east of england renewable and low carbon energy capacity study

for the department for energy and climate change

april 2011

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Quality Control

East of England Renewable and Low Carbon Energy Capacity Study

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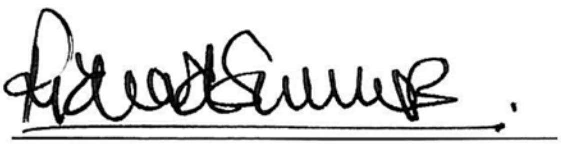
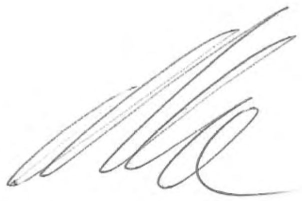
Signature:  Name: Richard Summers Title: Head of Planning	Signature:  Name: Steven Bainbridge Title: Spatial Planner
Date: 28th April 2011	Date: 28th April 2011

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The Landscape Partnership
Registered office
Greenwood House
15a St Cuthberts Street
Bedford
MK40 3JB

Registered in England No. 2709001

Checked by:

Kirsten Elder (Project Manager)
Principal Consultant

Prepared by:

Seyhan Turan
Senior Consultant (AECOM)

Prepared by:

Noah Nkonge
Senior Consultant (AECOM)

Prepared by:

Andrew Turton
Principal Consultant (AECOM)

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First Floor, Stonecross, Trumpington, High Street, Cambridge, CB2 9SU
Telephone: 01223 551800   Website: http://www.aecom.com

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Executive Summary

Introduction

This report examines the potential for renewable energy generation in the East of England. The information in this report has been prepared for informing the Department of Energy and Climate Change (DECC) of the potential uptake of renewable energy by 2020, and provides a basis for more detailed information to be available at a local level, which can be used to support local delivery of renewable energy schemes.

To ensure consistency between regional reporting, DECC commissioned a study to develop a standard methodology for conducting capacity assessments. The resultant methodology (the “DECC methodology”) was released in 2010 and additional funding from DECC was made available for regions to complete studies using this standardised methodology, and contribute towards developing a consistent set of regional and national targets.

This study is the first for the EoE using the DECC methodology to assess the potential for renewable and low carbon energy. The study has the following objectives:

- To assess the regional potential for providing renewable energy to contribute to DECC’s national statistics. This should include the likely potential by 2020 considering both natural and technical limitations, and uptake considerations.
- To establish the opportunities and constraints to the development of renewable and low carbon energy at a local scale (local authority level) to enable delivery at a local level.
- To establish the potential for renewable and low carbon energy generation at a local level to allow an understanding of the role which each local authority can play in contributing to regional and national generation. Targets will not be set; but an indication of potential will allow local authorities to establish ways in which increased uptake can be achieved.

The renewable and low carbon energy technologies that have been considered are:

- District Heating (DH) and Combined Heat and Power (CHP);
- Large scale onshore wind energy;
- Hydro energy;
- Biomass (including energy generation from dedicated energy crops, managed woodland, industrial wood waste and agricultural arisings, or straw);
- Energy from waste (including energy generation from slurry, food and drinks waste, poultry litter, municipal solid waste, commercial and industrial waste arisings, landfill gas production and sewage gas production);
- Microgeneration (including small scale wind energy, solar, and heat pumps).

A simple projection of energy consumption to 2020 is used for comparison of the potential renewable generation. Under the assumptions used, the total energy demand for the EoE is projected to rise by 2% between 2011 and 2020 with efficiency improvements partially offsetting increased demand from growth. The total predicted consumption for 2020 is 99,437 GWh, of which 69% is heat and 31% electricity.

Current levels of Renewable Energy

Information on current and planned renewable energy capacity has been obtained from a range of sources detailed in Appendix 1. In addition to this a literature study has been carried out to review the total installed capacity of the renewable installations in the region. The sources include East of England Renewables Energy Statistics[1] and statistical data provided by DECC[2].

Currently the highest installed capacity is from wind turbine installations and this is closely followed by biomass, landfill gas and energy from waste applications. Around half of the total wind capacity is awaiting construction and so the current installed capacity is likely to double in the next few years to around 330 MWe. The EoE region has a number of relatively large biomass installations including the 38MW straw power station in Ely, and a 38.5MW chicken litter plant in Thetford.

The current energy generation from operational plants is estimated at 2,394 GWh which represents 2.5% of the total regional energy demand (excluding transportation). If the in-construction and consented capacity is included, then this rises to 3.4% of the total regional demand or 3.3 % of the predicted 2020 energy demand. However when only the electricity use is taken into account, the total renewable energy generation in the region meets around 10.6 % of the total predicted 2020 electricity demand.

These results show that the region is currently a long way off the regional targets for 2015 of 16% and for 2020 of 20%, even with the inclusion of all capacity which is currently in construction or with planning consent.

Heat mapping

Heat mapping can be used as a guide to choosing sites for considering the installation of a District Heating (DH) network. Heat maps produced for this study can be used to locate areas where there is a high heat density, and then identify potential anchor loads or sources of heat for use on a scheme.

The current CHP capacity in the region is around 230 MWe, dominated by systems at the two British Sugar plants of 90 and 94 MW. The sensitivity analysis shows that the total potential capacity could be around 1,050 MWe at a threshold level of 3,000 kW / km^2 base on some simple uptake assumptions, although this is reduced if the threshold is higher.

Renewable energy resource potential

Table 1and Table 2 show the renewable energy resource potential and 2020 uptake expressed as a proportion of 2020 energy demands. These results demonstrate that under the assumptions used in this study, the total renewable energy resource potential could meet 220% of the projected 2020 energy demands. This may seem surprisingly high, but the majority of this (183%) is from wind generation if it is assumed that there are no limits on turbine installations from landscape impact or cumulative impact. If it is assumed that only 10% of the areas identified for wind generation can be developed, then the total resource potential expressed as a proportion of 2020 demands would be reduced to 55%.

When realistic uptakes for 2020 are considered, the potential for renewable energy in the East of England is around 9.3% of the projected energy demands.

It is important to remember that these figures are based on locally available resources and do not include the energy contribution from imported feedstocks, They also do not include the contribution that offshore technologies (primarily offshore wind) can make. However they do indicate that even under the very optimistic resource potential scenario, renewable energy can only meet around half of the region’s demand, and in reality, this is likely to be much lower.

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[1] East of England Renewable Energy Statistics by Renewables East, December 2009
[2] https://restats.decc.gov.uk/...2009/Regional-2009/Regional-spreadsheets-2003-2009-installed-capacity-MW.xls accessed in March 2011.

Table 1. Total accessible resource potential expressed as a percentage of 2020 projected energy demands.

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
THERMAL AND ELECTRICITY (% OF 2020 DEMAND)																	
Essex	101%	0%	2%	1%	0%	12%	1%	0%	0%	0%	0%	0%	2%	0%	0%	2%	**123%**
Hertfordshire	65%	0%	3%	1%	0%	16%	0%	0%	0%	0%	0%	0%	1%	0%	0%	3%	**92%**
Bedfordshire	152%	0%	4%	2%	0%	22%	3%	0%	0%	1%	0%	1%	3%	0%	0%	4%	**191%**
Cambridgeshire	305%	0%	3%	2%	0%	13%	0%	0%	0%	0%	0%	0%	5%	0%	0%	3%	**332%**
Norfolk	311%	0%	3%	2%	0%	51%	0%	0%	1%	2%	0%	0%	4%	0%	1%	3%	**379%**
Suffolk	287%	0%	3%	2%	0%	47%	0%	0%	1%	1%	0%	0%	5%	0%	1%	4%	**352%**
TOTAL	**183%**	**0%**	**3%**	**2%**	**0%**	**24%**	**1%**	**0%**	**0%**	**1%**	**0%**	**0%**	**3%**	**0%**	**0%**	**3%**	**220%**

Table 2. Contribution of each resource to 2020 projected energy demands based on uptake to 2020.

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
THERMAL AND ELECTRICITY (% OF 2020 DEMAND)																	
Essex	1.0%	0.0%	0.3%	0.4%	0.0%	0.1%	1.4%	0.0%	0.2%	0.3%	0.0%	0.3%	0.2%	0.0%	0.1%	2.3%	**6.6%**
Hertfordshire	0.7%	0.0%	0.4%	0.4%	0.0%	0.2%	0.5%	0.3%	0.3%	0.4%	0.0%	0.3%	0.1%	0.0%	0.0%	3.3%	**6.9%**
Bedfordshire	1.5%	0.0%	0.5%	0.6%	0.0%	0.2%	2.8%	0.3%	0.4%	0.6%	0.0%	0.7%	0.3%	0.1%	0.0%	4.1%	**12.2%**
Cambridgeshire	3.1%	0.0%	0.4%	0.8%	0.0%	0.1%	0.3%	0.1%	0.2%	0.3%	0.1%	0.5%	0.5%	0.0%	0.2%	3.1%	**9.7%**
Norfolk	3.1%	0.0%	0.4%	0.7%	0.0%	0.5%	0.3%	0.0%	1.1%	1.6%	0.0%	0.4%	0.4%	0.3%	1.4%	3.0%	**13.3%**
Suffolk	2.9%	0.0%	0.4%	0.8%	0.0%	0.5%	0.4%	0.0%	0.7%	1.0%	0.0%	0.4%	0.5%	0.3%	0.9%	4.4%	**13.1%**
TOTAL	**1.8%**	**0.0%**	**0.4%**	**0.6%**	**0.0%**	**0.2%**	**0.9%**	**0.1%**	**0.4%**	**0.6%**	**0.0%**	**0.4%**	**0.3%**	**0.1%**	**0.4%**	**3.1%**	**9.3%**

Delivery of renewable energy

This report provides an overview of the potential renewable and low carbon energy resource available in the East of England, and the level to which this may be taken up by 2020. The analysis considers a range of barriers to development, both in terms of accessing the resource, and the technical potential for turning these resources into energy. The capacity of supply chains to deliver renewable and low carbon energy generation and the high level economic feasibility have also been considered in assessing the potential uptake of this potential by 2020.

In reality, there are many barriers to the development of low carbon energy schemes. The delivery vehicles for schemes need to be structured in ways that help overcome barriers such as access to finance and that make maximum use of the opportunities. There are many schemes which may be technically, and even economically viable, but for which the barriers to delivery are too great to enable development to proceed. The opportunities for delivery of renewable and low carbon energy development need further and more detailed consideration at the local level.

The further report of this study to the EoE Steering Group will develop the county level outputs required in this report to DECC down to the local authority level outputs that local authorities and local communities could begin to use to develop local initiatives. The further report to the Steering Group will elaborate the interpretation of the various datasets and maps and take this initial outline of opportunities for local dissemination and delivery further to enable local authority councillors and officers and local communities to identify the next steps towards practical action. It is intended that a presentation will be made to the Steering Group when its members have received the draft report and that the results of the discussion will then be used to finalise the report as a basis for further initiatives at the local authority and local community levels.

1 Introduction

1.1 Report structure

This report assesses the potential for renewable and low carbon energy in the East of England. The report is based on the following structure:

- Introduction to the region
- A description of the methodology used to assess renewable and low carbon energy capacity potential.
- An assessment of baseline energy demands.
- An assessment of current levels of renewable and low carbon energy generation
- An assessment of the resource potential and 2020 potential for different renewable and low carbon energy resource and technologies.
- A summary issues for local dissemination and delivery of renewable and low carbon energy

1.2 The study area

The East of England (EoE) comprises the counties of Norfolk, Suffolk, Essex, Cambridgeshire, Bedfordshire, and Hertfordshire, and has a total of 52 local authorities, inclusive of county councils including 6 unitary authorities. Areas to the north and east of the region are predominantly rural with extensive agriculture, whilst the areas to the south are more urban with industrial and commercial activity, and a large number of towns within the commuter radius of London.

The population of the region in 2009 was 5.8 million, around 11% of England's total, and the EoE has the fastest rising population of all the English regions with a rise of 6.8% between 2001 and 2009. This is partially due to internal migration to the south and east for jobs and residence close to London, and partially due to international migration. The increase in population is causing an increased pressure on natural resources in the region, with water supplies in particular being under stress due to the region being the driest in the UK.

Figure 1. East of England showing existing regional boundary (blue) and the existing county boundaries within the region (purple).

The current Regional Spatial Strategy (RSS) for the region is known as the East of England Plan and runs from 2001 to 2021. The RSS sets targets for growth within the region, identifying broad areas for new residential and commercial growth, and employment opportunities. The RSS also sets targets for renewable energy production of 1,280 MW by 2015 and 1,600 MW by 2020 based on existing renewable energy capacity studies. The Localism Bill currently progressing through Parliament proposes to abolish Regional Spatial Strategies but it has been assumed that local authorities will continue to develop Local Development Frameworks on the basis of these regional targets for the time being.

1.3 Background to this study

Previous estimates of renewable and low carbon energy potential for the English regions have been conducted to inform both the regional and national targets for renewable energy generation. In line with the regional structure, these studies generally examined the potential and targets at a regional level, enabling regional policy and targets to be set which are then used to drive local policy. For the EoE, the most recent report was conducted in 2008 and was used to develop the targets of 1,280 MW by 2015 and 1,600 MW by 2020[3].

To ensure consistency between regional reporting, the Department of Energy and Climate Change (DECC) commissioned a study to develop a standard methodology to conducting capacity assessments. The resultant methodology (the "DECC methodology") prepared by SQW Consulting was released in 2010 and additional funding from DECC was made available for regions to complete studies using this standardised methodology, and contribute towards developing a consistent set of regional and national targets.

Following the abolition of regional assemblies, finance from DECC has continued to be provided for 2010/11 to the existing regional representatives. However the emphasis is on developing information which can be used at a more local level to promote the development of renewable and low carbon energy, rather than working to region-wide targets.

1.4 Objectives of this study

This study will be the first for the EoE using the DECC methodology to assess the potential for renewable and low carbon energy. The study has the following objectives:

- To assess the regional potential for providing renewable energy to contribute to DECC's national statistics. This should include the likely potential by 2020 considering both natural and technical limitations, and uptake considerations.
- To establish the opportunities and constraints to the development of renewable and low carbon energy at a local scale (local authority level) to enable delivery at a local level.
- To establish the potential for renewable and low carbon energy generation at a local level to allow an understanding of the role which each local authority can play in contributing to regional and national generation. Targets will not be set; but an indication of potential will allow local authorities to establish ways in which increased uptake can be achieved.

1.5 Scope of this study

This study assesses the potential for renewable and low carbon energy generation in the EoE including a likely uptake by 2020, based on the DECC methodology. The renewable and low carbon energy technologies that have been considered are:

- District Heating (DH) and Combined Heat and Power (CHP);
- Large scale onshore wind energy;

[3] Placing Renewables in the East of England. Arup. 2008.

- Hydro energy;
- Biomass (including energy generation from dedicated energy crops, managed woodland, industrial wood waste and agricultural arisings, or straw);
- Energy from waste (including energy generation from slurry, food and drinks waste, poultry litter, municipal solid waste, commercial and industrial waste arisings, landfill gas production and sewage gas production);
- Microgeneration (including small scale wind energy, solar, and heat pumps).

This study is concerned with the **resource potential** within the region and not simply renewable **energy generation** within the region. For some technologies that source and generate energy locally, for example wind turbines, this is considered to be an EoE resource. However for fuelled technologies such as biomass boilers which may use biomass sourced from within the region, or from outside the region, the energy generation is not considered as a local resource. It is therefore important to understand the difference between resource potential and generation potential. In the context of biomass, the regional (or local) resource is the level of biomass which can be locally sourced, not the output of a biomass technology.

The assessment of renewable and low carbon energy for transportation is outside of the scope of the study, although these potentially have a large role to play in reducing regional CO_2 emissions. It is important to note that there may be competition for resources between sectors and transportation may compete for resources identified in this study, for example biogas.

An assessment of the potential from emerging technologies such as geothermal energy generation and fuel cells is outside of the scope.

An assessment of the impact of demand reduction measures (for example, energy efficiency measures or passive solar design) is also outside the scope of the study. However, the rate of uptake of these measures will affect the uptake of renewable energy technologies and should be considered an important element of energy strategies.

The potential from offshore renewables (i.e. offshore wind and marine technologies) is also outside the scope of the study. Strategies for offshore generation are determined at a national level and are beyond the direct influence of regional organisations. The EoE is a major area for offshore wind development within the UK and this may impact onshore generation opportunities through (for example) local electricity networks. For the same reasons, renewable energy from co-firing is also excluded from the study. This is a form of renewable energy which the local authorities have very little influence over, and for which the source of the fuel cannot be easily defined as regional or non-regional.

Finally, whilst it is acknowledged that there is a link between low carbon and renewable energy deployment and the climate change agenda, the scope of this study does not include the effect of renewable energy generation on carbon emissions in the region. Potential carbon savings will be dependent on the level of fossil fuel generation displaced, which in turn is dependent on the future carbon intensity of the grid.

2 Methodology

2.1 Introduction

This study aims to examine the resource potential for a range of renewable and low carbon energy resources in the EoE, and their potential uptake by 2020. Previous studies examining the potential for renewable and low carbon resources in the EoE, or elsewhere in the UK, have all used different methodologies and therefore the results are inevitably inconsistent. The range of results can depend on a number of factors. One set of factors could be the detailed assumptions used, for example the yield from an energy crop. Another key variation can be due to the viewpoint taken in the assessment. If an assessment is purely conducted from an energy resource perspective, then the potential is likely to be high, but if other factors are the prime concern (for example straw availability for animal bedding), then the resource for energy production is likely to be lower.

In light of this level of variation, the results from a capacity study will always be approximate, and should be used as an assessment of the order of magnitude of a resource, and how this might compare with other resources and baseline energy demands. Therefore the results in this report aim to give an indication of the likely level of resource, and not the exact resource potential.

2.2 The DECC Methodology

The DECC methodology sets out a number of steps for a resource assessment and provides detailed assumptions and calculations for some of these steps along with recommended data sources.

The DECC methodology is based around a sequential constraint methodology, where constraints are progressively applied to reduce the natural resource (i.e. the maximum theoretical potential) to what is practically achievable. The stages in the methodology are numbered from 1 to 7, with stages 1 to 4 representing physical, technical, and regulatory constraints and stages 5 onwards representing delivery constraints such as supply chains and the economies of provision and operation. Figure 2 shows the various the various stages.

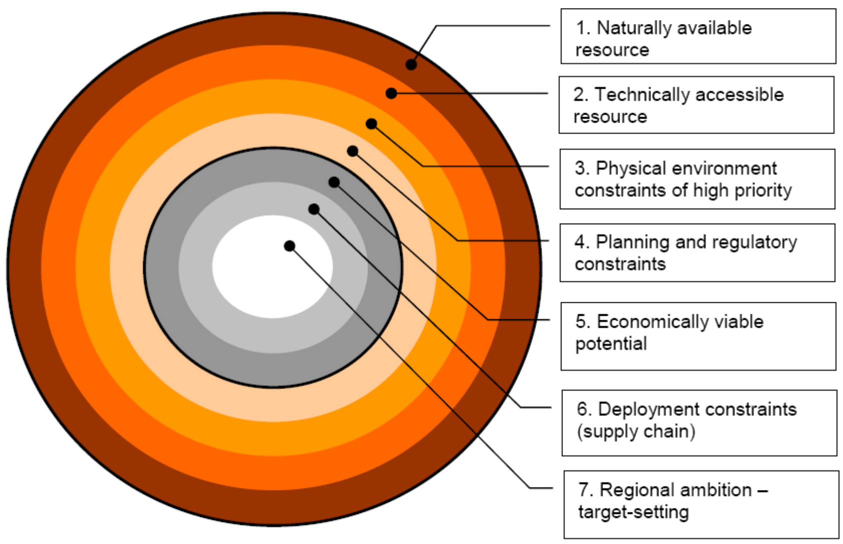

Figure 2. Stages for developing a comprehensive evidence base for renewable energy potential (Source: Renewable and Low-Carbon Energy Capacity Methodology for the English Regions, SQW Energy, January 2010)

The DECC methodology only provides method statements for stages 1 to 4, and each study is required to set out assumptions for stage 5 onwards. This study follows the DECC methodology where possible, using the same assumptions and data sources. However where the methodology is sparse, or where more appropriate assessment procedures are available, alternative processes have been included. Reports from other regions have identified areas where the methodology requires additional procedures and the recommendations from these reports have been reviewed and adopted where appropriate as part of this study.

The DECC methodology is designed to assess potential resource capacity (the energy which may be obtained, e.g. kW) but it does not specify how to calculate potential energy resource (the energy that can be obtained in a year, e.g. kWh). Capacity is not necessarily related to the resultant energy output, and this study includes an assessment of energy generation as well as resource capacity. This allows the contribution from the renewable and low carbon energy resources to be compared with the baseline energy demands.

The approach taken for each technology and resource is described in detail in Appendix 1. Where the DECC methodology was unclear as to the assumptions that should be used, assumptions based on experience in this sector have been applied and these are detailed.

2.3 Spatial resolution

This study aims to provide useful information on the potential renewable and low carbon sources of energy available in various areas within the EoE. This information is required by DECC to allow collation of the regional information (reflecting existing regional boundaries) information into a national assessment of renewable energy potential.

However the information is also of value at a local level, allowing individual local authorities to assess their potential and investigate the options for delivering renewable and low carbon energy generation. Therefore the analysis is conducted in a way which allows further use of the data at a local level to help drive the delivery of renewable and low carbon energy, and support individual authorities in the development of their LDF core strategies.

The level of resolution used in the analysis is dependent on the resolution of the input data. For analysis based around GIS mapping, the information is available in GIS format at any required resolution. All other analysis is conducted at local authority level where possible, or at the next available resolution for less well defined input information.

For the purposes of this report, information is presented at county level and regional level. Unitary authorities are assumed to be part of their existing traditional counties for the purposes of summary tables.

2.4 Steering group

The TLP / AECOM project team was guided by a steering group, which included representatives from Suffolk County Council, the local authorities and statutory consultees. A list of the steering group members is provided below.

- Suffolk County Council
- Environment Agency
- Energy Saving Trust
- Forestry Commission
- Natural England
- Bedford Borough Council (representing the local planning authorities)
- Cambridgeshire Horizons

3 Baseline Energy and CO_2 Emissions

3.1 Baseline energy consumption

It is important to understand the current levels of energy demand when discussing the potential for renewable and low carbon energy. In some cases, the potential renewable and low carbon resources are linked to the energy demand, for example the provision of heat. In all cases it is useful to be able to compare the level of renewable and low carbon resource with the current level of energy demand to understand the contribution that each resource can make.

Baseline energy demands have been calculated from DECC statistics on sub-national energy consumption for 2008. These are the latest statistics available and are shown in Figure 3. The total energy consumption excluding transportation in 2008 was 97,194 GWh.

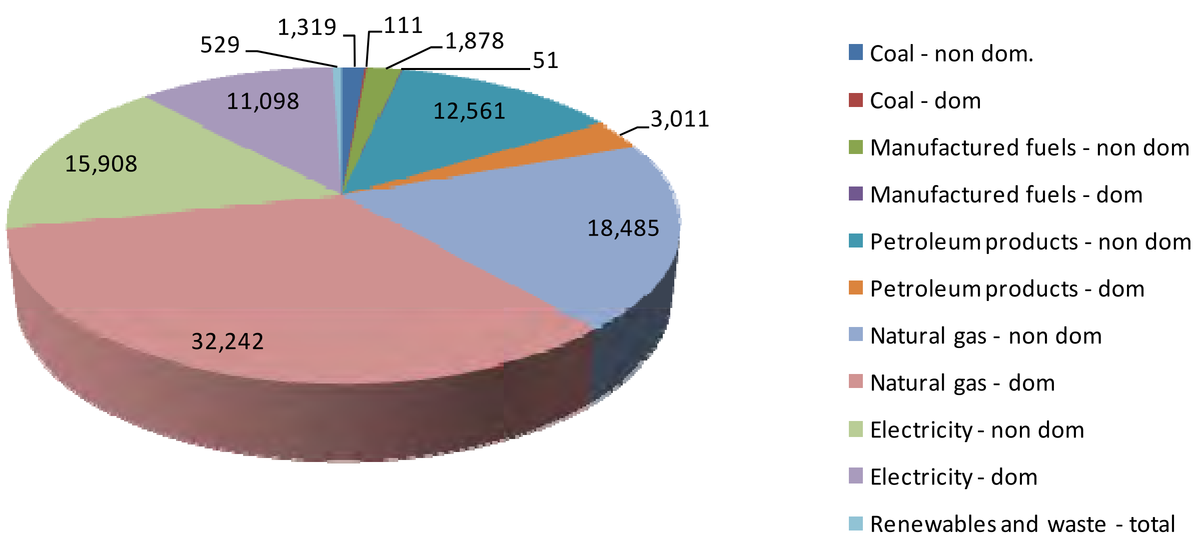

Figure 3. Baseline energy consumption for the EoE in 2008 (GWh) for different energy sources. Figures are shown for the domestic sector (dom) and the non domestic sector (non dom). Source – DECC Sub-national statistics.

Figure 3 shows that the largest energy consuming sector is natural gas for homes; making up around a third of the regional energy consumption. This shows the importance of targeting improvements to the thermal efficiency of the existing housing stock to reduce regional energy consumption levels. Overall the domestic sector accounts for around half of the region's energy demand, excluding transportation.

3.2 Projected baseline consumption to 2020

This report aims to assess the potential for renewable and low carbon energy by 2020 and therefore a simple projection of energy consumption to 2020 is required for comparison. A number of factors may influence the levels of consumption over this period:

- Growth in the number of homes
- Growth in employment and therefore the number of business buildings
- Changes in energy consumption due to behaviour
- Changes in energy consumption due to efficiency improvements.

This study provides a simple projection of energy demands up to 2020 using the following simple assumptions:

- Domestic growth is based on the RSS targets for house building in each local authority [4].
- Non-domestic growth is based on the RSS employment targets for each local authority.
- Electricity use in the domestic sector is assumed to increase by 0.5% each year to represent an increase in appliance use.
- Heating demand in the existing domestic and non-domestic sectors is assumed to reduce by 10% by 2020 representing improvements to thermal efficiency.

Under these assumptions, the total energy demand for the EoE is projected to rise by 2% between 2011 and 2020 with efficiency improvements partially offsetting increased demand from growth. The total predicted consumption for 2020 is 99,437 GWh, of which 69% is heat and 31% electricity.

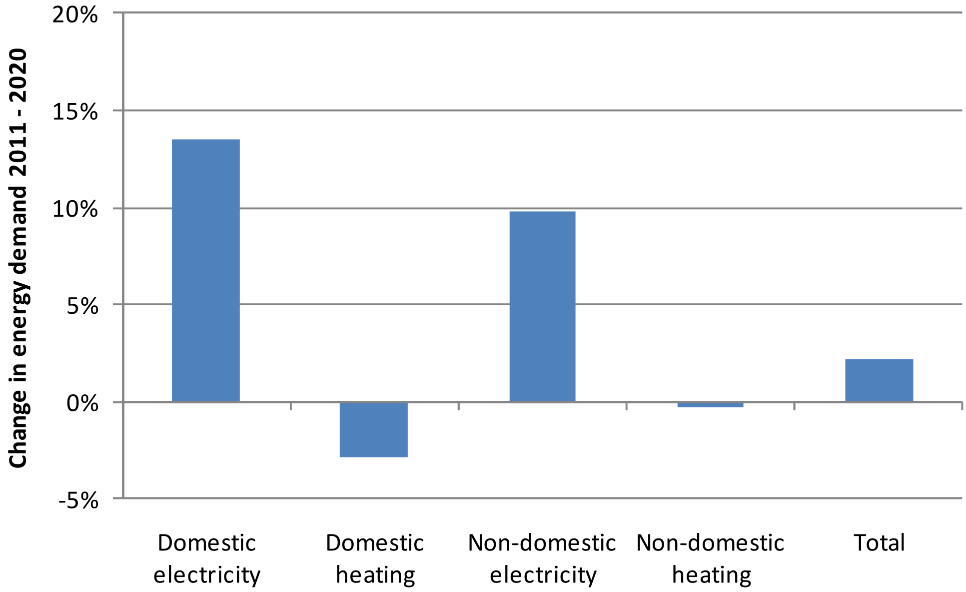

Figure 4. Projected change in energy demand between 2011 and 2020 taking into account growth, behaviour, and efficiency improvements. Note that this does not include fuel switching or transportation.

Figure 4 shows the relative change in demand for each of the energy use types, with domestic electricity predicted to exhibit the largest change. Heating energy consumption is predicted to reduce for both domestic and non-domestic with efficiency savings in the existing sector outweighing rises due to new development. Figure 5 shows these projections over the period to 2020 demonstrating that in the context of the region's total consumption, the changes are relatively small.

[4] We have used information from the Draft Review of the RSS to 2031.

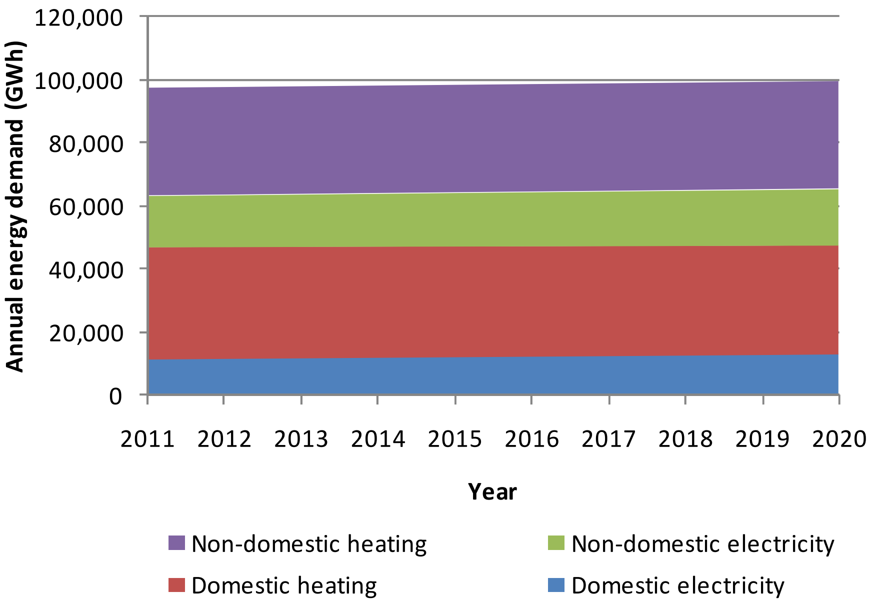

Figure 5. Projected energy demands over the period 2011 – 2020.

4 Current Renewable Energy Generation

4.1 Introduction

The monitoring of existing renewable installations in the EoE is an important part in delivering new renewable and low carbon energy. By understanding the current installed capacity, types of technology, and locations, and by comparing it with potential demand and capacity, it is possible to identify potential opportunities for, and barriers to, development. It also enables an estimate of how progress is being made towards achieving this potential, and where further effort is required. The DECC methodology provides a very theoretical assessment of renewable energy potential and comparing the results with current capacity can provide a check of how the theory matches reality.

As discussed earlier, there is an important difference between renewable energy generation and renewable energy sources, and therefore an understanding of current capacity can only act as a partial guide to the local resources for some technologies. For example a large number of biomass installations cannot be directly related to the potential resource.

4.2 Current and planned renewable energy installations in the East of England

Information on current and planned renewable energy capacity has been obtained from a range of sources detailed in Appendix 1. In addition to this a literature study has been carried out to review the total installed capacity of the renewable installations in the region. The sources include East of England Renewables Energy Statistics[5] and statistical data provided by DECC[6]. Reviewing the literature and the region–wide studies has provided a comparison with the data that has been collated from various other sources.

The tables included in this section summarise the current installations in the region. They only include installations which are currently operational, in construction, or have planning consent. All of the information relates to electricity producing renewables – due to the data sources and the monitoring data available, heat production is not recorded.

The tables show that the current capacity for renewable and low carbon energy generation is slightly less than 830 MWe (MW electric). Around 480 MW of this capacity is currently in operation and more than 200 MW has consent and/or is awaiting construction, and therefore likely to be in operation in the near future.

Existing installations in the region are plotted in Figure 6.

During the compilation of the data, inconsistencies between different datasets were noted. Discrepancies were observed for some of the matching installations, for example, different capacities. In addition to this, the list is not thought to be exhaustive and a small number of number installations may not appear on the list, particularly for small scale technologies.

[5] East of England Renewable Energy Statistics by Renewables East, December 2009
[6] https://restats.decc.gov.uk/...2009/Regional-2009/Regional-spreadsheets-2003-2009-installed-capacity-MW.xls accessed in March 2011.

Figure 6. Existing and consented installations in the region.

Table 3. Summary of capacity of renewable installations in operation, under construction or with planning consent. 2011.

	Total capacity	Operational	Under Construction	Awaiting Construction
Dedicated biomass	199.0	126.4	4.5	68.1
Landfill Gas	150.1	146.7	0.0	3.4
Sewage gas	27.2	27.2	0.0	0.0
Municipal and Industrial Waste	110.8	0.0	0.0	110.8
Photovoltaics	5.0	0.0	0.0	5.0
Wind	330.6	181.0	0.0	149.6
Hydro	0.04	0.02	0.0	0.02
Total	822.7	481.3	4.5	221

Table 4. Summary of capacity by County showing distribution across the region. 2011.

Capacity by County (MW)	Total capacity	Dedicated biomass	Landfill Gas	Sewage gas	Wind	Hydro	Municipal and Industrial Waste	Photo-voltaics
Essex	180.0	61.8	66.3	3.4	20.7	0.00	27.8	0.0
Hertfordshire	33.7	9.3	9.4	14.8	0.2	0.00	0.0	0.0
Bedfordshire	63.3	17.3	40.4	5.6	0.0	0.02	0.0	0.0
Cambridgeshire	338.4	44.0	12.5	3.4	195.5	0.01	83.0	0.0
Norfolk	143.6	42.0	10.8	0.0	85.9	0.01	0.0	5.0
Suffolk	62.2	23.2	10.7	0.0	28.3	0.00	0.0	0.0
Total	821.2	197.5	150.1	27.2	330.6	0.04	110.8	5.0

Table 5.Energy generation by technology and status (GWh per year), 2011

Annual energy generation by technology and status (GWh)	Total generation	Operational	Under Construction	Awaiting Construction
Dedicated biomass	1,395	887	32	477
Landfill Gas	789	772	0	18
Sewage gas	102	102	0	0
Municipal and Industrial Waste	418	0	0	418
Photovoltaics	4	0	0	4
Wind	869	476	0	393
Hydro	0 (0.1)	0 (0.1)	0	0
Total	3,156	2,236	32	888

Table 6. Energy generation by County showing distribution across the region (GWh per year), 2011

Annual energy generation by county (GWh)	**Total generation**	**Dedicated biomass**	**Landfill Gas**	**Sewage gas**	**Wind**	**Hydro**	**Municipal and Industrial Waste**	**Photo-voltaics**
Essex	849.2	433.3	348.6	12.8	54.4	0.0	194.9	0.0
Hertfordshire	171.0	65.2	49.4	55.8	0.6	0.0	0.0	0.0
Bedfordshire	354.8	121.2	212.7	20.9	0.0	0.1	0.0	0.0
Cambridgeshire	901.2	308.5	65.7	12.8	514.1	0.0	582.0	0.0
Norfolk	576.5	294.2	56.5	0.0	225.7	0.0	0.0	4.4
Suffolk	293.2	162.3	56.5	0.0	74.4	0.0	0.0	0.0
Total	3145.9	1384.7	789.4	102.3	869.2	0.1	776.9	4.4

Currently the highest installed capacity shown in Table 3 is from wind turbine installations and this is closely followed by biomass, landfill gas and energy from waste applications. Around half of the total wind capacity is awaiting construction and so the current installed capacity is likely to double in the next few years to around 330 MWe.

The capacity of technologies is not necessarily proportional to the energy produced and the outputs from the technologies show a different hierarchy. Figure 7 shows the split of predicted total energy generation for all the technologies at operational, in construction, or with planning consent.

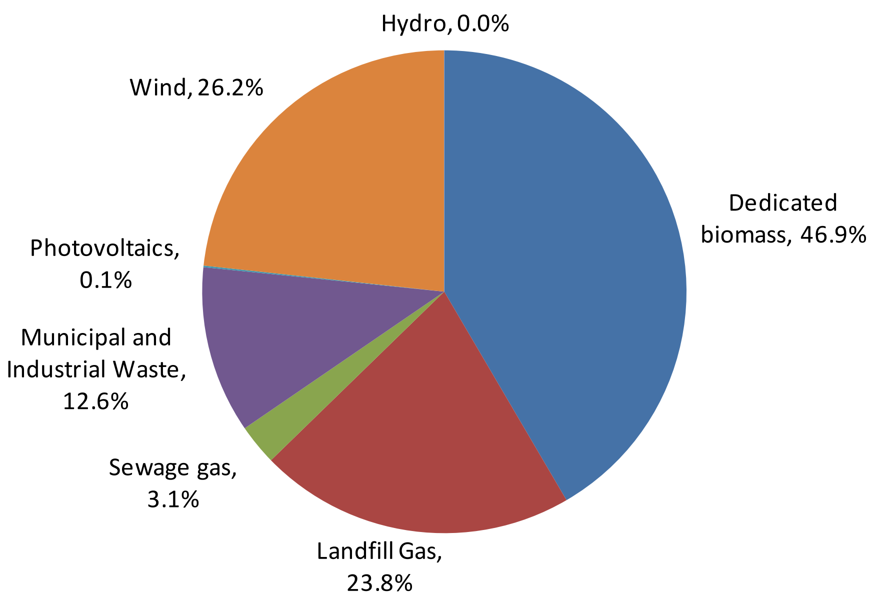

Figure 7. Annual energy production from each technology / resource across the region for systems currently operational, in construction, or with planning consent. The total annual generation is 3314 GWh.

The current energy generation from operational plants is estimated at 2,394 GWh which represents 2.5% of the total regional energy demand (excluding transportation). If the in-construction and consented capacity is included, then this rises to 3.4% of the total regional demand or 3.3 % of the predicted 2020 energy demand. However when only the electricity use is taken into account, the total renewable energy generation in the region meets around 10.6 % of the total predicted 2020 electricity demand.

These results show that the region is currently a long way off the regional targets for 2015 of 16% and for 2020 of 20%, even with the inclusion of all capacity which is currently in construction or with planning consent.

The data in this report has been checked against the figures published in the East of England Plan which state that 7% of electricity contribution is from the current installations. Therefore the figures appear to be consistent, allowing for some interim growth since the Plan's publication.

4.3 Comparison with other regions

This section presents a brief comparison of the EoE with other English regions. It examines both the current capacity of renewable technologies and resources, and also a high level appraisal of the resource availability.

From a resource perspective, the following observations can be made about the EoE:

- **Wind.** The wind speeds across the EoE are relatively low, due to its position on the east coast combined with low altitude. This may suggest the region has a poor resource. However the extensive rural areas combined with flat topology provides both large areas suitable for turbines and a reliable wind resource. The region therefore is suitable for wind generation and has a relatively large installed capacity.
- **Hydro.** The low lying nature of the region means that there is very little head height across the river system. Whilst there are a number of sites which may be suitable for hydro generation (and there are historically many sites where hydro power has been used in the past for milling), the capacity at these sites is low and the overall resource potential is likely to be very small.
- **Biomass.** The region has low levels of managed forestry when compared to other English regions, with a large amount of land used for intensive food production. This means that the regional resource of biomass is likely to be limited. However this does not limit the potential for generation from biomass with imported fuels.
- **Solar.** The levels of insulation across the UK are relatively uniform and there is no reason to suggest that the EoE should be any different to other regions in terms of resource. However the capacity of the region to accommodate solar arrays (land availability for commercial scale PV, and number of buildings for solar thermal or small scale PV) could influence the relative resource availability.
- **Waste.** Municipal Solid Waste (MSW) and Commercial & Industrial Waste is closely linked to population and commercial activity and so the region is not likely to differ significantly from other regions. Agricultural waste may show a greater potential in the EoE due to extensive farming, in particular food production and processing.
- **Heat Pumps.** Heat pumps are limited by available heat demand and so the region is unlikely to differ significantly from others from a resource perspective.

From this brief review, there are no particularly unusual features about the EoE and most resources apart from hydro are probably fairly typical when compared with other regions. However there are no resources which indicate an unusually high potential either.

Figure 8 shows a report of annual energy generation from the DECC RESTATS database for 2009. This demonstrates that out of all the English Regions, the EoE was producing the largest amount of renewable energy in 2009, with an output of around 2,100 GWh. Two technologies in particular support this position, wind, and landfill gas. The EoE has third largest output from wind turbines, after the North West, and the East Midlands (which predominantly has wind capacity on the eastern side adjacent to the EoE). There could be a number of reasons for the high levels of landfill gas including the population of the region, imports of waste from other areas, and the overall nature of waste management in the region compared with others.

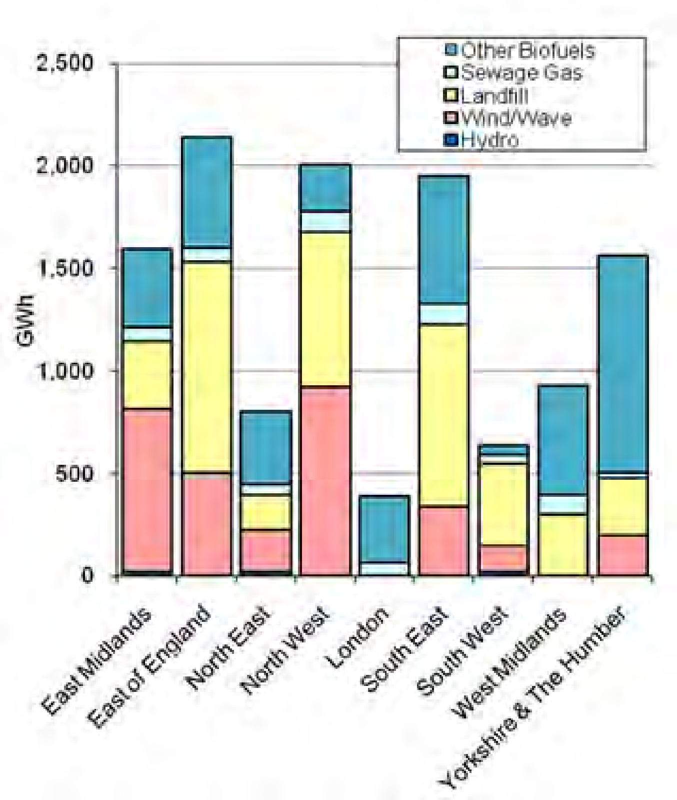

Figure 8. Energy generation (GWh) for each of the English regions in 2009. (Source – RESTATS).

The rapid development of technology means that the RESTATS extract from 2009 is likely to be out of date, and the current EoE output of 2,400 GWH shows that there has been over a 10% increase in output since 2009. This means that the present regional comparison may be different to the figures presented above. One purpose of this report is to provide up-to date statistics for DECC which can then be used for current comparisons between regions.

4.4 Summary of current capacity

This review of current capacity can act as a guide to the levels of resource, and the technical potential for the EoE, showing which resources and technologies are currently performing well. A review of recent datasets of installations suggests that the current renewable energy output is around 2,400 GWh per year with another 900 GWh either in construction or with planning consent. The installed capacity represents an increase in 300 GWh from the 2009 RESTATS database value for the region.

Whilst the largest installed capacity is represented by wind turbines, energy generation from biomass represents the largest energy output. This is due to the high capacity factors of biomass power stations providing a relatively consistent level of output. The EoE region has a number of relatively large biomass installations including the 38MW straw power station in Ely, and a 38.5MW chicken litter plant in Thetford.

Data showing sites with planning consent can provide a guide to the uptake of different technologies. The largest uptake is predicted to be for energy from waste with 110 MW currently consented and awaiting construction. The data suggests that there is currently zero installed capacity. Consents for wind farms at around 150MW represent an 80% increase on current capacity demonstrating a strong commercial interest for wind development in the region, and that a useful wind resource is accessible.

5 Low Carbon Energy Generation Potential

5.1 Introduction

Low carbon energy generating technologies are defined here as technologies that maximise the use of non-renewable energy sources by generating both heat and electricity simultaneously. Gas fired Combined Heat and Power (CHP) is currently the most common method of generating both heat and electricity from a non-renewable energy source (usually natural gas). Electricity generated by gas CHP can be used directly in a nearby site or exported to the local electricity grid. Heat generated by gas CHP can be transported for use in other buildings via water carried in a network of well insulated buried pipes, more commonly known as District Heating (DH).

5.2 Heat density demand mapping the East of England

Heat demand density in the EoE has been mapped to identify locations with high heat demand and high heat density which may be suitable for DH and CHP. The methodology for developing the heat demand density maps is outlined below and further details of the heat mapping process are provided in Appendix 1

5.2.1 Estimating heat demand for the East of England

To estimate heat demand, data on gas consumption (for both domestic and non-domestic uses) and Economy 7 electricity consumption (domestic uses only) at MLSOA[7] (Middle Layer Super Output Area) has been used. It has been assumed that all Economy 7 electricity consumption is used for the purpose of providing heat to dwellings.

The heat demand has then been calculated based on the assumption that gas boilers[8] are used to convert the gas into heat and that Economy 7 electricity use is converted directly into heat via the use of electric heating[9].

5.2.2 Converting heat demand to heat demand density

In order to convert from heat demand to heat demand density, the annual heat demand in an MLSOA is divided by the area of that MLSOA. This gives an average power density expressed as kW / km^2.

5.2.3 Plotting of heat demand density base maps

The heat demand density base maps produced for the EoE have been plotted at two scales – MLSOA and OA (Output Area)[10] scale. OAs are smaller than MLSOAs and OA data provides a higher resolution than the MLSOA level data. However as the full dataset that allows the heat demand for the EoE to be estimated as in Section 0 above is only available at MLSOA level, it has been necessary to make a number of assumptions to allocate the heat demand within each MLSOA to the smaller OAs that it contains.

The assumptions are as follows:

1. Domestic heat demand has been allocated to each OA based on the proportion of dwellings contained in that OA compared to the entire MLSOA in which it is situated, based on 2001 Census data.

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[7] MLSOA are statistical geographies developed by the Office for National Statistics (ONS) as part of the 2001 census. MLSOA 2008 figures as published by DECC (http://www.decc.gov.uk/en/content/cms/statistics/regional/mlsoa_llsoa/mlsoa_2009/mlsoa_2009.aspx) have been used as it is the most recent complete dataset available for domestic and non domestic gas consumption and Economy 7 domestic electricity consumption for the East of England.

[8] A gas boiler efficiency of 80% has been assumed for both domestic and non-domestic sectors

[9] An electric heater efficiency of 100% has been assumed

[10] The 2001 Area Classification of output areas is used to group together geographic areas according to key characteristics common to the population in that grouping. These groupings are called clusters, and are derived using 2001 population census data. This is a new classification produced using the same principles but a different statistical methodology from that used to produce the other area classifications. http://www.statistics.gov.uk/about/methodology_by_theme/area_classification/oa/default.asp

2. Non-domestic heat demand has been allocated to each OA based on the proportion of non-domestic building areas contained in that OA compared to the entire MLSOA in which it is situated, based on 2005 Generalised Land Use Database Statistics for England 2005[11].
3. As for MLSOA scale, heat density has been calculated by dividing total heat domestic and non-domestic heat demand in each OA by the area of the OA.

5.2.4 Plotting of OA scale heat demand density maps to identify areas which may have potential for CHP

DH in existing development is suited to areas of high heat density where a large amount of heat can be distributed over a relatively small amount of network infrastructure. This typically limits schemes to high density areas representing industrial areas or dense urban areas.

The viability of DH heat networks and CHP in new development differs from existing areas as the level of heat demand in new buildings is typically much lower as the Building Regulations ensure improvements in thermal efficiency. However the high standards required by CO_2 emissions regulations means that alternative lower cost options may not be available and the economic basis for selecting CHP and DH is significantly different.

The potential for DH powered by CHP can be assessed at a high level by setting a threshold heat density above which schemes become viable. Previous research into the economics of DH and CHP has suggested that a threshold of around 3,000 kW/km^2 can give financial returns of approximately 6%, which is below typical commercial rates of return but greater than the discount rate applied to public sector financial appraisal.[12]

An OA scale heat density map showing areas with a heat density greater than 3,000 kW/ km^2 has been plotted to show areas that may be suitable for DH and CHP in the EoE, shown in Figure 11.

5.2.5 Plotting of OA scale heat demand density maps to identify potential anchor loads and heat sources

Anchor loads which could act as a baseload for a DH scheme include buildings with a significant annual heat demand. Examples could include hospitals, leisure centres with swimming pools, local authority buildings and large industrial sites. For this study, the anchor loads that have been plotted are buildings that have an annual heat demand greater than 1,500 MWh.

Heat sources may be able to provide heat to a DH network. Heat sources are assumed to be existing (or under construction) CHP or electricity generating plant with an installed capacity greater than 1MWe. Heat sources meeting these criteria have been plotted. Potential anchor loads and heat sources are plotted in Figure 12.

The heat density demand maps for the EoE region are shown on the following pages. Table 7 provides a summary of the maps plotted. The OA heat density demand base map provides a higher resolution than the MLSOA map, and therefore subsequent maps are shown at OA level.

Table 7. Summary of heat density maps plotted

Type of heat density map plotted	Purpose	Scale plotted	Figure number
Heat density base map	Show heat density in East of England	MLSOA & OA	Figure 9 & Figure 10
Heat density greater than 3,000 kW/ km^2	Show areas which may have potential for CHP powered District Heating	OA	Figure 11
Heat density greater than 3,000 kW/ km^2 with anchor loads and heat sources plotted	Show areas which may have potential for CHP powered District Heating on the same map with potential heat sources	OA	Figure 12

[11] Published by the Department for Communities and Local Government
[12] The potential and costs of district heating networks (Faber Maunsell & Poyry, April 2009)

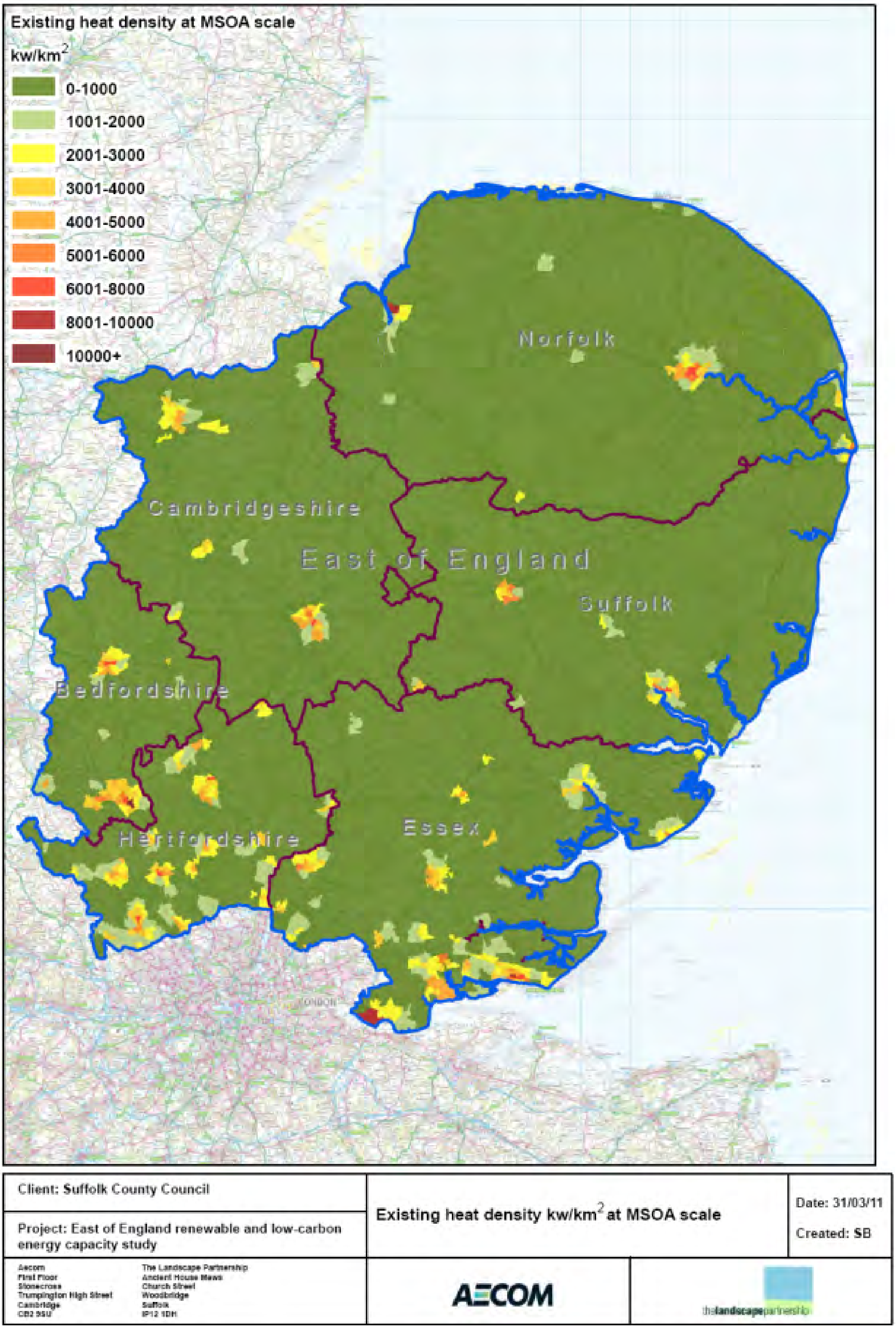


Figure 9. Heat density base map for East of England at Middle Layer Super Output Area (MLSOA) scale.

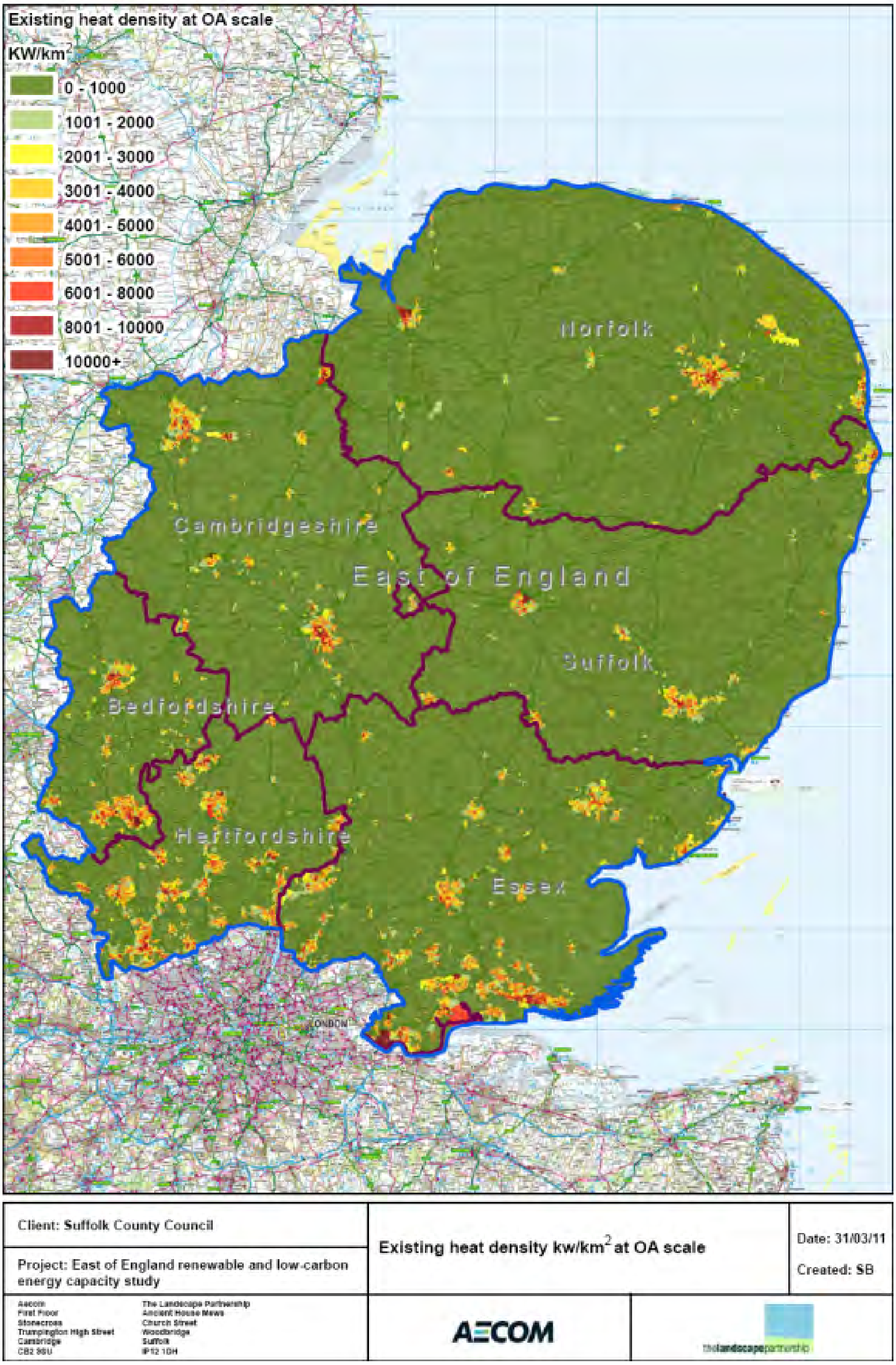
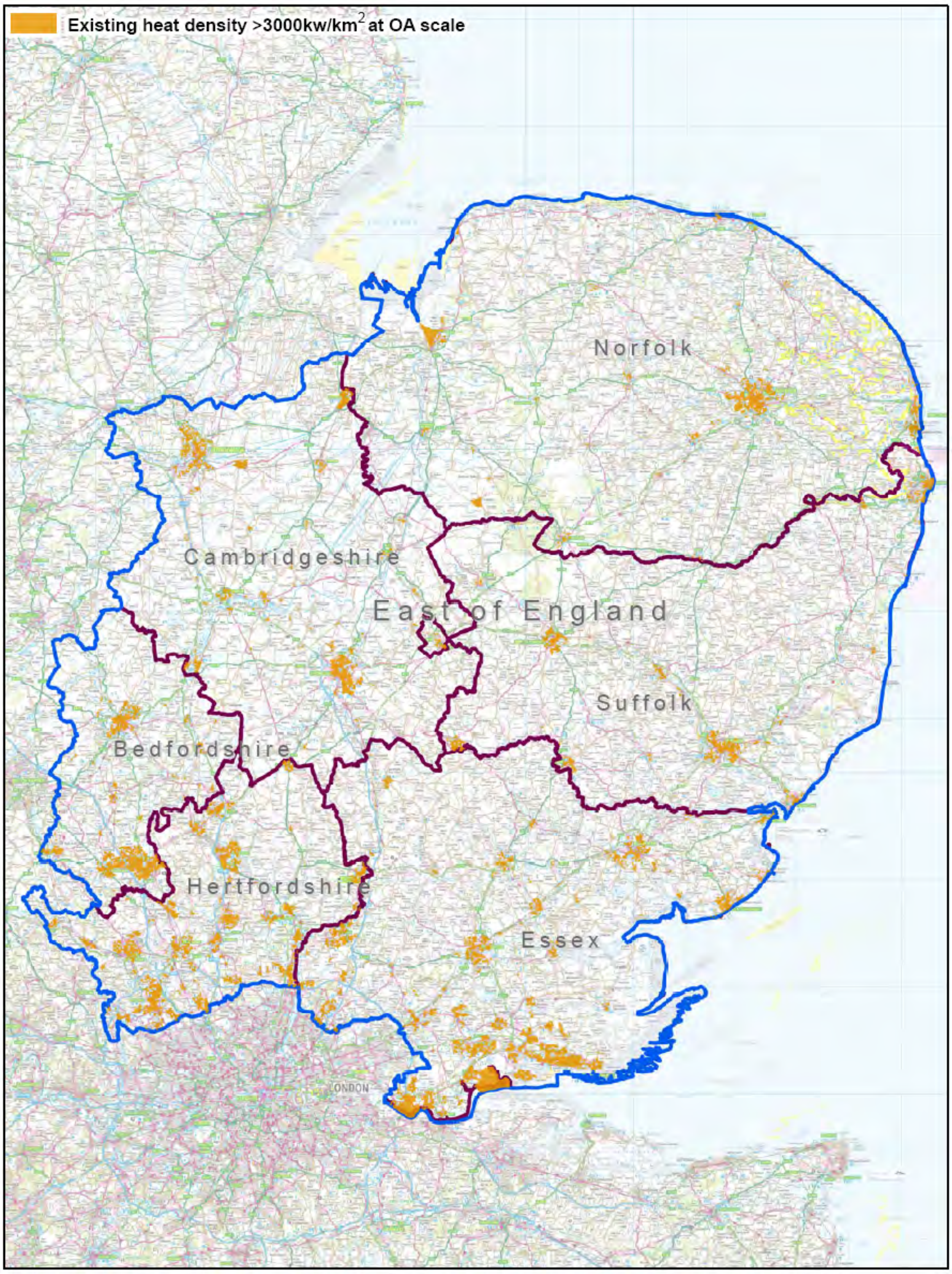
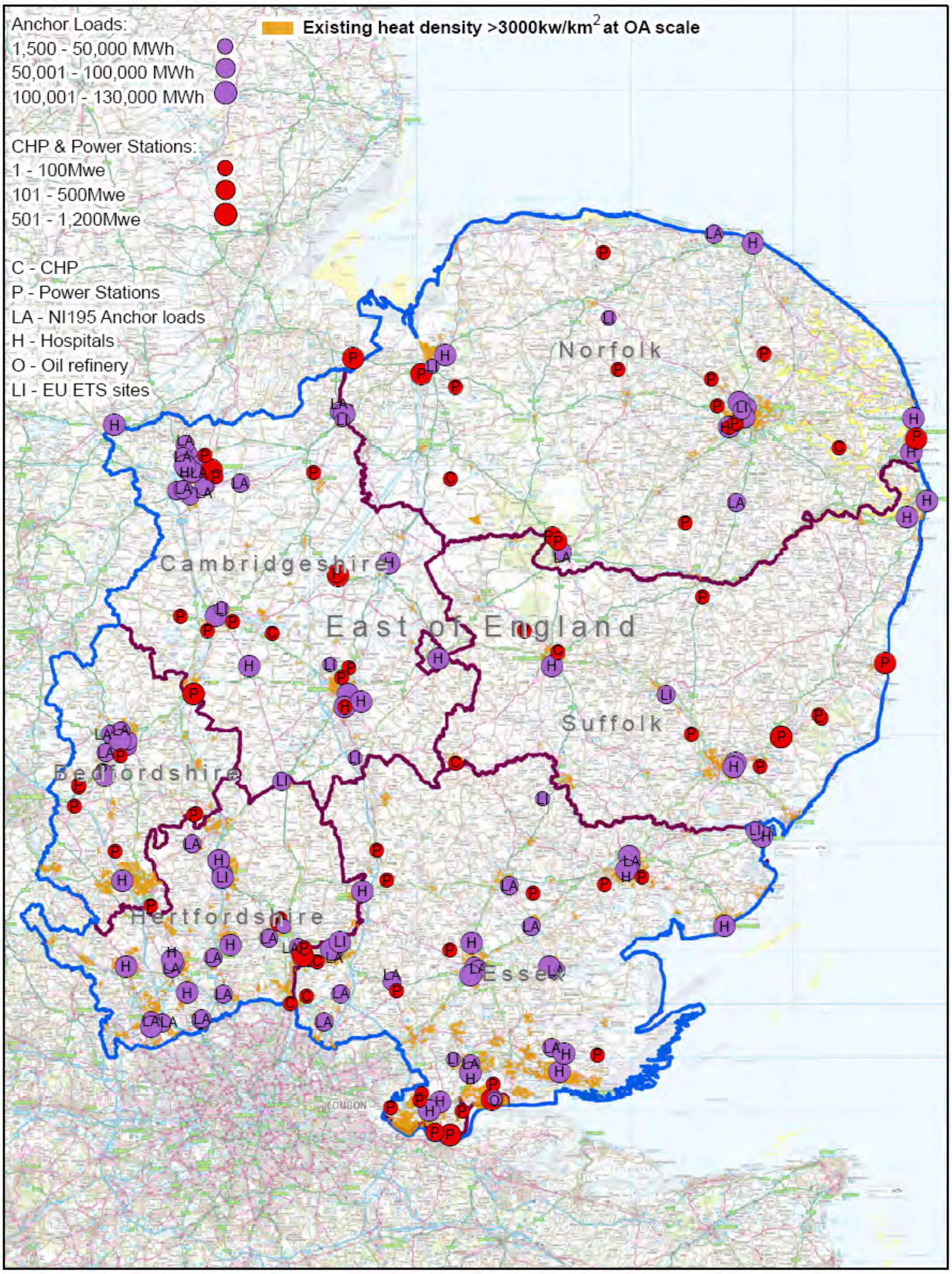


Figure 10. Heat density base map for East of England at Output Area (OA) scale.



Client: **Suffolk County Council**	Existing heat density >3000 kw/km^2 at OA scale	Date: 31/03/11
Project: East of England renewable and low-carbon energy capacity study		Created: SB
Aecom First Floor Stonecross Trumpington High Street Cambridge CB2 8SU The Landscape Partnership Ancient House Mews Church Street Woodbridge Suffolk IP12 1DH	AECOM	thelandscapepartnership

Figure 11. Heat density greater than 3,000 kW/ km^2



Client: Suffolk County Council	Existing heat density >3000 kW/km^2 at OA scale	Date: 31/03/11
Project: East of England renewable and low-carbon energy capacity study		Created: SB
Aecom, First Floor, Stonecross, Trumpington High Street, Cambridge, CB2 8SU — The Landscape Partnership, Ancient House Mews, Church Street, Woodbridge, Suffolk, IP12 1DH	AECOM	the landscape partnership

Figure 12. Heat density greater than 3,000 kW/ km^2 plus anchor loads and heat sources

5.3 Existing CHP and decentralised energy infrastructure

Existing CHP installations in the EoE as of March 2011 are shown in Table 8. This information was been obtained from the DECC CHP database[13] and the NHS Hospital Estates and Statistics CHP database for 2009/10[14].

The only known DH scheme in the EoE is located on the University of East Anglia Plain Campus in Norwich.

The total capacity identified is 231.2 MW, of which 184 MW is from the two industrial installations at the British Sugar plants in Wissington and Bury St Edmunds.

Table 8. Existing CHP installations in the East of England

CHP Site Name	CHP Post Code	Capacity, MWe
JOHNSON MATTHEY - ROYSTON	SG8 5HE	5.8
BURY ST EDMUNDS SUGAR FACTORY (CHP 2)	IP32 7BB	90
CANTLEY SUGAR FACTORY	NR13 3ST	15
WISSINGTON SUGAR FACTORY, BRITISH SUGAR PLC (CHP 2)	PE33 9QG	94
CRISP MALTINGS RYBURGH	NR21 7AS	1.2
FEN DRAYTON, STUBBINS MARKETING (CHP 2)	CB4 5SS	3.1
WALTHAM ABBEY, STUBBINS MARKETING	EN8 7LY	3.1
TOWER NURSERY, UK SALADS	CM19 5JP	3.1
VILLA NURSERIES	CM19 5LE	3.1
ABBEY VIEW	EN9 2AG	3.1
GENZYME - HAVERHILL	CB9 8PB	1.4
ADDENBROOKES HOSPITAL	CB2 2QQ	4.2
UNIVERSITY OF EAST ANGLIA (PLAIN CAMPUS)	NR4 7TJ	3.1
NORFOLK AND NORWICH UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	NR47UY	1.0

5.4 The potential for DH networks and CHP – cluster analysis.

It should be noted that the discussion around viability presented here is very high level, and all potential CHP and DH schemes should be assessed on a case by case basis, taking into account local conditions in terms of the number, size and type of heat users, and delivery mechanisms and financing. For this reason, the viability level of 3,000 kW/ km^2 should be used as a first level pass and the actual level may fall below or above this, with potentially large implications on the overall viable heat loads.

At lower heat densities, the overall level of heat demand which may be suitable for DH and CHP is extremely sensitive to the viability level. For example, for a threshold level of greater than 3,000 kW/km^2 per year of heat demand, DH is estimated to be viable for 50% (100%-50%) of existing building heat demand, but this reduces to about 25% (100-75%) of heat demand if the viability level is 5000 kW / km^2 or greater. At the higher viability levels (essentially the heavily urbanised areas) there is less sensitivity to the threshold viability level.

[13] http://chp.decc.gov.uk/app/reporting/index/viewtable/token/2

[14] http://www.hefs.ic.nhs.uk/ReportFilterConfirm.asp?FilterOpen=&Year=2009%2F2010&Level=S&Section=S06&SHA=&Org_Type=&Foundation=&Site_Type=&PFI=&getReport=Get+Report

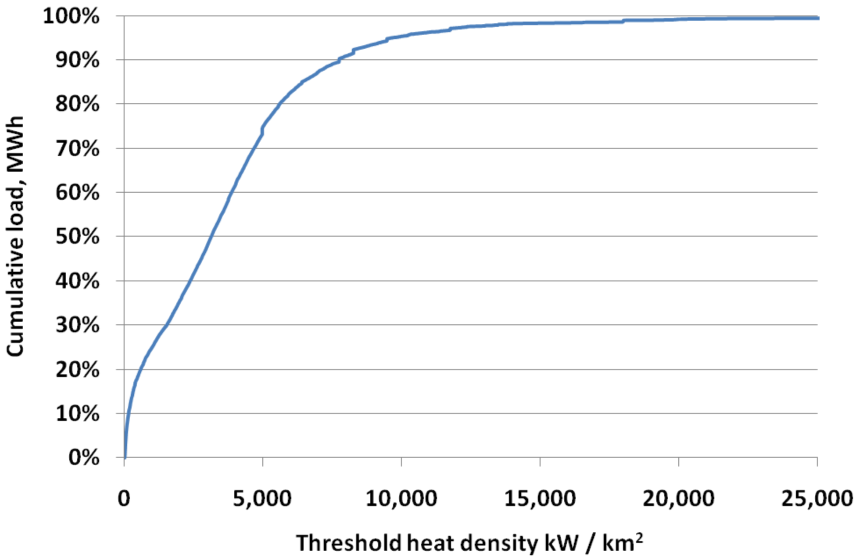


Figure 13 shows the sensitivity of the heat demand that could be met by CHP according to the assumed heat density threshold. The gradient of the curve provides an indication to the sensitivity; a steep gradient indicates a high level of sensitivity because a small change in threshold density provides a large change in heat load, whilst a low gradient indicates low sensitivity. The low gradient area of the curve above 10,000 kW / km^2 represents about 5% of the total demand and probably represents dense town and city centres and industrial areas.

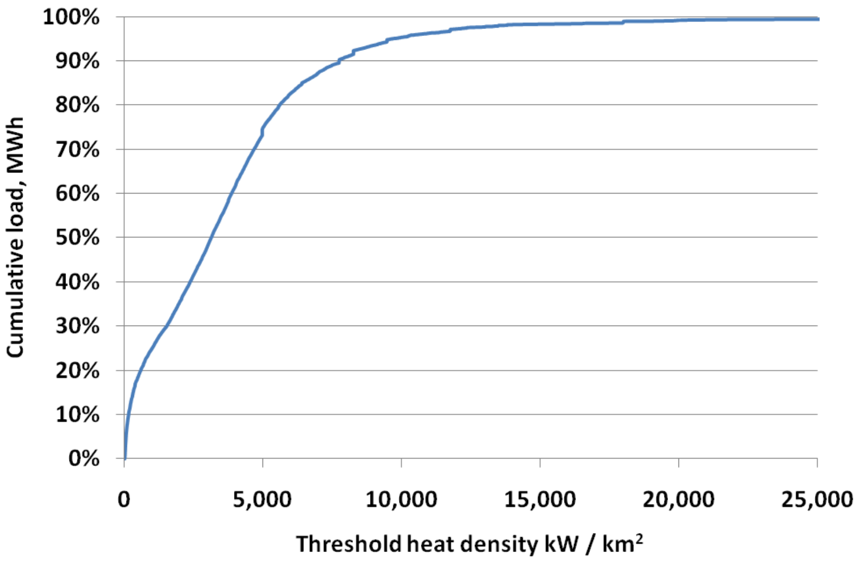


Figure 13. Sensitivity chart showing relation of overall heat load in the East of England to the viability level for DH / CHP. The chart can be used to read off the total heat load which falls above a threshold density level. For example, if the threshold density is 5,000 kW / km^2 then a total of 25% of the total heat load falls above this and may be viable for DH / CHP.

The heat density can be used to assess the potential for CHP and DH in the EoE, but as discussed above, it is important to consider the sensitivity of this capacity to the viability level. Table 9 shows the potential capacity of CHP, and corresponding CO_2 savings (assuming gas engine CHP) for different threshold levels.

Table 9. Potential installed capacity and CO_2 reduction from CHP depending on threshold assumed

Threshold density kW / km^2	Total CO_2 reduction across region, tonnes/yr	Capacity MWth	Capacity MWe
1,000	2,390	2,473	1533
2,000	2,054	2,147	1331
3,000	1,652	1,694	1051
4,000	1,220	1,173	727
5,000	798	727	451
6,000	552	459	285
7,000	403	312	194
8,000	291	170	105
9,000	207	119	74
10,000	150	79	49

The data in Table 9 shows that at a threshold of 3,000 kW / km^2, there is a potential CHP capacity of around 1,050 MWe, or approximately 4.5 times the current installed capacity. However with increased threshold density, the potential capacity reduces.

5.5 Summary

The heat density demand maps showing areas with heat density greater than 3,000 kW/km^2 and potential heat sources can be used as a guide to choosing sites for considering the installation of a District Heating (DH) network. These maps can be used to locate areas where there is a high heat density, and then identify potential anchor loads or sources of heat for use on a scheme. The Output Area (OA) resolution of the maps is sufficient for use in local authority evidence bases. One advantage of using Output Areas as a basis is that they are linked to population and are generally smaller in areas of high heat density and provide a greater resolution in areas of interest.

The current CHP capacity in the region is around 230 MWe, dominated by systems at the two British Sugar plants of 90 and 94 MW. The sensitivity analysis shows that the total potential capacity could be around 1,050 MWe at a threshold level of 3,000 kW / km^2 base on some simple uptake assumptions, although this is reduced if the threshold is higher.

It should be noted that these maps can be used for the identification of potential schemes, but that detailed feasibility studies would be required on a case by case basis to determine whether a district heat network is viable for a given area.

6 Renewable Potential – Wind Energy

6.1 Introduction

Wind turbines convert the energy contained in wind into electricity. Commercial-scale, free standing turbines have the potential to generate significant amounts of renewable energy. This section describes the EoE potential for renewable energy generation from large scale, onshore wind turbines. The potential for offshore wind energy generation is not included in the scope of this study. However offshore wind generation will form an important part of the overall UK renewable energy mix.

6.2 Methodology

The DECC methodology suggests that wind speeds of 5 m/s and above are potentially sufficient for wind turbine installations. Wind speed mapping of the EoE shows average speeds of 5.5 to 7+ m/s at 45m height throughout the region, according to the UK Wind Speed Database (Figure 14), which demonstrates that from a wind speed perspective, the entire region has a suitable resource. Although the wind speed is likely to be slightly higher at the heights of large scale turbines (typically 80-100m hub height) the wind speed data has not been altered to reflect this and hence provides a conservative view.

There are a number of constraints on the location of wind turbine developments due to physical, environmental, and technical restrictions. Therefore a constraint analysis has been carried out to estimate the practical available resource. Full details of the methodology are provided in Appendix 1.

6.3 Constraints analysis

Geographical information systems (GIS) mapping of the physical constraints to wind turbine development within the region has been carried out to identify areas where large scale wind energy generation may be feasible, based on a wind turbine with a 100m rotor diameter and 135m tip height. A tier of sequential constraints has been applied. The first tier named as “hard” constraints represents only the physical constraints such as roads, railways, inland waters, woodlands and the buffer zones applied to these physical constraints where turbines cannot be physically installed. The second tier named as “soft” constraints goes further and takes into account environmentally and historically sensitive locations including Ancient Woodlands and Areas of Outstanding Natural Beauty (AONBs).These are areas where turbines could be physically installed, but where other factors may prevent installation. A final layer has been introduced to represent the further considerations. These are less tangible than the previous two tiers and therefore called ‘considerations’ rather than constraints. Examples of these considerations include National Parks, heritage coasts and bridle ways, and whilst they may present a constraint, this will need to be assessed on a case by case basis. A full list of constraints can be found in the methodology in Appendix 1.

There are no official guidelines on whether wind turbines should be permitted or not when located in areas that are subject to the soft constraints and further considerations and decisions are taken as part of local planning. It is recommended that the potential impacts of wind turbines are considered on a case by case basis for each location. If these constraints are not considered in this way, then the potential for wind may be unnecessarily limited.

Figure 15 and Figure 16 show some results from the constraints mapping, showing consecutively the hard constraints, then the addition of soft constraints. It is clear how the soft constraint “buffer zones” around settlements significantly reduce the available area for wind turbine development and all potential wind developments should consider whether smaller buffer zones are adequate.

Figure 14. Map of wind speeds across the EoE region based on the UK Windspeed database.

Figure 15. Assessment of hard constraints to wind turbine development.

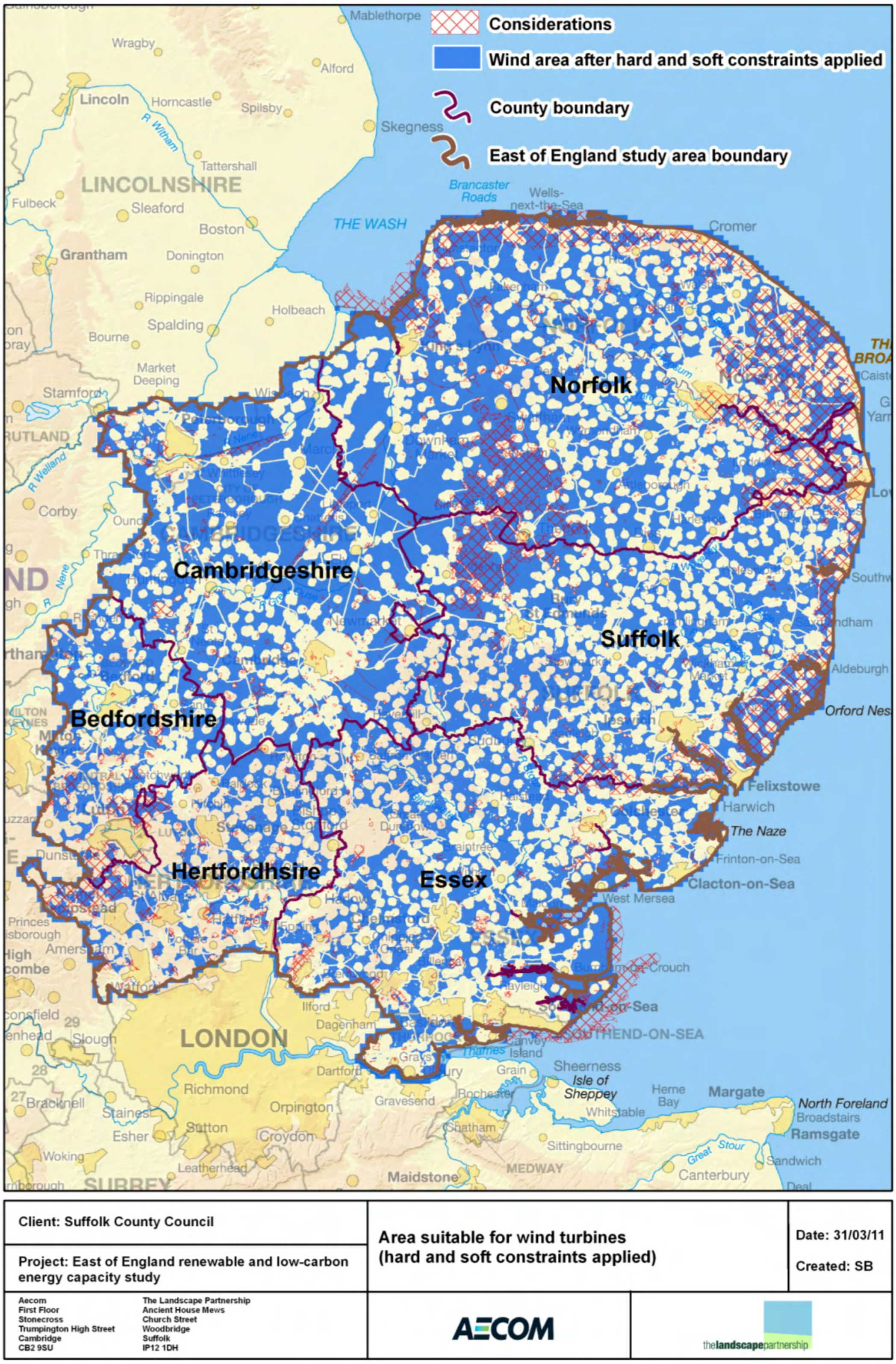


Figure 16. Assessment of hard and soft constraints to wind turbine development. Further considerations are also indicated for information but should not be considered a definite constraint.

6.4 Potential resource

A summary of the total accessible potential resource is presented in the tables below. In line with the methodology three separate analyses have been carried out taking into account the constraints of hard, soft and further considerations.

Table 10. Potential wind resource for each county by capacity (MW)

County	***Opportunity Assessment - Hard Constraints (MW)***	***Opportunity Assessment - Soft (hard and soft) Constraints (MW)***	***Opportunity Assessment - consideration (hard and soft and consideration) Constraints (MW)***
Essex	26,260	14,769	12,942
Hertfordshire	10,424	4,965	4,220
Bedfordshire	8,626	4,482	4,086
Cambridgeshire	25,342	17,328	16,750
Norfolk	41,902	25,990	18,534
Suffolk	29,182	17,066	12,686
Total	**141,736**	**84,599**	**69,218**

Table 11. Potential wind resource for each county by energy generation (GWh)

County	***Opportunity Assessment - Hard Constraints (GWh)***	***Opportunity Assessment -soft (hard and soft) Constraints (GWh)***	***Opportunity Assessment - consideration (hard and soft and consideration) Constraints (GWh)***
Essex	69,051	38,835	34,030
Hertfordshire	27,410	13,056	11,095
Bedfordshire	22,683	11,784	10,745
Cambridgeshire	66,636	45,563	44,045
Norfolk	110,181	68,340	48,736
Suffolk	76,734	44,875	33,358
Total	**372,695**	**222,453**	**182,009**

The constraints analysis identifies a total potential capacity of 84,599 MW after the hard and soft constraints have been taken into account. This assumes a uniform turbine density of 9 MW per km^2 (approximately 3 turbines per km^2) with no consideration of landscape impact or cumulative impact. If it is assumed that on average due to landscape impact and cumulative impact only 1 in 10 of viable areas is suitable for turbines, then the practical achievable resource is 8,460 MW.

6.5 Potential uptake by 2020

The uptake of wind generation to 2020 will not only depend on the level of constraints in the region, but also on the economics of generation, the ability of the supply chains to deliver, and the planning consent process. In line with the approach taken by this report to understand the scale of potential possible, it is considered that 10% of the total potential for wind is achieved by 2020 (at present only 2.1% has been achieved, or 4.0% if turbines in construction or with planning consent are included). This 10% is equivalent of 846 MW capacity and it represents almost five times the current capacity which appears to be a reasonable assumption for the potential uptake by 2020. Achieving 10% of the resource potential will provide 2,225 GWh per year, or 2.2% of the projected 2020 energy demand. If the consideration constraints restrict the potential further, then this achievable potential will be reduced.

7 Renewable Potential – Biomass Energy

7.1 Introduction

Biomass is a collective term for all plant and animal material. It is normally considered to be a renewable fuel, as the CO_2 emitted during combustion is assumed to be absorbed by plants or trees that are grown following cultivation of the crop. The DECC Methodology considers animal material as ‘biomass’ but for the purposes of this study we have assessed animal material as wet and dry waste rather than biomass. Most CO_2 associated with the use of biomass fuels is due to the processing and transportation stages, which typically rely on grid electricity and fossil fuels. Liquid biomass fuels are not considered in this study as they are assumed to be more applicable to the transport sector in the form of bio-diesel and bio-ethanol.

7.2 Existing biomass capacity

There is a number of operational biomass power schemes in the region. Examples of the large scale installations include:

- The 38 MWe Ely Power Station biomass plant at Elean Business Park, in Ely, Cambridge. This plant is known as world’s largest straw power station generating over 270GWh each year[15]. The fuel demand is 200,000 tonnes annually. This includes mostly cereal straw but also oil seed rape and miscanthus.
- The 38.5MWe Thetford Power Plant in Thetford, Norfolk. It is the largest chicken litter fuelled plant in the UK. The plant consumes 420,000 tonnes of litter annually.
- The 12.7 MWe Eye Power Plant in Suffolk. The plant consumes 140,000 tonnes of chicken litter per annum.

In addition to these, there is a significant number of other schemes that have either received planning consent or are currently at the planning application stage. These include:

- A 40MWe electricity producing plant from burning waste wood in Thetford Norfolk; planning application has been submitted.
- A 60MWe Tilbury Green Power Plant; currently at the post planning stage awaiting construction currently with the projections of importing biomass fuel from Europe but with aspirations to switch to local providers after three years of operation.
- A 40 MWe Mendlesham proposed straw fired Biomass Plant in Suffolk with local straw contracts. This project is at consultation stage.

7.3 Implications of existing and planned installations:

Current and planned installations cannot be determined and are limited by the resource available within the region. This is because biomass is a transportable fuel and can therefore be imported and exported. Hence the biomass resource in the region cannot be an indication of the biomass capacity in the region. However economics of the biomass fuel may be influenced by the increased number of installations as this is likely to increase the demand for biomass. Currently incentives are not sufficient to encourage the farmers in the region to grow biofuels or sell agricultural arisings such as straw for fuel purposes. This could potentially change in the future if the economics of the biomass fuels become attractive to the farmers in the region.

[15] http://www.eprl.co.uk/assets/ely/overview.html

7.4 Methodology

This assessment is based on the regionally available feedstock and not on the potential for biomass conversion technologies which may use imported feedstock.

A GIS mapping exercise has been carried out to estimate the potential from energy crops. Agricultural Land Classification data has been extensively used as the key indication of the resource availability in the region.

For the remaining resource, including managed woodlands and agricultural arisings (straw), a number of data sources have been consulted. Hence the resolutions of these resources are mostly at regional level as the data was available at regional level only. A list of the datasets that have been used to assess the potential is shown in Appendix 1.

The potential for energy from food waste, animal manures, industrial woody waste and other types of household and commercial waste is described in Section 8.

The details of the methodology for the biomass resource analysis can be found in Appendix 1.

7.5 Potential biomass resource

7.5.1 Agricultural arisings – Straw

In this report, agricultural arisings consist of straw from the production of wheat and oilseed rape. This resource is in high demand due to other uses in the region, such as a natural fertiliser, and for animal bedding.

The resource assessment has indicated that straw availability in the region is approximately 2.8 million tonnes a year. This figure has been derived from Defra Revised Agricultural Survey Data[16]. This would be reduced to 1.4 million tonnes available for energy generation, after allowing for 50% of the resource being left on the fields for fertiliser or used as bedding for the cattle in the region (whichever is the minimum) as per the DECC methodology. The remaining resource could in theory support 432 MWe of installed generation capacity.

However consultation with steering group members, Natural England and reviewed literature[17] suggest that this theoretical resource is mostly used up by local farmers as fertilisers or bedding material for animals and consequently there are not large resources of un-used waste straw in the region. Previous discussions with EPR Limited have also highlighted the difficulties in obtaining straw and the limited resource available due to competing uses. Hence currently there is in reality very little resource in the region. For these reasons the practical viable resource has been estimated to be 10% of this available resource. This is equivalent to 43 MWe of installed capacity and approximately 300 GWh electrical energy generation annually.

The straw power station owned by EPR at Ely is 38MW and so it can be assumed that based on a 10% availability assumption that the resource potential for the EoE has almost been achieved. Therefore the uptake by 2020 is considered to be 43 MW. This assumes that there is no change in the demands for straw over the next 9 years. In reality the availability of straw is likely to depend on the price commanded, and whilst fossil energy costs are rising (which may be favourable for straw energy generation), this will also impact upon the cost of fertiliser, and therefore maintain the current restrictions.

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[16] Revised 2009 County/Unitary Authority breakdown for Arable crops by Defra

[17] Biomass as a Renewable Energy Source Royal Commission on Environmental Pollution

7.5.2 Energy crops

A resource and constraints analysis has been carried out to estimate energy crop resource availability. Possible constraints on biomass energy crop production include the amount of land available for crop production subtracting the land allocated for food production, and the need to consider environmental and biodiversity issues.

There are only currently 320 ha of energy crops (all miscanthus) planted in the region[18], i.e. just under 0.4% of this total available resource. Lack of interest in the Energy Crops Scheme is seen as being the main reason for this very low uptake, presumably due to low economic attractiveness when compared to growing food produce.

The resource assessment showed that for the medium scenario, where energy crops are only grown on land not used for arable crops (see Appendix 1), there is the potential for planting approximately 85,000 ha of energy crops. If all of this crop were to be used for biomass electricity generation and CHP schemes, this could support an installed capacity of about 226 MWe and result in energy generation of 1,400 GWh electricity annually. This assumes water extraction restrictions prevent growth on all but 10% of the identified available land due to water stress.

The availability of water may significantly impact upon the true potential for energy crops due to the EoE being the driest and one of the most heavily farmed regions in the UK. Energy crop production tends to be water intensive and may require a higher level of water extraction than traditional food crops. This issue has been discussed with a Steering Group representative from the Environment Agency; who are responsible for issuing water extraction licenses. It was considered that if a location map of current “over committed” abstraction was overlaid onto a map of potential land for energy crops, this would show very few areas without water stress. It is therefore unlikely that the Environment Agency would be able to issue licenses for much of the land showing as potential for energy crops, meaning that the uptake could be even less than the 10% assumed for the medium scenario. The Environment Agency suggested that the most likely scenario for Energy Crops is a negligible change due to the water considerations. This scenario is used for projections in this report.

The Environment Agency is also concerned that much of Grades 3b, 4 and 5 land is grassland, and if converted to energy crops, this would impact upon water infiltration (consequently affecting water availability) and compete with livestock farming.

In general it can be concluded that the DECC methodology doesn’t allow for certain considerations, therefore although the DECC calculations may show potential for energy crops in the EoE; the reality is there is very limited availability.

For these reasons, we have considered it unlikely that there will be a significant increase in energy production from energy crops in the region. Therefore the current existing resource has been assumed to be the uptake for 2020. This could support an installed capacity of about 0.9 MWe and approximately result in 6 GWh electricity and 12 GWh thermal generation per annum.

7.5.3 Managed Woodland

Data from the Forestry Commission report has been used to assess the residual wood fuel from managed woodlands. The report suggests that in total there could be as much as 260,000 tonnes of wood fuel available from managed woodlands. This would be from both Forestry Commission and private sector woodland over 2ha in size. However this estimate is an upper limit and this figure has been constrained by the practicalities of recovering the fuel and the economic viability of the resource. It is unlikely that stemwood of 14cm in diameter or more will be available as larger sizes would tend to go into the sawn timber market where they would receive a higher price.

Therefore this estimate has been reduced to 67,000 oven dried tonnes (odt) wood fuel availability per annum consisting of thinnings and fellings from woodland and smaller scale stemwood. This could support 27 MWe and 54

[18] Based on data from the UK Government Energy Crop Scheme

MWth (MW thermal) of CHP capacity and an additional 204 MWth of boiler capacity. The annual energy generation is 847 GWh of heat and 190 GWh of electricity.

It is assumed that this level of generation could be achieved by 2020, either using a 50:50 split between CHP and boilers as assumed, or through some other conversion technology.

7.5.4 Industrial Woody Waste

Waste wood has been defined as wood that has been used “for another purpose before entering the waste stream”, i.e. it is post consumer or post industrial waste. As such forestry residues are not included in the definition of waste wood[19]. Industrial woody waste biomass consists of sawmill co-products from primary processing of timber and construction and demolition waste.

The amount of waste wood from sawmills in each local authority is estimated using information taken from Forest Research, the Forestry Commission’s Science Agency website[20], in March 2011. Primary processing co-products are understood to represent woody waste from sawmills.

The amount of waste wood from construction and demolition processes has been estimated from the WRAP Wood Waste Market in the UK Report (2009).

The available waste wood resource has been reduced by 50% to account for competing uses such as chipboard manufacture. It is assumed that waste wood would be combusted in CHP plants to generate renewable heat and electricity. A full set of assumptions are presented in Appendix 1.

The available resource of primary processing co-products in the EoE is estimated as 24,577 odt per annum. Primary processing co-products are understood to represent woody waste from sawmills. The wood waste stream available from construction and demolition in the EoE is estimated at 231,200 tonnes per year. Therefore the total currently available (in 2011) sustainable resource from industrial woody waste is estimated to be 255,777 tonnes per year.

The industrial woody waste resource in 2020 has been calculated by assuming that the quantity of industrial woody waste identified above increases by 1% per year between 2011 and 2020. This would equate to 279,740 tonnes in 2020.

The uptake in 2020 has been calculated by reducing the amount of biomass available for combustion in CHP by 50% to account for competing uses such as chipboard manufacture. Therefore the anticipated amount of industrial woody waste available for combustion in 2020 is 139,870 tonnes. This equates to approximately 47 MWth and 23 MWe, corresponding to 204 GWh of renewable heat and 163 GWh of renewable electricity.

7.6 Summary

Table 10 below summarises the total biomass resource potential in the region.

Table 12. Summary of biomass resource in the East of England showing potential capacity and generation by 2020.

Type of resource	**Uptake estimate 2020 (MWe)**	**Uptake estimate 2020 (GWhe)**	**Uptake estimate 2020 (MWth)**	**Uptake estimate 2020 (GWhth)**
Agricultural Arisings	43	303		
Energy crops	1	6	2	12
Managed Woodland	27	190	259	847
Industrial Woody Waste	23	163	47	204
Total	**94**	**662**	**308**	**1063**

[19] Waste Wood Survey for the East of England, prepared by ENVIROS on behalf of Renewables East, April 2007
[20] Forest Research, web address: http://www.eforestry.gov.uk/woodfuel/FR.do#

This study has found that the naturally available resource of some of the biomass fuels, including agricultural arisings, managed woodland, energy crops and industrial wood waste, can be substantial. However once the technical and physical availability and the financial viability has been taken into account the resource would be severely limited.

Table 12 shows a total energy generation potential of 1,725 GWh, representing 1.7% of the 2020 energy demand.

It is possible that the actual levels of energy generation which can be delivered from biomass in the region are much greater, but this may rely on importing of feedstock from other regions or countries, and therefore cannot be classed as a truly regional resource.

7.7 Biomass literature review

In parallel to the work that has been carried out in line with the DECC methodology a number of reports have been examined with regards to the regional biomass resource assessment. The purpose of this literature review is to compare the methodologies, review the data used, assumptions made; measure and compare the results and consequently enhance the vigour of this work. The DECC methodology takes a very theoretical approach and whilst providing a consistent assessment for all regions, the wealth of specialist knowledge and assessments made into biomass at a local and national scale is likely to provide a more realistic assessment of potential.

7.7.1 Waste Wood Assessment

Assessment of Biomass Fuel Feedstock Availability and Contracting Mechanisms for Northstowe[21]

This study was commissioned to undertake a biomass fuel feedstock market study for a proposed prototype ecotown of Northstowe. The study contains WID (Waste Incineration Directive) compliant waste wood assessment and this largely originates from municipal solid waste (MSW), commercial and industrial waste (CIW), and construction and demolition waste. This study provides a detailed analysis of waste wood availability in East of England and introduces discussions regarding the barriers to the potential uptake of waste wood use, incentives and policies. According to this report in the UK currently 80% of wood waste is landfilled, 16% is re-used and recycled and only 4% is being used for energy recovery amounting to 8 million tonnes of waste wood arisings ending up in landfills.

The report analysis suggests that total waste in East of England resulting from MSW, CIW and CDW are in the region of one million tonnes[22]. Of this, waste wood from MSW is approximately 36,000 tonnes which is 40% of the total produced wood waste. (This is sourced from Household Waste Recycling Centre networks). Based on this data, a total of 170,000 tonnes per annum of waste wood is available as a resource.

It is difficult to make a direct comparison as the types of waste streams studied in this report are different. Our report estimates 231,200 tonnes of wood waste stream available from construction and demolition in the EoE with a projected increases by 1% per year between 2011 and 2020. This data does not include the waste wood stream from MSW. The use of different data sources, scopes and the boundaries of the data used and significant differences in assumptions are the main reasons in discrepancy. However in line with the order of magnitude approach of this report, both the DECC methodology assessment and report assessment are similar.

Waste wood survey for the East of England[23]

Prepared by Enviros and commissioned by Renewables East this study investigates the waste wood (excluding forestry residues) potential in the region. The quantity, the source (whether it is MSW, C&I or construction and demolishing waste) and the quality of this biomass resource is explored in this report. The study is based on the

[21] Assessment of Biomass Fuel Feedstock Availability and Contracting Mechanisms for Northstowe (2009), by SLR for Renewables East
[22] on the WRAP ‘Review of wood waste arisings and management in the UK’ (June 2005)
[23] Waste wood survey for the East of England (2007), by Enviros on behalf of Renewables East

data resulting from extensive surveys with some extrapolation as it attempts to find the actual tonnages on the ground. Sawmill co-products were also taken into account.

The report establishes energy generation and panel production as being two major markets for the waste wood in the region. However the distance and thus the cost presents barriers to supply to these markets hence there may be an opportunity to recover this resource for the local biomass installed plants. Co-firing also presents an opportunity due to the changes in Waste Incineration Directive (pallets are now to be regarded as non-contaminated which accounts for 30% of all waste wood nationally).

The results of the study identified over 1.4 million tonnes of waste wood within the East of England. Of this total 51% of the arisings were from the industrial and commercial sector, 43% from construction and demolition and the remainder from the municipal sector. About 12% of this resource is Grade 4 (high content of panel products such as chipboard, MDF, plywood and fibreboard), amounting to 168,397 tonnes which was assumed to be suitable for biomass fuel. The rest had either competitive markets or was to hazardous and did not comply with the WID.

The results from this report again support the approximate levels of resource identified in this assessment of potential.

7.7.2 Managed Woodland

According to a number of sources, woodland in the UK and in East of England is largely unmanaged which theoretically presents a large potential for biomass fuel resource, since there are currently no competing uses for this resource. However unmanaged woodlands are not included in the DECC methodology or this study. There are barriers to using this resource, most importantly the fact that the woodlands are unmanaged (who will maintain the woodland and collect wood?) and that many are relatively small and distributed around the region, making the supply chain complex and expensive, unless at a very local scale.

Woodfuel in the East of England Prospects and Potential[24]

Funded by EEDA, The Countryside Agency and The Forestry Commission this report examines the potential wood resource in the region in detail. The main focus of the work is to explore the opportunities and resource potential for smaller scale biomass heating rather than large scale electricity generating plants. According to the report biomass resource due to woodlands and forestry in the region is substantially unmanaged (almost all from privately undermanaged woodland - perhaps 80% or more of the private woodlands are undermanaged) and therefore under-utilised. The report provides an indicative figure for woodfuel production capacity in the region of 205,000 tonnes per annum from undermanaged woodland resource. However the report also states that electricity generation plants could put pressure on this resource yet for smaller-scale wood heating, or possibly CHP, the resource is not likely to be limiting in the short-medium term.

The DECC assessment used in this report identifies approximately 260,000 tonnes of wood per year from managed woodland and therefore this could be almost doubled if wood could also be collected from unmanaged woodland.

7.7.3 Energy crops

The potential for energy production from energy crops in the east of England[25]

This is an MSc thesis by Stefan Laeger and a very comprehensive study exploring the energy crops potential in the region. The findings and the conclusions appear to be in line with our report; according to the study physical

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[24] Woodfuel in the East of England Prospects and Potential with special reference to the Norfolk & Suffolk Rural Priority Areas (2003), by Dr. Robert Rippengal of Anglia WoodNet Ltd for East of England Development Agency; Forestry Commission East of England Conservancy; Countryside Agency East of England Region

[25] The potential from energy Production in the East of England (2005), by Stefan Laeger, School of Environmental Sciences, University of East Anglia

potential is large (ignoring water stress issued) compared with modest economic potential and only miscanthus seems to be currently viable compared with the existing farming activities. The report estimates that miscanthus could be grown profitably on 3% to 8.9 % of the regions area. Short rotation coppice (SRC) is unlikely to be economically competitive therefore is not deemed to be viable.

Other reports describe a similar picture with a large physical resource potential but a significantly smaller realistic potential due to the economic factors. Current rise in food prices reinforces the arguments in these reports.

This land area availability is broadly in line with the assumptions made in this study. However estimates of the uptake figures in our report are limited to the existing crops as an increase is not expected in the region due to guidance from the Environment Agency on water availability restrictions. Therefore figures in our report may appear to be a lot lower than what is projected elsewhere.

7.7.4 Agricultural arisings - straw

National and regional supply/demand balance for agricultural straw in Great Britain[26]

The Central Science Laboratory in York was commissioned by the National Non-Food Crops Centre to undertake a mass balance analysis of the production and use of agricultural straw in the UK. The study estimates 1.6 million tonnes of wheat straw and close to 0.9 million tonnes of straw through other crop production (East of England figures). However the study also states "...*currently, the main reason for baling and removing straw from fields is for use in the livestock sector. Due to its relatively low bulk density, transport costs for hauling straw any significant distance are high. In the absence of nearby livestock or other markets for straw, it is typically more cost effective to plough straw back into soil."*

The world's largest straw power station is based near Ely around 15 miles north of the Application Site, and is rated at 38 MW, consuming around 200,000 tonnes of straw per year. The power station is owned by Energy Power Resources Limited (EPRL) who has also created a dedicated company for the provision of straw, Anglian Straw Limited.

The task of collecting the straw requires a significant amount of coordination with Anglian Straw collecting bales from over 500 sites across East Anglia. A discussion with Anglian Straw suggested that obtaining straw is a difficult process due to competing uses on farms, with farmers in general being very reluctant to sell.

Discussions with a local farmer[27] reinforce the view that selling straw for energy generation is the last resort for many farmers. Straw is currently often re-ploughed into the land, and collection of this resource poses additional cost and time-burden to the farmer. There are also nutrient benefits to ploughing the straw into the land and alternative fertiliser costs can be higher than the revenue from selling the straw for energy.

The evidence from the straw assessment report and discussions with Anglian Straw and farmers support the approach taken in this study, and suggest that the resource is extremely limited for energy generation.

[26] National and regional supply/demand balance for agricultural straw in Great Britain (2008), by Central Science Laboratory for National Non-Food Crops Centre
[27] Private communication with a Cambridgeshire farmer, 2010.

8 Renewable Potential - Energy From Waste

8.1 Introduction

This section examines the potential for energy generation from waste (EfW). For the purposes of this report, waste streams include:

- Municipal solid waste (MSW)
- Commercial and industrial solid waste (C&I)
- Wet organic waste
- Dry organic waste

8.2 Municipal Solid Waste

8.2.1 Methodology

The expected available waste stream in 2020 from MSW is based on the waste management targets given in the Draft Revision to the Regional Spatial Strategy (RSS) (March 2010) for the EoE. Full details of the methodology and assumptions are given in Appendix 1.

8.2.2 Resource Potential

The waste management targets for 2020/21 in the Draft Revision to the RSS estimates the total arising of MSW to be 3,044,000 tonnes per year. The resource is usually collected and managed at county / unitary level.

8.2.3 Uptake to 2020

The total MSW availability is reduced to 25% to allow for inert MSW components which cannot be used in an EfW plant, and components which are removed for recycling or recovery. This means that by 2020, 761,000 tonnes of MSW a year will be available for EfW. This equates to a total of 1.2% of the projected 2020 energy demand. There are a large number of drivers for EfW from both an energy generation, and waste management perspective. There is currently 110 MWe of capacity with planning consent or in construction, and it is possible that by 2020, the various drivers will cause a large increase in EfW. For the purposes of this study, we have assumed that the technical potential can be achieved by 2020. This assumes that the heat can also be used requiring the location of plants near DH schemes or industrial processes. Table 13 shows estimated thermal and electrical capacities and annual outputs.

Table 13. Estimated electrical and thermal capacities and annual energy generation by 2020 for EfW from MSW.

Uptake to 2020	Heat	Electricity
Capacity, MW	152	76
Output, MWh	667	533

8.3 Commercial and Industrial Solid Waste

8.3.1 Methodology

The expected available waste stream in 2020 from C&I Waste is based on the waste management targets given in the Draft Revision to the Regional Spatial Strategy (RSS) (March 2010) for the EoE. Full details of the methodology and assumptions are given in Appendix 1.

8.3.2 Resource Potential

The waste management targets for 2020/21 in the Draft Revision to the RSS estimates the total arising of C&I Waste to be 5,655,000 tonnes per year. It is important to note that this will include a component of industrial waste wood which is also discussed in the previous section on biomass. Consequently there is potential for double counting when adding up the potential of separate resources, and further analysis is required.

8.3.3 Uptake to 2020

It is assumed that 80% of the total C&I waste stream is collected in a format that can be used for EfW. This collected C&I availability is reduced to 25% (20% of the overall availability) to allow for inert C&I components which cannot be used in an EfW plant, and components which are removed for recycling or recovery. Therefore the anticipated amount of C&I available for combustion in 2020 is 1,175,350 tonnes. This equates to approximately 1.9% of the projected 2020 energy demands. For the purposes of this study, we have assumed that the technical potential can be achieved by 2020. This assumes that the heat can also be used requiring the location of plants near DH schemes or industrial processes.

Table 14 shows estimated thermal and electrical capacities and annual outputs for C&I waste.

Table 14. Estimated electrical and thermal capacities and annual energy generation by 2020 for EfW from C&I waste.

Uptake to 2020	Heat	Electricity
Capacity, MW	235	118
Output, MWh	1,030	824

8.4 Wet Organic Waste

The EoE has significant amount of resource from animal waste as being one the UK's major farming regions. According to the figures from Defra Agricultural and Horticultural Land Survey (2009) there are in total more than a million pigs and around 150,000 cattle in the region. Anaerobic Digestion (AD) can be used to convert these wastes into energy. The energy density of animal wastes is relatively low (the feedstock has already been digested once) and dedicated animal waste AD schemes (for example farm based AD) will have a low capacity.

Food wastes can also be used for AD, and have a much higher energy density, and can be added to animal waste schemes to increase capacity. The animal slurries can be used to provide a liquid consistency to the feedstock to aid digestion and movement through the plant. In this case, most of the energy derives from the food waste, but the process benefits from the slurries.

This study identifies a total of 3,076,000 tonnes animal wastes and 26,600 tonnes food waste per year, capable of supporting 15 MW of AD capacity. It is estimated that 80% of the animal waste resource can be practically accessed, and 50% of the food waste resource due to competing uses, resulting in a potential of 11 MWe and 13 MWth of AD. The annual energy generation equivalent to 0.1% of the 2020 predicted energy demand for the region. A typical commercial AD scheme is circa 1 MWe, and the potential is equivalent to around 11 schemes. There is currently a high level of interest in AD from an energy generation, waste management, and nutrient perspective, and a number of incentives are available. Given the drivers combined with a relatively small number of plants, it is assumed that this potential can be achieved by 2020.

Table 15 shows estimated thermal and electrical capacities and annual outputs for wet organic waste.

Table 15. Estimated electrical and thermal capacities and annual energy generation by 2020 for EfW from animal wastes and food waste using anaerobic digestion.

Uptake to 2020	Heat	Electricity
Capacity, MW	13	11
Output, MWh	55	56

8.5 Dry Organic Waste (Poultry Litter)

The natural resource for dry organic waste consists of the energy generation from poultry litter. Data on the number of broiler birds in the region has been taken from the Defra Revised 2009 County/Unitary Authority breakdown for livestock populations database. It has been assumed that the fuel from poultry litter is used solely for electricity generation. The EoE currently hosts two large chicken litter plants owned by EPR and totalling 51.2 MW.

The resource assessment in this study identifies approximately 835,000 tonnes of poultry waste fuel. This could support 76 MWe capacity suggesting that the regional resource can meet another 25 MW of capacity (assuming that all of the current EPR feedstock is sourced from within the region). 25 MW of capacity could be in operation in under 9 years and therefore the 2020 potential is assumed to be 76 MW. An output of 390 GWh corresponds to 0.4% of the 2020 projected energy demand.

8.6 Biogas

Landfill Gas

Data on existing landfill gas sites capacity has been taken from Ofgem ROC database. Very few new landfill gas installations are expected by 2020. This is due to the increasing move away from landfill as a waste management solution. 90% diversion of waste stream from landfill has been targeted by 2031[28].

Therefore, in line with the DECC guidance, 2020 resource assessment is based on the currently installed capacity. This sets an upper limit and diminishing resource has been anticipated over time. The gas captured from landfill sites is used for electricity generation only

Current existing capacity of landfill gas sites is in the region of 169 MW. Almost 165 MW of this capacity is already in operation with the remaining awaiting construction. This corresponds to 884 GWh of electricity production per annum.

Landfill gas sites in the region have been mapped and are shown in Figure 6 and the capacity in each county is listed in Table 16.

Sewage Gas

All data on sewage gas and energy generation has been obtained from Ofgem ROC database. In line with the DECC methodology all plants currently operational has been assumed to be in operation by 2020. Very little change in capacity is expected therefore the uptake rate has been assumed to be the same as the current capacity.

Current existing capacity of landfill gas sites is approximately 27 MW. All of this capacity is already in operation. This corresponds to 101 GWh of electricity production per annum.

[28] Draft Review of the RSS to 2031.

Table 16. Existing electrical capacities and annual energy generation from Landfill and Sewage Gas plants, equally indicating the uptake by 2020 as change in capacity was not predicted in the next 9 years.

Total Capacity by County	**Landfill Gas (MW)**	**Landfill Gas (GWh)**	**Sewage Gas (MW)**	**Sewage Gas (GWh)**
Essex	90	471	3.4	13
Hertfordshire	15	80	14.8	55
Bedfordshire	38	198	5.6	21
Cambridgeshire	7	36	3.4	13
Norfolk	9.3	49	0.0	-
Suffolk	9.6	50	0.0	-
Total	**169**	**884**	**27.2**	**101**

8.7 Summary

This section provides an overview of the resource potential and 2020 potential for energy from waste.

Table 17. Summary of energy from waste resource in the East of England showing potential capacity and generation by 2020.

Type of resource	**Uptake estimate 2020 (MWe)**	**Uptake estimate 2020 (GWhe)**	**Uptake estimate 2020 (MWth)**	**Uptake estimate 2020 (GWhth)**
MSW	76	533	152	667
C&I	118	824	235	1,030
Wet organic (AD)	11	56	13	55
Dry organic (poultry)	76	390		
Landfill Gas	169	884		
Sewage Gas	27	101		
Total	477	2788	400	1752

This study suggests that by 2020, the region could be making use of the resource potential for energy from waste.

Table 17 shows a total energy generation potential of 4,540 GWh, representing 4.6% of the projected 2020 energy demand.

9 Renewable Potential – Hydro Energy and Large Scale PV

9.1 Hydro Energy

9.1.1 Introduction

Hydro power involves the generation of electricity from passing water (from rivers, or stored in reservoirs) through turbines. The energy extracted from the water depends on the flow rate and on the vertical drop through which the water falls at the site, the head.

For the purposes of assessing the hydropower resource, small-scale hydro power (under 20MW) is considered because opportunities for large-scale hydro (e.g. large dams) are not applicable to EoE due to limited height in river levels. In contrast, small-scale hydro installations can be sited at small rivers and streams with little adverse impact on the river's ecology, for example, on fish migration patterns.

The British Hydro Association and Feed-in-Tariff installation databases have been examined to estimate the existing installation capacity. There are three installations in the region totalling 20 kW according to the British Hydro Association, but the total size of installations claiming FiTs are 55 kW. There is clearly a discrepancy between the databases, but in a regional context, the current installed capacity is negligible. In addition, there is a 20 kW scheme consented for Bedford, but not yet constructed.

9.1.2 Methodology

The hydro energy resource has been identified through engagement with the Environment Agency; a dataset has been provided by the Agency[29] and this identified all existing barriers within rivers in EoE. These represented sites where there is sufficient height in river level to provide a hydropower opportunity. These sites are mostly weirs, but could be other man-made structures, or natural features such as a waterfall.

According to the dataset, there are more than 1,200 sites, with an estimated total potential to 16 MWe of capacity. However most of these barriers are in the range of 0-10 kW and about 33% of these sites have high environmental sensitivity, significantly reducing the potential. The economically available resource potential is therefore much lower when schemes of negligible output (0-10 kW) and high sensitivity are excluded. Full details of the assumptions and methodology are provided in Appendix 1.

Following the application of the constraints detailed in the methodology, the accessible resource potential is 1.5 MW.

9.1.3 Potential uptake by 2020

As a further limitation, it is assumed that only 10% of this accessible potential is achieved before 2020 representing 150 kW, corresponding to 0.5 GWh of annual generation.

The 2020 uptake is extremely low, but at 150 kW, represents an increase of 110 kW from the current installed capacity of 20 kW (from the British Hydro Association) and the consented 20 kW scheme in Bedford. Assuming 20 kW per scheme, this represents over 5 schemes which still appear challenging given the current status.

The assessment of the hydro resource suggests that small-scale hydropower has a very limited role to play in renewable energy generation. This is due to a combination of facts; firstly EoE does not present a significant hydro resource potential. In addition to this the size of most of the sites is too small to be economic. Further feasibility can also only be determined after detailed analysis which may require a process of obtaining Environment Agency consents, construction licences, river consents, fish pass consents, etc. The Environment Agency is actively trying to streamline this process and is also in the midst of a follow up study on UK hydro schemes which should filter out sites that are probably unviable.

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[29] An email from Vicki Snell of Environment Agency to James Cuttings of Suffolk County Council, dated 4th March 2011

9.2 Large Scale Photovoltaics

9.2.1 Introduction

Large scale photovoltaic arrays or 'farms' are a recent concept for the UK. The poor commercial economics of PV in the UK have meant that in the past, the technology has not been used to generate electricity on a commercial basis. The poor economics arise out of the high capital cost of the technology combined with relatively low output due to low isolation levels. However there are commercial PV farms in other parts of the world, such as California, where a combination of higher outputs combined with support schemes has enabled development.

The introduction of Feed in Tariffs to the UK resulted in a sudden commercial interest in large scale PV farms in 2010, with the proposed tariffs resulting in potentially attractive commercial rates of return. Many of the proposed schemes were designed by investment companies keen to enter the new market. To maximise the economies of scale, the schemes were typically up to 5 MW, falling under the 5 MW limit imposed in the FiT regulation.

The large levels of commercial interest in PV farming have resulted in a review of the FiTs by Government. There is concern that a small number of very large schemes will monopolise the FiT budget, and that the incentives should be helping to allow cost effective installations, not providing an attractive commercial investment. The proposed review FiT rates for PV schemes over 50 kW are significantly lower and are expected to be introduced in August 2011, effectively preventing cost effective installation of large PV farms.

The sensitivity of PV interest to incentives means that predicting the uptake is not straight forward, and another suitable incentive may result in another rush to install PV farms.

9.2.2 Methodology

The recent interest in large scale PV farms means that no methodology is proposed in the DECC methodology. There are no specific constraints on the installation of farms, providing that a suitably large exposed area is available with no over shading.

The approach used in this work has been developed in consultation with the steering group to help assess the potential of large scale PV. The main requirement is land availability, and therefore considerations such as the competition of land for other uses such as food needs to be accounted for. These are similar to considerations around Energy Crops, and therefore the methodology is based around using the same land areas as for energy crops. Full details are provided in Appendix 1.

9.2.3 Resource potential

The analysis suggests that there is a maximum available resource potential of 28,000 MW. This is an extremely large capacity (almost half of the total UK electricity generation capacity) and is a result of the large areas of land deemed suitable for PV farms.

In line with the order-of-magnitude approach of this study, it is considered that achieving the resource potential will not be possible and if only 10% of the sites were suitable or available, then the capacity would be reduced to a practical potential of 2,800 MW.

9.2.4 Potential uptake by 2020

It is unknown how future policy will incentivise large scale PV and the past year demonstrates that update is entirely dependent on the availability of incentives and the economics of schemes. For this report, it is assumed that 10% of the practical potential can be achieved by 2020, resulting in an installed capacity of 280 MW, equivalent to circa 56 5 MW farms, or just over one per local authority. The equivalent energy generation is 236 GWh.

10 Renewable Potential – Microgeneration Energy

10.1 Introduction

This section assesses the following microgeneration technologies:

- Photovoltaics (building mounted)
- Solar thermal
- Heat pumps (air source and ground source)
- Small scale wind
- Micro wind
- Micro CHP (domestic and commercial)

10.2 Methodology

The methodology for calculating the potential for microgeneration is based around the DECC methodology, using simple uptake fractions and defined capacities for different technologies and building types. The DECC methodology overestimates the capacity for some technologies and further constraints have been applied. One example is limiting heat pumps to post 1980 dwellings which have higher levels of thermal efficiency.

Small scale wind generation is included as a microgeneration technology and is assessed using the above approach, rather than the wind mapping constraints approach which is used for large scale wind generation. In general the viability of small scale wind is dependent on micro factors (such as adjacency of buildings) and less dependent on the macro scale constraints such as wind speed, and therefore is more suitably assessed as a microgeneration technology.

Micro CHP is also considered in this section for domestic and commercial buildings. At the domestic scale, this technology is currently on the verge of becoming commercially available and could experience a measureable uptake over the next 10 years.

Full details of the methodology are provided in Appendix 1.

10.3 Resource potential

The potential for microgeneration is dependent on the number of buildings to which the technologies can be linked. The constraints analysis therefore considers both the current building stock in the EoE, and potential growth to 2020.

The data in Figure 17 and Table 18 show the total resource potential for microgeneration technologies by 2020 split by technology type and county. The total potential for renewable technologies is 4.3 MW with a further 2.3 MW from micro CHP (including heat and electricity). PV is has the largest single contribution with around 2 MW capacity potential.

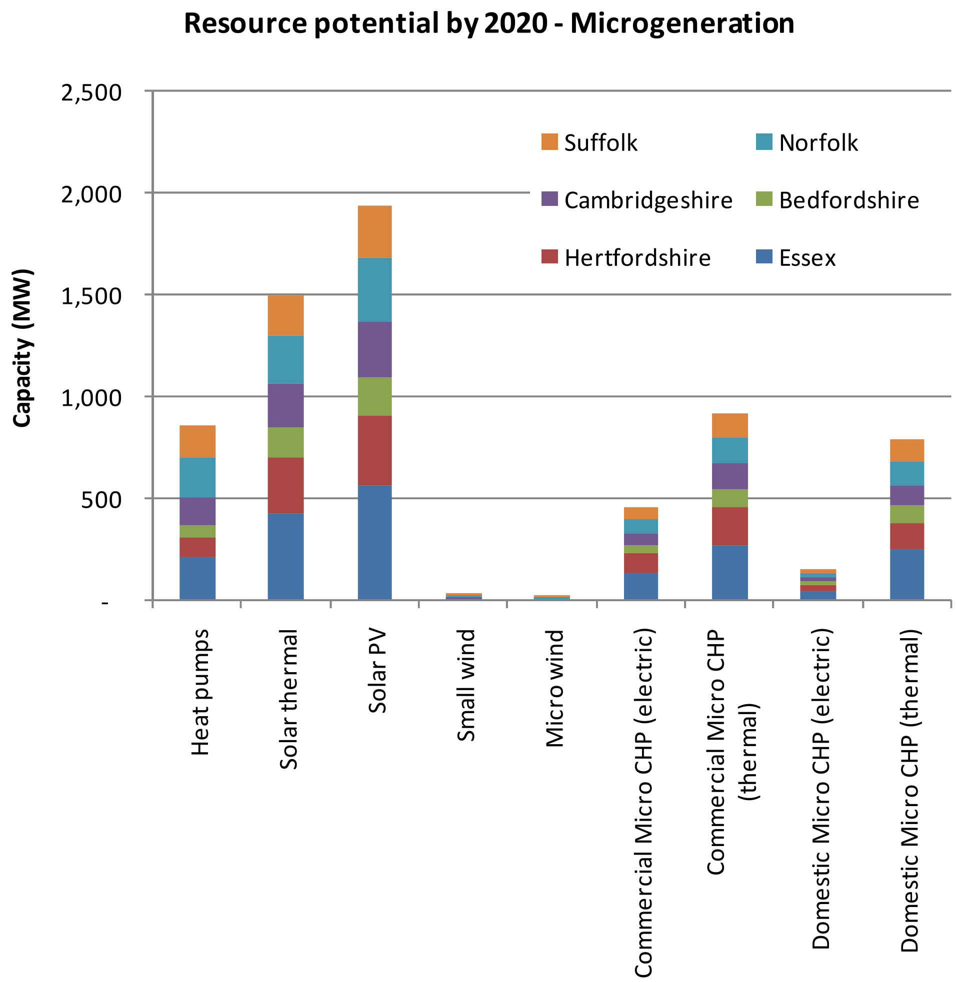

Figure 17. Resource potential by 2020 for different microgeneration technologies.

Table 18. Microgeneration resource potential by 2020 for each county in the East of England.

Resource potential (MW)	Renewable technologies						Low carbon technologies				
	Heat pumps	Solar thermal	Solar PV	Small wind	Micro wind	**Total renewable**	Commercial Micro CHP (electric)	Commercial Micro CHP (thermal)	Domestic Micro CHP (electric)	Domestic Micro CHP (thermal)	**Total low carbon**
Essex	211	433	567	6	4	**1,221**	135	270	50	249	**704**
Hertfordshire	103	267	340	3	1	**714**	96	193	27	133	**449**
Bedfordshire	60	151	187	2	1	**401**	39	79	17	86	**222**
Cambridgeshire	132	215	277	4	3	**631**	64	129	20	102	**315**
Norfolk	202	237	309	8	7	**762**	65	131	24	118	**337**
Suffolk	150	194	256	6	4	**610**	59	118	20	101	**298**
Total	**857**	**1,496**	**1,936**	**28**	**20**	**4,339**	**459**	**919**	**158**	**789**	**2,325**

The total corresponding energy potential from the resource potential is 13 TWh in 2020, or around 13% of the regional energy demand by 2020.

10.4 Uptake to 2020

The uptake of most microgeneration technologies by 2020 is likely to be significantly lower than the identified resource potential. At present, most of the technologies are uneconomic without financial input from grants or subsidies. Feed in Tariffs and the Renewable Heat Incentive can help provide a payback for many systems, but the significant capital expenditure can be a barrier to uptake. In addition, microgeneration technologies are often installed at a catalyst event, for example a heat pump may be installed when a boiler needs replacing, or a PV system when a roof is refurbished. The uptake of technologies is also therefore restricted by the periodicity of other events.

Full details of uptake assumptions are provided in Appendix 1. It is important to note that there is a significant degree of uncertainty around microgeneration technology uptake, and therefore the modelling in this report aims to establish a reasonable order of magnitude, rather than an accurate prediction.

The data in Figure 18 shows the total resource potential for microgeneration technologies by 2020 split by technology type and county. The total potential is around 0.8 MW (renewable) and 0.2 MW (micro CHP) with solar PV and heat pumps having the largest capacity potential.

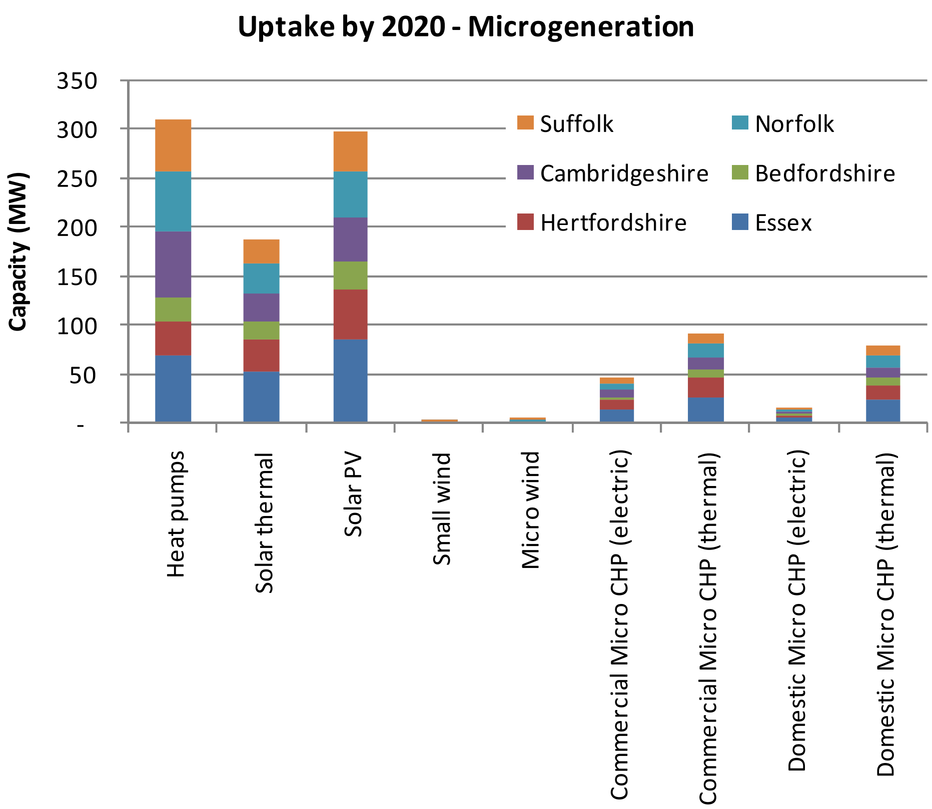

Figure 18. Potential uptake of different microgeneration technologies by 2020.

Table 19. Microgeneration uptake potential by 2020 for each county in the East of England.

	Renewable technologies						Low carbon technologies				
2020 uptake MW	Heat pumps	Solar thermal	Solar PV	Small wind	Micro wind	**Total**	Commercial Micro CHP (electric)	Commercial Micro CHP (thermal)	Domestic Micro CHP (electric)	Domestic Micro CHP (thermal)	**Total low carbon**
Essex	68	53	86	1	1	**209**	13	27	5	25	**70**
Hertfordshire	35	32	50	0	0	**118**	10	19	3	13	**45**
Bedfordshire	25	19	28	0	0	**73**	4	8	2	9	**22**
Cambridgeshire	67	29	44	0	1	**142**	6	13	2	10	**32**
Norfolk	61	30	48	1	2	**141**	7	13	2	12	**34**
Suffolk	52	24	40	1	1	**117**	6	12	2	10	**30**
Total	**309**	**186**	**296**	**3**	**5**	**799**	**46**	**92**	**16**	**79**	**232**
2020 uptake GWh	Heat pumps	Solar thermal	Solar PV	Small wind	Micro wind	**Total**	Commercial Micro CHP (electric)	Commercial Micro CHP (thermal)	Domestic Micro CHP (electric)	Domestic Micro CHP (thermal)	**Total low carbon**
Essex	120	46	75	1	1	**243**	59	118	13	65	**256**
Hertfordshire	61	28	44	0	0	**134**	42	84	7	35	**169**
Bedfordshire	44	17	25	0	0	**86**	17	35	5	23	**79**
Cambridgeshire	118	25	39	1	1	**183**	28	56	5	27	**117**
Norfolk	107	26	42	1	1	**177**	29	57	6	31	**123**
Suffolk	90	21	35	1	1	**148**	26	52	5	27	**109**
Total	541	163	260	4	4	**972**	201	402	41	207	**852**
Regional percentage	**0.54%**	**0.16%**	**0.26%**	**0.00%**	**0.00%**	**0.98%**	**0.20%**	**0.40%**	**0.04%**	**0.21%**	**0.86%**

The annual energy production from microgeneration technologies by 2020 is circa 1.8 TWh which is around 1.8% of the region's predicted baseline demand by 2020. Heat pumps and micro CHP make up the largest share and the contribution from small and micro scale wind is negligible.

10.5 Summary

This section aims to establish the level to which microgeneration technologies may contribute to the EoE's energy demands. The potential for microgeneration is partially determined by both the number and type of buildings, and so the potential will change over time as a result of further development.

By 2020, it is estimated that the total resource potential will be around 6.7 GW or 13% of the regional energy demand. However the uptake of technologies up to 2020 is likely to be significantly less, resulting in a capacity of around 1 GW corresponding to 1.8% of the region's demand.

11 Electricity Grid Infrastructure

11.1 Induction

The electricity grid is clearly an important factor in the uptake of electricity generating renewable and low carbon energy technologies in the region. An advantage of electricity generating technologies is that the output is not limited by the load (unlike for heat generating technologies) and the grid can be used to absorb generation at any time and distribute to anywhere.

However this relies on a suitable piece of grid infrastructure being available for connection – this means in the right place, and with the correct capacity. The Electricity Industry in the UK has three key stakeholder areas[30]:

- **Generators** - responsible for generating the energy we use in our homes and businesses. Generated electricity flows into the National Transmission network and through to the regional Distribution networks.
- **Distributors** - are the owners and operators of the network of towers and cables that bring electricity from the National Transmission Network to homes and businesses. Even so, they are not the organisations that sell electricity to the end consumer. This is carried out by organisations who make use of the distribution networks to pass the energy commodity to your property - the suppliers.
- **Suppliers** - are the companies who supply and sell electricity to the consumer. The suppliers are the first point of contact when arranging an electricity supply to domestic, commercial and smaller industrial premises.

The distribution network operator (DNO) in the East of England is UK Power Networks Eastern Power Networks (UKPNEPN). They are responsible for distributing electricity from the National Transmission Network to locations in the East of England via a "local" grid. It is to this grid that renewable and low carbon technologies will be connected, allowing the distribution of electricity away from the site of generation.

11.2 Changing demands on the local grid

The local grid is constantly being modified and added to for providing additional capacity:

- Increased electricity demand as the grid is decarbonised and electricity powered heating is installed in place of fossil fuel heating technologies such as gas boilers. This is expected as a result of government initiatives such as the Carbon Price Floor (currently out to public consultation) and the Feed in Tariff. This could require the reinforcement of the electricity grid to allow the increasing demands to be met.
- Increased summer electricity demand from a growth in cooling demand and air conditioning due to climate change. This could result in a need to reinforce the local grid as equipment such as transformers have a lower electrical rating in higher temperatures.
- Increased distributed energy generation from low and zero carbon technologies such as CHP, solar photovoltaics and wind turbines. This could lessen the need for grid reinforcement if decentralised electricity generating technologies are sited strategically, but it is also likely that grid reinforcement would be needed in some areas.
- Lifestyle changes: more social and commercial activity in evenings; more late night and Sunday shopping; more flexible working hours; increase in leisure activities

11.3 Integration of renewable energy

Network utilisation is highly variable, due to the history of network development and the inconsistent levels of growth which have been achieved in different locations within the region. The ability of the network to meet additional

[30] National Grid Website: http://www.nationalgrid.com/uk/Electricity/AboutElectricity/

demand depends upon the proposed level of demand at any particular location taking into account the network design and exact location on the network in relation to distribution lines and sub stations.

A study of the electricity distribution network in the East of England examined the impact of the grid on the potential for renewable energy generation [31]. The study concluded that whilst the design of the network may act as a barrier, this cannot be defined on a simple basis or mapped, but will need to be assessed on a case by case or development by development basis. Taking wind turbines as an example, the location of a wind farm in relation to the network may not be critical because the cost of installing a new connection to a suitable part of the grid may be relatively economic. However the design and capacity of the network at the point of connection may be more critical in terms of the viability of this connection, potentially requiring increased capacity in sub-stations or the network lines. Thus a simple geographic mapping exercise is not possible.

A general view is that the network is changing will continue to evolve in the future to allow incorporation of renewable electricity generators, not withstanding certain site restrictions.

The EEDA PIS concludes with a number of recommendations for developers, the public sector, and the network operators to ensure that the network becomes more flexible allowing the integration of higher levels of distributed generation. Many of the issues surrounding the network are at a national level and involve national policy and regulation, and a UK scale approach in relation to network storage and diversity, allowing a “smarter” network to absorb decentralised and inconsistent generation whilst meeting the demands imposed on it. This demand management includes the roll out of smart meters which can help ensure that the demand for electricity matches the supply, enabling the maximum potential of renewable electricity to be achieved [32].

[31] Power Infrastructure Study, East of England Development Agency, 2009, p4

[32] The Government has committed to the **roll out** of smart meters for both electricity and gas in all homes and most small businesses by the end of 2020. £8.6 billion will be spent in replacing some 47 million gas and electricity meters, which are expected to deliver total benefits of £14.6 billion over the next 20 years. The Government consulted on this roll out in May 2009, and the response is being published alongside this opportunities paper.

12 Summary of Renewable Potential

12.1 Introduction

This report aims to assess the potential renewable energy resource in the East of England, and the extent to which this can be taken up by 2020.

There are a large number of assumptions made in the assessments, and the level to which the potential can be achieved is dependent on a significant number of variables relating to resource constraints, technology constraints, economic viability, supply chain capacity, support schemes, incentives, and general levels of interest. It is impossible to predict how all these will impact on the future uptake and any assessment is likely to include a degree of error – this is after all an estimate.

Therefore the most important use of this report is not to establish detailed uptake values, but to understand the role that each resource can play in meeting future energy needs, and the order of magnitude which these may take.

All of the figures presented in this report imply a degree of accuracy due to the modelling process and assumptions used. However they should only be used as a guide to the relative contribution from each resource, and the approximate scale to which they can meet 2020 demands.

The following summary tables are split into the following sections:

- Total resource potential in terms of capacity and energy output (Tables 20 and 21)
- 2020 resource uptake in terms of capacity and energy output (Tables 22 and 23)
- Total resource potential and 2020 uptake expressed as a percentage of 2020 energy demands (Tables 24 and 25).

For simplicity, and due to the considerable number of unknowns around the potential of district heating and CHP, figures are presented for renewable technologies and resources only.

12.2 Resource potential

Table 20 and Table 21 show the total resource potential in terms of capacity and annual output for each renewable technology in each County.

Table 20. Total resource potential for thermal technologies and resources given in terms of capacity (MW) and annual output (GWh)

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
THERMAL CAPACITY (MW)																	
Essex	-	-	433	211	-	-	-	-	8	30	-	12	-	1	-	98	**793**
Hertfordshire	-	-	267	103	-	-	-	-	7	25	-	7	-	1	-	71	**479**
Bedfordshire	-	-	151	60	-	-	-	-	4	13	0	6	-	1	-	37	**271**
Cambridgeshire	-	-	215	132	-	-	-	-	4	14	1	9	-	1	-	57	**431**
Norfolk	-	-	237	202	-	-	-	-	23	85	0	7	-	6	-	60	**620**
Suffolk	-	-	194	150	-	-	-	-	10	38	0	6	-	4	-	64	**466**
TOTAL	**-**	**-**	**1,496**	**857**	**-**	**-**	**-**	**-**	**54**	**204**	**2**	**47**	**-**	**13**	**-**	**387**	**3,061**
THERMAL ANNUAL OUTPUT (GWh)																	
Essex	-	-	303	381	-	-	-	-	35	90	-	51	-	6	-	430	**1,295**
Hertfordshire	-	-	187	186	-	-	-	-	29	73	-	29	-	2	-	310	**817**
Bedfordshire	-	-	106	109	-	-	-	-	15	39	2	26	-	3	-	162	**461**
Cambridgeshire	-	-	151	238	-	-	-	-	16	40	9	39	-	3	-	248	**744**
Norfolk	-	-	166	365	-	-	-	-	99	254	0	32	-	26	-	264	**1,207**
Suffolk	-	-	136	271	-	-	-	-	44	112	1	26	-	15	-	282	**888**
TOTAL	**-**	**-**	**1,049**	**1,549**	**-**	**-**	**-**	**-**	**238**	**609**	**12**	**204**	**-**	**55**	**-**	**1,696**	**5,412**

Table 21. Total resource potential for electricity generating technologies and resources given in terms of capacity (MW) and annual output (GWh)

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
ELECTRICAL CAPACITY (MW)																	
Essex	14,768.9	11	567	-	0	4,843	90	3	4	-	-	6	97	1	7	49	**20,448**
Hertfordshire	4,965.3	4	340	-	0	3,296	15	15	3	-	-	3	31	0	1	35	**8,710**
Bedfordshire	4,481.5	3	187	-	1	1,860	38	6	2	-	0	3	31	1	0	18	**6,630**
Cambridgeshire	17,327.5	8	277	-	0	2,188	7	3	2	-	1	4	107	1	5	28	**19,958**
Norfolk	25,989.7	14	309	-	0	9,679	9	-	11	-	0	4	79	5	44	30	**36,173**
Suffolk	17,066.0	10	256	-	0	6,510	10	-	5	-	0	3	88	3	20	32	**24,003**
TOTAL	**84,599**	**49**	**1,936**	**-**	**1**	**28,376**	**169**	**27**	**27**	**-**	**1**	**23**	**432**	**11**	**76**	**194**	**115,922**
ELECTRICAL ANNUAL OUTPUT (GWh)																	
Essex	38,812.6	12	472	-	1	4,031	471	13	28	-	-	41	683	6	34	344	**44,947**
Hertfordshire	13,048.8	5	283	-	1	2,743	80	55	23	-	-	23	218	2	4	248	**16,735**
Bedfordshire	11,777.4	3	156	-	2	1,548	198	21	12	-	1	21	215	3	0	129	**14,085**
Cambridgeshire	45,536.8	9	230	-	1	1,821	36	13	13	-	4	32	747	3	26	198	**48,669**
Norfolk	68,301.0	16	257	-	0	8,055	49	-	79	-	0	26	551	27	225	212	**77,796**
Suffolk	44,849.4	11	213	-	0	5,418	50	-	35	-	1	21	616	16	101	226	**51,557**
TOTAL	**222,326**	**55**	**1,611**	**-**	**5**	**23,615**	**884**	**101**	**190**	**-**	**6**	**163**	**3,029**	**56**	**390**	**1,357**	**253,789**

12.3 2020 resource uptake for renewable energy

Table 22 and Table 23 show the 2020 resource uptake in terms of capacity and annual output for each renewable technology in each County.

Table 22. 2020 potential for thermal technologies and resources given in terms of capacity (MW) and annual output (GWh)

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
THERMAL CAPACITY (MW)																	
Essex	-	-	53	68	-	-	-	-	8	30	-	12	-	1	-	98	**270**
Hertfordshire	-	-	32	35	-	-	-	-	7	25	-	7	-	1	-	71	**176**
Bedfordshire	-	-	19	25	-	-	-	-	4	13	0	6	-	1	-	37	**105**
Cambridgeshire	-	-	29	67	-	-	-	-	4	14	1	9	-	1	-	57	**181**
Norfolk	-	-	30	61	-	-	-	-	23	85	0	7	-	6	-	60	**272**
Suffolk	-	-	24	52	-	-	-	-	10	38	0	6	-	4	-	64	**198**
TOTAL	**-**	**-**	**186**	**309**	**-**	**-**	**-**	**-**	**54**	**204**	**2**	**47**	**-**	**13**	**-**	**387**	**1,202**
THERMAL ANNUAL OUTPUT (GWh)																	
Essex	-	-	37	123	-	-	-	-	35	90	-	51	-	6	-	430	**772**
Hertfordshire	-	-	22	63	-	-	-	-	29	73	-	29	-	2	-	310	**530**
Bedfordshire	-	-	13	46	-	-	-	-	15	39	2	26	-	3	-	162	**305**
Cambridgeshire	-	-	20	122	-	-	-	-	16	40	9	39	-	3	-	248	**497**
Norfolk	-	-	21	110	-	-	-	-	99	254	0	32	-	26	-	264	**807**
Suffolk	-	-	17	93	-	-	-	-	44	112	1	26	-	15	-	282	**592**
TOTAL	**-**	**-**	**131**	**558**	**-**	**-**	**-**	**-**	**238**	**609**	**12**	**204**	**-**	**55**	**-**	**1,696**	**3,503**

Table 23. 2020 resource uptake for electricity generating technologies and resources given in terms of capacity (MW) and annual output (GWh)

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
ELECTRICAL CAPACITY (MW)																	
Essex	148	2	86	-	0	48	90	3	4	-	-	6	10	1	7	49	**454**
Hertfordshire	50	1	50	-	0	33	15	15	3	-	-	3	3	0	1	35	**210**
Bedfordshire	45	0	28	-	0	19	38	6	2	-	0	3	3	1	0	18	**162**
Cambridgeshire	173	1	44	-	0	22	7	3	2	-	1	4	11	1	5	28	**302**
Norfolk	260	2	48	-	0	97	9	-	11	-	0	4	8	5	44	30	**518**
Suffolk	171	2	40	-	0	65	10	-	5	-	0	3	9	3	20	32	**359**
TOTAL	**846**	**8**	**296**	**-**	**0**	**284**	**169**	**27**	**27**	**-**	**1**	**23**	**43**	**11**	**76**	**194**	**2,005**
ELECTRICAL ANNUAL OUTPUT (GWh)																	
Essex	388	2	72	-	0	40	471	13	28	-	-	41	68	6	34	344	**1,506**
Hertfordshire	130	1	42	-	0	27	80	55	23	-	-	23	22	2	4	248	**659**
Bedfordshire	118	0	23	-	0	15	198	21	12	-	1	21	21	3	0	129	**563**
Cambridgeshire	455	1	37	-	0	18	36	13	13	-	4	32	75	3	26	198	**911**
Norfolk	683	2	40	-	0	81	49	-	79	-	0	26	55	27	225	212	**1,478**
Suffolk	448	2	33	-	0	54	50	-	35	-	1	21	62	16	101	226	**1,048**
TOTAL	**2,223**	**8**	**247**	**-**	**0**	**236**	**884**	**101**	**190**	**-**	**6**	**163**	**303**	**56**	**390**	**1,357**	**6,165**

12.4 Contribution to 2020 projected renewable energy demands

Table 24 and Table 25 show the total resource potential and 2020 uptake expressed as a proportion of 2020 energy demands.

Table 24. Total resource potential expressed as a percentage of 2020 projected energy demands.

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
THERMAL AND ELECTRICITY (% OF 2020 DEMAND)																	
Essex	115%	0%	2%	1%	0%	12%	1%	0%	0%	0%	0%	0%	2%	0%	0%	2%	**137%**
Hertfordshire	77%	0%	3%	1%	0%	16%	0%	0%	0%	0%	0%	0%	1%	0%	0%	3%	**104%**
Bedfordshire	167%	0%	4%	2%	0%	22%	3%	0%	0%	1%	0%	1%	3%	0%	0%	4%	**206%**
Cambridgeshire	316%	0%	3%	2%	0%	13%	0%	0%	0%	0%	0%	0%	5%	0%	0%	3%	**343%**
Norfolk	436%	0%	3%	2%	0%	51%	0%	0%	1%	2%	0%	0%	4%	0%	1%	3%	**504%**
Suffolk	386%	0%	3%	2%	0%	47%	0%	0%	1%	1%	0%	0%	5%	0%	1%	4%	**452%**
TOTAL	**224%**	**0%**	**3%**	**2%**	**0%**	**24%**	**1%**	**0%**	**0%**	**1%**	**0%**	**0%**	**3%**	**0%**	**0%**	**3%**	**261%**

Table 25. 2020 resource uptake expressed as a percentage of 2020 projected energy demands.

Location	Onshore wind: commercial scale	Onshore wind: small and micro scale	Building scale solar (PV and solar thermal)	Heat pumps	Hydro: small scale	Large scale PV	Landfill gas	Sewage gas	Managed woodland - CHP	Managed woodland - Boilers	Energy crops	Waste wood	Straw	Wet organic waste	Poultry litter	Energy from waste: MSW and C&IW	**Total**
THERMAL AND ELECTRICITY (% OF 2020 DEMAND)																	
Essex	1.2%	0.0%	0.3%	0.4%	0.0%	0.1%	1.4%	0.0%	0.2%	0.3%	0.0%	0.3%	0.2%	0.0%	0.1%	2.3%	**6.8%**
Hertfordshire	0.8%	0.0%	0.4%	0.4%	0.0%	0.2%	0.5%	0.3%	0.3%	0.4%	0.0%	0.3%	0.1%	0.0%	0.0%	3.3%	**7.0%**
Bedfordshire	1.7%	0.0%	0.5%	0.6%	0.0%	0.2%	2.8%	0.3%	0.4%	0.6%	0.0%	0.7%	0.3%	0.1%	0.0%	4.1%	**12.3%**
Cambridgeshire	3.2%	0.0%	0.4%	0.8%	0.0%	0.1%	0.3%	0.1%	0.2%	0.3%	0.1%	0.5%	0.5%	0.0%	0.2%	3.1%	**9.8%**
Norfolk	4.4%	0.0%	0.4%	0.7%	0.0%	0.5%	0.3%	0.0%	1.1%	1.6%	0.0%	0.4%	0.4%	0.3%	1.4%	3.0%	**14.6%**
Suffolk	3.9%	0.0%	0.4%	0.8%	0.0%	0.5%	0.4%	0.0%	0.7%	1.0%	0.0%	0.4%	0.5%	0.3%	0.9%	4.4%	**14.1%**
TOTAL	**2.2%**	**0.0%**	**0.4%**	**0.6%**	**0.0%**	**0.2%**	**0.9%**	**0.1%**	**0.4%**	**0.6%**	**0.0%**	**0.4%**	**0.3%**	**0.1%**	**0.4%**	**3.1%**	**9.7%**

These results demonstrate that under the assumptions used in this study, the total renewable energy resource potential could meet 261% of the projected 2020 energy demands. This may seem surprising, but the majority of this (224%) is from wind generation if it is assumed that there are no limits on turbine installations from landscape impact or cumulative impact. If it is assumed that only 10% of the areas identified for wind generation can be developed, then the total resource potential expressed as a proportion of 2020 demands would be reduced to 55%.

When realistic uptakes for 2020 are considered, the potential for renewable energy in the East of England is around 10 % of the projected energy demands. It is important to remember that these figures are based on locally available resources and do not include the energy contribution from imported feedstocks. They also do not include the contribution that offshore technologies (primarily offshore wind) can make. However they do indicate that even under the very optimistic resource potential scenario, renewable energy can only meet around half of the region's demand, and in reality, this is likely to be much lower.

13 Delivery of renewable energy in the East of England

13.1 Introduction

This report provides an overview of the potential renewable and low carbon energy resource available in the East of England, and the level to which this may be taken up by 2020. The analysis considers a range of barriers to development, both in terms of accessing the resource, and the technical potential for turning these resources into energy. The capacity of supply chains to deliver renewable and low carbon energy generation and the high level economic feasibility have also been considered in assessing the potential uptake of this potential by 2020.

There are many barriers to the development of low carbon energy schemes. The delivery vehicles for schemes need to be structured in ways that help overcome barriers such as access to finance and that make maximum use of the opportunities. There are many schemes which may be technically, and even economically viable, but for which the barriers to delivery are too great to enable development to proceed. The opportunities for delivery of renewable and low carbon energy development need further and more detailed consideration at the local level.

13.2 Implications for Local Dissemination and Delivery

This study shows overall that the main opportunities for future provision are in energy from waste, energy crops and on-shore wind. Whilst this report is focussed principally on the requirements of DECC to enable it to compile a regionally sourced national picture of renewable and low energy capacity, it inevitably raises implications for local dissemination and delivery. It is therefore appropriate to look ahead to outline a framework of possibilities that can be explored by local authorities, local communities and commercial operators as a result of the study.

Awareness of the implications of climate change is growing at the global, national and local levels and local people are beginning to identify elements of a response that they can make in their daily lives and in initiatives such as the development of on-shore wind turbines in the countryside. Local authorities and commercial operators are now beginning to identify an overview and also some more specific opportunities for local action. Local authorities are principally involved at this stage in formulating policies in Local Development Frameworks and commercial operators are increasingly involved in identifying site development opportunities for provision such as wind turbines, anaerobic digesters and low to zero energy buildings.

13.3 Implications of "localism"

The East of England Regional Assembly (EERA) began to identify potential for renewable and low carbon energy provision and other initiatives in the East of England Plan as a framework for the preparation of Local Development Frameworks. But the Localism Bill (2010), which is now progressing through Parliament, proposes to abolish regional strategic planning and to introduce Neighbourhood Plans and Neighbourhood Development Orders within the context of Local Development Frameworks. This shift from the regional to the local and neighbourhood levels is likely to be reflected in a shift in focus from the national to the local and neighbourhood levels in identifying practical opportunities for delivering renewable and low carbon energy development projects.

Commercial developers and operators are beginning to come forward with proposals for renewable and low carbon energy projects including on-shore wind energy generation, heat and energy generation from various crops, biomass and waste fuels, solar energy generation and combined heat and power projects. At the same time, increasing local awareness of national targets to reduce carbon emissions is prompting people to look for opportunities to contribute to carbon reduction through action such as shifts from private to public transport and improvements in building insulation and energy use. Planning policy and commercial provision are beginning to engage with local community awareness.

13.4 Options for local delivery

The local role of this study of renewable and low carbon energy potential in the EoE in this evolving response to climate change is to provide a framework of information within which Local Authorities, local communities and neighbourhoods can take stock of the their current situations and identify practical opportunities for delivery. Some Local Authorities have already begun to undertake or commission local studies to provide a finer level of detail within the regional assessments on which to develop local policies and action plans. Local communities and neighbourhoods can also use the regional assessments and local assessments where they are available to identify local initiatives they could develop.

Various responses to the challenge of climate change can now be envisaged at the local level ranging from the provision of specialist national support to Local Authorities on major renewable and low carbon energy projects and a series of local pilot projects to work with local communities to enable them to identify, work up and implement specific practical projects. Within the EoE there is now an opportunity to disseminate the results of the current study and to explore these and other initiatives to achieve local delivery. This could clearly be linked to progress with Local Development Frameworks and also to the initial development of “localism” where neighbourhoods are keen to develop plans for their areas ranging from local housing and business development to renewable energy projects.

13.5 Way forward

The further report of this study to the EoE Steering Group will develop the county level outputs required in this report to DECC down to the local authority level outputs that local authorities and local communities could begin to use to develop local initiatives. The further report to the Steering Group will elaborate the interpretation of the various datasets and maps and take this initial outline of opportunities for local dissemination and delivery further to enable local authority councillors and officers and local communities to identify the next steps towards practical action. It is intended that a presentation will be made to the Steering Group when its members have received the draft report and that the results of the discussion will then be used to finalise the report as a basis for further initiatives at the local authority and local community levels.

Appendix 1 – Methodology

Introduction

Background

This document describes the methodology used to calculate the renewable and low carbon energy potential in the EoE. The Resource Assessment methodology is based around the DECC methodology which sets out a number of datasets, procedures, and assumptions which should be used as a basis for the regional assessments. However there is still a degree of flexibility within the DECC methodology and this section aims to clarify these uncertainties, as well as highlighting where the EoE study has used supplementary approaches to enhance the analysis.

For each resource or technology type, the DECC methodology describes constraints as “natural”, “technical”, “physical”, and “economic”, each constraint further limiting the potential for each resource. The use of some constraints is relatively straight forward, natural features such as Areas of Outstanding Natural Beauty or Sites of Special Scientific Interest are well established but other constraints can be more subjective and difficult to quantify. In particular, visual impact and land use need to be considered and agreed locally. This would make creating a resource potential map difficult with a number of differing external perspectives. Therefore this study uses the following method of assessing potential:

- Hard constraints. These are constraints which are based on known physical and technical limitations. There are fixed rules for assessment and little controversy over the selection of these. Taking wind farms as an example, this includes wind speed, and physical locational restrictions such as urbanised areas, transport and other infrastructure.
- Soft constraints. These are constraints which restrict the uptake of a resource due to a number of imposed rules which are not based on physical restrictions. An example is the location of an energy from waste facility. There are examples of EfW plants in urban areas, and emission requirements ensure that there should be no adverse impact. However public opposition (a soft constraint) can prevent their construction in these areas. In practice, these soft constraints may not form an absolute restriction and may not apply to all individual cases.
- Considerations. There are a number of other factors which need to be considered when defining viability which may impact the outcome, but have no fixed rules or policy. The most significant of these is the Green Belt policy which is designed to protect the countryside from development around major urban areas. However, some development may be possible but assessing this potential is beyond the approach that is required by the DECC methodology. In this capacity study, these “constraints” are recognised, but do not act as an absolute limitation on capacity.

Scope of this methodology document

During the study, this document will act as a methodology specification and a record of any changes or additions to the methodology. The methodology is likely to alter as work progresses, and therefore this document will be updated to act as a record of how the information was collected.

Presentation of results and data

Spatial resolution

This study aims to provide useful information on the potential renewable and low carbon sources of energy available in areas within the EoE. This information is required by DECC to allow collation of the regional (as under the existing regional boundaries) information into a national assessment of renewable energy potential.

However the information is also of value at a local level, allowing individual authorities and local communities to assess their potential and investigate the options for delivering renewable and low carbon energy. Therefore the results in the study are presented in a manner which allows further use of the data at this more local level:

- Datasets. All data collated as part of the study is stored and presented to the client at the resolution collected. This provides a record of “raw” information which can be further used for more localised research.
- Summary tables. All tabular information in the study relating to energy potential and capacity is presented at a county level where information is available at county level or more detailed. If information is not available at county level, then the regional potential is provided.
- Energy Opportunities Maps. These are provided at a sub-regional level allowing greater resolution to be presented. For the purposes of this study, the sub-regions which have been identified to correspond as far a possible with Local Economic Partnership (LEP) areas and to provide a convenient basis for dissemination of the study results are:
    - Hertfordshire and Bedfordshire
    - Cambridgeshire, Norfolk, and Suffolk
    - Essex
- Individual resource maps. Maps providing information on the potential and constraints for individual resource are presented at a regional level.

Identification of current renewable and low carbon energy capacity

There is no comprehensive database of current renewable and low carbon energy installations currently in existence. Therefore an assessment of current levels of renewable energy production for the EoE region requires the collation of information from a number of different data sources. These include:

- DECC Combined Heat and Power (CHP) database[33]
- DUKES capacity of, and electricity generated from renewable sources[34];
- RESTATS database;[35]
- UK Heat Map[36];
- Renewable UK (formerly BWEA) dataset on wind turbine location,
- Ofgem Renewables and CHP Register
- Low carbon buildings programme dataset, valid to February 2010
- Ofgem FIT Installations Statistical Report;[37]
- Renewables East Monitoring Reports, and
- ROCs register

This information is used to assess the current levels of renewable and low carbon capacity in the region. However in most cases, the information available on each installation is limited and so this can only be used as a guide. In determining the "real" potential for renewable energy, additional information is required and the limitations of these databases can result in under or overestimate of the current capacity. For example, a biomass installation may be using imported wood as a fuel, and whilst this is renewable energy, it does not utilise a local resource or energy potential.

[33] CHP database, DECC website accessed November 2010 http://chp.decc.gov.uk/app/reporting/index/viewtable/token/2
[34] Digest of UK Energy Statistics (DUKES) database, DECC.
[35] RESTATs, DECC website accessed November 2010, https://restats.decc.gov.uk/cms/welcome-to-the-restats-web-site
[36] UK heat map, DECC website accessed November 2010 http://chp.decc.gov.uk/heatmap/
[37] FIT Installations Statistical Report, Ofgem website accessed December 2010 https://www.renewablesandchp.ofgem.gov.uk/Public/ReportViewer.aspx?ReportPath=%2fFit%2fFIT+Installations+Statistical+Report_ExtPriv&ReportVisibility=1&ReportCategory=9

Resource assessment

Heat mapping of existing heat demands

In order to make inferences about the viability of DH, the concept of "heat density" has been used. This is defined by the equation below.

$$Heat\ density = \frac{Annual\ heat\ demand\ [H]}{Number\ of\ hours\ in\ a\ year\ [N] x\ Area[A]}$$

Where H is the total annual heat demand in kWh and N is the total number of hours in a year (8760 hours). The area A in km^2 of each Middle Layer Super Output Area (MLSOA) has been taken from the Government's Generalised Land Use Database. Areas of lakes and reservoirs have been removed from the total area of the MLSOA. The heat density is therefore the average heat demand per unit area averaged over a year.

Heat density is calculated to Output Area (OA) level using the following methodology:

- MLSOA data on gas and electricity consumption from DECC is used to provide an indication of energy demand. This is converted into heating demand with simple efficiency assumptions of 80% for gas heating and 100% for electric heating.
- The MLSOA data is broken down into OA using census information on house type for the domestic sector, and land use statistics for the non domestic sector (both from Neighbourhood Statistics).

The DECC methodology states that "if heat density exceeds 3,000 kW/km^2, the heat density is considered to be high." Consequently, this has been used as the threshold above which there may be potential for DH through CHP. The heat map includes additional information which may be used to help inform the identification of future potential district energy schemes. These include:

- The location and size of large public sector buildings
- Potential sources of waste heat including power generation stations
- Significant commercial and industrial loads including EU-ETS installations which may act as a heat source or demand.
- Existing CHP and DH infrastructure

The following heat maps will be presented:

- Heat map 1 – heat density (kW / km^2). This will be shown at MLSOA (raw data level) and OA (interpolated data level);
- Heat map 2 – threshold heat density (3000 kW / km^2) at MSOA and OA.

Calculating energy output from renewable schemes

The installed generating capacity (**Power**) is expressed in terms of MW throughout the report. This is a measure of the maximum or rated power that can be delivered by the technology. This is often different to the actual average output of a system. Some systems may not operate continuously (for example a power generation plant) whilst others may operate throughout the year at different capacities (such as wind turbines whose output depends on windspeed). Therefore the annual output (**Energy**) is a more useful measure of the actual output of different technologies. This is determined by multiplying the installed capacity by a capacity factor which describes the annual usage of the plant.

All energy generation technologies have a capacity factor less than 100% and this occurs for a variety of reasons. There may be reductions in generation due to maintenance, faults or variations in demand. The capacity factor for some technologies also reflects the fact that energy generation may be inherently intermittent, as for wind, or diurnal, as for solar.

The capacity factors used within the study are shown below in Table 26. The annual capacity for each technology for each technology is expressed in MW (as provided by the DECC methodology) but the use of capacity factors allows an estimate of actual energy generation. The approximate capacity factors given below are typical for the technologies.

Table 26 Capacity factors used to estimate annual energy generation

Energy generation method	**Capacity factor (% of operation at peak capacity during year)**	**Source**
Commercial scale, onshore wind	30%	DECC 2050 calculator
Hydro	38%	DECC 2050 calculator
Biomass heat (managed woodland)	34%	AECOM experience
Biomass CHP (heat)	50%	AECOM experience
Biomass CHP (electricity)	80%	AECOM experience
Energy from waste heat CHP (heat)	50%	AECOM experience
Energy from waste heat CHP (electricity)	80%	AECOM experience
Small scale wind	15%	AECOM experience
Solar PV	9.5%	Based on circa 850 kWh / kWp
Solar water heating	8%	Based on circa 500 kWh / m^2
Heat pumps	20%	AECOM experience
Commercial scale Micro CHP	50%	Assumes heat to power ratio of 2:1
Domestic scale Micro CHP	30%	Assumes heat to power ratio of 5:1

Commercial scale wind energy resource

Methodology – general description

The methodology for large scale wind resource is based around the DECC methodology of mapping physical and natural constraints, and combining the resultant potential with current technology performance and characteristics. In addition to the DECC methodology constraints, a number of additional constraints are used as detailed in table 2.

An assessment of the visual impact of wind turbines within the landscapes of the EoE is not been included. Studies undertaken within this and other parts of the county have attempted this but only very broad assessments can be made and, to genuinely identify potential areas, each local authority would need to agree to the assessments for its area. However, the results will be presented in the form of scenarios that lower the density of turbines to account for national landscape designations, the green belt and reflect the cumulative impact on landscapes, although not as a specific constraint. In addition we recommend that additional work be undertaken to consider the cumulative impact and restrictions on turbine development.

Natural resource and assumptions for energy generation

The natural resource for wind energy is based on the wind speed, which has been derived from the UK wind speed database. This often overestimates wind speeds compared to actual measured wind speeds; however, they are modelled at 45m height whereas the large-scale wind turbines modelled in this study are 85m to hub height, where wind speeds are likely to be significantly higher. Therefore, if there is an overestimate in wind speed due to the database, this is likely to be compensated by this approach.

Technically accessible resource

The technically accessible resource refers to the potential for energy generation based on the performance of the generating equipment. A standard turbine size of 2.5MW has been assumed, with rotor diameter of 100m, hub height of 85m and tip height of 135m. It has been assumed that the available land area could support 9 MW of installed capacity per square kilometre. This is equivalent to 3.6 turbines per square kilometre, using the standard turbine size introduced above.

Physically accessible resource

The physically accessible resource has been identified using GIS mapping, based on areas where it is physically impracticable to develop turbines. These constraints are summarised in Table 27 and include development on roads, railways and in close proximity to high voltage, overhead power lines.

Table 27: Natural and physical constraints for the location of wind turbines

Constraint	Methodology source	Details	Datasets	Type of constraint	Included in DECC statistics	Included in East of England Study
Natural and Physical constraints						
Natural resource - wind speed	DECC	Areas identified as suitable for wind turbines with speeds above 5 m/s at 45 m height	UK Wind speed database (NOABL)	Hard	Yes	Yes
Roads	DECC	Roads (A,B and Motorways) excluded and a 150m buffer adjacent to roads.	OS Strategi	Hard	Yes	Yes
Railways	DECC	Railways excluded and 150m buffer adjacent to railway	OS Strategi	Hard	Yes	Yes
Waterways	DECC	Inland waterways (rivers, canals, lakes and reservoirs) excluded	OS Strategi	Hard	Yes	Yes
Built-up areas	DECC	Built-up areas excluded	OS Strategi	Hard	Yes	Yes
Built-up areas – buffer	DECC	Buffer zone of 600m around built-up areas.	OS Strategi	Soft	Yes	Yes
Overhead power lines	AECOM	High Voltage overhead power lines and 300m buffer excluded based on National Grid's current policy that "consideration should be given to reducing the minimum layback of wind turbines from overhead power lines to three rotor diameters"[38]	OS Strategi	Hard	No	Yes
Air ports	DECC	Airports excluded	OS Strategi	Hard	Yes	Yes
Airports / Airfields – buffer	DECC	5 km buffer zone around airports	OS Strategi	Soft	Yes	Yes
Current MOD Sites	DECC	MOD sites excluded. No buffers proposed due to lack of additional information from the MOD apart from airfields.	OS Strategi MOD	Hard	Yes	Yes
Zero deployment of wind turbines assumed within National Parks		This constraint has been previously discussed with Natural England. Feedback is required as to the level of constraint (currently "consideration")	MAGIC	Consideration	Yes	Yes
Zero deployment of		This constraint has been previously	MAGIC	Considerati	Yes	Yes

[38] National Grid – internal use only, Review of the Potential Effects of Wind Turbine Wakes on Overhead Transmission Lines, TR (E) 453 Issue 1 – May 2009.

wind turbines assumed within 2km buffer of National Parks		discussed with Natural England. Feedback is required as to the level of constraint (currently "consideration")		on		
Zero deployment of wind turbines assumed within 50m of areas designated as National Trails		This constraint was applied in response to consultation with Natural England.	Natural England	Consideration	Yes	Yes
Zero deployment of wind turbines on areas designated as Heritage Coast		This constraint was applied in response to consultation with Natural England.	Natural England	Consideration	Yes	Yes
Zero deployment of wind turbines assumed within areas with international and national nature conservation designations (including SPAs, SACs, RAMSARs, SSSIs and NNRs)[39]		This constraint was applied in response to consultation with Natural England.	MAGIC website	Consideration	Yes	Yes
Zero deployment of wind turbines in areas defined as ancient woodland	DECC / AECOM	This constraint was applied in response to consultation with Natural England.	MAGIC	Soft	Yes	Yes
Zero deployment of wind turbines in areas defined as sites of historic interest. This excludes listed buildings which would be examined on a case by case basis.	DECC / AECOM	This constraint has been previously discussed with Natural England. Feedback is required as to the level of constraint (currently "consideration")	MAGIC	Consideration	Yes	Yes
Sensitivity to birds	DECC / AECOM	Lower turbine density assumed in areas of high sensitivity to birds (assumed to be 2.25 MW/km^2) Lower turbine density in areas of medium sensitivity to birds (assumed to be 4.5 MW/km^2) These constraints are applied in response to consultation with Natural England.	RSPB	Consideration	Yes	Yes
Bridleways		The British Horse Society recommends that a distance of at least 200m, but preferable 4 tip heights (equivalent to 540m in this case) should be maintained from bridleways.[40] This study assumes a 200m buffer zone.	Natural England	Consideration	Yes	Yes
Economic viability constraints						
Zero deployment of wind turbines assumed in areas where the average annual wind speeds is below 6 m/s at 45m height above ground level.		Discussion with wind farm developers has suggested that this is the minimum wind speed considered viable for commercial scale wind energy generation.	UK Wind speed database (NOABL)	Soft	No	Yes
Zero deployment of		This constraint has been applied to		Consideration	No	Yes

[39] The Conservation of Habitats and Species Regulations 2010, UK Statutory Instrument, April 2010
[40] The British Horse Society Advisory Statement on Wind Farms AROW20s08/1

wind turbines assumed within areas within 600m of residential properties.		residential properties to take into account potential adverse effects from wind turbine noise and/or visual dominance. There is no definitive guidance on this issue but the DECC methodology suggests that the minimum buffer distance that is required for a 2.5MW turbine is 600m. In practice, the minimum distance required between a wind turbine and residential properties is site specific and dependent on the characteristics of proposed turbine, the ambient background noise and the local terrain.		on		

The following designations are important considerations when identifying opportunity areas for wind turbines, but are not treated as absolute limitations or included in the analysis.

Table 28 Issues considered but not included in the assessment of the commercial wind energy resource

Constraints excluded from assessment	**Justification for not applying constraint**
Green belt	Planning decisions on wind farm applications where the Green Belt has been a material consideration have varied depending on whether exceptional circumstances were demonstrated. It is not clear where Green Belt policy will present a constraint on wind energy development, and this will need to be assessed on a case by case basis.
Local nature conservation designations (local nature reserves)	These have not been included as a constraint in accordance with national planning policy.
Electromagnetic links, such as radio links and microwave links	These have not been included as a constraint due to: (i) lack of accurate data on the location and physical characteristics of links; (ii) any buffer zones that should be maintained from links will be variable depending on negotiations with telecoms operators, who should be consulted during the planning of specific wind turbine sites
Air traffic control and radars (CAA and MoD) coverage zones	These areas were not constrained since there are already a number of wind farms located within these areas and a mitigating solution is likely to be found in the short to medium term to prevent degradation of performance. The MoD have been contacted for further advice but have not supplied any additional information.
Precision Approach Radars coverage zones (MoD)	These areas were not constrained since there are already a number of wind farms located within these areas and a mitigating solution is likely to be found in the short to medium term to prevent degradation of performance. The MoD have been contacted for further advice but have not supplied any additional information.
Tactical training areas (MoD)	These areas were not constrained since there are already a number of wind farms located within these areas and a mitigating solution is likely to be found in the short to medium term to prevent degradation of performance. The MoD have been contacted for further advice but have not supplied any additional information.
Air defence radars (MoD)	Defence radars require clear line of sight to operate effectively. However, these areas were not constrained since there are already a number of wind farms within line of sight of these radars and a mitigating solution is likely to be found in the short to medium term to prevent degradation of performance. The MoD have been contacted for further advice but have not supplied any additional information.

Shadow Flicker	Some sources recommend that a distance of up to 10 rotor diameters from homes should be maintained to avoid shadow flicker.[41] This has not been applied as a constraint in this study because it can usually be mitigated and is unlikely to affect the rate or scale of wind farm deployment.
Proximity to the electrical grid	This will be discussed qualitatively within the report.
Areas of non-designated peat	We do not have a dataset that enabled us to spatially identify these areas

Wind resource mapping information will be presented as follows:

- Hard constraints map with individual constraints at regional level
- Soft constraints map with individual constraints at regional level
- Consideration constraints map with individual constraints at regional level
- Combined map at sub-regional. Amalgamation of separate sub-constraints.

Hydro energy resource

Methodology – general description

This assessment largely follows the DECC methodology which stipulates the use of the "Mapping Hydropower Opportunities in England and Wales" report from the Environment Agency. [42]. There has been some discussion over the quality of data in this report and accompanying datasets in the methodology discussion for the South West. However at a simplistic level, the potential for hydro energy in the EoE is likely to be extremely limited due to the topology and potential errors are likely to have minimal impact on the overall regional capacity potential.

Natural resource and assumptions for energy generation

The natural hydro energy resource has been assessed using the recent Environment Agency study. A capacity factor has of 38% has been assumed for renewable electricity generation.

Technically accessible resource

The technically accessible resource is based on the Environment Agency study.

Physically accessible resource

The physically accessible resource for hydro energy generation has been considered to be the same as the technically accessible resource.

Economically viable resource

The constraints affecting the economically viable hydro energy resource are shown below in Table 29.

Table 29: Issues constraining the economically viable resource for hydro energy generation

Constraint on economically viable resource	**Justification for applying constraint**	**Source of dataset**
Zero deployment of hydro energy in areas of high environmental sensitivity.	Consultation with the Environment Agency.	Environment Agency
Zero deployment of hydro energy in areas where power output would be less than 10kW based on the head height of individual locations.	Consultation with the Environment Agency.	Environment Agency
Reduction in deployment of schemes to represent a likely uptake.	Only 10% of schemes are considered to come forward.	

[41] London Renewables/London Energy Partnership, Guidance Notes for Wind Turbine Site Suitability
[42] Mapping Hydropower Opportunities and Sensitivities
in England and Wales: Technical Report, Entec UK on
behalf of Environment Agency, 2010

Biomass

Methodology – general description

The study aims to establish the potential for energy generation from biomass resource available in the region only. It is likely that the total potential for energy generation from biomass is higher, but this will include imported biomass (from elsewhere in the UK or internationally) and is not a real measure of regional resource potential.

The methodology for biomass falls into two parts:

- Part A is an assessment based around the DECC methodology to provide a ground up assessment of biomass potential. This examines the potential sources of biomass and land availability, and makes some simple assumptions around productivity.
- Part B is a review of existing literature examining biomass availability in the region. There are many competing uses for biomass, and practicalities around collecting biomass, which the DECC methodology does not account for. Therefore existing studies will provide valuable additional information. This approach is additional to the DECC methodology and provides an alternative view to the theoretical DECC approach which has been criticised for not accounting for many other variables in the biomass supply chain.

The final assessment of resource potential will be based on both the above methods and a view taken as to the actual potential which may be achievable form biomass sources.

Part A - Natural resource and assumptions for energy generation

Energy crops

- Energy crops have been assumed to comprise short rotation coppice (SRC) and miscanthus. Existing areas of established SRC and miscanthus have been added to the land available for the natural resource.
- Land allocation for miscanthus or short rotation coppice is based on the high yield areas of the Defra Energy Crop Opportunity Maps.
- A yield of 10 oven dried tonnes (odt) / hectare (ha) has been assumed for SRC crops and 15 odt/ha for miscanthus between 2010 and 2020.
- All energy crops will be used in CHP plant, to maximise efficiency of use. (Electricity-only generation will result in large amounts of heat dumping).
- 6,000 odt represents 1MWe of installed CHP electrical capacity. A ratio of heat to power output of $2MW_{th}$ to $1MW_{e}$ has been applied.
- A capacity factor of 90% has been assumed to estimate the annual electrical output based on installed capacity.
- A capacity factor of 50% has been assumed to estimate the annual heat output based on installed capacity. This is based on AECOM experience of conducting feasibility studies for CHP schemes and reflects the fact that not all heat output will be used.

Managed woodland

- The natural resource for managed woodland comprises brash, thinnings and poor quality final crops and is based on information provided by the Forestry Commission covering both public sector and private sector woodland.
- Existing areas of established short rotation forestry (SRF) have been added to the land available for the natural resource.

- Each local authority's share of the regional wood fuel resource is equal to the proportion of the total area of woodland in the region which is within the local authority boundary.
- 50% of the fuel from managed woodland is used for heat production and 50% in CHP plants.
- The calorific value of the wood fuel resource is 12.5 GJ per oven dried tonne (odt). A conversion efficiency from wood fuel to heat of 80% has been assumed.
- A capacity factor of 34% has been used to estimate the likely installed capacity of wood fuel plant for heat production and 50% and 80% for heat and electricity production respectively from CHP plants.

Industrial woody waste

- Industrial woody waste biomass consists of sawmill co-products from primary processing of timber and construction and demolition waste.
- The amount of waste wood in each local authority will be estimated from information taken from local waste management plans.
- The available waste wood resource has been reduced by 50% to account for competing uses such as chipboard manufacture.
- Waste wood would be used in CHP plant, to generate both renewable heat and electricity.
- A fuel requirement of 6,000 odt would represent 1 MW_e of installed CHP capacity. A ratio of heat to power output of $2MW_{th}$ to $1MW_e$.
- A capacity factor of 90% has been assumed to estimate the annual electrical output.
- A capacity factor of 50% has been assumed to estimate the annual heat output. This is based on AECOM experience of conducting feasibility studies for CHP schemes and reflects the fact that not all heat output will be used.

Agricultural arisings (straw)

- Agricultural arisings consist of straw from production of wheat and oilseed rape.
- Wheat straw yield = 58% of regional wheat yield. [43]
- Oilseed rape straw yield = 144% of regional oilseed rape yield. [43]
- Straw would only be used for renewable electricity generation, not heat. Due to the large supply chains required for straw resources, it is likely that the resource will only be used in a few large plants, making the use of heat more challenging. The existing EPR straw power station at Ely operates on this principle.
- 6,000 tonnes of baled straw would represent 1 MW of installed capacity.

Part A - Technically accessible resource

Energy crops

The technically accessible resource for cultivated energy crops has been ascertained by considering three scenarios, in accordance with the DECC methodology.

1. High scenario. All available arable land and pasture (i.e. all grade1-4 agricultural land) could be planted with biomass energy crops.
2. Medium scenario. Energy crops can only be planted only on grade 3 land. The Eastern region is all defined as being under serious water stress and therefore it is assumed that a maximum of this land area could be used for energy crops as an upper limit [44].

[43] Consultation with DECC, April 2010

3. Low scenario. Energy crops can only be planted on land already submitted to the Energy Crop Scheme.

Managed woodland

The technically accessible, managed woodland resource has been determined based on the distribution of woodland across the region.

Industrial woody waste

To account for competing uses, it has been assumed that only 50% of the natural waste wood resource is available for energy generation.

Agricultural arisings (straw)

To account for competing demand for straw, such as straw bedding, it has been assumed that 1.5 tonnes of straw is required per annum per head of cattle and 200kg per annum per head of pigs in the region, up to a maximum of 50% of the total straw yield. This has been subtracted from the natural resource. This is compared with the outputs from other regional reports and consultation with farming representatives.

Part A - Physically accessible resource

The physically accessible resource has been assumed to be the same as the technically accessible resource. Previous biomass plant installations are disregarded due to unknown fuel sources.

Economically viable resource

The constraints affecting the economically viable resource are summarised in Table 31 below. It should be noted these constraints will not necessarily preclude the cultivation of biomass and all planning applications should be assessed on a case by case basis.

A number of constraints that may affect the deployment of biomass but which have not been included in the assessment are provided in Table 32.

Table 30 Issues constraining the physically accessible resource for biomass energy generation

Type of biomass	Constraint on physically accessible resource	Justification for applying constraint	Source of dataset
Energy crops	Exclusion of permanent pasture/grassland	This constraint has been applied in accordance with the DECC methodology.	MAGIC database
Energy crops	Exclusion of woodland (ancient and managed)		National Inventory of Woodland
Energy crops	Exclusion of roads and tracks		OS Strategi
Energy crops	Exclusion of areas of hardstanding		OS Strategi
Energy crops	Exclusion of rivers and lakes		OS Strategi
Energy crops	Exclusion of nature conservation areas (NNR, RAMSAR, SAC, SPA, SSSI, Local Nature Reserves)		MAGIC database
Energy crops	Exclusion of historic designations (Scheduled Monuments, Registered Battlefields, World Heritage Sites)		English Heritage

Table 31 Issues constraining the economically viable resource for biomass energy generation

Type of biomass	Constraint on economically viable resource	Justification for applying constraint	Source of dataset

[44] Water resources in England and Wales – current state and future pressures. Environment Agency. 2008.

Type of biomass	Constraint on economically viable resource	Justification for applying constraint	Source of dataset
Industrial woody waste	Reduction in deployment of 50%	Due to competing uses	
Straw	Reduction in deployment due to cattle and pigs up to 50% of total availability.	Due to competing need for animal bedding requirement	
Straw	Reduction in deployment of 50%	To account for straw left on fields as fertiliser	n/a

Table 32 Issues considered but not included in the assessment of the biomass resource

Type of biomass	Constraint excluded from assessment	Justification for not applying constraint
Energy crops	Public rights of way (PRoW).	PRoW are not mapped as a constraint because it is considered they can be located within areas of energy crop as with any other crop. The buffer zone is considered to be sufficiently small (a few metres) to cause negligible constraint on land availability.
Energy crops	SPS cross compliance buffers	It has been agreed with DECC that this will not be mapped, due to the lack of a comprehensive spatial dataset.
Energy crops	Biodiversity impacts	Natural England has been consulted on whether block planting limits should be imposed in locations with national and international landscape designations. Natural England did not propose any limits in its response.
Energy crops	Water stressed areas	The Environment Agency has been consulted about the implications of planting energy crops in water stressed areas. The response stated that water stress classification is not really relevant to crop production, as it is defined by water companies on the basis of household demand. The Environment Agency has advised that the Catchment Area Management Strategy is used as a guide to the availability of water in major aquifers and rivers for irrigation purposes and has referred to the Optimum Use of Water for Industry and Agriculture report as a source of data on water required for irrigation of these and other crops.

Part B – Review of existing data and reports

As outlined in the introduction to the methodology, the constraints assessment (Part A) of biomass will present a very theoretical view of the available resource. There are many competing uses of biomass, and difficulties in the collection and agglomeration of the resource, and these considerations need to be included when assessing the realisable potential. Therefore alongside the Part A approach, a review of existing literature is also used to compare the results and modify where necessary. These documents include both a review of regional resource availability, but also a review of national markets and demand. This allows a view on competing markets to be assessed to derive the level of biomass which is realistically available for energy generation.

Energy from waste

13.5.1 Methodology – General Description

The methodology for energy from waste largely follows the DECC methodology as outlined below.

Natural resource and assumptions for energy generation

<u>Wet organic waste</u>

Anaerobic Digestion is considered as the conversion process for generating bio-methane for energy production.

- Wet organic waste has been assumed to comprise slurry from cattle and pig farms and waste from food and drinks manufacturing.
- Figures for the number of cattle and pigs in the region have been taken from the Defra Agricultural and Horticultural Land Survey (2008).
- Each wet tonne of slurry produces 20m^3 of biogas and 1m^3 of biogas has an energy content of 5.8kWh.
- 225,000 tonnes of animal slurry represents 1MWe of installed CHP electrical capacity. A ratio of heat to power output of 2MW_{th} to 1MW_e has been applied. Note – the DECC methodology specifies 37,000 tonnes per 1MWe of installed electrical capacity. This is representative of high calorific value feedstocks (such as food waste) and the energy content of animal slurry is significantly lower, hence the revised value of 225,000 tonnes per year This assumes each wet tonne of slurry produces 20m^3 of biogas; 1m^3 of biogas has an energy content of 5.8kWh; and electricity generation efficiency of 30% with a 90% capacity factor. The biogas production figure is from "A detailed economic assessment of anaerobic digestion technology and its suitability to UK farming and waste systems", Andersons for NNFCC (2008) and is an average figure. The figure for energy content of biogas is the mid-point of the range of calorific values provided for sewage gas in DUKES (2009).
- Energy generation is considered to be in CHP mode where both the heat and electricity are used.
- 32,000 tonnes of food waste represents 1MWe of installed CHP electrical capacity. A ratio of heat to power output of 2MW_{th} to 1MW_e has been applied.
- A capacity factor of 90% has been applied to the installed wet organic waste capacity to estimate the annual electrical output.
- A capacity factor of 50% has been assumed to estimate the annual heat output based on installed capacity. This is based on AECOM experience of conducting feasibility studies for CHP schemes and reflects the fact that not all heat output will be used.

Dry organic waste

- The natural resource for dry organic waste consists of the potential for energy generation from poultry litter.
- Data on the number of broiler birds in the region has been taken from the Defra Agricultural and Horticultural Survey (2008).
- Each bird produces around 43.2 kg of poultry litter per year.
- The fuel from poultry litter is used solely for electricity generation.
- 11,000 tonnes of poultry litter represents 1MW_e of installed electrical capacity.
- A capacity factor of 90% has been used to estimate the likely energy generation from installed plant.

Municipal solid waste (MSW)

- Information is sourced on current waste generation from local waste management plans. Projections are based on the trajectories given in the Draft Regional Spatial Strategy. MSW availability for energy from waste is 25% of total MSW generation to allow for inert materials and recycling.
- MSW would be used in CHP plant, to generate both renewable heat and electricity.
- 10,000 tonnes of MSW would represent 1 MW_e of installed CHP capacity. A ratio of heat to power output of 2MW_{th} to 1MW_e.
- A capacity factor of 90% has been assumed to estimate the annual electrical output.

- A capacity factor of 50% has been assumed to estimate the annual heat output. This is based on AECOM experience of conducting feasibility studies for CHP schemes and reflects the fact that not all heat output will be used.

Commercial and industrial waste

- Data source is EERA National Study into Commercial and Industrial Waste Arisings. 80% of the waste is assumed to be collected as potential resource, and 25% of this is deemed suitable for energy from waste due to recycling and inert materials.
- C&I would be used in CHP plant, to generate both renewable heat and electricity.
- 10,000 tonnes of C&I would represent 1 MW_e of installed CHP capacity. A ratio of heat to power output of $2MW_{th}$ to $1MW_e$ has been assumed. In reality the calorific value of C&I waste may differ from MSW but the variation in waste streams makes this difficult to quantify on a generic basis.
- A capacity factor of 90% has been assumed to estimate the annual electrical output.
- A capacity factor of 50% has been assumed to estimate the annual heat output. This is based on AECOM experience of conducting feasibility studies for CHP schemes and reflects the fact that not all heat output will be used.

Landfill gas production

- Landfill gas production is assumed to be constant to 2020, with reduction in existing capacity being balanced by new capacity. Post 2020, it is expected that the capacity will reduce due to closure of existing plants and reduced levels of landfill.
- The gas captured from landfill sites is used for electricity generation only.
- A capacity factor of 60% has been assumed to estimate the annual electrical output.

Sewage gas production

- All plants currently operational will be in operation by 2025.
- The gas captured from sewage gas sites is used for electricity generation only.
- A capacity factor of 42% has been assumed to estimate the annual electrical output.

Technically accessible resource

- It has been assumed that 80% of the slurry resource can be collected for energy generation.
- To account for competing uses, it has been assumed that only 50% of the food and drink waste resource is available for energy generation.
- It has been assumed that all of the dry organic waste resource will be available for energy generation.
- It has been assumed that 35% of the MSW resource and 50% of the C&I resource will be available for energy recovery by 2020.
- No further constraints have been applied to calculate the technically accessible resource from landfill gas production and sewage gas production.
- It is assumed that there will be no additional capacity from Landfill gas post 2020 due to reduction in biodegradable element. It has been assumed that 65% of biodegradable MSW will be recycled or composted due to LATs.

Physically accessible resource

The DECC methodology does not identify further constraints that could be applied to calculate the physically accessible resource.

Economically viable resource

The DECC methodology does not identify further constraints that could be applied to calculate the economically viable resource.

Large Scale Solar PV arrays

The UK Government Feed In Tariffs (FITs) provide a guaranteed revenue for renewable electricity schemes, and have resulted in high levels of interest in large scale PV farms (of up to 5 MW capacity). Large scale PV farms are not included in the DECC methodology and therefore this study develops a new methodology to assess the contribution that these systems could make to overall levels of renewable energy generation.

Natural resource and assumptions for energy generation

- A natural solar resource of around 1150 kWh/m^2 per year is assumed. This is based on the Photovoltaic Geographical Information System (PVGIS)
- A PV panel power density of 1 kWp per 7 m^2 of panel is assumed.

Technically accessible resource

- To allow for access and banked arrays, around 25% of the available ground area is covered resulting in an effective density of 1 kWp per 30 m^2. This is based on AECOM experience of working on projects with a 3.5MW farm requiring 10 ha of land.
- The amount of land available for arrays will be dependent on a number of factors including competing demands. Therefore this study uses the same land availability assessment as used for energy crops to provide an alternative use of the equivalent land.
- Additional area constraints are under consideration and will be refined during the analysis.

Physically accessible resource

It has been assumed that the physically accessible resource is the same as the technically accessible resource.

Economically viable resource

The realisable delivery of large scale PV farms is heavily dependent on subsidy through the FITs, and recent Government announcements have suggested that these will be reduced for large PV farms. The commercial potential for the development of farms is therefore currently uncertain. A simplistic approach is taken for this study of up to 10% of the physically accessible resource becoming economically viable by 2020.

Microgeneration

Methodology – general description

Under the term “microgeneration” the following main technology types are considered:

- Solar water heating
- Photovoltaics (building mounted)
- Ground source heat pumps
- Air source heat pumps
- Micro wind

- Small scale wind
- Micro CHP

There are a number of potential difficulties in assessing the potential and uptake of microgeneration technologies. In particular the technologies are all relatively immature in the UK market and there is a corresponding lack of historical uptake information, and the performance characteristics and potential improvements in many of the technologies are uncertain. Another key uncertainty is the cost of the technology – at present most microgeneration technologies are uneconomic without some form of subsidy. The Feed In Tariff (FIT) provides a subsidy for electricity generating technologies and has resulted in a significant increase in uptake. However the proposed Renewable Heat Incentive is currently not finalised by the UK Government and the final proposals could have a big impact on the cost effectiveness of the various technologies and therefore eventual uptake.

One approach to evaluate the potential uptake of microgeneration technologies is to simulate the potential consumer demand based on established "willingness to pay" techniques. A report for BERR (now BIS) in 2008 conducted analysis for the UK, and some regions separately, using this approach[45]. Whilst this does offer one possible view on what may happen, there are a large number of assumptions required in the modelling, and the results can be very sensitive to these assumptions.

For this report, a simpler and more transparent approach is taken. This falls into two parts:

1. Assess the potential capacity for the different technologies based on basic suitability rules.
2. Estimate a reasonable level of uptake by 2020 given current and historic consumer behaviour.

The basic methodology follows that suggested in the DECC methodology, but additional constraints are added to reduce the potential to levels which are representative of economic viability. The eventual uptake of microgeneration technologies will depend on a number of factors, not least the large unknowns of technology performance and economics. Therefore it is important that this study provides as assessment of approximate capacity (order of magnitude) rather than precise predictions. This will allow an assessment of the contribution that microgeneration may make in the overall regional renewable energy generation.

Photovoltaics

Photovoltaic arrays are considered under microgeneration as building mounted. Large independent PV arrays are discussed elsewhere.

Constraint type	**Details**
Existing buildings potential	- 25% of all dwellings - 40% of all commercial properties - 80% of all industrial properties
New development potential	- 50% of all buildings
System capacity	- 2kW Domestic - 5 kW Commercial - 10 kW Industrial
Realistic uptake	- Existing domestic – 10% of potential - Existing commercial / industrial – 25% of potential - New build – 25% of potential

[45] "Growth Potential for Microgeneration in England, Wales, and Scotland". BIS. 2008.

Solar thermal

The assumptions for solar thermal systems are similar to those for solar PV.

Constraint type	Details
Existing buildings potential	- 25% of all dwellings
New development potential	- 50% of all dwellings
System capacity	- 2kW Domestic - No / limited potential (commercial and industrial)
Realistic uptake	- Existing domestic – 10% of potential - New build – 25% of potential

Heat pumps

Ground source heat pumps use either horizontal or vertical collector arrays. Surface arrays are used for smaller schemes where sufficient surface area is available, and generally have a lower cost. All domestic installations are assumed to be surface based. Vertical loops require boreholes to be drilled, or for collectors to be installed within foundation piles on new build projects. Some commercial applications may be vertical where sufficient land area is not available.

Air source heat pumps extract thermal energy from the air and therefore are not constrained by land area. They are generally less efficient than ground source systems and so unlikely to be installed in preference to a ground source system where the latter is viable.

The low temperature output of heat pumps means that they are only suitable for relatively efficient buildings, and the age restrictions in the constraints represents this.

Constraint type	Details
Existing buildings potential	- 100% of post 1980 dwellings off gas grid - 25% of commercial off gas grid - 25% of industrial off gas grid
New development potential	- 50% of all dwellings - 50% of all commercial - 50% of all commercial
System capacity	- 5kW Domestic - 25 kW commercial - 50 kW Industrial
Realistic uptake	- Existing domestic – 20% of potential - New build – 25% of potential

Micro CHP

Domestic micro CHP systems are currently pre-commercial and under trial by a number of manufacturers. There are a large number of systems currently being trialled and after some false starts, it appears that commercial systems will soon be available. Most systems are based around Stirling engines and this study only considers this technology type. Fuel cell CHP systems are also being developed but these have a longer commercialisation timeframe. Stirling CHP systems operate best in dwellings with a high thermal demand and the constraints reflect this.

Commercial scale micro CHP systems are more commercial and are based around internal combustion engines. One key driver for commercial CHP is to achieve economic operation and at the smaller scale, CHP is less efficient and more expensive per kW, therefore the uptake is currently relatively low.

Constraint type	**Details**
Existing buildings potential	- 100% of pre 1920 detached and semi detached homes on gas grid - 10% of commercial on gas grid
New development potential	- 0% of all dwellings - 0% of all commercial
System capacity	- 1 kWe Domestic - 50 kWe commercial
Realistic uptake	- Existing domestic – 10% of potential - Existing commercial – 10% of potential

Micro and small wind

Micro wind turbines are typically around 2 m diameter and 1 kWe capacity. After much interest around 2005/2006, recent trials have demonstrated that the location and installation of the turbines is critical to successful operation and that the resultant market is likely to be much smaller than initially thought [46]. Wind turbines are susceptible to turbulence and low wind speeds in built up areas, and therefore best suited to open rural areas.

Small wind turbines are typically in the order of 10 – 20m high (hub height) with common sizes of 6 kW and 15 kW. There require sufficient installation space and like micro turbines, are best suited to areas with a good undisturbed wind resource. However their greater height and lower susceptibility to turbulence means that they can (and are) installed in more urban locations where a reasonable resource may be obtained (for example, large car parks or low rise industrial estates).

Due to the importance of an undisturbed wind flow and the susceptibility to local surroundings, the performance of small and micro scale wind is far less dependent on the theoretical wind speed (which does not account for these factors). This study does not therefore consider wind speed when assessing these turbines (this is a departure from the DECC methodology).

[46] Warwick Wind Trials Project. 2008.

Constraint type	Details – micro wind	Details – small wind
Existing buildings potential	• 10% of rural detached houses • 0 % commercial	• 1% rural detached houses (representing farms) • 10% rural commercial • 1% urban commercial
New development potential	• 0% domestic • 0% commercial	• 1% of new homes (1 per 100 homes) • 10% of new rural commercial and industrial buildings • 1% of new urban commercial and industrial buildings
System capacity	• 1 kW	• 6 kW
Realistic uptake	• 25%	• 10% rural detached houses • 10% rural commercial and industrial • 10% new build (domestic, commercial, and industrial)