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Cambridgeshire Renewables Infrastructure Framework - Baseline Data, Opportunities and Constraints

climatechangesolutions

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Introduction

This study provides a technical baseline assessment of Cambridgeshire's energy demand and renewable energy resource for the Cambridgeshire Renewables Infrastructure Framework (CRIF). It provides an underpinning evidence base for the CRIF to obtain a key understanding of the main opportunities and high level constraints facing renewable energy deployment in Cambridgeshire.

Cambridgeshire faces tough energy and carbon objectives

In May 2011 the Government adopted the 4th Carbon Budget[1] which requires a 50% reduction in carbon emissions by 2025 based on 1990 levels. Applying the 4th carbon budget to Cambridgeshire emissions implies a 43% reduction between 2010 and 2025, which needs to be delivered through a combination of energy efficiency improvements, national electricity grid decarbonisation, local renewable energy deployment and transport measures. Committee on Climate Change advice to Government proposes an 18% renewable electricity target and a 35% renewable heat target for 2030. This equates to a 28% overall renewable energy target for Cambridgeshire (excluding transport). It is worth noting that some of the district councils have set their own targets such as Cambridge City Council which has a carbon reduction target of 89% by 2050 with interim targets in between.

Cambridgeshire is already doing well

Cambridgeshire already has the greatest installed renewable energy capacity in the East of England and has one of the highest renewable energy outputs of any county in England. Wind turbines play a key role in this output and Fenland currently has the greatest number of installed wind turbines. East Cambridgeshire also has one of the largest dedicated biomass plants in the country due to the straw burning plant near Ely. 7% of Cambridgeshire's energy demand is already met by renewable energy installations.

Potential for greater deployment

The technical theoretical potential of Cambridgeshire's renewable energy resource is extremely large at over 200% of Cambridgeshire's current energy demand. This figure has been calculated after consideration of primary technical constraints but secondary deployment constraints will substantially reduce this potential. Primary technical constraints include aspects such as wind speed and available land area for wind turbines or the orientation of roof space for solar technologies. Deployment constraints incorporate issues such as economic feasibility and obtaining planning permission, . Wind has the greatest potential and constitutes over 70% of the overall renewable energy resource, followed by heat pumps and PV which could each contribute up to 30% and 15% of energy demand respectively. Biomass and energy from waste technologies could contribute a further 15% to Cambridgeshire's energy demand.

All technologies are needed

Although the majority of the technical potential resides in the wind resource, there is still a great deal of potential from the other technologies and the successful deployment of renewable energy in Cambridgeshire will require the utilisation of all technologies. Policy support for renewable energy needs to consider all forms of energy as renewable heat and renewable electricity are both needed in order to realise Cambridgeshire's share of the UK targets. Traditionally there has been a focus nationally on renewable electricity, but the main energy

[1] *Committee on Climate Change (2010) The Fourth Carbon Budget Reducing emissions through the 2020s ; http://www.theccc.org.uk/reports/fourth-carbon-budget*

demand in the housing sector is for heat. The analysis suggests that the main area for improvement and the biggest challenge for Cambridgeshire is that of deploying renewable heat technologies which currently contribute very little to energy demand.

South Cambridgeshire and Huntingdonshire have the largest resource

Huntingdonshire and South Cambridgeshire, the two biggest districts, have the greatest renewable energy potential and also the greatest energy demand. Although these two districts have the largest technical wind resource they also have substantial PV and air source heat pump potential as they have a larger building stock than the other districts. Due to their large size these two districts are also likely to have the greatest number of off-gas properties which further increases their renewable energy opportunities in terms of substituting heat pumps or biomass boilers for oil heating systems. Cambridge lacks the wind resource but has substantial potential for air source heat pumps and PV, although the higher density urban environment and relatively large number of conservation areas does limit the potential for building integrated technologies compared with the other districts.

District heating opportunity lies in Cambridge and Huntingdon

Although the technical potential of district heating networks served by CHP is estimated at 9% of Cambridgeshire's overall heat demand, its practical deployment potential is much smaller due to a number of reasons including the challenge of establishing heat networks in the existing built environment.

The potential for district heating resides in urban areas focused on town centres where there is high density of heat demand due to the presence of high density public sector, commercial and domestic buildings. The vast majority of the potential lies in Cambridge and Huntingdon, with some further potential in other market towns. More detailed heat mapping analysis based on suitability of potential anchor load buildings and the scale of heat demand that could enable the development of heat networks, suggests that only Cambridge and Huntingdon have suitable deployment potential for heat networks. If a quarter of the total district heating potential in Cambridge and Huntingdon were connected to a heat network then approximately 1% of the county's energy demand could be met by district heating systems fuelled by low carbon fuel sources. District heating feasibility studies are currently underway in Cambridge and St Neots.

The 'supply potential' of the biomass and energy from waste resource that could fuel CHP plant feeding heat networks is less than the technical potential for district heating in Cambridgeshire. However, as outlined above, the deployment potential of district heating networks is far lower than this and is focused on central areas in Cambridge and Huntingdon. An ambitious deployment target for district heating networks in Cambridge and Huntingdon would constitute approximately a tenth of the overall district heating technical potential, and could easily be met by Cambridgeshire's endemic biomass and EfW fuel resource. Although the combustion of solid biomass fuel would be challenging in Cambridge due to an Air Quality Management Area (AQMA) covering most of the city centre, a district heating network could rely on fuels with a low impact on local air quality, such as natural gas or biogas.

Deployment options for renewable energy in Cambridgeshire

Four deployment scenarios have been developed to enable an assessment of the local deployment potential of renewable energy within Cambridgeshire. The scenarios do not constitute a prediction of what will happen or an opinion on what should happen. They are simply an attempt to model deployment of different renewable energy technologies under varying future market and policy environment, and their key function is that of informing the debate on future policy options for renewable energy in Cambridgeshire. A brief description of the scenarios is provided below:

- Scenario 1 (Low scenario) - has a commercial (high) interest rate, low financial incentives for the microgen technologies (reduced levels of FIT and RHI) and low levels of national, regional and local support to encourage uptake of renewable energy.
- Scenario 2 (Medium scenario) - has a low interest rate, maintains current levels of financial incentives for renewable energy technologies and has medium levels of national, regional and local support to encourage uptake of renewable energy.
- Scenario 3 (High scenario) - has a low interest rate, maintains current level of financial incentives for renewable energy technologies and has high levels of national, regional and local support to encourage uptake of renewable energy.
- Scenario 4 (High without wind) - the same as scenario 3, but excludes any contribution from wind.

Figure 0-1 compares the four deployment scenarios with the current installed capacity and the 28% renewable energy target for 2030 taken from the Committee on Climate Change advice to Government[2]. Scenario 1 equates to 11% of Cambridgeshire energy demand whereas scenario 3 equates to 47% of energy demand. Scenario 4 achieves a 19% contribution even without any wind, although it would require a significant contribution from PV and biomass.

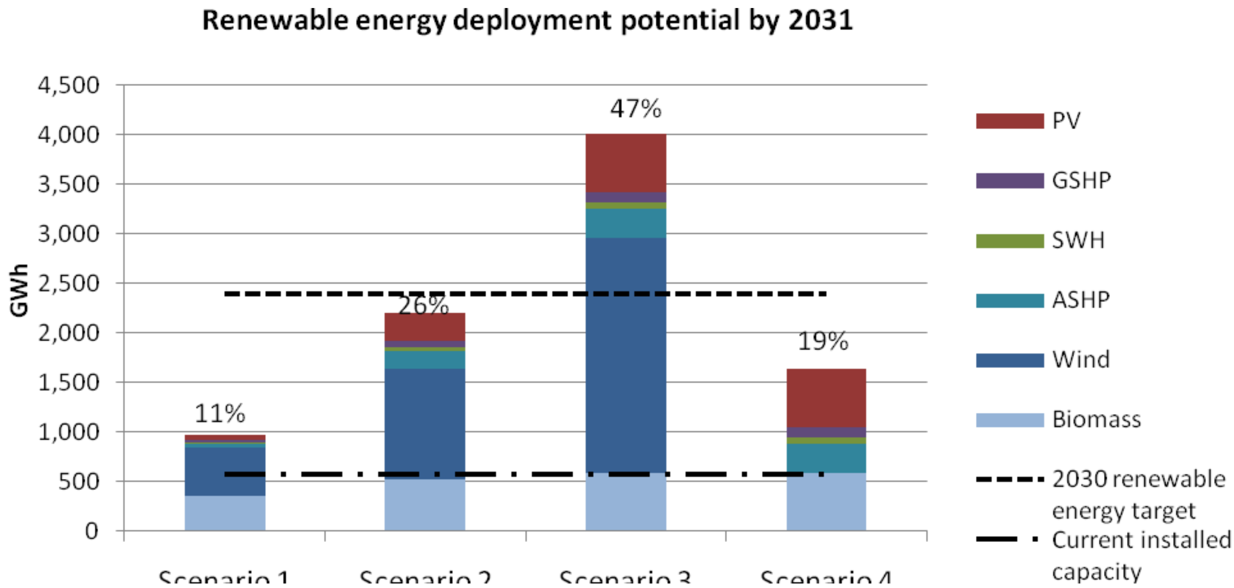


Figure 0-1: Renewable energy deployment potential in Cambridgeshire

The 28% renewable energy target therefore lies between scenarios 2 and 3. If Cambridgeshire were to aim for its pro-rata share of the UK renewable energy target, wind would need to play an important role. Nonetheless, the high existing renewables capacity provides Cambridgeshire with an excellent springboard for delivering the deployment levels within these scenarios, and suggests that the 28% target is achievable.

A substantial amount of infrastructure is needed

Delivering these scenarios could involve the deployment of 50,000 renewable energy installations under scenario 1 increasing up to almost 400,000 installations under scenarios 3 and 4. The majority of these installations are domestic PV solar roofs, although the number of

[2] *Committee on Climate Change (May 2011) The Renewable Energy Review*

solar roofs would be less if a proportion of these installations were undertaken on non-domestic roof space where larger panels could be installed. Approximately 100 large wind turbines would be needed in scenario 1 compared to 450 turbines in scenario 3.

Technology	Scenario 1	Scenario 2	Scenario 3	Scenario 4
PV (2.5 kW)	28,140	134,234	288,634	288,634
SWH	7,970	21,045	40,437	40,437
GSHP (5kW)	3,404	10,728	17,359	17,359
ASHP (5kW)	7,269	31,484	47,908	47,908
Wind (2.5 MW)	94	212	455	0
Biomass (1.5 MW)	16	25	35	35
Total	**46,893**	**197,729**	**394,829**	**394,373**

Table 0-1: Number of installations associated with the deployment scenarios

Renewable energy has the potential to help close the carbon gap to meet the 4th carbon budget objectives

Cambridgeshire will need substantial improvements in energy efficiency and a significant contribution from local renewable energy, as well as relying upon a nationally decarbonised electricity grid to achieve a 50% carbon reduction by 2025.

Figure 0-2 illustrates the contribution of renewable energy to Cambridgeshire carbon reduction objectives under each of the deployment scenarios. Current and target emission levels in 2025 are labelled with dashed lines to demonstrate the extent of carbon reduction required to hit the targets. Each segment demonstrates the change in emissions associated with the specific measure. The red segment, for example, illustrates how much emissions would increase from current levels if there was a 5.5% increase in energy demand by 2025. If, on the other hand, energy efficiency measures were successfully implemented to reduce energy demand by 22% by 2025, then the resulting decrease in emissions would be equal to the sum of the green and the purple segments. The blue segment at the base of the stack shows Cambridgeshire's residual carbon emissions in 2025 even if all the carbon reduction measures in the above segments were to be successfully implemented.

When combined with ambitious energy efficiency improvements (22% decrease in energy demand) and grid decarbonisation, scenario 3 could drive down carbon emissions to below the 4th Carbon Budget target, with the other deployment scenarios going part way towards the target. However, it should be noted that although transport emissions are included in this overall Cambridgeshire carbon reduction target, the impact of transport carbon reduction measures are not considered – and therefore the renewable energy contribution does not necessarily need to fill the whole gap. Nonetheless, it is generally acknowledged that the potential for carbon reductions in transport is smaller than the potential for reducing emissions related to heat and power consumption in buildings.

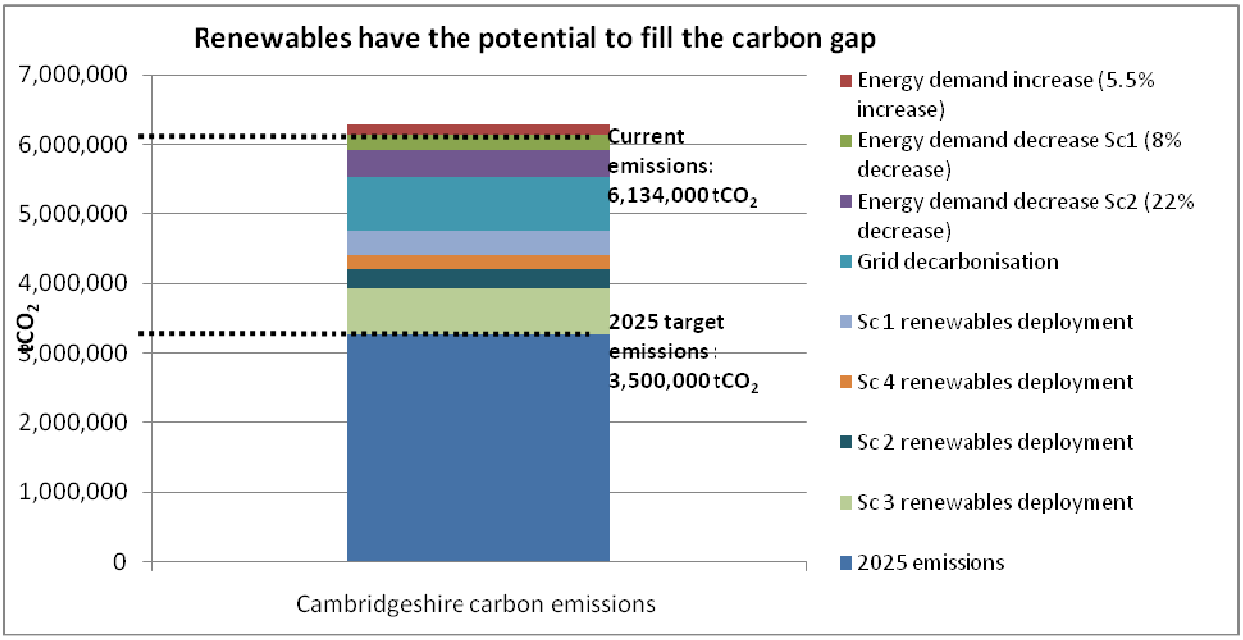


Figure 0-2: Potential contribution of renewable energy to Cambridgeshire carbon reduction targets

Cambridgeshire renewable energy resource has significant investment potential

Scenario 2 has an investment potential of £3 billion in projects with an indicative rate of return of 5 to 10%. This illustrates the substantial economic benefits that would accompany the installation of renewable energy infrastructure at these scales.

Energy efficiency and renewable energy are both needed

Figure 0-2 demonstrates that energy efficiency improvements, local renewable energy supply and national grid decarbonisation measures are all needed in order to meet carbon reduction objectives in Cambridgeshire. In addition to this, although reductions in future energy demand would increase the proportion of energy consumption that could be met by local renewable energy supply, the overall impact is relatively small. For example, the contribution of renewable energy to Cambridgeshire's energy demand under scenario 2 could increase from a quarter to one third if energy consumption is driven down by a quarter over the next few decades. Although this all helps in reducing carbon emissions, it illustrates that significant renewable energy contributions will be needed regardless of whether Cambridgeshire manages to achieve ambitious energy efficiency improvements.

1 Introduction

1.1 Aims of the study

This study provides a technical baseline assessment of Cambridgeshire's energy demand and renewable energy resource for the Cambridgeshire Renewables Infrastructure Framework (CRIF). It aims to provide the underpinning evidence base for the CRIF to obtain a key understanding of the main opportunities and constraints facing renewable energy deployment in Cambridgeshire.

1.2 Overview of approach

The key steps of the methodology for undertaking this renewable energy baseline and opportunities study are outlined in Figure 1-1 below. Current and future energy demand across Cambridgeshire has been assessed, and a series of future energy demand scenarios have been developed. This forms the basis for evaluating the potential contribution that renewable energy can make to Cambridgeshire's energy needs. The technical renewable energy resource has been mapped and quantified, and this technical potential has fed into deployment scenarios for renewable energy in Cambridgeshire in 2031. Constraints have been applied, considering the issues that could hinder the deployment of the renewable energy technologies such as planning, maturity of technology and financial incentives. In addition, a heat mapping exercise has identified areas of district heating potential where combined heat and power systems could be deployed. These patterns of supply and demand for renewable energy have then been brought together to highlight the key opportunities for deploying renewable energy in Cambridgeshire.

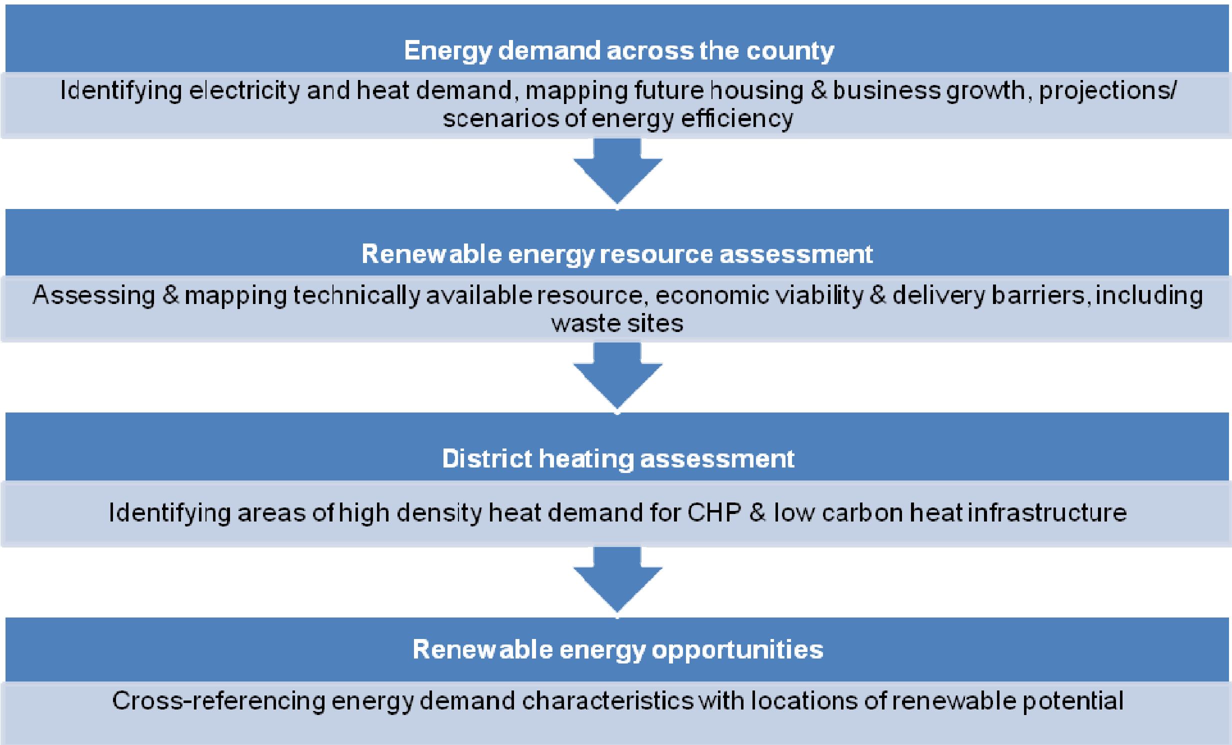


Figure 1-1: Key steps in the assessment of renewable energy opportunities in Cambridgeshire

The analysis has been undertaken at the both the district and county levels so as to explore where the main opportunities lie, and to compare the potential across the districts for the different types of renewable energy technology.

1.3 East of England Renewable and Low Carbon Energy Capacity Study

The East of England Renewable and Low Carbon Energy Capacity study was completed in June 2011 and provides an assessment of the potential renewable energy and district heating resource across the whole of the East of England. The study followed the Government's recommended methodological approach (see below) in providing an estimate of the region's renewable energy potential. The East of England assessment provides a useful overview of the renewable energy resource across the region and the position of Cambridgeshire relative to other counties. It also highlights the existing contribution of renewable energy in each of the counties.

The East of England study provides a great deal of useful data for this CRIF assessment of opportunities and constraints within Cambridgeshire. However, further analysis has also been needed in order to build upon the East of England results as the East of England study does not provide a breakdown by district, and for some technologies a greater resolution of data is required to provide a more detailed understanding of the deployment potential. Further information on the data provided by the East of England study and the additional analysis that has been required is provided in section 5 below.

1.4 Decarbonising Cambridge study

The Decarbonising Cambridge report [3] was produced for Cambridge City Council in 2010 in order to assess the potential from renewable and low carbon energy sources in the city. The study was carried out to inform policy in new development sites by providing an evidence base and identifying the necessary support mechanisms to achieve policy goals. This CRIF report expands the study area to the whole of Cambridgeshire and is in line with the general findings of the Decarbonising Cambridge study. . The technologies that were considered in the Decarbonising Cambridge study included district heating, biomass, energy from waste, wind, and other technologies such as pyrolysis, gasification and anaerobic digestion. The main conclusions are summarised below:

- **District heating:** The study concluded that the main potential for district heating was in the city centre due to high heat density. Section 6 outlines these findings in more detail.
- **Biomass:** It was found that there is a significant amount of biomass resource in the area however there also a significant uncertainty around the currently available resource as well as barriers in terms of deploying the technology.
- **Energy from waste:** Due to landfill taxes, economics for energy from waste is getting more favourable. The new Mechanical Biological Treatment (MBT) plant which will be managing all of the county's residual municipal solid waste opened in 2009 and has the potential to provide energy through refuse derived fuel.
- **Wind:** There is limited potential for wind due to the urban characteristics of the area.

[3] *Cambridge City Council (August 2010) Decarbonising Cambridge: A renewable and low carbon energy study*

- **Other technologies:** Gasification and pyrolysis can be used as conversion technologies however there is limited experience of using the latter technology in UK. Anaerobic digestion is also not likely to be suitable for Cambridge due to its urban characteristics. However micro generation technologies such as PV, solar thermal and heat pumps are expected to have an increased uptake and could contribute to the renewable energy generation in the region.

1.5 Renewable energy policy context

1.5.1 General climate change and energy policy

There is a wide range of national policy which influences renewable energy development in the UK and Cambridgeshire. A significant amount of new legislation and policy has recently been put in place.

- Climate Change Act

The Climate Change Act 2008 introduced a statutory target of reducing carbon dioxide emissions by at least 80% below 1990 levels by 2050, with an interim target of 34% by 2020. Government departments have prepared carbon budgets to indicate how greenhouse gas emissions will be reduced across the Government estate and in sectors where each takes a policy lead. The Act also created a framework for climate change adaptation. A national Climate Change Risk Assessment is currently being undertaken and will be completed in 2012.

- 4th Carbon Budget

The Climate Change Act requires Parliament to set ‘carbon budgets’ for 5 year periods which sets the maximum amount of emissions to be emitted in order to hit the target of 80% reduction in carbon emissions by 2050. Within this context, the Committee on Climate Change published the 4th Carbon Budget in December 2010 which sets out the required pathway for the period 2023-2027 and considers the level of emissions for ensuring long term compliance with the 2050 target. According to the report, it is recommended that the UK decreases its emissions by 50% by 2025 (below 1990 levels) within the ‘Domestic Action Budget’ i.e. without the support from the international carbon markets. In May 2011, the government announced its commitment to adopt the recommendations of Committee on Climate Change and the recommended target is now legally binding.

- 15% renewable energy target

In response to EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources, the UK has committed to sourcing 15% of its energy from renewable sources by 2020 – a five-fold increase on the share of about 3% in 2009, in less than a decade. This target covers all energy needs, including electricity, heat and transport.

- Renewable Energy Review, Committee on Climate Change, May 2011

In 2010, the Government asked the Committee on Climate Change to review the potential for renewable energy and provide advice on suitable future renewable energy targets, specifically the level of appropriate ambition beyond 2020. The Committee on Climate Change published its findings in May 2011 and the Renewable Energy Review provides options for renewable electricity and renewable heat targets for 2030 and beyond.

- Feed-In Tariff (FIT), Renewable Heat Incentive(RHI)

FITs came into effect on 1 April 2010 and provide generation linked payments for a range of small scale renewable electricity technologies of <5MW: wind, hydro, anaerobic digestion, micro CHP and PV.

The RHI is a tariff-based scheme with payments made to the generators of renewable heat per unit of heat output. It will be available for all scales of installation within industrial, public and commercial sectors from Autumn 2011. The scheme will be extended to the domestic sector in 2012 with an interim arrangement ('RHI Premium Payment') put in place to provide around £15m of grants for renewable heat installations, equivalent to around 25,000 homes. Unlike FITs, the RHI will be paid from general taxation rather than a pass through to consumer energy bills.

The existence of these support mechanisms is very relevant for the findings of this study as both FIT and RHI transform eligible renewable energy technologies into attractive investment options and hence accelerate the rate of uptake of these technologies.

1.5.2 Planning and building control policy

- **National Planning Policy Framework**

Planning policy in the UK is about to undergo fairly substantial upheaval with the Government consulting on a draft National Planning Policy Framework during Summer 2011. This aims to streamline the planning system with simplified planning guidance and a speeding up of planning decisions. Decentralisation of decision-making is also a key feature of these planning reforms with neighbourhood plans simultaneously being introduced through the Localism Bill.

A key element of the new proposals is a 'presumption in favour of sustainable development' which requires local planning decision-making to favour development if it contributes to the Government's definition of sustainable development. The draft Framework explicitly mentions renewable energy as a component of sustainable development and makes it clear that local authorities should consider identifying suitable areas for renewable and low-carbon energy.

When it comes into force in 2012 or 2013, the new National Planning Policy Framework will cancel the PPS 1 Supplement on Climate Change which has been a key policy document in encouraging local planning for renewable energy. However, until the new Framework comes into force the PPS 1 Supplement and accompanying documents are still the Government's official planning policy documents on climate change issues.

- **Planning Policy Statement 1 (PPS1): Delivering Sustainable Development and the PPS1 Supplement (Planning and Climate Change)**

PPS1 has had a key role over the past few years in encouraging local authorities to compile accurate renewable energy evidence bases on the potential within their areas so as to inform planning policy. PPS1 expects new development to make good use of opportunities for decentralised and renewable or low-carbon energy. The supplement to Planning Policy Statement 1 'Planning and Climate Change' highlights situations where it could be appropriate for planning authorities to anticipate levels of building sustainability in advance of those set nationally. This could include where:

- there are clear opportunities for significant use of decentralised and renewable or low carbon-energy; or
- without the requirement, for example on water efficiency, the envisaged development would be unacceptable for its proposed location.

The PPS 1 Supplement requires local planning authorities to develop planning policies for new developments that are based on:

"….an evidence-based understanding of the local feasibility and potential for renewable and low-carbon technologies, including microgeneration".

- **Planning Policy Statement 22 (PPS22): Renewable Energy**

  PPS22 sets out the Government's policies for renewable energy, to which planning authorities should have regard when preparing Local Development Documents and when taking planning decisions.

  Local policies should reflect paragraph 8 of PPS22 which states that:

- *Local planning authorities may include policies in local development documents that require a percentage of the energy to be used in new residential, commercial or industrial developments to come from on-site renewable energy developments.*

- **Zero carbon timeline and allowable solutions**

The Government has set out a timeline for improving the carbon performance of new developments through tightening Building Regulation standards for new homes:

- 2013 – a 44% carbon reduction beyond 2006 requirements; and,
- 2016 – a 100% carbon reduction beyond 2006 requirements.

In the March 2008 budget Government also announced its intentions for all non-domestic buildings to be zero carbon by 2019. Therefore, the various phases of development across the county will face stricter and stricter mandatory requirements, and all housing development after 2016 will need to account for all carbon emissions from regulated energy uses.

The government is introducing a more flexible definition of 'zero carbon' to guide building policy which will apply a minimum requirement for energy efficiency and on-site renewable energy, and a set of off-site 'allowable solutions' to allow the residual emissions to be offset. The allowable measures have yet to be fully defined but could include large scale off-site renewable energy infrastructure, investment in energy efficiency measures for existing building stock, energy efficient white goods and building controls, or S106 contributions. Cambridgeshire Horizons are undertaking work to develop a Carbon Offset Fund in preparation for the allowable solutions mechanism so that funds can be effectively targeted towards low carbon infrastructure.

Future developments in Cambridgeshire will therefore need to achieve minimum fabric standards and some onsite renewable energy generation, with financial contributions for investment in allowable solutions to offset the residual emissions. For any specific development site, developers will need to assess the prospects for different technical solutions including combined heat and power, biomass, medium to large scale wind turbines, heat pumps, PV and solar water heating before determining the contribution of allowable solutions in offsetting the residual carbon emissions. Building Regulations will therefore drive the growth of renewable energy in the county. Local planning policies are also expected to complement and in some cases exceed Building Regulations which would further ramp up the uptake of renewable energy technologies.

- **Local Climate Change Strategies and Initiatives**

  Individual district councils are carrying out work in different areas to minimise the impacts of climate change. Examples of these include Cambridge City Council setting a carbon reduction target of 89% to be achieved by 2050 in its Climate Change Strategy and Action Plan, and Fenland District Council signing up to the CRed Initiative to reduce carbon emissions by 60% by 2025. Most of the district councils also have local planning policies promoting renewable energy in new developments which is contributing to the growth of renewable energy in Cambridgeshire.

2 Cambridgeshire's Carbon Objectives

2.1 Background to the CRIF

The Cambridgeshire Renewables Infrastructure Framework (CRIF) is providing a structure for supporting the development of renewable energy in Cambridgeshire. As well as identifying opportunities to generate renewable energy in the county, it is providing the framework for delivering projects on the ground through the involvement of the community and providing an attractive setting for investment. The findings of the project will inform planning policies and demonstrate Cambridgeshire's commitment to lead on the transition to a low carbon economy.

This report relates to Workpackage 1 which is providing a technical evidence base for the CRIF, looking at the energy demand baseline and future growth areas together with the potential for renewable energy technologies across the county. Workpackage 2 and 3 will build upon the findings of this report to identify the most appropriate delivery pathways for realising renewable energy potential in Cambridgeshire.

2.2 Carbon reduction objectives for Cambridgeshire

2.2.1 Quantifying Cambridgeshire's carbon reduction objectives

As outlined above, the 4th Carbon Budget requires the UK to reduce carbon emissions by 50% by 2025 compared to 1990 levels. Transposing this target to Cambridgeshire, compared to an estimated baseline of 7 million tonnes of CO_2 in 1990, the required emissions by 2025 should be no higher than 3.5 million tonnes of CO_2. With emissions currently at 6.1 million tonnes of CO_2 in the county, this represents a 43% decrease in emissions to be achieved in only 14 years and is illustrated in Figure 2-1. This highlights the significance of the task that lies ahead for Cambridgeshire in the near future and the necessity of exploring different options to meet this challenge.

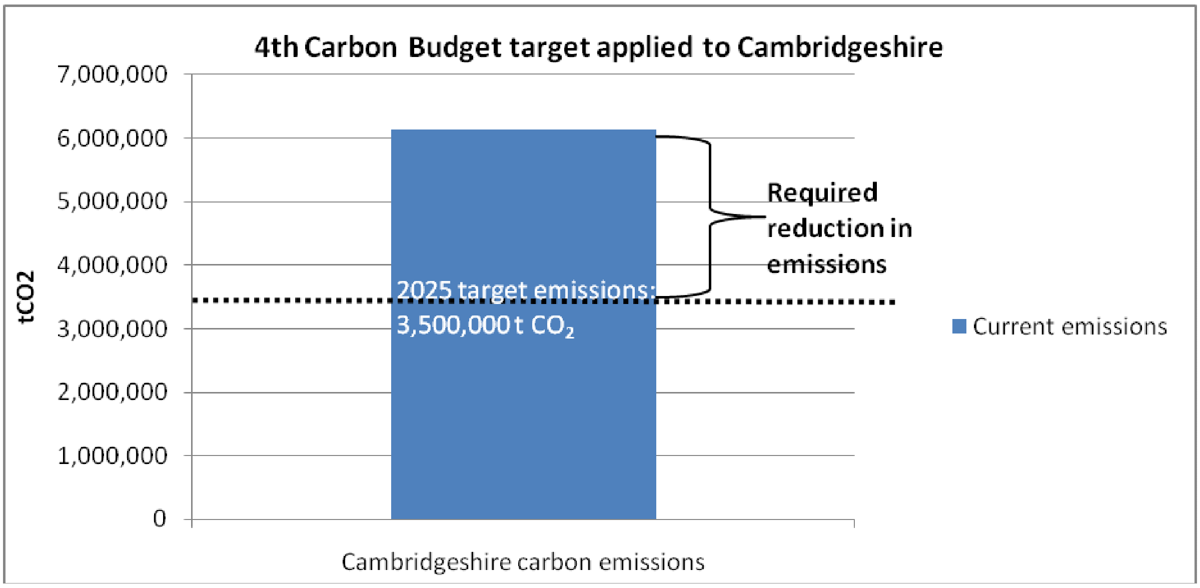


Figure 2-1: Cambridgeshire's pro rata carbon reduction target under the 4th Carbon Budget

2.2.2 Cambridgeshire's carbon reduction challenge

Figure 2-2 explores the potential role of key carbon reduction approaches in helping Cambridgeshire achieve its pro rata carbon reduction target under the 4th Carbon Budget.

Three different energy efficiency scenarios have been considered to understand the impacts on carbon emissions if energy efficiency was improved in Cambridgeshire[4]. These are explained in more detail in Section 8. The impact of grid decarbonisation has also been incorporated to assess possible further reductions without using local renewable energy technologies[5]. The figure below illustrates the carbon reductions that are possible from these different options and the 'carbon gap' that would need to be filled through other measures including renewables and sustainable transport. Although transport emissions are included in this overall Cambridgeshire carbon reduction target, the impact of transport carbon reduction measures are not considered. Nonetheless, carbon reductions in transport are typically more difficult to achieve than reductions from energy use in buildings.

It is estimated that if the energy demand of Cambridgeshire was reduced by 8% through energy efficiency measures, this would result in carbon savings of 0.2 $MtCO_2$. If energy efficiency was prioritised and implemented vigorously to achieve an ambitious reduction of 22% in energy demand, a further 0.4 MtCO2 would be saved. This would result in total savings of 0.6 $MtCO_2$ from energy efficiency measures. Figure 2-2 below demonstrates that even if energy consumption in buildings was reduced by 22% and grid decarbonisation was achieved in line with government targets (reducing carbon emissions by a further 0.8 MtCO2), the total emissions reductions would be 1.4 MtCO2, falling significantly short of the 50% target to be reached by 2025. The following analysis assesses the potential that Cambridgeshire's local renewable energy resource could play in closing this carbon gap.

[4] *The energy efficiency scenarios have been based on DECC's '2050 Pathways Analysis' assessing different options for meeting the 80% reduction target by 2050. The pathways that were incorporated were Reference, Alpha and Epsilon indicating an increase of 5.5% and a reduction of 8% and 22% in energy demand respectively.*

[5] *0.296 was used as the decarbonised grid factor sourced from DECC's 'Valuation of energy use and greenhouse gas emissions for appraisal and evaluation' study.*

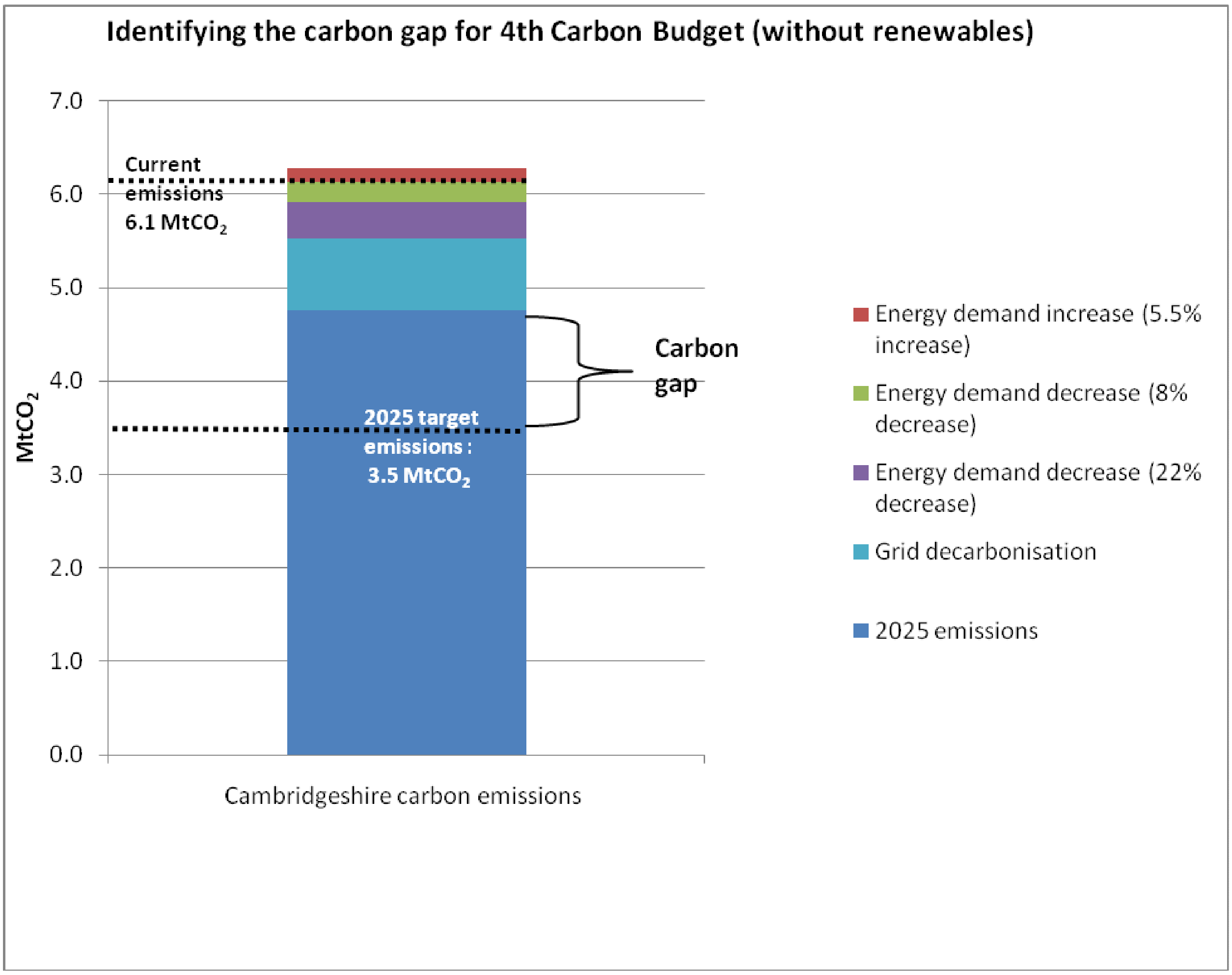


Figure 2-2: Assessing the potential impact of energy efficiency improvements and grid decarbonisation on Cambridgeshire carbon emissions

2.3 Renewable energy objectives for Cambridgeshire

2.3.1 National objectives for renewable energy

The Committee on Climate Change's Renewable Energy Review provides a number of options for renewable electricity and renewable heat targets for 2030 and beyond. Its preferred renewable energy scenarios for electricity and heat would give the following targets for electricity and heat:

- 18% contribution from onshore renewable electricity by 2030
- 35% contribution from renewable heat by 2030

The Committee on Climate Change has outlined that these renewable heat and electricity targets are consistent with the 4th Carbon Budget and the levels of renewable energy deployment that will be needed in order to achieve the 50% carbon reductions by 2025. The Government is currently digesting The Renewable Energy Review and will use it to inform the UK's renewable energy targets for 2030 and beyond. Therefore, although the Government has not yet set the 2030 renewable energy targets, these percentages are currently the best available estimate.

2.3.2 Cambridgeshire's renewable energy targets

Combining the Committee on Climate Change renewable heat and electricity targets into an overall renewable energy target (for both electricity and heat) for Cambridgeshire equates to a renewable energy target of 28% by 2030. This renewable energy target has been calculated by assessing the ratio of heat and power consumption within Cambridgeshire so as to evaluate the overall level of energy demand that would be met if 18% of electricity and 35% of heat was generated from renewable sources.

Transposing these possible national targets for renewable electricity and renewable heat to Cambridgeshire leads to the following targets for 2030:

- 18% renewable electricity
- 35% renewable heat
- 28% renewable energy (both heat and electricity)

The analysis below assesses the potential of Cambridgeshire's renewable energy resource to meet these targets and to 'fill' Cambridgeshire's carbon reduction gap identified above.

2.4 Housing growth in Cambridgeshire

Although the substantial housing growth and associated physical and social infrastructure for the Cambridge Sub-Region over the next few decades presents a huge challenge to the objective of reducing carbon emissions by 50% by 2025, it also presents an opportunity for integrating renewable energy within Cambridgeshire. The 6 main development locations in Cambridgeshire are outlined in Table 2-1, and these are supplemented by general housing growth across Cambridgeshire's market towns. The majority of the large growth sites are located around Cambridge with Northstowe ecotown located at a former MoD site in South Cambridgeshire.

Location	Description	District
Cambridge East	Eastern urban extension to the city of Cambridge. Three main development areas include: North of Newmarket road, north of Cherry Hinton and Cambridge Airport.	Cambridge City, South Cambridgeshire
Cambridge North West	Two major areas include University of Cambridge and NIAB.	Cambridge City, South Cambridgeshire
Cambridge Southern Fringe	Four major areas including: Trumpington meadows, Clay and Glebe farm, Bell school and Addenbrookes.	Cambridge City, South Cambridgeshire
Market Towns	Significant amount of Housing planned to develop by 2021 in the three districts.	Fenland, Huntingdonshire, East Cambridgeshire.
Northstowe	Large eco-town serving as an exemplar for sustainability through incorporating energy efficiency, renewable energy and water saving applications.	South Cambridgeshire
Orchard Park	New community development, 60% of homes already occupied	South Cambridgeshire

Table 2-1: Key growth sites in the Cambridge sub-region

The monitoring team within the planning department at Cambridgeshire County Council have provided housing growth figures from 2010 to 2026, and these have been supplemented by housing figures for 2026 to 2031 and employment land data from the Long Term Delivery Plan (2008). These figures have been used in the assessment of future energy demand and the county's renewable energy potential.

District	Additional housing units by 2026	Housing units 2026 to 2031	Employment land (m^2)
Cambridge	10,829	-	176,913
East Cambridgeshire	5,165	-	84,380
Fenland	3,487	-	56,967
Huntingdonshire	10,803	-	176,488
South Cambridgeshire	15,601	-	254,872
Total	**45,885**	**12,500**	**749,620**

Table 2-2: Cambridgeshire projected housing and employment land growth between 2010 and 2030

3 Energy consumption in Cambridgeshire

3.1 Current energy consumption and carbon emissions in Cambridgeshire

The annual energy consumption and carbon dioxide emissions of Cambridgeshire's built environment, broken down by domestic versus non-domestic use and by district for the most recent available year (2009) are illustrated in Figure 3-1 and Figure 3-2. They show that energy consumption is slightly greater in the domestic sector than in the non-domestic sector with heating demand in housing constituting the greatest element of energy consumption in Cambridgeshire. The balance between heat and power demand in the non-domestic sector is fairly equal.

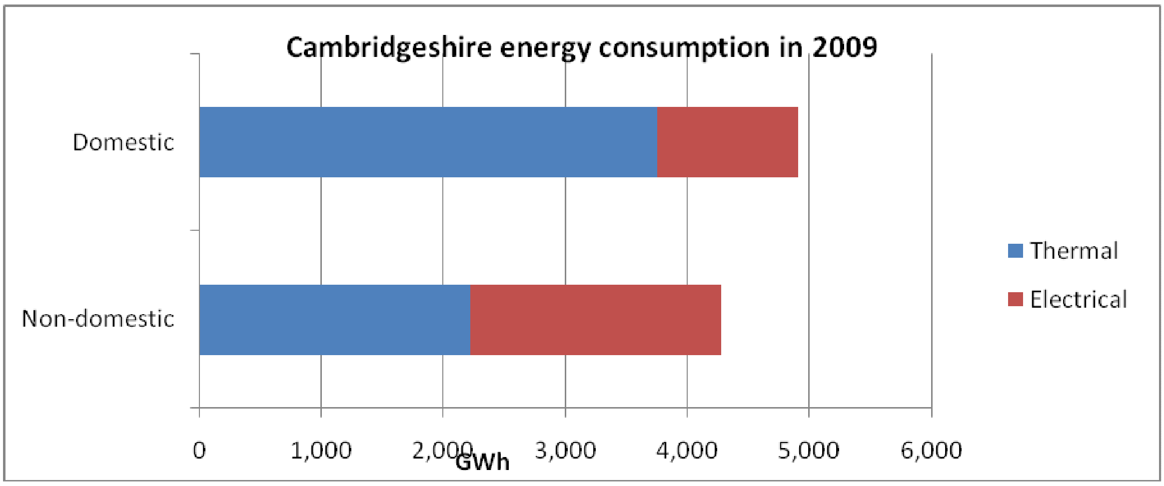


Figure 3-1 Cambridgeshire energy consumption (2009)

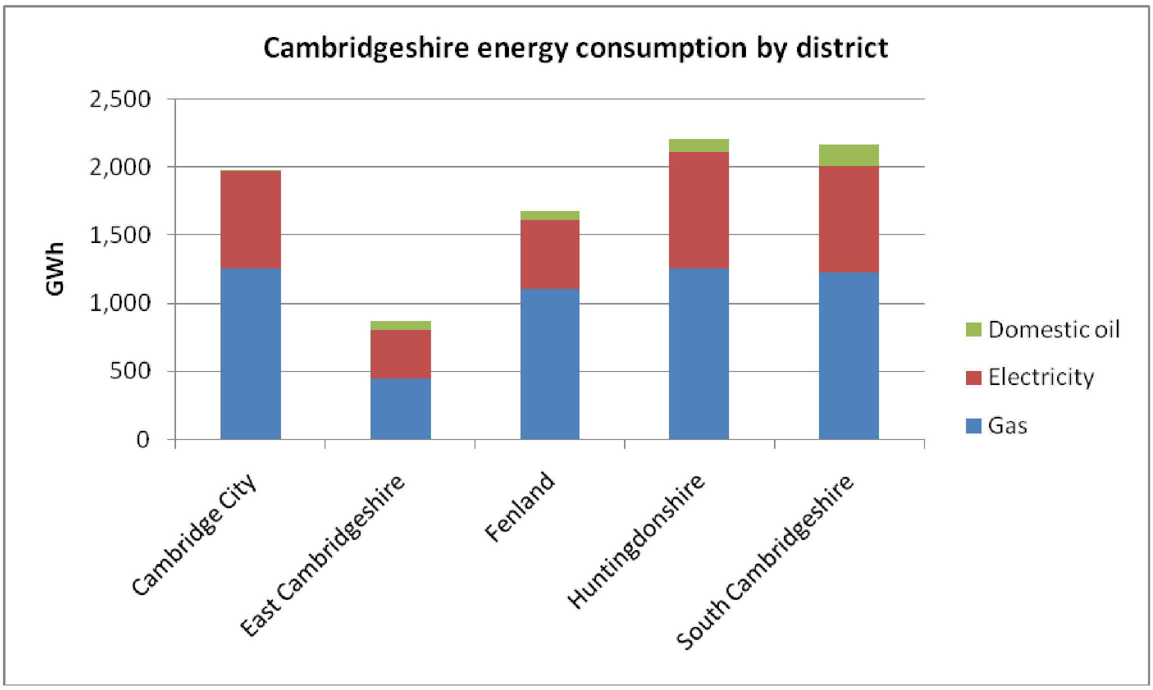


Figure 3-2 Cambridgeshire energy consumption by district

Figure 3-3 shows that the main source of carbon emissions in Cambridgeshire is related to electricity consumption in the non-domestic sector. Although oil consumption for domestic heating is much smaller than gas, its contribution to CO_2 emissions is still fairly significant due to the relatively high carbon intensity of oil. Future carbon emissions will be influenced by changes in the carbon intensity of electricity in the UK as more renewable and low carbon sources of generation are developed, however for the purpose of this study, the carbon intensities of electricity imported from the distribution network, gas and heating oil have been assumed as 0.542tCO_2/kWh, 0.185 tCO_2/kWh and 0.265tCO_2/kWh respectively (Defra, 2010).

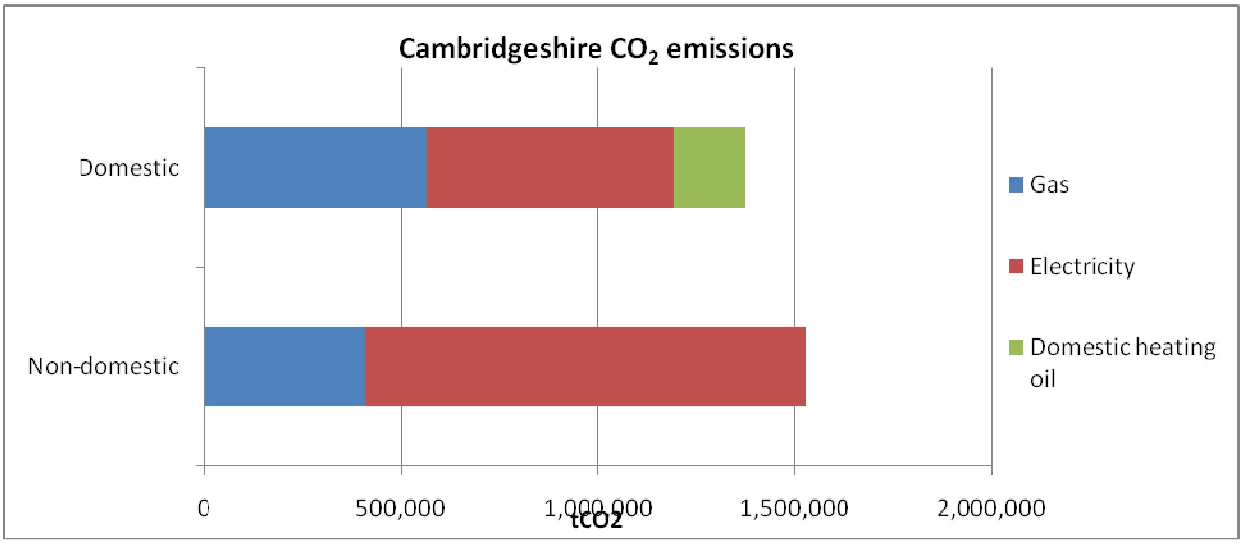


Figure 3-3 Cambridgeshire CO_2 emissions, 2009

3.2 Projection of future energy consumption in Cambridgeshire

The projected future energy consumption of Cambridgeshire's built environment in 2031 is shown in Figure 3-4 below. Projections of housing growth and employment land growth have been modelled so as to estimate associated heat and power consumption. This 2031 projection constitutes a small increase in both heat and power consumption in Cambridgeshire compared to current consumption which is due to the growth in new development. This analysis has not incorporated any assumptions relating to an increase or decrease in the energy demand of the existing built environment. The energy demand scenarios outlined later in the report provide the basis for assessing the impact of either an increase or a decrease in energy demand (depending on the balance of economic growth and energy efficiency improvements over the next 20 years) on the potential contribution from the county's renewable energy resource.

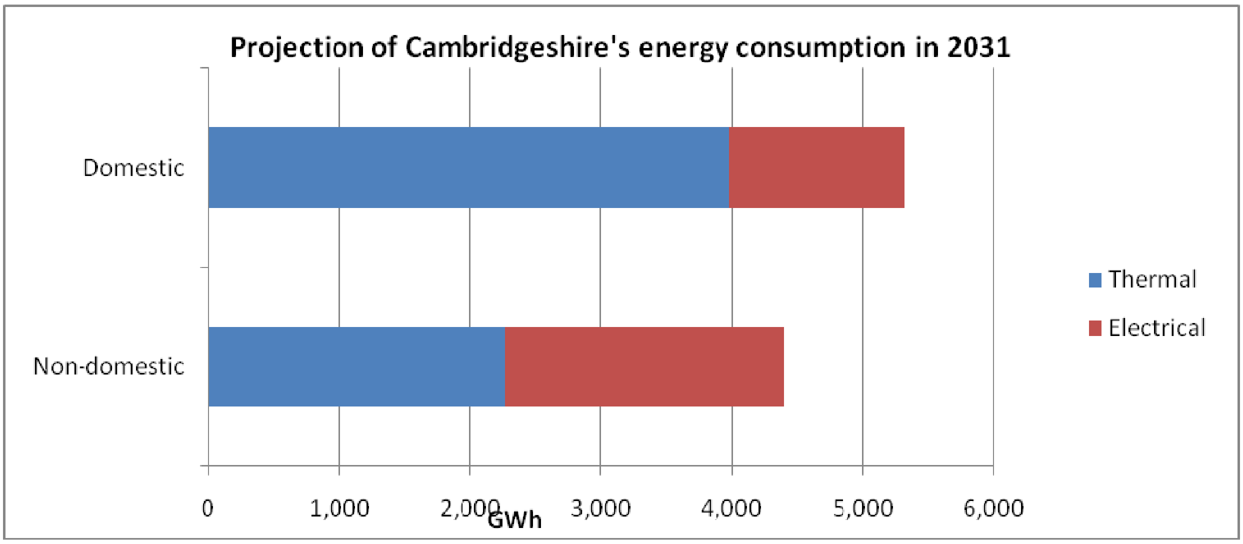


Figure 3-4: Estimate of Cambridgeshire energy demand in 2031

4 Present contribution of renewable energy

4.1 Cambridgeshire is already doing well

Cambridgeshire already has a relatively high renewable energy contribution. Figure 4-1 compares the renewable energy installations that are operational or planned across the East of England and is based on data presented in the East of England Renewable and Low Carbon Energy Capacity study. It illustrates that Cambridgeshire has by far the largest renewable energy output in the East of England, mainly due to its substantial wind resource.

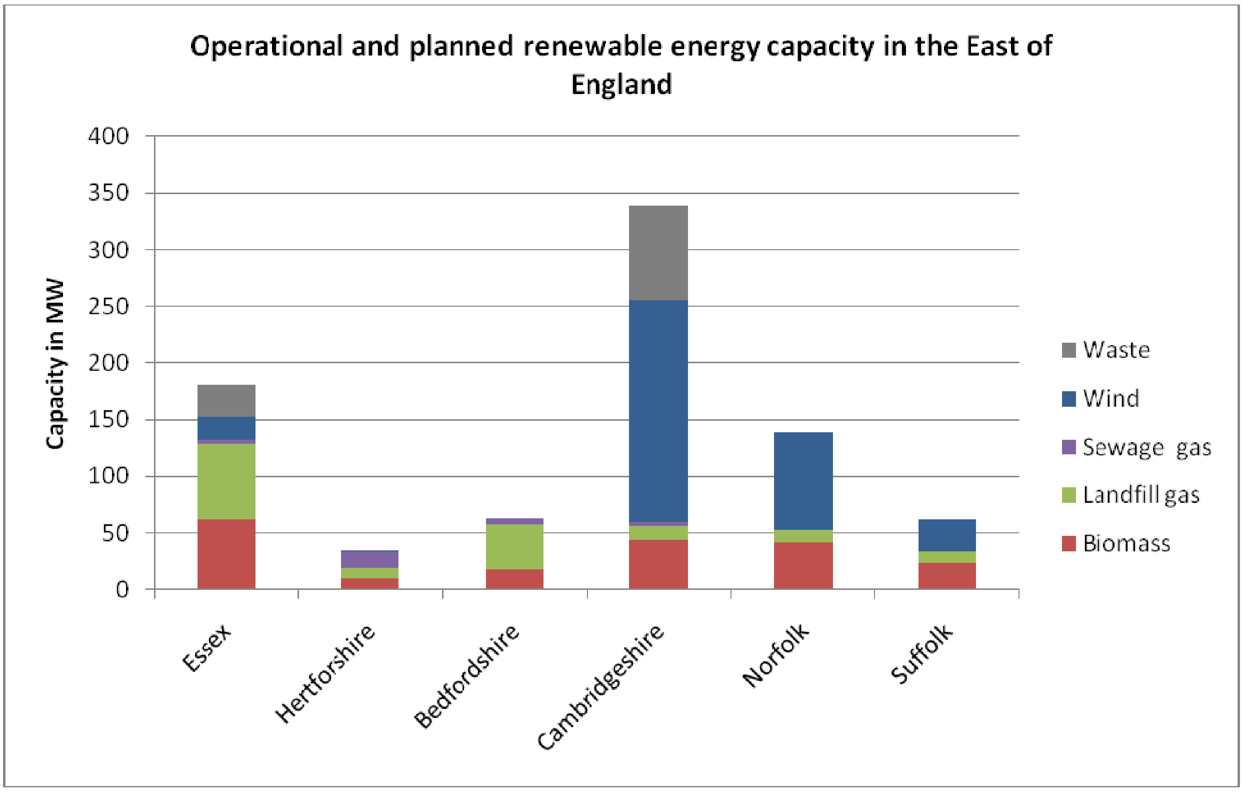


Figure 4-1: Operational and planned renewable energy installations in East of England

Figure 4-1 provides a slight overestimate of the current renewable energy output on the ground in Cambridgeshire as the numbers include a large energy from waste plant that is planned for Peterborough and also a significant number of renewable energy projects which have obtained planning approval but have not been built yet (these are outlined below). Nonetheless, it provides an effective indicator of Cambridgeshire's current prowess in terms of renewable energy installations.

4.2 Current installed capacity across the districts

Cambridgeshire County Council's planning department provides a monitoring report on the current installed capacity of renewable energy in the county and the data is illustrated in Figure 4-2. The current installed capacity in Cambridgeshire is 167 MW with over half of this capacity located in Fenland district in the form of wind turbines.

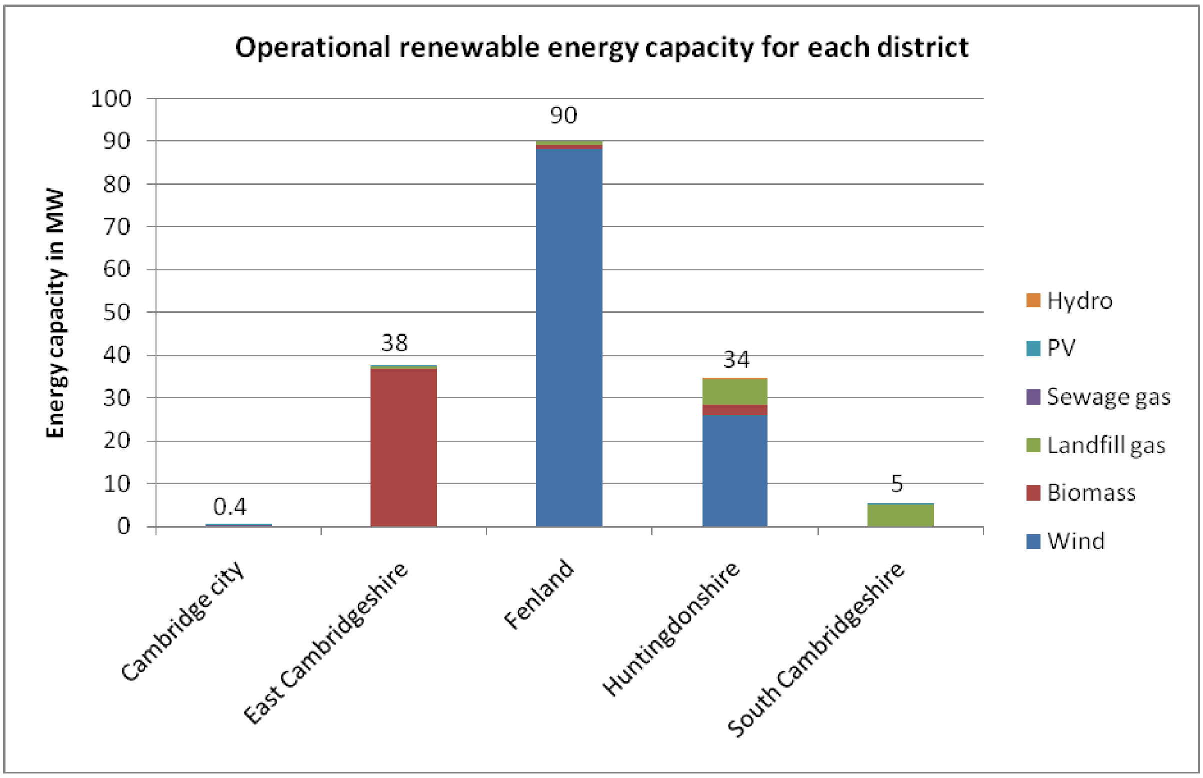


Figure 4-2: Current renewable energy installed capacity by district

Wind energy is the dominant contributor overall representing almost 70% of the total capacity. Huntingdonshire also has a substantial installed wind resource with 26MW of installed capacity. Biomass also makes a large contribution due to the large straw burning plant in East Cambridgeshire. The microgen technologies currently contribute only a tiny proportion to Cambridgeshire's renewable energy capacity.

The locations of the existing renewable energy installations in Cambridgeshire are illustrated in Figure 4-3 which illustrates the dominance of Fenland and Huntingdonshire in contributing to Cambridgeshire's installed renewable energy capacity. The existing installations in Peterborough are also included to show the renewable energy installations on the edge of the study area.

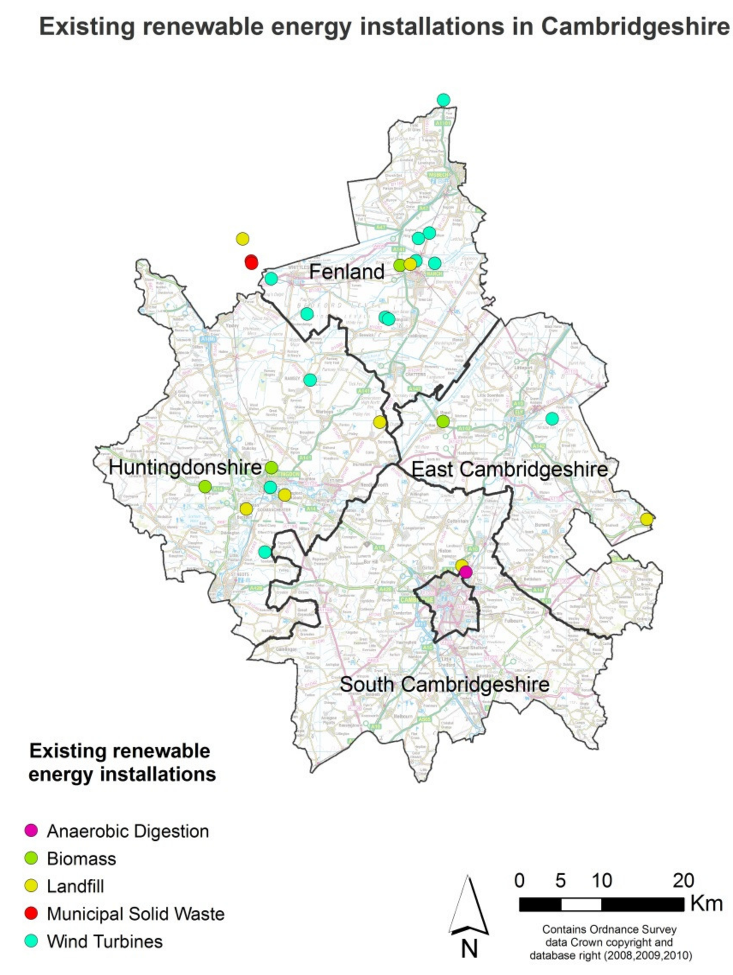


Figure 4-3: Location of existing renewable energy installations in Cambridgeshire

4.3 Recent approved renewable energy projects

During the past year a number of additional renewable energy projects have successfully obtained planning permission and are either currently under construction or awaiting construction. Information on these projects has been obtained from the Department of Energy and Climate Change REStats website[6].

[6] https://restats.decc.gov.uk/cms/welcome-to-the-restats-web-site

District	Under or Awaiting Construction (MW)		
	Biomass	Wind	Total
Fenland	1.2	16	17.2
Huntingdonshire	4.5	20	24.5
South Cambridgeshire		26	26
Total	5.7	62	**67.7**

Table 4-1: Capacity of recently approved projects that are yet to be built

There is an additional capacity of 6MW planned for biomass and 62MW for wind installations located in Fenland, Huntingdonshire and South Cambridgeshire districts. Assuming all these new installations go ahead, they will increase Cambridgeshire's renewable energy capacity by an additional 40%.

5 Renewable energy technical potential

5.1 Methodology

5.1.1 Overview of approach

The assessment of Cambridgeshire's renewable energy technical potential has followed the key steps outlined in the Department of Energy and Climate Change's (DECC) recommended methodology. Figure 5-1 summarises the key stages of DECC's 'Renewable and Low-Carbon Energy Capacity Methodology for the English Regions' which aims to standardise regional assessments of the potential for renewable energy. The approach taken to assess Cambridgeshire's renewable and low carbon energy potential has involved applying progressive layers of analysis to the theoretical potential, in order to establish a more realistically achievable potential taking account of some key high level constraints. Although the diagram illustrates all 7 recommended stages of the assessment, the DECC methodology does not provide any guidance or criteria to address economic and supply chain constraints (stages 5 to 7). The impact of economic and deployment constraints are dealt with in chapter 7 so as to provide an assessment of the deployment potential of renewable energy in Cambridgeshire.

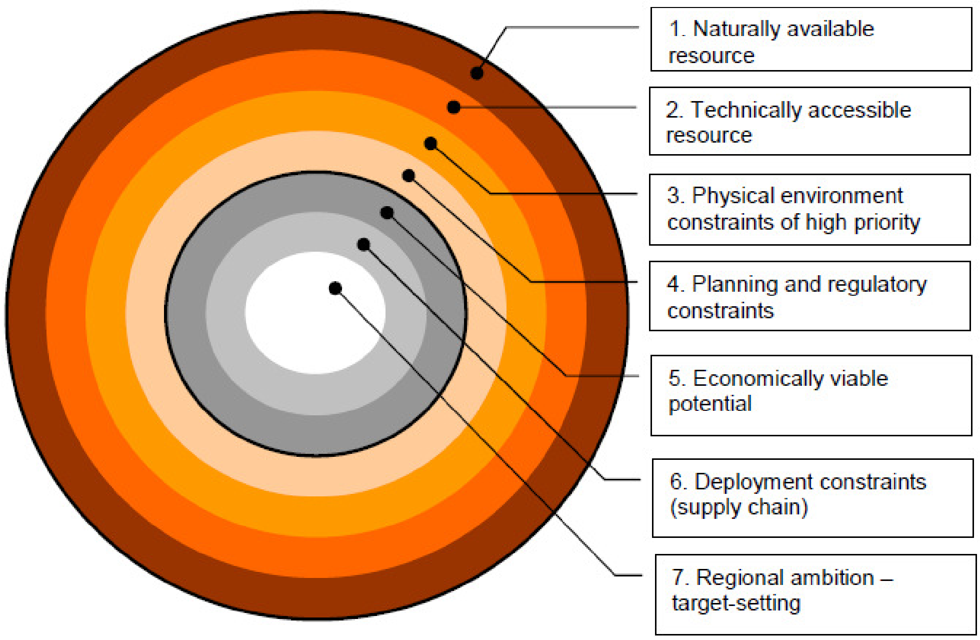


Figure 5-1: Overview of DECC Methodology for undertaking renewable energy resource assessments (Source: DECC/SQW Energy)

The four stages of the technical potential assessment are:

- Stages 1 and 2: Naturally available resource and technically accessible resource – this is the opportunity analysis of what currently available technology can capture and convert into useful energy.
- Stages 3 and 4: High priority physical environment constraints and planning and regulatory constraints – this is the constraints analysis of the high level restrictions that

the physical environment and planning designations or other legislation places on the deployment of the technology. However, neither the technical nor the deployment assessment address specific site constraints and issues.

The stage 1 to 4 assessments cover both the existing and the future built environment of Cambridgeshire as it includes the renewable energy potential associated with the planned new developments between now and 2031.

5.1.2 Assessing 'technical potential'

The 'technical potential' refers to the output from stages 1 to 4 of the DECC methodology, and is defined as the total renewable energy resource that could be delivered if all technically suitable sites or locations were developed. The technical potential is then further constrained by economic considerations and other deployment barriers, such as obtaining planning permission or site-specific technical constraints that cannot be assessed in detail within the scope of this study. Nonetheless, the technical potential provides a good indication of which renewable energy technologies have the greatest potential within a certain area or region.

5.1.3 Data gap analysis

The East of England Renewable Energy Capacity Study provides an assessment of the renewable energy potential across Cambridgeshire following the DECC methodology outlined above. However, the East of England study does not provide a breakdown by authority and it provides a very high level assessment of heat demand, which does not provide the necessary data for modelling CHP and district heating potential. Table 5-1 outlines the key sources of analysis for the different technology assessments undertaken in this study.

Renewable energy assessment	Source of analysis		
	Undertaken new analysis	EoE study	Decarbonising Cambridge
PV & SWH technical potential	✓		
Wind technical potential	✓	✓	
Heat pumps technical potential	✓		
Biomass technical potential		✓	
EfW deployment potential	✓		
Existing EfW infrastructure	✓		
Deployment potential calculations	✓		
Heat mapping low resolution		✓	
Heat mapping high resolution	✓		✓
Existing renewables infrastructure	✓	✓	✓

Table 5-1: Data 'gap' analysis - utilising data from previous studies

5.2 Wind potential

5.2.1 Overview of approach

A GIS analysis has been undertaken to identify sites which are theoretically suitable for wind turbines. The DECC methodology for assessing wind potential has been followed and is summarised in Figure 5-2. The process is essentially that of mapping sites where wind turbines could be located by applying a series of high level constraints that limit the geographical scope for installing turbines.

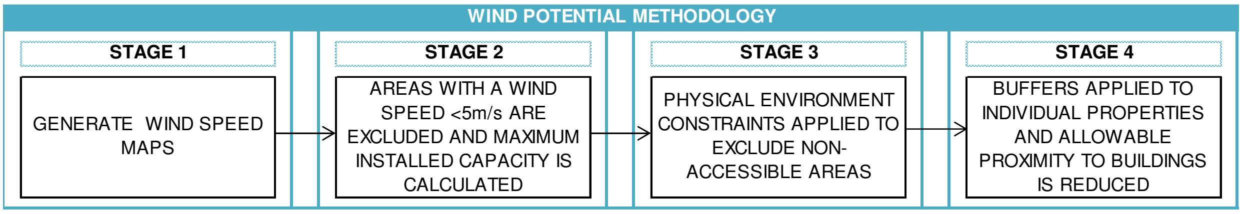


Figure 5-2: Methodology for assessing the technical potential of wind in Cambridgeshire

Assessment of technical potential

The ‘technical potential’ is defined as the wind generation that could be delivered if turbines are installed at all potential sites which do not have absolute constraints to wind. The maximum number of wind turbines that could be installed at each site is determined by the separation distance between turbines required to prevent air stream interference and any associated operational detriment to the turbines. In line with the DECC Methodology, we have assumed a separation distance equivalent to five rotor diameters. In addition, we have assumed a wind turbine capacity of 2.5MW to provide an upper estimate of the potential[7]. The generation potential is based on an assumed capacity factor of 25%, and a 95% turbine availability factor[8]. Capacity factors are highly dependent on wind speed and site specific parameters which influence wind flow. 25% is taken as an reasonable estimate of performance, being a conservative reduction on the 10 year annual average wind farm performance of 28% (published by DECC, for all on-shore UK wind farms).

The absolute constraints that have been applied to the wind analysis in calculating the technical potential for large-scale wind turbines are outlined in Table 5-2 below. These include the key constraints of buildings, roads, waterways, woodland, airports, MoD sites and buffer zones around these constraints. The assessment has also included nationally and internationally designated nature conservation sites including Sites of Special Scientific Interest, Special Areas of Conservation, Special Protection Areas, National Nature reserve and Ramsar Sites.

The technical potential does not address all potential site constraints and issues that would need to be considered to determine whether a site or location is suitable for wind turbines. Impact on landscape and townscape, the historic environment, or other site-specific issues would need to be considered with regard to any site.

[7] The typical dimensions of a 2.5MWe wind turbine are: height to the tip of the blade at the top of its swept area of approximately 135 m, and rotor diameter of 100m. With the quoted load factor and availability assumptions such turbines would be expected produce approximately 5,200MWh/yr, equivalent to the current typical annual consumption of approximately 1,250 households.
[8] Annual generation (MWh/yr) = Capacity (MWe) x Capacity Factor (%) x Availability (%) x Hours in Year (hrs)

Assessment stage	Large -scale turbines (~ 2.5MW)		Medium -scale turbines (~0.25MW)	
	Layer	Buffer	Layer	Buffer
Stage 1: Naturally available resource	Wind speed at 45 m agl	-	Wind speed at 25 m agl	-
Stage 2: Technically accessible resource	Exclude areas with wind speed @ 45m above ground level < 5m/s	-	Exclude areas with wind speed @ 25m above ground level < 5m/s	-
Stage 3: Non accessible areas due to physical environment constraints	Roads (A, B, and motorways)	-	Roads (A, B, and motorways)	-
	Railways	-	Railways	-
	Inland waters	-	Inland waters	-
	Residential properties	-	Residential properties	-
	Commercial buildings	-	Commercial buildings	-
	Airports and airfields	-	Airports and airfields	-
	MoD training sites	-	MoD training sites	-
Stage 4: Areas where wind developments are unlikely to be permitted	Ancient woodland	-	Ancient woodland	-
	Roads (A, B, and motorways) and Railways	150m	Roads (A, B, and motorways) and Railways	150m
	Residential properties	600m	Residential properties	400m
	Commercial buildings	50m	Commercial buildings	50m
	Civil airports and airfields	5km	Civil airports and airfields	3km
	MoD airbases	5km	MoD airbases	3km
	Sites of historic interest	-	Sites of historic interest	-
	International and National Designations for Nature Conservation	-	As per DECC methodology	-
	International and National Landscape designations	-	As per DECC methodology	-

Table 5-2: Parameters and constraints applied to the assessment of wind technical potential

The assessment has identified all individual buildings in Cambridgeshire and applied a buffer of 600m for large wind turbines and 400m for medium turbines, so that the assessment of technical potential does not allow turbines nearer than 600m and 400m to a building respectively. For non-domestic buildings, the buffer was applied as 50 m. The identification of individual buildings constitutes an approach which goes beyond the DECC recommended standard approach of applying ‘settlements’ as constraints rather than individual buildings. Given that a large proportion of Cambridgeshire’s environment is rural, there are a significant number of isolated and clustered properties that are not classified as “built-up areas”. It is therefore considered appropriate to apply a buffer around each individual property within the study area as an additional layer of constraint in order to avoid a large overestimation of potential development opportunities. This reflects the fact that owners of all properties, even isolated rural properties, can raise objections and there is a reasonable likelihood that if a development is closer than a stated 'rule of thumb' (600m in this case for large turbines) it will not achieve planning permission or be perceived as a high planning risk by wind developers.

Large-scale wind turbines are typically favoured commercially due to their considerably greater power output and much lower capital costs per kW installed. However, medium-scale turbines can be an alternative where smaller turbines are favoured due to their lower visual impact. The assessment has considered the potential from both large and medium scale wind turbines, and has assessed the potential output from a combination of large and medium scale turbines which would have the scope of increasing the potential through locating medium scale turbines nearer to buildings.

Scale	Capacity	Hub height	Rotor diameter
Large	2.5MW	85m	100m
Medium	250kW	31m	27m

Table 5-3: Capacity and size of wind turbines assessed

5.2.2 Maps of Cambridgeshire technical wind potential

Figure 5-3 illustrates the technical potential for siting large scale wind turbines in Cambridgeshire.

Table 5-4 represents the total technical potential for large scale wind energy in Cambridgeshire after the constraints outlined above have been applied and the impact of the Lordsbridge observatory exclusion zone. It shows that almost 14,000GWh of electricity could be generated based on the available space for 2,500 wind turbines.

District	Total MW installed	Annual generation (GWh)
Cambridge	20	42
East Cambridgeshire District	1,688	3,511
Fenland District	1,018	2,117
Huntingdonshire District	2,088	4,343
South Cambridgeshire District	1,863	3,875
Cambridgeshire	**6,675**	**13,887**

Table 5-4: Technical potential of large scale wind in Cambridgeshire

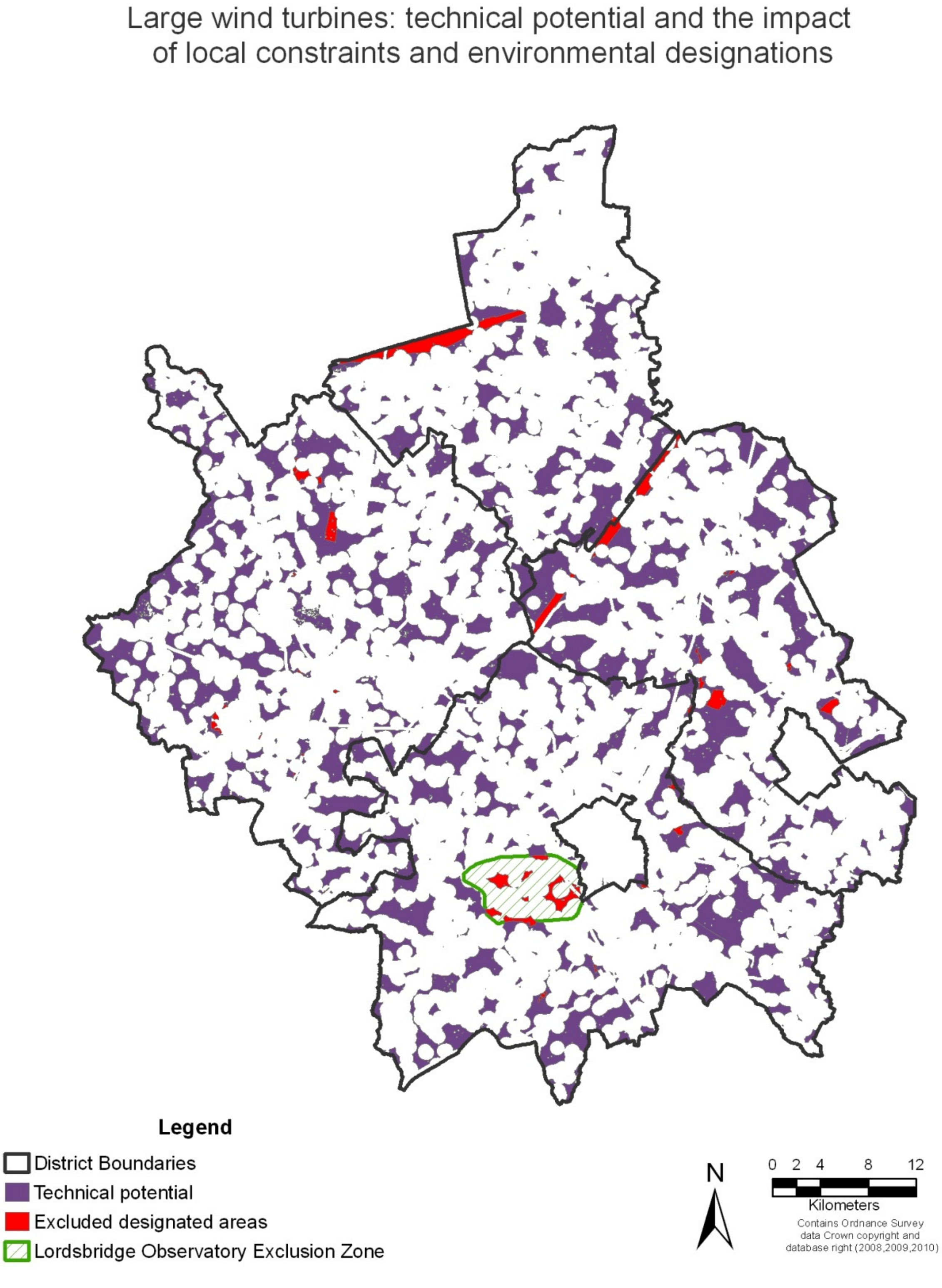


Figure 5-3: Technical potential of large scale wind in Cambridgeshire

Figure 5-3 illustrates that Cambridgeshire is a predominantly rural county with substantial scope for installing wind turbines. This assessment identifies a technical potential of over 2,500 large scale and 13,000 medium scale turbines to be installed on Cambridgeshire farm land.

Housing growth and associated infrastructure over the coming decades will also reduce the total area that is potentially available for turbine locations. However, the impact of these sites on the total area available to wind turbines will be small overall, particularly as they are generally located on the immediate periphery of existing urban areas (Northstowe excluded) which are locations not available to turbines. If the identified growth sites are all developed then they would only reduce the total technical potential by a couple of percentage points.

5.2.3 Wind technical potential based on urban settlement constraint rather than individual buildings

The East of England study assesses the wind technical potential taking urban settlements rather than individual buildings as a constraint layer. This provides a very large estimate of technical potential as it considers that all areas outside towns and villages are available for wind turbines regardless of whether there are individual dwellings in the vicinity. The wind technical potential estimated by the East of England study is almost three times the potential in this report at 41,500GWh per year. The map of the larger technical potential as outlined in the East of England report is found in the Appendix 2.

5.2.4 Wind technical potential based on a combination of large and medium scale turbines

Figure 5-4 illustrates the additional areas that could be available for medium scale turbines in addition to large scale turbines. The area of potential for large turbines has been excluded to ensure that the two technologies are additional – therefore potential for medium wind exists primarily in a 200m wide belt around the outside of the large wind sites. This is due to the buffer zone applied to residential buildings being 200m smaller for medium sized turbines than for large turbines. The extra land area available due to the smaller buffer would allow the space for 13,000 medium scale turbines to be installed. In combination with the large scale turbines this could generate an overall potential of 19,390GWh, which is a third greater than the output from large scale turbines alone.

District	Total MW installed	Electricity generation (GWh)
Cambridge	31	60
East Cambridgeshire District	2,355	4,621
Fenland District	1,608	3,099
Huntingdonshire District	3,165	6,135
South Cambridgeshire District	2,824	5,474
Cambridgeshire	**9,982**	**19,390**

Table 5-5: Technical potential from a combination of large and medium scale turbines

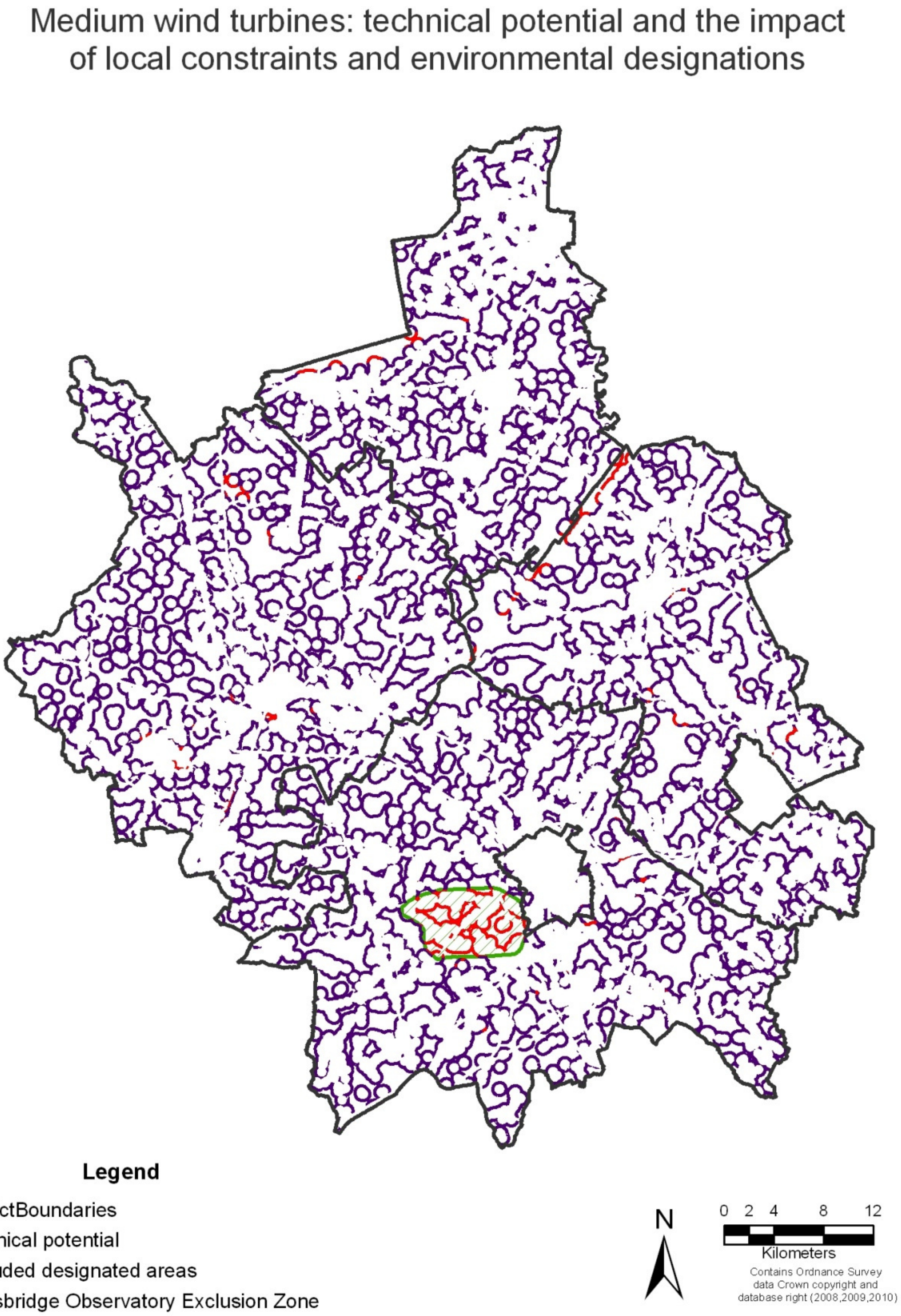


Figure 5-4: Additional areas available to medium scale turbines (above and beyond large turbine potential sites)

5.3 Biomass and Energy from Waste potential

5.3.1 Overview of approach

The overview of the approach to estimating the technical potential from biomass and energy from waste are outlined in the figure below.

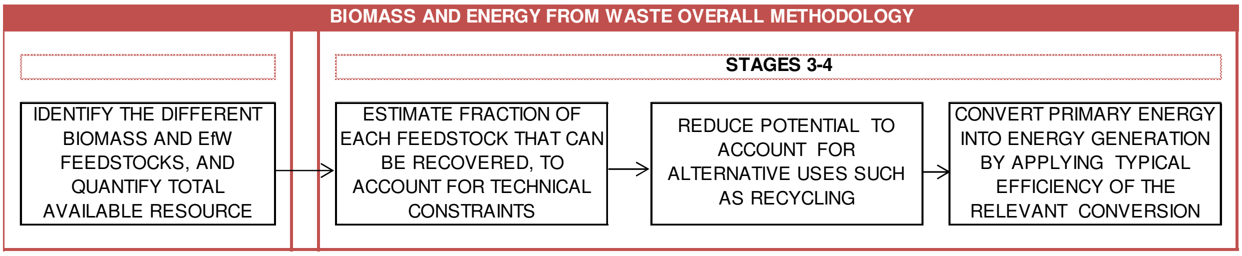


Figure 5-5: Methodology for assessing the technical potential of biomass in Cambridgeshire

The assessment of biomass and energy from waste technical potential has been undertaken in two parts – the biomass potential has been taken from the East of England study which provides a breakdown of the different biomass feedstocks whereas the energy from waste potential has been estimated through quantifying the waste flows in Cambridgeshire.

5.3.2 Biomass potential

The biomass potential was taken from the East of England study and Peterborough has been excluded from the potential. Table 5-6 shows the technical potential of electricity and heat generation from biomass sources.[9]

District	Electricity generation (GWh)	Heat generation (GWh)	% of energy demand
Cambridge	149	17	2%
East Cambridgeshire	104	12	1%
Fenland	115	13	2%
Huntingdonshire	207	23	3%
South Cambridgeshire	179	20	2%
Total	**753**	**85**	**10%**

Table 5-6 Technical potential of biomass in Cambridgeshire

The technical potential of biomass indicates that this resource alone could meet 10% of the county's energy demand if all of this potential was deployed. Around 80% of this biomass potential comes from straw which has the potential to produce 680GWh of electricity per year. The 38MW straw power station in Ely currently generates 270GWh of electricity each year which indicates that Cambridgeshire already achieved 40% of its technical potential of producing energy from straw and around 30% of the total energy it could technically generate from its biomass sources.

[9] *Derived and sourced from AECOM (2011) East of England renewable and low carbon energy capacity study (not published yet)*

5.3.3 Energy from waste potential

The energy from waste potential was estimated by identifying the 2031 waste flows in Cambridgeshire and the potential quantities available for energy generation. The three key waste flows include Municipal Solid Waste (MSW), Commercial and Industrial waste (C&I) and Construction and Demolition waste (C&D). The energy potential from C&D waste has already been quantified in the form of waste wood in the East of England study's biomass potential figures and therefore this energy from waste assessment on consider the potential from MSW and C&I waste.

The volumes of waste and future recycling targets have been sourced from the Cambridgeshire and Peterborough Minerals and Waste Development Plan[1] and discussions have been held with waste planning staff at Cambridgeshire County Council. In order to extract the amount of waste specific to Cambridgeshire, figures were used from a previous study carried out by Jacobs Babtie [10]. Energy potential has been quantified based on the targets set as well as taking into account the current and planned energy from waste plants in the region. Figure 5-6 shows the waste flow diagram for municipal solid waste (MSW) and identifies the potential waste flows available for energy generation in 2031. The 2031 waste flow diagrams for C&I waste is found in Appendix 2.

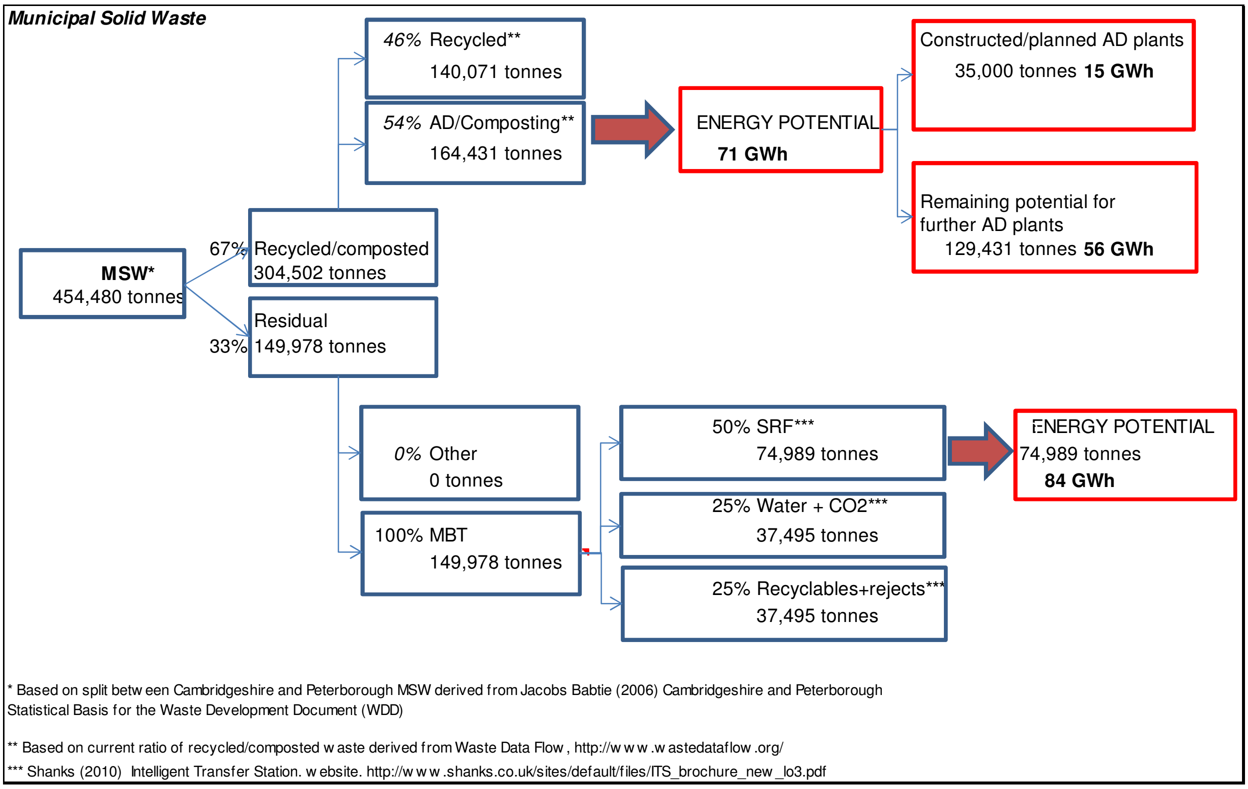


Figure 5-6 Future energy from waste potential from municipal and solid waste

[1] *Cambridgeshire County Council and Peterborough City Council (2010) Cambridgeshire and Peterborough Minerals and Waste Development Plan Core Strategy*

[10] *Jacobs Babtie (2006) Cambridgeshire and Peterborough Statistical Basis for the Waste Development Document (WDD)*

The waste flow diagram shows the quantity of material that will be diverted for recycling and composting, and the residual waste that will be processed at the Waterbeach MBT plant. The waste flow diagram demonstrates that the key energy from waste potential from MSW is compostable waste which could form a feedstock for AD plant and the residual waste product from the MBT plant (known as Solid Recovered Fuel – SRF) which also can be used as a fuel.

The waste flow diagram also includes the existing and planned energy generation plant so as to identify the proportion that is already going (or about to go) to energy generation, and the remaining potential. There is currently one anaerobic digester (AD) plant in operation with a capacity of 30,000 tonnes per annum, and there are plans to potentially double its capacity. A second AD plant is planned with a capacity of 10,000 tonnes per annum. These two AD plants could provide the capacity to process 70,000 tonnes of waste per annum if the commercial plant was to double in size in line with the current proposals. It has been assumed that this capacity would be split equally to process MSW and C&I waste and therefore 35,000 tonnes has been allocated to MSW in the figure above.

There is also an incineration plant in Addenbrookes Hospital incinerating about 1,400 tonnes of clinical waste a year and a gasification plant in Huntingdon receiving approximately 45,000 tonnes of waste per year including recovered wood from construction and demolition waste in the region.

The technical potential for energy from waste is presented in Table 5-7.

Waste streat	Installed capacity (MWe)	Electricity generation (GWh)	Heat generation (GWh)	% of Cambridgeshire's energy demand
MSW - food waste	1.7	13.3	18.9	0.4%
MSW - garden waste	2.0	16.0	22.9	0.5%
C&I - food waste	0.8	6.3	9.0	0.2%
Renewable fraction of SRF	4.0	31.6	52.7	1.0%
C&I - residual waste	6.9	54.8	123.2	2.1%
Total	**15**	**122**	**227**	**4.1%**

Table 5-7: Technical potential of energy from waste

It is assumed that the energy from waste plants would operate as CHP plants. Accordingly, it is estimated that MSW and C&I waste in the county have a technical potential of 122GWh of electricity and 227GWh of heat generation equivalent to 4% of Cambridgeshire's energy demand.

5.3.4 Mapping waste facilities

The proposed waste management sites in the waste LDF (from the Waste Site Specific Proposals Plan) are mapped in Figure 5-7. This includes the sites proposed in Peterborough to illustrate the density of proposed sites near to Huntingdonshire and Fenland in Peterborough. These sites have the potential for locating energy from waste facilities.

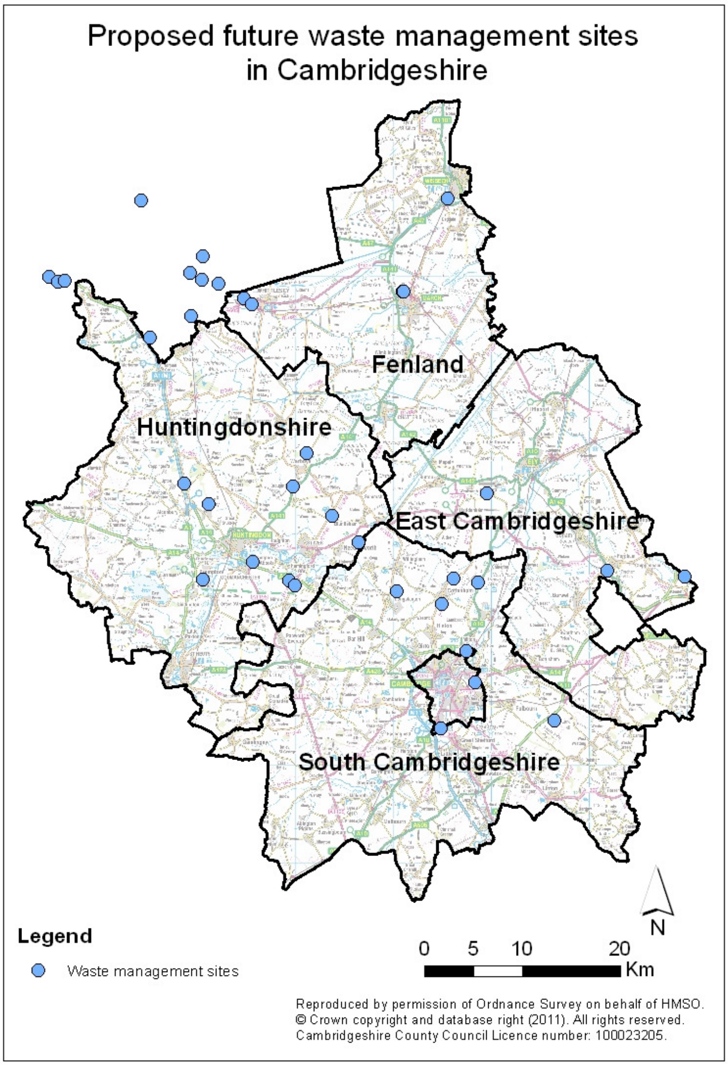


Figure 5-7: Proposed future waste management sites in Cambridgeshire

5.3.5 Landfill gas potential

Potential from landfill gas was also sourced from the East of England study and was estimated to produce 19.1GWh of electricity in Cambridgeshire with 3.6MW of installed capacity. This technical potential is lower than the current installed capacity as it was assumed that some of the existing plants will be closed down and there will be less landfill waste due to higher rates of recycling.

5.4 PV potential

5.4.1 Assessing technical potential of PV

The PV methodology calculates the actual roof area that could accommodate PV panels and calculates an installed PV capacity from this, as outlined in Figure 5-8. The orientation of roofs was accounted for by only considering south, south east and south west facing roofs.

Differentiation was also made between horizontal and inclined panels based on the different efficiency factors under these conditions. The impact on PV potential of over-shading and competing roof space uses in high and medium density areas was incorporated by applying constraint factors. Finally, constraints on the installation of PV on roofs in conservation areas were considered by assuming a lower installation rate on buildings in conservation areas. Additional roof space created by an increase in properties between now and 2031 due to increases in domestic and non-domestic buildings have been incorporated by considering projections of housing and employment land provided by Cambridgeshire County Council.

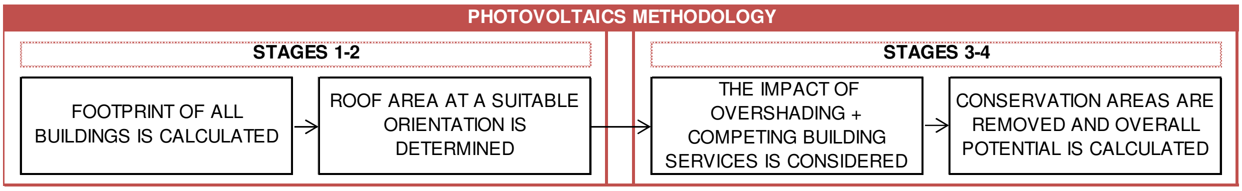


Figure 5-8: Methodology for assessing the technical potential of PV in Cambridgeshire

5.4.2 Summary of PV technical potential

District	Installed capacity (MW)	Electricity generation (GWh)	% of District/Cambridgeshire's electricity demand
Cambridge	232	169	22%
East Cambridgeshire	298	216	56%
Fenland	380	275	53%
Huntingdonshire	547	397	43%
South Cambridgeshire	528	383	44%
Total	**1,985**	**1,439**	**42%**

Table 5-8: Technical potential of PV in Cambridgeshire

Total technical potential of PV in Cambridgeshire is equivalent to 1,985MW of installed capacity generating 1,439GWh of electricity. If all this technical potential was deployed, it would meet 42% of Cambridgeshire's electricity demand.

The highest potential for PV installations is in Huntingdonshire and South Cambridgeshire due to greater number of buildings and hence larger roof space in these districts as well as a relatively lower number of buildings designated under conservation areas than in Cambridge. When potential is measured on the basis of density (MWh/ha), the greatest potential of PV is clustered in Cambridge where building density is highest. Please refer to the Appendix of maps for a map of the distribution of PV potential across Cambridgeshire.

5.5 Solar water heating potential

5.5.1 Assessing technical potential of solar water heating

Two different methodologies were used to assess solar water heating potential across domestic and non-domestic buildings in Cambridgeshire. For the domestic stock a system size of 3m^2 per dwelling was used and only 20% of flats and 75% of houses were assumed to be suitable due to lack of roof space for installing panels on flats and for higher density housing. In the same way as for the assessment of PV potential, constraints were applied in conservation areas assuming a reducing number of panels to be installed. To avoid double-counting, it was assumed that SWH would take priority over the installation of PV panels as they may be competing for the same roof space. Therefore the potential of this technology was deducted from total PV potential. The methodology for working out the potential in domestic buildings is summarised in Figure 5-9.

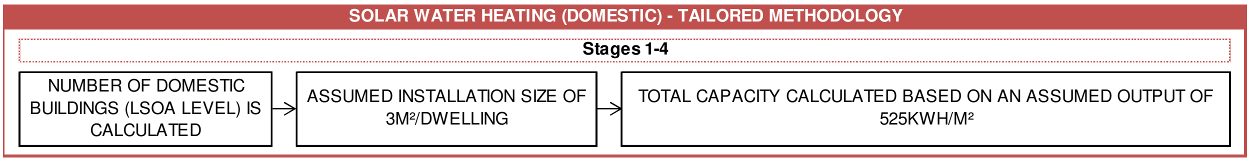


Figure 5-9 Methodology for assessing the technical potential of SWH in Cambridgeshire for domestic stock

For the non-domestic stock, it was assumed that 75% of the properties would be suitable for the installation of SWH systems. Non-domestic buildings generally have a fairly low hot water demand and therefore a typical SWH system would not require significant amounts of roof space. The hot water demand was predicted based on published benchmarks[11]. The non-domestic SWH systems were sized to produce 50% of the predicted hot water demand. A lower installation rate in conservation areas has been assumed for both the domestic and non-domestic assessment.

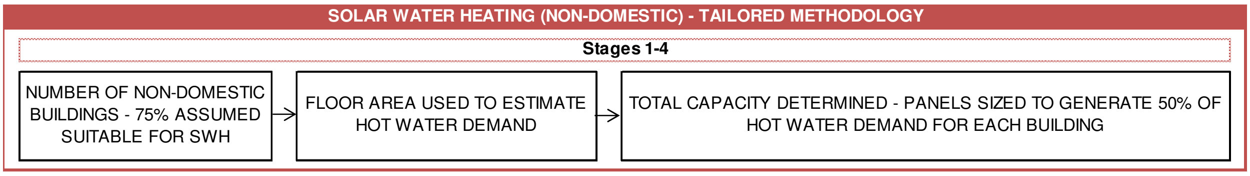


Figure 5-10: Methodology for assessing the technical potential of solar water heating in Cambridgeshire

5.5.2 Summary of solar water heating technical potential

The technical potential of SWH is 134GWh which could supply 2% of Cambridgeshire's heat demand. As expected, this is much lower than the PV potential due to the fact that SWH installation sizes are limited by the hot water demand of a building as excess hot water cannot be exported to neighbouring buildings. In the case of PV however, the whole of the available roof space can be utilised with excess electricity exported to the local grid.

District	Heat generation (GWh)	% of District/Cambridgeshire's heat demand
Cambridge	23	1%
East Cambridgeshire	18	2%
Fenland	22	1%
Huntingdonshire	36	2%
South Cambridgeshire	36	2%
Total	**134**	**2%**

Table 5-9: Technical potential of solar water heating in Cambridgeshire

[11] *CIBSE (2007) CIBSE Guide F: Energy efficiency in buildings Section 20, Second Edition*

5.6 Heat pump potential

5.6.1 Ground source heat pumps

5.6.1.1 Assessing technical potential for ground source heat pumps

Separate methodologies have been used for assessing the technical potential of heat pumps for domestic and non-domestic buildings due to their differing characteristics. Due to the space requirements of GSHP, it has been assumed that no flats would be suitable. Across the remaining housing stock, only houses with an Energy Efficiency Rating (EER) of C or higher, corresponding to 7.9% of the stock[12], were assumed to be technically suitable for GSHP. This is due to the poor performance of heat pumps in thermally inefficient buildings. In line with the DECC methodology, a fixed capacity of 5kW was assumed for all suitable domestic properties.

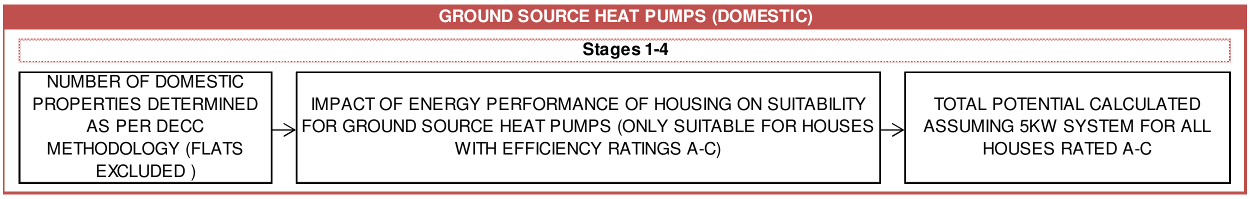


Figure 5-11: Methodology for assessing the technical potential of GSHP in domestic buildings in Cambridgeshire

For non-domestic properties, the methodology is similar to the DECC methodology however further constraints were applied and it was assumed that only 5% of existing commercial properties would be suitable for ground source heat pumps. For industrial properties, the suitable proportion of the stock was assumed to be 40%. The remaining 60% was assumed to either have space constraints or not be eligible for heat pumps due to poor energy efficiency performance of the buildings.

For future developments, the potential for ground source heat pumps was based on applying the same methodology to projected domestic and non-domestic development. In addition, it was assumed that 75% of the existing domestic building stock that currently have an EER of less than C could be technically upgraded to at least a C rating by 2031.

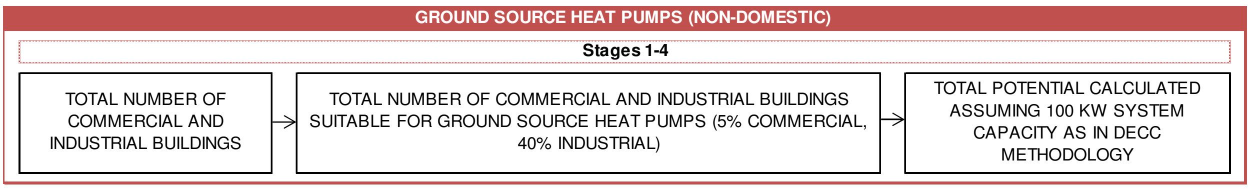


Figure 5-12: Methodology for assessing the technical potential of GSHP in non-domestic buildings in Cambridgeshire

5.6.1.2 Summary of ground source heat pump technical potential

Table 5-10 shows the technical potential of ground source heat pumps in Cambridgeshire by local authority. If all this potential was installed, the technology could meet up to 13% of heat

[12] *DCLG (2007) English House Condition Survey, Summary Statistics Table 7.2, Standard Tables, Summary Statistics* *http://www.communities.gov.uk/housing/housingresearch/housingsurveys/englishhousecondition/ehcsdatasupporting/ehcsstandardtables/summarystatistics/*

demand. However, the electricity consumption associated with this scale of heat pump use would be significant, corresponding to a 12% increase in Cambridgeshire's electricity demand.

District	Installed capacity (MW)	Heat generation (GWh)	% of heat demand	% Increase in electricity consumption[13]
Cambridge	147	178	11%	9%
East Cambridgeshire	119	144	16%	15%
Fenland	139	167	10%	13%
Huntingdonshire	249	300	14%	13%
South Cambridgeshire	237	286	14%	13%
Total	**890**	**1,075**	**13%**	**12%**

Table 5-10: Technical potential of GSHP in Cambridgeshire

5.6.2 Air source heat pumps

5.6.2.1 Assessing technical potential for air source heat pumps

The methodology for assessing the technical potential of ASHP is similar to GSHP however, because this technology does not require a ground heat exchanger it has wider applicability within towns and cities. Hence, flats were also included whilst estimating the total technical potential. Properties that have an EER banding of C or less were excluded from the assessment, as these properties would not be technically suitable due to the low temperature heat output from ASHP.

The calculated GSHP potential has been subtracted from the ASHP potential in order to avoid double-counting as these technologies are mutually exclusive. Whilst doing this, it was assumed that GSHP would be of first preference due to their higher efficiency. For non-domestic buildings, 50% of buildings are assumed to be suitable for ASHP.

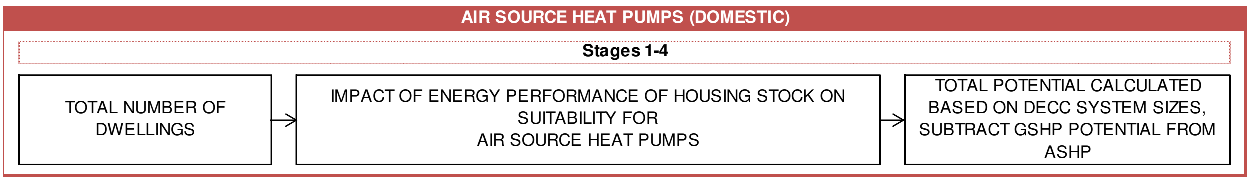


Figure 5-13: Methodology for assessing the technical potential of ASHP in housing in Cambridgeshire

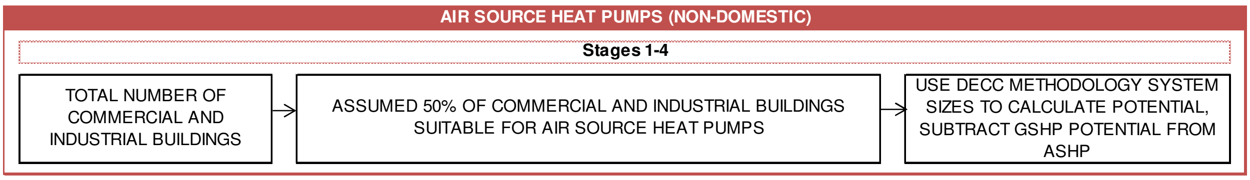


Figure 5-14: Methodology for assessing the technical potential of ASHP in non-domestic buildings

[13] *Based on a coefficient of performance of 2.5 sourced from EST field trial: EST (2010) Getting warmer: a field trial of heat pumps http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF*

5.6.2.2 Summary of air source heat pump technical potential

District	Installed capacity (MW)	Heat generation (GWh)	% of heat demand	% Increase in electricity consumption[14]
Cambridge	288	348	22%	20%
East Cambridgeshire	134	161	18%	19%
Fenland	163	197	12%	17%
Huntingdonshire	293	354	17%	18%
South Cambridgeshire	289	349	17%	18%
Total	**1,166**	**1,409**	**17%**	**19%**

Table 5-11: Technical potential of ASHPs in Cambridgeshire

The total technical potential for ASHPs is equivalent to 1,409GWh which would meet 17% of Cambridgeshire's heat potential. With a lower coefficient of performance than GSHP, the additional electricity demand associated with this level of heat pump deployment is also very significant, equivalent to 19% of electricity consumption. This additional electricity demand could have implications for the capacity of the local electricity distribution network and may require local grid reinforcement to enable the greater electrical supply. The national programme of electrical grid decarbonisation is also key to the carbon savings from heat pumps and in the short term heat pumps would deliver negligible carbon savings due to the current high carbon content of the grid.

5.6.3 Potential of heat pumps in off-gas properties

Properties that are not connected to the gas grid are a significant source of potential for heat pumps as they would be replacing heating systems that run with electricity or heating oil which are more carbon intensive than natural gas. Therefore the prioritisation of the installation of heat pumps in off-gas properties would ensure the reduction of carbon emissions in an effective way.

Energy consumption figures for Cambridgeshire suggest that on average 5.6% of homes use heating oil in Cambridgeshire and this figure could go up to as much as 11% in East Cambridgeshire. Installing heat pumps in these properties as well as in properties that use electric heating would both reduce the running costs of heating for the residents and help to reduce carbon emissions.

5.7 Summary of renewable energy technical potential

5.7.1 Overview of Cambridgeshire's renewable energy technical potential

Table 5-12 provides a summary of the technical potential of renewable energy in Cambridgeshire. Although the technical potential could provide 226% of Cambridgeshire's energy demand, the majority of this resource is wind, and the potential from renewable heat technologies is far less at approximately 60% of Cambridgeshire's heat demand.

ASHPs and PV have the second and third largest technical potentials at approximately 16% and 15% of energy demand respectively. The PV and ASHP technical potentials are both large because these technologies could potentially be installed in or on most buildings. GSHP potential is also large at 12.6% as there are a lot of rural properties in Cambridgeshire with

[14] *Based on a coefficient of performance of 2.2 sourced from EST field trial: EST (2010) Getting warmer: a field trial of heat pumps http://www.energysavingtrust.org.uk/Media/node_1422/Getting-warmer-a-field-trial-of-heat-pumps-PDF*

available garden space for installing the ground loop pipework. Biomass and EfW have a combined potential of almost 13% with the largest contribution coming from the agricultural straw resource. The aggressive recycling targets in the Waste LDF will divert a lot of material away from general waste streams thereby reducing the EfW potential. SWH has a fairly low potential at just under 2% of energy demand as it is constrained by the hot water demand in buildings. The potential from landfill gas is very small as the quantity of landfilled waste will decline in the future.

Technology	Installed capacity (MW)	Electricity generation (GWh)	Heat generation (GWh)	Carbon savings ($MtCO_2$)	% of Cambridgeshire's energy demand
PV	1,591	1,304		508,706	15%
SWH	-	-	134	29,252	1.6%
GSHP	890	-	1,075	105,000	12.6%
ASHP	1,166	-	1,409	114,494	16.6%
Biomass	132	753	85	312,094	10%
EfW	25	194	362	154,645	2.6%
Wind	6,675	13,888	-	5,416,167	163.3%
Landfill gas	5.4	28.2	-	11,016	0.3%
Total	**10,484**	**16,167**	**3,065**	**6,651,375**	**226%**

Table 5-12: Overview of renewable energy technical potential in Cambridgeshire

Figure 5-15 highlights the dominance of wind's contribution to the county's technical resource. Wind could provide four times the county's current electricity demand and twice its overall energy demand. Nonetheless, the technical potential of the other renewable energy technologies is still fairly significant, and if wind is removed from the picture their combined contributions could still supply 60% of the county's energy demand.

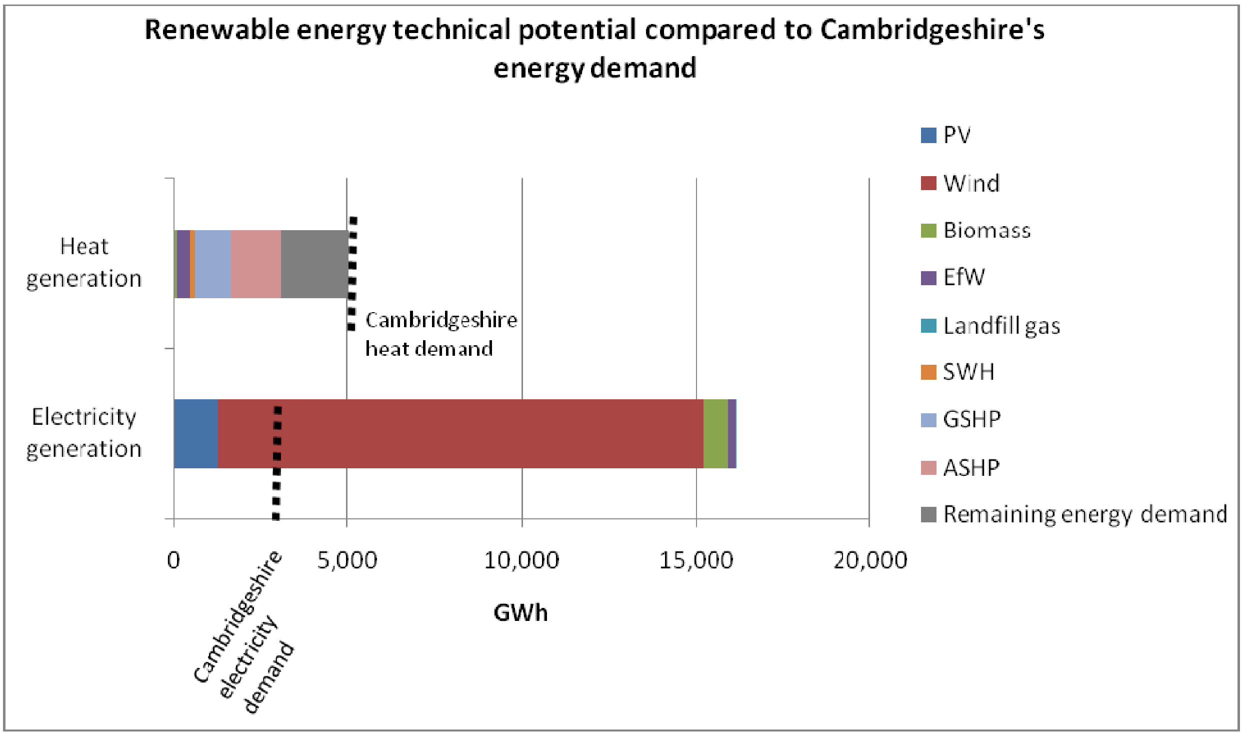


Figure 5-15: Renewable heat and electricity technical potential

Figure 5-16 outlines the renewable energy technical potential across the districts. The greatest potential resides in Huntingdonshire followed closely by South Cambridgeshire – these two districts have both a substantial wind potential and large microgeneration potential due to their relatively large building stock. The rural nature of these districts makes them suitable for the deployment of GSHPs and small biomass particularly for off gas areas.

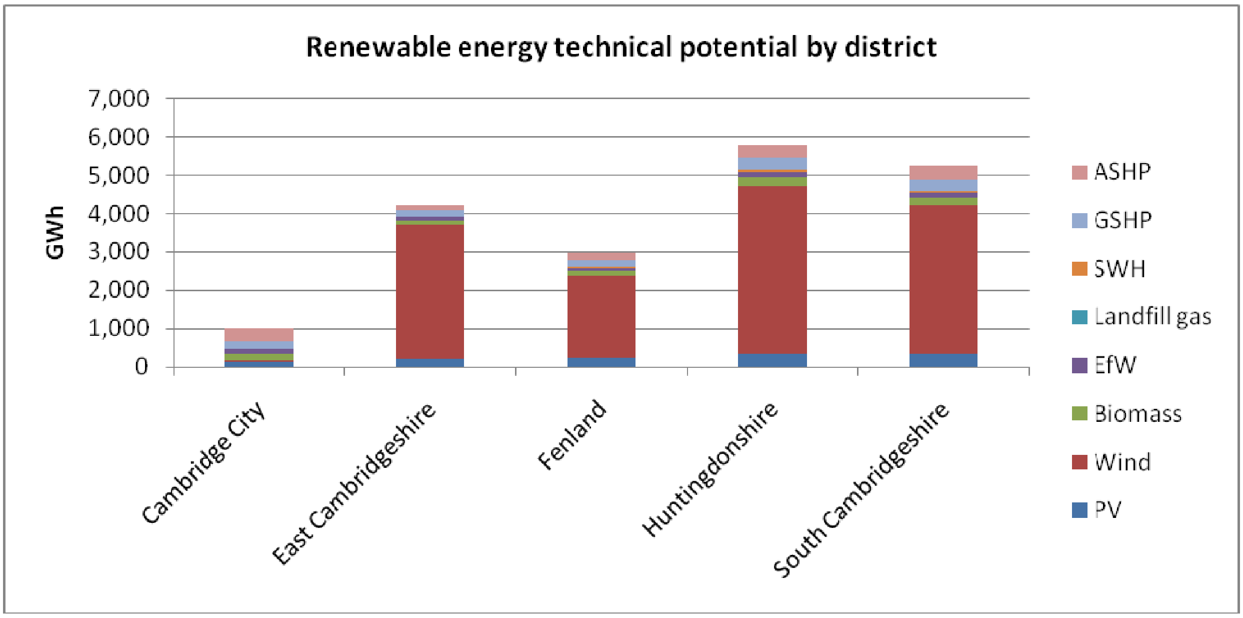


Figure 5-16: Renewable energy technical potential by district

5.7.2 Comparison with existing deployment for wind and biomass

Wind and biomass have the largest installed capacity currently in Cambridgeshire. Due to the very large technical potential of wind, the current installations only represent a fraction of the technical resource. However, as the biomass and energy from waste technical potential is much smaller, almost a third of the technical resource is already deployed

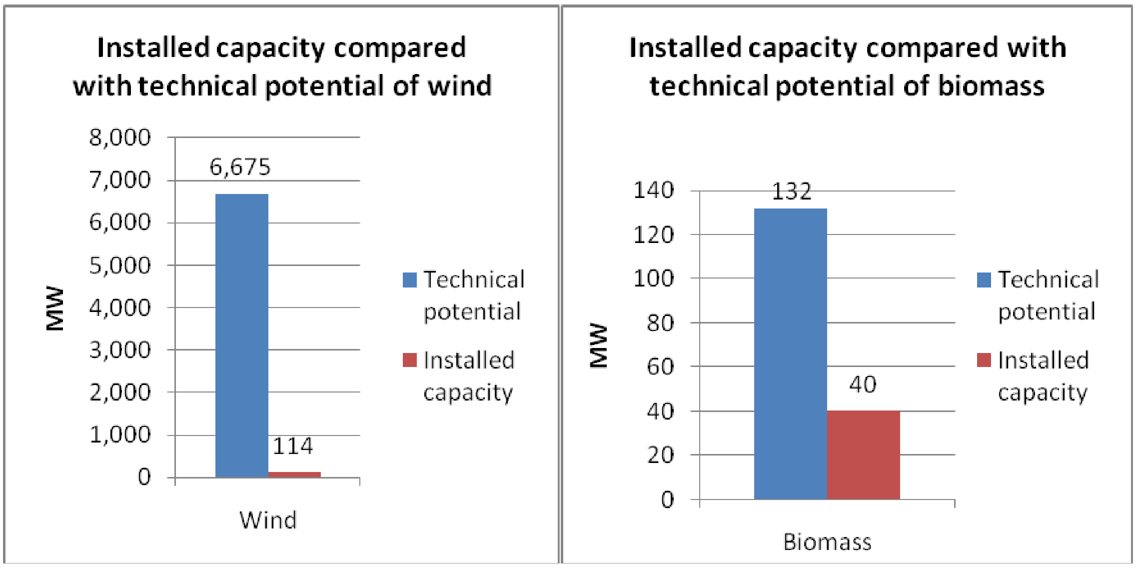


Figure 5-17: Comparison of the technical potential of wind and biomass with their current installed capacity

6 District heating and CHP potential

6.1 Methodology

An overview of the approach to mapping heat demand and quantifying CHP and district heating potential is outlined in Figure 6-1. The analysis has mapped heat loads across the county, and then provided a more refined assessment of areas which have potential for district heating.

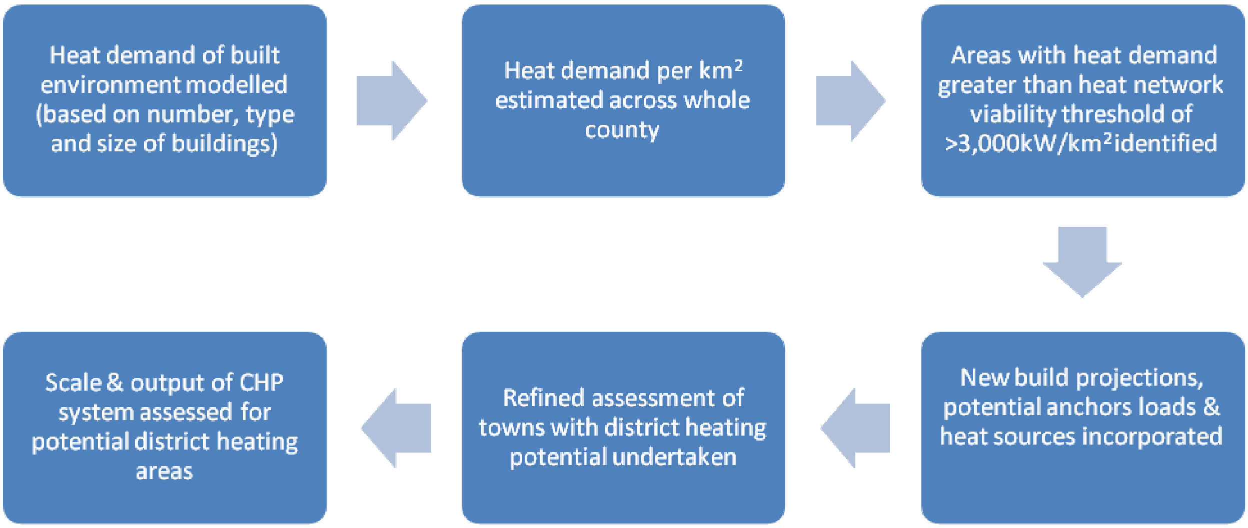


Figure 6-1: Heat mapping methodology overview

The key steps in the methodology were:

- All individual buildings in Cambridgeshire (both domestic and non-domestic) have been identified through the use of three different data sets and the average energy consumption of typical houses in Cambridgeshire determined
- Heat demand for non-domestic buildings was determined from CIBSE[15] benchmarks which are viewed as an industry standard. Domestic building heat loads were determined from national statistics on the gas consumption of domestic properties in Cambridgeshire. Boiler efficiencies of 80 or 85% were assumed for converting fuel demand to heat demand when analysing building loads (80% was used for any more dated benchmarks)
- New developments were mapped and their heat demand modelled
- Areas with high heat demand were identified based on a threshold of 3,000 kW/km2 in line with DECC recommended methodology
- Potential heat sources were identified from recognised datasets including the register of EU-ETS heat installations, waste incinerators, power stations, and large industrial users

[15] *The Chartered Institute of Building Services Engineers: Documents used: TM46 "Energy Benchmarking" (2008) and CIBSE Guide F (2004)*

identified from the VOA dataset. Potential anchor loads were identified by filtering the LLPG building dataset to identify building types with high baseloads, and the VOA dataset to identify large heat users

- Adjacent areas of high heat demand were aggregated together, and the total heat demand in each aggregated area determined, along with the split between domestic and commercial heat demand in each of these areas

A detailed overview of the methodology is provided in Appendix 1.

6.2 Mapping heat demand in Cambridgeshire

The heat mapping assessment provides a strategic overview of the locations within each district which have a high heat density and are therefore potential candidates for the installation of district heating systems. These district heating systems could then distribute renewable or low carbon heat to Cambridgeshire's buildings. Heat demand maps have been produced for each local authority, with the heat density represented in a graded colour scale in units of kW/km^2.

Figure 6-2 below highlights the areas in Cambridgeshire with a heat demand over the threshold of 3,000 kW/km^2 where district heating networks could be viable. The greatest potential resides in Cambridge followed by Huntingdon and the remaining larger towns in Cambridgeshire. In general the areas of high heat demand make up a relatively small portion of the total land area of the county, which is in keeping with the predominantly rural nature of the district. From this map it is possible to gain a high level strategic overview of the key areas which may be suitable for district heating and local heat networks – which can then be examined in further detail in the subsequent higher resolution mapping.

Areas of high heat density in Cambridgeshire

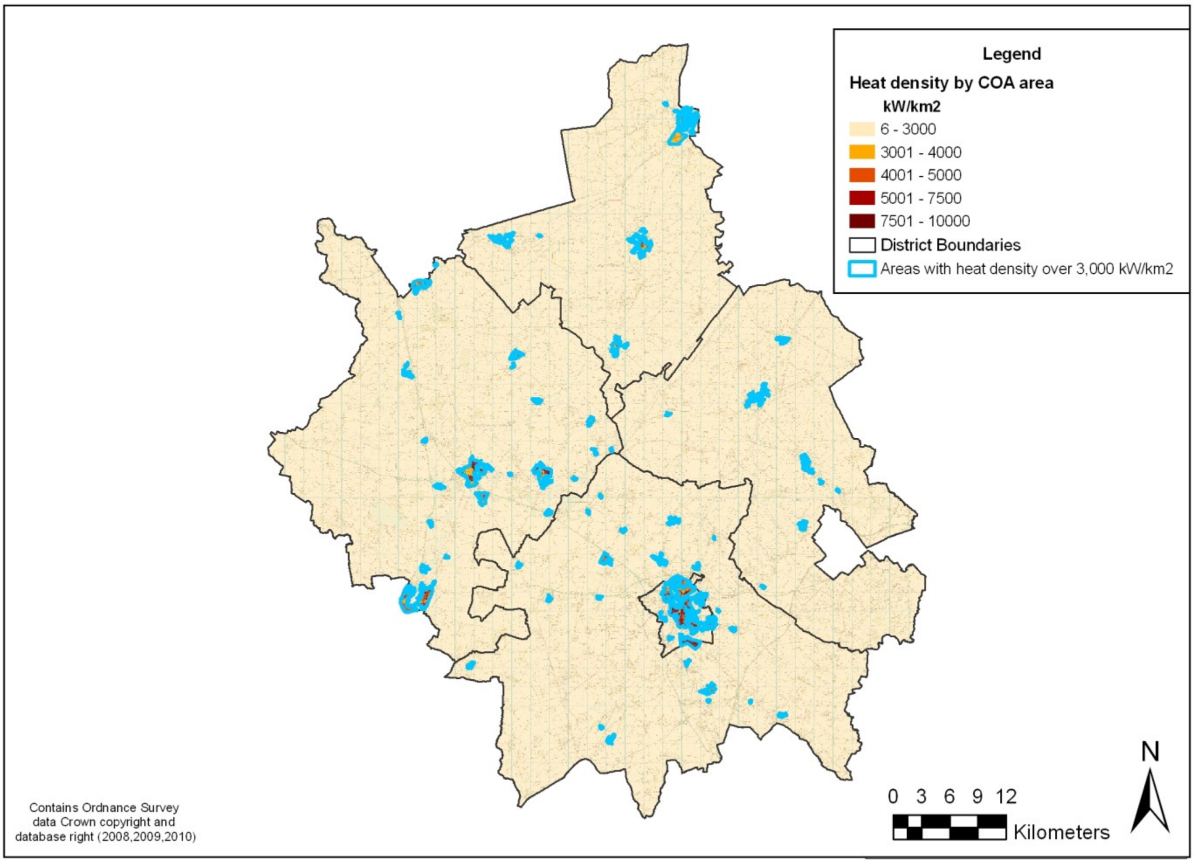


Figure 6-2: Areas with potential for district heating in Cambridgeshire

Table 6-1 provides a quantification of high density heat demand across the districts, and the percentage of Cambridgeshire's heat demand that could therefore potentially be met by district heating networks. The 'district heating technical potential' for Cambridgeshire is approximately 9% of the total heat demand, with two-thirds of this potential residing in Cambridge and Huntingdonshire.

District	Total heat demand (GWh)	Heat demand in COA areas with heat density >3,000 kW/km2	Baseload which could be fed by DH with CHP (GWh)	% of total heat load which could be met by DH with CHP	% of district heating potential for Cambridgeshire
Cambridge	1119	715	166	15%	36%
East Cambridgeshire	463	120	25	5%	5%
Fenland	1011	335	77	8%	17%
Huntingdonshire	1196	670	147	12%	32%
South Cambridgeshire	1255	205	45	4%	10%
TOTAL	**5,044**	**2,045**	**460**	**9%**	**100%**

Table 6-1: District heating potential across Cambridgeshire

The heat map for Huntingdonshire is presented and discussed below as an example; the remaining four district heat maps are presented in the Appendix of maps.

The areas of high heat demand in Huntingdonshire are concentrated in a limited number of urban areas, making up a small part of the area of the district. Huntingdon is the largest area of high heat demand, with further concentrations in St Neots (in the south), St Ives (to the east) and Yaxley (in the North). This is exactly as would be expected in a predominantly rural area such as this.

Significant new development is proposed in the district in the coming years, represented by the blue and green hatched areas on the map, and the graduated blue and green dots with black borders. It is noted that many of the proposed new developments are located in or on the outskirts of the larger existing settlements. The larger developments may act as triggers to kick start district heating in these regions – if new development provides a suitable location for the inception of a district heating network, these networks then have the potential to be extended in to areas of high heat load in existing buildings nearby.

There are no major heat sources (power stations/ CHP stations) within the district, although one power station is located just over the border south of St Neots, and another is located to the north in Peterborough.

Based on this county level mapping, high resolution maps of Huntingdon, St Neots, St Ives) and Yaxley have been prepared and are presented in the appendices. The high resolution map of Huntingdon is analysed in section 6.4 below.

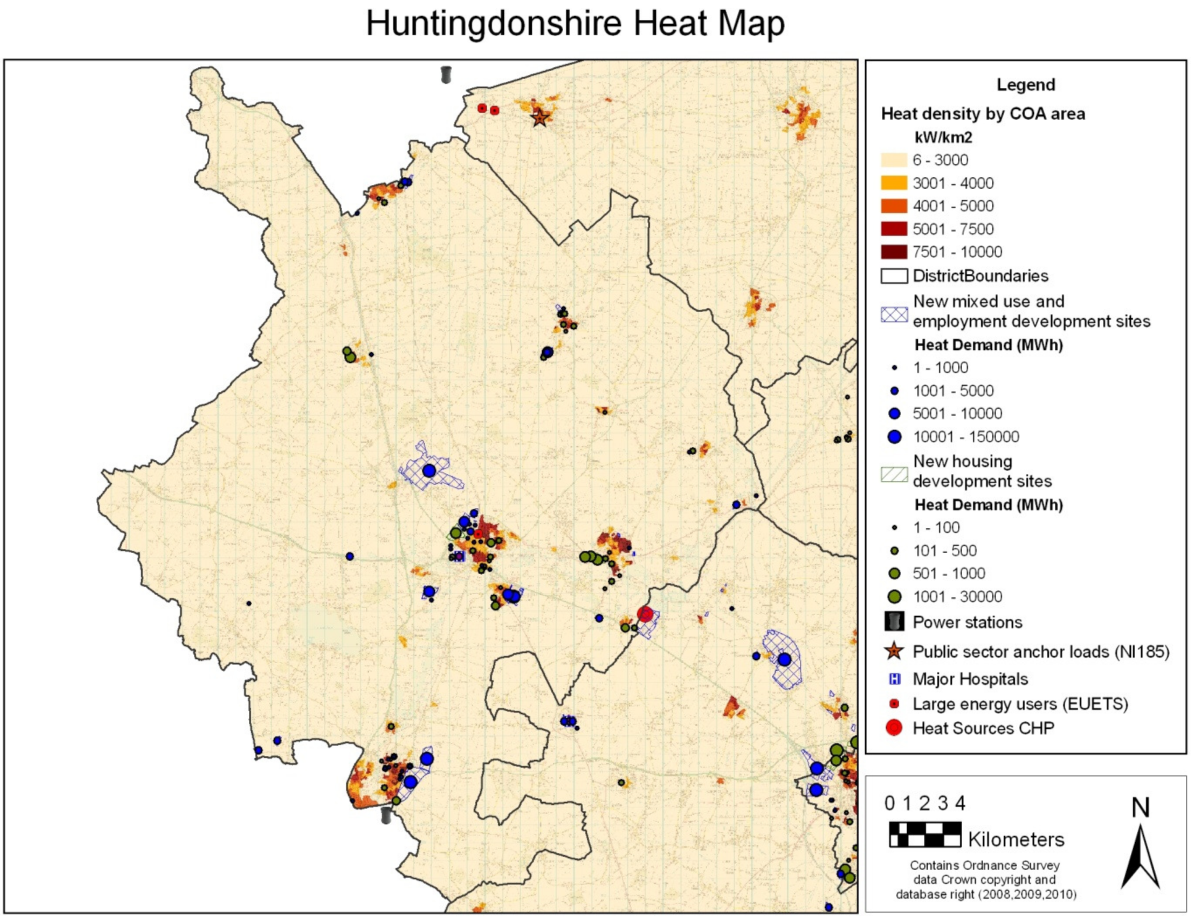


Figure 6-3: Example heat map of Huntingdonshire District

6.3 Assessment of the technical potential for CHP supplying district heat networks

6.3.1 Using the heat mapping to estimate CHP potential

The methodology for assessing the potential for CHP and district heating is summarised in Figure 6-4. The heat mapping exercise identified areas with a high heat demand density which may be suitable for district heating or local heat networks. For the areas where district heating is not feasible, large buildings with a high heat demand have been assessed for their suitability for in-building CHP, whereby an individual CHP unit can be installed in large buildings that have a suitable balance of heat and electricity demand.

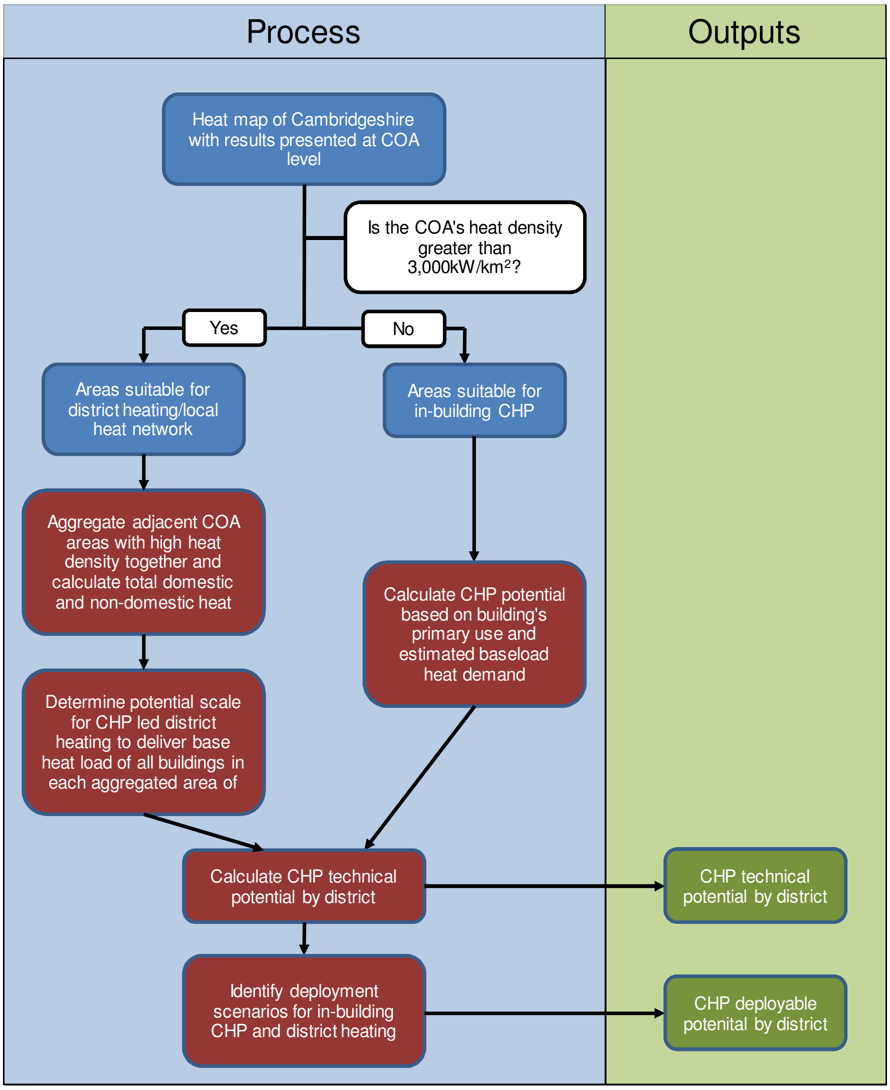


Figure 6-4: Overview of approach to estimating CHP potential across Cambridgeshire

Key elements of the approach:

- The assessment identifies the potential for in-building CHP and CHP led district heating schemes. The potential heat delivered by these schemes was based on the estimated baseload heat demand for each area or building, as CHP should be sized to meet baseload in order to maximise efficiency and running hours
- The baseload heat demand for each district heating area was determined as 20% of domestic heat demand plus 30% of non-domestic heat demand. This heat load was then used to determine the scale of CHP technology suitable for each of the areas of high heat demand
- The baseload heat demand for in-building CHP was determined on a building-by-building basis according to the building type – e.g. swimming pool centres have a high baseload due to pool heating and hot water demand, whereas office buildings have a

low baseload as they use little hot water and no heating in summer months. A list of building types deemed suitable for CHP are included in appendix 1

- The likely peak output (in kWe for electricity and kWth for thermal) of each CHP unit was determined on the basis of the baseload to be met and the assumed number of annual running hours (these are specified in the appendices).

6.3.2 CHP units in individual buildings

Large buildings often have a suitable scale and balance of heat and power demand to support their own CHP unit. Combined heat and power technology can prove to be a cost effective means of meeting a building's heat load and electrical consumption and a useful carbon reduction technology due to the efficiency benefit of generating heat and power simultaneously. Although in-building CHP units are likely to be fuelled by natural gas in the short term, there is potential in future for the use of biogas or biodiesel in CHP units.

CHP is best suited to buildings with a high baseload heat demand – this means that there is a high year-round demand for heat, allowing the unit to run for as many hours as possible in the year. Baseload heat demand is any year round process requiring heat such as: hot water generation for showers, toilets and catering, swimming pool heating, process heat loads which can be fed by hot water (e.g. in food production or drying and forming processes). For this reason buildings such as hotels, sports centres, swimming pools, hospitals, and certain industrial users are generally best suited to the installation of CHP at building level.

It is assumed that no systems below 5kW (domestic scale) would be installed in non-domestic buildings. This is due to the emergent nature of the technology, and the fact that very small non-domestic buildings frequently have no gas supply, relying on electric space and water heating.

Benchmark category	Baseload (% of total heat load)
Dry sports and leisure facility	35%
Fitness and health centre	45%
General accommodations	30%
General manufacturing	20%
Hospital (clinical and research)	50%
Hotel	40%
Laboratory or operating theatre	20%
Sw imming pool centre	60%
University campus	10%

Figure 6-5: Non-domestic building types suitable for CHP technologies

6.3.3 Technical potential of CHP

The technical potential of CHP linked to both district heating networks and individual CHP in large buildings is presented in Figure 6-6. The technical potential from CHP linked to district heating networks is approximately six times the potential from in-building CHP.

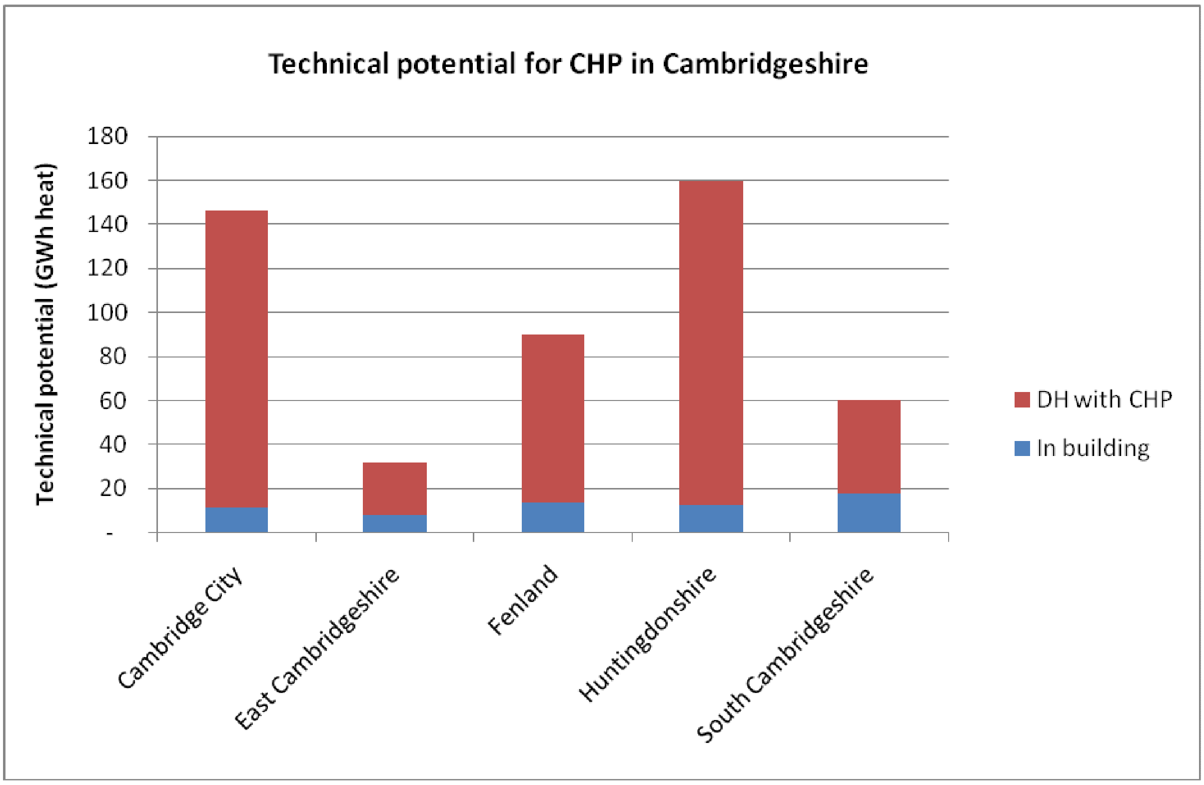


Figure 6-6: Technical potential for CHP systems in Cambridgeshire

CHP with district heating networks

The analysis has identified 711 Census Output Areas (COA) areas in a total of 110 separate aggregations which had heat densities of over 3,000kW/km2 with potential for district heating networks. Cambridge and Huntingdonshire have the greatest potential for district heating and work is currently underway to progress the development of district heating in these areas. This reflects the fact that they contain the larger urban centres within the county .whereas the remaining districts are of a more rural nature, with fewer areas of high heat density.

Individual CHP units in large buildings

In Cambridgeshire, approximately 163,000 domestic buildings and 7,500 non-domestic buildings are located in areas of low heat density, and may have the potential for installation of in-building CHP. Of the total technical potential (62.8 GWh/year), 75% of the total potential is from non-domestic buildings with the remaining 25% in domestic buildings.

6.4 More detailed assessment of towns identified with district heating potential

6.4.1 Key attributes of district heating networks

There are a range of parameters which affect the viability of developing a district heating system in a particular location. These include:

1. **High aggregated heat load (domestic and commercial)** – the scale of the high heat load areas determine the scope for district heating networks (calculated by aggregating adjacent COA areas of heat demand with heat density > 3,000 kW/km^2).

2. **Good load diversity/ mix -** the ratio of commercial to domestic demand and a good balance of mixed demand – domestic only schemes typically have poor viability due to short periods of heat demand and extensive heat distribution networks required.
3. **Proximity of major heat sources (capable of leading a scheme) -** is there a major heat source with the potential to be lead heat source for a DH scheme (e.g. EFW plant, power station, large CHP) nearby?
4. **Proximity of lesser heat sources** - are there smaller waste heat sources within the boundaries of the high density heat area such as smaller CHP schemes or industrial sites that could prove low cost supplementary or peak heat loads for a network.
5. **Commercial anchor loads** - are there large commercial users present within the high heat density area?
6. **Public sector anchor loads** - are there large public sector users present in the high heat density area?
7. **Major new developments** - are there major new development sites adjacent to or within the high heat density area?
8. **Existing DH infrastructure** - are there significant existing DH schemes present or adjacent to the high heat density area that could be extended?
9. **Previous DH studies** - have previous DH studies been carried out which could facilitate more rapid scheme development?
10. **Physical constraints** – are there constraints to the installation or routing of a hot water pipe network, such as un-bridged rail, road or rivers?

6.4.2 Assessing the 'top ten' opportunities for district heating in Cambridgeshire

The top ten areas of district heating potential have been assessed in greater detail against these key district heating parameters. The maps of district heating feasibility for the ten areas are found in the appendix.

Aside from Cambridge, the majority of the areas of high density heat demand in Cambridgeshire possess relatively few of the necessary attributes for developing district heating networks. The identified areas constitute relatively small urban environments, ranging from market towns to large villages, which have a comparatively small overall heat demand and a limited number of large commercial or public buildings which could act as anchor loads for a district heating network. Outside Cambridge, Huntingdon is the only location which has a good mix of building types, plus large new developments in the near vicinity, and is therefore an optimum candidate for developing district heating networks.

Cambridgeshire's small heat loads limit the potential for district heating schemes

A typical district scale heating system would have a thermal production of 40,000 to 400,000 MWh of heat per annum. The total heat loads in the identified opportunity areas are in the range of 30 to 190,000 MWh per year. The majority of district heating systems are initially made up of early anchor loads such as new developments, public sector buildings, hotels, and large commercial and industrial consumers. Network penetration can then increase gradually over time as a wider network of non-domestic users and in some cases higher density housing are connected. Operational district heating networks therefore serve significantly less than 100% of the total heat load in an area, even when fully established. Serving existing lower density domestic properties is particularly challenging due to high connection costs and typically with existing buildings only larger blocks of flats would be connected. As much of the existing housing stock in Cambridgeshire is likely to be relatively low density, one would expect only a small proportion of the total housing stock to be potential candidates for district heating even where the density of demand at a specific location (such as for a particular housing block) is very high.

Therefore, as a high level indicator, the total heat load that could be met by a scheme is unlikely to exceed the total commercial heat load in an area. On this basis, only two of the areas identified outside Cambridge could potentially achieve a district-scale scheme based on existing building stock – Huntingdon and Wisbech.

6.4.3 District heating opportunities in Cambridge

The Decarbonising Cambridge report[16] carried out a detailed heat mapping exercise for Cambridge. This is clearly the area with the greatest potential for the installation of district heating in Cambridgeshire. The mapping results for this study and the Decarbonising Cambridge report are very similar with high concentrations of heat primarily focussed around the city centre. A comparison of the approach and results from the two heat mapping assessments are found in Appendix 1.

Figure 6-7 shows that the areas of high density heat demand in Cambridge are primarily located within the city centre and are not found near to the large areas of new build around the periphery of the city. This limits the prospects for developing heat networks in the new development areas and then feeding them into the existing built environment.

Cambridge City Heat Map - 50m grid basis

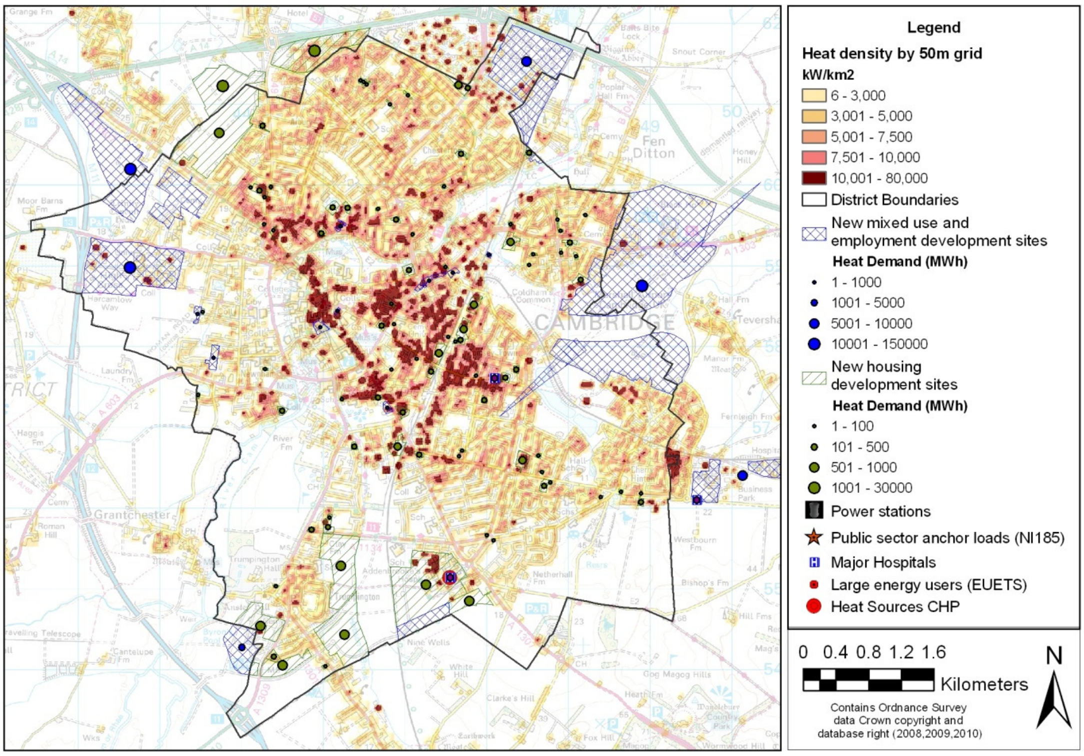


Figure 6-7: Heat map of Cambridge

[16] *Cambridge City Council (August 2010) Decarbonising Cambridge: A renewable and low carbon energy study*

The key conclusions from the Decarbonising Cambridge report are:

- Outside the city centre, areas of high heat demand are relatively dispersed.
- The main opportunity for district heating is likely to be in the urban extension sites, of which only the Bell School site is in close proximity to an area of existing high heat density (Addenbrookes). The approaches to meeting energy demands at these sites are covered by specific area action plans.
- There may be opportunities for district heating in the city centre on the basis of heat density.
- Exploitation of these opportunities will be subject to overcoming the technical, economic and practical barriers that retrofitting a community heating network in a historic city centre presents.
- Mapping areas of high heat demand with proposed development sites suggests that there could be an opportunity for cost-effective community heating in the redevelopment of CB1, around the station area.
- Most areas of highest heat demand are in the Cambridge air quality management area (AQMA) which will restrict the ability of operating biomass fuelled schemes.

These conclusions demonstrate that whilst the potential for district heating in Cambridge is quite large due to the high density areas in the city centre, the delivery of district heating in practice would be more difficult. Work is underway to assess the commercial viability of district heating in the city centre.

6.4.4 District heating opportunities in Huntingdon

Figure 6-8 illustrates the district heating opportunity within Huntingdon, and maps of an additional nine areas with district heating potential are presented in the appendix.

The heat load has been assessed on a $50m^2$ grid basis and identifies the COA areas which have a heat load of over 3,000 kW/km^2 (which are cross-hatched in red in the map). Areas with the darkest red colouration are those with the highest heat demand density, and conversely those with very pale colouration have low heat demand density. Large areas of dark red or areas with many dark red pinpoints close together are the areas which are most likely to be viable for scaling up a district heating network. These are also likely to be areas with larger commercial demands. Areas with more even, paler colouration will have many smaller buildings widely dispersed such as housing estates, and are likely to be poorly suited to installation of a district heating system.

Also presented in the map are a range of potential “triggers” which could prove beneficial in developing a district heating system, such as potential anchor loads, new development sites or heat sources.

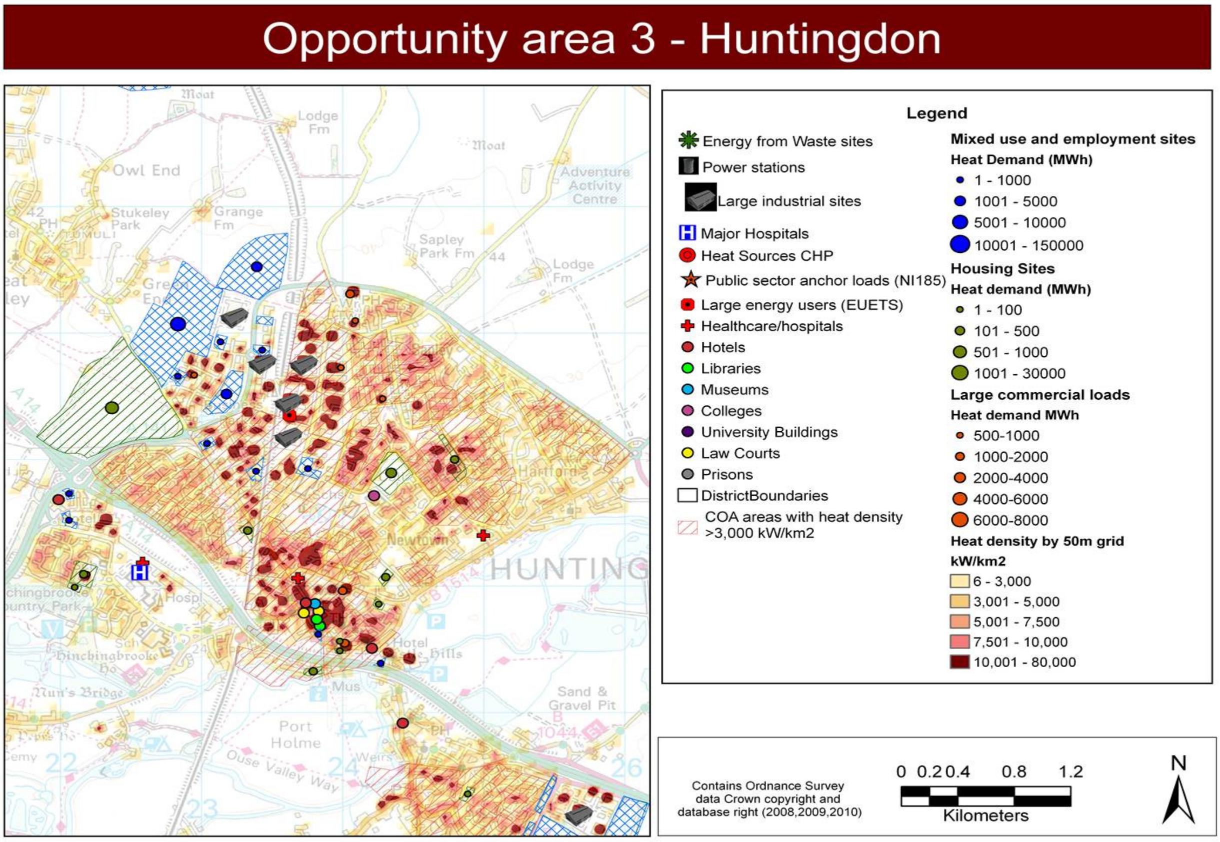


Figure 6-8: Opportunity area heat map for Huntingdon

The new development sites on the edge of Huntingdon are of particular interest, as district heating can prove to be a highly cost effective way of achieving carbon emission reductions in new developments. If large new developments sites are adjacent to areas of high heat density there is a good opportunity for developing a heat network.

A number of potential heat sources - large energy users covered under the EUETS scheme (those with larger boilers over 20MW) - are plotted on the map. All these sites may have the potential to export low cost or waste heat into a district heating network and could therefore improve the viability of a network compared to the use of conventional fossil fuel fired CHP.

Potential anchor loads are also plotted, including large energy users identified in the EUETS, hospitals, hotels, and a number of buildings which are likely to be publically owned such as libraries, museums and colleges. Large energy users often offer the best potential for connection to district heating networks as the cost of connecting the building is generally low relative to the quantity of heat purchased. Public sector organisations are key customers as they typically view carbon reduction as a higher priority than commercial clients, and are more likely to pursue a district heating connection even when the financial returns are marginal.

Examining the map above, we would identify two key opportunities for installation of heat networks:

1. Development of a town centre heat network focussed on the high heat density region to the south of the map – perhaps using the public buildings (libraries, healthcare, courts) and hotels as anchor loads

2. Development of a heat network to the north-west of Huntingdon, relying on the new developments as anchor heat loads and looking to extend into the industrial area either side of the railway.

6.4.5 District heating opportunities in St Neots

St Neots is potentially well positioned to use low carbon heat due to the opportunity of using waste heat from Little Barford power station. Little Barford which is a 680 MW combined cycle gas turbine power station located south of St Neots could provide a very significant proportion of heat demand in the town if the waste heat is utilised in a district heating framework. It is only 2 miles away from the town centre and lies in close proximity to the major urban extension to the north east of the power station. A study is currently underway to investigate district heating in the area.

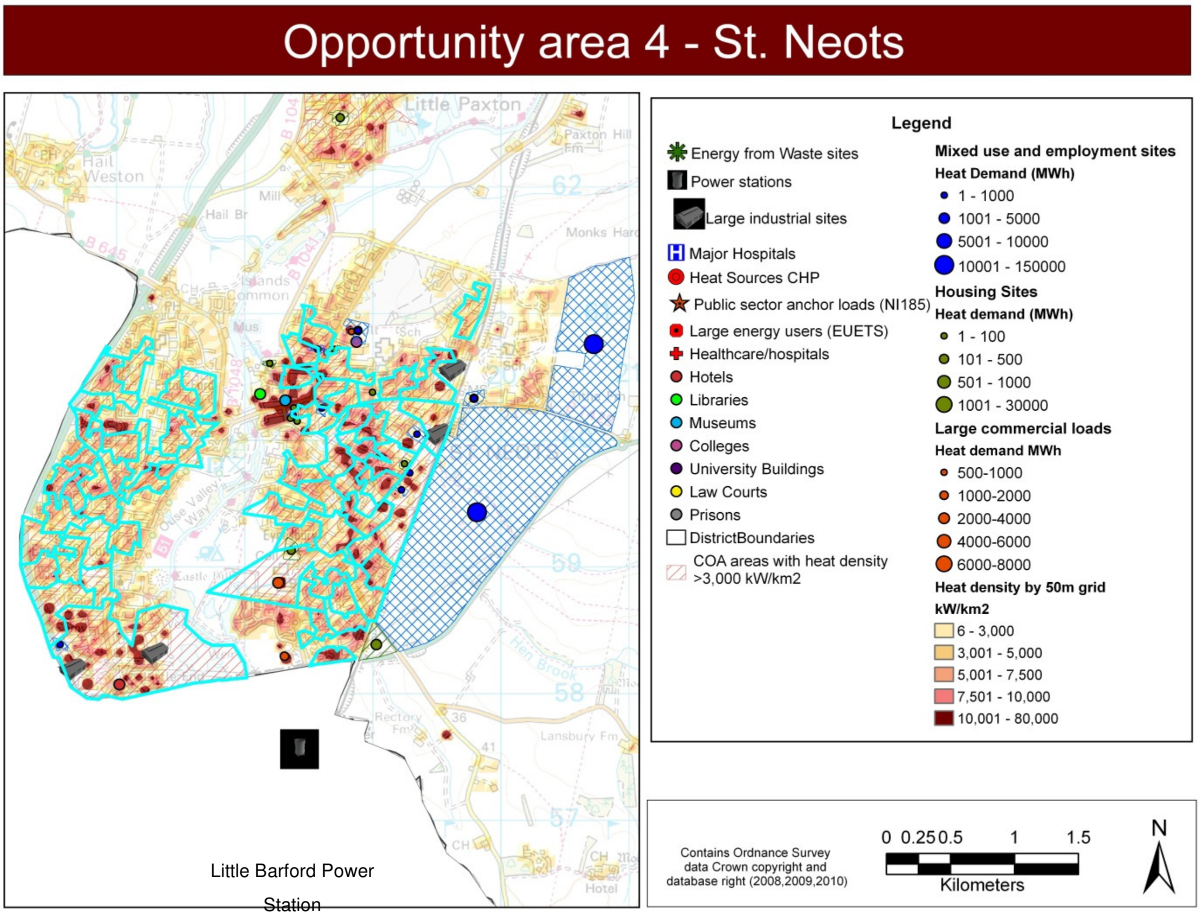


Figure 6-9 Opportunity area heat map for St. Neots

6.5 Deployment potential of CHP within Cambridgeshire

6.5.1 Deployment potential of CHP serving district heating networks

The technical potential of CHP serving district heating networks is 9% of Cambridgeshire's heat demand. The technical potential assessment assumes that 100% of the buildings in the high heat density areas would be connected to the district heating systems, and the systems would likely serve 100% of the base load. In practice each connection would be made only if it was economically viable to do so, and the network would serve significantly less than 100% of the buildings. The uptake of district heating in the UK has been limited, especially when compared with certain European countries such as Norway and Denmark. This is due to a wide range of barriers. A recent report[17] identified the three key barriers to UK development of district heating networks as follows:

- Economic barriers – Project risk: the very large up-front capital required is the greatest barrier to development of DH networks. DH is viewed by many to be a risky investment due to the following:
  - A perceived lack of experience and knowledge of DH in the UK
  - Limited understanding of tariff structures and management of the customer connection process.
  - Barriers to accessing capital due to uncertainty in predicting financial viability and customer uptake
  - Unfamiliarity with the concept of district heating among consumers and the public sector.
- Economic barriers – Project cost:
  - Lack of local expertise and supply chain for DH delivery.
  - UK housing mix is less suited to DH development than many other European countries, as there are fewer large blocks of flats or apartments and more individual dwellings
  - Lack of standardisation of contract structures
  - Increased financing costs due to uncertainty over revenue risks
- Institutional issues – the UK has variable levels of engagement from the public sector to underwrite the risks of DH schemes and provide anchor loads for the core of new schemes – this can be due to:
  - Energy viewed as a lower priority by LA's compared to education and health
  - Inconsistency and lack of transparency in the application of planning policy and/or building regulations
  - Lack of familiarity among LA's with district heating technologies

In light of the economic and institutional barriers affecting the uptake of district heating and local heat networks, we have initially presented the data at three levels of uptake: 10%, 5% and 2.5% of the technical potential. These values have been chosen as they represent lower deployment rates than market-driven renewable energy technologies with positive policy environments. Furthermore, when a district heating scheme is developed it would not serve 100% of the buildings in its catchment area – typically it would begin with key public sector, commercial and industrial anchor loads then extend to more customers over time. Existing low density housing is very rarely viable for district heating connection. In practice therefore, the district heating system would serve a relatively small proportion of the total heat demand.

These results are presented in Table 6-2.

[17] *POYRY/DECC/Faber Maunsell: "The potential and costs of district heating networks", 2009*

District	Technical potential (GWh)	10% Uptake (GWh)	5% Uptake (GWh)	2.5% Uptake (GWh)
Cambridge	166	17	8	4
East Cambridgeshire	25	2	1	1
Fenland	77	8	4	2
Huntingdonshire	147	15	7	4
South Cambridgeshire	45	4	2	1
Total	**460**	**46**	**23**	**11**
% of total heat demand for Cambridgeshire	**9.1%**	**0.9%**	**0.5%**	**0.2%**

Table 6-2: Deployment potential of CHP serving district heating networks

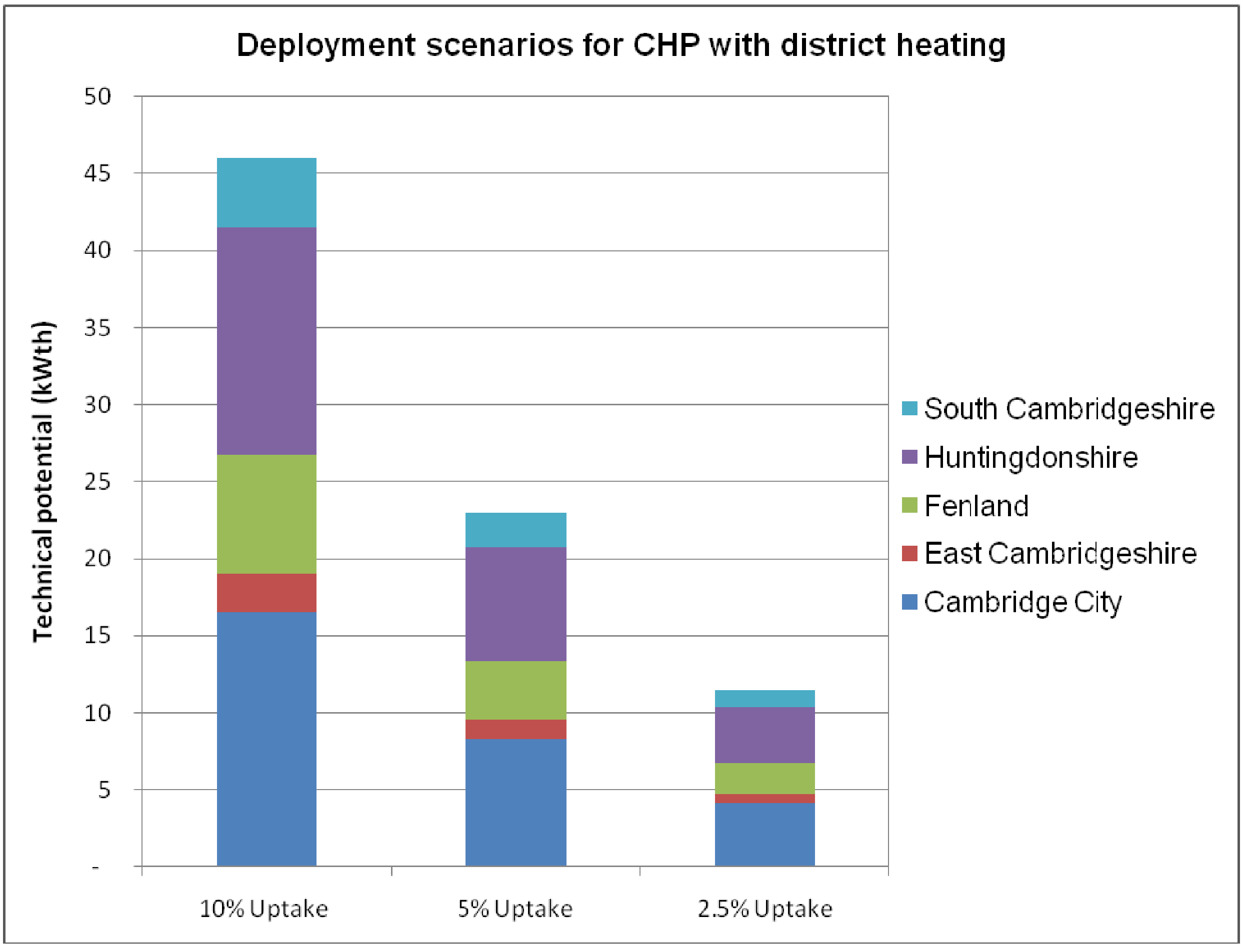


Figure 6-10: Potential uptake scenarios for district heating and local heat networks

As Cambridge and Huntingdon are the areas with greatest potential to support heat networks, we have selected these areas in isolation and considered the proportion of the building stock in each area which might realistically be connected to a heat network. In practice, networks would be focussed on the higher density city/town centre areas and therefore we consider a realistic proportion of total building load which could be met by a district heating network economically to be in the region of 12.5-25%. This scenario is presented in Table 6-3.

Council	Technical potential in selected areas (GWh)	25% of buildings (GWh)	12.5% of buildings (GWh)
Cambridge	112	28	14
Huntingdonshire	40	10	5
Total	**152**	**38**	**19**

Table 6-3 Deployment potential of CHP serving district heating networks in areas of greatest potential

6.5.2 Deployment potential of CHP units in individual buildings

The technical potential of in-building CHP outlined above estimates that 1.2% of the county's heat demand could be provided by CHP units in large buildings. However, in practice, the uptake of CHP units serving large buildings in the UK has been relatively slow, and it is limited by a range of constraints. Successful implementation of a CHP unit into a building requires a detailed appraisal of the building's energy demand and potentially complex design solutions to integrate the technology into the building. CHP technology is also significantly larger than equivalent heat-only plant and additional plant space is therefore required for its installation. The following are a range of key constraints to CHP development:

- Physical: Plant room space required, routing of flues, noise, air quality legislation (biomass CHP systems)
- Technical: Integration with existing building services plant, whether there is sufficient baseload heat demand.
- Economic: Economic viability varies and can be affected by energy prices, the amount of heat rejected, the ratio of gas to electricity price, availability of financial support or incentives.
- Knowledge barriers: Lack of understanding of CHP technology and investment risk.

Also presented are the deployment potential scenarios for CHP units in individual large buildings based on uptake rates of 2.5%, 5% and 10% of the technical potential. Barriers to the deployment of CHP units in buildings have changed relatively little in recent years, and the future uptake of CHP in Cambridgeshire is unlikely to exceed a small percentage of the technical potential unless there is a substantial change in the general policy framework.

District	Technical potential (GWh)	10% Uptake (GWh)	5% Uptake (GWh)	2.5% Uptake (GWh)
Cambridge	11.3	1.1	0.6	0.3
East Cambridgeshire	7.7	0.8	0.4	0.2
Fenland	13.4	1.3	0.7	0.3
Huntingdonshire	12.4	1.2	0.6	0.3
South Cambridgeshire	18.0	1.8	0.9	0.4
Total	**62.8**	**6.3**	**3.1**	**1.6**
% of total heat demand for Cambridgeshire	**1.2%**	**0.1%**	**0.1%**	**0.0%**

Table 6-4: Deployment potential of in-building CHP

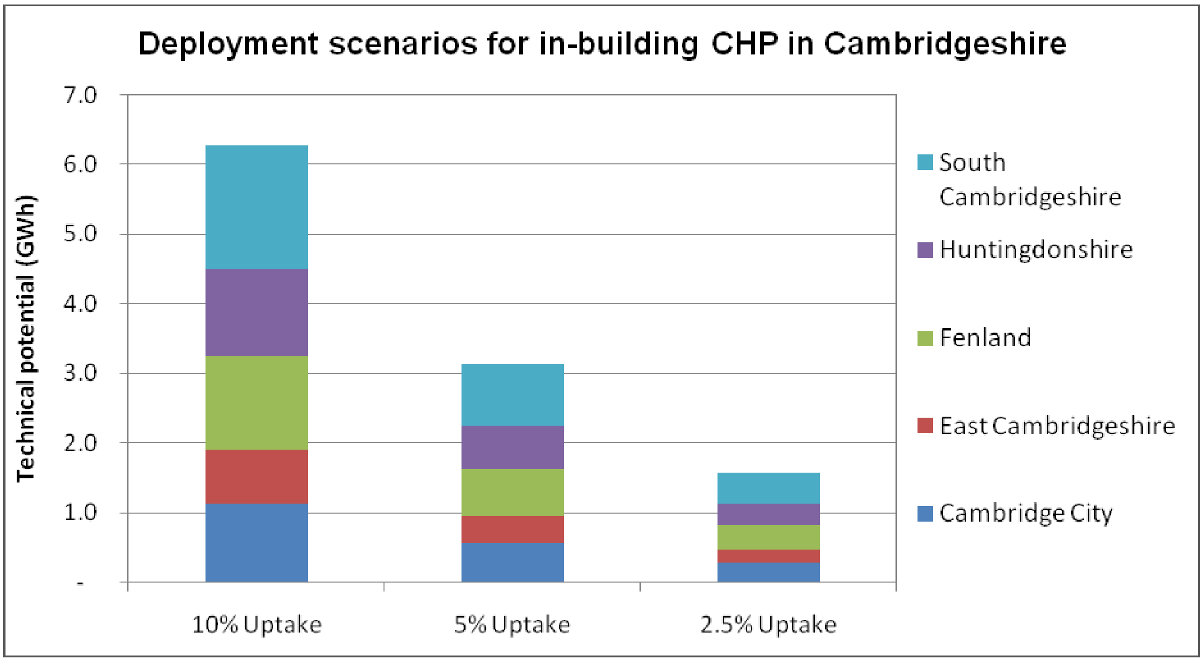


Figure 6-11: Potential uptake scenarios for in-building CHP in Cambridgeshire

6.6 Comparison of biomass supply potential with the district heating demand potential

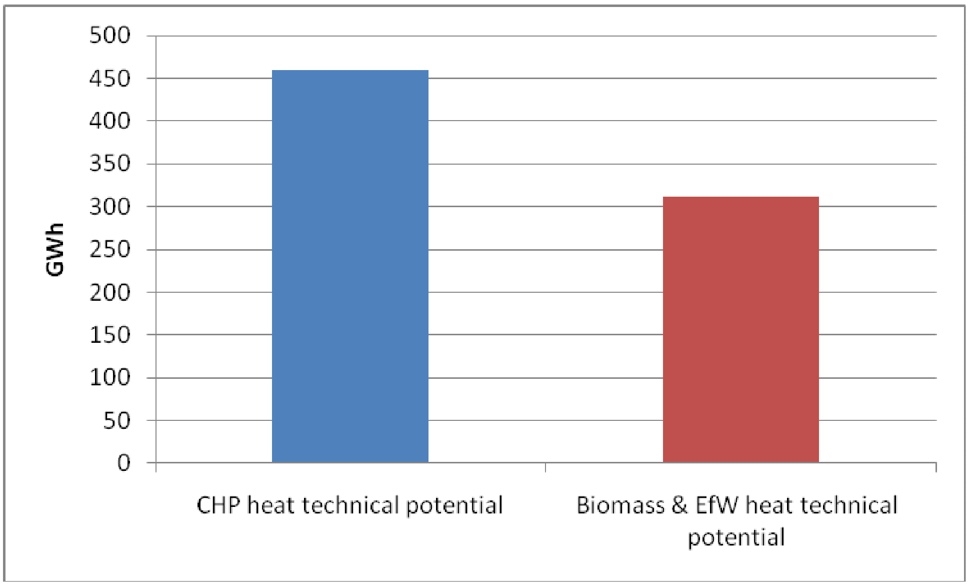


Figure 6-12: Comparing the biomass supply potential of with the district heating demand potential

The figure illustrates that the ‘supply potential’ of the biomass and energy from waste resource that could fuel CHP plant feeding heat networks is less than the technical potential for district heating in Cambridgeshire[18]. However, as outlined above, the realistically deployable potential of district heating networks is far lower than this and is focused on central areas in Cambridge

[1818] Please note that a very significant proportion of biomass (sourced from the East of England study) came from straw which was assumed to be used only for renewable electricity generation as they are likely to be used in few lar ge plants where heat generation is more challenging.

and Huntingdon. An ambitious deployment target for district heating networks in Cambridge and Huntingdon would constitute approximately a tenth of the overall technical potential figure, and could easily be met by Cambridgeshire endemic biomass and EfW fuel resource.

7 Scenarios of renewable energy deployment

7.1 Introduction to the deployment scenarios

The consideration of deployment potential constitutes stages 5 to 7 within the DECC methodology for undertaking renewable energy assessments. It involves applying the economic and deployment constraints that further limit the proportion of the technical potential that can be practically delivered on the ground. Four deployment scenarios have been developed to enable an assessment of the local deployment potential of renewable energy within Cambridgeshire. The deployment scenarios provide a range of future options for renewable energy illustrating how deployment may be affected by changing market and policy conditions, and are therefore a guide for policy making and target-setting. The scenarios are not a prediction of what will happen and neither do they constitute an opinion on what should happen. They are simply an attempt to model how the deployment of the different renewable energy technologies might vary depending on the future market and policy environment. Their key function is that of informing the debate on future policy options for renewable energy in Cambridgeshire. The starting point for these scenarios is the technical potential of each renewable energy resource in Cambridgeshire, and the available evidence base regarding the practical uptake rate of these technologies in the UK and other European countries.

The four deployment scenarios are entitled Low, Medium, High and High Without Wind, and the market and policy conditions underpinning these scenarios are found in the table below. The main features of each scenario includes:

- Low scenario - has a commercial (high) interest rate, low financial incentives for the microgen technologies (reduced levels of FIT and RHI) and low levels of national, regional and local support to encourage uptake of renewable energy.
- Medium scenario – has a low interest rate, maintains current levels of financial incentives for renewable energy technologies and has medium levels of national, regional and local support to encourage uptake of renewable energy.
- High scenario – has a low interest rate, maintains current level of financial incentives for renewable energy technologies and has high levels of national, regional and local support to encourage uptake of renewable energy.
- High without wind – the same as scenario 3, but excludes any contribution from wind.

Inputs	Scenario 1 (low)	Scenario 2 (medium)	Scenario 3 (high)	Scenario 4 (high without wind)
Discount rate	9%	7%	6%	6%
Energy price [1]	DECC - 'low' energy prices	DECC - 'high' energy prices	DECC - 'high high' energy prices	DECC - 'high high' energy prices
Financial incentives (FIT/RHI)	lower than current tariff rates	current rates	current rates (FIT/ RHI designed to give fixed return & will adjust to energy prices)	current rates (FIT/ RHI designed to give fixed return & will adjust to energy prices)
Project deployment rate (wind/biomas)	8%/ 80%	15%/ 100%	30%/ 100%	0%/ 100%
Green policy support (for building integrated technologies)	Low	Medium	High	High

Table 7-1: Input parameters for the deployment scenarios

7.2 Summary of deployment modelling methodology

The key elements of the modelling underpinning the deployment scenarios are outlined in Figure 7-1.

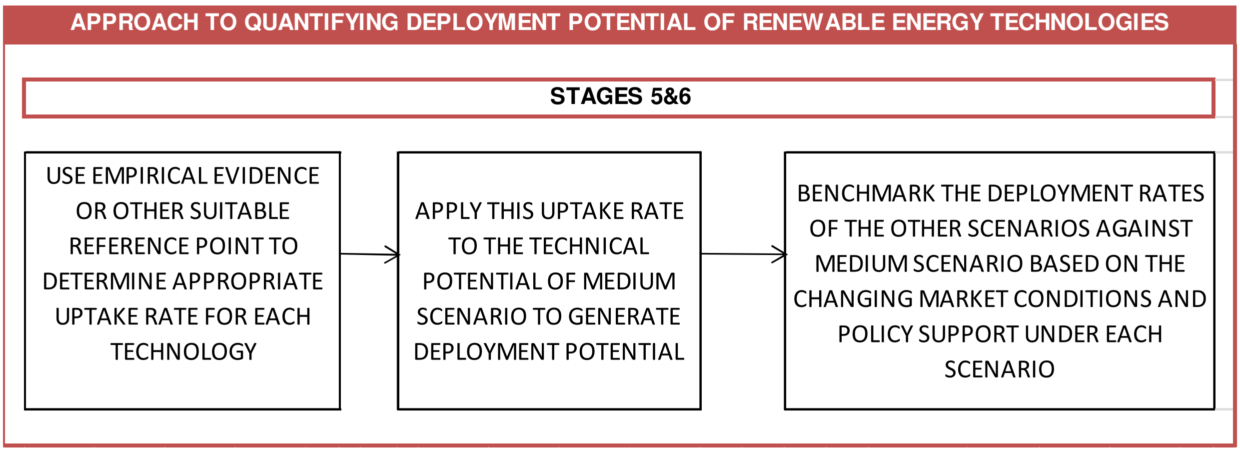


Figure 7-1: Approach to modelling of deployment scenarios

The key steps underpinning the scenarios include:

- Identifying empirical evidence for the deployment of the different renewable energy technologies;
- Applying the financial subsidies provided by ROCs, FIT and RHI to the economic assessment which have drastically improved the economics of renewable energy installations, particularly for the microgeneration technologies of PV, solar water heating and heat pumps.
- Applying a 'share of utility rule' to assess the propensity of a consumer to invest in renewable energy based on the level of return on investment.

7.2.1 Modelling economic potential

The subsidy provided by feed-in tariffs and the renewable heat incentive enables RE technologies to be considered economically viable in most locations where they are technically viable. However, whether they are installed in any given location is dependent on the economic decision making of individual consumers and organisations. For example, the decision to invest in RE is dependent on having access to capital and the alternatives to investing this capital in RE. The economic potential under each scenario was derived through a two-step process; the internal rate of return (IRR) for each technology was first calculated to assess the attractiveness of the investment opportunity and then the probability of a consumer investing in the RE technology was calculated based on the 'share of utility rule'[19] outlined below. The share of utility rule assesses the probability of a consumer investing in a particular investment by comparing the rate of return on that investment with that of an alternative investment. The economic modelling has used the share of utility rule to compare the return on the RE investment with the alternative of investing the money in the bank. Where the IRR for the investment in the RE technology is equal to that of the interest rate on the bank investment (which is equal to the discount rate chosen for each scenario) then the probability of RE investment is 50%, and where the IRR is greater than the discount rate then the probability of RE investment is greater than 50%.

$$\text{Probability of investment} = \frac{IRR_{\text{(renewable investment)}}}{IRR_{\text{(renewable investment)}} + IRR_{\text{(alternative investment)}}}$$

7.2.2 Modelling deployment and uptake rate

Deployment coefficients have been produced for each of the scenarios to model the impact of the deployment parameters on the uptake of the RE technologies. The deployment parameters include differing levels of local and central government support, readiness of the wider market for RE installations (such as capacity of local electric grid to accept distributed power generation or increased electrical demand from heat pumps) and planning approval and consenting rates for larger scale installations. These deployment coefficients determined the amount of projects that would be deployed from the projects that were defined as 'economic potential' in the previous step of the methodology. The way the deployment coefficients were determined was specific to each technology and are explained in more detail in the following sections.

[19] *Trafford Publishing (2007) Principles of Marketing Engineering:* http://www.mktgeng.com/downloadfiles/technotes/tn09%20-%20conjoint%20analysis%20technical%20note.pdf

7.3 Deployment modelling methodology by technology

7.3.1 Wind

The deployment rate of wind projects was based on empirical evidence of planning permissions across England. According to the statistics published by BWEA[20], 25% of planning applications for wind turbines were successful in England in 2009. Considering the already high installed capacity in Cambridgeshire, the planning approval rates were set lower at 15% in Cambridgeshire for medium scenario. Approval rates of 7.5% and 30% were assumed for the low and high scenarios respectively. The High Without Wind scenario assumed a 0% planning approval rate for wind projects.

7.3.2 Biomass

The deployment rate for biomass was determined based on current installation rates in Cambridgeshire for biomass and energy from waste plants. Current installed capacity already accounts for 30% of the technical potential in Cambridgeshire and therefore deployment coefficients were set so that medium scenario would enable the deployment of 45% of the technical potential.

7.3.3 Photovoltaics and solar water heating

The deployment potential of PV and solar water heating was based on the uptake rates that were achieved in Germany. It was estimated that 11% of its technical potential was achieved within 10 years of implementation of the FITs in Germany. The German FITs are set at similar rates to the UK tariffs and given the similar levels of affluence and market conditions between the two countries; it is assumed that similar rates of growth in PV installations could also be possible in the UK. It is also assumed that SWH has the same rate of growth as PV as it has similar deployment characteristics (i.e. it is a solar, roof-top technology) and in the same way as PV is supported by the FIT, SWH will be supported by the RHI in both non-domestic and domestic buildings from 2012 onwards.

Therefore, the deployment coefficient of these technologies was set as to achieve 11% of technical potential for the medium scenario. The remaining scenarios were benchmarked against the medium scenario to reflect the different conditions defining the scenarios.

7.3.4 Heat pumps

Due to a lack of empirical evidence regarding the mainstream roll out of heat pumps, the scenarios have modelled the impact of the various deployment challenges for heat pumps. Energy efficiency uptake is used as a proxy for installing heat pumps as they typically require a number of changes within the property. Heat pump installations are typically more complex and involved than PV or SWH as they require external space for locating the heat pump in addition to the internal components and the heating/ radiator system may need adjusting to a low temperature system. They are a less well known technology and they are directly competing against incumbent gas boilers. Heat pump uptake is benchmarked against the Committee on Climate Change's (CCC) Uptake of Energy Efficiency in Buildings report[21] as this is a key national report looking at the potential for energy efficiency and carbon reductions in buildings.

[20] *British Wind Energy Association (2009) State of the industry report: http://www.bwea.com/pdf/publications/Industry_Report_08.pdf*
[21] *Committee on Climate Change (2009) Uptake of Energy Efficiency in Buildings: http://downloads.theccc.org.uk/docs/Element%20Energy_final_efficiency_buildings.pdf*

Disruptive measures such as floor and solid wall insulation were considered in order to understand the likely uptake rates for heat pumps.

GSHP were assumed to have lower deployment rates than ASHP, on the basis that the installation process is more disruptive than ASHP, requires external space for installing pipework, and is subject to additional risks due to ground conditions. As a result, deployment coefficient was set at 10% for the medium scenario for air source heat pumps and 5% for ground source heat pumps.

The large scale deployment of heat pumps in Cambridgeshire would lead to investment costs in the local electricity grid due to an increased demand for power. This grid investment cost is factored into the economic appraisal of heat pump deployment by assuming a charge of £1,000 for every property installing a heat pump. The actual extent and costs of the reinforcement which may be required are unclear. The Phase 1 technical potential assessment assumes that 75% of Cambridgeshire's housing stock will be suitable for installing heat pumps by 2031 due to a large scale low carbon refurbishment programme over the next twenty years. However, the deployment scenarios have down-scaled this assumption so that 40% to 60% of the county's housing stock is assumed to benefit from refurbishment over the next twenty years and is therefore available for the installation of heat pumps. Summary of the deployment potential

7.3.5 Deployment potential scenarios

Figure 7-2 provides an overview of the four renewable energy deployment scenarios. The deployment potentials are compared with both the current installed capacity and the 28% renewable energy target for 2030 taken from the Renewable Energy Review. Scenario 1 equates to 11% of Cambridgeshire energy demand whereas scenario 3 equates to 47% of energy demand. Scenario 4 achieves 19% contribution even without any wind, although it would require a significant contribution from PV and biomass. The high existing renewables capacity provides Cambridgeshire with an excellent springboard for delivering the deployment levels within these scenarios.

Scenario 3 is the only scenario to achieve the 28% renewable energy target, and this is due to the large contribution from wind. This demonstrates the significant potential that wind has to offer and also the important role that wind would need to play if Cambridgeshire were to aim for very ambitious renewable energy targets. Table 7-2 provides the underlying figures for these deployment scenarios with the GWh contribution of each technology for each scenario.

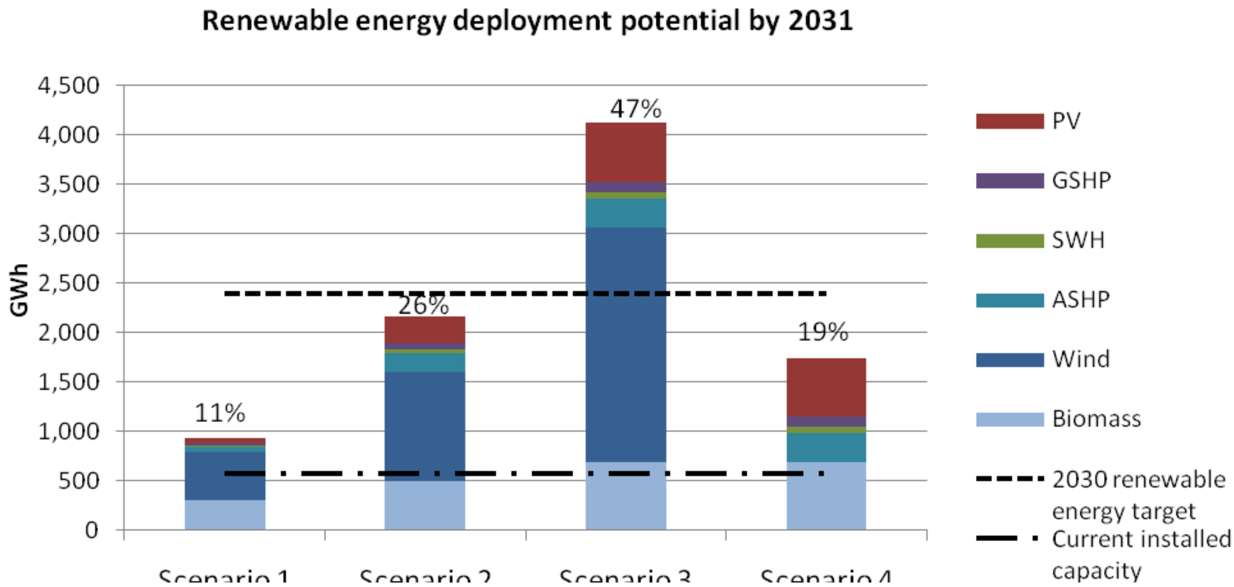


Figure 7-2: Renewable energy deployment potential in Cambridgeshire

The biomass and EfW potentials are combined into a single biomass category for the deployment potential scenarios due to the similarities between the different biomass and EfW feedstocks and their common potential to serve CHP units or heat networks.

Technology	Scenario 1	Scenario 2	Scenario 3	Scenario 4
PV	58	275	592	592
SWH	13	34	66	66
GSHP	21	65	105	105
ASHP	44	190	289	289
Wind	487	1,105	2,369	0
Biomass	354	526	591	591
Total	**977**	**2,196**	**4,012**	**1,643**
% of Cambridgeshire's energy demand	**11%**	**26%**	**47%**	**19%**

Table 7-2: Renewable energy deployment potential in Cambridgeshire in GWh

7.3.6 Assessing the number of installations associated with each scenario

Table 7-3 outlines the number of renewable energy installations that would be associated with the delivery of these scenarios. The PV installations refer to the number of domestic solar roofs that would be associated with each scenario, ranging from approximately 30,000 in scenario 1 to 290,000 solar roofs in scenarios 3 and 4. Air source heat pumps play a key role in the scenarios with approximately 7,000 installations in scenario 1 increasing to almost 50,000 in scenarios 3 and 4. Approximately 100 large wind turbines would be needed in scenario 1 compared to 450 turbines in scenario 3.

Technology	Scenario 1	Scenario 2	Scenario 3	Scenario 4
PV (2.5 kW)	28,140	134,234	288,634	288,634
SWH	7,970	21,045	40,437	40,437
GSHP (5kW)	3,404	10,728	17,359	17,359
ASHP (5kW)	7,269	31,484	47,908	47,908
Wind (2.5 MW)	94	212	455	0
Biomass (1.5 MW)	18	27	30	30
Total	**46,895**	**197,730**	**394,824**	**394,368**

Table 7-3: Number of installations associated with the deployment scenarios

7.3.7 Assessing the deployment potential of renewable electricity and renewable heat

In practice, energy use in buildings is broken down into heat and power consumption, and the different energy supply technologies either generate heat or electricity (or both in the case of CHP). Historically renewable energy policy has tended to focus on renewable electricity at the expense of heat. The Renewable Heat Incentive aims to redress this imbalance. The Committee on Climate Change's Renewable Energy Review outlines separate renewable heat and renewable electricity in order to examine the different challenges facing heat and electricity, and to ensure that the UK achieves a comprehensive renewable energy solution.

Figure 7-3 compares Cambridgeshire's renewable electricity deployment potential with the 18% renewable electricity target for 2030 from the Committee on Climate Change's Renewable Energy Review report. It shows that Cambridgeshire easily has the potential to meet the suggested 18% target, and could reach this level of deployment through a combination of wind, PV and biomass, or it could even meet it through wind or PV alone due to the significant available resource associated with these two technologies.

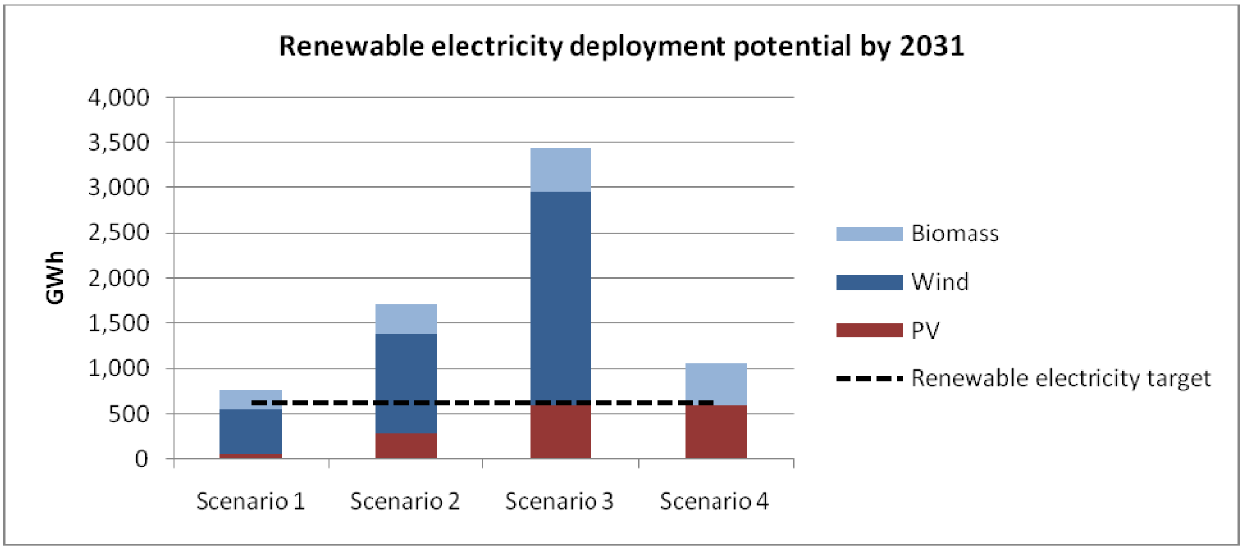


Figure 7-3: Renewable electricity deployment potential in Cambridgeshire

Figure 7-4 highlights the challenge for Cambridgeshire in terms of generating sufficient levels of renewable heat. The Committee on Climate Change expects renewable heat to play a far greater role over the coming years. It considers heat to be both a challenge, as it is starting from a very low position, and also an opportunity due to the scope for greater deployment of heat pumps and biomass. The majority of the heat demand in Cambridgeshire resides in the domestic sector and this is where the deployment of renewable heat would need to be focused. In addition, the greatest potential for energy efficiency improvements resides in housing, and specifically with regard to heat consumption in housing. Cambridgeshire has a far greater renewable electricity potential than heat potential – and although scenario 3 achieves the 28% renewable energy target, the renewable electricity generated by wind is in effect compensating for the lack of renewable heat.

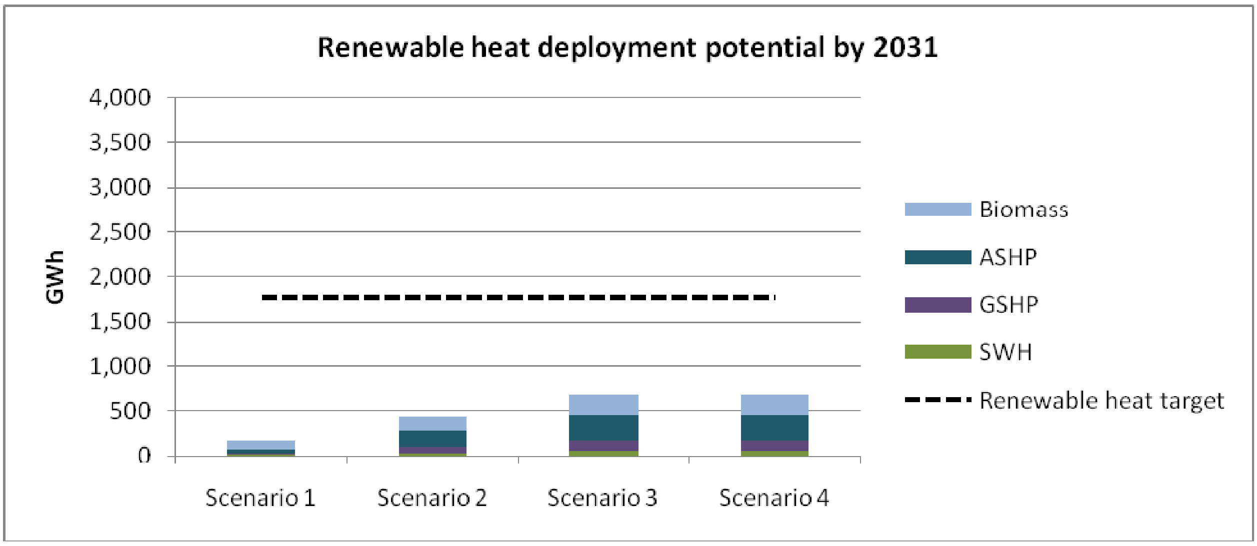


Figure 7-4: Renewable heat deployment potential in Cambridgeshire

7.3.8 Assessing deployment potential by district

The greatest renewable energy potential resides in Huntingdonshire followed by South Cambridgeshire. Although these two districts have the largest wind resource they also have substantial PV and air source heat pump potential as along with Cambridge they have a larger building stock than the other districts.

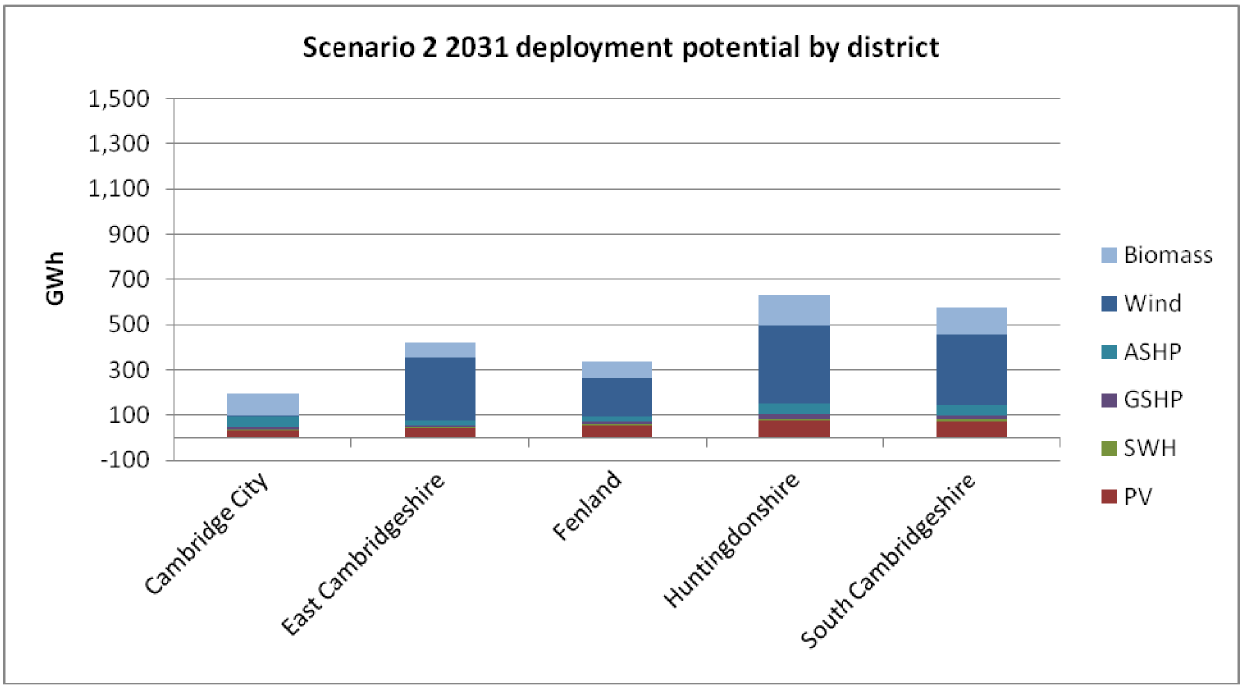


Figure 7-5: Renewable energy deployment potential by district under scenario 2

7.3.9 Evaluating contribution of district heating potential

Figure 7-6 illustrates the potential contribution to low carbon heat supply that could be made by district heating. Scenario 4 shows the technical potential for district heating which corresponds to approximately twice the potential from biomass under scenario 4. The three district heating deployment potential scenarios from the previous chapter are added to scenarios 1 to 3 in Figure 7-6 to compare their potential contribution with that of the other renewable heat technologies. In practice district heating is difficult to deliver and would only serve a limited proportion of the buildings in the area where a scheme is actually installed – and for this reason the deployment scenarios for district heating assume 2.5%, 5% and 10% of the technical potential to be realistically deployable. As is clear in Figure 7-6, the heat demand from areas that could potentially be served by district heating networks is similar to the heat generation potential from biomass, which would form a useful match if the biomass resource were to be used in as the fuel for these district heating networks. Alternatively the fuel could be brought in from outside the county thereby increasing the overall contribution of renewable energy within Cambridgeshire.

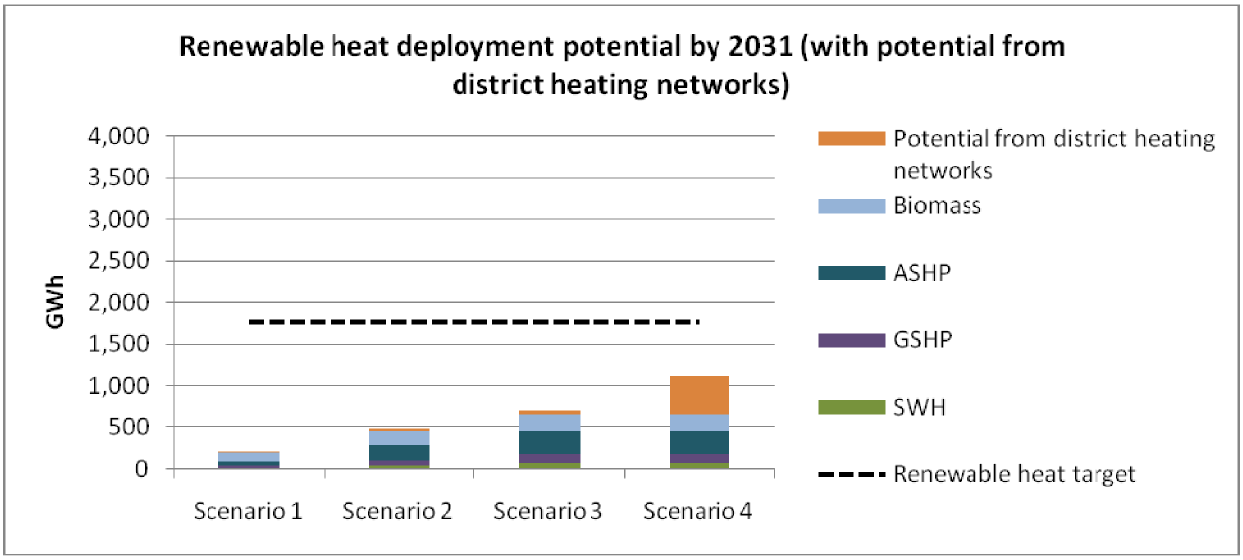


Figure 7-6: Evaluating the contribution that the district heating technical potential could make to low carbon heat supply

7.4 Role of new development in contributing to the deployment potential

The substantial housing and employment land growth over the next twenty years will in its own right significantly increase renewable energy installations in Cambridgeshire. In complying with Building Regulation requirements for zero carbon housing from 2016 and zero carbon non-domestic buildings from 2019, developers will need to install renewable energy onsite or contribute to offsite low carbon infrastructure. A general assessment of the Cambridge Sub-Region's housing and employment projections suggests that up to 400GWh per year will be financed or installed in association with the new development. Combining the new build renewables output with the current installed capacity of approximately 600GWh, will enable Cambridgeshire to achieve the deployment scenario 1 of 900GWh of renewable energy.

7.5 Contribution of renewable energy to Cambridgeshire carbon objectives

Figure 7-7 illustrates the contribution of renewable energy to Cambridgeshire carbon reduction objectives under each of the deployment scenarios. The carbon reductions from the renewable energy scenarios build upon the carbon savings from grid decarbonisation and energy efficiency improvements. The incremental carbon reductions from an 8% and 22% decrease in energy demand is presented in the green and purple segments respectively. Therefore, the total carbon reductions associated with a 22% decrease in energy demand would be the sum of the green and the purple segments. In contrast the burgundy segment demonstrates the increase in carbon emissions that would result from an energy demand increase of 5.5% (DECC reference pathway).

The carbon reductions associated with scenarios 1 to 4 are highlighted in mauve, orange, dark green and light green. These show that when combined with the most aggressive energy efficiency scenario and grid decarbonisation, scenario 3 could drive down carbon emissions to below the 4th Carbon Budget target, with the other deployment scenarios going part way towards the target. However, it should be noted that although transport emissions are included in this overall Cambridgeshire carbon reduction target, the impact of transport carbon reduction measures are not considered – and therefore the renewable energy contribution does not necessarily need to fill the whole gap. Nonetheless, it is generally acknowledged that the potential for carbon reductions in transport is smaller than the potential for reducing emissions related to heat and power consumption in buildings.

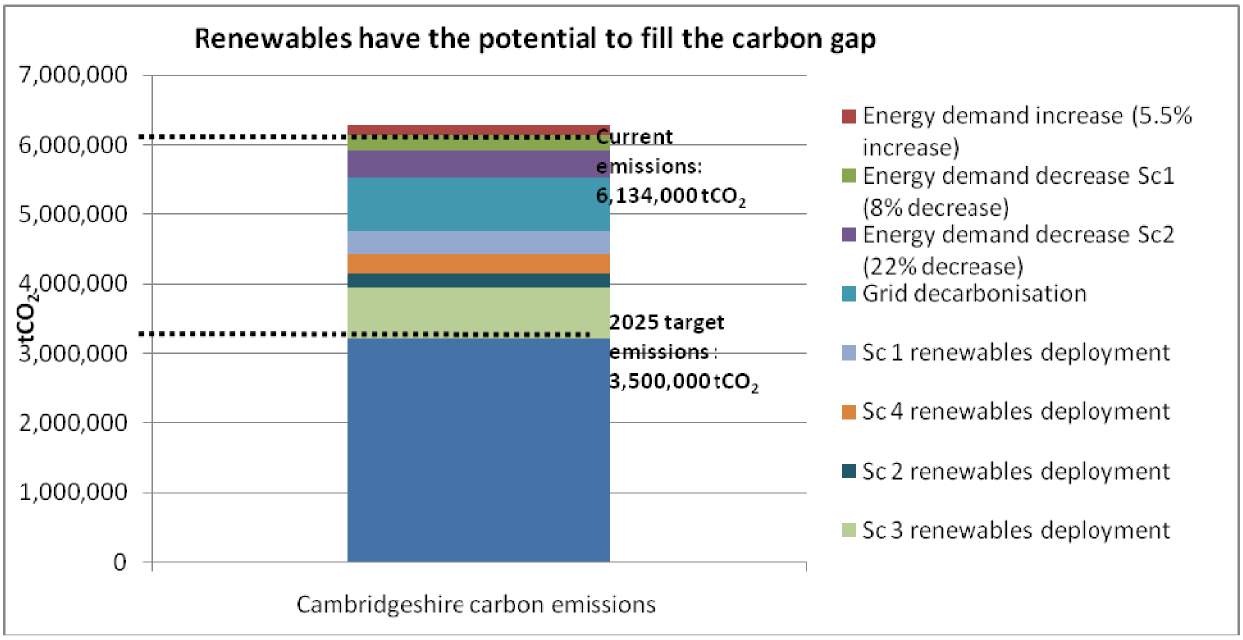


Figure 7-7: Potential contribution of renewable energy to Cambridgeshire carbon reduction targets

In order for Cambridgeshire to play its role in delivering the 4th Carbon Budget 50% carbon reduction target it will need substantial improvements in energy efficiency and a significant contribution from local renewable energy, as well as relying upon a nationally decarbonised electricity grid.

7.6 Investment opportunity

The total investment opportunity associated with each of the scenarios is outlined in Table 7-4. The total capital investment associated with scenario 1 is £900 million, scenario 2 is £3 billion, scenario 3 is £6.2 billion and scenario 4 is £4.7 billion. The majority of this investment cost is associated with the PV installations, and for example in scenario 3 the investment cost of PV is double that of wind even though the output of wind is four times than that of PV.

This large investment potential illustrates the substantial economic benefits that would accompany the installation of renewable energy infrastructure at these scales. The degree to which this economic opportunity could benefit Cambridgeshire, would depend upon the scope to which Cambridgeshire based industries and workforce are involved in the delivery of the infrastructure.

Technology	Scenario 1	Scenario 2	Scenario 3	Scenario 4
PV	£371	£1,770	£3,806	£3,806
SWH	£46	£120	£231	£231
GSHP	£28	£89	£144	£144
ASHP	£48	£207	£315	£315
Wind	£293	£664	£1,423	£0

Biomass	£135	£200	£225	£225
Total	**£920**	**£3,051**	**£6,145**	**£4,722**

Table 7-4: Level of capital investment associated with each deployment scenario in £millions

8 Assessing impact of energy demand reductions

8.1 Introducing the energy efficiency scenarios

The study has also assessed the impact of differing levels of energy demand on Cambridgeshire's renewable energy potential, so as to understand the degree to which a smaller energy demand in the future might minimise the need to exploit Cambridgeshire's renewable energy resource.

Three scenarios of future energy demand have been used to explore the impact upon renewable energy requirements. These scenarios have already been considered above in the analysis of carbon reduction objectives for Cambridgeshire and the possible contributions from different sectors. The energy efficiency scenarios are all taken from the Department of Energy and Climate Change's 2050 Pathways Analysis. There are seven 2050 Pathways looking at different approaches to achieving the 80% carbon reductions by 2050. Each of the pathways has differing packages of energy efficiency, renewable energy, nuclear power and Carbon Capture and Storage. The Low, Medium and High energy efficiency scenarios outlined below are based on the 'reference', 'alpha' and 'epsilon' pathways, respectively, and correspond with a 5.5% increase, a 8% decrease and a 22% decrease in energy demand by 2030. The 'reference pathway' considers the business as usual approach with a failure to achieve substantial carbon reductions, and an increase in energy demand. The alpha pathway represents a middle energy efficiency rate amongst the 2050 pathways whilst the epsilon energy efficiency rate is the highest of the 2050 pathways.

Scenario	Description	Source
Low	5.5% increase in energy demand by 2030	Reference pathway (DECC 2050 Pathways Analysis)
Medium	8% decrease in energy demand by 2030	Alpha pathway (DECC 2050 Pathways Analysis)
High	22% decrease in energy demand by 2030	Epsilon pathway (DECC 2050 Pathways Analysis)

Table 8-1: Energy efficiency scenarios for 2031

8.2 Impact of future energy demand on the contribution from renewable energy

Although the energy demand across the scenarios varies by 27%, the resulting impact on the contribution from renewable energy is fairly small. For example, the renewable energy deployment scenario 2 would meet 24% of future energy demand if energy demand increases by 5.5% as opposed to 33% of future energy demand if energy demand were to reduce by a quarter over the next 20 years. In other words, under an ambitious policy of energy efficiency improvements for the next 20 years the contribution from renewable energy supply (for deployment scenario 2) would only increase from a quarter to a third of Cambridgeshire's energy demand.

Future energy demand scenarios	Renewable energy deployment scenarios			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Baseline scenario (current energy demand including new build projections)	11%	26%	47%	19%
Low energy efficiency scenario	11%	24%	45%	18%
Medium energy efficiency scenario	12%	28%	51%	21%
High energy efficiency scenario	15%	33%	60%	25%

Table 8-2: Impact of energy efficiency improvements on contribution from renewable energy

This again illustrates the necessity of combining all approaches to delivering carbon reductions and reducing dependence on fossil fuels; energy efficiency improvements, local renewable energy supply and national grid decarbonisation measures are all needed in order to meet carbon reduction objectives.

Appendix 1 – Heat mapping

Appendix 1A – Heat mapping methodology

Data Sources

Heat loads at building level have been determined using the following datasets:

- Non-residential building data for Cambridgeshire was obtained from Valuation Office Agency (VOA) data detailing floor areas and usage categories for non domestic buildings.
- Local Land and Property Gazetteer (LLPG) data has been used to identify the locations of the buildings and differentiate between commercial and residential properties.
- Details of existing domestic building stock at Output Area level were be obtained from National Statistics and used to derive energy benchmarks specific for each Output Area.
- Details of proposed future developments have been identified through liaison with planning contacts at each district council. Assumptions were used to estimate possible energy consumption from each site.
- Industrial major heat users have been identified through examination of the VOA data to identify large floor plan industrial and manufacturing sites.

Benchmarking approach

Benchmark data has been used to determine the estimated energy demands from four different categories of building:

1. Existing domestic properties:

   National statistics provide details of the total gas consumption of domestic properties, and the number of domestic properties, in each output area. This is then used to determine average domestic energy consumption for each output area.

2. Existing commercial properties

   Industry standard benchmark data from CIBSE[22] has been used to determine heat loads from non domestic buildings.

3. Existing industrial properties

   Industry standard benchmark data from CIBSE[23] has been used to determine heat loads from industrial buildings. This has been calculated for space heating load only on the basis of their floor area as stated in the Valuation Office Agency (VOA) data. Industrial process loads are heavily process specific and therefore cannot be estimated based on the limited datasets available.

4. Future domestic properties

   Heat loads for future domestic properties have been calculated on the basis of the Energy Saving Trust's Advanced Practice Energy Efficiency (APEE) standard. This is a

[22] *The Chartered Institute of Building Services Engineers: Documents used: TM46 "Energy Benchmarking" (2008) and CIBSE Guide F (2004)*
[23] *The Chartered Institute of Building Services Engineers: Documents used: TM46 "Energy Benchmarking" (2008) and CIBSE Guide F (2004)*

specification for new housing which achieves a reduction in carbon emissions of approx 30% compared to the 2006 building regulations

5. Future non-domestic development

   Industry standard detailed benchmark data from CIBSE has been used to determine heat loads for future non domestic buildings. This data has been refined to reflect the impact of the 2006 building regulations and a further 25% reduction applied to reflect further improvements to low energy building design in the near future.

Assumptions

Plant efficiencies

The heat maps present the heat demand of the buildings in the specific area. In order to calculate heat demand from the energy consumption data and benchmark data, assumptions have been made regarding the efficiency of heating plant in existing buildings.

The following table outlines the efficiencies which have been used in these calculations.

Table 0-1 Assumed plant efficiencies

Building type	Heating system efficiency
Existing commercial	85%/ 80%[24]
Existing domestic	85%
Existing council / county assets	80%
Future commercial	86%
Future domestic	90%

Table 0-2 Assumed plant efficiencies

New development sites

Detailed assessment of site-by-site development proposals is outside the scope of this study, In order to estimate the potential energy demand of future development sites we have employed a set of assumptions based on the land area and proposed usage of each development site. Development site data was provided by each district council, and was classed as one of three categories:

- **Residential development**

  Highly urban sites: 50 dwellings per hectare. Used in Cambridge only.

  Semi/extra-urban sites: 35 dwellings per hectare. Used for all sites outside Cambridge.

- **Mixed use development**

  Sites were defined by scale, according to the definitions presented in Table 0-3 below. Number of housing units and non-domestic floor areas were assigned pro-rata relative to the size of the site and the maximum extent of development at each scale.

- **Employment land**

  A fixed set of assumptions was used to determine floor areas of A1 retail, office and warehouse development for each employment site. These are outlined in Table 0-4 below.

[24] *85% used with benchmarks dated 2008, 80% used with older benchmarks from CIBSE guide F (these typically date from around the year 2000)*

Scale	Site size range	Housing units at maximum site size	A1 retail development (m^2 at maximum site size	Office development (m^2 at maximum site size)
Small	Up to 4.3 Ha	100	2,500	2,700
Settlement extension	4.3 - 47.7 Ha	900	10,000	60,000
Urban extension/new settlement	47.7 - 189.3 Ha	4,000	75,000	180,000

Table 0-3: Development assumptions used for mixed use development sites

Scale	Site size	A1 retail development (m^2 at maximum site size	Office development (m^2 at maximum site size)	Warehouse development (m^2 at maximum site size)
Base scale	10 Ha	10,000	18,000	12,000

Table 0-4: Ratio of non domestic development to site area for employment sites

Potential heat sources and anchor loads

The study has identified and mapped a number of potential heat sources and anchor loads to assist in reviewing the heat maps. A selection of key items have been presented on the district scale maps, and all items are presented on the more detailed maps of the “zones of high potential”:

- **Waste Heat:** Our analysis examined the location and scale of major existing and future sources of waste heat in the region and consider these where they occur in close proximity.
    - The register of EU ETS installations (heat generating plant of over 20MW and CHP installations)
    - Power stations were identified from EU ETS data.
    - Locations and scale of existing and proposed energy from waste (EfW) plants obtained from the appropriate Waste Planning Authorities (WPA’s)
    - RESTATS Planning Database 2010 – details of locations and size of biomass plants, biomass CHP, landfill gas sites and others
    - UKWIN (UK Without Incineration Network) locations of existing and proposed incinerators and their capacities
    - Examination of VOA data to identify large industrial sites where the installation of CHP systems which could export heat may be an option.
- **Potential Anchor loads**
    - Examination of VOA data to identify large industrial and manufacturing sites.
    - Large scale future developments are included in the maps as possible anchor loads, with graduated markers to indicate potential energy demand.
    - Examination of LLPG data to identify the locations of key potential anchor loads (public sector and otherwise), such as hotels, schools, university buildings, hospitals/healthcare buildings, prisons, etc.

- Data from the East of England study was also presented in the maps, including a layer identifying large public sector buildings (heat demand over 1,500 MWh/annum from NI185 data), major hospitals and large energy consumers indentified from EUETS data.

- **Existing heat distribution infrastructure**
  - The regional study for the East of England identified that the only existing heat distribution infrastructure in the region is located at the University of East Anglia in Norwich – indicating that no district heating infrastructure is present in Cambridgeshire..

Processing and presentation of data

The heat map has been created using ArcGIS software. Heat load data has been imported into this software from Microsoft Excel® spreadsheets detailing building locations and their heat loads.

A number of separate layers are included in this heat map to represent the different heat loads present in the region. Colour coding of output areas according to heat load is augmented by the inclusion of point heat loads to identify areas with many large heat users. Major physical constraints are identified (rivers, railways), as well as roads.

Future developments have been identified on the map as hatched areas, with scaled point loads to identify the predicted energy demand. Domestic, and mixed use/employment development areas are differentiated using different hatching patterns. Finally, the potential anchor loads/major heat users have been represented using a range of symbols.

Methodology for estimating CHP and district heating potential

Assumptions required: CHP technologies

As our assessment of the technical potential is heat led (e.g. based on heat demand), it is necessary to define the technology solutions which are suitable for CHP implementation at different scales. It is assumed that all CHP systems are fuelled by natural gas.

The table below outlines the different scales of CHP used in our calculations and the assumed technology solution employed at each scale.

				Size (kWe)		Size (kWth)	
Technology type	Scale	Assumed technology	Heat to Power ratio	Lower	Upper	Lower	Upper
In-building	Domestic	Stirling engine	1.85	1	2	2	4
In-building	Micro	Gas engine	1.2	5	50	6	60
In-building	Small	Gas engine	1.2	50	500	60	600
CHP/DH	Local heat network	Gas engine	1.2	100	4,500	120	5,400
CHP/DH	District heat	Gas turbine	1.8	3,000	30,000	5,400	54,000
CHP/DH	Transmission	Gas turbine	1.8	30,000		54,000	-

Table 0-5: Definition of scales for CHP units

Of the technologies listed above, domestic scale CHP units are an emergent technology, which have only recently become commercially available. Although some limited financial incentives are in place to encourage uptake (in the form of Feed-in-Tariff support for 10,000 installations across the UK), CHP technology at this scale remains relatively unproven. It is best suited to domestic properties with poor insulation which are difficult to improve (e.g. solid walled properties). In these properties the CHP unit will be able to run for a large proportion of the year, maximising electrical generation and improving its financial viability. Due to its emergent status we have not included domestic scale CHP in our technical potential figures.

Micro and small CHP units are typically suited to individual buildings with high baseload heat demands such as those with high domestic hot water use, process heat loads or swimming pools. At this scale CHP is usually provided by a gas engine – this is an internal combustion engine, modified to allow the efficient off-take of heat.

Larger systems are used to supply local or district heat networks or large industrial sites. Smaller systems in this category may be gas engines, but as the amount of heat required increases, gas turbines become more commonplace. These are very similar in design to the gas turbines used for commercial electricity generation, although they are typically optimised to achieve a high combined efficiency in generating electricity and heat. Turbines of this type are suited to large schemes feeding a number of buildings through district heating mains.

Assumptions required: In-building CHP

Our assessment of in-building CHP potential is based on our dataset of energy demands at building level taken from the heat mapping exercise. For non-domestic buildings, 30 benchmark categories (from CIBSE TM46 "Energy Benchmarks") were used to estimate heat loads. Of these 30 benchmarks, the following categories were deemed to be technically suitable for the installation of CHP.

It is assumed that the CHP will meet the baseload heat demand of the building only (e.g. hot water, swimming pool heating, and any other loads which are present most of the time). This is due to the fact that CHP systems operate less efficiently if they are required to vary heat output to match demand.

Assumptions required: Local heat networks and district heating

The assessment of the CHP capacity of areas with the potential for heat networks is based on the total domestic and commercial demand in the area of high heat density. The baseload heat demand for each area was determined as 20% of domestic heat demand plus 30% of non-domestic heat demand. This heat load was then used to determine the scale of CHP technology suitable for each of the areas of high heat demand.

Appendix 1B – Cambridge heat map – comparison with Decarbonising Cambridge study

The Decarbonising Cambridge report[25] carried out a detailed heat mapping exercise for Cambridge City. This is clearly the area with the greatest potential for the installation of district heating in Cambridgeshire. The mapping results for this study and the Decarbonising Cambridge report are very similar with high concentrations of heat primarily focussed around city centre areas.

In our assessment of heat demand across Cambridgeshire, we have carried out the heat demand mapping at two different resolutions. The first is by output area (COA) level – a set of geographical areas containing approximately 100 dwellings. The second is an assessment of heat demand by 50m grid square, similar to the 100m scale used in the decarbonising Cambridge study. The results from the two studies are presented below.

[25] *Cambridge City Council (August 2010) Decarbonising Cambridge: A renewable and low carbon energy study*

Figure 0-1: Findings of the heat mapping study in the Decarbonising Cambridge report

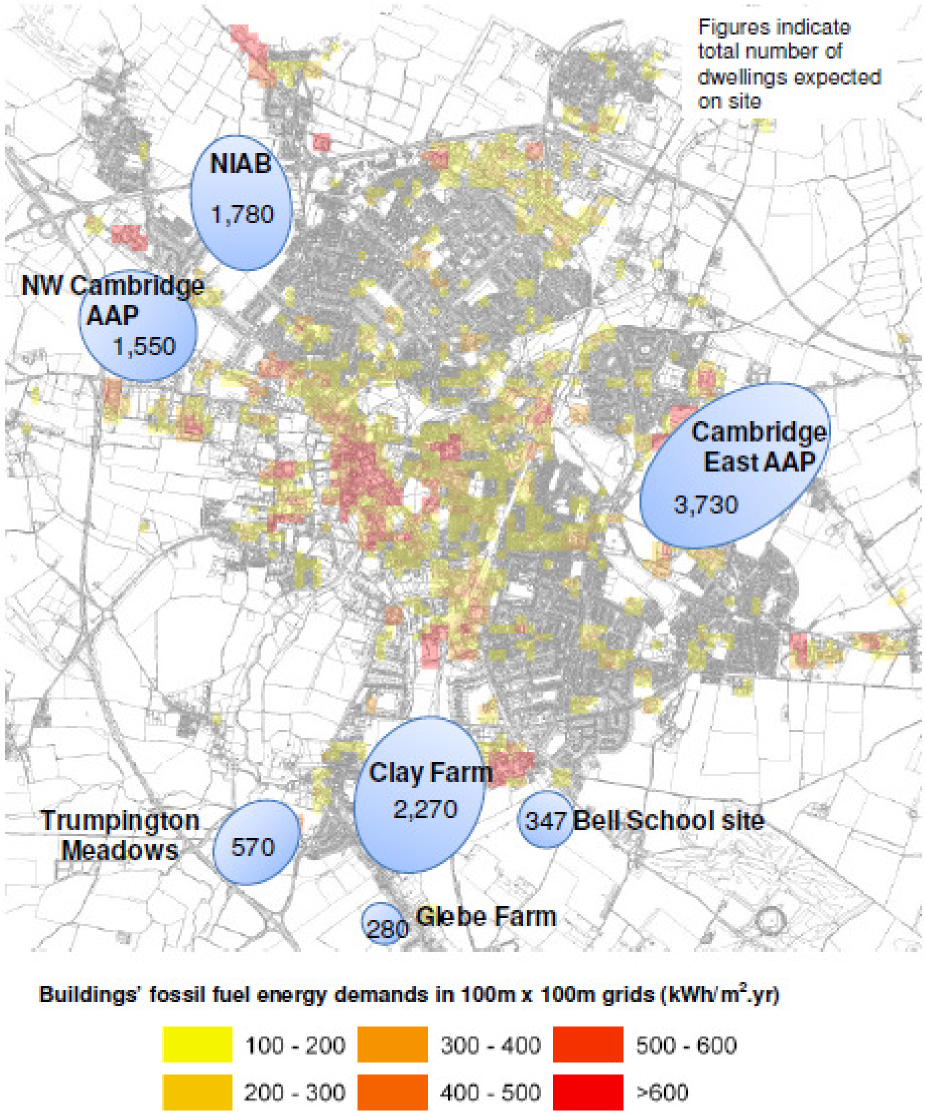
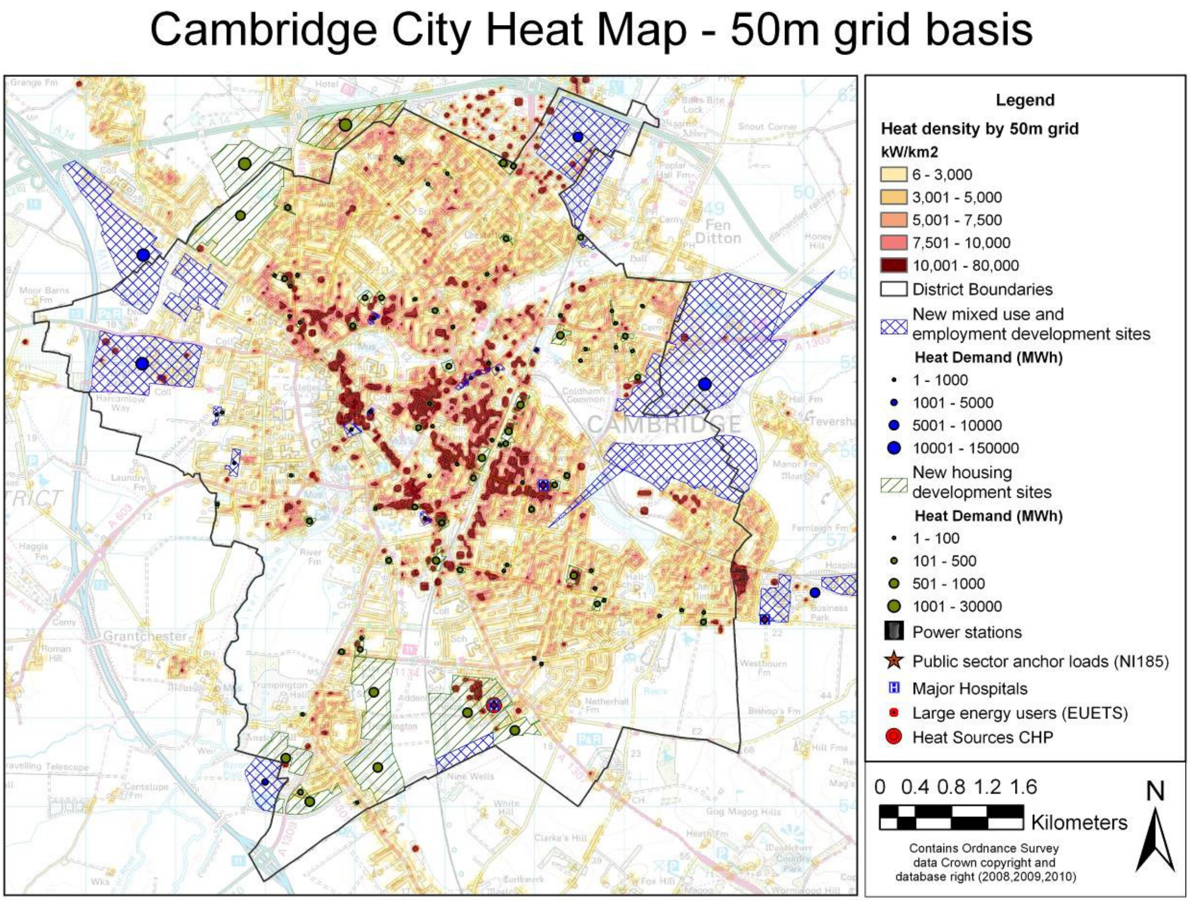


Figure 18: Areas of high heat density and urban extension sites in Cambridge

Figure 0-2: Findings of Camco's analysis of heat demands in Cambridge



The broad pattern of heat density across the city is very similar, with high concentrations of heat primarily focussed around the city centre area.

There are two key differences in presentation between the two studies; these are outlined below along with their impact on the mapping:

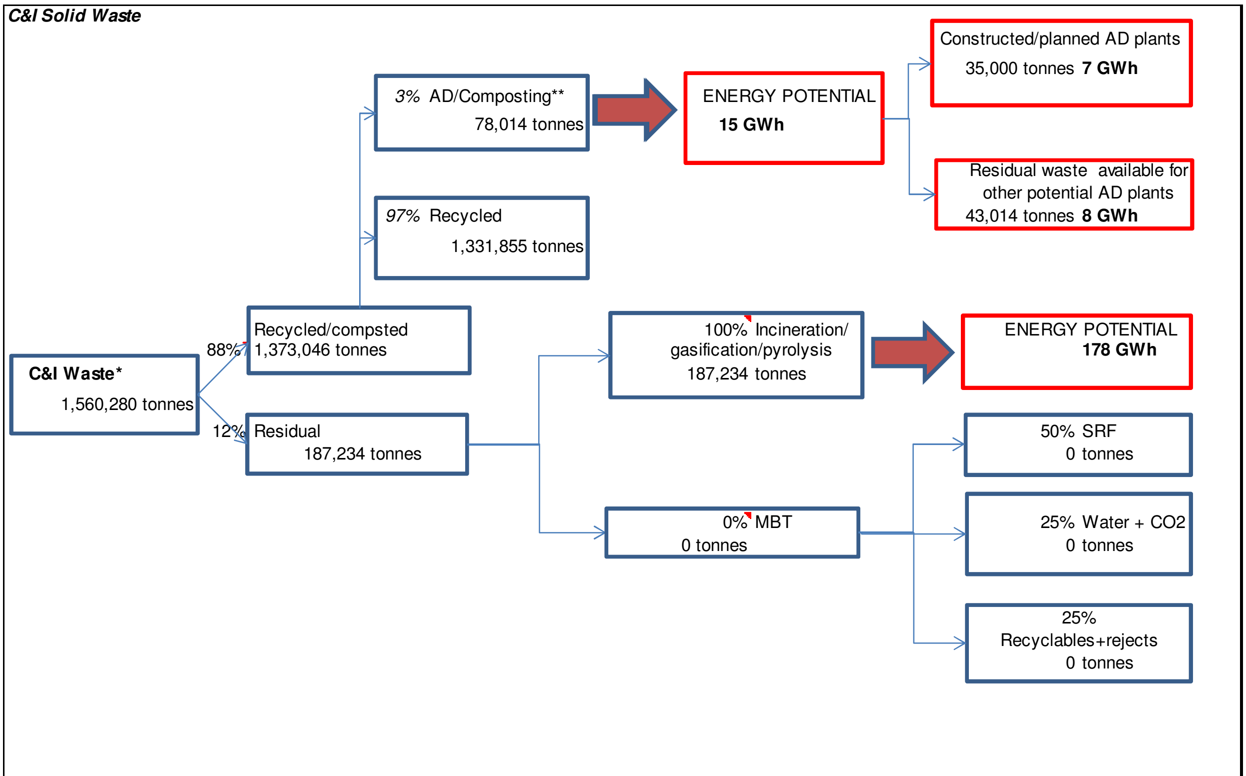
Item	Decarbonising Cambridge study	CRIF assessment	Impact
Minimum heat density threshold	100kWh/m2/yr	3,000 kW/km2 (in line with DECC methodology)	Decarbonising Cambridge study uses a higher threshold for viability than the value defined in the DECC methodology and used in the Camco study – hence identifies a smaller area as being potentially viable.
Source dataset for building type and size	OS addresslayer data, building footprints and assumed number of floors	LLPG data and mastermap for domestic properties, VOA data with floor areas for non-domestic	Camco's methodology should provide greater accuracy in determining non domestic building floor areas for calculation of total heat loads, as fewer assumptions are required in the calculation process.

Appendix 1C - Qualitative assessment of the viability of district heating in the towns identified

Site Number	Site name	Total aggregated heat load (Domestic and Commercial)	Load diversity	Major heat sources nearby (capable of leading a scheme)?	Lesser heat sources within high density heat load area?	Commercial/ Industrial anchor loads present?	Major new developments present?	Public sector/other anchor loads present?	Existing DH infrastructure ?	DH studies carried out?	Physical constraints present?	Total
		Dom+Com and MWh/Annum	Ratio Com:Dom demand	Yes/No, and details	Yes/No and details	Yes/No and details	Yes/No and details	Yes/No and details	Yes/No and details	Yes/No	Rivers, rail, major roads, archaeology, topology	/16
1	Wisbech	164,803 MWh/annum	22:78	No	Possibly – 3 EUETS registered sites and a number of large industrial	Yes – Some significant commercial loads, and several large industrial sites	No data provided – assumed no	Yes – museum, hospital, swimming pool	No	No	Primary road, river both pass through the area although on outskirts of area of greatest heat demand	
2	March	78,108 MWh/annum	9:91	No	No	No	No data provided – assumed no	Museum, libraries (3 buildings), hotels (3 buildings)	No	No	No - River Nene passes through centre of high heat load area – but is bridged	
3	Huntingdon	175,633 MWh/annum	21:79	No	Possibly – 1 EUETS site and several large industrial	Yes - Several large commercial and industrial users	Yes – infill sites and large potential development on north west fringe	Yes – healthcare, law courts, museum, library, hotel, colleges	No	No	Yes – railway with limited bridging bisects area of high heat density	
4	St. Neots	189,572 MWh/annum	11:89	Yes – Power station just over Cambridgeshire border.	No	Some large industrial loads, few large commercial loads	Yes, but separated from main heat load area by railway	No -Relatively few - library, Museum, college –	No	No	Yes- river (single bridge) through centre of two high heat density areas plus railway blocking route to new development	
5	St Ives	113,046 MWh/Annum	9:81	No	No	One large industrial load	Yes, but separated from high heat areas	No - A few hotels, two libraries	No	No	No	
6	Yaxley	53,027MWh/ Annum	3:97	No	No	No	No major scale developments	No	No	No	No	
7	Whittesley	46,512MWh/ Annum	9:81	No	No	No	No data provided – assumed no	Leisure centre, hotel, libraries	No	No	No, although railway may limit expansion to south	
8	Ely	59,802MWh/ Annum	12:88	No	No	One commercial, one industrial, on outskirts	No – some infill housing sites	A few within areas of high heat load – law court, museums, library.	No	No	No	
9	Bar Hill	32,185 MWh/Annum	29:71	No	No	One large commercial, one hotel	No	Library	No	No	No	
10	Chatteris	40,754 MWh/Annum	8:92	No	No	No	No data provided – assumed no	3 hotels, school, one large industrial	No	No	No	

Appendix 2 – Future energy from waste potential from commercial and industrial waste

The diagram below shows the waste flow diagram for commercial and industrial waste in Cambridgeshire. The targets for recycling are sourced from the Cambridgeshire and Peterborough Minerals and Waste Development Plan Core Strategy. The volumes of waste was quantified as explained in Section 5.3.3.



* Based on split between Cambridgeshire and Peterborough MSW derived from Jacobs Babtie (2006) Cambridgeshire and Peterborough Statistical Basis for the Waste Development Document (WDD)
** Based on ratio of composted waste to recycled/reused waste in Wales. EA (2007) The survey of industrial and commercial (I&C) waste arisings in Wales, http://www.environment-agency.gov.uk/research/library/publications/107692.aspx

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