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# BERR

## BARRIERS TO RENEWABLE HEAT PART 1: SUPPLY SIDE

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## LIST OF ACRONYMS

| | |
|---|---|
| AD | Anaerobic Digestion |
| ASHP | Air Source Heat Pumps |
| BERR | Department for Business, Economy and Regulatory Reform |
| BHA | Biomass Heat Accelerator |
| CHP | Combined Heat and Power |
| CIF | Cost, insurance, freight |
| CT | Carbon Trust |
| DH | District Heating |
| DTI | Department of Trade and Industry |
| ESCo | Energy Services Company |
| EST | Energy Saving Trust |
| E&Y | Ernst and Young |
| EC | European Commission |
| FED | Final Energy Demand |
| GSHP | Ground Source Heat Pumps |
| R&D | Research and development |
| RDA | Regional Development Agency |
| RES-E | Renewable Energy Supply – Electricity |
| RES-H | Renewable Energy Supply – Heat |
| RTFO | Renewable Transport Fuels Obligation |
| SRC | Short rotation coppice |

# 1. INTRODUCTION

This report presents the findings from Part 1 of a two-part project commissioned by BERR to answer the question 'how much renewable heat could be delivered in 2010, 2015 and 2020 under different assumptions on barriers, and at what cost, assuming that financial subsidies are not a barrier?'

## 1.1 Objectives

The aim of the analysis is to:

- add to the information from the call for evidence by building a clear picture of:
  - the impact of barriers/ constraints on supply and demand to renewable heat in the UK;
  - the costs of overcoming these barriers; and
- to build scenarios for the deployment of renewable heat – taking into account the impact of barriers identified.

This work will feed into a model of financial instruments for renewable heat, which is being completed alongside this project.

## 1.2 Overview of approach

For the purposes of this project we are working to the following definitions.

A **barrier** is something that prevents the maximum uptake of renewable heat:

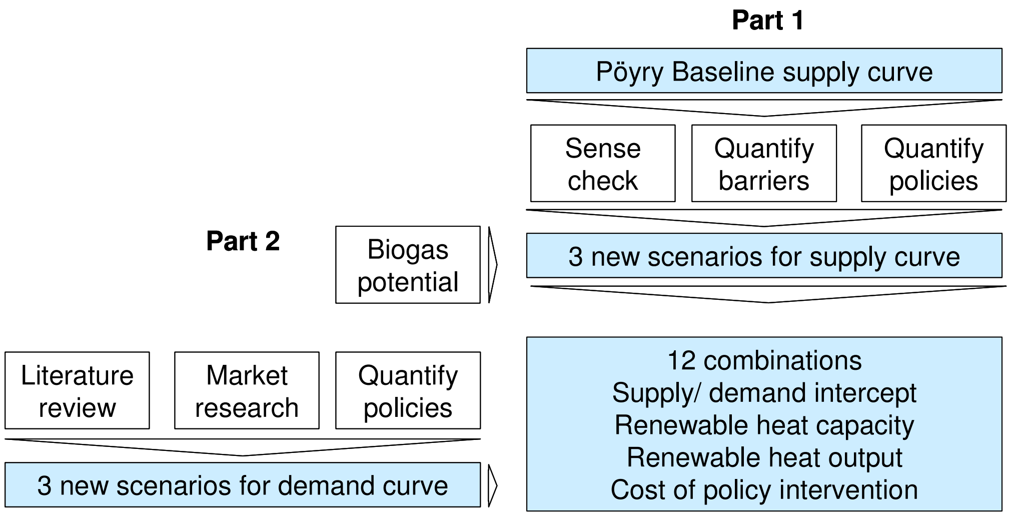
- reduces or delays capacity being installed; or
- prevents or delays installed capacity running at optimal output.

**Demand side barriers**: these put a heat user off using renewable heat (either resulting in them using an alternative non-renewable fuel or in deciding not to replace existing heating equipment entirely).

**Supply side barriers**: these stop getting the heat equipment up and running how, when and where the customer wants.

Some issues will be both supply and demand barriers e.g. planning because it can affect the decision of whether or not to try biomass heat and it can delay the completion of a project once it's started.  Part 1 of this project focuses on barriers to the supply side and the tasks being undertaken are summarised in the diagram below. Given the time available we have built on existing information; a list of references is provided in Appendix 3.

**Figure 1 Overview of project approach**




### *Technology categorisation*

For the purposes of the qualitative and quantitative assessment it has been necessary to split different renewable technologies into different categories, determined by the technology, its fuel type and the end users. For the majority of analysis we have worked to the five categories listed in the left hand side of Figure 2 below (biomass, solar thermal, ground source heat pumps, geothermal and biogas).

**Figure 2 Technology categorisation**

| **List of tranches for this project** | | | **Poyry** | **E&Y** | **DUKES** |
|---|---|---|---|---|---|
| *Technology* | *Tranche* | *Sub-category* | *Category* | *Category* | *Category* |
| Biomass | Pellet Stoves/Wood Burners | D, C, I, P | Biomass Heat Non Grid Connected | Residential Biomass | Wood Combustion - Domestic |
| | Boilers (Wood, Pellet & Straw) | D, C, I, P | | Commercial Biomass | - |
| | Wood Waste Boilers | C, I, P | Biomass Heat Grid Connected | Industrial Biomass | Wood and Straw Combustion |
| | Fuel Switching | D, C, I, P | - | - | - |
| | CHP | I, P | - | Energy from Waste | Municipal Solid Waste Combustion |
| Solar Thermal | Solar Thermal | D, C, I, P | Solar Heat | Solar Thermal | Active Solar Heating |
| GSHP/ASHP | GSHP/ASHP | D | GSHP | Heat Pumps | - |
| Geothermal | District Heating | D, C, I, P | Geothermal Heat | - | Geothermal Aquifers |
| Biogas | Stand-Alone Waste Heat | I | Biogas electricity only | Anaerobic Digestion | Sewage Sludge Digestion |
| | District Heating | D, C, I, P | | | Landfill gas |
| | Gas Main Injection | D, C, I, P | | | |

| Key | |
|---|---|
| D | Domestic |
| C | Industrial |
| I | Commercial |
| P | District heating/ public sector |
| CHP | Combined heat and power |
| GSHP | Ground source heat pump |

# 2. BARRIERS TO THE UPTAKE OF RENEWABLE HEAT

There are a wide range of factors that determine the extent to which the theoretical potential of renewables is exploited. One group of barriers are ‘financial’ i.e. where the costs of choosing, installing and running renewable heat are higher than for an alternative fuel or where it would be cheaper to continue to use old equipment rather than replace it. A second group are ‘non-financial’ and relate to e.g. a lack of awareness that renewable heat is an option or a lack of availability of the necessary equipment. This project focuses on this second group, and for Part 1, on the barriers that affect the supply side i.e. the ability to provide the equipment that a user needs.

## 2.1 Identifying and ranking barriers

For this project we have identified the key barriers to renewable heat in the UK. In order to provide a high level ranking of their impact, we have used the following criteria to indicate their relative impact on renewable heat supply. This ranking has informed our quantification of the barriers.

- End uses affected: industrial, commercial, domestic, district heating/ public?
- Prevent or delay: does the barrier limit the installation of renewable heat capacity or does it delay it (or both)?
- Capacity[1] or capacity factor: does the barrier stop the installation of capacity or prevent its optimal use once installed (or both)?
- Knock-on: does this barrier magnify other barriers i.e. would overcoming it have a positive indirect impact?
- Overall: does our qualitative and quantitative research indicate that this is a fundamental barrier to the deployment of renewable heat. Note that some barriers may be important for a particular technology, but, given the relative scope for different renewable technologies, may not constitute a ‘high’ barrier when considered against the other constraints.

## 2.2 Barriers identified

The following tables summarise the key barriers to renewable heat in the UK and rank them against the criteria above. The table headings are explained below.

- Ranking: overall importance of this barrier in terms of the extent to which it reduces uptake.
- Supply side/ demand side: describes whether the supply or demand side is affected by a particular barrier.
- Industrial/ commercial/ domestic/ public: this shows which end users the barriers impact on.
- Prevents: notes where the barrier prevents the uptake of renewable heat (rather than delaying it, see heading below).

1 Number of units, average size of unit, general reduction in uptake

- Delays: barrier delays the uptake of renewable heat but does not necessarily prevent it completely.
- Reduced capacity: the barrier affects the installed capacity (as well as or rather than the capacity factor, see heading below).
- Capacity factor: barrier leads to a sub-optimal capacity factor e.g. due to fuel constraint or technical problems.
- Impact on other barriers: describes whether overcoming this barrier could have a magnified impact by reducing the impact of other barriers too.

**Table 1 Barriers to biomass in the UK**

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of trained engineers and plumbers | The installation and maintenance of new biomass heat plants requires skilled personnel. If there is not a sufficient number of trained personnel this will prevent and delay biomass heat uptake. | High | Yes: a limited availability of skilled installers will pose problems for suppliers. | Yes: fear that in case the equipment fails to work repairing will be delayed might put end users off. | √ | √ | √ | √ | X | √ | √ | √ | √ | More skilled engineers would also enable companies to grow faster and cover a larger geographical area. |
| Air Quality issues | The burning of biomass can present issues for air quality. This can have an impact in two different ways (i) biomass boilers may be required to meet stringent emissions standards (affecting fuel and technology choice) and (ii) their use may not be possible in some areas at all if it would take air quality standards beyond limits specified in the Clean Air Act. | High | Yes: planning permission will not be granted where the combustion of biomass would cause air quality to deteriorate below accepted levels. | No | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| District heating Infrastructure | The installation of district heating systems will require significant changes to infrastructure which may take a number of years. The size of the pipes used in district heating (10-15 greater than those used in natural gas systems) may restrict their application to very high density areas. Retrospective installation is exceptionally expensive and disruptive. | High[2] | Yes: a lack of district heating infrastructure limits the amount of biomass heat which could be distributed effectively. Since DH is most efficient biomass heat method this is a major disadvantage. | No | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |
| Unreliable supply | There is a lack of intermediaries that are creditworthy and have a variety of contracts that enable them to mitigate climatic, price and other risks. Fuel import and handling infrastructure is also expected to cause a constraint in future. | High | Yes: unreliable fuel supply makes it difficult for suppliers to secure a constant heat supply. | Yes: unreliable fuel supply can be perceived as unreliable heat supply which could put end users off. | √ | √ | √ | √ | X | √ | √ | √ | X | n/a |

2 If the levels of renewable heat required to meet the EU targets are to be achieved, it will be necessary to overcome this barrier.

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of competitive products/technical viability in on-gas areas | Vast majority of dwellings' heating demand in UK is served by natural gas systems. Biomass systems cannot compete in terms of capital, fuel supply, size in this market, which is a gas replacement rate of 1.5 million units per year. | Medium | Yes: lack of market impedes supplier development. | Yes: complexity (and cost) of biomass systems will deter users. | X | X | √ | X | √ | √ | √ | X | X | |
| Complexity and feasibility of using heat generated in biomass CHP schemes | Heat recovery systems are often not fitted as the disbenefits of a potential loss of electrical generation capacity), combined with low value for heat outweigh the benefits in many circumstances. | Medium/ High[3] | Yes | No | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |

3 For this project, we assume that financial barriers are overcome and the barriers we consider are non-financial. While we do consider this barrier important, if the appropriate price signals were in place that would do more to overcome this barrier than it would those categorised as 'high'.

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Definition of biomass waste | Forestry materials, municipal arisings and straw are all secondary products; consequently some of these materials might fall under the legal definition of waste. Waste falls under certain regulations which affect storage, handling, transport and use for heat generation. | Medium/ High | Yes: some sorts of biomass cannot be used / have to be treated differently by suppliers. | Yes: an association of biomass heating with waste can cause negative perceptions of the technology. It also has planning implications. | √ | √ | √ | √ | √ | √ | √ | X | √ | Changing the definition of waste in favour of biomass could affect the available resource base and the fuel supply. This is not to imply that the waste hierarchy should be ignored or amended, but rather that suitable material should be removed from regulatory controls |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of high specification kit manufacturers | Manufacturing capacity in the UK is fairly limited. However, equipment is widely available from other European countries such as Austria and Italy. | Medium | Yes: suppliers rely on the availability of high specification kit. | No | √ | √ | √ | √ | √ | √ | √ | X | √ | Higher quality equipment could potentially benefit from eased planning requirements. |
| Planning permission | Long term planning processes and the risks of planning failure associated with, for example, lorry movements, visual impact, noise, waste incineration etc. pose a significant barrier to the deployment of biomass heat plants. | Medium | Yes: planning permissions is a prerequisite for the successful installation of biomass plants. | No | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |
| High space requirements | A potential barrier to the deployment of pellet or wood chip boilers is the greater space requirement compared to gas fired boilers. This is due to the larger boiler size, the need for fuel delivery infrastructure and adequate fuel storage. | Medium | Yes: limited space will prevent suppliers to install biomass plants. | Yes: larger equipment in comparison to conventional heating systems might discourage customers. | X | √ | √ | √ | √ | X | √ | X | X | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of new companies set up | The number of existing companies is not sufficient to achieve a significant up-take of biomass heat. | Medium | Yes: a lack of suppliers will automatically limit supply. | No | √ | √ | √ | √ | √ | √ | √ | X | √ | The creation of new companies would entail more trained personnel. |
| Lack of ESCo development | Energy Service Companies can mitigate against the high cost of equipment and fuel supply insecurities by selling heat rather than equipment/ fuel. | Medium | Yes: novel products would bring new markets into focus. | Yes: novel financial products would enhance delivery of biomass heat by reducing project risks. | √ | √ | √ | √ | √ | √ | √ | X | √ | It would also influence improved fuel supply, increased demand for equipment driving down unit prices and de-risking the supply chain |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Geographic coverage – travel requirements | There can be a lack of local suppliers[4] in some areas, meaning that suppliers have to travel relatively long distances to service their customers. This not only increases response times and so costs but also reduces the number of customers a supplier can help. | Low | Yes: distances between suppliers and customers makes it time consuming and costly to service the whole UK area. | Yes: customers prefer a local contact that is more visible and readily accessible. | √ | √ | √ | √ | X | √ | √ | X | √ | Delivery networks and the availability of skilled personnel would follow the geographical patterns of biomass heat supply. |

4 By this we mean branch offices, or individual representatives, of national firms as well as local businesses.

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resource (fuel) availability | Biomass heat is dependent on resources such as wood, straw, energy crops and waste. The amount of resources available are a potential barrier to the uptake of biomass heat. (We assume that competition from other markets will be addressed via the relative economics of different uses). | Low[5] | Yes: a limited resource base can potentially limit the available fuel for biomass heat plants. | Yes: although resource availability is primarily a supply barrier it can affect end-users choice of fuel. (Unreliable fuel supply is also assumed to have an impact on demand, captured against the relevant barrier above). | √ | √ | √ | √ | X | X | √ | √ | X | n/a |
| Poor historical performance | Despite the maturity of the technology, plant performance has often fallen bellow desired standards. | Low | No: there is sufficient well established equipment available from other countries such as Austria. | Yes: past problems may cause negative perceptions of the technology. | √ | √ | √ | √ | X | √ | X | √ | √ | Better performing equipment would enable suppliers to grow faster. |

5 For the purposes of this project it is assumed that the import of biomass fuels is possible. As discussed later in this document, even in the face of rising global demand for biomass fuels, although the cost of biomass may increase in response, it is not expected that the availability of fuels will in itself act as a constraint. Rather, the real barrier in terms of fuel availability is constraints on the fuel supply chain (i.e. the infrastructure to distribute the fuels) rather than on the availability of the resource itself.

**Table 2 Barriers to biogas in the UK**

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating collection and distribution | The installation of district heating systems will require significant changes to infrastructure which may take a number of years. The size of the pipes used in district heating (10-15 greater than those used in natural gas systems) may restrict their application | High | Yes: a lack of district heating infrastructure limits the amount of biogas heat which could be distributed effectively. | Yes: these systems are usually rurally located and therefore distributed heating is more costly. | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |
| Lack of R&D on the collection of landfill gas for distribution in heating systems/ gas injection | There is currently a lack of understanding of the options of landfill gas distribution in heating systems. | Medium/ High | Yes: the options in the UK are not well developed. | Yes: see supply side. | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Switch to sustainable energy crops for biogas | Lack of incentives for farmers to grow/use crops for biogas rather than traditional uses. | High | Yes: more crops could be made available for biogas | No: main barrier is on supply (although perception of limited fuel availability could impact on demand) | √ | √ | √ | √ | √ | √ | √ | X | n/a | n/a |
| For AD – Digestate standards | There are limited options at the moment for the disposal of waste occurring in AD. | Medium | Yes: projects will not proceed if there is a question mark over the ability of the developer to dispose of waste from the system, which may be as much as 80% of input volume. This applies to AD only. | No | √ | √ | √ | √ | √ | √ | √ | √ | √ | The possibility provides greater assurance to food supply chain that digestate was safe and possibly encourage European manufacturers of disposal options to enter the UK marketplace |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| for AD – 3rd party views on digestate | Supermarkets are reticent to accept food grown on land where digestate has been spread before. | Medium | Yes: there are currently limitations on digestate disposal options. Supermarkets are reticent and Soil Association will not confirm organic status on land spread with digestate | Yes: many supermarkets are reluctant to accept food that has been grown on land spread with digestate. | √ | √ | √ | √ | √ | √ | √ | √ | √ | Increased acceptance of the use of digestate would enhance the market acceptability for new technology providers due to greater disposal options. |
| for AD – presence of lower cost composting as a waste management solution for Local Authorities | Local Authorities have in many cases chosen composting as their management solution to landfill diversion. Therefore it is limiting the market for AD[6]. | Low | No | Yes | √ | √ | √ | √ | √ | √ | √ | X | √ | Encouraging more technology providers into the UK since this would expand the market considerably. |

6 It is acknowledged that much of the waste that is composted by the domestic sector (e.g. vegetable peelings) are low in calorific value and that there are not any policies are in place to encourage individuals to compost cooked food waste due to health and pest concerns.

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| for AD – Technology suppliers | There is a lack of active players in the UK. Resources to support e.g. labs for digestate and biogas analysis are also limited. | Medium | Yes: only a handful of suppliers are active in the UK market, although over 75 have been identified as potentially able to supply/install/operate kit. | Yes: the lack of activity reduces awareness of options and potentials. | √ | √ | √ | √ | √ | √ | √ | X | √ | The creation of new companies would entail more trained personnel. |
| for AD – Animal bi-products disposal regulations | Bio-security – Handling ABPR wastes on mixed farms requires strict animal hygiene regulations to be applied. This is a disincentive to participate. | Medium | Yes: reduces numbers of farms interested in receiving food waste in digesters. | Yes: the regulations imposed on farmers might prevent them from taking part in AD. | √ | √ | X | √ | √ | √ | √ | √ | √ | It will impact on all digestate disposal related barriers by improving information flow and engagement. |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| for AD and landfill gas – Planning permission | The current planning system retards the development of community scaled schemes due to waste logistics and odour. This is mainly due to a lack of understanding from planners, other regulators. | Medium | Yes | Yes: long lead times deter market development. | √ | √ | X | √ | √ | √ | √ | X | X | n/a |
| Complexity and feasibility of using biogas heat | There is a frequent lack of co-location of AD/biogas facilities and heat sinks. | Medium | Yes: drivers for AD, landfill and sewage gas exploitation are a) landfill diversion and b) ROCs – heat is a low value by-product used in heating the reaction vessels of bio-digesters or dumped. | No | √ | √ | √ | √ | √ | √ | √ | √ | n/a | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| for landfill – Landfill gas levels declining and Local Authorities seriously unlikely to refresh reserves | The lifetime of landfill sites is declining rapidly due to landfill diversion. It will retard development of new sites to virtually zero. | Medium | Yes: a lack of landfill gas will directly impact on the supply side. | No | √ | √ | √ | √ | √ | √ | √ | √ | n/a | n/a |
| Lack of skilled technicians/operatives | As with biomass heat, there is a need for installers and maintenance engineers plus skilled biologists to maximise gas yields. | Medium | Yes: a limited availability of skilled installers will pose problems for suppliers. | Yes: fear that in case the equipment fails to work repairing will be delayed might put end users off. | √ | √ | √ | √ | √ | √ | √ | X | √ | More skilled engineers would also enable companies to grow faster and cover a larger geographical area. |
| for AD – Waste handling licences, if importing 3rd party waste | For AD systems a waste handling licence is needed which adds a bureaucratic barrier. | Low | No | Yes: the need of getting a licence might put people off. | √ | √ | X | √ | √ | X | √ | X | n/a | n/a |
| Mainly for AD – Process parameters/ technology | AD technology is complicated and the technology choices are not straightforward. | Low | Yes for AD: technology choices are many fold and complicated. | No | √ | √ | √ | √ | √ | √ | √ | X | n/a | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| for AD – Waste handling infrastructure | There is a lack of a proper waste handling infrastructure for AD in the UK. | Low | Yes: although there is already an infrastructure in place for landfill and sewage, it requires optimisation for AD. | Yes: complexity of waste collection may deter local authorities. | √ | √ | √ | √ | √ | √ | √ | X | No | n/a |

**Table 3 Barriers to geothermal in the UK** (given the extent and implications of these two barriers, geothermal has not been considered further)

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of a high temperature resource | The UK is physically placed in an area that does not have available high temperature geothermal resources – either hydrothermal reservoirs or hot rock sources. Low temperature resources, like that in the UK, are not as cost effective. | High | Yes: as the physical constraint of the resource reduces its potential to deliver. | No: the resource is unavailable in many areas. | √ | √ | √ | √ | √ | √ | √ | √ | n/a | n/a |
| Mismatch of geothermal resource to population centres | Low temperature hydrothermal reservoirs are present across the UK, however the distribution of this resource does not fall under the larger population centres. | High | Yes – When the resource is not matched to the demand then the potential supply is reduced, as it can not be utilised at source. | Yes: If the energy resource is not available locally then perception of the efficiency will be reduced. | X | X | √ | √ | √ | √ | √ | √ | √ | If there was a greater match of the supply of geothermal energy to the demand then the resource potential would be greater and more efficient to utilise. |

**Table 4 Barriers to solar thermal in the UK**

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of trained engineers and plumbers | The installation and maintenance of new solar thermal installations requires skilled personnel. If there is not a sufficient number of trained installers this will delay solar thermal uptake.<br><br>If there are not enough (or they are otherwise too busy) heating engineers and plumbers which can be quickly trained in the skills of solar thermal installations this will delay solar thermal uptake | High | Yes: a limited availability of skilled installers will pose problems for suppliers. | Yes: fear that in case the equipment fails to work repairing will be delayed might put end users off. | √ | √ | √ | √ | X | √ | √ | √ | √ | More skilled engineers would also enable companies to grow faster and cover a larger geographical area. |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Difficulty fitting solar to existing roofs | Range of roof types, collector fittings and health and safety requirements create problems for quick and cost effective installation. | High | Yes: complexity of installing solar thermal to existing roofs poses a problem for suppliers. | Yes: increased costs might put off consumers. | √ | √ | √ | √ | √ | √ | √ | X | √ | This would also reduce overall costs. |
| Difficulty fitting solar to existing heating systems | Retro fitting to existing heating systems can be complex and costly. | High | Yes: complexity and difficulty of fitting to existing cylinders or having to replace cylinders poses barriers for suppliers. | Yes: increased costs might put off consumers. | √ | √ | √ | √ | √ | √ | √ | X | √ | This would also reduce overall costs. |
| Compatibility of combi boilers | Some combi boilers are compatible with solar while others are not. | Medium | Yes: it wastes time and prevents up take. | Yes: confusion prevents installations which could have gone ahead. | X | X | √ | X | √ | X | √ | X | X | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Availability of low cost high quality collectors manufactured in the UK | There is a small manufacturing base for solar collectors in the UK . | Low | | | √ | √ | √ | √ | √ | √ | √ | X | √ | A vibrant home manufacturing base would invest in R&D appropriate to UK market. |
| Building control | All heating installations (including solar ) need to be checked by building inspector or installed by "competent person". | Low | Yes: this adds extra cost and uncertainty. | Yes: consumers might be confused. | X | X | √ | X | X | √ | √ | X | X | n/a |
| Geographic coverage – travel requirements | Existing companies do not cover the whole of the UK which poses difficulties in terms of travel requirements. | Low | Yes: distances between suppliers and customers makes it difficult to cover the whole UK area. | Yes: customers prefer local suppliers which are accessible. | √ | √ | √ | √ | X | √ | √ | X | √ | Local availability of supply and installation skills will help reduce costs of installation. |

**Table 5 Barriers to GSHP in the UK**

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of trained engineers and plumbers | The installation and maintenance of new heat pump installations requires skilled personnel. If there is not a sufficient number of trained installers this will delay GSHP uptake.<br><br>If there are not enough (or they are otherwise too busy) heating engineers | High | Yes: a limited availability of skilled installers will pose problems for suppliers. | Yes: fear that in case the equipment fails to work repairing will be delayed might put end users off. | √ | √ | √ | √ | X | √ | √ | √ | √ | More skilled engineers would also enable companies to grow faster and cover a larger geographical area. |
| Difficulty of retrofitting to existing buildings | The technology requires low temperature heat distribution system for optimal performance. | Medium/ High | Yes most existing central heating heat distribution systems (radiators) are not ideal for heat pump applications | Yes: adds to cost to address this issue | √ | √ | √ | √ | X[7] | √ | √ | √ | X | n/a |

7 We assume that in terms of supply side barriers, to which these categorisations primarily refer, although the difficulty of retrofitting may make it more time consuming and costly to install heat pumps, it would not actually prevent suppliers providing this service. If we were looking from the demand side, we may consider that this barrier actually prevents the uptake of renewables (end users may be put off from installing renewables due to the extra hassle factor in the case of retrofit).

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lack of space to install collectors (GSHP) | Some buildings will not have access to sufficient space for horizontal or even vertical collectors. | Medium/ High | Yes: increases complexity and cost to go vertical instead of horizontal | Yes increases costs | √ | √ | √ | √ | √ | √ | √ | √ | n/a | n/a |
| Availability of aquifers for ground water heat pumps | Not all areas have suitable aquifers. | Medium | Yes: Particularly important for large installations. | Yes: it will increases costs for end users. | √ | √ | X | √ | √ | √ | √ | √ | n/a | n/a |
| Permissions to use aquifers | It is a complex, time consuming and uncertain process for gaining lasting permission for ground water heat pumps. | Medium | Yes: the application process is complex and takes time. | Yes: short licensing period creates uncertainties. | √ | √ | X | √ | √ | √ | √ | X | X | n/a |
| Geographic coverage – travel requirements | Existing companies do not cover the whole of the UK which poses difficulties in terms of travel requirements. | Low | Yes: distances between suppliers and customers makes it difficult to cover the whole UK area. | Yes: customers prefer local suppliers which are accessible. | √ | √ | √ | √ | X | √ | √ | X | √ | Local arability of supply and installation skills will help reduce costs of installation. |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity supply capacity | The lack of three phase electricity supply limits the capacity of domestic installations[8]. Overall capacity of local networks may also become an issue for other sectors. | Low | Yes: may need to use bivalent systems or alternative strategies to implement heat pump solution. | Yes: it is likely to increase costs | X | X | √ | X | √ | √ | √ | √ | X | n/a |

8 The specification of a heat pump will vary depending on the nature of the electricity system. Three-phase systems use three circuit conductors, each of which carries an alternating current of the same frequency. The current on each conductor reaches its instantaneous peak at a different time which makes it possible to produce a magnetic field which rotates in a specific direction. This field helps to make the design of motors more straightforward; it is not produced by single phase systems (which are common in the domestic sector where the primary use of the electricity is lighting and heating).

**Table 6 Barriers to ASHP in the UK**

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Awareness and understanding of the technology | There is lack of awareness and understanding of the requirements/potential of installing ASHP; this will delay the expansion of the market. | High | Yes: limited awareness and understanding of requirements and potential among suppliers | Yes: lack of awareness of ASHP technology limits current demand and interest in technology. | √ | √ | √ | √ | √ | √ | √ | X | n/a | n/a |
| Lack of trained engineers and plumbers | The installation and maintenance of new heat pump installations requires skilled personnel. If there is not a sufficient number of trained installers this will delay ASHP uptake.<br><br>If there are not enough (or they are otherwise too busy) heating engineers | Medium | Yes: a limited availability of skilled installers will pose problems for suppliers. | Yes: fear that in case the equipment fails to work repairing will be delayed might put end users off. | √ | √ | √ | √ | X | √ | √ | √ | √ | More skilled engineers would also enable companies to grow faster and cover a larger geographical area. |
| Difficulty of retrofitting to existing buildings | The technology requires low temperature heat distribution system for optimal performance. | Medium | Yes most existing central heating heat distribution systems (radiators) are not ideal for heat pump applications. | Yes: adds to cost to address this issue | √ | √ | √ | √ | X | √ | √ | √ | X | n/a |

| Barrier name | Description of barrier | Ranking | Supply side | Demand side | Industrial | Commercial | Domestic | Public | Prevents | Delays | Capacity | Capacity factor | Impact on other barriers | What and how? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Geographic coverage – travel requirements | Existing companies do not cover the whole of the UK which poses difficulties in terms of travel requirements. | Medium | Yes: distances between suppliers and customers makes it difficult to cover the whole UK area. | Yes: customers prefer local suppliers which are accessible. | √ | √ | √ | √ | X | √ | √ | X | √ | Local availability of supply and installation skills will help reduce costs of installation. |
| Noise and planning | Fan noise may lead to planning rejection | Medium | Yes: it delays the installation. | Yes: it may be rejected. | √ | √ | √ | √ | √ | √ | √ | X | X | n/a |
| Electricity supply capacity | The lack of three phase electricity supply limits the capacity of domestic installations. Overall capacity of local networks may also become an issue for other sectors. | Low | Yes: may need to use bivalent systems or alternative strategies to implement heat pump solution. | Yes: it is likely to increase costs of ASHP. | X | X | √ | X | √ | √ | √ | √ | X | n/a |

# 3. SUPPLY CURVE FOR RENEWABLE HEAT

The starting point to the quantitative analysis for this project is the renewable heat supply curve produced for BERR by Pöyry[9]. The analysis considers each of the EU-27 countries and the assumptions behind it aim to facilitate comparison of the costs of renewable generation in different countries on a like for like basis.

Pöyry assumes a baseline level of renewable heat output that increases considerably over the time span of the projections and exceeds the BERR projection throughout (both projections are shown in the table below).

**Table 7 Pöyry and BERR baseline assumptions (TWh)**

| | BERR (original[10]) | | | | Pöyry | | | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | % of total | 2020 | % of total | 2010 | % of total | 2020 | % of total |
| Biomass Heat Non Grid | 7.2 | 98% | 7.2 | 98% | Split not provided | | 16.0 | 44% |
| Biomass Heat Grid Connected | 0.0 | 0% | 0.0 | 0% | | | 19.8 | 54% |
| Geothermal Heat | 0.2 | 2% | 0.2 | 2% | | | 0.0 | 0% |
| Ground Source Heat Pumps | 0.0 | 0% | 0.0 | 0% | | | 0.0 | 0% |
| Solar Heat | 0.0 | 0% | 0.0 | 0% | | | 0.7 | 2% |
| Total | 7.3 | | 7.3 | | 18 | | 36.5 | |

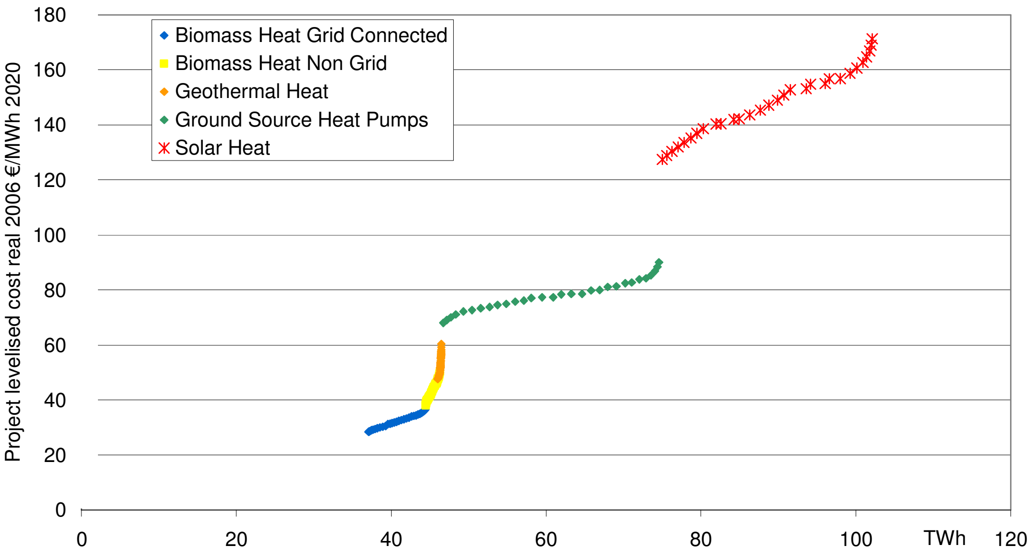
Source: BERR and Pöyry

The volume of renewable heat in the UK that could be made available at a particular resource cost over and above this baseline level is presented as a supply curve (the central scenario is illustrated in the diagram below). The costs shown are understood to include capital (for equipment) plus fixed operational (i.e. maintenance) and variable operational (i.e. fuel) costs. The maximum output that could be achieved from each type of resource in the UK in 2020 at these costs is shown in the table below. These data have been used to sense check the scenarios that follow.

9 Pöyry (2008) Compliance costs for meeting the 20% renewable energy target in 2020 A report to the Department for Business, Enterprise and Regulatory Reform, March 2008. In addition to drawing on the published report we have also used quantitative data that BERR was able to provide (the supply curve for RES-H in 2020 plus the baseline split for RES-H in 2020).

10 The table shows both the breakdown of the original BERR scenario for 2010 (total heat output has subsequently been amended to 5TWh per annum) and the Pöyry projection for 2020.

**Figure 3 Central scenario supply curve (real 2006 €/MWh)**




Source: Pöyry

**Table 8 Maximum output under central scenario cost assumptions (TWh)**

| | 2020 Baseline | 2020 Additional | 2020 Total |
|---|---|---|---|
| Biomass Heat Non Grid | 16.0 | 7.4 | 23.4 |
| Biomass Heat Grid Connected | 19.8 | 1.8 | 21.6 |
| Geothermal Heat | 0.0 | 0.2 | 0.2 |
| Ground Source Heat Pumps | 0.0 | 28.1 | 28.2 |
| Solar Heat | 0.7 | 27.5 | 28.2 |
| Total | 36.5 | 65.1 | 101.7 |

Source: BERR and Pöyry

## 3.1 Sense check of Pöyry supply curve

BERR has asked us to sense check the Pöyry supply curve as it forms the basis for the remainder of the project. Our review is summarised in the table below. Additional details have been provided to NERA for their compilation of a revised cost curve.

**Table 9 Review of Pöyry supply curve**

| **Total TWh** | |
|---|---|
| Across all technologies | The total TWh figures are within the range of total resource potentials listed in the published literature reviewed for this study<br>The balance of output by technology projected for 2020 (45% biomass, 28% each of solar thermal heat and GSHP, geothermal negligible) is also within the range of output levels that we have considered in developing the scenarios for this project |
| **TWh by technology** | It is not clear from the report whether the capacity factors are subsequently adjusted for availability or whether they represent a combined capacity factor. We have assumed the latter. |
| Biomass heat capacity factor<br>Grid capacity factor 65%<br>Non-grid capacity factor: 38% | The grid capacity factor is typical of an average industrial/ commercial/ public sector biomass plant (industrial and commercial would usually be higher than public sector).<br>The non-grid capacity factor appears quite high based on projects that Enviros has been involved with.<br>The main downward impacts have typically been the result of extended commissioning or fuel quality problems, particularly for larger sites. We would assume an annual average across all end users closer to 30% |
| Solar thermal capacity factor<br>Capacity factor 13% | This is somewhat higher than we would expect based on project experience, particularly if in the high scenarios it is necessary to go beyond the most attractive i.e. highest capacity factor installations<br><br>The Enviros assumption is closer to 10% which assumes that solar thermal is used for water heating only[11]. The capacity factor would be marginally higher if solar thermal is also used for space heating (the installed capacity would usually be adjusted to reflect the increased demand). |

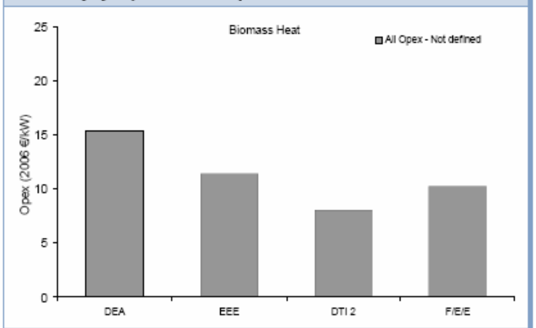
11 This is based on the average capacity factor of a flat plate panel and a tube system from the DTI Side by Side Trials (on the assumption that the UK market is broadly split 50:50 flat plate vs tube). On this basis the output is 680 kWh/kW (rather more than figures from BRE which suggest 439 kWh/kW). To compare solar water heating on a like for like basis with the alternative (typically a gas boiler/ system with hot water cylinder) then an adjustment is required. A typical gas hot water system (boiler and storage and pipes) will have an efficiency at best of 70% to deliver an equal amount of hot water. This gives an adjusted capacity factor of 11% (680/0.70 equates to 970 kWh/kW).

| | |
|---|---|
| GSHP capacity factor<br>Capacity factor 50% | This figure is considerably higher than what we would expect if the GSHP is only used for heating.<br>We would assume that on average a GSHP system produces heat at full output for half of the time during the heating season, i.e. a capacity factor of 25%. This is consistent with other published data (30% EST 2005, 20% E&Y 2007). |
| Geothermal<br>Capacity factor 50% (not clear from table whether factor for UK) | Given the small sample size of current plant in the UK there is limited evidence on which to base any comment however, this appears broadly in line with the level we would expect. |
| **Technology costs by technology** | |
| Biomass heat (non grid) capital costs | 2010 cost is consistent with our experience of northern European supplied boiler technology at c. 100 kW capacity. Eastern European sourced units can be sourced at lower cost (perhaps 2/3 cost) with some installation capability in UK.<br>2020 – Eastern European sourcing plus increased demand side should drive down prices past 404 euros. Working on basis of 2/3rd 2010 price takes us to 300 euros/kW installed.<br>Civil engineering costs will be a significant cost – expect at least 10% additional cost on all but the smallest schemes. |
| Biomass heat (non grid)[12] operational costs<br>The Pöyry OPEX costs are €8/kW/yr based on the F/E/E report[13] | This seems very optimistic. Enviros would expect 5% of Capex so 100 kW unit costing 45,000 euros would have an Opex of 2,250, or 22.5/kW/yr. |

**Biomass Heat Non Grid capex assumptions**

| | 2010 Costs (€/kW) | 2020 Costs (€/kW) |
|---|---|---|
| Technical CAPEX | 470 | 404 |
| Civils CAPEX | 0 | 0 |
| Connection CAPEX | 0 | 0 |
| Planning CAPEX | 0 | 0 |
| Total CAPEX | 470 | 404 |

**Poyry opex assumptions vs. other sources**




12 Note this differentiates between biomass generation connected to a grid rather than between users that are on or off the gas grid.

13 Fraunhofer ISI, Energy Economics and Ecofys (2005) Economic analysis of reaching a 20% share of renewable energy sources in 2020 – Annex 1 to the final report

Biomass heat (grid) capital costs

Includes large scale biomass and district heating

**Biomass Heat Grid Connected capex assumptions**

| | 2010 Costs (€/kW) | 2020 Costs (€/kW) |
|---|---|---|
| Technical CAPEX | 425 | 365 |
| Civils CAPEX | 0 | 0 |
| Connection CAPEX | 0 | 0 |
| Planning CAPEX | 0 | 0 |
| Total CAPEX | 425 | 365 |

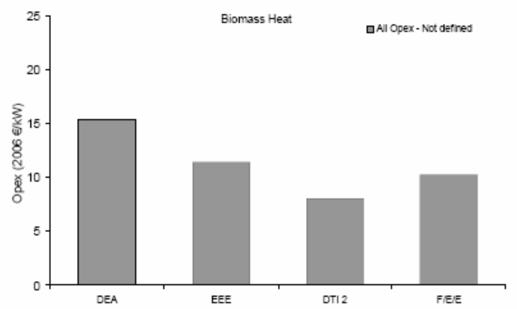
At 1 MW European manufacturers will be charging 300 Euros/kW for the boiler capital equipment alone. Consequently the Pöyry numbers seem very low for a fully functional district heating scheme including marginal costs such as heat exchanger/meter. A more representative cost would be 835 euros per kW installed, (300 boiler, 535 distribution and heat meters) based on recent scheme costings in London. This is the cost of retrospective installation of the DH system into a city. A new build installation will have reduced costs of 735 euros/ KW installed.

The percentage reduction proposed in the Pöyry model by 2020, i.e. 16%, is reasonable

Biomass heat (grid) operational costs

The Pöyry OPEX costs are €19/kW/yr based on the F/E/E report

**Poyry opex assumptions vs. other sources**




This seems reasonable

GSHP capital costs

**Ground Source Heat Pumps capex assumptions**

| | 2010 Costs (€/kW) | 2020 Costs (€/kW) |
|---|---|---|
| Technical CAPEX | 1366 | 1067 |
| Civils CAPEX | 0 | 0 |
| Connection CAPEX | 0 | 0 |
| Planning CAPEX | 0 | 0 |
| Total CAPEX | 1366 | 1067 |

There is a wide range in installed costs – the Pöyry projection falls within the range we would expect (somewhere between £600/kW and £2,000/kW).

Prices could fall more between 2010 and 2020 – Pöyry make quite a conservative assumption.

GSHP operational costs

The Pöyry GSHP OPEX costs are €56/kW/yr based on the F/E/E report.

This appears to be within the range we would expect (although in the past we have made assumptions around electricity running costs of around £55/kW/year, but this is dependent on the electricity price assumed over this period).

Solar heat capital costs

**Solar Heat capex assumptions**

| | 2010 Costs (€/kW) | 2020 Costs (€/kW) |
|---|---|---|
| Technical CAPEX | 1336 | 1168 |
| Civils CAPEX | 0 | 0 |
| Connection CAPEX | 0 | 0 |
| Planning CAPEX | 0 | 0 |
| Total CAPEX | 1336 | 1168 |

This appears to reflect a reasonable average between the costs of retrofit and new build solar heating. Based on current projects we estimate the cost to be around £1,600/kW and £600/kW depending on the project.

As for GSHP, it is possible that costs could decline more sharply than this over time – this seems to be a relatively conservative assumption.

Solar heat operational costs

The Pöyry OPEX costs are €13/kW/yr based on the F/E/E report

No further data included.

OPEX costs are somewhat higher than we might expect (e.g. £4/kW/yr) (again this will depend on the electricity price, efficiency and exchange rate assumptions used).

Geothermal capital costs

**Geothermal Heat capex assumptions**

| | 2010 Costs (€/kW) | 2020 Costs (€/kW) |
|---|---|---|
| Technical CAPEX | 1533 | 1320 |
| Civils CAPEX | 0 | 0 |
| Connection CAPEX | 0 | 0 |
| Planning CAPEX | 0 | 0 |
| Total CAPEX | 1533 | 1320 |

This a reasonable assumption based on development costs of Southampton system which included small scale CHP in first phase. Heat only will not vary considerably though since most of the development cost is civils.

For heat only systems Ungemach (2004) suggests 200 to 700 euros per kW installed.

2020 are not reasonable. Even though the GEOTHERMAL HEATING & COOLING ACTION PLAN FOR EUROPE projects a 50% reduction in geothermal costs by 2020 there is no reason to think that the learning curve of the UK's one example, Southampton, will lead to efficiency savings elsewhere.

Geothermal operational costs

The Pöyry OPEX costs are €56/kW/yr based on the F/E/E report

No further data included

This figure appears unrealistically high and may reflect the business structuring of the ESCO venture running the Southampton scheme. Ungemach (2002) suggests a range of 9 – 16 euros/MWh/year based on experience in France. This is a more reasonable range.

Source: all tables and charts reproduced from Pöyry (2007)

### *Summary of findings*

Given the extent to which project-specific factors affect the costs and operation of renewable heat developments, when comparing data of the type described above it can be difficult to ensure of comparing like with like. The comments above are based on our understanding of the assumptions that were made, drawn from published documents and spreadsheet information provided by BERR. On this basis, the majority of assumptions behind the supply curve produced by Pöyry appear within a plausible range, but in developing a supply curve for use in this project, Enviros has recommended that NERA adjusts some of the cost and operation assumptions in line with our comments above. At the time of writing, the assumptions to be used were being finalised.

# 4. PROJECTIONS OF HEAT OUTPUT

## 4.1 Step 1: assumptions provided by BERR and information from Pöyry

### 4.1.1 Renewable heat output in 2020 (three BERR scenarios)

Business as usual (BAU) projections for renewable heat in the UK vary between published sources. For the purposes of this project we have used the revised BERR baseline projection which assumes renewable heat output remains constant at 5TWh per year until 2020[14] as a starting point. This BAU is assumed to include the impact of all firm and funded policy measures to support renewable heat.

Three different scenarios for increased renewable heat uptake have also been constructed in order to estimate renewable heat output and quantify the costs of overcoming barriers to achieve those output levels. These scenarios are based on assumptions for renewable heat output in 2020 (provided by BERR) and are summarised in the table below. The scenarios distinguish between heat currently generated from electricity (elec) and heat generated from other fuels (other).

**Table 10 BERR assumptions for scenarios in 2020 (TWh)**

| | Description | Final energy demand | | | Renewable contribution to final energy demand | | |
|---|---|---|---|---|---|---|---|
| | | Heat (elec) | Heat (other) | Total | Heat (elec) | Heat (other) | Total |
| Baseline | Business as usual output from renewable heat in the UK | 12 | 625 | 637 | 5* | | 5 |
| Scenario 1 | 6.5% of final energy demand for heat from renewables | | | | 29 | 12 | 42 |
| Scenario 2 | 10.5% of final energy demand for heat from renewables | | | | 55 | 12 | 67 |
| Scenario 3 | 14.1% of final energy demand for heat from renewables | | | | 78 | 12 | 90 |

Source: BERR. * The baseline assumption includes a projection of total heat output from renewables in 2020 and does not distinguish between renewable heat currently generated from electricity and that generated from other fuels.

### 4.1.2 Renewable heat output in 2020 (fourth scenario)

BERR has also asked us to consider whether it would be possible to achieve levels of renewable heat output beyond those defined by Scenario 3, the highest scenario.

14 We also reviewed the assumptions made in the Ernst and Young report prior to this baseline being chosen, summarised in Appendix 2.

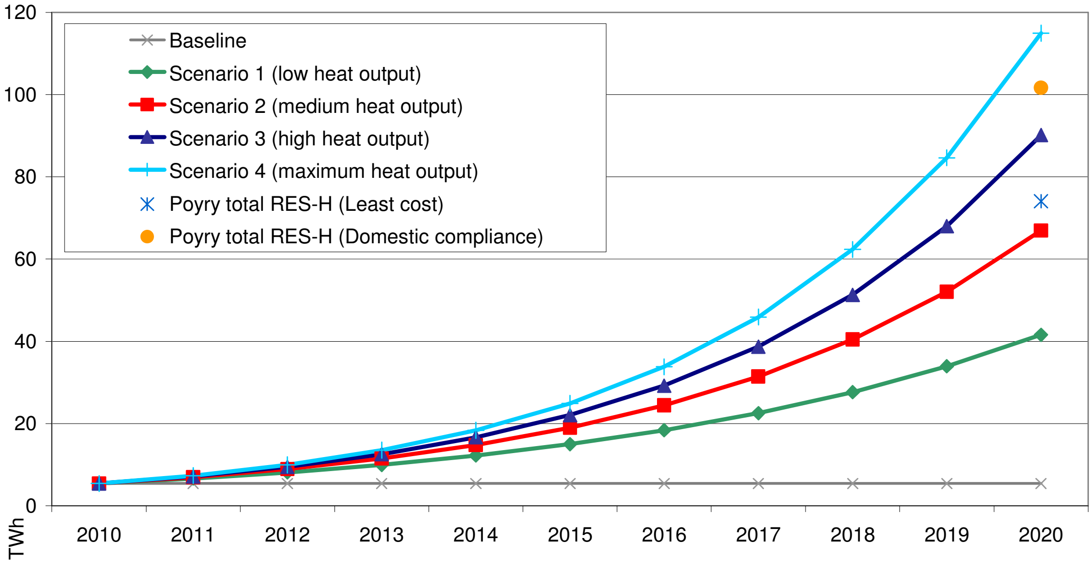
In our view, Scenario 3 shows the maximum potential output from biogas (and geothermal). However, it could be feasible to achieve additional output from biomass, solar thermal and heat pumps. For the last two of these, solar thermal in particular, this would assume some (legislative) requirement so that a large proportion of buildings (rather than predominantly new build) fit renewable heat. For biomass, the assumption is that electricity only renewable generation could be encouraged to run in CHP mode (i.e. no extra fuel is required although there may be a (slight) reduction in electrical output for those power stations used in this way).

These assumptions result in projected total heat output of 115TWh for Scenario 4 in 2020 compared to 90.1 in Scenario 3.

### 4.1.3 Profile between current day and 2020

In order to describe renewable heat output in 2010 and 2015 as well as 2020 it is necessary to profile the projections between the current day and 2020. We have assumed that it would not be possible to implement and see the benefits of any new policies to deliver increased renewable output before 2010[15]. As a starting point we have assumed that from 2010 total renewable heat output follows the growth path illustrated in the chart below in each scenario.

**Figure 4 Profile of total heat output between 2010 and 2020**




Source: BERR data manipulated by Enviros

The range of heat output widens over time (the scenarios range from 15TWh to 25TWh in 2015 as compared to from 42TWh to 115TWh in 2020). This range is intended to span the range of plausible outcomes. The two Pöyry central case projections (also shown in the diagram) sit within the range described by these four scenarios.

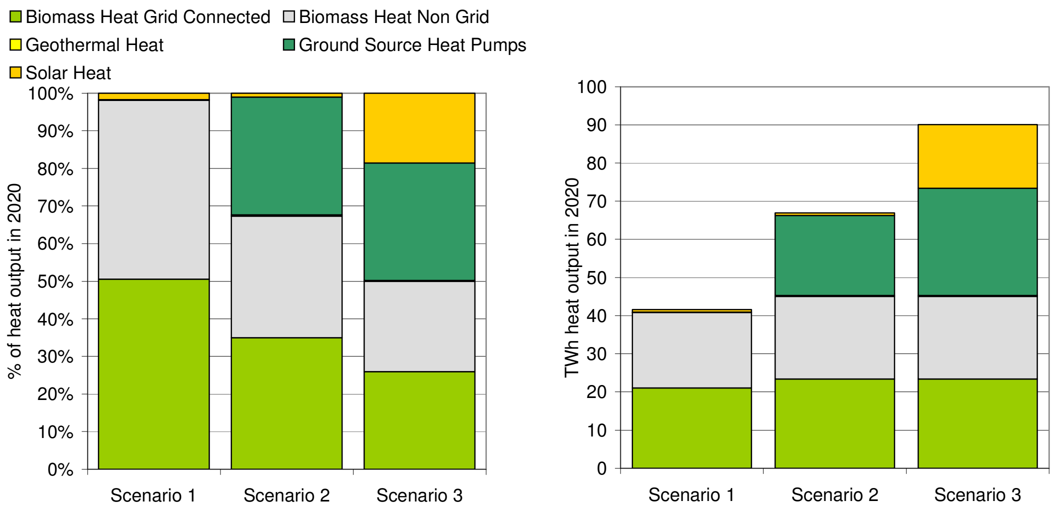
15 Due to the time necessary to design and implement any policy support and to the resulting time lag to develop projects or to implement the changes to existing projects that would result from that support.

### 4.1.4 Contribution of different technologies in 2020

Each of these total output levels could be met in a range of different ways. As a starting point, we have taken the Pöyry baseline and supply curve for 2020 to establish the fuel mix that this implies for each of these output levels[16]. This analysis was restricted to Scenarios 1 to 3 given that total heat output in Scenario 4 is higher than the heat output levels projected by Pöyry.

The figure below shows that in absolute terms (right three columns) total TWh output from biomass (both grid and non-grid) increases slightly between Scenarios 1 and 2 (at which point it reaches it is maximum output and hence it is constant between Scenarios 2 and 3). However, in relative terms, the share of biomass falls from almost 98% in Scenario 1 to 67% in Scenario 2 and 50% in Scenario 3. This results from the increased uptake of (mainly) GSHP in Scenario 2 and also Solar Heat in Scenario 3. Geothermal output in all scenarios is negligible (and as biogas and air source heat pumps are not included in the Pöyry analysis, they do not contribute in any scenario).

**Figure 5 Output mix in 2020 (BERR 2020 output levels and Pöyry output mix)**




Source: BERR and Pöyry manipulated by Enviros

## 4.2 Step 2: development of scenarios for this project

### 4.2.1 Baseline assumptions

All scenarios are based on a baseline which assumes business as usual and that none of the barriers is overcome by 2020. Based on data from BERR the baseline is a constant 5-7TWh output of renewable heat in each of 2010, 2015 and 2020. The level and split of technologies used for this project has been based on the data provided by BERR (Table 7) plus other information from market intelligence and the literature including, for instance the Pöyry and Ernst and Young analysis (shown in the table below).

16 i.e. we have assumed Pöyry baseline output plus additional output from the supply curve, taking the most cost effective resource first and working up it. The development of projections of heat output from different technologies developed for this project is described in the following section of this report.

**Table 11 Baseline assumptions (TWh)**

| TWh | Biomass | Heat Pumps | Biogas | Solar Thermal | Geothermal | All |
|---|---|---|---|---|---|---|
| All years | 5.26 | 0.04 | 0.60 | 0.35 | 0.01 | 6.26 |
| Source | BERR[17] | Enviros | E&Y | Enviros | DUKES | |

Source: see table

### 4.2.2 Contribution of different technologies in 2020

The starting point for this project is that all financial barriers are eroded i.e. that cost does not constitute a barrier to the supply of renewables through the provision of grants or financial support in some other unspecified way. The Pöyry curve reflects a world without financial barriers but also one without other supply-side barriers. It does not take into account the potential impact of biogas and air source heat pumps. With these points in mind we have formulated the technology splits shown in the diagrams below (these data for each sector in each scenario in 2010, 2015 and 2020 are also provided in an appendix to this document).

The output level for each technology was first analysed bottom-up, based on our view of likely growth rates for each technology once different barriers had been overcome. This was then sense checked against the total volume of heat projected from the other technologies, both to ensure that the total level of heat demand expected under the scenario was met and also that the relative contribution of different technologies appeared appropriate, given the scenario assumptions.

17 revised total pro rated based on original breakdown

**Figure 6 Output mix in 2020 (BERR 2020 output levels and Enviros output mix)**

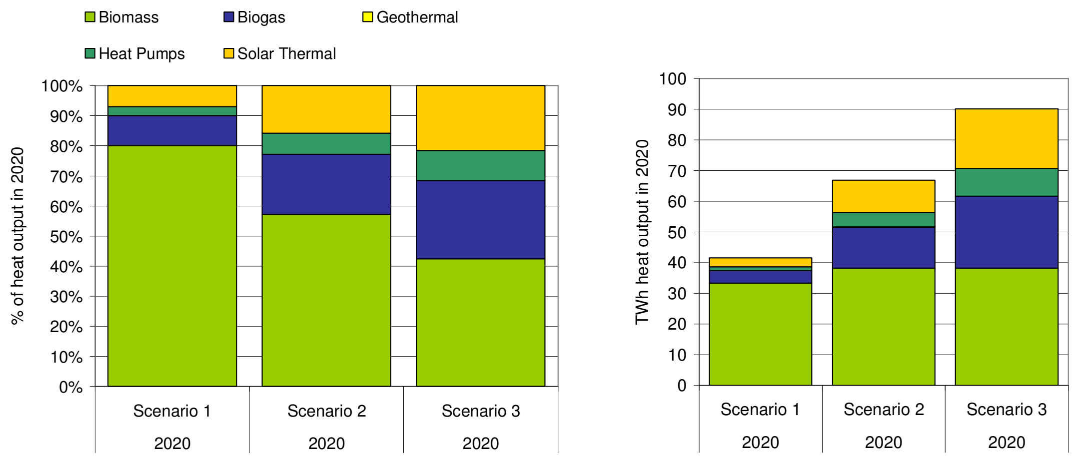
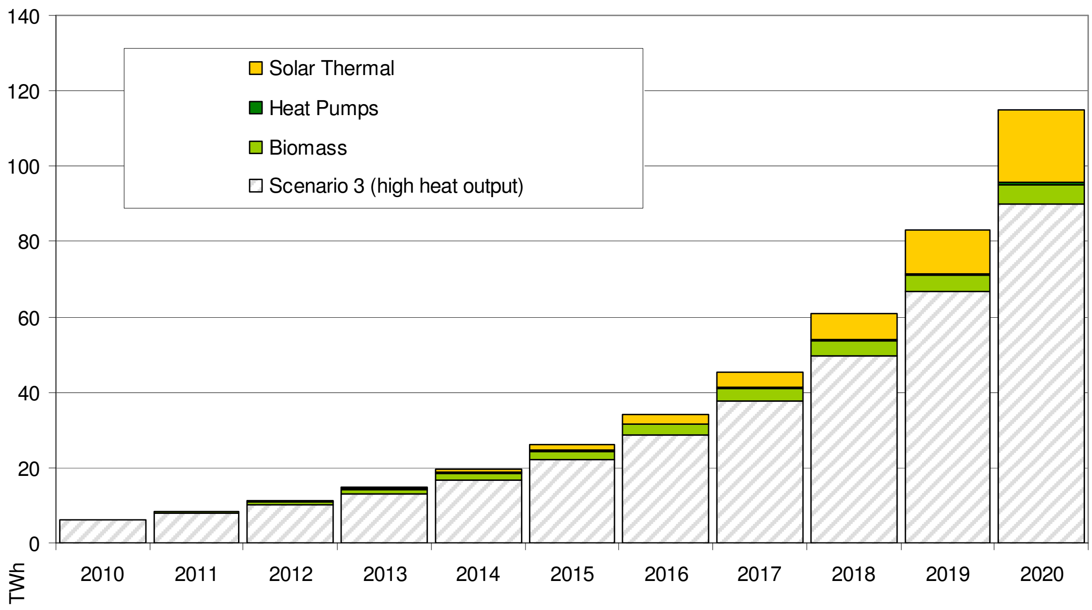



**Figure 7 Output mix for Scenario 4 over time (Enviros output levels and Enviros output mix)**




Source: BERR and Enviros. Note: 'biomass' includes both 'grid' and 'non grid' (i.e. both light green and grey in Figure 5 ).

Key differences to the output mixes based on the Pöyry supply curve are:

- The inclusion of a contribution from biogas, assumed to be greatest in Scenario 3 (in relative and absolute terms). Part 2 of this project will consider biogas in more detail. It is assumed that there is potential for this rate of growth through the use of CHP rather than electricity-only generation[18,19].

18 We have also considered the use of biogas through injection as biomethane, focussing on the use of biogas that goes into heat only systems. The re-direction of biogas from CHP for gas-grid injection is also an option that we will consider in more detail as part of the additional research

- The contribution from biogas results in a lower level of output from heat pumps (which include both air source and ground source heat pumps).
- The split between heat pumps and solar thermal is assumed to be more equal in output terms than under the Pöyry supply curve. This is on the basis that similar levels of implementation could and should be expected to be achieved from both in order to meet the target levels specified.
- The contribution from geothermal is assumed to be negligible in all three scenarios (evidence for this is provided in Appendix 3).
- Biomass is assumed to contribute close to 38TWh output in both Scenarios 2 and Scenario 3 (reflecting an assumption of the maximum biomass fuel available for heat generation provided by BERR. Refer to Section 5 which reports the impact of these scenarios on biomass fuel consumption).

### 4.2.3 Growth rate by technology

The table below shows the average annual compound growth rate in heat output that the first three Scenarios above imply by technology for all end users between each of the five years. Annual growth rates across all technologies are also shown in the table below (based on the aggregate path illustrated in Figure 4 ).

**Table 12 Average annual growth rates by technology (% of base year)**

| | Scenario 1 | Scenario 1 | Scenario 2 | Scenario 2 | Scenario 3 | Scenario 3 |
|---|---|---|---|---|---|---|
| | 2010 to 2015 | 2015 to 2020 | 2010 to 2015 | 2015 to 2020 | 2010 to 2015 | 2015 to 2020 |
| Biomass | 18% | 23% | 21% | 24% | 23% | 21% |
| Biogas | 20% | 23% | 35% | 36% | 44% | 43% |
| Geothermal | | | Assumed constant | | | |
| Heat pumps | 62% | 23% | 88% | 38% | 108% | 42% |
| Solar thermal | 25% | 23% | 40% | 41% | 44% | 55% |
| Average all | 19% | 23% | 25% | 29% | 29% | 33% |

Source: Enviros

We have compared these rates of growth against those seen in other countries for renewable heat technologies and against our view of what the market can deliver

into biogas for Part 2 of this project. In our view, it is unlikely that large-scale biogas injection could be achieved prior to 2015.

19 We have discussed with BERR the consistency of these assumptions with other work modelling the uptake of renewable electricity, which may compete for use of the same feedstock. We have provided additional details of our assumptions around the use of different feedstocks for renewable heat in Section 7 of this document.

formed from discussion with market participants for this project and review of literature (see table below).

As the table notes, we are broadly comfortable that these annual rates of growth are feasible in principle. However, the literature has not provided examples of these rates of increase being sustained over the ten year period necessary in order to meet the target output levels.

**Table 13 Assessment of maximum build rates (Scenario 3)**

| Technology | Enviros estimate for the purposes of this project | Observed growth in other EU countries | Market estimates or projections |
|---|---|---|---|
| Biomass | 24% based on our experience and understanding of the market.<br>This assumes the introduction of policies (and legislation) that: promote the installation of District Heating to new buildings, improved awareness for the technology and changes to Part L of the Buildings Regulations.<br>Our assumption takes into account observed market growth rates of the small scale boilers in some EU countries (see column to the right).<br>Our estimate is lower than the maximum growth potential of 42% calculated based on the 2020 projection of 84.1TWh/year heat pump output reported in Ernst and Young (2007). . | Germany: 64%<br>Austria: 37%<br>Finland: 88%.<br>Observed growth rates of small scale boilers (<35kW).<br>Source: European Pellet Centre (2005). | France: 11.1%<br>Germany: 6.3 %<br>Italy:12.7%<br>These are the highest projected growth rates of demand for biomass and waste fuel input.<br>Source: European Communities (2006). |

| Technology | Enviros estimate for the purposes of this project | Observed growth in other EU countries | Market estimates or projections |
|---|---|---|---|
| Biogas | 44% based on the assumption that biogas plants that generate only electricity are converted to combined heat and power in the UK.<br>This would depend on strong incentives to meet the EU renewable heat targets. As a result, our rate of growth exceeds that seen in other markets or in the UK considerably. | France: 0%<br>Italy:2.7%<br>Source: EurObserv'ER (2007)<br>Germany: 70% 2005 to 2006<br>Source: Defra (2006) | 4.84% observed growth rate in the UK in 2006 (EurObserv'ER 2007) |
| Heat pumps | 108% based on our experience and understanding of the market in the UK and based on observed growth rates in other EU countries (see column to the right). i.e. this figure assumes that the maximum technical potential is realised when all barriers have been overcome<br>This estimate is lower than the maximum growth rate observed within a single country in the EU (Hungary, see column to the right).<br>Other estimates of build rates include a potential of 50% by Ernst and Young (2007)[20]. While 50% is lower than our estimate for a single year the cumulative projected increase by Ernst and Young (2007) is substantially higher than our projections. | France: 31%<br>Germany:46%<br>Denmark: 0%<br>Italy: 25%<br>Hungary: 131%<br>Source: EurObserv'ER (2007) | 24.8% calculated based on a projection of at least 100,000 new installations per year from 2008 onwards (DTI 2003). |
| Solar thermal | 55% based on the assumption that the growth will be primarily driven by the new builds market and there will be sufficient number of solar thermal engineers.<br>In addition, we assume that installation costs will decline so retrofitting of systems on existing buildings will become increasingly more attractive.<br>This is consistent with an estimate of 47% market growth rate based on Ernst and Young (2007) projections of 35.1TWh/year by 2020.<br>The estimate is also within the range of observed growth rates in other EU countries (see column to right) | France: 83.1%<br>Germany: 56.1%<br>Denmark: 55.3<br>Italy:46.4%<br>These are the total market growth rates observed in 2006.<br>Source: EUROBSERV'ER (2007) | Estimates for the potential growth of the solar thermal market suggest growth at a rate of 29% under some constraints (DTI 2003).<br>Other figures however, suggest higher estimates of market growth under no constraints 43%. |

20 Calculated based on the 2020 projection of 80.3 TWh/year heat pump output

| Technology | Enviros estimate for the purposes of this project | Observed growth in other EU countries | Market estimates or projections |
|---|---|---|---|
| Geothermal | Geothermal is assumed not to grow for the purposes of the projections in this report.<br>This reflects both a limited resource base in the UK and also limited experience of the successful implementation of projects to date. | n/a | n/a |

Source: Enviros

### 4.2.4 Split by end user

In order to help ensure that the growth rates in these scenarios are reasonable, we have split the projected output by end user and assessed the impact of overcoming the various barriers on different types of end user. Where the projected impact on different types of end user did not appear consistent (either with other sectors or with the scenario as a whole), we have adjusted either the projection of total heat output for a specific technology or the balance of use between sectors in a given scenario.

Our projections have drawn on current information about the relative uptake of different technologies amongst different types of end users. This share is assumed to remain constant over time, i.e. the impact of overcoming each barrier is assumed to have a similar proportionate impact on different sectors[21]. This is a simplifying assumption[22]; there are a whole multitude of reasons why barriers may have a varied impact and also why the relative split of uptake between end-users might change over time. However it has not been possible to investigate these in detail for this project. The assumptions made are summarised in the table below.

**Table 14 Split of total output by end user (% of heat output)**

| | | Biomass | Biogas | Geothermal | Heat pumps | Solar thermal |
|---|---|---|---|---|---|---|
| Domestic | Domestic | 42% | 33% | | 30% | 90% |
| Industrial | Industrial/Commercial | 17% | 33% | | 5% | 1% |
| Commercial | | | 0% | | 40% | 2% |
| Public | Civic (including DH) | 18% | 33% | 100% | 25% | 7% |
| | CHP schemes/heat recovery | 23% | | | | |

Source: Enviros. Source: Enviros own estimates based on information from DUKES, Carbon Trust and discussion with trade associations/ other industry bodies.

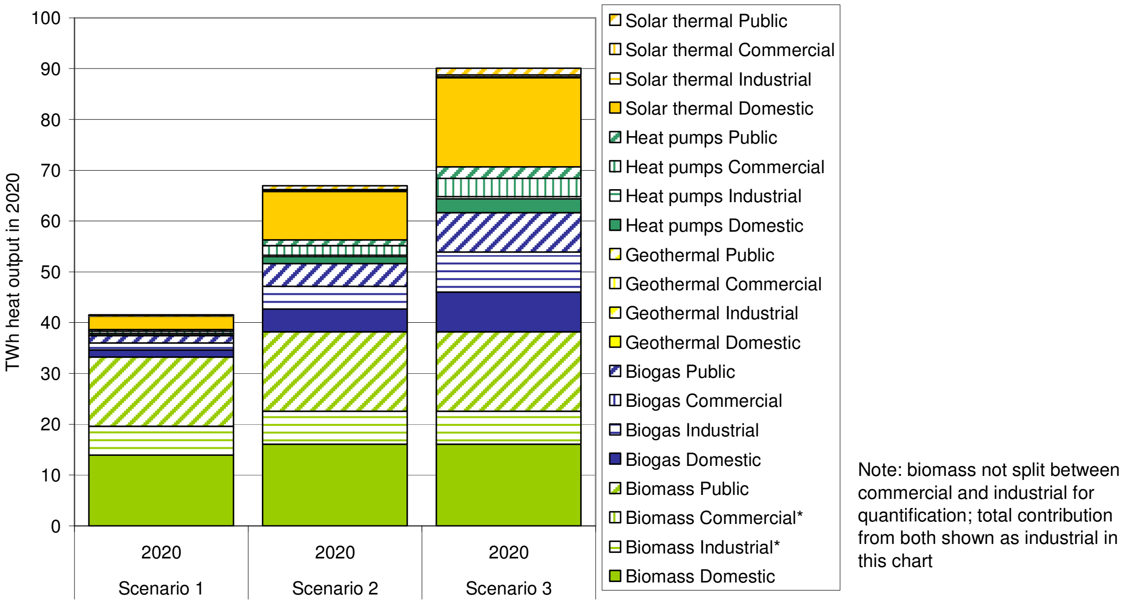
21 The absolute magnitude of the impact of different barriers will depend on level of energy use, unit size etc. which does vary by end user group.

22 However, in our view, still one that results in plausible projections of the uptake of renewable heat.

### 4.2.5 Scenario projections by end user

These assumptions result in the emissions scenarios summarised in the chart below. Given the assumption that the split remains equal over time, the growth rates implied are the same as those shown in the table above for the relevant technology.

**Figure 8 Scenario output projections by end user**




Source: Enviros

***Domestic sector: sense check***

Given the relatively large contribution of the domestic sector to biomass, heat pumps and solar thermal shown above we have checked that for these sectors, the level of uptake implied by the projections appears reasonable in additional detail.

The table below summarises the comparison of actual data against the scenario projections in 2020. It shows that despite the sustained and rapid rates of growth described above, a small proportion of households are assumed to install biomass heat even in the highest projection (Scenario 3). However, solar thermal and heat pumps are most cost efficient when incorporated into new build premises but these projections would require that a proportion are also retrofitted into existing buildings.

*Comment on projections for biomass and biogas*

It has been assumed that biomass and biogas is installed in units of 0.025MW and runs at a load factor of 30% resulting to average annual heat output of 66MWh. This compares to average annual heat use in the domestic sector of around 18MWh a year. The higher heat load reflects the assumption that these technologies would typically be installed in sites with a larger than average heat load; for instance, farms or large houses with out buildings. As an indication, data from EST provides the following heat loads for different types of large dwelling:

- Farm, 5 dwellings served with heat, clustered: 100 MWh

- Farm, 7 buildings served with heat, clustered: 140 MWh
- Farm, 3 dwellings served with heat, buildings widely dispersed: 60 MWh.

**Table 15 Output check for the domestic sector**

| | Actual | | | | Projections | | | |
|---|---|---|---|---|---|---|---|---|
| | Total number of domestic premises* | Number of domestic premises preferred for technology** | % of domestic premises preferred* for technology | Total heat demand*** | Total heat output for domestic sector | % of total heat supplied by renewables | Total number of units installed | % of domestic premises where demand supplied by renewables |
| | million | million | % | TWh | TWh | % | million units | % |
| **Technology** | **2006** | **2006** | **2006** | **2006** | **2020** | **2020** | **2020** | **2020** |
| **Actual** | 26.4 | | | 487 | | | | |
| Biomass | | 4.4 | 17% | | | | | |
| Heat pumps | | 4.4 | 17% | | | | | |
| Solar thermal | | 13.2 | 50% | | | | | |
| **Scenario 1** | | | | | | | | |
| Biomass | | | | | 14.0 | 2.9% | 0.2 | 0.7% |
| Heat pumps | | | | | 0.4 | 0.1% | 0.0 | 0.1% |
| Solar thermal | | | | | 2.6 | 0.5% | 1.1 | 3.7% |
| **Scenario 2** | | | | | | | | |
| Biomass | | | | | 16.1 | 3.3% | 0.2 | 0.8% |
| Heat pumps | | | | | 1.4 | 0.1% | 0.1 | 0.4% |
| Solar thermal | | | | | 9.5 | 2.0% | 4.0 | 2.8% |
| **Scenario 3** | | | | | | | | |
| Biomass | | | | | 16.1 | 3.3% | 0.2 | 0.8% |
| Heat pumps | | | | | 2.7 | 0.6% | 0.2 | 0.8% |
| Solar thermal | | | | | 17.5 | 3.6% | 7.3 | 24.7% |

Source: Enviros and data sources provided in Appendix. * Housing Statistics (2008). **'preferred' defined as follows: biomass and heat pumps – premises off the gas grid; solar thermal – residential building physically capable of accepting a solar AEAT (2005). *** DTI (2007).

# 5. BARRIER QUANTIFICATION OF COSTS TO OVERCOME BARRIERS

## 5.1 Prioritising barriers for quantification

The main supply-side barriers to the uptake of the potential level of biomass heat output that Pöyry projects are summarised in section 2.2 of the report. We have used the criteria analysis shown in that table to establish which barriers have the greatest immediate impact on renewable heat output and which would be the most expensive to overcome. The diagram overleaf shows the output of this analysis. It should be interpreted as follows.

- Reading first down the left hand side, the barriers at the top are those that are expected to have the biggest impact on the uptake of renewable heat, i.e. on output.
- Then, reading from left to right, the group of barriers on the left hand side are those that, typically, it will be most cost effective to overcome on a per MWh basis.
- As a result, those in the top left hand corner are those to address first (because they have a considerable impact on heat output and are relatively low cost). Those in the bottom right hand corner are relatively low impact and high cost and so are those that we assume would be addressed last.

There are a number of points that it is important to note about this analysis:

- The first is that it is indicative, based on the research undertaken for this project. The impact and cost of overcoming any barrier will depend on the exact way in which it is overcome and the specifics of the capacity (or output) level targeted.
- The second is that in some cases a number of barriers must be overcome to 'release' the heat output; for instance, in the case of biomass, fuel supply chain improvement and planning support is required if the increased uptake of renewable heat set out in these Scenarios is to be achieved.
- The third is the impact of any barrier changes over time. For instance, technology barriers would typically be overcome by funding R&D, supporting incubator projects or creating comparative advantage in the UK to attract inward investment. These types of activity may take a relatively long time to have an impact and it may be difficult to attribute that impact to the intervention rather than other (market) factors. As a result, these barriers have been categorised as being costly on a per MWh basis, but the long term value of such projects should not be ignored, particularly given the extent of market penetration that the scenarios considered for this project require.

**Figure 9 Relative impact of overcoming different barriers**

Costs to overcome barrier per unit heat output →

Impact of overcoming barrier on uptake of renewable heat

| | Barrier results from: Supplier/ installer base | Infrastructure | Resources | Other standards | Technology |
|---|---|---|---|---|---|
| Overcoming barrier has strong positive impact | Installation capacity constraints e.g. trained installers (B, S, G, A) | Unreliable supply (B)<br>District Heating infrastructure (B, I) | Finite number of new buildings (S, G, A)<br>Lack of incentives to grow energy crops (I)<br>Complexity and feasibility of using (waste) heat (B) | Air Quality (B)<br>Definition of biomass waste (B) | Lack of R&D for grid injection (I) |
| Overcoming barrier has positive impact | Lack of high spec manufacturers (B)<br>Installation capacity constraints (I)<br>Lack of (new) suppliers or ESCos** (B, I) | Complexity of distributing heat (B, I) | Finite number of sites with sufficient space (B, G)<br>Resource levels declining (I)<br>Permission to use aquifers (G) | Planning permission (B, I, G, A)<br>Animal biproduct disposal regulations (I)<br>Noise (A)<br>Digestate Standards (I) | Lack of competitive products in on-gas areas (B)<br>Compatibility of combi boilers (S) |
| Overcoming barrier has relatively low impact | Lack of manufacturers (S) | Waste handling infrastructure (I) | Fuel availability* (B, I) | Waste licensing (I)<br>Building Controls (S) | Poor historical performance (B)<br>Technology complexity (I)<br>Lack of three phase systems (G, A) |

Notes: B: Biomass, I: Biogas, G: GSHP, A: ASHP, S: Solar Thermal * assumes imports of biomass permitted **either a shortfall in the total, or the fact that they are concentrated rather than spread across the UK

## 5.1 Cost quantification

The cost estimates for each technology for each Scenario are set out below. The highest costs are for Scenario 4. They should be summed across columns to give the total cost by 2020, that is, costs reported for 2015 include costs incurred from 2011 to 2015, while costs for 2020 include those incurred from 2016 to 2020. They are all discounted back to 2008 money (using a discount rate of 3.5%). All training costs and capital costs are assumed to be incurred the year before the individual or equipment is required to install capacity[23]. Scenario 2 and 3 have been amended to ensure that total fuel input for biomass does not exceed 44TWh (158PJ) in 2020.

23 This assumption is made for simplicity. In some instances, e.g. where the cost reflects for the development of infrastructure, it could be argued that costs would be spread over a longer time period i.e. that they would be required earlier.

**Table 16 Breakdown of costs for Scenario 1**

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| Biomass: fuel supply[24] | Every 50kt of additional fuel supply requires an additional tree handling/ fuel handling facility.<br>Each has an associated cost of £200k (based on costs under the bioenergy infrastructure scheme) covering marketing, business set up and administration and purchase of specialist capital items | 1.1 | 8.4 | 15.7 |
| Biomass: lack of qualified installers | Additional capacity above existing installer base (estimated to be around 325MW per year in 2010) requires industry to train one specialist installer per MW installed capacity.<br>Cost of training £20,000[25] per installer, incurred the year before installation required. | 0.0 | 7.0 | 13.7 |
| Biomass: air quality issues | Based on required deployment rates the required installed capacity can be met through off gas rural system development for non-grid systems where air quality issues should largely be avoided.<br>This is based on an estimate that 57k oil fired domestic boilers are replaced each year and 4,000 larger scale units are replaced each year.<br>However, some training / awareness raising required for local authority planning officers. Assume 25% of new non-domestic sites require 3 days' consultancy support each at £1,000 per day. Domestic sites supported via helpline of 2 consultants full time at £500 per day plus £50k set up costs. Based on estimates of other similar projects. | 0.3 | 1.1 | 1.1 |
| *Biomass: total Scenario 1* | | *1.4* | *16.6* | *30.5* |
| Solar thermal: lack of solar energy installers | Even if there are sufficient engineers to fit the solar capacity required, some of them will need training to fit solar. Assumes currently 3,000 solar thermal engineers with a combined annual installation capacity of 125MW (assumes spend around 25% of their time on solar each). Any additional capacity over and above that level requires the training of engineers to become solar engineers. Assume that this training costs £3,000 training cost per installer and that each installer can fit 0.17MW capacity per year (assumes new installers spend around 100% of their time on solar). | 0 | 1.8 | 4.0 |

24 For the purposes of this project it is assumed that biomass fuels can be imported and that there is therefore no restriction on the quantity available (although prices could be assumed to reflect increasing global demand for biofuels i.e. also to increase). Rather than availability of the fuels themselves, the constraint is expected to be the ability to deliver these to end users.

25 Costs for biomass assumed higher than for other technologies due to range of different technologies and need for training around fuel supply.

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| Solar thermal: lack of heating engineers | Assume that there are currently around 10,000 heating engineers that could be trained to be solar engineers. Once the need for solar engineers exceeds this level, will not only need to provide specific solar training (row above) but also engineering training. Assumes £5,000 cost to train a heating engineer and that each engineer will be able to fit 0.17MW capacity per year. This constraint does not bite in Scenario 1 | 0.0 | 0.0 | 0.0 |
| Solar thermal: lack of solar design specialists | More complicated systems will require specialists with more detailed knowledge than for standard installations. Estimate that this will be necessary for around 10% of non domestic installations. Assume that there are currently sufficient to meet the installation capacity of the 3,000 solar engineers above and that one design engineer can deal with 0.200MW capacity per year. Assume a cost of £5,000 each.<br>Current capacity exceeded by only a small amount in Scenario 1. | 0.0 | 0.0 | 0.0 |
| Solar thermal: retrofitting | Assumes that costs above and beyond those in the supply curve to fit solar systems both to existing buildings (roofs) and to existing heating systems. However, assume cost does not bite in Scenario 1 on the basis that all capacity can be met on new build.<br>Assume cost of £750 per roof fitting plus £750 for heating system gives a total of £1,500 per solar installation. Assume average capacity of solar unit is 0.0025 MW gives a cost of £600,000 per MW installed. | 0.0 | 71.7 | 160.4 |
| *Solar thermal: total Scenario 1* | | *0.0* | *73.5* | *164.3* |
| Heat pumps: lack of borehole engineers (GSHP) | Once exceed 2,500 borehole engineers estimated to be available today, will need to provide borehole engineering training. Assumes £5,000 cost to train a borehole engineer and that each new engineer installs GSHP for 100% of the time will be able to fit 0.5MW capacity per year. | 0.1 | 0.3 | 0.0 |
| Heat pumps: lack of design specialists (GSHP) | More complicated systems will require specialists with more detailed knowledge than for standard installations. Estimate that this will be necessary for around 30% of non domestic installations. One design engineer can deal with 1MW capacity per year at a training cost of £5,000. | 0.0 | 0.0 | 0.0 |
| Heat pumps: retrofitting (GSHP) | Assumes that costs of £500,000/MW above and beyond those in the supply curve to retrofit GSHP (either to disturb an established site to install ground collectors or to fit GSHP to existing heating systems). | 0.0 | 10.2 | 13.4 |

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| Heat pumps: awareness raising (ASHP) | The availability of installers for ASHP is not considered a barrier given that it would not require the specialist skills involved with some of the other technologies considered here and that it would be displacing the fitting of other heating e.g. boilers.<br>However, the key barriers is to ensure that the supply side is aware of the option of ASHP and Government could support this through a website and guidance. We have assumed a fixed cost of £50k to set this up plus an additional £12k per year to maintain it.<br>This is assumed constant for all scenarios as the guidance need not vary with the installed capacity. | 0.1 | 0.1 | 0.0 |
| *Heat pumps: total Scenario 1* | | *0.1* | *10.6* | *13.5* |
| Biogas: cost of plant upgrades (Landfill gas) | Assumes that any additional plants above baseline need to be upgraded to capture waste heat and convert to hot water in heat exchangers (£1m). Additional costs to provide heat main (£500/m3) and meters (£1k). Barrier does not bite for scenario 1 | 0.0 | 0.0 | 0.0 |
| Biogas: cost of plant upgrades (Sewage gas) | Assumes that any additional plants above baseline need to be upgraded to capture waste heat and convert to hot water in heat exchangers (£1m). Additional costs to provide heat main (£500/m3) and meters (£1k). | 3.5 | 27.9 | 49.2 |
| Biogas: lack of appetite to use crops for energy | Assumes that to deliver sufficient output from biogas in highest scenario, AD plant using energy crops are required in 2020. To overcome a lack of awareness/ lack of incentive to change existing practices even for cost effective plant[26], assume that support worth an extra 50% of the value of silage (£25/tonne) - the competing use of the fuel - is required. Barrier does not bite for Scenario 1 | 0.0 | 0.0 | 0.0 |
| *Biogas: total Scenario 1* | | *3.5* | *27.9* | *49.2* |
| **Scenario 1 total** | | **5.0** | **128.5** | **257.5** |

26 Since this project assumes that financial barriers are overcome as a given

**Table 17 Breakdown of costs for Scenario 2**

| Barrier | Assumptions | Cost (£m) 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Biomass: fuel supply | As for Scenario 1 | 1.3 | 9.9 | 18.5 |
| Biomass: lack of qualified installers | As for Scenario 1 | 0.0 | 9.0 | 16.5 |
| Biomass: air quality issues | As Scenario 1 but assumes 50% of additional non-domestic sites in this Scenario require consultancy support and helpline manned by an extra two people (i.e. four in total). | 0.3 | 1.5 | 2.4 |
| *Biomass: total Scenario 2* | | *1.6* | *20.5* | *37.4* |
| Solar thermal: lack of solar energy installers | As for Scenario 1 | 0.4 | 9.8 | 30.3 |
| Solar thermal: lack of heating engineers | As for Scenario 1 | 0.0 | 0.0 | 66.2 |
| Solar thermal: lack of solar design specialists | As for Scenario 1. Current capacity exceeded by only a small amount in Scenario 1. | 0.0 | 0.0 | 0.0 |
| Solar thermal: retrofitting | As for Scenario 1, but assume that by 2020, 34% of capacity will be retrofit rather than new build based on current build rate of building stock. | 0.0 | 157.9 | 1,648.8 |
| *Solar thermal: total Scenario 2* | | *0.4* | *167.7* | *1,745.3* |
| Heat pumps: lack of borehole engineers (GSHP) | As Scenario 1 | 0.1 | 0.9 | 1.2 |
| Heat pumps: lack of design specialists (GSHP) | As Scenario 1 | 0.0 | 0.1 | 0.1 |
| Heat pumps: retrofitting (GSHP) | As for Scenario 1, but assume that by 2020, 34% of capacity will be retrofit rather than new build based on current build rate of building stock. | 0.0 | 12.5 | 73.2 |

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| Heat pumps: awareness raising (ASHP) | As Scenario 1 | 0.1 | 0.1 | 0.0 |
| *Heat pumps: total Scenario 2* | | *0.2* | *13.5* | *74.6* |
| Biogas: cost of plant upgrades (Landfill gas) | As for Scenario 1 | 17.2 | 235.0 | 550.5 |
| Biogas: cost of plant upgrades (Sewage gas) | As for Scenario 1 | 6.2 | 75.4 | 197.5 |
| Biogas: lack of appetite to use crops for energy | As for Scenario 1 | 0.0 | 0.0 | 0.0 |
| *Biogas: total Scenario 2* | | *23.4* | *310.4* | *748.0* |
| **Scenario 2 total** | | **25.5** | **512.1** | **2,605.3** |
| **Scenario 2 incremental costs on Scenario 1** | | **20.6** | **383.6** | **2,347.8** |

**Table 18 Breakdown of costs for Scenario 3**

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| Biomass: fuel supply | As for Scenario 1 and Scenario 2 | 1.5 | 11.1 | 17.4 |
| Biomass: lack of qualified installers | As for Scenario 1 and Scenario 2 | 0.2 | 8.9 | 14.4 |
| Biomass: air quality issues | As Scenario 1 and 2 but assumes 100% of additional non-domestic sites in this Scenario require consultancy support and helpline manned by an extra two people (i.e. six in total). | 0.4 | 2.2 | 3.9 |
| *Biomass: total Scenario 3* | | *2.0* | *22.3* | *35.7* |
| Solar thermal: lack of solar energy installers | As for Scenario 1 and Scenario 2 | 0.6 | 15.8 | 73.9 |

| Barrier | Assumptions | Cost (£m) 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Solar thermal: lack of heating engineers | As for Scenario 1 and Scenario 2 | 0.0 | 0.0 | 238.6 |
| Solar thermal: lack of solar design specialists | As for Scenario 1 and Scenario 2 | 0.0 | 0.0 | 0.1 |
| Solar thermal: retrofitting | As for Scenario 1, assume that by 2020, 65% of capacity will be retrofit rather than new build. | 0.0 | 250.3 | 5,182.8 |
| *Solar thermal: total Scenario 3* | | *0.6* | *266.1* | *5,495.4* |
| Heat pumps: lack of borehole engineers (GSHP) | As Scenario 1 and Scenario 2 | 0.1 | 1.7 | 2.7 |
| Heat pumps: lack of design specialists (GSHP) | As Scenario 1 and Scenario 2 | 0.0 | 0.2 | 0.3 |
| Heat pumps: retrofitting (GSHP) | As for Scenario 1, assume that by 2020, 65% of capacity will be retrofit rather than new build. | 0.0 | 49.5 | 456.0 |
| Heat pumps: awareness raising (ASHP) | As Scenario 1 and 2 | 0.1 | 0.1 | 0.0 |
| *Heat pumps: total Scenario 3* | | *0.2* | *51.4* | *459.1* |
| Biogas: cost of plant upgrades (Landfill gas) | As Scenario 1 and 2 | 68.9 | 1220.1 | 2367.2 |
| Biogas: cost of plant upgrades (Sewage gas) | As for Scenario 1 and 2 | 7.6 | 191.8 | 404.5 |
| Biogas: lack of appetite to use crops for energy | As for Scenario 1 and 2 | 0.0 | 0.0 | 54.5 |

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| *Biogas: total Scenario 2* | | *76.5* | *1,411.9* | *2,826.1* |
| **Scenario 3 total** | | **79.3** | **1,751.7** | **8,816.3** |
| **Scenario 3 incremental costs on Scenario 2** | | **53.8** | **1,239.6** | **6,211.0** |

**Table 19 Breakdown of costs for Scenario 4**

| Barrier | Assumptions | Cost (£m) | | |
|---|---|---|---|---|
| | | 2010 | 2015 | 2020 |
| Biomass: fuel supply | As for Scenario 1, Scenario 2, and Scenario 3 | 1.9 | 13.6 | 19.0 |
| Biomass: lack of qualified installers | As for Scenario 1, Scenario 2, and Scenario 3, but with the additional assumption of segregation and separation facilities/effort enable extra 100kt waste wood to be utilized. Assumed conversion efficiency factor of 87% this extra waste wood generates additional 0.41 TWh heat. | 1.7 | 8.9 | 14.4 |
| Biomass: air quality issues | As Scenario 1, 2 and 3 but assumes 100% of additional non-domestic sites in this Scenario require consultancy support and helpline manned by an extra two people (i.e. six in total). | 0.6 | 3.1 | 4.4 |
| Utilisation of heat generated in biomass CHP | Assuming each year 8MW of additional heat capacity is released from an average of 2 power stations starting to run in CHP mode. Additional costs: £1m extra capex for the conversion, £10m for district heating mains (assuming 20km additional heat network) and £1.7m for metering for each power station. Assume offset by extra revenues from from selling of ROC and extra heat (£1.07m each year). | 23.8 | 80.7 | 13.4 |
| *Biomass: total Scenario 4* | | *27.9* | *106.4* | *51.2* |
| Solar thermal: lack of solar energy installers | As for Scenario 1, Scenario 2, and Scenario 3 | 1.6 | 30.2 | 159.8 |
| Solar thermal: lack of heating engineers | As for Scenario 1, Scenario 2, and Scenario 3 | 0.0 | 26.5 | 599.5 |
| Solar thermal: lack of solar design specialists | As for Scenario 1, Scenario 2, and Scenario 3 | 0.0 | 0.0 | 0.2 |
| Solar thermal: retrofitting | As for Scenario 1, assume that by 2020, 65% of capacity will be retrofit rather than new build. | 0.0 | 450.9 | 10,553.2 |
| *Solar thermal: total Scenario 4* | | *1.6* | *507.7* | *11,312.7* |

| Barrier | Assumptions | Cost (£m) 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Heat pumps: lack of borehole engineers (GSHP) | As for Scenario 1, Scenario 2, and Scenario 3 | 0.2 | 1.8 | 3.1 |
| Heat pumps: lack of design specialists (GSHP) | As for Scenario 1, Scenario 2, and Scenario 3 | 0.0 | 0.2 | 0.3 |
| Heat pumps: retrofitting (GSHP) | As for Scenario 1, assume that by 2020, 65% of capacity will be retrofit rather than new build. | 0.0 | 53.8 | 511.4 |
| Heat pumps: awareness raising (ASHP) | As for Scenario 1, Scenario 2, and Scenario 3 | 0.1 | 0.1 | 0.0 |
| Cost of retrofit in a vertical boreholes | Assume £200,000 cost of retrofit 1 MW capacity to a vertical borehole | 0.0 | 21.5 | 204.6 |
| *Heat pumps: total Scenario 4* | | *0.2* | *77.4* | *719.5* |
| Biogas: cost of plant upgrades (Landfill gas) | As for Scenario 1, Scenario 2, and Scenario 3 | 68.9 | 1220.1 | 2367.2 |
| Biogas: cost of plant upgrades (Sewage gas) | As for Scenario 1, Scenario 2, and Scenario 3 | 7.6 | 191.8 | 404.5 |
| Biogas: lack of appetite to use crops for energy | As for Scenario 1, Scenario 2, and Scenario 3 | 0.0 | 0.0 | 54.5 |
| *Biogas: total Scenario 4* | | *76.5* | *1,411.9* | *2,826.1* |
| **Scenario 4 total** | | **106.2** | **2,103.4** | **14,909.5** |
| **Scenario 4 incremental costs on Scenario 3** | | **26.9** | **351.7** | **6,093.2** |

***Comment on costs: uncertainty around the assumptions***

The cost estimates inevitably depend on the assumptions made, both in terms of the number of units/ capacity installed and in terms of the costs of delivering that change. We have built on published data where possible but in many instances it has been necessary to make an estimate based on market intelligence and our experience. Many of the costs depend on the number of units installed or the capacity of those units. Barriers are therefore more expensive to overcome on a per TWh basis for low load factor technologies (like heat pumps or solar thermal).

We have not undertaken any statistical analysis to establish where within the range of possible outcomes these cost estimates fall. However, in our view, they are likely to be on the low side. For instance, we assume that new installers work on the technologies for which they have trained 100% of the time. In fact, it is possible that they only work on a particular technology for a proportion of the time and therefore a larger number of individuals would require training to deliver the capacity required.

***Comment on costs: costs not included***

We are of the view that for any of the output levels described by the three scenarios to be delivered in 2020 it is necessary for there to be some long term market signal in place. We have in mind specific binding targets for renewable heat (rather than just for renewable energy). This would help to overcome a reluctance of the industry to trust that there will be sufficient demand for renewable heat to make it worth addressing some of the key supply side barriers i.e. increasing installer capacity at the level required here.

These estimates do not include the costs of setting up an information scheme that could help to raise awareness of such a signal, or of establishing an accreditation scheme/ other industry standards that could help to show that heat is being

# 6. BIOMASS: FUEL COSTS AND CONSTRAINTS

The ITT for this project asks from where the biomass fuels required for the growth of the UK biomass heat market could come and how much they will cost at different levels of demand, taking into account increased demand for biomass across the EU by 2020.

In this section we summarise the projected TWh heat output from biomass in each of the scenarios and the implications for biomass fuel requirement. The information provided below is intended to help ensure that the projections of biomass use are consistent with the assumptions for other concurrent projects commissioned by BERR (e.g. around electricity generation).

## 6.1 Biomass fuel use for heat generation

The table below summarises the projected heat output from biomass under the baseline and each of the three scenarios. It also shows the fuel input requirement and an estimate of the possible fuel split (assumed constant in all scenarios for simplicity). Comprehensive and consistent data on the current consumption of different biomass fuels for heating in the UK does not exist. The estimates below reflect Enviros' view based on participation in a range of heat projects and discussions with various fuel suppliers.

**Table 20 Projections of biomass fuel demand (TWh)**

| | Baseline Heat output TWh All years | Baseline Heat output % All years | Baseline Fuel input TWh*** 2010 | All scenarios Heat output TWh** 2010 | All scenarios Fuel input TWh*** 2010 |
|---|---|---|---|---|---|
| Domestic | 2.2 | 42% | 2.5 | 2.2 | 2.5 |
| Industrial | 0.9 | 17% | 1.0 | 0.9 | 1.0 |
| Commercial* | | | | | |
| Public | 2.2 | 41% | 2.5 | 2.2 | 2.5 |
| *of which* | | | | | |
| *Public (civic)*** ** | *0.9* | *18%* | *1.1* | 0.9 | *1.1* |
| *Public (CHP)*** ** | *1.2* | *23%* | *1.4* | 1.2 | *1.4* |
| Total | 5.3 | | 6.0 | 5.3 | 6.0 |

*Commercial included in Industrial.

** A scenario breakdown of heat output by each fuel type is provided in Appendix 4.

*** Assumes average conversion efficiency of 87% HHV for all technologies and end users. The projections above are intended to indicate the order of magnitude of fuel use from different users in each scenario. Although the actual efficiency will vary due to a whole range of factors (including for instance, size, capacity factor, fuel type) in our view this is a reasonable average assumption.

**** A scenario breakdown of heat output from CHP by sector is provided in Appendix 4.

| | Scenario 1 Heat output TWh **2015** | Scenario 1 Fuel input TWh** **2015** | Scenario 2 Heat output TWh **2015** | Scenario 2 Fuel input TWh** **2015** | Scenario 3 Heat output TWh **2015** | Scenario 3 Fuel input TWh** **2015** |
|---|---|---|---|---|---|---|
| Domestic | 5.0 | 5.8 | 5.6 | 6.4 | 6.1 | 7.0 |
| Industrial | 2.0 | 2.3 | 2.3 | 2.6 | 2.5 | 2.8 |
| Commercial* | | | | | | |
| Public | 4.9 | 5.6 | 5.4 | 6.3 | 6.0 | 6.9 |
| *of which* | | | | | | |
| *Public (civic)* | *2.2* | *2.5* | *2.4* | *2.7* | *2.6* | *3.0* |
| *Public (CHP)* | *2.8* | *3.2* | *3.1* | *3.5* | *3.3* | *3.8* |
| Total | 12.0 | 13.8 | 13.3 | 15.3 | 14.5 | 16.7 |

| | Scenario 1 Heat output TWh **2020** | Scenario 1 Fuel input TWh** **2020** | Scenario 2 Heat output TWh **2020** | Scenario 2 Fuel input TWh** **2020** | Scenario 3 Heat output TWh **2020** | Scenario 3 Fuel input TWh** **2020** |
|---|---|---|---|---|---|---|
| Domestic | 14.0 | 16.1 | 16.1 | 18.5 | 16.1 | 18.5 |
| Industrial | 5.7 | 6.5 | 6.5 | 7.5 | 6.5 | 7.5 |
| Commercial* | | | | | | |
| Public | 13.6 | 15.7 | 15.7 | 18.0 | 15.7 | 18.0 |
| *of which* | | | | | | |
| *Public (civic)* | *6.0* | *6.9* | *6.9* | *7.9* | *6.9* | *7.9* |
| *Public (CHP)* | *7.7* | *8.8* | *8.8* | *10.1* | *8.8* | *10.1* |
| **Total** | **33.3** | **38.2** | 38.2 | 44.0 | 38.2 | 44.0 |

Source: Enviros. Note: *Commercial included in Industrial. ** Assumes average conversion efficiency of 87% HHV for all technologies and end users. The projections above are intended to indicate the order of magnitude of fuel use from different users in each scenario. Although the actual efficiency will vary due to a whole range of factors (including for instance, size, capacity factor, fuel type) in our view this is a reasonable average assumption.

The table above shows that the highest projection for biomass fuel input is in 2020 for Scenario 2 and Scenario 3 where it reaches 44TWh (based on the BERR estimate of maximum available biomass fuel for heat generation). The fuel split estimated by sector is shown in the table below, together with its implications for fuel use in this highest projection (assumed constant in all years and scenarios for simplicity).

**Table 21 Biomass fuel use split by end user (%)**

| | Assumed constant in all years and scenarios | | | | |
|---|---|---|---|---|---|
| | **Pellets** | **Logs**** | **Wood chips***** | **Other****** | **All** |
| Domestic | 10% | 85% | 4% | 1% | |
| Industrial | 0% | 0% | 70% | 30% | |
| Commercial* | | | | | |
| Public | 0% | 0% | 0% | 0% | |
| *of which* | | | | | |
| *Public (civic)* | 10% | 0% | 90% | 0% | |
| *Public (CHP)* | 0% | 0% | 60% | 40% | |
| **Fuel input 2020 Scenario 3 (highest heat estimate) (TWh)** | | | | | |
| All | 2.6 | 15.7 | 19.2 | 6.5 | 44.0 |
| % of total | 6% | 36% | 44% | 15% | |

Source: Enviros. Note: *Commercial included in Industrial. **including arboriculture thinnings. ***including sawmill co-product, waste wood. **** chicken litter & straw.

## 6.2 Biomass availability

The UK is currently using a relatively small fraction of the technically available biomass resource in the UK for heat and electricity generation. In addition fuel can be imported from growing and increasingly mature pellet markets across Europe and North America. New growing markets, for example in China and Russia, are expected to make important contributions to increasing global supply.

### 6.2.1 UK Resources

The UK has a large untapped resource of biomass which could be used to generate heat.

The Government's 2007 Biomass Strategy[27] concludes that there is significant potential to expand the UK supply of biomass without any detrimental effect on food supplies, and in a sustainable manner, by:

- sourcing an additional 1 million dry tonnes of wood per annum from currently unmanaged woodland in England, and from increasing the recovery of wood for energy from managed woodland and other sources of wood waste products across the UK

- increasing the amount of perennial energy crops produced in the UK to meet market demands – with the potential to use up to a further 350,000 hectares across the UK by 2020[28]. This brings the total land availability for biofuel and

27 Defra (2007) UK Biomass Strategy http://www.defra.gov.uk/Environment/climatechange/uk/energy/renewablefuel/pdf/ukbiomassstrategy-0507.pdf
28 DTI (2004) Renewables Innovation Review Biomass: www.berr.gov.uk/files/file22017.pdf

energy crops to around 1 million hectares, equivalent to 17% of total UK arable land

- increasing supply from organic waste materials such as manures and slurries, certain organic wastes, source separated waste biomass and waste derived Solid Recovered Fuels (SRF).

By expanding existing biomass supplies in this way Defra estimates the potential future biomass resource in the UK to be a total of approximately 96.2TWh (8.3Mtoe). If it is assumed UK biofuel crop production can supply half of the 5% (by volume) target for 2010[29] this gives a total theoretical biomass resource level in the UK of around 10Mtoe[30].This compares with a total UK energy need of currently 165Mtoe[31].

Table 22 gives estimates of the amount of UK biomass resource that could be technically available (i.e. neglecting financial and market constraints and excluding biofuel crop production).

**Table 22 Estimated technical potential of biomass energy sources and for energy crop production[32]**

| Biomass Type | Technical Potential (TWh of primary energy) |
|---|---|
| Forest wood fuel | 13.0 |
| Straw | 14.5 |
| Wood waste | 26.0 |
| Waste | 15.5 |
| Agricultural waste | 10.0 |
| Energy crops | 17.2 |
| **Total** | **96.2** |

Source: UK Biomass Strategy 2007

The strategy document also notes that these estimates could be considered conservative. The European Environment Agency (EEA) recently estimated the environmentally compatible energy potential of the UK to be 13.5Mtoe in 2010, 19.0Mtoe in 2020 and 24.5Mtoe in 2030. [33] in this study we assume that the principal resources available for biomass heat are forestry derived fuels, either directly

29 Based on the amount of biofuel feedstocks needed to supply 50% of the 5% (by volume) RTFO target, with a 55:45 split between biodiesel and bioethanol.

30 These assessments do not take into account the biofuel production that could be sourced from waste oils which currently are disposed of to landfill or additional straw produced with first generation biofuel feedstocks.

31 Excludes non-energy use of fuels (12.6Mtoe), final consumption of oil for air, rail and national navigation (16.1 Mtoe) and other primary energy uses not included in the three categories, such as mechanical power, energy for cooking/catering, use by the energy industries and other transformation and distribution losses (17.8Mtoe).

32 Defra (2007) UK Biomass Strategy http://www.defra.gov.uk/Environment/climatechange/uk/energy/renewablefuel/pdf/ukbiomassstrategy-0507.pdf

33 Defra (2007) UK Biomass Strategy http://www.defra.gov.uk/Environment/climatechange/uk/energy/renewablefuel/pdf/ukbiomassstrategy-0507.pdf

sourced for forestry operations or via sawmills, or from recycled waste wood[34]. The biomass sector review indicated that up a considerable volume of fuel were available from energy crops. In our opinion this is highly unlikely under current market pressures for agricultural land to a) increase the amount of cereal production for food uses and b) increase the acreage of wheat and oilseed rape for biofuels.

For the purposes of this project it is important to bear in mind that there will be competition for the use of biomass from a range of different sources, including electricity generation. Therefore, although the maximum projection for the consumption of biomass heat shown above (44.0TWh) is well within the range shown in the biomass strategy there would also be demand for electricity generation. In addition, if the mix between fuels were to follow the pattern assumed for this project (Table 21), demand for some types of fuels could be expected to outstrip UK availability. It has been assumed for this project that imports of biomass fuel are allowed and that if there is a constraint to fuel supply this will be as a result of a lack of infrastructure to allow an efficient and sufficient fuel supply chain.

### 6.2.2 UK fuel suppliers

There are a large number of wood chip, log and pellet suppliers across the UK which source wood from tree surgery, forest management or wood waste e.g. from the timber trade.[35]

Many wood fuel suppliers however are very small and may have seasonal variation in output. To overcome this issue, fuel brokerage companies such as Forever Fuels are beginning to be established, reducing supply risk. The company uses back hauling to make delivery more efficient. Reducing transportation requirements is particularly important for wood fuels due to their low energy density. Companies like this can aggregate the supply of a large number of small suppliers in regional hubs and, as a result, can provide pellets to customers anywhere in the UK within 48 hours.

Companies import and store pellets from Scandinavia, to allow wider physical stock coverage, and to allow for seasonality and market growth. However, local production is expected to develop over time to cover the majority of demand[36]. Forever Fuels estimates that current demand for wood pellets for heating in the UK is around 10,000 tonnes, with supply growing to match. Any excess UK fuel and imports is directed to lower value co-firing.

Other large companies that aggregate supply and help develop regional supply chains include: Midland Wood Fuel, Renewable Heat & Power Ltd (RHPL) and South West Wood Fuels Ltd (SWWF).

***Pellet supply***

Domestic production of wood pellets in the UK is small but increasing. The largest commercial plants, such as Balcas and Welsh Biofuels, have a stated production

34 There is considerable use of straw bale burners already in the UK. Consequently, whilst straw combustion systems do present challenges, we do not consider there to be any technical constraints that apply to these systems over and above wood fuelled systems.

35 Suppliers within a 50 miles radius of any UK address can be found at http://www.bigbarn.co.uk/

36 Discussion with Graham Hilton, Forever Fuels

capacity of 50,000 tonnes of pellet per year[37]. We understand that Balcas plans to construct a new wood pellet facility in the UK, increasing production to 100,000 tonnes.

Further increases in pellet production are constrained by a lack of raw materials. Potentially, over 1 million tonnes of forest waste and arboricultural arisings are available in the UK annually. However, competition for this resource with the furniture board industry is a considerable barrier to the industry's expansion. Some of the approximately 20,000ha of dedicated energy crops due to be planted by 2009 may be pelletised[38].

The majority of UK manufactured pellets are currently produced from sawdust but additional pelletised animal feeds could be diverted to biomass. Animal feed currently sold for around 50-60£/tonne could fetch a premium if sold to the energy market (90-200£/tonne) however it would mean that feed suppliers would have to move away from familiar and established markets, potentially creating a barrier in the short term.

Demand for pellets for co-firing has historically exceeded demand from the heat sector. However the tightening of the cap on the support awarded for co-firing from April 2006 has resulted in a decrease in the level of biomass co-fired. It is anticipated that by 2011 75% of the biomass used in co-firing could have to come from energy crops[39]. Energy crops represent a relatively small proportion of the total technically available biomass resource in the UK and co-firing should not therefore compete with the heat market for much of the other biomass fuel sources available in the UK in the medium to long-term.

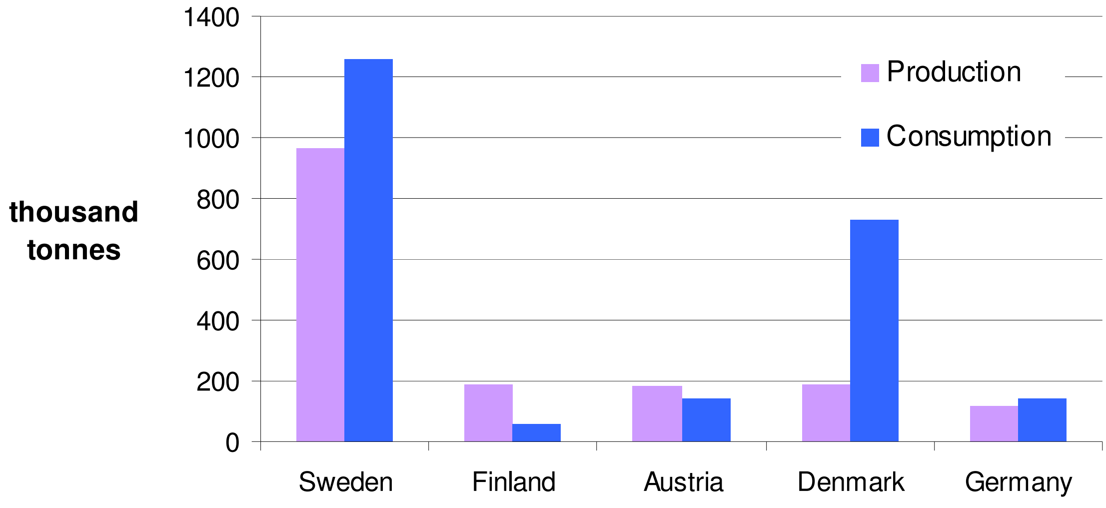
### 6.2.3 International resources

Increasingly mature pellet markets are developing across Europe, notably in Sweden, Denmark, Austria, Germany and Italy. The pellet market in North America is well established and exports large volumes of pellets to Europe. New markets are also being developed. For example, China hopes to dramatically increase pellet production both for domestic consumption and international markets.

Demand and supply of pellets are not typically aligned within individual countries as can be seen in Figure 10 Pellets can be produced and used locally, but can also be shipped internationally to match production and demand. Currently much of the North American produce is shipped to Europe for use in power generation, and within North America pellets tend to be used for heating within the domestic sector. Much of the Scandinavian and Baltic product is also shipped to Europe. The relative immaturity of the global pellet market has lead to some supply shortages however stability is increasing as the market develops.

37 BioEnergy Group Imperial College London (2006) UK Task 40 Co-firing Report 2006 http://www.bioenergytrade.org/downloads/ukcofiringfinal.pdf
38 BioEnergy Group Imperial College London (2006) UK Task 40 Co-firing Report 2006 http://www.bioenergytrade.org/downloads/ukcofiringfinal.pdf
39 BioRegional Development Group (2006) Biomass Fuel Assessment for the Z squared combined heat and power plant http://www.bioregional.com/programme_projects/opl_prog/zsquared/Z-squared%20Biomass%20fuel%2006.03.21%20-%20FINAL.pdf

**Figure 10 Production and consumption of wood pellets across selected EU Member States in 2004[40]**



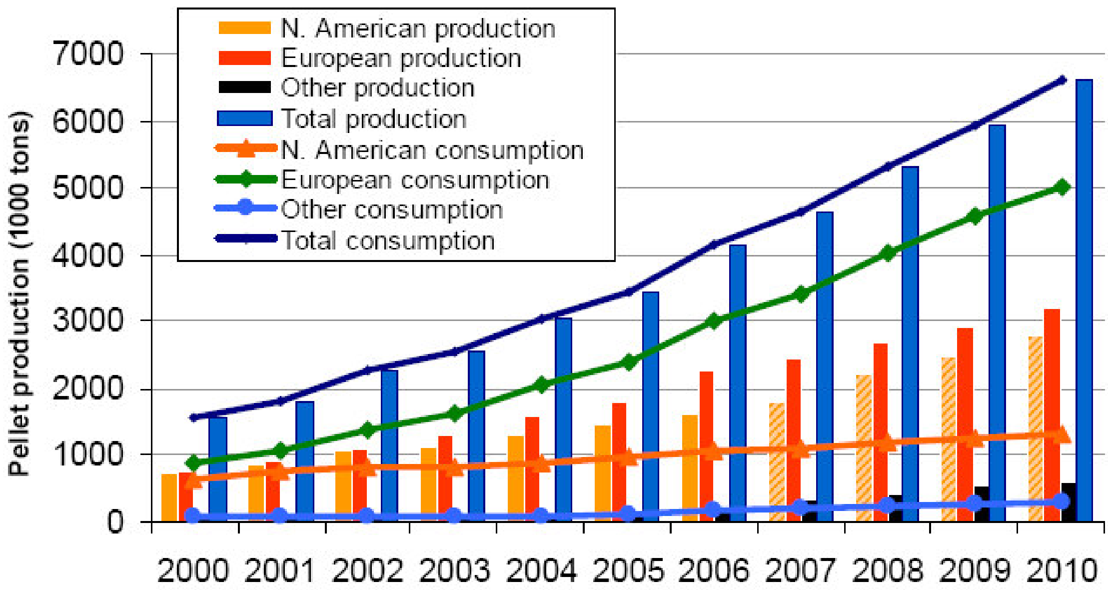

Source: European Pellet Centre

Global production and consumption of pellets are anticipated to rise significantly between 2007 and 2010 as shown in the diagram overleaf. The main increase in demand is expected to be from Europe and production levels across Europe and North America are expected to grow. However, other producers such as China will are expected to make an increasingly important contribution[41].

40 European Pellet Centre, http://www.pelletcentre.info/cms/site.aspx?p=953

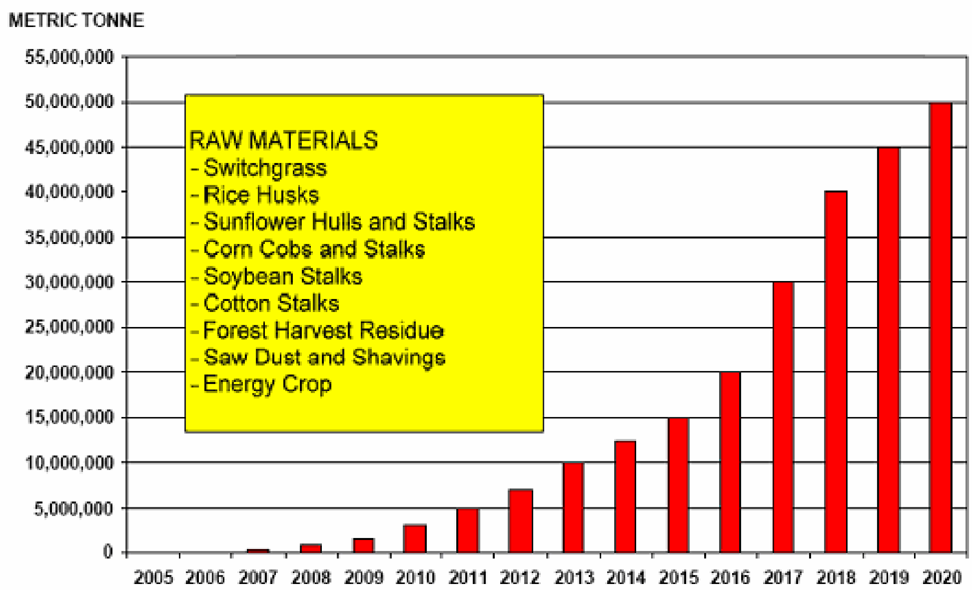
41 China plans to increase production of pellets for international markets to 50 million tonnes a year by 2020 as can be seen in the diagram Russia also has huge potential for pellet production with 880 million hectares of woodland Source: Interpellets 2007, http://www.newsfox.com/pte.mc?pte=070711012.

**Figure 11 Projected global pellet production and consumption[42]**




Source: Canadian Wood Pellet Association 2007

**Figure 12 Projected pellet production in China[43]**




Source: Wood Pellet Association of Canada

The UK is already importing an increasing volume of pellets, mainly for use in co-fired power plants. As discussed above, UK fuel brokerage companies are begin-

42 Swann, J. (2006) Wood pellet association of Canada http://www.meia.mb.ca/documents/JohnSwaan_KeynoteAddress_WoodPellets.pdf

43 Swann, J. (2006) Wood pellet association of Canada, http://www.meia.mb.ca/documents/JohnSwaan_KeynoteAddress_WoodPellets.pdf

ning to strategically import and store pellets at UK docks to hedge against supply risk and price volatility.

## 6.3 Cost of biomass

The delivered cost of biomass varies considerably depending on its type, quality, volume and the location to which it is delivered. A number of sources of quoted price are compared in the text below.

### 6.3.1 Enviros estimate

The table below shows our best estimate of the current prices of different biomass fuels in the UK based on discussions between Enviros and over forty suppliers.

**Table 23 Cost of biomass fuels**

| Category | Typical price (£/t) | Price range (£/t) | Calorific density (MJ/kg) | £/GJ | Comments |
|---|---|---|---|---|---|
| Forest wood chip | 45 | 35-100 | 11 | 4.09 | UK and imports esp. Canada |
| Sawmill residues | 27 | 20-30 | 11 | 3.3 | UK |
| Recycled wood chip | 25 | 0-45 | 11 | 2.27 | Current UK users are Boardmills and Lockerbie, Wilton 10 & Slough H&P |
| Wood pellets | 120 | 90-200 | 17 | 7.06 | Local suppliers across UK, can be imported |
| Arboriculture waste | 20 | 0-37 | 11 | 1.37 | Local suppliers across UK |
| Sheal meal | 102 | | 14.8 | 6.2 | Imported (Price CIF) + £10/t haulage |
| Olive cake | 105 | | 18.8 | 5.04 | Imported (Price CIF) + £10/t haulage |
| Straw | 35 | 31-39 | 14 | 2.5 | Local suppliers across UK |
| Straw pellets | 72 | 80-90 | 16.5 | 5.16 | UK and imported |

Source: Enviros, 2008. Note: CIF – cost, insurance, freight.

### 6.3.2 UK Log Pile website

In comparison, the UK Log Pile website[44] gives the following estimates for the current price of biomass fuel:

- Logs in stove: 0 to 5.1p/kWh[45] (0 - 14.17£/GJ)

44 http://www.nef.org.uk/logpile/pellets/cost.htm

45 This reflects the wide range in the cost of logs, from free to those who have access to their own wood to the cost of logs bought in individual bags.p/kWh is based on a 300kg load of logs de-

- Wood chip: 1.5 to 2.1p/kWh[46] (4.17 – 5.83£/GJ)
- Pellets: 3.0 to 3.5p/kWh[47] (8.33 – 9.72£/GJ)

The pellet price falls in the middle of the Enviros range while the wood chip price falls within the range but towards the lower end.

#### 6.3.3 AEAT

In a report for BERR[48], AEAT quotes the following prices:

- Wood chips 0.53-0.85p/kWh (1.47 – 2.36£/GJ)
- Wood pellets (residential supply) 1.5-3.0p/kWh (4.17- 8.33£/GJ)
- Straw 0.75 – 1.25p/kWh (2.08 – 3.47£/GJ)
- Energy crops (as chip) 0.68 – 1.27p/kWh (1.89 – 3.53£/GJ)

The pellet and straw price range is consistent with the Enviros figures. The wood chip prices used are significantly lower than the forestry wood chip price we have estimated and are closer to the recycled wood chip price estimated by Enviros.

Of these different fuel types, pellets are most likely to be subject to price fluctuations resulting from increased demand for biomass across other European Member States. Increased demand may also have a small impact on the cost of small round wood and some forestry products.

***Pellet prices***

Pellet prices have increased in recent years as the price of the fossil fuels used to produce and transport the pellets has risen. As biomass markets develop further and biomass is seen as another energy commodity, biomass prices may shadow oil or gas prices further.

The misalignment of supply and demand can lead to price volatility. Demand for pellets has grown across Europe with increased use both in the heat market and in co-firing. Production levels have also grown however a shortage in late 2006 created a large price spike in pellet markets across European and the USA.

High oil prices in the autumn of 2005 accelerated sales of pellet-fired stoves and boilers. A very cold winter in Europe created both stronger demand and a significant shortage of raw material for pellet production. The combinations of low wood harvesting levels due to the extremely low temperatures and large amounts of snow, with rapidly growing demand and supply-side problems created unexpected shortages of pellets in both European and US markets.

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livered with a 30% moisture content bought at a cost of 45£/tonne in a stove with a 70% efficiency. Wood bought at 30£/tonne with the same water content would cost 0.9p/kWh.

46 Based on a local delivery cost 45£/tonne (25% moisture) and 60£/tonne (30% moisture); calorific wood value 2778kWh/tonne.

47 3p/kWh is based on pellets at 130£/tonne at 85% efficiency (HHV), a price that can be achieved for bulk orders. 3.5p/kWh is based on pellets at 175£/tonne again at 85% efficiency.

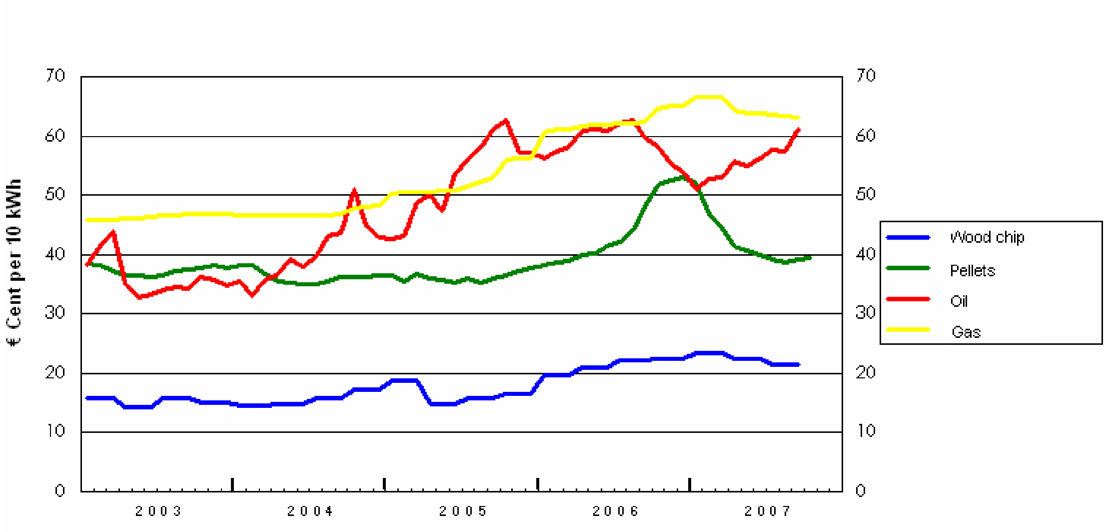
48 AEAT (Future Energy Solutions) (2005) Renewable Heat and Heat from CHP Plants – Study and Analysis http://www.berr.gov.uk/files/file21141.pdf

A continued shortage of raw material through 2006 finally led to a sharp increase in prices, which rose from an average of 180€/tonne to 270€/tonne[49]. These price increases were experienced in most of the European countries with developed pellet markets, though some younger markets with a small number of market players, such as Ireland, experienced less price volatility[50].

The price volatility experienced in 2006 had a negative effect on consumer confidence and resulted in a drop in sales of pellet stoves and boilers both in EU markets and the USA for the first time in a decade. Pellet producers were also affected by the extremely mild winter of 2006-2007, with fuel demand 30% lower than a typical year, resulting in high stock levels.

Supply is expected to keep up with increasing demand in the medium to long term with production levels across the EU, North America and China expected to increase significantly[51]. The pellet price spike experienced across Europe and America can be clearly seen in the German fuel price data as shown in Figure 13 The diagram also shows how the cost of wood chips has also risen fairly steadily since 2003.

**Figure 13 Historical Prices of wood chips, pellets, oil and gas in Germany[52]**




Source: CARMEN 2007

The pellet market may face future price spikes during periods of high demand and low production levels for example during cold spells. This potential price volatility is reflected in the large pellet price range given above (90-200£/t). In addition, pellet and wood chip prices may rise independently of demand as fossil fuel prices increase.

49 Residential sector bulk delivered
50 Renewable Energy World (2008) Time for stability: An update on international wood pellet markets
http://www.renewableenergyworld.com/rea/news/story?id=51584
51 Swann,J. (2006) Wood pellet association of Canada
http://www.meia.mb.ca/documents/JohnSwaan_KeynoteAddress_WoodPellets.pdf
52 Centrales Agrar-Rohstoff Marketing und Enwicklings Netzwerk, http://www.carmen-ev.de/dt/energie/bezugsquellen/hackschnipreise.html

# 7. BIOGAS: FUEL USE

We have been asked to provide some detail on our assumptions regarding the use of different biomass fuel sources under the various scenarios. This is in light of the fact that renewable heat will compete with some other users in some instances (for instance, competition from electricity generation). The table below sets out our assumptions.

**Table 24 Biogas fuel use**

| Scenario | Technology | Origin of heat* | Rationale | Heat output in 2020 (TWh) |
|---|---|---|---|---|
| Baseline | Landfill gas | | DUKES DATA | 0.55 |
| Baseline | Sewage gas | | DUKES DATA | 0.05 |
| Baseline | Anaerobic digestion | | DUKES DATA | 0.00 |
| *Baseline* | *All* | | | *0.60* |
| Scenario 1 | Landfill gas | HRE | Heat recovery fitted to existing sewage & landfill biogas systems | 3.2 |
| Scenario 1 | Sewage gas | HRE | | 0.3 |
| Scenario 1 | Anaerobic digestion | HRN, HRH | Heat recovery on existing projects. New farm-based systems begin to come on stream | 0.7 |
| *Scenario 1* | *All* | | | *4.2* |
| Scenario 2 | Landfill gas | HRH | Electricity utilization declines and gas is used progressively in heat only mode | 11.8 |
| Scenario 2 | Sewage gas | HRN | Additional heat recovery capacity installed | 1.0 |
| Scenario 2 | Anaerobic digestion | HRN, HRH | Food waste systems on stream, more farm-based systems | 0.7 |
| *Scenario 2* | *All* | | | *13.5* |

| Scenario | Technology | Origin of heat* | Rationale | Heat output in 2020 (TWh) |
|---|---|---|---|---|
| Scenario 3 | Landfill gas | HRE | Progressive use of landfill based on heat only provision | 12.3 |
| Scenario 3 | Sewage gas | HRN | All sewage sludge digested and used in CHP with heat recovery | 2.0 |
| Scenario 3 | Anaerobic digestion | HRH | Significant deployment of farm based systems running in heat-only mode | 9.1 |
| *Scenario 3* | *All* | | | *23.4* |

*Heat Recovery from existing facilities, (HRE), Heat recovery from new CHP facilities (HRN), Heat recovery from heat-only facilities (HRH).

** Based on an assumed gas engine power:heat efficiency of 1:1.3; with assumption that 25% of waste heat is used to drive the digestion process, with therefore 1MWh of heat available for every MWh of electricity produced.

# 8. ELECTRICITY: INPUT AND OUTPUT UNDER DIFFERENT SCENARIOS

## 8.1 Electricity input: heat pumps

We have also been asked to check the electricity input requirement that the scenarios imply for heat pumps. We have made the assumptions shown in the table below which, combined with the heat output projections described above result in a maximum of 2.63TWh electricity demand for heat pumps in 2020.

Given the relative input requirements of the two technologies, as well as being contingent on the volume of heat output projected, this level depends on the relative split between ASHP and GSHP assumed. It should be noted that for the purposes of this project, air source heat pumps are assumed to be those which are optimised for heating. This is in contrast to air conditioners (which are also sometimes referred to as ASHP) which are set up for cooling. This is the reason for the relatively low proportion of ASHP assumed below[53].

**Table 25 Electricity input for heat pumps by scenario**

| % of HP heat output | All scenarios 2010 | All scenarios 2015 | All scenarios 2020 |
|---|---|---|---|
| GSHP | 90% | 60% | 50% |
| ASHP | 10% | 40% | 50% |
| **Electricity input** | **Scenario 1 2010** | **Scenario 1 2015** | **Scenario 1 2020** |
| GSHP | 0.01 | 0.07 | 0.16 |
| ASHP | 0.00 | 0.06 | 0.21 |
| Heat pumps | 0.01 | 0.13 | 0.36 |
| **Electricity input** | **Scenario 2 2010** | **Scenario 2 2015** | **Scenario 2 2020** |
| GSHP | 0.01 | 0.14 | 0.59 |
| ASHP | 0.00 | 0.13 | 0.78 |
| Heat pumps | 0.01 | 0.27 | 1.37 |
| **Electricity input** | **Scenario 3 2010** | **Scenario 3 2015** | **Scenario 3 2020** |
| GSHP | 0.01 | 0.23 | 1.13 |
| ASHP | 0.00 | 0.21 | 1.50 |
| Heat pumps | 0.01 | 0.44 | 2.63 |

Source: Enviros. Assumes average annual capacity factor of 25% for both technologies; 3:1 ratio heat out: electricity in for ASHP; 4:1 ratio heat out: electricity in for GSHP.

53 For instance, data from the Federation of Environmental Trade Associations (FETA) indicates that around 90% of heat pumps are ASHP, but we understand that this refers primarily to air conditioning units which are much more common.

## 8.2 Electricity output: CHP

We have estimated the electricity output implied by each of the heat output scenarios, taking into account the proportion of that heat generation that we consider would be generated by CHP. The findings are summarised in the table below which shows a maximum electricity output of 7.70TWh in 2020 under Scenario 3.

**Table 26 Electricity output from CHP**

**Proportion of heat generation from CHP rather than heat only**

| | |
|---|---|
| Biomass | 56% of public and 100% of industrial biomass is assumed to be from CHP |
| Biogas | CHP only for biogas in the public sector; domestic and industrial sectors heat only |

**Heat to power ratio**

| | |
|---|---|
| Biomass | Heat to power ratio assumed to be 3:1 for both technologies |
| Biogas | |

| **Electricity output** | **Scenario 1** | **Scenario 1** | **Scenario 1** |
|---|---|---|---|
| | 2010 | 2015 | 2020 |
| Biomass | 0.70 | 1.60 | 4.44 |
| Biogas | 0.07 | 0.17 | 0.46 |
| All CHP | 0.77 | 1.76 | 4.9 |
| **Electricity output** | **Scenario 2** | **Scenario 2** | **Scenario 2** |
| | **2015** | **2015** | **2020** |
| Biomass | 0.70 | 1.77 | 5.10 |
| Biogas | 0.07 | 0.32 | 1.49 |
| All CHP | 0.77 | 2.09 | 6.59 |
| **Electricity output** | **Scenario 3** | **Scenario 3** | **Scenario 3** |
| | **2010** | **2015** | **2020** |
| Biomass | 0.70 | 1.94 | 5.10 |
| Biogas | 0.07 | 0.42 | 2.60 |
| All CHP | 0.77 | 2.35 | 7.70 |

Source: Enviros

## APPENDICES

# 1. KEY ASSUMPTIONS

***Capacity factor***

In order to calculate the installed capacity required to deliver the heat output targets in each scenario, we have used the capacity (load) factor assumption in the table below. These represent average annual heat output per unit installed capacity, taking into account heat load and availability.

**Table 27 Average annual capacity factor (% of hours in year)**

| Technology | Tranche | Enviros assumptions | Sources used |
|---|---|---|---|
| Biomass[54] | Pellet Stoves/Wood Burners | Domestic / Commercial: 30%<br>Public: 50%<br>Industrial 70% | Source: Enviros, based on CT (2005), DTI (2007), Ernst and Young (2007), EST (2005), Pöyry (2008) |
| Biomass | Boilers (Wood, Pellet & Straw) | As above | As above |
| Biomass | Wood Waste Boilers | As above, none for domestic | As above |
| Biomass | Fuel Switching | As above | As above |
| Biomass | CHP | 50%[55] | As above |
| Solar Thermal | Solar Thermal | 11% | Source: Enviros, based on Ernst and Young (2007), EST (2005), Pöyry (2008) |
| GSHP/ASHP | GSHP/ASHP | 25% | Source: Enviros, based on Ernst and Young (2007), EST (2005), Pöyry (2008) |
| Geothermal | District Heating | 30% | Enviros |
| Biogas | Stand-Alone Waste Heat | 60% | Source: Enviros, based on Pöyry (2008) |
| Biogas | District Heating | As above | As above |
| Biogas | Gas Main Injection | As above | As above |

***Average unit size***

In order to calculate the costs of delivering different levels of output we have used an estimate of the total number of units installed (since many of costs are per unit installed). The table below presents the assumptions used.

54 BERR raised the view that these load factors might be considered low. In our experience and drawing on evidence from the CT Biomass Heat Accelerator, load factors are often lower than might be expected and lower that would be optimal given the configuration and sizing of a system. Extended commissioning periods are not uncommon and even after a period of bedding in, load factors at these kinds of level are common.

55 Throughout this study we have aimed to use relatively conservative assumptions, or at least those that fall in the middle of the plausible range, in order to ensure that heat output is not systematically overestimated.

**Table 28 Average unit size (MW)**

| Technology | Tranche | Enviros assumptions | Notes |
|---|---|---|---|
| Biomass | Pellet Stoves/Wood Burners | Domestic: 0.025<br>Commercial: 0.250<br>Industrial: 1.000<br>Public: 3.000 | Source: Enviros, based on CT (2005), DTI (2007), Ernst and Young (2007) and EST (2005) |
| Biomass | Boilers (Wood, Pellet & Straw) | As above | As above |
| Biomass | Wood Waste Boilers | As above | As above |
| Biomass | Fuel Switching | As above | As above |
| Biomass | CHP | 20.000 | Source: Enviros, based on CT (2005), DTI (2007) and Ernst and Young (2007) |
| Solar Thermal | Solar Thermal | 0.0025 | Source: Enviros, based on Ernst and Young (2007) and EST (2005) |
| GSHP/ASHP | GSHP/ASHP | 0.0050 | Source: Enviros, based on Ernst and Young (2007) and EST (2005) |
| Geothermal | District Heating | 5.000 | |
| Biogas | | Domestic: 0.025<br>Industrial: 1.000<br>Commercial: 0.250<br>Public: 5.000 | Source: Enviros, based on CT (2005), DTI (2007), Ernst and Young (2007) |
| | Stand-Alone Waste Heat | 1.2000 | Source: DTI (2007) |
| | District Heating | As above | As above |

# 2. REVIEW OF ERNST AND YOUNG BASELINE ASSUMPTIONS

In order to put the BERR baseline assumptions into context we reviewed the business as usual (BAU) assumptions for Ernst and Young[56] as described in its report (Pöyry does not give a detailed description of its baseline assumptions). Our findings are summarised in the table below.

**Table 29 Summary of Ernst and Young BAU assumptions**

| Categorisation Enviros (E&Y) | Assumptions and sources | Current contributionTWh | BAU in 2020TWh |
|---|---|---|---|
| **Biomass (Industrial biomass)** | Current contribution: DUKES data 'Wood combustion – industrial' and 'Straw combustion' from 2005<br>BAU in 2020: Assumes declines to zero based on linear extrapolation of DUKES data 'Wood combustion – industrial' and 'Straw combustion' from the years 2003-2005<br>Would expect actual baseline level to be higher (at worst flat) even if there is a dip in the short term.<br>Does this capture full range of potential biomass fuels for sector? | 1.8 | 0 |
| **Biomass (Commercial biomass)** | No data / assumed to be included in residential or industrial biomass | - | - |
| **Biomass (Residential biomass)** | Current contribution: DUKES data[57] 'Wood combustion – domestic' from 2005<br>BAU in 2020: Assumed flat based on linear extrapolation of DUKES data 'Wood combustion – domestic' from the years 2003-2005<br>Does this capture full range of potential biomass fuels for sector? | 2.4 | 2.4 |
| **Biomass (Energy from Waste)** | Current contribution: DUKES data 'Municipal solid waste combustion' from 2005<br>BAU in 2020: Assumed flat based on linear extrapolation of DUKES data 'Municipal solid waste combustion' from the years 2003-2005<br>Use for heat depends on use for electricity/ extent to which CHP | 0.4 | 0.4 |
| **Biogas (Anaerobic Digestion)** | Current contribution: DUKES data 'Sewage sludge digestion' from 2005<br>BAU in 2020: Assumed to fall based on linear extrapolation of DUKES data 'Sewage sludge digestion' from the years 2003-2005<br>Would expect to be flat as a minimum | 0.6 | 0.2 |

56 Ernst and Young (2007): Renewable heat initial business case. Report for DEFRA/BERR.
57 Internet link: http://stats.berr.gov.uk/energystats/dukes7_1_1.xls

| Categorisation<br>Enviros (E&Y) | Assumptions and sources | Current contributionTWh | BAU in 2020TWh |
|---|---|---|---|
| **Solar thermal (Solar thermal)** | Current contribution: DUKES data 'Active solar heating' from 2005<br>BAU in 2020: Assumed to quadruple – considerable increase expected when compared against other sources, based on linear extrapolation of DUKES data 'Active solar heating' from the years 2003-2005<br>Split between sectors – all domestic? | 0.3 | 1.2 |
| **GSHP/ ASHP (Heat pumps)** | Current contribution: sources quoted for the calculation are the Energy Savings Trust Report 'Potential for Microgeneration'[58] and the AEAT Report 'Renewable Heat and Heat from Combined Heat and Power Plants'[59]<br>BAU in 2020: Assumed to increase by around 360% based on extrapolation of data on the number of installations of GSHPs. It is not clear which years' data are used (based on footnote 2005-2006, in text 2003-2005)<br>Split between sectors – all domestic? | 0.03 | 0.11 |
| **Geothermal (Geothermal)** | No calculation undertaken by E&Y<br>Enviros proposed calculation:<br>Current contribution: DUKES data 'Geothermal aquifers' from 2005<br>BAU in 2020: Flat based on linear extrapolation of DUKES data 'Geothermal aquifers' from the years 2003-2005 as per E&Y for other technologies | 0.01 | 0.01 |

58 Internet link: http://www.berr.gov.uk/files/file27558.pdf
59 Internet link: http://www.berr.gov.uk/files/file21141.pdf

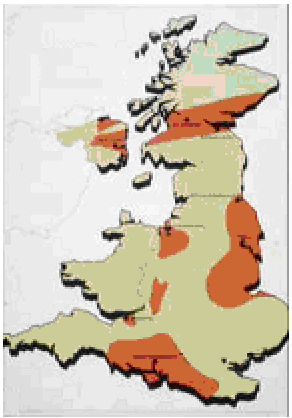
## 3. ASSUMPTIONS FOR GEOTHERMAL

The three scenarios in our report assume no increased output from geothermal. This reflects the limited resource available in the UK. In addition, a lack of successful examples of projects of this type makes the other technology types more attractive options to achieving the output levels required in each scenario (even once barriers in the form of costs have been alleviated).

### *UK resource potential*

The resource potential for additional heat from geothermal in the UK is limited (our baseline assumption is 0.096TWh based on data from BERR). A recent estimate of the geothermal heat potential gives a figure of 0.18TWh for the additional realisable potential by 2020[60]. The low potential is a result of a mismatch of the main population centres and the geothermal resources as indicated in the map below.

**Figure 14 Map of geothermal resources in the UK**



Source: Reproduced from Smith, M. (2000) Southampton Energy Scheme

### *Current project status*

Geothermal energy is used to a very limited extend in the UK. The City of Southampton Energy Scheme is the only major geothermal energy which is currently operational. There have been two other geothermal projects in the UK so far. A site at Cleethorpes was abandoned in the mid 1990s and the Penryn site has been used for experimental purposes only. According to the International Geothermal Association, the installed thermal capacity in the UK is 10.2 MW with an annual output of 12,700 MWh.[61] Hence the contribution of geothermal energy is negligible in the UK.

An example of the barriers geothermal encountered in the UK is the Cleethorpes geothermal project which is described in detail in Box 1 below.

60 Figure converted from ktoe to TWh by using a conversion factor of 0.01163; Source: Ragwitz and Resch (2006) Economic analysis of reaching a 20% share of renewable energy sources in 2020.
61 Data from 2000; Source:http://iga.igg.cnr.it/geoworld/geoworld.php?sub=duses&country=uk

**Box 1: Geothermal heat projects in the UK: example of Cleethorpes geothermal project[62]**

| |
|---|
| The aim of the Cleethorpes geothermal project was to use low temperature geothermal energy. It was initially planned to heat a 10–20 acre glasshouse area and other dwellings including with a visitor centre.<br><br>The project was originally planned for a site in Cleethorpes but was transferred to another site using the same geothermal aquifer in East Hull after the planning approval given by the Local Authority has been turned down. Although some progress has been made on the planning and design stages, the finalisation of agreements with the City Council has been delayed. The expected completion date was well outside the initial programme. Subsequently the contract has been cancelled and a new application has been made. |

***Key barriers***

- The UK is physically placed in an area that does not have available high temperature geothermal resources - either hydrothermal reservoirs or hot rocks. Low temperature resources, which are available in the UK, are not as cost effective.
- Since geothermal is best utilised through district heating systems it is therefore best to utilise in built up, populated areas. Generally, the distribution of low temperature hydrothermal reservoirs (Fig 1) do not fall under some of the larger population centres although there are certain areas where there is a match.
- The technology currently available is inadequate to utilise a number of potential geothermal resources. Further R&D could help to develop systems that can utilise a greater number of potential resources in the UK.[63]

***Overcoming the barriers***

France provides an example of how the barriers to geothermal energy can be overcome. The following policies managed by ADEME have been implemented to support geothermal energy[64]:

- continuation of the European Research Programme on Hot Dry Rock (HDR) potential;
- development of the use of metropolitan low-enthalpy resources with an extension of the existing geothermal District Heating plants to new consumers;
- development of the use of high-enthalpy resources in the French Overseas Departments; and
- the extension of the Long Term Guarantee System, which was initially planned for 15 years, by a further 10 years.

62 http://www.geothermie.de/egec-geothernet/download/ge1994.pdf

63 Research in both the geothermal resource and the technology that could be used to extract the heat from the resource would assist the development of this energy type. Improved technologies could increase the available potential.

64 http://geothermie.de/egec-geothernet/ci_prof/europe/france/french.pdf

These policies were reportedly very successful. Out of the 74 plants operating at the end of 1986, 61 plants are still in operation today. They heat and produce hot water for around 200,000 housing units. This corresponds to an annual output of 1.9TWh.[65]

***Assumptions for this project***

In our scenarios we assume no increase in the number of geothermal schemes in the UK to 2020 as there are few local authorities in which projects would be technically feasible, and significant resources would be required to overcome the planning, technology and project timeline risks involved. These would apply even if working in a PFI/ ESCo arrangement such as Southampton. All UK projects to date (both successful and failed) have received central government or EU grants in excess of £1million. The cost of unblocking barriers would be similar if not greater for any future schemes.

The combined impact of technical limitations and project cost/risk prevented further consideration of the sector in the scenario projections.

65 http://www.ademe.fr/anglais/technical%20files/geothermal.pdf

# 4. HEAT OUTPUT PROJECTIONS

The tables below provide the heat output projections under each scenario described in section 4.2, a breakdown of heat output from CHP schemes and breakdown of biomass heat output by fuel type.

**Table 30 Scenario heat output projections by technology (TWh)**

| **Scenario 1** | **TWh** | **2010** | **2015** | **2020** |
|---|---|---|---|---|
| Biomass | Domestic | 2.2 | 5.0 | 14.0 |
| | Industrial* | 0.9 | 2.0 | 5.7 |
| | Commercial* | | | |
| | Public | 2.2 | 4.9 | 13.6 |
| Biogas | Domestic | 0.2 | 0.5 | 1.4 |
| | Industrial | 0.2 | 0.5 | 1.4 |
| | Commercial** | | | |
| | Public | 0.2 | 0.5 | 1.4 |
| Geothermal | Domestic** | | | |
| | Industrial** | | | |
| | Commercial** | | | |
| | Public | 0.0 | 0.0 | 0.0 |
| Heat pumps | Domestic | 0.0 | 0.1 | 0.4 |
| | Industrial | 0.0 | 0.0 | 0.1 |
| | Commercial | 0.0 | 0.2 | 0.5 |
| | Public | 0.0 | 0.1 | 0.3 |
| Solar thermal | Domestic | 0.3 | 0.9 | 2.6 |
| | Industrial | 0.0 | 0.0 | 0.0 |
| | Commercial | 0.0 | 0.0 | 0.1 |
| | Public | 0.0 | 0.1 | 0.2 |
| **All** | **All** | **6.3** | **15.0** | **41.6** |

| **Scenario 2** | **TWh** | **2010** | **2015** | **2020** |
|---|---|---|---|---|
| Biomass | Domestic | 2.2 | 5.6 | 16.1 |
| | Industrial* | 0.9 | 2.3 | 6.5 |
| | Commercial* | | | |
| | Public | 2.2 | 5.4 | 15.7 |
| Biogas | Domestic | 0.2 | 0.9 | 4.5 |
| | Industrial | 0.2 | 0.9 | 4.5 |
| | Commercial** | | | |
| | Public | 0.2 | 0.9 | 4.5 |

| Scenario 2 | TWh | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Geothermal | Domestic** | | | |
| | Industrial** | | | |
| | Commercial** | | | |
| | Public | 0.0 | 0.0 | 0.0 |
| Heat pumps | Domestic | 0.0 | 0.3 | 1.4 |
| | Industrial | 0.0 | 0.0 | 0.2 |
| | Commercial | 0.0 | 0.4 | 1.9 |
| | Public | 0.0 | 0.2 | 1.2 |
| Solar thermal | Domestic | 0.3 | 1.7 | 9.5 |
| | Industrial | 0.0 | 0.0 | 0.1 |
| | Commercial | 0.0 | 0.0 | 0.2 |
| | Public | 0.0 | 0.1 | 0.7 |
| **All** | **All** | **6.3** | **19.0** | **67.0** |

| Scenario 3 | TWh | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Biomass | Domestic | 2.2 | 6.1 | 16.1 |
| | Industrial* | 0.9 | 2.5 | 6.5 |
| | Commercial* | | | |
| | Public | 2.2 | 6.0 | 15.7 |
| Biogas | Domestic | 0.2 | 1.2 | 7.8 |
| | Industrial | 0.2 | 1.2 | 7.8 |
| | Commercial** | | | |
| | Public | 0.2 | 1.2 | 7.8 |
| Geothermal | Domestic** | | | |
| | Industrial** | | | |
| | Commercial** | | | |
| | Public | 0.0 | 0.0 | 0.0 |
| Heat pumps | Domestic | 0.0 | 0.5 | 2.7 |
| | Industrial | 0.0 | 0.1 | 0.5 |
| | Commercial | 0.0 | 0.6 | 3.6 |
| | Public | 0.0 | 0.4 | 2.3 |
| Solar thermal | Domestic | 0.3 | 2.0 | 17.5 |
| | Industrial | 0.0 | 0.0 | 0.2 |
| | Commercial | 0.0 | 0.0 | 0.3 |
| | Public | 0.0 | 0.2 | 1.4 |
| **All** | **All** | **6.3** | **22.0** | **90.1** |

Source: Enviros. Totals may not sum exactly due to rounding. Note *Biomass Commercial included in Industrial. ** Assumed to be zero in all scenarios.

**Table 31 Scenario heat output projections from biogas and biomass CHP schemes (TWh).**

| Scenario | Technology | Sector | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Scenario 1 | Biomass | Public CHP schemes/heat recovery | 1.2 | 2.8 | 7.7 |
| | Biomass | Industrial CHP | 0.9 | 2.0 | 5.7 |
| | Biomass | All | 2.1 | 4.8 | 13.3 |
| | Biogas | Public CHP | 0.2 | 0.5 | 1.4 |
| | All CHP | | 2.3 | 5.3 | 14.7 |
| Scenario 2 | Biomass | Public CHP schemes/heat recovery | 1.2 | 3.1 | 8.8 |
| | Biomass | Industrial CHP | 0.9 | 2.3 | 6.5 |
| | Biomass | All | 2.1 | 5.3 | 15.3 |
| | Biogas | Public CHP | 0.2 | 0.9 | 4.5 |
| | All CHP | | 2.3 | 6.3 | 19.8 |
| Scenario 3 | Biomass | Public CHP schemes/heat recovery | 1.2 | 3.3 | 8.8 |
| | Biomass | Industrial CHP | 0.9 | 2.5 | 6.5 |
| | Biomass | All | 2.1 | 5.8 | 15.3 |
| | Biogas | Public CHP | 0.2 | 1.2 | 7.8 |
| | All CHP | | 2.3 | 7.1 | 23.1 |

Source: Enviros.

**Table 32 Biomass heat output by fuel type (TWh)**

| Scenario | Sector | Fuel type | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| **Scenario 1** | Domestic | Pellets | 0.2 | 0.5 | 1.4 |
| | | Logs | 1.9 | 4.3 | 11.9 |
| | | Wood chips | 0.1 | 0.2 | 0.6 |
| | | Other | 0.0 | 0.1 | 0.1 |
| | Industrial | Pellets | 0 | 0 | 0 |
| | | Logs | 0 | 0 | 0 |
| | | Wood chips | 0.6 | 1.4 | 4.0 |
| | | Other | 0.3 | 0.6 | 1.7 |
| | Public (civic) | Pellets | 0.1 | 0.2 | 0.6 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.9 | 1.9 | 5.4 |
| | | Other | 0.0 | 0.0 | 0.0 |
| | Public (CHP) | Pellets | 0.0 | 0.0 | 0.0 |
| | | Logs | 0.0 | 0.0 | 0.0 |

| | | | | | |
|---|---|---|---|---|---|
| | | Wood chips | 0.7 | 1.7 | 4.6 |
| | | Other | 0.5 | 1.1 | 3.1 |
| **Scenario 2** | Domestic | Pellets | 0.2 | 0.6 | 1.6 |
| | | Logs | 1.9 | 4.7 | 13.7 |
| | | Wood chips | 0.1 | 0.2 | 0.6 |
| | | Other | 0.0 | 0.1 | 0.2 |
| | Industrial | Pellets | 0.0 | 0.0 | 0.0 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.6 | 1.6 | 4.6 |
| | | Other | 0.3 | 0.7 | 2.0 |
| | Public (civic) | Pellets | 0.1 | 0.2 | 0.7 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.9 | 2.2 | 6.2 |
| | | Other | 0.0 | 0.0 | 0.0 |
| | Public (CHP) | Pellets | 0.0 | 0.0 | 0.0 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.7 | 1.8 | 5.3 |
| | | Other | 0.5 | 1.2 | 3.5 |
| **Scenario 3** | Domestic | Pellets | 0.2 | 0.6 | 1.6 |
| | | Logs | 1.9 | 5.2 | 13.7 |
| | | Wood chips | 0.1 | 0.2 | 0.6 |
| | | Other | 0.0 | 0.1 | 0.2 |
| | Industrial | Pellets | 0.0 | 0.0 | 0.0 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.6 | 1.7 | 4.6 |
| | | Other | 0.3 | 0.7 | 2.0 |
| | Public (civic) | Pellets | 0.1 | 0.3 | 0.7 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.9 | 2.4 | 6.2 |
| | | Other | 0.0 | 0.0 | 0.0 |
| | Public (CHP) | Pellets | 0.0 | 0.0 | 0.0 |
| | | Logs | 0.0 | 0.0 | 0.0 |
| | | Wood chips | 0.7 | 2.0 | 5.3 |
| | | Other | 0.5 | 1.3 | 3.5 |

Source: Enviros

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