

Renewable heat initial business case

DEFRA / BERR

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Dear Sir

Subject: Initial Business Case on the need for support in the UK renewable heat sector

In accordance with our contract dated 16 November 2006, we have prepared our Initial Business Case ('IBC') on the need for support in the UK renewable heat sector.

Purpose of our IBC and restrictions on its use

This IBC was prepared on instructions of DEFRA and BERR solely for the purpose of evaluating whether there is a need for support for the UK renewable heat sector and for assessing the level of support required for an agreed list of renewable heat technologies. The IBC should not be relied upon for any other purpose. In carrying out our work and preparing this IBC, we have worked solely on the instructions of DEFRA and BERR, and for DEFRA and BERR's purposes.

Our report may not have considered issues relevant to any third parties, any use such third parties may choose to make of our report is entirely at their own risk and we shall have no responsibility whatsoever in relation to any such use

Scope of our work

Our work in connection with this assignment is of a different nature to that of an audit. The IBC is based on inquiries of and discussions with DEFRA, BERR and key stakeholders in the UK renewable heat sector. We have not sought to verify the accuracy of the data or the information and explanations provided by yourselves or other key stakeholders, a more detailed review of each of the technologies may reveal material issues that relate to the data in this report that this review has not.

We have used reasonable efforts to provide representative cost and capacity data through liaison with DEFRA, BERR and key stakeholders in the UK renewable heat sector. However, it should be noted that the costs of renewable heat generation will vary from site to site and over time, and as such the data in this report are unlikely to reflect any particular renewable heat project.

Our work has been limited in scope and a more detailed study may reveal material issues that this study has not. The findings and subsequent recommendations of the IBC are based on the known regulatory environment as at the date of this letter, which may be subject to change since the IBC has been issued.

If you would like to clarify any aspect of this review or discuss other related matters then please do not hesitate to contact us.

Yours faithfully

Ernst & Young

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Introduction

1. According to the Biomass Task Force Report (April 2006), heat accounts for over a third of primary energy consumption within the UK, yet only 1% of the heat market is currently sourced from renewable fuels and no targets are in place to increase this level of contribution. Whilst the use of renewable fuel sources for electricity generation is currently supported by the Renewables Obligation, and a Renewable Transport Fuel Obligation has recently been announced to support the use of biofuels, no similar incentives exist for the generation of heat from renewable sources.
2. This document seeks to compare the market potential of different renewable heat technologies, their cost effectiveness in abating carbon emissions and the potential level of support they will require to be commercially viable (when compared to conventional heating alternatives). This document also describes some of the barriers to deployment of renewable heat technologies and current enabling mechanisms.

Market potential

3. We set out below a summary of various estimates of the market and technical potential (in 2020) of the renewable heat and waste heat markets by technology, based on market assumptions as set out in Section 3 of our report. For the avoidance of doubt, market potential, as set out in the table below, is inclusive of current contribution and Business as Usual scenarios, i.e. current contribution and Business as Usual data should not be added to market potential.

Table 1: Summary of market and technical potential for renewable heat by technology

	<i>Residential Biomass TWh/y</i>	<i>Commercial Biomass TWh/y</i>	<i>Industrial Biomass TWh/y</i>	<i>AD CHP TWh/y</i>	<i>EfW TWh/y</i>	<i>Solar TWh/y</i>	<i>GSHP / ASHP TWh/y</i>	<i>Total TWh/y</i>
'Business as Usual' (2020)*	2.4	-	0.0	0.2	0.4	1.2	0.11	4.31
Current contribution	2.4	-	1.8	0.6	0.4	0.3	0.03	5.53
Market potential (low)	13.5	2.1	7.9	1.5	1.7	4.9	4.9	36.5
Market potential (low) as a percentage of technical potential (low)	69%	35%	43%	38%	11%	14%	6%	20%
Market potential (high)	23.6	3.7	13.8	3.4	5.7	17.1	20.1	87.4
Market potential (high) as a percentage of technical potential (low)	121%	62%	76%	85%	38%	49%	25%	49%
Technical potential (low)	19.5	6.0	18.2	4.0	15.0	35.1	80.3	178.1
Technical potential (high)	84.1	24.9	75.5	91.0	22.8	35.1	80.3	413.7

Source: Future EnergySource; y Solutions, Biomass Task Force, BERR, ILEX, Energy Saving Trust, industry data

4. A review of the markets from both a low and a high market potential view suggests that biomass, followed by solar and GSHP, has the greatest market and technical potential for renewable heat delivery.
5. For industrial biomass, the Business as Usual estimate in 2020 assumes a reduction in use from the current contribution levels of 1.8TWh/y to zero by 2020. Although this technology is cost competitive (in some situations), the use of industrial biomass has declined over the past three years, which has been attributed to increasingly strict emissions controls by local authorities.

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6. The graphs below summarise the breakdown of market potential, high and low scenarios, by renewable and waste heat technology:

Figure 1: Market potential (high) (TWh)

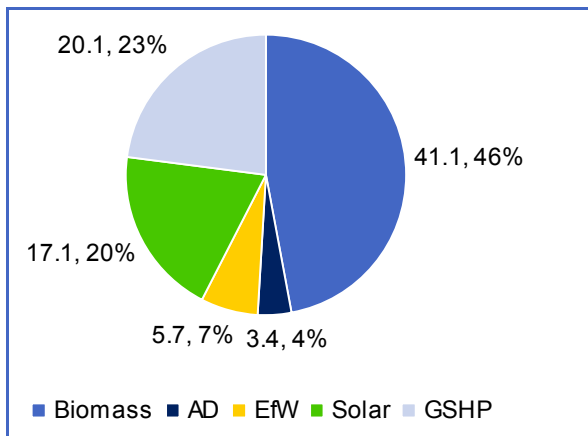
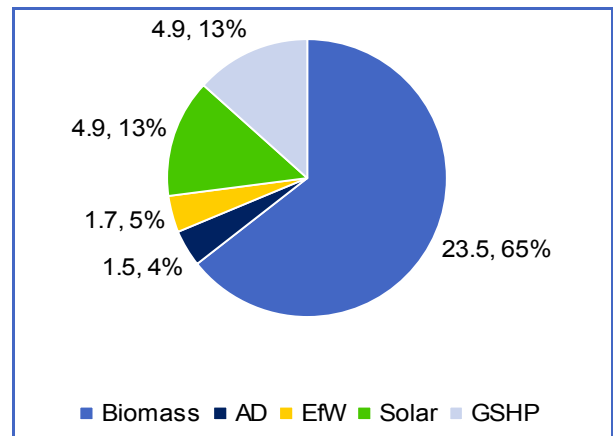


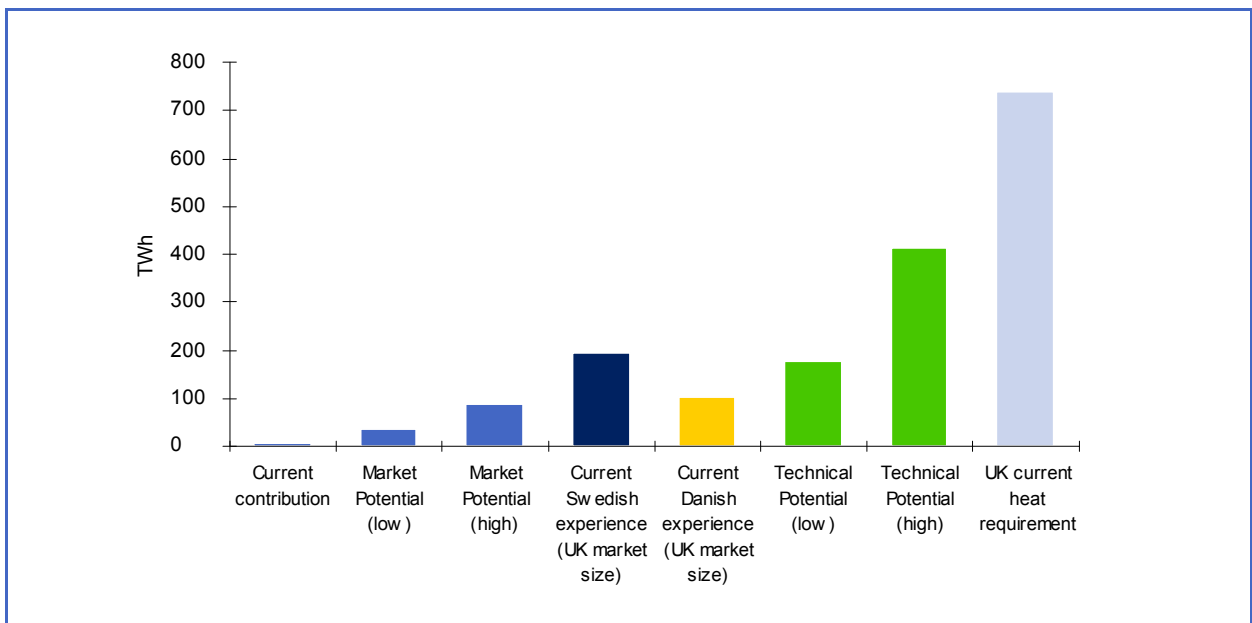
Figure 2: Market potential (low) (TWh)



Note: 'Biomass' comprises the total of residential, commercial and industrial biomass per Table 1.

7. The use of renewable heat in Sweden and Denmark^{1,2} (which are comparatively mature renewable heat markets) provides a benchmark of market potential in respect of the UK. The chart below shows the UK's current and potential supply of heat from renewable sources. Market and technical potential estimates are derived from a number of publicly available reports on renewable heat (see References in Appendix C). The market size for Denmark and Sweden represents renewable heat as a proportion of overall heat demand in those markets, pro-rated to UK market size for comparability with UK numbers.

Figure 3: UK, Sweden and Denmark renewable heat potential



- Although Sweden benefits from its large forestry industry and associated by-products, it may not provide a realistic benchmark for the UK market. Denmark provides a reasonable benchmark of the potential contribution from renewable heat. Around 60% of Danish consumers receive heat via

¹ Heat Supply in Denmark: Who What Where and Why, Danish Energy Authority, January 2005

² Energy in Sweden, Swedish Energy Agency, November 2005

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district heating schemes, of which 17% is derived from biomass and around 25% from waste. Straw represents 50% of the biomass fuel source for these schemes. Denmark has been particularly proactive in putting in place at an early stage the grant and legislative infrastructure necessary to promote district heating.

- Based on the large contribution from waste in Denmark it might be realistic to assume that the potential contribution of EfW CHP (between 1.7TWh and 5.7TWh) has been underestimated for the UK. A more detailed review of the market potential for the larger scale technologies in the UK may be required.
8. A number of reports from different authors have been reviewed (see Appendix C) to assess the market potential for renewable and waste heat in the UK. Based on the wide ranging estimates for market and technical potential in these third party reports, we would estimate that the market potential for renewable and waste heat in the UK is between 37TWh and 87TWh by 2020, equivalent to between 5% and 12% of the current UK heat requirement. Should there be an extensive use of district heating schemes in the UK, and readily available feedstocks (such as in Sweden), the market potential for renewable heat could be considerably higher. A lack of defined targets and policy measures for increasing the use of renewable heat are the key reasons for the UK's current low contribution from renewable heat.
 9. Whilst it is recognised that district heating (DH) led large scale residential schemes are a possible major source of renewable heat uptake, it should also be noted that where possible, electricity and cooling (ie. trigeneration) could also be provided from these schemes and that this will be a particularly important source of low carbon energy, particularly in urban areas (where temperatures are rising fastest and air conditioning is being used more frequently). DH schemes should therefore remain committed to providing distributed energy across multiple sectors.

Funding required

10. In order to assess the level of funding support required for each technology (ie to provide economic parity between renewable and waste heat technologies and the conventional heat alternatives) a comparison has been made against equivalent gas, oil and electric heating alternatives (where appropriate) in domestic, commercial and industrial applications. The level of funding support required, (in terms of support per MWh), has been calculated using a levelised cost comparison. Note that funding support cannot be directly compared to cost effectiveness in this report since the two sets of numbers are derived from different methodologies. Assumptions used in the levelised cost comparison are set out in Appendix D.
11. For biomass CHP, AD CHP and EfW CHP (technologies that would typically export heat rather than displace alternative fuel costs), a heat offtake price of £30 per MWh has been assumed (source: EY proprietary data) when assessing the level of support required. In addition, the counterfactual for these technologies comprises CCGT derived power and gas-fired heating, for the purposes of assessing the maximum carbon abatement impact of supporting these technologies.
12. It is recognised that heat users looking to achieve some carbon savings are likely to consider investing in CHP (gas or renewable) before looking specifically at renewable CHP. The economics and carbon benefits of switching to gas-fired CHP is outside of the scope of this report; similarly, this study does not use gas-fired CHP as a counterfactual, since the extent of carbon abatement achieved under this comparison will be less than that of replacing CCGT power and gas-fired heating.
13. The cost of making customer connections, for example through District Heating (DH) applications, has not been considered in detail within this analysis; the cost of installing such heat infrastructure is highly project specific. Instead, a sensitivity has been performed for renewable CHP technologies (AD, Biomass and EfW), whereby a 20% increase in capital (capex) and maintenance (O&M/opex) costs have been assumed to reflect the cost of installing and maintaining a DH scheme.
14. The table below summarises the funding support required for each of the technologies considered (figures in brackets represent no additional funding support required compared to the equivalent fossil

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fuel based technology). Within the range of support required for the CHP technologies also include a sensitivity for the additional costs incurred for installing and maintaining a district heating network.

Table 2: Funding support required by technology

	Biomass (Res)	Biomass (Com)	Biomass (Ind)	Biomass CHP	AD CHP	EfW CHP	GSHP/ ASHP	Solar thermal
Cost of support (£ per MWh support required to be cost competitive)								
Relative to gas	2-23	2-12	(1)-4	(3)-3	(51)-33	(15)-7	28-51	29-51
Relative to oil	13-22	(4)-1	0-1	n/a	n/a	n/a	34-47	34-47
Relative to electricity	(26)-(34)	n/a	n/a	n/a	n/a	n/a	(1)-12	3-16

*Figures in brackets indicate that no support is required for that technology relative to gas/oil/electrical heat generation. Where technologies do not have an equivalent gas/oil/electrical method of generating heat, these are marked 'not applicable'.

15. The level of funding support required for each technology varies depending on the conventional heating alternative being considered, and the technology specific assumptions applied. Heat pumps and solar thermal technologies appear to require funding support under virtually all the scenarios studied when compared to gas or oil-fired heat. Furthermore, by applying various technology specific sensitivities it is evident that funding support requirements will vary considerably depending on project specific circumstances. Key reasons for the wide range in results are as follows:

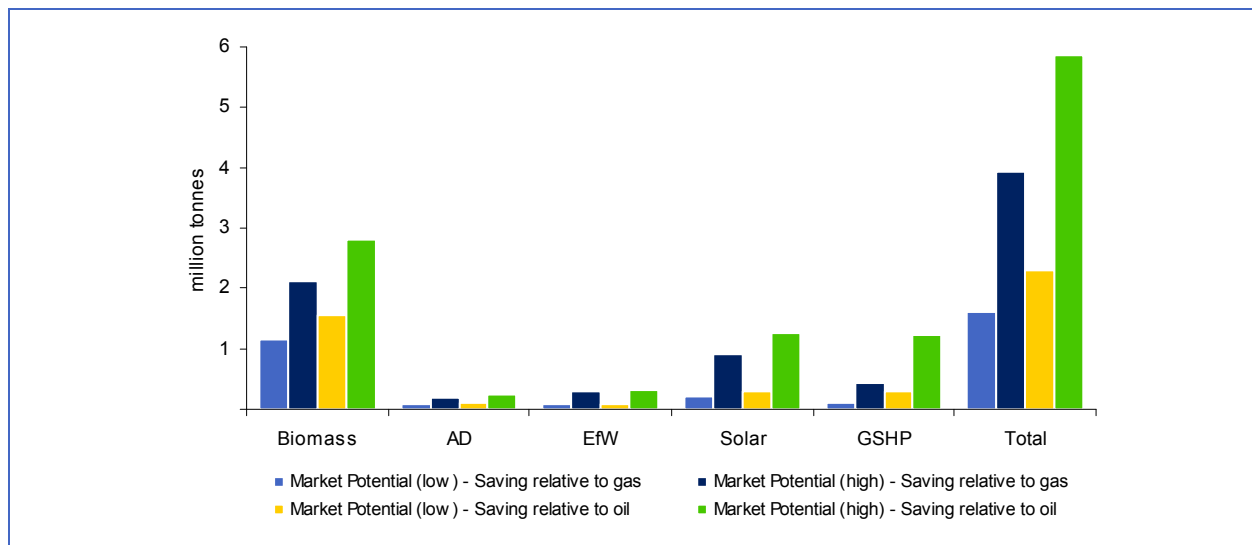
- The cost competitiveness of biomass in all applications is largely determined by feedstock type (100% wood chip or a mixture of wood chip and pellets) and feedstock price. Significant economies of scale appear to exist for biomass technologies, as demonstrated by the near cost competitiveness of biomass in commercial and industrial applications.
- The funding support required for AD and EfW is largely influenced by gate fees. The results suggest that renewable heat from AD and EfW may not require any funding support to be cost competitive, when adequate gate fee income is being received.
- When the costs of installing and maintaining a DH scheme are considered, additional funding support will be required. In new-build applications it may be possible to recover some of the capital investment through a connection charge to end users.
- The methodology applied in assessing funding support required does not factor in future improvements in technology efficiency or future technology cost reductions as both measures are difficult to predict with any certainty (as demonstrated by recent increases in wind energy technology prices due to global resource constraints and increased demand).

Carbon saved

16. The chart below summarises the potential tonnes of carbon that could be saved per annum should the full market potential in 2020 be realised:

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Figure 4: Carbon saved by technology



- The use of renewable heat from biomass is anticipated to contribute the most significant carbon savings of the technologies considered.
- Displacement of oil-fired heating as a result of utilising renewable heat will contribute more carbon savings than displacement of gas.

Cost effectiveness

17. Cost effectiveness has been calculated on the basis of the societal cost per tonne of carbon saved, taking account of the possible range in level of funding support required to ensure cost competitiveness. The societal cost of funding support, which feeds into the calculation of cost effectiveness, uses a discount rate of 3.5% to represent the cost to society for each tonne of carbon saved. The cost of carbon saved is summarised in the table below:

Table 3: Cost effectiveness of renewable heat technologies in achieving carbon savings

Societal analysis	Biomass (Res)	Biomass (Com)	Biomass (Ind)	Biomass CHP	AD CHP	EFW CHP	GSHP/ ASHP	Solar thermal
Cost £ per tonne of carbon saved								
Relative to gas	13-396	41-259	(23)-97	(120)-8	(1,289)-1,351	444-735	1,148-2,309	445-857
Relative to oil	161-281	(59)-23	(4)-12	n/a	n/a	n/a	785-1,128	410-582
Relative to electricity	(561)-(651)	n/a	n/a	n/a	n/a	n/a	(227)-(407)	(135)-(264)

- The societal cost calculation excludes the value of ROCs, LATS credits and the value of the Landfill Tax component of gate fees for CHP and waste technologies respectively. EFW CHP and AD CHP are assumed to receive some gate fee income relating to handling or tipping fees.
- The cost per tonne of carbon saved varies widely depending on the technology being considered and its particular application. In residential applications, biomass appears to provide the most cost efficient carbon savings, particularly when compared to electrical heat.

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Barriers to the deployment of renewable heat technologies

18. A consultation process with key industry stakeholders was used in conjunction with desk-top research to identify a number of non-financial barriers to the deployment of renewable heat technologies. A detailed explanation of barriers specific to each technology is provided in section 3, and can be summarised diagrammatically as follows:

Figure 5: Barriers to the deployment of renewable heat technologies



19. All the above barriers (with the exception of retro-fit and market failure), are typical of any immature market and analogous to, for example, the wind energy industry in the early 1990s.
20. The cost of retro-fitting renewable heat technologies to existing premises, together with the consequential obsolescence (or part obsolescence) of existing heating equipment, represents a critical barrier to the uptake of renewable heat technologies.
21. The use of centralised district heating-led schemes requires the installation of heat transmission infrastructure. Where district heating is being applied in a retro-fit scenario, the cost of installing such infrastructure can prove prohibitive. Furthermore, extensive permitting and consenting is required to install heat transmission infrastructure underneath existing public highways. The UK does not benefit from a large number of existing district heating networks, unlike Denmark for example, where district heating networks have been developed and installed since 1979 in response to the OPEC oil price shocks of that era.
22. Barriers to the use of district heating networks could be addressed through various legislative measures (for example providing installers with the necessary statutory powers to more easily implement DH networks). Denmark adopted legislative action to drive the development of DH networks, forcing planners to assess public heat demand in order to prioritise future heat supply installations. New laws (in 1988 and 1994) also banned the use of electric heating in new and existing dwellings; this ensured that sufficient demand was in place to support the necessary infrastructure investment required for the district heating networks. The use of franchises similar to those awarded for cable TV could also be considered.

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23. Set out below is a brief summary of other key barriers identified as hindering the development of the UK renewable heat market, and a summary of whether a long term support mechanism will help overcome each barrier. It should be noted that other support mechanisms such as R&D support, capital grants or planning guidelines may address particular barriers in a more efficient manner than long-term support mechanisms.

Table 4: Other key barriers impacting the renewable heat sector

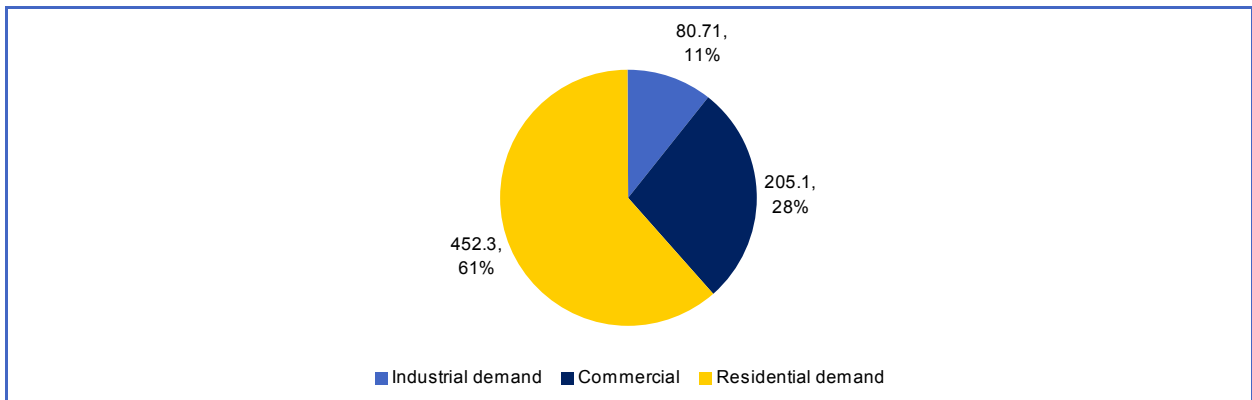
Barrier	Ability to resolve with a long-term support mechanism	Comments
Market Failure	Yes	A long term robust support mechanism that compensates for the externalities of conventional heating sources will address this issue. The level of support required for these technologies is discussed in Table 2. Other forms of financial support eg. R&D support measures, capital grants and soft loans (or any combination thereof), may provide a more effective method of addressing market failure than a long-term support mechanism alone.
Technical	Yes	<p>Higher capital costs than conventional systems (as the market for many technologies is relatively immature in the UK), combined with a lack of readily available third party capital to fund new installations, represents significant barriers.</p> <p>A long-term support mechanism should provide the security to facilitate investment and encourage established companies into the market (eg as the wind power sector has grown on long-term regulatory support, large corporates have entered the market (eg GE / Siemens)).</p>
Planning	No	<p>Requires specific long-term planning support. The recent implementation of and ongoing consultation on PPS22 sets out national policies for land use across the country and in particular guidance for local authorities in promoting renewable energy projects. In its existing form, PPS 22 has been criticised as being weak, particularly in that it does not mandate the use of renewable energy in new developments and conversions.</p> <p>Other planning tools in favour of renewable energy technologies include: Part L of the Building Regulations, which primarily promotes energy efficiency; the current review of the General Permitted Development Order; and the Code for Sustainable Homes. Whilst these work towards promoting low carbon homes, they do not specifically support the deployment of renewable heat technologies.</p> <p>The Merton Rule, adopted in October 2003 in London Borough of Merton's Unitary Development Plan, made Merton the first local authority in the UK to include a minimum target for the use of renewable energy in new and refurbished developments within planning policy. The impact of this decision will be significant over time as a further 80 local authorities are following suit. This impact will, however, be limited to new build developments and refurbishments.</p> <p>The London Energy Partnership (part of the Greater London Authority) has been tasked with setting up and delivering the Mayor's Energy Action Areas to showcase low carbon developments in London. These four pilot areas are Merton, Barking, New Wembley, and a joint proposal from Southwark of the Elephant & Castle regeneration area and the Southwark concerto community. The pilot Areas are expected to deliver carbon savings ranging from 40 per cent - 60 per cent; the Southwark Concerto community aim to achieve carbon savings in excess of 60 per cent by 2010. Initiatives such as these help to promote renewable heat technologies, though they do not overcome the financial barriers associated with investing in these technologies.</p> <p>Infrastructure is still geared towards fossil fuel based heat generation, eg gas infrastructure initially benefited from public sector investment.</p>
Networks	Partly	Natural networks such as farming co-operatives to supply biomass will arise to meet the needs of market entrants. However, mechanisms to accredit the by products of some technologies e.g. AD are also required.

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Barrier	Ability to resolve with a long-term support mechanism	Comments
Fuel supply	Yes	As markets develop, fuel supply constraints should start to become resolved, such as standard fuel supply contracts, greater volumes of fuel supply and standardised fuel quality etc. The demand for energy crops for use in co-firing should help stimulate the growth and maturity of fuel supply markets.
Knowledge and experience	Indirectly	A long-term support mechanism for renewable heat should help create a robust and stable investment environment which will lead to greater levels of participation by external funders, and the development of a larger skill base for installation and operation.
Perception	Indirectly	Public perception of renewable heat technologies will improve indirectly from a long-term support mechanism as a result of higher levels of installation and greater familiarity with the technologies available.

24. An analysis of heat demand in the UK demonstrates the high level of heat consumed by the residential sector as summarised below :

Figure 6: Heat demand by sector (TWh)



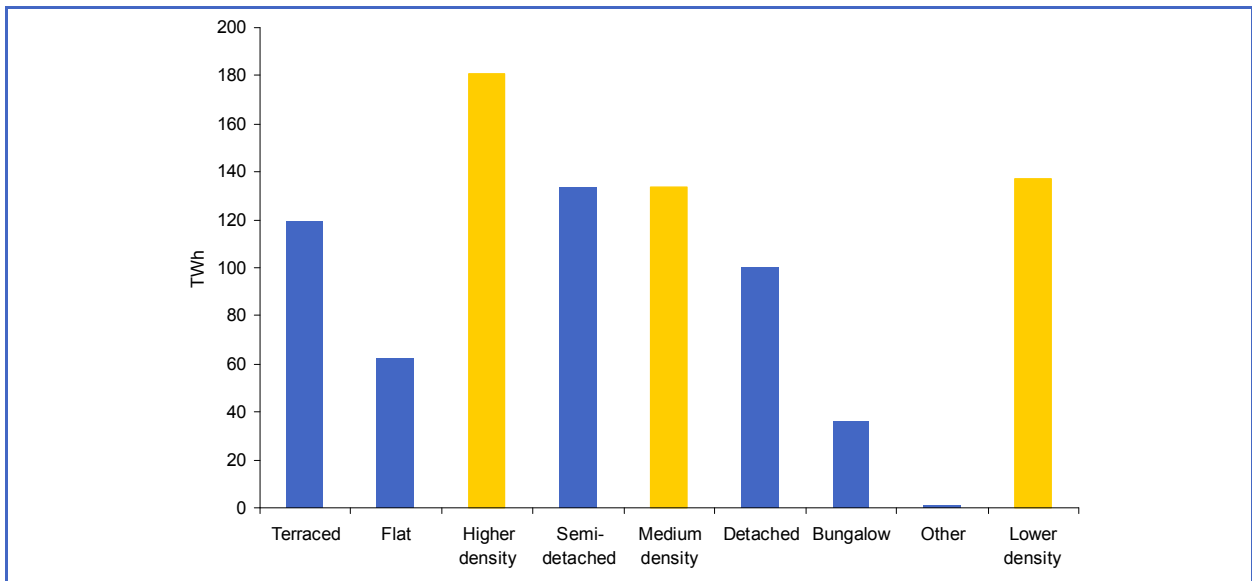
SoSource: urce: Future Energy Solutions

- Large scale biomass, EfW CHP and AD have a restricted use for residential heating without adequate DH networks. Concerns over the fuel transportation requirements of biomass, EfW and AD projects may restrict the levels of deployment that are achievable, particularly in densely populated areas.
- Solar and GSHP technologies are not expected to contribute significantly to the heat demand of the large commercial or industrial users given the physical space requirements to accommodate large scale installations.

25. Higher density housing accounts for approximately 40% of the residential heat demand as set out below:

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Figure 7: Residential heat demand by dwelling type



Source: Source: Future Energy Solutions

- The widespread use of residential biomass heating in higher density housing is likely to be limited given the volume of fuel required (which would need substantial storage), and strict air emissions controls. The lack of physical space in higher density housing areas is also likely to restrict the widespread application of solar thermal and GSHP technologies, given the requirement for adequate suitable roof space or accessible land for the installation of solar thermal and GSHP respectively.
- In the absence of district heating schemes, renewable heat will largely be confined to embedded heat generation in industrial and commercial areas, as summarised in the renewable heat feasibility matrix below:

Table 5: Technologies considered suitable by application

Feasibility matrix	Biomass	AD	EfW CHP	GSHP	Solar thermal
Industrial	✓	✓	✓		
Commercial	✓	✓	✓		
High density housing	✓	✓	✓		
Medium density housing	✓	✓	✓	✓	✓
Low density housing				✓	✓

■ Embedded use
 ■ District heating
 ■ Micro-generation

Note: Allocation of technologies is indicative only; the application of each technology is site-specific and will depend on the specific nature of the project.

Existing financial support mechanisms

26. We set out below a summary of the existing financial support mechanisms that are available for renewable and waste heat:

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Table 6: Existing support mechanisms

Measure	Appraisal
Projects excluding micro generation	
Support mechanisms for RE through the RO affects several technologies namely EfW CHP, Biomass CHP and AD CHP.	Given the undeveloped market for heat, the RO will distort the market in circumstances where CHP is technically viable but the carbon abatement cannot be monetised, therefore favouring electric power output. Recent proposals to band specific technologies under the RO may have a beneficial impact on the financial viability of specific CHP technologies.
EfW will continue to benefit from gate fees due to increases in Landfill Tax and the value of certificates under the Landfill Allowance Trading Scheme (LATS). EfW CHP technology does not gain any additional benefit over power-only configurations in relation to gate fees.	EfW CHP achieves an improved level of carbon abatement when compared to power only EfW configurations. Current proposals following the government's Energy White Paper suggest making certain EfW technologies (such as gasification) automatically eligible for ROCs for at least 65% of their output.
Grants such as the Bio-energy Capital Grants Scheme can be effective in promoting the use and or development of particular technologies.	Capital grants can be effective support measures in particular when applied to path finding initiatives such as the Bio Energy Capital Grants Scheme, Bio-Energy Infrastructure Scheme and Energy Crops Scheme, the latter two of which may be effective in creating networks of producer/growers to overcome some of the fuel supply issues for biomass. These grants do not, however, promote the commercialisation of biomass on a large scale.
The Enhanced Capital Allowances (ECA) Scheme – The ECA scheme allows companies to claim 100% of the capital allowance for specified high quality CHP and domestic biomass boilers, in the first year of purchase from their tax bill.	Prior to the March 2007 Budget, the effectiveness of ECAs was limited only to projects owned by corporates making taxable profits. Changes in the Budget now enable the payment of tax credits in the event ECAs cannot be offset against taxable profits.
The soft loans for energy efficiency are limited to £100,000 and are available for specific project types.	Soft loans are only available for nearly commercially viable small projects (pay back in five years) and whilst useful in limited circumstances, cannot be considered to be a major driver of market development (eg. the wood industry co-product segment).
Micro generation	
Zero and reduced rate VAT.	Reduced rates of VAT apply for some micro renewable energy technologies, such as biomass boilers and ASHP; a move which could help improve the economics of qualifying technologies.
Exemption from personal income tax on exported electricity from micro renewable generation.	Although this stimulates demand for electrical micro generation equipment, it may have an impact on small scale renewable heat and power systems, and may help prepare the market for renewable heat technologies.
Low Carbon Buildings Programme (LCBP).	With additional funding made available in the 2007 Budget, LCBP provides incentives to install micro generation including thermal solar and GSHP. The impact of the grant allows home owners to achieve a payback on their investment over a reduced time period. The grant mechanism has had the paradoxical effect that it has created and restricted the market at the same time. For example, homeowners who want to make use of micro generation might not proceed with installing technologies if grants are only made available in discrete blocks of funding. Non-financial drivers, such as building regulations and planning measures, together with improving public awareness have led to increased uptake of solar thermal and heat pump technology, with only c.10% of installations receiving grants.
Zero Stamp Duty on zero carbon homes	Announced in the 2007 Budget, Treasury proposes waiving Stamp Duty on zero carbon homes up to £500k and a reduced rate for homes of higher value. This could encourage property developers to incorporate micro renewable heat technologies in new or refurbished homes in order to achieve a zero carbon rating.
Energy Efficiency Commitment (EEC)	Licensed energy suppliers must achieve minimum energy savings and carbon reductions from domestic customers, based on defined targets. A levy is charged on the electricity bills of consumers, which is aggregated into a fund, which is then recycled back to provide end users with a type of grant for installing mainly energy efficiency measures in homes. Some micro renewable

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Measure	Appraisal
	technologies, including solar thermal and GSHP/ASHP are included under the scheme, though little take-up has been witnessed to date.
Carbon Reduction Commitment (CRC)	<p>Currently under consultation, CRC would be a cap-and-trade programme targeted at high energy users, specifically those whose annual electricity consumption exceeds 3GWh per annum. This is likely to include retailers, hotels, office buildings, rail operators, public sector buildings, universities, hospitals, light industry. It has been suggested that if renewable heat were included as a means of achieving the target under CRC, then this would encourage take up of this technology in the non-domestic sector.</p> <p>A potential weakness of the CRC in relation to supporting renewable heat is that it encourages users to seek the cheapest form of emissions reductions first (typically energy saving measures) and may not induce sufficient investment in renewable heat technologies to be effective in stimulating this market.</p>

- Some of the indirect support mechanisms, for example the value derived from the sale of green power in CHP installations under the RO, and increasing gate fees for waste disposal, have a significant impact on the financial viability of certain projects.
- When a project has either an RO component or income from gate fees, then it is already receiving substantial existing support. This is reflected in some of the technology sensitivities applied for AD and EfW CHP, where different scenarios for gate fees have a very significant impact on project economics.
- Despite existing support measures, no long-term mechanism exists to support the generation of renewable or waste heat in a heat-only application. The EU ETS does provide indirect support for projects above 20MW, but heat-only projects at this scale are rare. Existing grant programmes for micro generation help support the uptake of such technologies. However, recent increasing levels of uptake appear to be driven primarily by building regulations, planning measures and improving public awareness, rather than grant support.

27. Comparing the effectiveness of capital grants programmes to revenue support mechanisms can be complex and inappropriate for the following reasons:

- Revenue support mechanisms are based on incentivising production, unlike capital grants.
- Grants are generally more suitable for small-scale applications, due primarily to the potentially high administration costs associated with revenue support mechanisms, and the reduction in capital outlay required resulting from grants.
- Revenue support mechanisms would be impractical in residential embedded generation situations where property ownership may change during the longevity of the revenue support programme.
- Grants can be useful for proving new technologies.
- Revenue support is generally more cost effective, and has historically been shown to be successful in helping develop sustainable markets largely due to their longer-term nature.

Non financial support mechanisms

28. In addition to the financial support mechanisms for renewable heat, the support from changing attitudes at a societal level is beginning to make an impact on individuals and their representative bodies. For example the path finding initiative at Merton:

“The council will encourage the energy efficient design of buildings and their layout and orientation on site. All new non-residential developments above a threshold of 1,000 sqm will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy

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requirements. The use of sustainable building materials and the re-use of materials will also be encouraged, as will the use of recycled aggregates in the construction of buildings. This will be subject to the impact on the amenity of the local environment, taking into account the existing character of the area."

29. With 80 other local authorities following the lead of Merton the impact on new build will be significant. Merton is also considering extending the requirement to residential developments. The key constraint of using planning policy to stimulate uptake is that it incentivises installations in new build developments only, and current targets of 10% could be more ambitious. Some local authorities are considering more challenging targets, for example Kirklees Council requires 30% of energy in new and refurbished buildings to come from renewable sources by 2011.
30. Public awareness of renewable heat technologies is improving, however for most individuals other financial priorities will always limit the levels of uptake achieved.

Total cost of support

31. The total cost of supporting renewable heat in the UK has been estimated by applying the level of support required to make each technology cost competitive (minimum and maximum levels of support required under the scenarios evaluated) to the high and low market potential estimates. The total cost of supporting renewable heat is summarised in the table below:

Table 7: Cost of support by technology

Cost assumption	Biomass (residential)	Biomass (commercial)	Biomass (industrial)	AD	EfW CHP	GSHP/ ASHP	Solar thermal	Total
	Compared to gas (low to high), oil and electric heating. Scenarios include 100% wood chip, 50% pellets and 120% fuel cost	Compared to gas (low to high), oil and electric heating. Scenarios include 100% wood chip, 50% pellets and 120% fuel cost	Compared to gas (low to high), oil and electric heating. Scenarios include 100% wood chip, 50% pellets and 120% fuel cost	Scenarios with and without gate fees compared to gas (low to high cost), assumes ROCs received	Scenarios with low and high gate fee compared to gas (low to high cost), assumes ROCs received	Compared to gas (low to high cost), oil and electric heating	Compared to gas (low to high cost), oil and electric heating	
Assumptions								
Lowest level of support required £/MWh	-	-	-	-	-	-	3	
Highest level of support required £/MWh	23	12	4	33	7	51	51	
Market potential (low) TWh	13.5	2.1	7.9	1.5	1.7	4.9	4.9	36.5
Market potential (high) TWh	23.6	3.7	13.8	3.4	5.7	17.1	20.1	87.4
Annual funding requirement (£m)								
Market potential (low), lower cost	-	-	-	-	-	-	15	15
Market potential (low), higher cost	311	25	32	50	12	250	250	929
Market potential (high), lower cost	-	-	-	-	-	-	60	60
Market potential (high), higher cost	543	44	55	112	40	872	1,025	2,692

Executive summary

- Supporting renewable heat could cost up to £2,692m per annum. These numbers are heavily influenced by:
 - › the timing, longevity and form of any support mechanisms employed
 - › the technology mix chosen to increase the contribution of renewable heat
 - › technological developments and cost reductions in coming years
- Solar and GSHP will be more expensive to support than other technologies, but are reasonably straightforward to install and operate, which should help encourage uptake in the domestic sector.
- Large EfW and AD CHP projects already have the potential to be commercially viable solutions due to the support from ROCs and increasing levels of potential gate fee income.
- Biomass becomes increasingly less cost effective with smaller plant capacities, and this may slow the rate of growth within the commercial sector despite smaller schemes being easier to implement than larger schemes. Residential biomass projects are less cost effective since automated units are dependent on pellet use, resulting in a higher feedstock price.

Conclusion

- The market potential for renewable heat is large, with the potential to deliver between 37 TWh and 87 TWh by 2020 (equivalent to between 5% and 12% of the current UK heat requirement). There is market failure in that carbon savings resulting from the use of renewable heat are not currently being recognised through some form of support regime.
- Significant carbon abatement in the order of 4 to 5 million tonnes per annum could be achieved. The cost effectiveness of renewable heat in terms of cost per carbon saved varies considerably between different renewable and waste heat technologies, but under a number of different scenarios certain technologies compete effectively with the cost of carbon saved by onshore wind when compared to CCGT.
- The overall cost of supporting renewable and waste heat technologies could be up to £2.7 billion per annum by 2020.
- Large biomass boilers, biomass CHP and EfW CHP are more cost effective in terms of carbon abatement, but have a lower market potential than micro generation.
- A number of barriers have been identified that should be addressed to maximise the contribution from renewable heat:
 - The infrastructure requirements for district heating
 - The significant fluctuations in price, availability and quality of biomass feedstocks
 - Non-financial barriers such as public awareness and concerns over technical performance, and compliance with planning and building regulations
- On the basis of the levelised cost comparison undertaken, renewable heat will require support. The *Renewable Heat Support Mechanisms* report, which follows the IBC, outlines existing and possible future support mechanisms, both financial and non-financial, that could be used to stimulate the market for renewable heat and help achieve market potential.

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Definitions

ACT	Advanced Combustion Technology
AD	Anaerobic Digestion
ASHP	Air Source Heat Pumps
BERR	Department for Business, Enterprise and Regulatory Reform
Biomass Taskforce Report	Report compiled by the Biomass Task Force dated October 2005
BMW	Biodegradable Municipal Waste
Capex	Capital Expenditure
CCGT	Combined Cycle Gas Turbines
CCL	Climate Change Levy
CERT	Carbon Emissions Reduction Target (formerly EEC3)
CHP	Combined Heat and Power
CHPA	Combined Heat and Power Association
Contribution Projection	The projection of new heat capacity in 2010 and 2020 as included in the FES Report and Biomass Taskforce Report
Cost Effectiveness of Carbon	The results of the societal analysis for Treasury on renewable heat technologies, presented both on a cost per carbon tonne basis (£/tonne), and the total cost to achieve the tonnes of carbon saved per the Contribution Potential
CRC	Carbon Reduction Commitment (formerly the Energy Performance Commitment, EPC)
DEFRA	Department for Environment, Food and Rural Affairs
DH	District Heating
E&Y	Ernst & Young LLP
ECAs	Enhanced Capital Allowances
EEG	Erneubare Energie Gesetz (German renewable energy law)
EfW	Energy from waste
EST	Energy Saving Trust
EU ETS	European Union Emissions Trading Scheme
FES Report	Report compiled by Future Energy Solutions (AEA Technology) entitled "Renewable Heat and Heat from Combined Heat and Power Plants – Study and Analysis"
Funding Requirement	The results of the commercial analysis on the economic barrier for renewable heat technologies, presented both on a £/MWh basis and total funding required to achieve the 2010 Contribution Projection
GC	Green Certificate
GSHP	Ground Source Heat Pumps
GWh	Gigawatt hour (1,000MWh)
IBC	Initial Business Case
IPPC	Integrated Pollution Prevention and Control
IRR	Internal Rate of Return
kW	Kilo Watt
kWh	Kilowatt hour (1,000 Watt hours)
LATS	Landfill Allowance Trading Scheme
LEC	Levy Exemption Certificate
MW	Mega Watt
MWh	Megawatt hour (1,000kWh)

Definitions

MSW	Municipal Solid Waste
MTC	Million tonnes of carbon
NGO	Non Governmental Organisation
NPV	Net Present Value
O&M	Operation and Maintenance
Opex	Operating Expenditure
PFI	Private Finance Initiative
PPA	Power Purchase Agreement
PPS22	Planning Policy Statement 22: Renewable Energy - this sets out the Government's policies for renewable energy, which planning authorities should have regard to when preparing local development documents and when taking planning decisions
Public Sector / Commercial	Commercial & Public Office, Warehouse and Factory Buildings
RDF	Refuse Derived Fuel
REA	Renewable Energy Association
RO	Renewables Obligation
ROC	Renewables Obligation Certificate
SME	Small and Medium Enterprise
tC	Tonnes of carbon
TWh	Terawatt hour (1,000GWh)
VAT	Value Added Tax

1. Introduction

According to the Biomass Task Force Report (April 2006), heat accounts for over a third of primary energy consumption within the UK³, yet only 1% of the heat market is currently sourced from renewable fuels and no targets are in place to increase this level of contribution. Whilst the use of renewable fuel sources for electricity generation is currently supported by the Renewables Obligation, and a Renewable Transport Fuel Obligation has recently been announced to support the use of biofuels, no similar incentives exist for the generation of heat from renewable sources.

As part of its commitment to promoting renewable heat, Government has appointed Ernst & Young LLP (E&Y) to:

- Quantify the potential size of the renewable heat market, and the potential carbon savings that could result from realising this potential.
- Determine the areas of the renewable heat sector where there is most likely to be a market failure.
- Identify other key barriers that are limiting the uptake of renewable heat.
- Assess the current level of support for renewable heat to be utilised in various sectors.
- Obtain the initial views of the key industry sectors as to potential benefits of long-term support.
- Gather market views on the level of additional financial support likely to be required and potential forms of support to realise the potential of renewable heat.
- Identify the practical considerations that would need to be factored into the design of possible support mechanisms or a wider support framework.

As an outcome of this work, E&Y has undertaken an assessment of whether there is a need for support (by way of Government intervention) for the renewable heat sector. This report constitutes an Initial Business Case (IBC) justifying the need for support. In preparing the IBC, we have undertaken a focused consultation exercise with key stakeholders in the renewable heat sector.

A second phase of work has been undertaken whereby appropriate support measures or mechanisms (either singularly or in combination) have been identified that could help support a sustainable and cost effective renewable heat market.

The IBC comprises three main sections as outlined below:

Table 8: Outline of IBC

Executive Summary	An analysis of the key findings identified.
Methodology	Setting out the key methodologies employed as part of this study.
Technology analysis	An analysis of the economics of the individual technologies consisting of market potential, support required, cost effectiveness, barriers to implementation and current support available.

³ Biomass Task Force: Report to Government, October 2005

Introduction

The IBC includes a range of Appendices that include a copy of the questionnaire for reference, a control list of the parties approached and responses received, references used and the assumptions made in the economic analysis of the individual renewable and waste heat technologies studied.

2. Methodology

2.1 Outputs

The methodology underlying the IBC focused on delivering three key outputs:

Table 9: Outputs from the IBC

Output 1	<p>An economic analysis, focusing on two areas:</p> <ul style="list-style-type: none"> • Societal analysis: A comparison by technology of cost effectiveness of carbon reduction. The analysis applies criteria agreed with DEFRA/BERR, representing the requirements of Treasury. • Commercial analysis: A comparison of the funding requirement of each technology in order to ensure commercial competitiveness with alternative conventional heat technologies. The analysis has been performed on a levelised cost basis as agreed with DEFRA/BERR.
Output 2	To identify other (ie non financial) barriers that either currently, or may in the future, prevent the market potential of renewable heat technologies from being realised.
Output 3	To appraise existing support mechanisms, both direct and indirect, that impact on the renewable heat sector.

2.2 Approach

A consultation was carried out with key stakeholders already active in and / or knowledgeable of the UK renewable heat sector. Parties approached were provided with an opportunity to respond, either to a questionnaire that was compiled and agreed with DEFRA/BERR, or to participate in a workshop facilitated by E&Y. The questionnaire is included in Appendix A to this report.

In total E&Y approached 31 external parties during the consultation exercise, and responses were received from 20 parties. The parties approached included:

- Trade associations for the main renewable heat technologies;
- A range of NGOs and public sector bodies;
- Key industry players for the renewable heat technologies;
- Some utilities; and
- Individuals within government.

Specific meetings have been held with three key parties, namely the Renewable Energy Association (REA), the Combined Heat and Power Association (CHPA) and the Carbon Trust, and regular contact has been maintained with the REA throughout the consultation. E&Y attended a BERR workshop on 15 December 2006, covering the report, Economic Analysis of Biomass Energy (Version 3)⁴, at which participants' comments relating to the consultation were collated.

⁴ *The Economics of Biomass, George Marsh, BERR December 2006*

Methodology

2.3 Technologies

The renewable heat technologies considered in this IBC, and the applications they relate to, are set out below.

Table 10: Technologies considered within the IBC

Technology	Residential	Commercial	Industrial	Centralised
Biomass	✓	✓	✓	✓
GSHP/ASHP	✓	✓	✗	✗
Solar thermal	✓	✓	✗	✗
Geothermal	✗	✗	✗	✗
Energy from Waste (EfW)	✗	✓	✓	✗
Anaerobic Digestion (AD)	✗	✗	✗	✓
Landfill Gas	✗	✗	✗	✗

Note from the table above that the commercial category of heat users includes the public sector. Furthermore, in the case of biomass, district heating is included in the industrial category and combined heat and power (CHP) in the commercial category (ie stand alone energy projects, selling heat to third parties). The solar thermal category covers hot water only. Whilst space heating solar thermal installations are being realised in certain European countries, the market is yet to develop in the UK.

It has been agreed with DEFRA that geothermal has been excluded from the analysis due to the limited resource potential in the UK. EfW by way of advanced conversion technology (ACT) has been excluded given the relative lack of maturity of this technology. EfW with CHP has been included in the analysis. It should however be noted that omission of ACT in this analysis should not exclude such technologies from any future renewable heat targets or long-term support mechanisms. In particular, RO qualifying EfW technologies may have an important role to play as both a waste management solution and in the generation of renewable heat and power.

Landfill gas is currently an economic technology for electricity generation. However, the economics for heat generation are dependent on the cost of the heat transmission infrastructure required. Whilst landfill gas was included in the consultation, the feedback received indicated that the market size for renewable heat from landfill sites is limited due to the distance of the majority of landfill sites from suitable heat users, and no clear feedback regarding technology economics for heat use was received during the consultation. Landfill gas has therefore been excluded from the scope of the IBC. Injection of biogas into the gas grid has not been considered within the IBC given the early stage of this technology.

Methodology

2.4 Economic analysis

2.4.1 *Generic steps*

An economic analysis was undertaken for each of the renewable heat technologies, and the following outputs were produced:

- Market potential
- Support required
- Cost effectiveness

The market potential outputs consist of the current contribution (TWh/y) of the technology, a 'business-as-usual' scenario, and potential market size (based on estimated realisable potential ("market potential") and technically feasible market potential ("technical potential").

Levels of support required (in terms of £/MWh) for each of the renewable and waste heat technologies were assessed by comparing the technologies to conventional heating alternatives. Through a levelised cost analysis, a required level of support was identified that would make each technology cost competitive with conventional heating alternatives including gas, oil and in some cases electricity.

The cost effectiveness output comprises the cost of the carbon saved for each of the heat technologies (£/tC), and is produced for the societal impact only (at 3.5% discount rate), since carbon emissions are considered in the context of society as a whole rather than for individual firms.

The carbon intensity figures for each renewable heat technology in relation to conventional sources of heat are provided in Appendix D. Biomass, AD and solar thermal are assumed to be entirely carbon neutral (transportation/manufacturing carbon element excluded). GSHP and ASHP have lower carbon abatement factors since these consume electricity in their operation. EfW is assumed to have a lower carbon abatement factor since it is likely to be of mixed waste stream with some fossil fuel contribution.

These outputs are presented in section three of this report for each technology.

The methodology behind the different approach undertaken for each of these analyses is outlined in the following sections.

2.4.2 *Commercial analysis (used to calculate support required)*

- Using a levelised cost methodology, the capital costs of commercial and industrial scale renewable and waste heat technologies have been annualised over their estimated useful economic life at an appropriate annuity factor (this is the same as the discount factor per Table 11 below). Residential technologies are evaluated assuming the full capital cost is incurred upfront, since it is considered more likely that users will consider the investment in renewable heat technology as a one-off cost that will contribute to the capital value of their property. This difference in methodology has no effect on the funding support required under the commercial analysis.
- Ongoing operating costs, input fuel costs (where appropriate), fuel cost savings (where appropriate) and other sources of revenue (eg income from the sale or

Methodology

power or gate fee receipts (where appropriate) are then discounted at a discount rate appropriate for a particular type of plant owner. This methodology results in a levelised cost per MWh for each of the technologies being considered.

The table below summarises the estimated useful economic life of each of the renewable and waste heat technologies considered, and the discount rates applied for each technology:

Table 11: Useful economic life and discount factors applied to each technology

Technology	NPV period*	Discount factor
Biomass residential	10 years	5%
Biomass commercial	10 years	8%
Biomass industrial	20 years	8%
GSHP/ASHP	20 years	5%
Solar thermal	25 years	5%
AD CHP	20 years	12%
Biomass CHP	20 years	8%
Energy from Waste CHP	20 years	8%

** the NPV period is the period of time over which the NPV is calculated. The period reflects our estimate of the life of each type of installation.*

Through comparing the levelised cost of each renewable and waste heat technology with the levelised cost of an equivalent gas, oil (and in some cases electrical heat) alternatives, the level of support required to achieve cost competitiveness was identified. In the case of gas heating comparisons, the level of funding required was assessed for low, medium and high gas price scenarios.

The levelised cost analysis excludes the impact of taxation. A more detailed explanation of the methodology applied to specific renewable and waste heat technologies is provided in Section 3.

2.4.3 Societal analysis (used in calculating cost effectiveness)

For each of the renewable and waste heat technologies, a societal cost analysis was performed to assess the cost effectiveness (in terms of cost per tonne of carbon benefit) of providing the required levels of support. The societal analysis was performed by applying a discount factor of 3.5% to the ongoing operational cashflows of each technology over the estimated useful economic life.

The societal analysis excludes the impact of taxation, and the impact of existing support mechanisms (eg grants received or support for renewable energy in the case of CHP). The useful economic life assumptions used for the societal analysis are summarised below:

Table 12: Assumption for useful economic life of each technology

Biomass residential	10 years
Biomass commercial	10 years
Biomass industrial	20 years

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GSHP/ASHP	20 years
Solar thermal	25 years
AD	20 years
Biomass CHP	20 years
Energy from Waste	20 years

Through comparing the levelised societal cost of each renewable and waste heat technology with the levelised cost of the conventional heating alternatives, the societal cost of support was identified.

Cost effectiveness of achieving carbon savings were calculated for each renewable heat technology on a cost per carbon tonne basis (£/tC). Cost effectiveness is calculated as the societal cost of support divided by the net carbon savings per MWh of output. Cost effectiveness therefore provides a measure of the cost to society in achieving one tonne of carbon savings in relation to heat-related and other support mechanisms which may apply to the technology. Note that the LATS credits and the Landfill Tax elements of gate fees, together with income derived from the Renewables Obligation are excluded from cost effectiveness calculations for carbon abatement since the real cost to society is gross of economic benefits already received by a technology, thus indicating the full carbon cost to society of all forms of support for a particular technology.

These results are presented separately for each technology in Section 3 of the report.

2.4.4 Sensitivities

A number of sensitivities have been applied to the results of the economic analysis, in particular:

- A range of gas fuel prices to enable a comparison for each technology on a low, medium and high gas price scenarios;
- A variation in the mix of biomass content; either 100% woodchip; or 50% pellets, 50% woodchip;
- A 20% increase in the cost of biomass fuel applied to both the above scenarios;
- Variation in the AD waste streams by comparing those receiving a gate fee to those not receiving a gate fee;
- A 50% increase in the cost of biomass fuel source for the biomass CHP plant;
- A 50% increase in the gate fee received by EfW CHP plants; and
- A 20% increase in capital and operating costs of biomass, AD and EfW CHP technologies to reflect the installation and operation of a DH scheme.

2.4.5 Limitations

It is important to note the following points in respect of the analysis performed:

- The gas and oil price forecasts are based on third party analysis. Given the recent volatility in gas prices, economic comparisons involving gas price forecasts are inherently uncertain.

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- Biomass fuel supply costs are based on current cost estimates. Long-term fuel supply contracts are not currently available in the market, making long-term price forecasting highly uncertain.
- The analysis does not take account of potential reductions in capital and operating costs as the market for renewable heat technologies expands. Cost reductions that may be realised will reduce the cost of carbon saved in the future.
- Appendix D provides a list of the technology specific assumptions used in undertaking this analysis. Tax, including the impact of Enhanced Capital Allowances on certain heat technologies such as biomass CHP, has not been included in the levelised cost calculations. Some of the key tax implications are considered in the commercial analysis.

3. Technology analysis

3.1 Biomass

Biomass involves using wood, straw or selected other organic matter (eg chicken litter) to fuel combustion. Given the low density of these fuels in comparison to fossil fuels, greater volumes of input are required to produce the same amount of energy. In the UK, the largest energy market for biomass is the residential use of logs on open fires for space heating. In addition, there are six biomass combustion electricity generation schemes currently in operation.

3.1.1 Market potential

A number of publicly available reports were analysed to produce a range of estimates for current contribution, business as usual estimates, technical potential and market potential at 2020 for the domestic, commercial and industrial, heat sectors as summarised in the table below.

Table 13: Market potential for biomass

	Residential TWh/y	Commercial TWh/y	Industrial TWh/y
Current contribution ⁵	2.4	-	1.8
'Business as Usual' (2020)*	2.4	-	0
Technical potential (low) ³	19.5	6.0	18.2
Technical potential (high) ⁶	84.1	24.9	75.5
Market potential (low)**	13.5	2.1	7.9
Market potential (high) ⁷	23.6	3.7	13.8

* 'Business as Usual' scenario does not include commercial biomass technologies since this is not categorised in DUKES. It is assumed therefore that commercial biomass would be included within either residential or industrial. It is an extrapolation to 2020 from 2003 to 2005 heat production attributable to biomass.

** Market Potential (low) based on achieving 7% renewable heat in the UK by 2015³. Long term market potential likely to be slightly higher.

Current contribution of biomass heat has been extrapolated to 2020, giving a projected 'base case' scenario (assuming current trends continue). Industrial biomass use has decreased over the past three years, hence it is projected to be zero by 2020. Recent trends have been attributed to increasingly strict emissions controls by local authorities⁵. Residential biomass has been projected to remain unchanged in the business-as-usual scenario, which is significantly below both technical and market potential estimates.

Technical potential takes into account all potential sources of biomass feedstock and assumes these to be used in the generation of heat. Consequently it gives a picture of overall market size, although this may be practically difficult to achieve given other constraints such as demand for biomass for power generation, the use of energy crops in biofuels production, and actual site availability.

According to reports from the Biomass Task Force and the Carbon Trust, market potential for biomass heating is significantly higher than is currently installed. A key

⁵ Digest of UK Energy Statistics ('DUKES'), July 2006

⁶ Renewable Heat and Heat from Combined Heat and Power Plants – Study and Analysis ("FES Report"), Future Energy Solutions ("FES"), AEA Technology, 2006

⁷ Biomass Sector Review for the Carbon Trust, The Carbon Trust, October 2005

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component of biomass use could be derived from woody energy crops and dry agricultural residues⁷.

The market potential estimate suggests that biomass heat could contribute between 1.8% and 3.1% of the UK's total heat demand (based on total heat market of 770 TWh/y).

3.1.2 Biomass support required

Using a levelised cost analysis, the cost of heat produced from biomass sources has been calculated, and through a comparison with alternative conventional heat sources (gas and oil) the level of funding required has been assessed. A number of scenarios have been modelled to show the effect of different feedstock fuel prices.

The analysis set out in this section provides a summary of the levelised costs, funding support required and cost effectiveness of biomass boilers, based on a typical size of project for each application (residential, commercial or industrial). A summary of each application is provided below and detailed cost assumptions are given in Appendix D.

Table 14: Summary of biomass projects by application

Biomass	Residential	Small commercial	Medium commercial	Industrial
Plant size	20kW (to replace similar gas boiler)	100kW (to replace similar gas boiler)	1,000kW (to replace similar gas boiler)	20,000kW (to replace similar gas system)
Feedstock	Wood chip or pellet/log	Wood chip	Wood chip	Wood chip

The table below summarises the level of funding support required assuming feedstock consists of 100% woodchip:

Table 15: Biomass support required – 100% wood chip

100% wood chip	Residential £/MWh	Commercial £/MWh	Industrial £/MWh
Cost of heat produced	45	14	8
Support required to be cost competitive with gas (low)*	14	7	3
Support required to be cost competitive with gas (med)*	10	5	1
Support required to be cost competitive with gas (high)*	2	2	(1)
Support required to be cost competitive with oil*	13	(4)	0
Support required to be cost competitive with electricity*	(34)	N/A	N/A

*This relates to the funding required to make biomass economically attractive for replacing gas, oil or electricity.

On the basis of the figures above, residential, commercial and industrial woodchip (or wood logs for residential) biomass heating all require support when compared to an equivalent gas-fired heating system. A comparison to oil fired heat suggests that wood chip fired biomass is already competitive in a commercial application, primarily due to

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higher fuel costs of oil. The high cost of running an electric boiler also makes residential biomass boilers look cost competitive in this scenario.

The table below summarises the level of funding support required assuming feedstock consisting of 50% woodchip and 50% pellets:

Table 16: Biomass support required – 50% pellet

50% wood chip, 50% pellet	Residential £/MWh	Commercial £/MWh	Industrial £/MWh
Cost of heat produced	51	18	N/A
Support required to be cost competitive with gas (low)*	20	10	N/A
Support required to be cost competitive with gas (med)*	16	8	N/A
Support required to be cost competitive with gas (high)*	8	5	N/A
Support required to be cost competitive with oil*	19	0	N/A
Support required to be cost competitive with electricity*	(28)	N/A	N/A

**This relates to the funding required to make biomass economically attractive for replacing gas, oil or electricity.*

The table above shows that where residential or commercial biomass uses an equal combination of wood chip and pellets, support is required to ensure cost competitiveness with gas equivalents. Commercial biomass boilers appear to need less support than residential, particularly when compared to oil fired heating, largely due to lower biomass fuel prices obtained by buying in larger volumes. Residential biomass appears competitive against electric boilers only.

The table below summarises the level of funding support required assuming feedstock consists of 100% woodchip and a 20% increase in fuel costs:

Table 17: Biomass support required – 20% increase in fuel cost, 100% wood chip

100% wood chip 20% increase in fuel costs	Residential £/MWh	Commercial £/MWh	Industrial £/MWh
Cost of heat produced	46	15	9
Support required to be cost competitive with gas (low)*	16	8	4
Support required to be cost competitive with gas (med)*	11	6	2
Support required to be cost competitive with gas (high)*	4	3	0
Support required to be cost competitive with oil*	15	(3)	1
Support required to be cost competitive with electricity*	(33)	N/A	N/A

**This relates to the funding required to make biomass economically attractive for replacing gas, oil or electricity.*

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With a 20% increase in biomass fuel price, woodchip (or logs for residential) biomass becomes even less competitive than gas heating under low and medium gas price scenarios.

With high gas prices (being a 40% increase on the medium scenario), wood chip/log biomass appears to be competitive with an equivalent gas boiler at an industrial scale only.

Similarly, woodchip biomass used in commercial applications could be more economic than an equivalent oil-based scheme, although woodchip biomass would require support in order to be competitive with residential oil boilers.

The table below summarises the level of funding support required assuming feedstock consists of 50% woodchip and 50% pellets, and a 20% increase in fuel costs:

Table 18: Biomass support required – 20% increase in fuel cost, 50% pellet

50% wood chip, 50% pellet 20% increase in fuel costs	Residential £/MWh	Commercial £/MWh	Industrial £/MWh
Cost of heat produced	54	19	N/A
Support required to be cost competitive with gas (low)*	23	12	N/A
Support required to be cost competitive with gas (med)*	18	10	N/A
Support required to be cost competitive with gas (high)*	11	7	N/A
Support required to be cost competitive with oil*	22	1	N/A
Support required to be cost competitive with electricity*	(26)	N/A	N/A

*This relates to the funding required to make biomass economically attractive for replacing gas, oil or electricity.

Applying the 20% fuel price increase when using both wood chip and pellet fuel, suggests that biomass would require support regardless of whether replacing gas or oil fired heating in both residential and commercial applications.

3.1.3 Biomass cost effectiveness

The cost effectiveness of supporting biomass heat (in terms of cost per tonne of carbon saved) has been assessed using a levelised cost analysis with a societal discount rate of 3.5%. The table below summarises the cost effectiveness of supporting biomass under a 100% woodchip fuel mix:

Table 19: Biomass cost effectiveness – 100% wood chip

100% wood chip	Residential £/tC	Commercial £/tC	Industrial £/tC
Cost per tonne relative to gas (low)	234	148	75
Cost per tonne relative to gas (med)	149	107	38
Cost per tonne relative to gas (high)	13	41	(23)
Cost per tonne (oil)	161	(59)	(4)
Cost per tonne (electricity)	(651)	N/A	N/A

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100% wood chip	Residential £/tC	Commercial £/tC	Industrial £/tC
Comparative cost per tonne (onshore wind vs gas CCGT)*	215	215	215

*Source Defra

The most cost effective deployment of biomass is in an industrial application using 100% woodchip feedstock. When commercial wood chip biomass replaces oil-fired heat, it predominately becomes a cost effective means of achieving carbon savings. Compared to gas or oil, commercial and industrial biomass appears to be a more cost effective technology for saving carbon emissions than onshore wind.

The table below summarises the cost effectiveness of supporting biomass under a 50% woodchip, 50% pellet fuel mix:

Table 20: Biomass cost effectiveness – 50% pellet

50% wood chip, 50% pellet	Residential £/tC	Commercial £/tC	Industrial £/tC
Cost per tonne relative to gas (low)	344	219	N/A
Cost per tonne relative to gas (med)	258	178	N/A
Cost per tonne relative to gas (high)	122	113	N/A
Cost per tonne (oil)	242	(6)	N/A
Cost per tonne (electricity)	(590)	N/A	N/A
Comparative cost per tonne (onshore wind vs gas CCGT)*	215	215	215

*Source Defra

When pellets are introduced as a feedstock, greater support is required; hence cost effectiveness reduces per tonne of carbon saved. However, commercial sized biomass would still appear to be a more economic means of achieving carbon savings than residential, but only when gas prices are medium to high can this technology achieve more cost effective carbon savings spent than onshore wind.

The table below summarises the cost effectiveness of supporting biomass under a 100% woodchip fuel mix with a 20% increase in fuel costs:

Table 21: Biomass cost effectiveness – 20% increase in fuel costs, 100% wood chip

100% wood chip 20% increase in fuel costs	Residential £/tC	Commercial £/tC	Industrial £/tC
Cost per tonne relative to gas (low)	264	173	97
Cost per tonne relative to gas (med)	179	132	59
Cost per tonne relative to gas (high)	43	66	(1)
Cost per tonne (oil)	183	(41)	12
Cost per tonne (electricity)	(635)	N/A	N/A
Comparative cost per tonne (onshore wind vs CCGT)*	215	215	215

*Source Defra

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Fuel price increases reduce the cost effectiveness of carbon saved from biomass. Under high gas price scenarios (being a 40% increase on the medium scenario), biomass appears to be cost effective compared to an equivalent oil-fired technology in commercial applications. Even under this fuel price scenario, commercial and industrial biomass is a more cost effective means of achieving carbon savings than onshore wind.

The table below summarises the cost effectiveness of supporting biomass under a 50% woodchip, 50% pellet fuel mix with a 20% increase in fuel costs:

Table 22: Biomass cost effectiveness – 20% increase in fuel costs, 50% pellet

50% wood chip, 50% pellet 20% increase in fuel costs	Residential £/tC	Commercial £/tC	Industrial £/tC
Cost per tonne relative to gas (low)	396	259	N/A
Cost per tonne relative to gas (med)	311	218	N/A
Cost per tonne relative to gas (high)	175	152	N/A
Cost per tonne (oil)	281	23	N/A
Cost per tonne (electricity)	(561)	N/A	N/A
Comparative cost per tonne (onshore wind vs CCGT)*	215	215	215

*Source Defra

Similarly, with pelletised fuel, an increase in fuel costs will have significant effect on the cost effectiveness of this technology, to achieve carbon savings.

3.1.4 Biomass CHP support required

In the case of biomass CHP (which is taken to be a large scale, 30MWth (8MWe) woodchip fired plant), the additional capital cost of CHP configuration is offset by additional income received from electricity sales and ROC income. Given the current uncertainty over the number and price of ROCs received for biomass CHP (due to ROC banding proposals), the analysis assumes one ROC per MWh.

The table below shows the support required for biomass CHP when compared to gas:

Table 23: Biomass CHP support required – excluding DH costs

Base case	£/MWh
Cost of heat produced	(40)
Support required to be cost competitive with gas (low)*	1
Support required to be cost competitive with gas (med)*	(1)
Support required to be cost competitive with gas (high)*	(3)

* This relates to the funding required to make biomass CHP economic compared to industrial gas boilers and gas CCGT

Biomass CHP appears to be marginally economic compared with an industrial gas boiler and gas-fired CCGT power under a medium to high gas price scenario. This is largely attributable to biomass CHP being able to benefit from the sale of ROCs as well as brown power and heat. In this situation therefore, it appears that the RO covers much of the cost of operating the plant. This analysis does assume that a

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market exists for the heat offtake, however, and some form of long-term support is likely to be required to incentivise investment where an uncertain heat market exists.

The table below shows the support required for biomass CHP assuming a 50% increase in fuel costs:

Table 24: Biomass CHP – 50% increase in fuel costs, excluding DH costs

50% increase in fuel cost	£/MWh
Cost of heat produced	(30)
Support required to be cost competitive with gas (low)*	3
Support required to be cost competitive with gas (med)*	2
Support required to be cost competitive with gas (high)*	(1)

* This relates to the funding required to make biomass CHP economic compared to industrial gas boilers and gas CCGT

If biomass fuel costs increase by 50%, the plant becomes less economic compared to industrial gas boilers and CCGT, and in this scenario appears to require additional support under low and medium gas price scenarios.

To reflect the potential impact of DH costs, a 20% increase in capex and opex has been assumed to determine the likely level of support required where DH is included:

Table 25: Biomass CHP – including DH costs

20% increase in capital cost and O&M	£/MWh
Cost of heat produced	(35)
Support required to be cost competitive with gas (low)*	2
Support required to be cost competitive with gas (med)*	1
Support required to be cost competitive with gas (high)*	(2)

* This relates to the funding required to make biomass CHP economic compared to industrial gas boilers and gas CCGT.

With a 20% increase in capex and opex for DH infrastructure, support is required under low and medium gas scenarios. Although the support required is not significant per MWh, these costs may only be recoverable in certain circumstances (eg. new build or redeveloped areas, where a connection charge can be enforced). Applying a connection charge to existing dwellings may be difficult to achieve in practice.

3.1.5 Biomass CHP cost effectiveness

The table below summarises the cost effectiveness (in terms of cost per tonne of carbon saved) of providing the support required to make biomass CHP cost competitive with conventional heat and power alternatives.

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Table 26: Biomass CHP cost effectiveness – excluding DH costs

Base case	£/tC
Cost per tonne relative to gas (low)	(45)
Cost per tonne relative to gas (med)	(74)
Cost per tonne relative to gas (high)	(120)
Comparative cost per tonne (onshore wind vs CCGT)*	215

*Source Defra

The analysis indicates that biomass CHP is cost effective in achieving carbon savings, particularly compared to onshore wind. It is likely that the use of heat and power in biomass CHP, and the increased load factor, improves the cost effectiveness compared to onshore wind, despite biomass emitting some carbon emissions in processing and generation (e.g. harvesting, processing and transport).

The table below summarises the cost effectiveness of biomass CHP assuming a 50% increase in fuel costs:

Table 27: Biomass CHP cost effectiveness – 50% increase in fuel costs, excluding DH costs

50% increase in fuel cost	£/tC
Cost per tonne relative to gas (low)	8
Cost per tonne relative to gas (med)	(21)
Cost per tonne relative to gas (high)	(67)
Comparative cost per tonne (onshore wind vs CCGT)*	215

*Source Defra

A 50% increase in biomass fuel costs causes a significant reduction in the cost effectiveness of this technology, illustrating the sensitivity of biomass to changes in fuel price.

The table below shows the cost effectiveness of biomass CHP with additional capital and O&M costs reflecting the use of a DH network:

Table 28: Biomass CHP cost effectiveness – including DH costs

20% increase in capital cost and O&M	£/tC
Cost per tonne relative to gas (low)	(40)
Cost per tonne relative to gas (med)	(69)
Cost per tonne relative to gas (high)	(115)
Comparative cost per tonne (onshore wind vs CCGT)*	215

*Source Defra

The analysis undertaken suggests biomass CHP used in conjunction with a DH network is a more cost effective technology for abating carbon emissions than onshore wind.

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3.1.6 *Biomass barriers to implementation*

The following are typical barriers identified from our consultation process for biomass heat and biomass CHP technology.

Financial barriers

Market failure

The market does not place a value on the carbon-abatement potential for a unit of delivered biomass heat. This was cited as the most common market failure by respondents during the workshop.

Incentives for sustainable energy

The RO has resulted in the biomass industry focussing its time, investment and innovation in developing electricity based solutions for domestic, commercial and industrial users. Proposals to place certain technologies within 'bands' under the RO, may provide biomass CHP with additional revenue support than it currently receives.

Non-financial barriers

Perception and knowledge

Workshop participants suggested that a lack of knowledge and understanding of the technologies available, feedstock supply and concerns over operational performance amongst potential purchasers were significant barriers to deployment.

A lack of understanding amongst the wider construction industry (architects, consulting engineers and builders) was also identified as a major barrier to the deployment of biomass in the residential sector.

Electricity generation is often considered the favourable option over heat generation due to the infrastructure requirements to distribute heat, and ROC income available to renewable power production.

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Feedback from the consultation suggested that the image of steam is old/historic/noisy and generally not hi-tech, suggesting technology options are not well understood publicly.

Concern about the availability of ongoing O&M and product support was also identified as a barrier.

For smaller scale applications, we understand that specific flue requirements limit the number of buildings in the UK that can be fitted with biomass boilers.

Fuel supply

Although technologies are well developed, with several large suppliers of equipment and construction services, the fuel supply market is relatively undeveloped. This poses difficulties in terms of feedstock availability, fuel quality and price.

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District heating

Retrofitting a district heating system, particularly in a dense urban environment, may result in significant disruption, high levels of installation costs resulting from civil works and an onerous permitting and consenting process.

High levels of perceived development risk, in addition to the high capital costs of installing heat transmission infrastructure, represents a significant barrier to the deployment of district heating networks.

A developer of a district heating network faces largely unproven heat demand, and the risk of subsequent disconnection of customers.

A DH-led heating scheme represents the most likely source of large scale residential renewable heat uptake. Legislative and policy changes to ensure DH installation on new developments, to accelerate the permitting and consenting process, and perhaps some specific financial support to subsidise the cost of long-term heat transmission infrastructure could lead to significant levels of DH-led renewable heat installation.

Suppliers

Currently biomass heating projects are being delivered by a relatively small number of SME developers (typical permanent staff numbers are less than 10), despite the large potential market for this technology. The relatively low value of a renewable heat unit (as compared to a unit of renewable electricity which benefits from a wide range of fiscal measures – the ROC, the LEC, CCL and EU ETS indirectly) has meant that larger contract heating companies that have significantly larger capacity (eg Dalkia, Vital Energi etc.) have not yet become involved in the renewable heat sector.

3.1.7 *Current support*

The support mechanisms currently in place are broadly as follows:

Renewables Obligation (RO)

Renewable electricity currently qualifies for additional income through the sale of ROCs under the Renewables Obligation. The RO provides a long-term revenue based support mechanism that provides some certainty in pricing and creates an investment environment suitable to facilitate long-term investment decision-making.

Energy Efficiency Commitment (EEC)

Under proposed changes to the EEC (to be called the Carbon Emissions Reduction Target or CERT, formerly EEC3), it is likely that end users will be able to access future EEC funding, which may be deployed in a similar fashion to the existing mechanism (which typically comes in the form of a grant from an energy supplier). Licensed energy suppliers are incentivised to provide financial assistance to customers towards energy efficiency and micro generation technologies, for example biomass boilers (residential).

Grants

At present, the carbon-abatement provided by biomass heating is supported by grant schemes which are not necessarily broad enough or large enough to encourage the development of a long term sustainable renewable heat market.

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The third round of the Bio-energy Capital Grants Scheme was launched on the 29 December. The five year scheme is worth £10-15m in England over the two financial years to 31 March 2008. It will support the installation of biomass-fuelled heat and combined heat and power projects in the industrial, commercial and community sectors.

The first round of the Bio-Energy Infrastructure Support Scheme is closed for new applications. However, Defra will be launching a second round of the scheme for England only. The details will be broadly similar to the first round and a total of £3.5m has been allocated UK-wide. There is a maximum grant ceiling of £200,000 per producer group or business.

The Energy Crops Scheme (ECS) provides establishment grants for two energy crops, short-rotation coppice (SRC) and miscanthus.

In Scotland the Bioenergy Infrastructure Scheme, funded by Defra and administered by Forestry Commission Scotland, was set up to provide grants to farmers, foresters and businesses to help develop the supply chain required to harvest, store, process and supply energy crops and woodfuel to energy end-users.

The Low Carbon Buildings Programme (LCBP) provides grant support of between 30% - 50% for micro generation technologies, including biomass boilers. This grant is available over the short term, but there is no guarantee as to the longevity of the programme, although it was recently extended in the March 2007 Budget.

Grant support schemes for biomass heating are considered to be 'stop/start' in nature by the participants in the consultation process, and are not considered to be universally available.

Administrative complexity in relation to grant funding can limit the take-up of grants.

Loans

The Carbon Trust Energy Efficiency Loans Scheme can provide capital (up to £100,000) to fund energy saving projects that have a payback of five years or less. The loans are unsecured but conditions apply.

Uptake of loans within certain sectors using biomass heating plant has been significant (primarily in the 'Wood-industry co-product' segment – which includes technology manufactured by companies such as Talbotts, Ranheat and Mawera). Large levels of uptake are believed to be attributable to this particular market sector being able to benefit from gate fees rather than paying for fuel costs.

The EU ETS would act as indirect support for projects above 20MW, but heat-only projects at this scale are rare.

VAT reduction

The decision by the Government to reduce VAT on grant funded micro renewable CHP is a move which could help improve the economics of qualifying technologies.

However, in the opinion of one of the consultees, such savings will only be significant if this reduction is available for one-off domestic customers and on the total installation of the micro renewable CHP boiler and not just the product.

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Taxation

The Enhanced Capital Allowances (ECA) scheme allows companies to claim 100% of the capital allowance against taxable profits for specified good quality renewable CHP, biomass boilers and room heaters in the first year of purchase.

The March 2007 Budget announced changes whereby non-taxpaying entities will receive a tax credit in relation to unclaimable ECAs. This is a welcome amendment, however such tax relief is only available to corporates and not individuals.

3.2 AD CHP

Anaerobic digestion involves the conversion of organic matter to energy by microbiological organisms. This produces three outputs; biogas, which can be used to generate heat and electricity; fibre, which can be used as a fertiliser; and, liquor which can also be used as a fertiliser.

3.2.1 AD CHP market potential

Table 29: Market potential of anaerobic digestion CHP

	Industrial TWh/y
Current contribution ⁵	0.6
'Business as Usual' (2020)*	0.2
Technical potential (low) ³	4.0
Technical potential (high) ⁶	91.0
Market potential (low)**	1.5
Market potential (high) ⁶	3.4

⁵Refers to extrapolated data to 2020 based on 2003 to 2005 trend in heat generated from Anaerobic Digestion

*^{**}Market potential (low) based on achieving 7% renewable heat in the UK by 2015³. Long term market potential likely to be slightly higher.*

The wide range of estimates from third parties in terms of technical potential highlights the difficulties in providing such estimates and the limited reliance that can be placed on them. FES estimates a higher technical potential than the base case and market potential largely because they estimate limitations relating to location of heat users relative to the digestion plant and the infrastructure required to transport the heat. The Biomass Task Force estimates a technical potential much lower than FES.

The trend in the last three years, which provide the basis for the 'business as usual' scenario, has been downwards as older plant is decommissioned. In the current regulatory environment, ROC-eligible plant may be developed to maximise electrical output, meaning that heat from AD CHP could remain static or even decline in the future.

The market potential shows the different views of the Biomass Task Force and FES, with AD potentially contributing between 0.2% and 0.4% of the UK heat supply.

3.2.2 AD CHP support required

The table below summarises the estimated levels of support required for AD CHP to be cost competitive (assuming the receipt of gate fees, and income from the sale of electricity, ROCs and heat) based on the levelised cost analysis performed. This

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analysis is based on a 2,188kWth (2,100kWe) AD CHP plant. Details of the assumptions used in this analysis are given in Appendix D.

Note that the cost assumptions used in the base case scenario do not include costs associated with installing and maintaining a DH scheme. Again, further analysis has been performed to show the impact of 20% additional capex and opex on the funding required and cost effectiveness.

Table 30: AD support required – with gate fees, no DH costs

With gate fee	£/MWh
Cost of heat produced	(45)
Support required to be cost competitive with gas (low)*	(41)
Support required to be cost competitive with gas (med)*	(45)
Support required to be cost competitive with gas (high)*	(51)

** This relates to the funding required to make AD CHP economic compared to commercial gas boilers and gas CCGT power.*

Even with a modest gate fee of £21/tonne, the figures above demonstrate the importance of gate fees on the economics of anaerobic digestion. In this situation, AD CHP does not appear to need additional support over and above existing support mechanisms.

The table below summarises the estimated levels of support required for AD CHP to be cost competitive (assuming no gate fees are received) based on the levelised cost analysis performed:

Table 31: AD CHP support required – no gate fees, no DH costs

Without gate fee	£/MWh
Cost of heat produced	30
Support required to be cost competitive with gas (low)*	33
Support required to be cost competitive with gas (med)*	30
Support required to be cost competitive with gas (high)*	24

** This relates to the funding required to make AD CHP economic compared to commercial gas boilers and gas CCGT power.*

AD CHP that do not benefit from gate fee income do not compete with gas alternatives, and funding support is required to ensure cost competitiveness.

In a similar manner to Biomass CHP, the following table shows the effect of increasing capex and opex by 20% to reflect the additional costs associated with installing and maintaining a DH network.

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Table 32: AD CHP support required – with gate fees and DH costs

With gate fee and 20% increase in capex and opex for DH	£/MWh
Cost of heat produced	(34)
Support required to be cost competitive with gas (low)*	(30)
Support required to be cost competitive with gas (med)*	(34)
Support required to be cost competitive with gas (high)*	(39)

* This relates to the funding required to make AD CHP economic compared to commercial gas boilers and gas CCGT power.

AD CHP is less sensitive to capex and opex than it is to gate fees, although a 20% increase has a c.25% negative impact on the support required to be cost competitive with gas. The costs of installing and maintaining a DH network may not be recoverable, hence developers have historically been reluctant to incur these costs unless they have to (eg. where it is a condition of planning).

3.2.3 AD CHP cost effectiveness

The table below summarises the cost effectiveness of providing AD CHP with the required level of support:

Table 33: AD CHP cost effectiveness

Without gate fees	£/tC
Cost per tonne relative to gas (low)	1,351
Cost per tonne relative to gas (med)	1,279
Cost per tonne relative to gas (high)	1,164
Comparative cost per tonne (onshore wind vs gas CCGT)*	215

*Source Defra

AD CHP results in a higher cost of carbon savings than onshore wind. Existing barriers discussed below highlight possible reasons why AD CHP has not widely been implemented in the UK, such as proximity to heat consumers. It is worth noting that cost effectiveness in the table above excludes gate fees, ROC income and tax benefits attributable to AD CHP, and it is on this basis that it does not appear cost effective when compared to onshore wind.

When an element of gate fee is added to this calculation (at £21/tonne), to account for handling or tipping fees that might be charged (but are unrelated to Landfill Tax or LATs and hence there is no double-counting of the carbon benefits), the cost effectiveness is as follows:

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Table 34: AD CHP cost effectiveness – no DH costs

With £21/tonne gate fees**	£/tC
Cost per tonne relative to gas (low)	(1,102)
Cost per tonne relative to gas (med)	(1,174)
Cost per tonne relative to gas (high)	(1,289)
Comparative cost per tonne (onshore wind vs gas CCGT)*	215

*Source Defra

**£21 per tonne gate fee takes into account possible tipping / handling fees charged by the plant, which are unrelated to carbon benefits from Landfill Tax and LATS

The receipt of gate fees are an important factor in the cost effectiveness of AD CHP. A low gate fee (such as £21/tonne) makes this technology cost effective in carbon abatement terms, particularly when compared to the cost effectiveness of onshore wind.

The cost effectiveness of AD CHP with some gate fee (£21/tonne) and additional capital and operating costs to reflect the use of a DH network is detailed below.

Table 35: AD CHP cost effectiveness – with DH costs

With £21/t gate fee and 20% increase in capex and opex	£/tC
Cost per tonne relative to gas (low)	(627)
Cost per tonne relative to gas (med)	(688)
Cost per tonne relative to gas (high)	(786)
Comparative cost per tonne (onshore wind vs gas CCGT)*	215

*Source Defra

**£21 per tonne gate fee takes into account possible tipping / handling fees charged by the plant, which are unrelated to carbon benefits from Landfill Tax and LATS

AD CHP becomes around 40% less cost effective for abating carbon when additional capex and opex are incurred (to reflect the use of a DH scheme).

3.2.4 AD CHP barriers to implementation

The following are typical barriers identified from our consultation process for this technology.

Financial barriers

Market failure

AD CHP appears to be cost competitive when receiving gate fee income, despite the value of carbon abatement not being realised in relation to heat production. The ability to monetise the value of carbon abatement would improve the economics of AD CHP where gate fee revenue cannot be realised.

Revenue

Both the heat and electricity produced are potentially important revenue streams, with electrical output qualifying for ROCs. However, few schemes meet the requirement of having both access to the electricity grid and accessible local heat demand.

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Operating cost base

The cost of using anaerobic digestion is generally more expensive than alternative waste treatment technologies in particular.

Finance

There has been limited experience of lenders and other third party financiers investing in AD CHP plant in the UK to date. Technology risk, the credit quality and track record of AD CHP equipment providers and contractors, and the lack of adequate deal flow in the UK has limited the appetite of third party investors.

Non-financial barriers

Complexity of the market

Unlike other technologies, AD CHP cuts across the boundaries agricultural waste disposal, environmental protection, and renewable energy production. Policies and regulation in each of these areas do not necessarily specifically support anaerobic digestion.

Legislation

Lack of UK-wide certification for digestate means that the issues such as a lack of confidence in the quality of the digestate cannot be addressed and therefore open a potentially lucrative market, which would also have benefit of displacing natural gas used in production of nitrogen based fertilisers.

Perception and knowledge

Modern anaerobic digestion plant is different from the small-scale, rural farm systems used historically. Many facilities have been built world-wide, but there is still uncertainty about the ability of the technology to work.

3.2.5 AD CHP current support mechanisms

AD CHP can benefit from ROCs and grants in a similar way to biomass CHP.

The Enhanced Capital Allowances scheme allows companies to claim 100% of the capital allowance against taxable profits for specified good quality renewable CHP, biomass boilers and room heaters in the first year of purchase.

The March 2007 Budget announced changes whereby non-taxpaying entities will receive a tax credit in relation to unclaimable ECAs. This is a welcome amendment; however, such tax relief is only available to corporates and not individuals.

3.3 Energy from waste (EfW) CHP

Waste represents an increasingly important fuel source and contributes to the achievement of landfill diversion targets. It can help reduce carbon emissions, through displacement of fossil fuels and avoids methane production resulting from the decomposition of landfilled biodegradable waste.

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3.3.1 EfW market potential

Table 36: Market potential of Energy from Waste

	TWh/y
Current contribution ⁵	0.4
'Business as Usual' (2020)*	0.4
Technical potential (low) ⁶	15.0
Technical potential (high) ⁶	22.8
Market potential (low)**	1.7
Market potential (high) ⁶	5.7

⁵Extrapolated data to 2020 based on 2003 to 2005 trend in EfW heat production.
⁶ILEX report assumes equal production of heat and power from large scale EfW⁶

The 'business as usual' scenario assumes no increase in heat from EfW to 2020, based on the last three years' data. This is consistent with the low build rate of heat only and CHP EfW plants to date.

Technical potential takes into account realisable energy from waste projects by 2020. The majority of EfW projects have to date not utilised CHP technology. The key barrier to the future development of EfW is most likely to be planning (due to high levels of public opposition), which, combined with long construction lead times, suggests little new EfW CHP capacity will be added in the near term.

Furthermore, it is likely that EfW CHP projects would need to be close to residential and commercial buildings to present an opportunity for viable heat offtake, which may further limit the exploitation of heat from EfW due to planning constraints.

3.3.2 EfW CHP support required

In the case of EfW, a 440 tonne per annum plant has been modelled, capable of producing 40MWth heat and 24MWe power. Further details of the assumptions used are detailed in Appendix D.

The table below summarises the estimated levels of support required for EfW CHP to be cost competitive to gas based on the levelised cost analysis.

Table 37: EfW CHP support required – with gate fees, no DH costs

Base case – with gate fee	£/MWh
Cost of heat produced	(23)
Support required to be cost competitive with gas (low)*	0
Support required to be cost competitive with gas (med)*	(1)
Support required to be cost competitive with gas (high)*	(2)

* This relates to the funding required to make EfW CHP economic against industrial gas boilers and gas CCGT

Assuming gate fees of £55/tonne, the plant is marginally more economic than gas (at medium to high prices) and therefore does not appear to require funding support. It

⁶ Extending ROC Eligibility to Energy from Waste with CHP, ILEX Energy Consulting, September 2005

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should be noted that the gate fees achievable may exceed £55/tonne due to increasing pressure on local authorities to achieve landfill diversion, and the March 2007 budget increasing the annual step in landfill tax from £3/tonne per annum to £8/tonne per annum.

The table below summarises the estimated levels of support required for EfW CHP to be cost competitive to gas under a high gate fee scenario (assuming an £80/tonne gate fee):

Table 38: EfW CHP support required – high gate fees, no DH costs

50% increase in gate fee	£/MWh
Cost of heat produced	(56)
Support required to be cost competitive with gas (low)*	(12)
Support required to be cost competitive with gas (med)*	(13)
Support required to be cost competitive with gas (high)*	(15)

* This relates to the funding required to make EfW CHP economic against industrial gas boilers and gas CCGT

Assuming gate fees of £80/tonne, EfW becomes economically preferable to gas derived heat generation under all gas price scenarios.

To model the impact of costs associated with installing and operating a DH scheme, a 20% increase in capex and opex has been assumed:

Table 39: EfW CHP support required – with gate fees and DH costs

20% increase in capital cost and O&M	£/MWh
Cost of heat produced	(5)
Support required to be cost competitive with gas (low)*	7
Support required to be cost competitive with gas (med)*	6
Support required to be cost competitive with gas (high)*	4

* This relates to the funding required to make EfW CHP economic against industrial gas boilers and gas CCGT

There is a significant impact on the support required for EfW CHP when the costs for installing and maintaining the DH network are included. Under this scenario, EfW requires support under all gas price scenarios, reflecting the substantial additional cost incurred with installing a DH scheme, which is often not recoverable for project developers.

3.3.3 EfW cost effectiveness

The table below summarises the cost effectiveness of providing EfW CHP with the required level of support to ensure cost competitiveness. The Landfill Tax and LATS elements of gate fees, ROC income and tax benefits are excluded from the cost effectiveness numbers in the table below, which should be a consideration when comparing these against onshore wind.

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Table 40: EfW cost effectiveness

With £20/tonne gate fee**	£/tC
Cost per tonne relative to gas (low)	521
Cost per tonne relative to gas (med)	491
Cost per tonne relative to gas (high)	444
Comparative cost per tonne (onshore wind vs CCGT)*	215

*Source Defra

**£20 per tonne gate fee takes into account possible tipping / handling fees charged by the plant, which are unrelated to carbon benefits from Landfill Tax and LATS

In terms of cost effectiveness, EfW appears to be less economic than onshore wind per tonne of carbon saved.

The cost effectiveness of EfW CHP with additional costs for installing and maintaining a DH network are detailed below.

Table 41: EfW CHP cost effectiveness – with DH costs

With £20 gate fee** and 20% increase in capex and opex	£/tC
Cost per tonne relative to gas (low)	735
Cost per tonne relative to gas (med)	705
Cost per tonne relative to gas (high)	658
Comparative cost per tonne (onshore wind vs CCGT)*	215

*Source Defra

**£20 per tonne gate fee takes into account possible tipping / handling fees charged by the plant, which are unrelated to carbon benefits from Landfill Tax and LATS

Increasing capital costs and O&M by 20% has a negative impact on cost effectiveness of between 27% and 30%.

3.3.4 Barriers to EfW

Financial barriers

Large volumes of municipal solid waste and commercial and industrial waste, together with increased incentives to divert waste from landfill suggests a significant market potential exists. Gate fee income, potential future eligibility for ROCs (pending the Government’s review of ROC banding) and possible sales of heat, would suggest there are few financial barriers to the deployment of EfW CHP. Post-tax nominal project returns for EfW projects typically tend to be between 8% – 12% which does attract third party finance providers to the sector.

Non-financial barriers

Planning

A key reason for delayed or cancelled projects is the opposition from local planners and the general public to waste incineration facilities. Environmental groups have criticised unsorted waste incineration as more harmful to the environment than fossil fuels such as gas as a result of the mix of emissions given off during combustion. Despite cleaner combustion and better waste sorting technologies, public perception

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remains largely against EfW. Consequently, it is believed that few EfW CHP plants will be built before 2010.

District Heating

Retrofitting of a district heating system, particularly in dense urban environments, may result in significant disruption, high levels of installation costs and onerous permitting and consenting processes. Furthermore, new build heat transmission infrastructure can be prohibitively expensive, and in the absence of a proven market for heat offtake, can represent a high risk investment. A strategic level, Government led initiative to franchise strategic district heating networks, together with a public sector commitment to purchase heat offtake could represent a solution to these barriers.

The number of opportunities for local authorities to use district heating in new and existing developments may be limited by the requirement to transport waste and public opposition.

3.3.5 Current support for EfW

At present, electricity generated from mixed wastes only qualifies for ROCs if it is through using advanced conversion technologies such as anaerobic digestion, gasification or pyrolysis.

The qualification of good quality CHP EfW to receive ROCs based on the proportion of biodegradable waste within the feed stock (subject to minimum content requirements) is currently being considered by Government, however, issues are expected to be encountered in respect of waste sampling to ascertain biodegradable content.

The Enhanced Capital Allowances scheme allows companies to claim 100% of the capital allowance against taxable profits for specified Good Quality CHP in the first year of purchase.

EfW will continue to attract reasonable gate fees due to increasing levels of landfill tax (increased by £8/tonne per annum following the March 2007 Budget) and the impact of the and Landfill Allowance Trading Scheme (LATS) on local authority disposal costs.

3.4 Solar thermal

Solar water heating harnesses solar heat-radiation by warming water or other liquid that is passed through solar panels. The heat produced is suitable predominantly for residential space heating, with usage in the commercial sector constrained by a variety of different factors. The heat generated by solar water heating in the UK is not high enough for use in the industrial sector.

3.4.1 Solar thermal market potential

Table 42: Market potential of solar thermal

	TWh/y
Current contribution ⁵	0.3
'Business as Usual' (2020)	1.2
Technical potential (low) ⁶	35.1

Technology analysis

	TWh/y
Technical potential (high) ⁶	35.1
Market potential (low) ³	4.9
Market potential (high)*	17.1

*Whilst FES state a market potential of 17.1TWh by 2020, the Energy Saving Trust estimate a market potential of only 6TWh/y by 2050⁹.

The number of solar thermal installations has increased steadily over the past three years hence a 'business as usual' scenario showing growth of some 0.9TWh to 2020 based on a 2003 to 2005 trend.

The technical potential for solar thermal, according to the FES report, is based on all buildings in the UK, of suitable location and roof area. Modelling performed by the Energy Saving Trust reveals a much lower market potential, only 6TWh by 2050. The FES report also estimates a market potential by 2020 considerably higher than the EST report.

3.4.2 Solar thermal support required

The levelised cost analysis for solar thermal was undertaken on a standalone system basis, whereby the capital and operating costs of a solar thermal system, in addition to the alternative fuel cost savings (gas, oil and electricity) resulting from the output of the solar thermal system were assessed. It has therefore been assumed that in both new build and retro-fit scenarios, a gas, oil or electric heating system is installed in addition to the solar thermal technology, to act as back up for space heating and hot water supply.

The methodology for calculating the level of funding support required does not take account of the capital cost of the gas, oil or electric equivalent equipment on the basis such equipment would be required in all situations. The methodology does not distinguish any potential savings (or costs) that may be realised in a new-build scenario from installing a smaller capacity gas, oil or electric heating system as a result of the solar thermal system installation.

Table 43: Solar thermal support required

	New build £/MWh	Retro-fit £/MWh
Cost of heat produced	48	61
Support required to be cost competitive with gas (low)*	38	51
Support required to be cost competitive with gas (med)*	34	47
Support required to be cost competitive with gas (high)*	29	42
Support required to be cost competitive with oil*	34	47
Support required to be cost competitive with electricity*	3	16

* This relates to the funding required to make solar thermal economically attractive for replacing gas, oil or electricity.

⁹ Potential for Microgeneration Study and Analysis, Energy Saving Trust, November 2005

Technology analysis

Solar thermal appears to require support over gas (under all price scenarios), oil and electric heat generation.

The retro-fit scenarios assume higher equipment costs than new build scenarios equivalent to £130/kW installed.

3.4.3 Solar thermal cost effectiveness

The table below summarises the cost effectiveness of providing solar thermal with the required level of support to ensure cost competitiveness with alternative technologies:

Table 44: Solar thermal cost effectiveness

Societal impact Base case	New build £/tC	Retro-fit £/tC
Cost per tonne relative to gas (low)	626	857
Cost per tonne relative to gas (med)	556	787
Cost per tonne relative to gas (high)	445	676
Cost per tonne (oil)	410	582
Cost per tonne relative to electricity	(264)	(135)
Comparative cost per tonne (onshore wind vs gas CCGT)*	215	215

*Source Defra

Solar thermal appears to be a costly means of achieving carbon emissions compared with onshore wind. It is, however, cost effective when compared to an electric boiler, which is largely a result of the high emissions factor attributable to delivered electricity supply.

3.4.4 Barriers to implementation of solar thermal

Financial barriers

Cost

Solar thermal has a higher capital cost than conventional heat options and, even when economic, high initial capital costs and installation costs result in an unattractive payback period to investors. Without some financial support, solar thermal installation is highly dependant on customers willing to invest for non-financial reasons.

Non-financial barriers

Perception and knowledge

The public perception of many micro technologies, including solar thermal, is that they are complicated, unproven and of dubious benefit, based on feedback from the consultation exercise.

Planning

Current planning delays experienced by installers may benefit from the outcome of the revised General Permitted Development Order. However, there are continuing

Technology analysis

problems in some areas such as information about the application of building regulations.

Tax

There is no incentive for private landlords (Sch A Tax) to include these technologies within rented premises as they cannot offset the cost against rental income for tax purposes and the benefits accrue to the tenant (and would be unlikely to be passed through in commensurate increases in rental income).

3.4.5 *Current support*

The Low Carbon Buildings Programme provides grants for microgeneration technologies to householders, community organisations, schools, the not-for-profit sector and private businesses.

The Energy Efficiency Commitment (EEC) programme also provides end users with a type of grant for installing energy efficiency measures in homes. This scheme does include solar thermal and GSHP, although take-up has been limited for these technologies under this programme.

3.5 *Heat pumps*

3.5.1 *Heat pumps*

GSHP works by pumping liquid through the earth at a depth of about 1.5m. Given the relatively constant temperature of the earth at this depth, the small amount of electricity used to pump the water into the earth can generate a significant amount of heat with temperatures of up to 50°C. Alternatively, a borehole can be drilled to an appropriate depth in order to tap a 'well' of hot water situated underground.

GSHPs are suitable for space and water heating, making them applicable for both the residential and commercial sectors. GSHP is typically sized on the basis of space heating and therefore may require additional top-up heating (which may come from conventional sources such as electric immersion heaters) for hot water. We have not considered the additional cost of electrical top-up in such cases.

Another major constraint in deploying GSHP is the availability of suitable land in close proximity to the buildings, which can be used to dig either a trench or a borehole. New builds in the residential and commercial sectors are most likely to adopt GSHP technology as they can be designed specifically to incorporate the technology, and do not result in existing technology becoming redundant.

The source of the heat for ASHP is the external ambient air. As external temperature is more variable than in the ground, coefficients of performance are likely to be lower, but so too are installation costs as no trenching or ground drilling is required. ASHPs have yet to become widely available for the domestic market, however capital costs do appear to be showing signs of falling as the market develops.

Technology analysis

3.5.2 Heat pump market potential

Table 45: Overall market potential for heat pumps

	TWh/y
Current contribution*	0.03
'Business as Usual' (2020)**	0.11
Technical potential (low) ⁶	80.3
Technical potential (high) ⁶	80.3
Market potential (low) ³	4.9
Market potential (high)***	20.1

*Based on FES estimate of 600 – 700 installations producing around 30GWh heat⁶ corroborated with Energy Saving Trust estimate of 546 units at the end of 2005⁹

**Based on extrapolation of 2005 and 2006 data to 2020 (around 2,400 installations).

***Whilst FES estimate a market potential of 20.1TWh/y by 2020, the Energy Saving Trust estimate a figure of around 12TWh/y by 2050⁹

Increasing numbers of GSHP installations over the period 2003 to 2005 gives a 'business-as-usual' scenario nearly four times current levels by 2020. The technical potential outlined in the FES Report is based on GSHP installed in all off-gas grid homes, plus a proportion of commercial properties.

In reality, actual market potential is likely to be significantly lower, as indicated by the Biomass Task Force, (7% renewable heat by 2015), and Energy Saving Trust. The EST report entailed detailed modelling of the GSHP market, hence its projections for 2050 may be a strong indicator of the levels of GSHP installed without the benefit of a financial support mechanism. The EST report also suggests that such levels of installation could be achieved earlier if a suitable support mechanism were introduced.

3.5.3 Heat pump support required

The levelised cost analysis for GSHP and ASHP technology was undertaken on a standalone system basis, whereby the capital and operating costs of a GSHP or ASHP system, in addition to the alternative fuel cost savings (gas, oil and electricity) resulting from the output of the GSHP or ASHP system were assessed. It has therefore been assumed that in both new build and retro-fit scenarios, a gas, oil or electric heating system is installed in addition to the GSHP or ASHP system, to act as top up for space heating and for hot water supply.

The methodology for calculating the level of funding support required does not take account of the capital cost of the gas, oil or electric equivalent equipment on the basis such equipment would be required in all situations. The methodology does not distinguish any potential savings (or costs) that may be realised in a new-build scenario from installing a smaller capacity gas, oil or electric heating system as a result of the GSHP or ASHP system installation.

Table 46: Heat pump support required

	GSHP (new build) £/MWh	GSHP (retro-fit) £/MWh	ASHP (new build) £/MWh	ASHP (retro-fit) £/MWh
Cost of heat produced	49	61	51	62
Support required to be cost	38	49	39	51

Technology analysis

	GSHP (new build) £/MWh	GSHP (retro-fit) £/MWh	ASHP (new build) £/MWh	ASHP (retro-fit) £/MWh
competitive with gas (low)*				
Support required to be cost competitive with gas (med)*	34	45	36	47
Support required to be cost competitive with gas (high)*	28	39	30	41
Support required to be cost competitive with oil*	34	45	35	47
Support required to be cost competitive with electricity	(1)	11	1	12

* Funding required to make the technology as economically attractive as gas, oil or electricity.

Both GSHPs and ASHPs appear to need funding support to compete with gas, oil and electric heating. On the basis of the figures above, GSHPs and ASHPs would need marginally less funding per MWh compared with solar thermal (including both new-build and retro-fit scenarios).

Based on assumptions over installed capacity and load factors, both GSHP and ASHP systems could generate approximately 56% of the total residential heat demand.

The level of support required for ASHP systems is marginally higher than GSHP equivalents due to lower efficiency factors (source EST report).

Under retro-fit scenarios, additional equipment and installation costs result in a higher level of support being required. With technology cost reductions in ASHP technology in particular (given the technology is in its infancy and the large level of electrical components involved) the estimated required level of support may reduce rapidly.

3.5.4 Heat pump cost effectiveness

Table 47: Heat pump cost effectiveness

Societal impact Base case	GSHP (new build) £/tC	GSHP (retro fit) £/tC	ASHP (new build) £/tC	ASHP (retro-fit) £/tC
Cost per tonne relative to gas (low)	1,596	2,053	1,813	2,309
Cost per tonne relative to gas (med)	1,424	1,881	1,625	2,121
Cost per tonne relative to gas (high)	1,148	1,604	1,325	1,821
Cost per tonne (oil)	785	1,039	863	1,128
Cost per tonne relative to electricity	(407)	(246)	(393)	(227)
Comparative cost per tonne (onshore wind vs gas CCGT)*	215	215	215	215

*Source Defra

The table above shows that GSHPs and ASHPs are significantly less cost effective in achieving carbon savings than solar thermal or onshore wind.

Technology analysis

3.5.5 *Barriers to implementation for heat pumps*

Perception

Public perception or lack of knowledge of technologies is a key issue for GSHP and ASHP.

Tax

GSHP and ASHP are similar to solar thermal in that there is little incentive for landlords to install the technology in rented premises.

Current support

The Low Carbon Buildings Programme provides capital support to GSHP and ASHP technologies.

The Energy Efficiency Commitment (EEC) programme also provides end users with a type of grant for installing energy efficiency measures in homes. Although solar thermal and GSHP are eligible for funding under the EEC, take-up for these technologies has been limited to date.

Appendix A Questionnaire

SECTION A

Market information

If further space is needed to answer any question please complete on a separate sheet clearly marking upon it the question to which it relates.

The objective of this Section is to obtain market information on current and potential future market for each of the technologies.

A.1 The Future Energy Solutions report, compiled in 2003 by AEA technology, states that the potential Renewable Heat market is an additional 34.9TWh/y by 2020. Do you agree with this analysis?

If you disagree, please provide reasons:

A.2 What is the current level of installations for each Renewable Heat technology in the UK, both in terms of number and heat generating capacity?

Please provide relevant market information in this regard:

A.3 What is the potential future market size for each technology?

Please provide details of any targets, market forecasts and timings in this regard and any critical factors which underpin these forecasts. Please provide targets, forecasts and/or timings for the following years. Please can you also explain your main reasons for suggesting these estimates.

2010
2015
2020

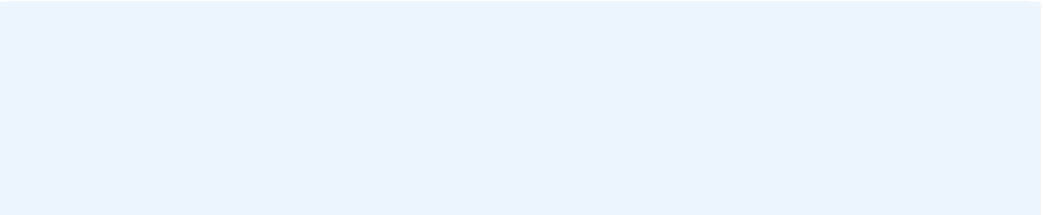
A.4 How are the current and future market sizes for each technology broken down between different types of energy user/energy generator?

Please provide any breakdowns, if possible using the following categories:

- i. Residential users
- ii. Public sector/commercial users
- iii. Industrial users
- iv. Independent energy generators

Appendix A

Items i.-iii. above refer to energy users installing their own Renewable Heat facilities, and item iv. typically refers to large scale centralised energy projects



SECTION B

Economics

The objective of this Section is to understand the economics of each technology, based on the 'typical' installation size, operational capacity and load factor.

For certain technologies there are several categories of installation (eg biomass installations vary from domestic wood burners to biomass fuelled combined heat and power stations with multi MW capacity). Please state clearly which type of biomass installation you are referring to when responding, including which fuel type. Please also distinguish between installations which are solely renewable heat and those which involve combined heat and power.

NB: For certain technologies (such as biomass and combined heat and power) please differentiate the cost information (requested in questions B1 to B4 below) per installation for the different types of energy user listed in question A.4. For example, a biomass installation is likely to differ in cost and output depending on whether it is targeted for a residential, commercial or industrial user. Please provide data, where appropriate, for each user type where possible.

B.1 What is the capital cost for a typical installation, (heat only, and separately combined heat and power) by technology (please specify the characteristics of installation by size and capital cost per unit as follows:

- Development costs:
- Equipment, construction and installation costs, including grid connection cost:
- Financing costs:
- Initial working capital/reserve account requirements:

B.2 What is the annual operating cost for a typical installation (heat only, and separately combined heat and power) by technology?

Where relevant, please clearly indicate the type of fuel assumed and separately schedule out the fuel cost from other costs (ie in particular in relation to biomass and energy from waste technologies):

- O&M:
- Fuel supply:
- Other:

Appendix A

B.3 What are the typical efficiency and load factors, by technology? (Heat only and separately combined heat and power)

Please clearly set out the criteria separately:

B.4 What is the estimated unit cost of production? (Heat only, and separately combined heat and power)

Please state clearly the assumptions applied:

B.5 In the case of district heating (heat only or combined heat and power) please state the assumptions applied in relation to the installation of heat transmission infrastructure, including:

- Capital costs (equipment and construction costs)
- Permitting and development costs
- O&M costs
- Heat throughput and possible sales values.

SECTION C

Barriers to deployment

The objective of this Section is to consider the non-financial challenges presenting barriers to increased deployment of the Renewable Heat technologies beyond current levels, in particular to reach future targets or forecasts that will require industry growth.

C.1 What are the key barriers to new Renewable Heat facilities being installed in the UK?

C.2 What are the most common areas of market failure within the Renewable Heat market? Please provide examples

Appendix A

C.3 In relation to large scale centralised projects, what have been the key development challenges?

Please provide experience of delivering regulatory approvals within the last 5 years, especially with regard to Planning Permissions, Waste Management Licences and Integrated Pollution Prevention and Control (IPPC) permits and other relevant operating permits for an energy production, process plant or other similar infrastructure project in the UK.

Where possible, please include information in the public domain to enable specific case studies to be highlighted, including the planning/permitting authority, facility type and scale, location, date and if any of the planning applications were subject to formal appeal or judicial review to enable the planning consents to be granted.

C.4 In the case of combined heat and power projects, please comment on

- a. the impact of fuel costs and their volatility, on the economics of projects and heat subsidies that may be required; and
- b. the effect of existing statutory obligations and planning processes on the level of access to land that developers can obtain in order to lay cables and pipes.

SECTION D

The objective of this Section is to obtain initial views on the possible options for support mechanism and views on their advantages and disadvantages for the technologies discussed and the Renewable Heat sector as a whole. Furthermore we wish to gain views on a national target for Renewable Heat.

D.1 What support (both financial and non-financial) currently exists in the UK Renewable Heat market?

Please comment on the effectiveness and sufficiency of existing support mechanisms (including both Government and non-Government support) by technology (heat only, and separately combined heat and power). Please respond under the categories of support mechanism provided.

What type of support might you wish to see for the Renewable Heat sector? Please provide reasons justifying the support mechanism(s) identified, where possible referring to examples in other markets:

Appendix A

Tax incentives:
Grants:
Soft (advantageous) Loans:
Market led tariff mechanisms:
Other:

D.2 Should Renewable Heat targets be created? Should these targets apply to specific technologies?

Please provide reasons, the level of the target and the timing of the target:

D.3 Please state the specific mechanism(s) and overall volume of support (by £ per MW/TWh) that you think is required to provide a long term and sustainable Renewable Heat market in the UK (recognising that different mechanisms and types of support may be necessary for different technologies and for heat only or separately combined heat and power).

D.4 Would the level of support above help to deliver the market potential for each technology as set out in question (A1) of this Questionnaire?

D.5 What other factors need to be considered within a long term support framework? Please identify any potential both financial and non-financial benefits from developing the renewable heat industry in the UK (for example avoided electricity grid infrastructure costs, employment, agricultural benefits etc).

Appendix B Renewable heat technologies and applications

Renewable heat technologies

Biomass

Biomass involves using wood, straw or selected other organic matter (eg chicken litter) to fuel combustion. Given the low density of these fuels, in comparison with fossil fuels, greater volumes are required to produce the same amount of energy. In the UK, the largest energy market for Biomass is the residential use of logs on open fires for space heating. In addition, there are six biomass combustion electricity generation schemes currently in operation.

Ground source heat pumps (GSHP)

GSHP works by pumping liquid through the earth at a depth of about 1.5m. Given the relatively constant temperature of the earth at this depth, the small amount of electricity used to pump the water into the earth can generate a significant amount of heat with temperatures of up to 50°C.

GSHPs are suitable for space and water heating, making them applicable for both the residential and commercial sectors. However, the major constraint is the availability of suitable land in close proximity to the buildings, which can be used to dig either a trench or a borehole. New builds in the residential and commercial sectors are most likely to adopt GSHP technology as they can be designed specifically to incorporate external boreholes.

Solar water heating

Solar water heating harnesses solar heat-radiation by warming water that is passed through solar panels, which are placed in direct sunlight. The heat produced is suitable predominantly for residential space heating, with usage in the commercial sector constrained by a variety of different factors. The heat generated by solar water heating is not high enough for use in the industrial sector.

Solar Water Heating is more widespread in warmer regions of the world and given the UK's climatic conditions would have to be used in conjunction with other heat sources in order to ensure a reliable supply of heat energy.

Geothermal

Geothermal heat energy can be harnessed by extracting water from a geothermal aquifer, a naturally occurring reservoir in the earth's crust. Water is extracted by pump through a borehole, generally for up to 20-30 years at which point the aquifer will have cooled below the level required to generate sufficient heat.

There is limited geothermal potential in the UK, with limited practicality due to the location of the aquifers and the unreliability of the lifecycle of the aquifer.

Appendix B

Energy from waste (EfW)

EfW comprises four key technologies which can be used to derive energy from Municipal Solid Waste (MSW).

- Mass-burn – combustion of all MSW;
- Fluidised bed combustion – MSW is burned in a bed of sand, which ensures more complete combustion;
- Pyrolysis gasification – MSW is burnt with restricted supply of oxygen resulting in liquid fuel for use in engines; and
- Refuse derived fuel (RDF) – separation of combustible MSW which can then be used in coal fired boilers.

There are 19 EfW plants in the UK, predominantly using the mass burn process. At present these EfW plants are principally used to generate electricity, although the technology is available to produce heat energy as required.

In the UK, EfW plants have been met with strong public opposition especially from people living near to sites on which processing plants have been proposed. Given the need for heat energy suppliers to be in relatively close proximity to their market, the potential issue of not being able to build EfW plants in central locations presents a significant risk to the success of this technology in the heat energy market.

The cost of an EfW plant is greater than that of a conventional electricity generating station because of the low density of MSW, in comparison with fossil fuels, and the need for advanced pollution control equipment. A 100,000 tonne/year EfW plant is likely to cost £50-60 million to construct with additional distribution infrastructure and operating costs.

Anaerobic digestion

Anaerobic digestion involves the conversion of organic matter to energy by microbiological organisms. This produces three outputs; biogas, which can be used to generate heat and electricity; fibre, which can be used as a fertiliser; and, liquor which can also be used as a fertiliser.

Anaerobic digestion technology can be used to convert four key types waste to energy:

- Process sewage – Regulatory constraints in UK water market may make investment in sewage gas plants for heat energy unattractive. Sewage plants are generally located away from residential and commercial buildings meaning heat distribution is hard;
- Animal waste – This sector is also constrained by other regulatory and economic forces relating to the agricultural sector. Centralised processing of animal waste is likely to result in lack of proximity to relevant market, whilst individual processing on farms is likely to be too expensive;
- Organic MSW - The proximity to a viable heat market is again a problem for this type of waste; and
- Food waste – Processing plants for food waste are likely to be nearer commercial sites, so energy can be transferred to the end user more effectively.

Appendix B

Landfill gas

Landfill gas is released from the decomposition of waste in landfill sites. If abstracted correctly, the biogas produced can be used to generate electricity or heat energy. As with many of the other renewable heat technologies in order to benefit from the heat generated, the end consumer needs to be in close proximity to the processing plant. Residential and commercial properties are not generally located near to large landfill sites. Injection of biogas into the gas grid has not been considered within the IBC given the early stage of this technology.

Biomass combined heat and power

There are several Biomass CHP projects under development in the UK. The technology includes anaerobic digestion, gasification, energy recovery from the thermal treatment of bio-fuels, solid biomass, bio-degradable, residual wastes and EfW eligible for ROCs. Although technologies are well developed, with several large suppliers of equipment and construction services, the fuel supply market is relatively undeveloped. This poses difficulties in terms of volume, fuel quality and price.

Renewable heat applications

Residential

The UK residential sector comprises some 25 million dwellings of varying types, ages and sizes that have a total energy demand of 453 TWh/year (FES 2006). Energy demand from these residential dwellings is highly seasonal, making it hard to fully utilise renewable heat systems. Improved heating efficiency and insulation have led to a gradual decline in energy requirement, although this has been partially offset by higher comfort standards.

Areas of the residential sector that have been highlighted as being more likely to adopt renewable heat technology are:

- The 1 million additional dwellings forecast to be built by 2020 (Barker Review);
- The 4.4 million dwellings in the UK without connection to the gas main; and
- The 5% of dwellings per year that require a replacement boiler.

Public sector / Commercial

This sector comprises organisations that, in general, have a level of energy usage which is unlikely to be particularly significant in comparison with the overall cost base of the organisation. Therefore energy issues are unlikely to be a top priority for them.

The sector can be broadly divided into two types of heat energy users; the highly seasonal users similar to the residential sector which have a total energy demand of 125 TWh/year; and, users with a continuous energy requirement who demand some 80 TWh/year.

Given the cost of replacing boilers and heating equipment, it is likely that the areas of the commercial sector most likely to adopt new technologies are the 5% of users requiring a replacement boiler each year.

Appendix B

Industrial

This sector comprises space heating, as used by both the residential and commercial sectors, and process heat resulting in a high level of energy utilisation at 81 TWh/year. Energy consumption within the industrial sector is often a significant part of the cost of the business, so there is generally a greater focus on managing energy usage to keep costs under control.

Given the high cost of capital and the high level of competition within this sector, capital expenditure is generally focused on improving productivity. Therefore, as with both the residential and commercial sectors the estimated 5% per annum renewal rate of boilers and heating equipment is likely to be the core market for renewable technologies in this sector. In addition, the criticality of energy supply to industrial businesses means any new technologies will have had to be well proven before they are adopted by the sector.

Appendix C References

1. Heat Supply in Denmark: Who What Where and Why, Danish Energy Authority, January 2005
2. Energy in Sweden, Swedish Energy Agency, November 2005
3. Biomass Task Force: Report to Government, October 2005
4. The Economics of Biomass, George Marsh, BERR December 2006
5. Digest of UK Energy Statistics (DUKES), July 2006
6. Renewable Heat and Heat from Combined Heat and Power Plants – Study and Analysis, Future Energy Solutions (FES), AEA Technology, 2006
7. Biomass Sector Review for the Carbon Trust, The Carbon Trust, October 2005
8. Extending ROC Eligibility to Energy from waste with CHP, ILEX Energy Consulting, September 2005
9. Potential for Microgeneration – Study and Analysis, Energy Saving Trust, November 2005

Appendix D Technology assumptions

General

- Electricity sales: £0.07/kWh (ROCs plus brown power less PPA discount)
- Electricity sales: £0.04/kWh (discounted brown power only)
- Heat sales: £0.03/kWh (E&Y proprietary data)
- Electricity cost: £0.10/kWh (typical cost to residential consumer)

Carbon emissions

Table 48: Carbon assumptions

Fossil fuel emissions factors	Carbon intensity	Unit	Source
Natural gas	0.058	tC/MWh	DEFRA
Heating oil	0.078	tC/MWh	DEFRA
CCGT	0.104	tC/MWh	DEFRA
Fossil fuel boiler efficiency	87%-90%		DEFRA
Biomass - All			
Carbon saving relative to gas	0.058	tC/MWh	DEFRA
Carbon saving relative to oil	0.078	tC/MWh	DEFRA
GSHP			
Units heat produced per unit electricity input	3.16	MWhth/MWhe	Energy Saving Trust (heat generated divided by energy input)
Carbon saving relative to gas	0.025	tC/MWh	DEFRA
Carbon saving relative to oil	0.045	tC/MWh	DEFRA
Carbon saving relative to electricity	0.071	tC/MWh	DEFRA
ASHP			
Units heat produced per unit electricity input	3.0	MWhth/MWhe	DEFRA
Carbon saving relative to gas	0.023	tC/MWh	DEFRA
Carbon saving relative to oil	0.043	tC/MWh	DEFRA
Carbon saving relative to electricity	0.069	tC/MWh	DEFRA
Solar Thermal			
Carbon saving relative to gas	0.058	tC/MWh	DEFRA
Carbon saving relative to oil	0.078	tC/MWh	DEFRA
Carbon saving relative to electricity	0.104	tC/MWh	DEFRA
AD CHP			
Carbon saving relative to gas	0.058	tC/MWh	Assumed same as Biomass
Carbon saving relative to oil	0.078	tC/MWh	Assumed same as Biomass
EFW - CHP			
Carbon saving relative to gas	0.046	tC/MWh	FES
Carbon saving relative to oil	0.061	tC/MWh	FES

Appendix D

Gas

Table 49: Gas boiler assumptions

Gas	Residential	Small Commercial	Medium Commercial	Industrial
Plant size	30kW (Worcester Condensing Systems Gas Boiler Greenstar 24i)	110kW (Keston C110)	1,000kW (20xKeston C55 boilers (rated at 50kW each)	20,000kWth
Capex	£50/kW (approx £650 product, £100 labour, £100 parts plus VAT)	£45/kW (Keston C110)	£60/kW (Keston C55, multiple small commercial units joined therefore assume labour and parts approx double cost of product)	£50/kW (source:BERR)
Opex	£150/yr (source: Worcester-Bosch)	£330/yr (source: Keston)	£3,000/yr (source: Keston)	£1/kWth installed (source:BERR)
Load factor	6% (average 1.4 hrs per day over a year)	35% (assumes mixed applications with lower heat demand, per Carbon Trust report)	50% (assumes 12 hours per day)	75%
Discount factor	5%	8%	8%	8%
Operating life	15 years	20 years	20 years	20 years
Efficiency	85% (source: EY proprietary data)	85% (source: EY proprietary data)	85% (source: EY proprietary data)	85% (source: EY proprietary data)

CCGT

Table 50: CCGT plant assumptions

CCGT	Centralised
Plant size	8MWe
Capex	£440/kWe (source: BERR)
Opex	£7/kWe (source: BERR)
Load factor	85% (source: BERR)
Efficiency	58% (source: BERR)
Discount factor	8%
Fuel cost – Low	£0.009/kWh (source: BERR)
Fuel cost – Medium	£0.013/kWh (source: BERR)
Fuel cost – High	£0.018/kWh (source: BERR)
Plant Life	20 years

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Oil

Table 51: Oil fired boiler assumptions

Oil	Residential	Small commercial	Medium commercial	Industrial
Plant size	20kW (Worcester Combi Oil Boiler Heatslave 20/25)	100kW (Ideal Falcon GTE7 Oil)	1,000kW (Vitoplex 300)	20,000kW
Capex	£60/kW (approx. £1,100 product, £300 labour, £100 parts plus VAT)	£50/kW (assume same as residential less VAT)	£50/kW (assume same as residential less VAT)	£50/kW (source:BERR)
Opex	£150/yr (source: Worcester-Bosch)	£330/yr (assume same as gas)	£3,400/yr (assume same as gas)	£1/kWth (source:BERR)
Load factor	9% (average 2.2 hrs per day over a year)	35% (assumes mixed applications with lower heat demand, per Carbon Trust report)	50% (average 4.5 hrs per day over a year)	75%
Discount factor	5%	8%	8%	8%
Operating life	15 years	20 years	20 years	20 years
Efficiency	85% (assume same as gas)	85% (assume same as gas)	85% (assume same as gas)	85% (source:BERR)

Electricity

Table 52: Electric boiler assumptions

Electricity	Residential
Plant size	9kW (Heatrae Sadia Electromax Combined Electric Boiler & Domestic Hot Water Store)
Capex	£175/kW (£1,200 product, £200 installation, plus VAT)
Opex	£150/yr (similar to gas)
Load factor	20% (average 4.5 hrs per day over a year)
Discount factor	5%
Operating life	15 years
Efficiency	100% (source: BERR)

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Biomass

Table 53: Biomass boiler assumptions

Biomass	Residential (pellet/log)	Small commercial	Medium commercial	Industrial
Plant size	20kW (to replace similar gas boiler)	100kW (to replace similar gas boiler)	1,000kW (to replace similar gas boiler)	20,000kW (to replace similar gas system)
Capex	£250/kW (Energy Saving Trust and compared to Treco boilers)	£225/kW (Carbon Trust data)	£225/kW (Carbon Trust data)	£360/kW (based on Carbon Trust data)
Opex	2% of capital cost	5% of capital cost	5% of capital cost	£0.002/kWhth (per Carbon Trust Report)
Load factor	9% (average 2.2 hrs per day over a year)	35% (assumes mixed applications with lower heat demand, per Carbon Trust report)	50% (average 12 hrs per day over a year)	75%
Discount factor	5%	8%	8%	8%
Fuel cost (pellets)	£0.022/kWh (per FES Report, average of low (£0.015/kWh) and high (£0.030/kWh) pricing scenario)	£0.015/kWh (per FES Report, with bulk discount)	£0.015/kWh (per FES Report, with bulk discount)	N/a
Fuel cost (logs)	£0.009/kWh (BERR, Carbon Trust)	N/a	N/a	N/a
Fuel cost (wood chip)	N/a	£0.007/kWh (FES Report, average of low (£0.005/kWh) and high (£0.009/kWh), agrees to Carbon Trust report)	£0.007/kWh (FES Report, average of low (£0.005/kWh) and high (£0.009/kWh), agrees to Carbon Trust report)	£0.007/kWh (FES Report, average of low (£0.005/kWh) and high (£0.009/kWh), agrees to Carbon Trust report)
Operating life	10 years	10 years	10 years	20 years
Efficiency	85% (source: BERR)	80% (source: BERR)	80% (source: BERR)	80% (source: BERR)

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GSHP / ASHP**Table 54: Heat pump assumptions**

GSHP	Residential
Plant size	5 kW (EST data)
Capex (new build)	£800/kW (based on EST data and cost savings associated with new build)
Capex (retro-fit)	£1,200/kW (based on EST data)
Opex	GSHP: £92 p.a., ASHP: £100 p.a. (source: DEFRA)
Load factor	20% (assumes GSHP meets around half of total heat demand in a household)
Efficiency	GSHP: 315%, ASHP: 300% (based on EST data – since one unit electrical used to drive pump generates around three units of heat)
Discount factor	5% (individuals)
Fuel cost	£0.10/kWh (electricity used to drive pump)
Operating life	20 years

Solar thermal**Table 55: Solar thermal assumptions**

Solar thermal	Residential
Plant size	6 kW (Baxi Solarflo Megatech DIRECT Unvented Domestic Hot Water Systems)
Capex	New build : £470/kW (£2,000 product, £300 labour, £100 parts plus VAT) Retro-fit: uplift cost by £130/kW installed (source: EST)
Opex	0.5% of capital cost (£200 over life of product, per EST data)
Load factor	6% (source: DEFRA)
Efficiency	80% (Energy Saving Trust)
Discount factor	5%
Operating life	25 years

Anaerobic digestion**Table 56: Anaerobic digestion plant assumptions**

Anaerobic digestion	Industry
Plant size	2,188kWh (EY proprietary data)
Capex	£11.3m (EY proprietary data)
Opex	10% of capex (EY proprietary data)
Load factor	78% (EY proprietary data)
Discount factor	12%

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Anaerobic digestion	Industry
Gate fee	£21 (average between plants which receive high gate fees and those receiving little/none)
Throughput	146,000 tonnes per annum
Operating life	20 years

Biomass CHP

Table 57: Biomass CHP assumptions

Biomass CHP	
Plant size	30,000kWth (approx. 8,000kWe, source: BERR)
Capex	£934/kWth (£3.5m/MWe, data on file from BERR RO Banding Report)
Opex	£80/kWe installed (£10.70/MWhe per Carbon Trust Report)
Load factor	85% (Carbon Trust)
Discount factor	8%
Fuel cost	£0.007/kWh (per large biomass)
Operating life	20 years
Efficiency	80% (source: BERR)

Energy from waste

Table 58: EfW assumptions

Energy from waste	Electrical only	CHP
Plant size	32MWe (based on 440,000 tonne capacity E&Y benchmark plant)	40MWth, 24MWe (based on 440ktpa plant scaled down electrical capacity per ILEX Report)
Capex	£180m (based on E&Y benchmark data)	£210m (based on E&Y benchmark data, plus CHP conversion per ILEX Report)
Opex	£12m/y (based on E&Y benchmark data)	£12.4m/y (based on E&Y benchmark data plus additional for CHP per ILEX Report)
Load factor	87% (based on E&Y benchmark data)	87% (based on E&Y benchmark data)
Discount factor	8%	8%
Gate fee	£55/tonne (average on E&Y benchmark data)	£55/tonne (average on E&Y benchmark data) £20/tonne used in cost effectiveness calculation (tipping/handling fees)
Electrical sales	£0.040/kWh (brown power only)	£0.050/kWh (some ROC income)
Heat Sales		£0.03/kWh
Operating life	20 years	20 years