with increases in average seasonal performance factor (SPF) with installation year. The following scenarios are designed to explore the impact of lower than baseline SPFs, and cost reductions and performance improvements not being achieved:

- **Low initial SPF** – all baseline SPF values decreased by 0.5 (all other assumptions as per the baseline, including SPF improvements through time). This reflects a scenario where heat pumps underperform in terms of efficiency relative to the baseline.

Note that in practice “suitability” is not a binary distinction in every case. In some cases (e.g. lack of space to house a biomass boiler, or no access to ground for GSHP coil installation) there may be limited options. In others however, the distinction is less clear. For example, a heat pump could technically be installed in a poorly insulated dwelling. However, the higher differential between heat extraction and delivery temperatures would likely lead to a lower SPF and hence a longer payback period.
• No SPF improvement – all baseline assumptions apart from change in SPF for heat pumps with installation year. Baseline includes increase in SPF of 1.0 by 2026. In this scenario we assume no change through time.

• Low SPF & no improvement – the combination of the above two scenarios.

• No HP cost reduction – all baseline assumptions apart from capital cost forecasts for heat pumps. Baseline includes capex reduction of 38% by 2030. In this scenario costs remain constant through time (but RHI levels are degressed as per the baseline).

• Const. SPF and cost – heat pump costs and SPF values all remain constant through time.

Results

The following graph shows renewable heat delivered in 2030 under these various technology cost and performance assumptions.

Figure 42: Impact of heat pump cost and performance improvements on renewable heat uptake (all include RHI to 2030)

In the baseline, ASHP SPF values (retrofit) start at 2.5 in 2011, increasing to 3.5 for new installations by 2026. The corresponding values for GSHPs are 3.3 (2011) and 4.3 (2026).

The results above demonstrate the impact of SPF values being lower than this initially, and what may happen in the event that performance improvements for future installations do not come about. In all cases total uptake of renewable heating technologies falls well short of meeting the CCC Medium abatement scenario. This demonstrates the importance of (successful) heat pump trials in Scotland to:

• Validate manufacturer claims relating to efficiency (in particular SPF as opposed to COP).
• Provide confidence to consumers that renewable heating technologies can perform as claimed (note that the perception that SPF will be low could also be damaging to heat pump uptake).
The ongoing Energy Saving Trust trials and monitoring under the Renewable Heat Premium Payment Scheme will provide valuable data that will allow a more robust assessment of the future role of heat pumps.

6.7.6 Fuel price scenarios

Introduction

Fuel prices affect the relative attractiveness of the various heating system options. Fuel price projections are taken from IAG data (gas, oil and electricity) and E4Tech work for DECC on biomass (see section 6.3.5). The fuel price scenarios include:

- **High high oil price** – all fuel price projections based on Central case values with the exception of oil. The ‘high high’ prices give values closer to today’s actual heating oil price.

- **High high gas and oil** – gas and oil price projections based on ‘high high’ values (all other fuel prices from Central case).

- **High high elec. prices** – all fuel prices as per the baseline (Central case), with the exception of electricity prices (set to the high high scenario values). This scenario investigates the impact of more rapidly increasing electricity prices, which may come about in the context of financial support for low carbon generation (RO, FiT etc.) and increasing electrification of heat and transport.\(^{130}\)

- **Low BM prices** – biomass (pellet) price forecasts in line with the low scenario (Central fuel prices for fossil fuels).

- **High BM prices** – biomass (pellet) price forecasts in line with the high scenario (Central fuel prices for fossil fuels).

Results

The impact of these fuel price scenarios on renewable heat output in 2030 is shown below.

\(^{130}\) Historically electricity prices have been linked to wholesale energy costs. However, support for renewables and increased demands on the grid could break this correlation in the future. I.e. costs of low carbon generation support, grid reinforcement, increased generation capacity etc. are expected to be borne to a greater extent by electricity consumers.
Based on the technology mix currently available, meeting renewable heat targets in the domestic sector will depend on heat pumps. Obtaining maximum benefit from heat pumps in turn depends on access to low carbon electricity at reasonable prices.

However, support for renewables is likely to put continued upward pressure on electricity prices. The High high elec. prices scenario suggests that continued rises in electricity prices above other energy prices poses a threat to the uptake of heat pumps for domestic heating.

These results suggest that uptake of biomass boilers does not depend strongly on biomass price forecasts. Biomass boilers are adopted mainly by consumers off the gas grid, where counterfactual fuel prices are relatively high. With an RHI in place, the main barrier to their uptake is the high capital cost, rather than fuel prices. However, access to a reliable fuel supply will be critical for biomass boilers to play their part. Results of the consultation suggest that fuel availability is not currently a barrier to domestic biomass boiler uptake. However, were concerns that this could change with increased demand for biomass from other sectors (e.g. due to co-firing biomass in power stations or uptake of biomass CHP).

### 6.7.7 Capital cost barrier removal

**Introduction**

An important reason for the low historical uptake of renewable heating technologies in the UK has been the high capital cost relative to the counterfactual (fossil fuel) options. The RHI is designed to bridge the cost gap between fossil fuel heating systems and renewable heating technologies, thus making these technologies attractive to consumers in economic terms. However, renewable heating technologies are likely to remain more expensive to

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131 The slight fall in overall uptake in the ‘Low BM prices’ scenario is due to lower ASHP uptake when biomass prices drop. The fact that increased biomass boiler output does not fully compensate for this reduction is an artefact of the model linked to the supply side growth rate restriction.
purchase than the fossil fuel alternatives. One of the main barriers cited by the stakeholders contacted for this study is the high upfront costs (and uncertainty around payback period). Given that most householders make decisions based on relatively high discount rates (i.e. they are averse to upfront capital costs), high capital cost represents an important barrier that could restrict uptake even with an RHI in place.

In this section we explore scenarios under which the additional capital costs of renewable heating options are removed via one of two mechanisms, described below.

**Loans**

Under the loans scenarios the additional capital cost for renewable heating technologies is removed, i.e. consumers pay the same capital cost for a renewable heating technology as they do for the fossil fuel alternative. In these scenarios a loan repayment term is added to the calculation of overall utility (in the logit equation), representing the amount the consumer would have to repay over a ten year loan period. We explore the impact of a variety of interest rates payable on the loan:

- **Loan_3.5%** – interest rate of 3.5% represents a soft loan. This figure is consistent with the UK Government’s Green Book discount rate (used for in appraisals of how public funds are spent).
- **Loan_8%** – represents a low commercial rate of interest (e.g. typical mortgage rate).
- **Loan_15%** – typical commercial interest rate for an unsecured loan over ten years.
- **Loan: £2k, 0%** – a £2,000 interest free loan (repayable over four years) is offered to all consumers. This scenario represents a loan scheme currently on offer from the Scottish Government being extended (to 2030).

**ESCO models**

These scenarios represent an energy services company (ESCO) model. This is based on a company funding the additional cost of installing renewable heating technologies in homes (so that consumers see no additional capex relative to a standard heating system); in return for some or all of the ongoing RHI payments. In these scenarios we assume:

- In return for providing the capital for renewable heat installations, the company demands ongoing income to provide a certain rate of return (IRR). Investments are evaluated over 20 years and we test the minimum IRR demanded as a sensitivity.
- Consumers are unlikely to be willing to opt for a renewable heat installation (even for no additional capital cost) unless they receive a financial gain. In the scenarios below we consider cases where consumers demand at least 20% saving on fuel bills (relative to installing a standard heating system).
- Annual RHI payments must be sufficient to satisfy the two demands above, i.e. ensure that consumers see a fuel bill saving (of at least 20%), and provide the company with an adequate annual income.

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132 At the time of writing the Bank of England base rate remains at a historic low (0.5%), hence mortgage finance is currently available at rates significantly below 8%. However, this figure is more typical of mortgage interest rates over longer periods.
In cases where RHI payments are insufficient, there is deemed to be no commercial opportunity, and the consumer is not offered the zero capital cost renewable heat installation.

The scenarios are:

- **ESCO_3.5%** – IRR demanded by the ESCO set to a low value, e.g. as may be the case if funds could be provided from the public sector.
- **ESCO_10%** – represents ESCOs demanding 10% IRR for providing the capital for the renewable heat installation. This is around the minimum level at which a commercial organisation may be able to invest.
- **ESCO_15%** – 15% IRR required by ESCOs, a more typical commercial rate of return.

**Results**

Renewable heat uptake in Scottish dwellings under these loan and ESCO scenarios is presented below. Note that in all cases RHI support is continued to 2030.

![Renewable heat in Scottish dwellings for a selection of scenarios in 2030](image)

**Figure 44:** Renewable heat uptake in Scottish dwellings under scenarios in which the capital cost barrier is eliminated / reduced (all include RHI to 2030)

The principal differences between the Loan and ESCO scenarios are as follows:

- Under the Loan scenarios the capital cost of renewable heating technologies is reduced for all consumers, whereas in the ESCO scenarios the capital cost is only reduced for some technology-consumer combinations (those for which the criteria above are met).
- In the Loan scenarios consumers repay the loan over a certain period – this is accounted for in the logit calculation with a loan coefficient (see below). In contrast, in the ESCO scenarios the company recoups the capital outlay by taking a share of the RHI (so the consumer perceives lower ongoing RHI revenue).
These differences, together with the relative coefficients applied to loan repayments and RHI income in the logit calculation, explain the different technology mix that could be achieved (e.g. Loan 3.5% versus ESCO 3.5% scenarios).

The mathematics behind the uptake modelling used include an annuity factor, which in the case of fuel bills for example can be thought of as the amount a consumer is willing to pay upfront for each unit on ongoing fuel bill saving. We use an annuity factor for RHI payments of 4.9 and in the case of loans over ten years a factor of 6.1 for loan repayments. Note that a lower annuity factor implies higher discounting behaviour. The difference between these two numbers explains why uptake of more expensive technologies is higher under the ESCO scenarios than the Loan scenarios – i.e. consumers dislike lower RHI payments (ESCO scenarios) less than they dislike ongoing loan repayments (Loan scenarios).

The main conclusions from the results above include:

- Reducing the capital costs faced by consumers could lead to higher uptake overall (including the more expensive technologies) provided that medium to low cost finance is offered.
- There are limited opportunities for ESCO-type companies to facilitate greater uptake unless they do not demand commercial rates of return. E.g. social ESCOs with access to low or zero cost finance could facilitate greater renewable heat deployment.
6.8 Summary of stakeholder feedback

6.8.1 Stakeholders contacted

A mentioned above (section 3.4), telephone conversations were held with around twenty stakeholders in Scotland’s renewable heat market. We contacted a range of individuals and organisations, as shown by the chart below.

![Composition of stakeholder group that provided input into the study: Scotland’s Renewable Heat Future](image)

*Figure 45: Stakeholder group composition*

We used the consultation exercise as an opportunity to validate our modelling assumptions and to gain views on the barriers to deployment of renewable heat in Scotland in the period to 2030. A summary of the main barriers, along with current actions and suggested further action required, are summarised in the following sections. We have grouped barriers by theme (e.g. funding, education, planning) and within these, presented the barriers in order of perceived importance, based on the number of stakeholders mentioning the barrier and the importance they attached to it.
### 6.8.2 Barriers to dwelling-scale technology uptake

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Current action</th>
<th>Stakeholder suggestions for further action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNDING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- High upfront costs of renewable heating technologies and uncertainty over payback periods (even with an RHI). - Lack of funding to assist with high upfront costs. - Disruption and / or extra cost of possibly having to install a new distribution system. - Delay to introduction of the domestic RHI.</td>
<td>- Scottish Government (SG) interest free loans (£2,000) for renewables. - Generally believed that SG understands importance of structuring RHI correctly, and importance of ensuring Green Deal (GD) and Energy Company Obligation (ECO) can promote renewable heat and need to be designed to make them accessible to all households, but will need to work with DECC to secure it.</td>
<td>- Consider raising the £2,000 loan limit. - Better promotion of long-term benefits to householders to offset high upfront cost through consumer-facing organisations such as the Energy Saving Trust (EST) and Community Energy Scotland (CES). - Support for group purchasing e.g. at community level, from organisations such as CES could be used to help lower energy cost and bring social benefits of community inclusion. - ECO and GD – careful design needed to encourage microgen uptake in all areas. Ensuring local authorities (LAs) can be a source of financing in GD / ECO would help. Depending on details of GD / ECO, LAs could use the funding as a ‘springboard’ for schemes like uHIS but for renewable heat. - Ensure access to appropriate financial support via ECO and GD. Funds should be targeted at consumers most in need of extra financial support. - Renewable heat could be included in GD / ECO, which would help ensure that renewable heating technologies go into insulated homes, and refurbishment work / disruption would happen in one go.</td>
</tr>
<tr>
<td><strong>CONSUMER EDUCATION AND CONFIDENCE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Lack of awareness of alternative heating systems and a desire for something familiar. - Scepticism over performance of RH technologies. - Warranty / guarantee concerns (who to approach if issues arise). - Concerns over a lack of independent, impartial advice for</td>
<td>- EST plays key role here but there are concerns over capacity (within existing resources) to deliver sufficiently in-depth advice and support. - CES promotes ‘demo’ installations. More examples needed. - The Microgeneration Certification Scheme (MCS) provides consumer confidence. MCS must avoid overstating COPs of</td>
<td>- Further promotion of demo installations in homes and in public / community buildings, e.g. via EST / Energy Saving Scotland Green Homes Network and CES. - Expansion of Energy Saving Scotland advice provision to cope with higher demand. - Better education of households, politicians and media of meaning of ‘renewable heat’. - Establish an equivalent of the ABTA scheme (for the travel industry) to offer assurance to consumers that someone will offer redress even if the original</td>
</tr>
</tbody>
</table>
interested households.¹³³ heat pumps. - The Construction Licensing Executive accredits MCS installers and operates a licensing scheme for trade associations (TAs). This may encourage MCS installers to become TA members, giving householders greater confidence in redress if things go wrong.
- SG guidance on safe & sustainable installation of low carbon tech.

installer is no longer in business. - Expand MCS scheme (or other accreditation scheme) to cover good system design. Accredited assessors should be able suggest which heating technology would best suit each home. This should also cover provision of advice on operation and maintenance.
- Message of insulation first should be promoted by renewable heating installers and consumer-facing organisations such as EST.

PLANNING

- The Environmental Protection Act / Air Quality standards restricting rollout of biomass. Anecdotal evidence suggests some LA planning officers request expensive mitigation technology on small scale biomass installations.
- SG has a good level of ambition and the right direction of travel but planning authorities do not always share this vision.
- SG should reach a conclusion on general permitted development for ASHPs and permitted noise levels.

- SG should enforce consistency between planning authorities, by providing clearer guidelines e.g. dB levels allowed and air quality issues.
- Biomass combustion should be encouraged at larger scales where emissions abatement technologies are cost-effective.
- Better alignment between central SG policies and planning authorities, especially among planning officers and / or environmental health officers.

INDUSTRY

- The incumbent heating system industries are often unaware of renewable heat options and unable / unwilling to promote them.
- Vocational qualifications for electricians, plumbers etc. now include training on renewables systems.
- The SEAM centre at Inverness College UHI provides training on renewable heat.

- Increased training of builders / plumbers so they can be better advocates for renewable heating technologies.
- Raising customer awareness would drive companies to train their installers to offer renewable heating options and / or advice on these.

¹³³ Sufficient advice is available once householders decide to look into a renewable technology. Awareness is a greater issue, although locating the specific advice needed is sometimes seen as difficult.
### 6.8.3 Barriers to district heating deployment

<table>
<thead>
<tr>
<th>ECONOMIC CONSIDERATIONS</th>
<th>Current action</th>
<th>Further action required</th>
</tr>
</thead>
<tbody>
<tr>
<td>- High upfront costs at risk (e.g. lack of connections ruining economic case), long payback, poor rate of return on investment.</td>
<td>- DH loans fund from the SG. Unsecured loans (as with DH loans fund from the SG) are good for HAs as there are limits on the levels of secured loans they can take out.</td>
<td>- Public funding required for DH to happen widely. Some form of grant support is essential in the current financial climate, even for established projects. However, significant additional public funds are currently unlikely so support should focus on catalysts e.g. funding for feasibility studies and design phase.</td>
</tr>
<tr>
<td>- High cost of groundworks and allowing for changes of plans during digging means urban projects are difficult to finance.</td>
<td>- Structural funds e.g. Scottish Biomass Heat Scheme considered very positive and beneficial. - A DH uplift was considered in the consultation for the RHI but a decision was made that it was too complicated to define. However the RHI may help to raise interest more generally in using renewable sources of heat for DH schemes.</td>
<td>- SG should provide guidance to potential developers to help them assess full lifetime economics DH.</td>
</tr>
<tr>
<td>- Lack of LA funds in current economic climate.</td>
<td></td>
<td>- Large proportion of upfront cost of DH is groundworks. DH could be considered in high rise, tenements, and rural areas (depending on heat density). LAs and others should be given support to identify such areas.</td>
</tr>
<tr>
<td>- Lack of an uplift for DH in the RHI.</td>
<td></td>
<td>- SG could explore the possibility of providing an uplift on top of RHI.</td>
</tr>
<tr>
<td>- Potential financial conflict between commercial developers (who desire commercial rate of return) and housing association partners (trying to provide affordable warmth).</td>
<td></td>
<td>- Greater promotion of DH benefits to consumers, and greater billing transparency of current energy costs.</td>
</tr>
</tbody>
</table>

#### EDUCATION & SUPPORT FOR DEVELOPERS (INCLUDING LOCAL AUTHORITIES)

| - Lack of independent, impartial advice around legal / financial details. | - SG has committed to set up an expert commission on DH. - Procurement Scotland is developing guidelines on purchasing renewable heating for the public sector. - The Heat and the City project aims to aid discussion between LAs and share learning. - Community Energy Programme case studies available from EST. - SG’s FREDS group established a heat mapping pilot which is | - Establish a SG-backed agency or advice service, perhaps based on the support that exists in Austria, to provide expert, independent, impartial advice on the technical aspects of proposed schemes as well as financial and legal matters and project management. |
| - Lack of confidence in technology from developers due to some projects which have run into difficulty. | - Lack of knowledge from LAs of their building stock, local heat loads etc. | - Support facilitated networking between LAs to share best practice. - Establish ESCOs to run schemes. |
| - Lack of knowledge from LAs of their building stock, local heat loads etc. | | - Better guidance from SG is needed on whether LAs should pursue DH. |
| | | - LAs should establish an energy officer role, with the person responsible for energy in broad terms and with a view of all the different areas involved which would help to bring all necessary partners together. |
being trialled by Highland Council and is to be rolled out to other LAs.

<table>
<thead>
<tr>
<th>PLANNING</th>
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</thead>
<tbody>
<tr>
<td>- Lack of national and local vision with regards to district heating.</td>
</tr>
<tr>
<td>- LAs’ concerns over air quality issues, especially with biomass.</td>
</tr>
<tr>
<td>- National Planning Framework (NPF2): potential for heat networks should be taken into account when considering major new developments.</td>
</tr>
<tr>
<td>- SG is investigating use of waste heat from large generators.</td>
</tr>
<tr>
<td>- Forestry Commission Scotland (FCS) report on flue gas particulate abatement technologies.</td>
</tr>
<tr>
<td>- Technical guidance on screening assessments for biomass boilers for LAs available from Defra.</td>
</tr>
<tr>
<td>- Modelling of predicted fine particulate emissions from biomass boilers under different deployment scenarios for the SG.</td>
</tr>
<tr>
<td>- Introduce planning condition for developments with large waste heat production to ensure use is made of heat. Compliance should be based on connecting existing demands (not just promises to connect future developments).</td>
</tr>
<tr>
<td>- National framework on district heating could be established with regulation at LA level (although the risk that this could lead to inconsistencies between local authority areas would have to be managed).</td>
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</table>

6.8.4 Feedback on modelling assumptions

Other main points of feedback from stakeholders are summarised below.

Cost of technology (dwelling scale and DH)

- Heat pumps: £900/kW for pump alone. Pump is most expensive part of installation and typically makes up 50–60% of total installation cost in a domestic installation.
- Biomass boiler costs are in the region of £12,000 per installation although this is variable. ¹³⁴
- DH costs quoted as c.£10–11k per house connected. Largest cost is often in groundworks (digging up roads, protecting existing pipework, relaying pavements etc.). Therefore DH is well suited to: new build, rural areas (subject to sufficient heat density), tenements.

¹³⁴ The individual biomass boiler cost assumptions used are broadly consistent with this figure.
Likelihood of future cost reductions

- Heat pump costs will not fall dramatically, 10% at most. In a very optimistic scenario, costs could fall by more like 20%, but this was seen as unlikely. The technology is largely mature (as has been used commercially for many years). Japan is a major source of units and already has very efficient manufacturing supply chain. Predicted market in UK (even with RHI) will not be sufficient to allow for economies of scale. Move to manufacturing and/or assembly in UK/Scotland could help lower costs, but this was not viewed as likely.

- Biomass boilers are already a mature technology and cost reductions are therefore unlikely. However, introduction of a fuel quality standard (pellet size and moisture content) would provide a boost to consumer confidence.

State of fuel supply

- Currently plenty room for expansion in pellet fuel supply for homes. However this may be threatened by large biomass electricity generating plants (pellets also suitable for co-firing with coal).

\[135\] We test the impact of less optimistic heat pump cost reductions in the modelling – see section 6.7.5.
6.9 Acknowledgements

The authors are grateful to all stakeholders who provided input to this study. In particular, we would like to acknowledge and thank:

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Cate Lyon  Energy Saving Trust
Elaine Waterson  Energy Saving Trust
Rebecca Carr  Forestry Commission Scotland
Cameron Maxwell  Forestry Commission Scotland
John Smith  Royal Town Planning Institute
Richard Howard  Scottish Enterprise
Christine McKay  Scottish Government
Daniel Borisewitz  Scottish Renewables
Peter Dennis  SEAM Centre
Eric McRory  SEPA
John Birchmore  SHREWS ltd
Rufus Ford  SSE
Cath Cooper  SSE
Terry Seward  UK Heat Pump Association

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136 Sustainable Energy and micro-renewables centre, Inverness College UHI.
137 Scottish Environment Protection Agency.