9 Recommendations for further work

The aim of this chapter is to set out how individual local authorities, and other key stakeholders, can use and build on the outputs from this study.

IntroductionThe outputs provided by this study, for each local authority, consist of:

1. An estimate of the maximum economic potential for each type of renewable energy technology or resource type,
2. A set of Energy Opportunities Plans (EOPs) consisting of GIS data layers and maps showing the location of schemes, resource and constraints, where appropriate.

A key aim of this study was to try to collate and carry out as much analysis as possible using national and regional datasets to minimise the additional amount of evidence base work that would be required at a local authority level. We believe we have done that, and that the EOPs produced by this study provide sufficient evidence for a local authority to develop general policies in support of renewable energy as part of a core strategy. However, there is more value that can be added to this data at a local authority. We see these areas of further work to be as follows:

1. Developing local authority area wide targets for renewable energy;
2. Developing a more detailed EOP to inform planning policy, development management and wider corporate and strategic action.

The further local work that would be required for each is set out in more detail below.

9.1 Local authority targets for renewable energy

Individual local authorities, or sub-regional groups of authorities, may wish to set area wide targets for renewable energy generation. These targets may take the form of installed capacity in MW, or annual energy generation in MWh or a proportion of energy demand in %. There could be separate targets for renewable electricity and heat, or an overall target.

Such targets can provide a useful benchmark for an area of the scale of deployment that will be required to make a meaningful contribution to the UK renewable energy targets by 2020. It also can act as a stimulus for corporate and wider stakeholder action to assist in increasing the deployment of renewable energy.

In order to develop the renewable energy potential figures that have been supplied as part of this study into a target, the further work that would be required at a local authority level is likely to consist of the following:

- Engage with relevant local stakeholders to explore how much of the potential for each resource set out in this study is likely to be realised, given more detailed local information on constraints, proposals and plans. This study sets out some examples of scenarios that could be used.
- Consider issues of resource allocation between local authorities. One issue with trying to develop targets at a local authority level is that resources such as biomass and energy from waste do not respect boundaries. Therefore, one local authority may contain an energy recovery facility that takes waste from a neighbouring local authority. The first local authority would see a contribution to its renewable energy generation target whilst the second wouldn't. Therefore, if you know that there are plans or proposals for these sort of facilities in neighbouring authorities, you should discount any contribution from this resource towards your own target. Conversely, if your area is to host such a facility, then this could enable a higher target.
- Once suitable possible targets or target ranges have been agreed, these would then need to be taken through the local authority political approval process

9.2 Developing the EOP for policy and corporate use

By its nature, this study has been restricted to using regional and national datasets. However, there is additional data available at local authority level that can be superimposed (in GIS format) to the EOPs to add more value, particularly in relation to potential heat loads, and we recommend that local authorities should do this. This could then be used to inform planning policy, development management and wider corporate and strategic action. The additional data could include:

- Candidate sites for new developments
- Strategic new development sites
- Preferred sites for locating energy recovery facilities
- Public sector buildings
- Local authority or public land ownership

- Fuel poverty data
- Social housing
- Local knowledge of potential renewable heat customers
- Local environmental or landscape constraints, such as Local Nature Reserves, or greenbelt

The local authority will have many of these datasets available in house, or could engage with local public sector or other stakeholders to obtain them.

Specifically in relation to wind power, this regional study has used the OS Strategi dataset to identify the location of existing dwellings. A disadvantage of this dataset is that it assumes that there are no (commercial scale) wind power opportunities in urban areas. If a local authority wanted to have a picture of the potential for brownfield wind development in their urban areas, then they may wish to commission a more detailed wind assessment that would make use of Address Point data or OS MasterMap data.

9.3 Using the more detailed EOP

This enhanced EOP can then be used to facilitate the deployment of renewable and low carbon energy. These include:

- Informing the setting of renewable energy or carbon reduction targets for new development sites or areas;
- Assist in identifying strategic areas for renewable energy deployment, as part of Area Action Plans or Core Strategy development. This may require more detailed viability assessment;
- Assisting development management in terms of developing site briefs, or discussion with developers around incorporating renewable energy into new developments;
- Assist in identifying locations for energy from waste facilities to deal with residual MSW, and identify potential heat loads;
- Identifying areas of potential for district heating networks, as a starting point for more detailed viability assessment;
- Informing corporate action to facilitate the deployment of low carbon and renewable energy. This could involve action in any number of the following roles:
    - Land owner,
    - Procurement of energy services,
    - Financing and delivery vehicles,
    - Property developer,
    - Transport infrastructure,
    - Waste management,
    - Leadership.

Appendices

Appendix A Detailed description of methodology

A.1 Identification of installed capacity

Since the installation of renewables is not recorded consistently and in one place, details of installed capacity had to be aggregated from a number of sources, including:

- DECC CHP database[41]
- DUKES capacity of, and electricity generated from renewable sources[42];
- RESTATS database;[43]
- UK Heat Map[44];
- Natural England dataset;[45]
- CO2 sense dataset;
- Ofgem Renewables and CHP Register, data retrieved from April 2010 to December 2010;
- Low carbon buildings programme dataset, valid to February 2010;
- Ofgem FIT Installations Statistical Report;[46]
- Microgeneration Partnership.

A.2 Heat mapping of existing stock

In order to make inferences about the viability of district heating, the concept of “heat density” has been used. This is defined by the equation below.

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

Annual heat demand [H] has been estimated using DECC data for gas consumption at the MLSOA level. The gas consumption from residential and commercial uses has been combined for each MLSOA. An 80% efficiency factor has been assumed for conversion of gas supplied to heat demand. It has been assumed that 2.6% of gas supplied to the residential sector is used for cooking, based on statistics from DECC[47] (and has consequently been removed from the figure for annual heat demand).

The number of hours [N] in a year is 8760.

The area [A] in km^2 of each MLSOA has been taken from the Generalised Land Use Database.[48]

Potential issues with this method are:

- This approach misses heat supplied by other heating fuels. These are unlikely to be viable for district heating networks anyway. A small amount of electricity will be used for heating, especially in city centre flats and commercial buildings. However it is not possible to extract this split from the data.
- The highest resolution that we can carry out heat mapping for is at MLSOA scale. A large heat load will influence the average heat density for that entire MLSOA and could be misleading.

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 district heating with CHP can be considered viable.

The heat map shows additional information that could be used to inform the identification of future potential district heating schemes. These include:

- The location and size of large public sector buildings;
- Significant commercial and industrial loads;
- Potential sources of waste heat including power generation stations;
- Existing CHP and district heating infrastructure.

A.3 Microgeneration uptake in existing stock

The potential uptake of renewable microgeneration technologies in the existing housing stock and in the bulk of the existing non-residential building stock in each local authority was projected using a spreadsheet model developed by

[41] CHP database, DECC website accessed November 2010 http://chp.decc.gov.uk/app/reporting/index/viewtable/token/2
[42] Digest of United Kingdom energy statistics, DUKES database
[43] RESTATs, DECC website accessed November 2010, https://restats.decc.gov.uk/cms/welcome-to-the-restats-web-site
[44] UK heat map, DECC website accessed November 2010 http://chp.decc.gov.uk/heatmap/
[45] Wind turbine developments potentially relevant to the North, South and West Yorkshire, East Yorks & Humber, Natural England dataset, provided November 2010
[46] 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

[47] The UK Low Carbon Transition Plan, DECC, July 2009
[48] Topics, Neighbourhood Statistics website, Office for National Statistics, accessed October 2010

AECOM. This forecasts the uptake of microgeneration technologies based on information about:

- The rates at which 'Primary' systems come up for necessary replacement and at which 'Discretionary' purchases are considered;
- The current housing stock and non-residential building stock;
- The identity and attributes of 'Primary' heating system options (including some renewables) and of 'Discretionary' renewables systems; and
- The relationship between system attributes (including cost and 'nuisance' factors) and purchasing decision-making – the Choice Model.

Installations in new homes and new non-residential buildings are subject to different drivers and were considered separately (section A.4).

The system attributes assumed to influence purchasing decisions are:

- Capital cost;
- Net annual energy costs: electricity & heating fuel costs (after any renewables savings) minus any incomes from feed in tariffs, renewable heat incentive and exports of electricity to the grid;
- Annual maintenance costs;
- Whether fuel storage is required (e.g. for biomass pellets or woodchip);
- Whether the garden needs to be dug up (for ground source heat pumps installation in homes); and
- Whether additional indoor 'cupboard' space is needed (for micro-CHP units in homes, as the technology is typically larger than the generator being replaced).

The model accounts for projected real (i.e. excluding inflation) changes in costs and prices over time.

A.3.1 Rate of consideration for Primary and Discretionary systems

It is assumed in the model that householders or landlords may purchase microgeneration technologies in one of two situations:

1. As the 'Primary' heating system for a home, as a necessary replacement for a previous heat generator that has reached the end of its life. Once homes reach an age equal to the typical service life of a boiler, it is assumed that a fixed percentage of homes need a new primary heat generator each year. The replacement rate is assumed to be 6% per year. As the replacement is 'of necessity', it is assumed that one of the list of suitable heating options must be selected;
    - Condensing gas boiler,
    - Condensing oil boiler,
    - Condensing LPG boiler,
    - Direct electric heating,
    - Ground source heat pump,
    - Air source heat pump,
    - Stirling engine CHP,
    - Fuel cell CHP (non-residential only),
    - Biomass pellet boiler, or
    - Biomass woodchip boiler.
2. As a 'Discretionary' purchase where the status quo is not to have a micro generator, and therefore one of the 'system' options is not to install one. By definition, Discretionary systems may be purchased at any time. The assumption made in the model is that 10% of households and businesses consider purchasing a microgeneration system each year.

    The following Discretionary generator options are included in the model:

    - Micro-wind turbines
    - Small wind turbines
    - Solar water heating
    - Solar PV

A.3.2 Existing building stock

The rates of consideration are combined with data on the building stock to determine the number of primary heat generator replacements being selected and the number of discretionary purchases of micro generators being considered each year.

System suitability for non-residential buildings is assumed to depend only on building type. For homes, the suitability of technology options depends on:

- Home type (house or flat),
- Age (pre-1980, 1981 – 2005 or 2006 – 2016),
- Tenure (owner occupied, private rented, or social rented),
- Rurality (urban, suburban, or rural), and
- Gas connectivity (connected to mains gas or off-gas).

As such, the model requires data on:

- The current total number of homes, and the breakdown by type, age, tenure, rurality and gas connection; and
- The number (and where possible the floor area) of non-residential buildings by type.

A.3.3 Housing stock data

The modelling uses the most up to date and comprehensive data on house numbers and typology that were identified. Data on the numbers of homes in each local authority area were obtained from Communities and Local Government 'Dwelling Stock Estimates' (CLG, 2010). The breakdown of the housing stock was arrived at as follows:

- The percentage split by home type (house or flat) was based on Strategic Housing Market Assessment reports. (No SHMA was found for Doncaster, so the split was assumed to be the average for Yorkshire & Humber.)
- The percentage split by age was based on a sample of Private Housing Stock Condition Surveys published by local authorities in or around 2004.
- Percentage by tenure was taken from the last English House Condition Survey Regional Report Supplementary Tables (CLG, 2006).
- The percentage split by rurality was based on rural-urban designation of Middle Super Output Areas obtained through a custom query on the Neighbourhood Statistics portal of the Office of National Statistics website. The ONS RUURB designations are different from the 'urban – suburban – rural' split used in the model. The breakdown in the model was derived by: grouping source data for all MLSOAs designated 'Urban' and assuming 75% are 'suburban' (for the purposes of the model); grouping source data for all other MSOAs as 'rural'.
- The percentage split by gas network connectivity was based on data published on ruralfuelpoverty.org.uk (resulting from research on Hard to Treat Homes).

The housing stock classification adopted in the model results in 144 housing sub-types. The number of homes of each sub-type in each local authority is assumed to be the total number of homes multiplied by the respective percentages for type, age, tenure, rurality and gas connectivity.

The total number of homes in the stock is assumed to decline at 0.07% per year, reflecting historical rates of demolition.

A.3.4 Non-residential building stock data

The modelling uses available data on non-residential buildings, accepting that with the possible exception of Valuation Office Agency data on Bulk classes, the data are not comprehensive. The numbers of non-residential buildings by type were obtained as follows:

Bulk class types (Valuation Office Agency)

- Retail
- Offices
- Warehouses
- Factories

Other types (Local Authority data, as available)

- Hospitality
- Health
- Schools
- Leisure centres

The total number of non-residential buildings is assumed to be constant for the purposes of the model.

A.3.5 The Choice Model for projecting purchasing decisions

At the heart of the AECOM take-up model is a choice model for forecasting purchasing decisions given the attributes of alternative, competing system options. In outline, the choice model is based on the theory that consumers make decisions to maximise 'utility' – the net benefits as perceived by the consumer, and that consumers' utility calculations are based on differences in specific attributes of the available options.

Day-to-day utility calculations are largely implicit and evaluation varies from consumer to consumer. A particular type of market survey called a 'conjoint survey' was used to collect data in a way that can reveal the implicit utility calculations, given a set of what are assumed to be the key attributes. A statistical technique called 'conditional logit', a form of regression analysis, was then used to calculate the coefficients of the formulas that each group of consumers is implicitly using to make choices. The survey distinguished owner-occupiers from landlords and non-domestic building owners and, as expected, found they valued attributes differently. The survey and analysis also distinguished between 'Primary' and 'Discretionary' choices and hence developed independent uptake models. The coefficients derived were highly statistically significant, showing that within the groups identified, consumer survey responses suggested strong similarity in the implicit calculation of utility.

The benefit of the use of conditional logit analysis is that the results can be used to forecast purchasing decisions given the attributes of alternative system options. For Primary decisions, the model calculates the proportion of consumers that will select each of the suitable system options, given their attributes. (Costs, fuel prices, etc. vary over time, while non-cost attributes stay constant.) The modelling principles are identical for Discretionary decisions with the notable inclusion of "do nothing" among the system options.

A detailed mathematical explanation of the choice model is outside the scope of this report but further information on the conjoint survey and conditional logit analysis underpinning the modelling is available in the original Element Energy research report used as the basis for the model. [49]

A.4 Microgeneration uptake in new development

Our analysis was based on standard assumptions about the renewable energy output that a range of technologies could deliver for different types of building. The microgeneration technologies considered for new development were:

- Solar PV
- Solar water heating
- Air source heat pumps
- Ground source heat pumps
- Biomass boilers
- Small scale wind

We have assumed that 21,145 homes will be built annually across the region, in the locations shown in Table 23 below.

Typical development scenarios were derived from CLG research analysing the cost of Code for Sustainable Homes compliance.[50] These were used to break down homes in to different development types and estimate the mix of homes compared to flats.

Expected employment/job numbers were taken from the RSS. These were converted into potential area (in m^2) of new commercial development per building type using the "Planning for Employment Land" report produced for Yorkshire Forward in 2010[51] and an Arup report produced for the Homes and Communities Agency and Regional Development Agencies, analysing typical employment densities.[52]

[49] The growth potential for Microgeneration in England, Wales and Scotland, Element Energy, TNS, Willis, K., Scarpa, R., Munro, A., 200

[50] Code for Sustainable Homes: A Cost Review, CLG, March 2010

[51] Planning for employment land, translating jobs into land, Roger Tyms and Partners, April 2010

[52] Employment Densities: A Full Guide, Arup Economics and Planning, July 2001

Capabilities on project:
Building Engineering - Sustainability

Local authority	Annual number of homes
Barnsley	1015
Bradford	2700
Calderdale	670
Craven	250
Doncaster	1230
East Riding of Yorkshire	1150
Hambleton	280
Harrogate	390
Kingston Upon Hull, City of	880
Kirklees	1700
Leeds	4300
North East Lincolnshire	512.5
North Lincolnshire	747.5
Richmondshire	200
Rotherham	1160
Ryedale	200
Scarborough	560
Selby	440
Sheffield	1425
Wakefield	1600
York	850

Table 23 Expected residential development in Yorkshire and Humber (Source: correspondence with Local Government Yorkshire and Humber).

Size	Type	Number of dwellings	Density per hectare	% flats	% terraced	% semi	% detached	Num. flats	Num. terraced	Num. semi	Num. detached
small	brownfield	20	80	40%	35%	20%	5%	8	7	4	1
Small	greenfield	50	40	40%	30%	20%	10%	20	15	10	5
small	edge of town	10	40	0%	40%	20%	40%	0	4	2	4
medium	edge of town	650	40	30%	30%	20%	20%	195	195	130	130
medium	Urban (mixed)	350	80	50%	25%	20%	5%	175	87.5	70	17.5
Large	edge of town	3300	40	30%	30%	20%	20%	990	990	660	660

Table 24 Housing development types used in projecting renewable energy uptake for Yorkshire & Humber (Source: Code for Sustainable Homes: A Cost Review, CLG, March 2010)

Type of building	m^2
Offices B1	255
Retail & Leisure	187
Industry	1050
Storage	818
Health & Education	5000
Other	426

Table 25 Assumed gross internal area per workspace (Source: Planning for employment land, translating jobs into land, Roger Tyms and Partners, April 2010 and Employment Densities: A Full Guide, Arup Economics and Planning, July 2001)

Local authority	Offices B1	Retail & Leisure	Industry	Storage	Health & Education	Public Services Other	Other
Barnsley	3230	5000	17000	6500	5500	-920	9200
Bradford	23370	15800	26180	17500	19000	-1840	39100
Calderdale	4180	2200	-3400	3000	3500	0	8280
Craven	760	1000	-1020	500	250	0	1840
Doncaster	1140	1800	26520	3500	5250	-1380	16560
East Riding of Yorkshire	2660	3800	-3400	2000	9250	-1380	7360
Hambleton	190	800	680	1000	750	-1840	4600
Harrogate	1520	2000	340	1500	2250	-920	5980
Kingston Upon Hull, City of	6460	7000	0	-3500	7000	-1380	1840
Kirklees	1900	4000	21080	8000	6000	-1380	11960
Leeds	22800	7000	74120	22000	16250	3680	51520
North East Lincolnshire	1900	800	-680	2000	10500	1380	5060
North Lincolnshire	3040	1200	0	5000	2750	-460	5980
Richmondshire	0	1000	0	500	1000	-920	2760
Rotherham	2280	4000	13600	5000	8500	460	19320
Ryedale	380	400	680	500	500	-460	3220
Scarborough	380	400	680	0	1000	-460	3220
Selby	0	600	-680	0	250	0	-4140
Sheffield	22230	13600	8500	8000	25500	3220	47840
Wakefield	6080	7400	-5440	4500	6500	-1840	13800
York	9120	9000	7140	9000	12000	2300	10580

Table 26 Additional commercial/employment floorspace expected by new, non-domestic development in Yorkshire and Humber, in m^2 (Source: Planning for employment land, translating jobs into land, Roger Tyms and Partners, April 2010 and Employment Densities: A Full Guide, Arup Economics and Planning, July 2001)

A.5 Calculating energy output from renewable schemes

The installed generating capacity is expressed in terms of megawatts MW throughout the report. This is a measure of the maximum power that can be delivered by the technology.

The installed generating capacity is not the same as actual generation. The installed capacity must be multiplied by a capacity factor which represents the proportion that is likely to be generated in practice.

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 27. The annual generation for each technology has been expressed throughout the report in Gigawatt Hours (GWh).

Energy generation method	Load factor	Availability	Overall Capacity factor	Source of information
Commercial scale, onshore wind	n/a	n/a	30%	DECC 2050 calculator[53]
Commercial scale, offshore wind	n/a	n/a	35%	DECC 2050 calculator[53]
Hydro	n/a	n/a	38%	DECC 2050 calculator[53]
Wave	25%	90%	23%	DECC 2050 calculator[53]
Tidal stream	40%	90%	36%	DECC 2050 calculator[53]
Tidal range	24%	95%	23%	DECC 2050 calculator[53]
Biomass heat (managed woodland)	n/a	n/a	340%	AECOM experience
Biomass CHP (heat)	n/a	n/a	50%	AECOM experience
Biomass CHP (electricity)	n/a	n/a	90%	AECOM experience
Biomass co-firing (electricity)	n/a	n/a	81%	DUKES 2009[54]
Energy from dry organic waste (heat)	n/a	n/a	59%	DUKES 2009[54]
Energy from wet organic waste (heat)	n/a	n/a	80%	DUKES 2009[54]
Energy from MSW, C&I waste CHP (heat)	n/a	n/a	50%	AECOM experience
Energy from MSW, C&I waste CHP (electricity)	n/a	n/a	80%	AECOM experience
Energy from waste, landfill gas	n/a	n/a	60%	DUKES 2009[54]
Energy from waste, sewage gas	n/a	n/a	42%	DUKES 2009[54]
Small scale wind	n/a	n/a	15%	AECOM experience
Solar PV	n/a	n/a	10%	AECOM experience
Solar water heating	n/a	n/a	7%	AECOM experience
Air source heat pumps	n/a	n/a	30%	AECOM experience
Ground source heat pumps	n/a	n/a	30%	AECOM experience

Table 27 Capacity factors used to estimate annual energy generation

[53] The 2050 calculator tool, DECC, http://2050-calculator-tool.decc.gov.uk/ , website accessed January 2011
[54] Digest of United Kingdom energy statistics, DUKES database

A.6 Scenario modelling

The DECC Pathways to 2050 study was used to estimate changes in energy demand, based on scaling population rations for the UK to the Yorkshire and Humber region.

Population	2008	2010	2015	2020	2025
Yorkshire and Humber	5,231,400	5,327,500	5,572,000	5,818,000	6,055,400
UK	61,411,692	62,309,130	64,531,754	66,754,043	68,863,174

Table 28 Population estimates for the UK and Yorkshire Humber region between 2008 and 2025 (Source: 2050 Pathways Analysis, DECC, July 2010)

Four energy scenarios were modelled using different configurations of the 2050 calculator; these are described in Table 29.

A.6.1 Heating and cooling

The heat sector comprises space heating, hot water and cooling for domestic and non-domestic buildings. Non-domestic buildings include buildings within the service sector but exclude buildings in the industrial sector

A.6.2 Industry

Industrial emissions – both direct process and combustion emissions and indirect emissions from the use of non-decarbonised electricity – will be determined by the combination of future output levels and the emissions produced per unit of output.

A.6.3 Lighting and appliances

Domestic and non-domestic lighting and appliances were considered separately. Domestic products include consumer electronics, home computing, cold appliances, wet appliances and lighting. Non-domestic products include lighting, catering and computing, with other appliances grouped in a separate category.

Energy Scenario	1	2	3	4
Description	Reference case	Ambitious but reasonable effort across all sectors to improve energy efficiency	Very ambitious attempt to improve energy efficiency	Large scale electrification of regulated energy use
Average temperature of homes	Average room temperature increases to 20 degrees (a 2.5 degree increase on 2007)	Average room temperature increases to 18 degrees (a 0.5 degree increase on 2007)	Average room temperature decreases to 17 degrees (a 0.5 degree increase on 2007)	Average room temperature increases to 20 degrees (a 2.5 degree increase on 2007)
Home insulation	Average thermal leakiness of dwellings decreases by 25%	Average thermal leakiness of dwellings decreases by 33%	Average thermal leakiness of dwellings decreases by 40%	Average thermal leakiness of dwellings decreases by 25%
Home heating electrification	Proportion of domestic heat supplied using electricity is 0-10%, as today	Proportion of domestic heat supplied using electricity is 20%	Proportion of domestic heat supplied using electricity is 20%	Proportion of domestic heat supplied using electricity is 80-100%
Home heating that isn't electric	Dominant domestic heat source is gas (biogas if available)	Dominant domestic heat source is gas (biogas if available)	Dominant domestic heat source is mixture of gas/biogas, coal/biomass and heat from power stations.	Dominant domestic heat source is gas (biogas if available).
Commercial heat / cooling demand	Space heating demand increases by 50%, hot	Space heating demand increases by 30%, hot	Space heating demand stable, hot water demand	Space heating demand increases by 50%, hot

	water demand by 60%, cooling demand by 250%	water demand by 50%, cooling demand by 60%	increases by 25%, cooling demand is stable	water demand by 60%, cooling demand by 250%
Commercial heating electrification	Proportion of non domestic heat supplied using electricity is 0-10%, as today	Proportion of non domestic heat supplied using electricity is 0-10%, as today	Proportion of non domestic heat supplied using electricity is 0-10%, as today	Proportion of non domestic heat supplied using electricity is 80-100%
Commercial heating that isn't electric	Dominant non domestic heat source is gas (biogas if available)	Dominant non domestic heat source is gas (biogas if available)	Dominant domestic heat source is mixture of gas/biogas, coal/biomass and heat from power stations.	Dominant non domestic heat source is gas (biogas if available)
Home light and appliance demand	Energy demand for domestic lights and appliances increases by 20% (compared to 2007)	Energy demand for domestic lights and appliances is stable	Energy demand for domestic lights and appliances decreases by 40% (compared to 2007)	Energy demand for domestic lights and appliances increases by 20% (compared to 2007)
Home light and appliance technology	Energy used for domestic cooking remains at 63% electricity and 37% gas	Energy used for domestic cooking remains at 63% electricity and 37% gas	Energy used for domestic cooking remains at 63% electricity and 37% gas	100% electric
Commercial light and appliance demand	Energy demand for lights and appliances increases by 33%. Energy for cooking is stable	Energy demand for lights and appliances increases by 15%. Decreases by 5% for cooking	Energy demand for lights and appliances decreases by 5%. Decreases by 20% for cooking.	Energy demand for lights and appliances increases by 33%. Energy for cooking is stable
Commercial light and appliance technology	60% electricity and 40% gas (no change from 2007)	60% electricity and 40% gas (no change from 2007)	60% electricity and 40% gas (no change from 2007)	100% electric
Industrial processes	Industrial sector is same size and intensity in 2025 (no change from 2007)	Industrial sector is same size and intensity in 2025 (no change from 2007)	Industrial sector is same size and intensity in 2025 (no change from 2007)	Industrial sector is same size and intensity in 2025 (no change from 2007)

Table 29 Description of energy demand scenarios

A.6.4 Offshore technologies

It is assumed that offshore renewable energy development develops according to projections modelled in the DECC 2050 study, as shown in Table 30. The proportion serving Yorkshire and Humber region has been estimated using population rations.

Technology	UK	Yorkshire and Humber
Offshore wind (MW)	30,834	2,605
Wave (MW)	201	17
Tidal stream (MW)	40	3
Tidal range (MW)	300	25

Table 30 Estimated offshore renewable energy capacity in 2025

A.6.5 Biomass co-firing

It has been assumed that a maximum of 713MW will be included in the regional renewable energy capacity in the form of biomass cofired at coal power stations.

A.6.6 Imported biomass

The following schemes have been assumed to operate using biomass imported into the region: Drax Ouse (290MW), Drax Heron (290MW), Stallingborough Helius (65MW).

Capabilities on project:
Building Engineering - Sustainability

A.6.7 Renewable energy pathway modelling

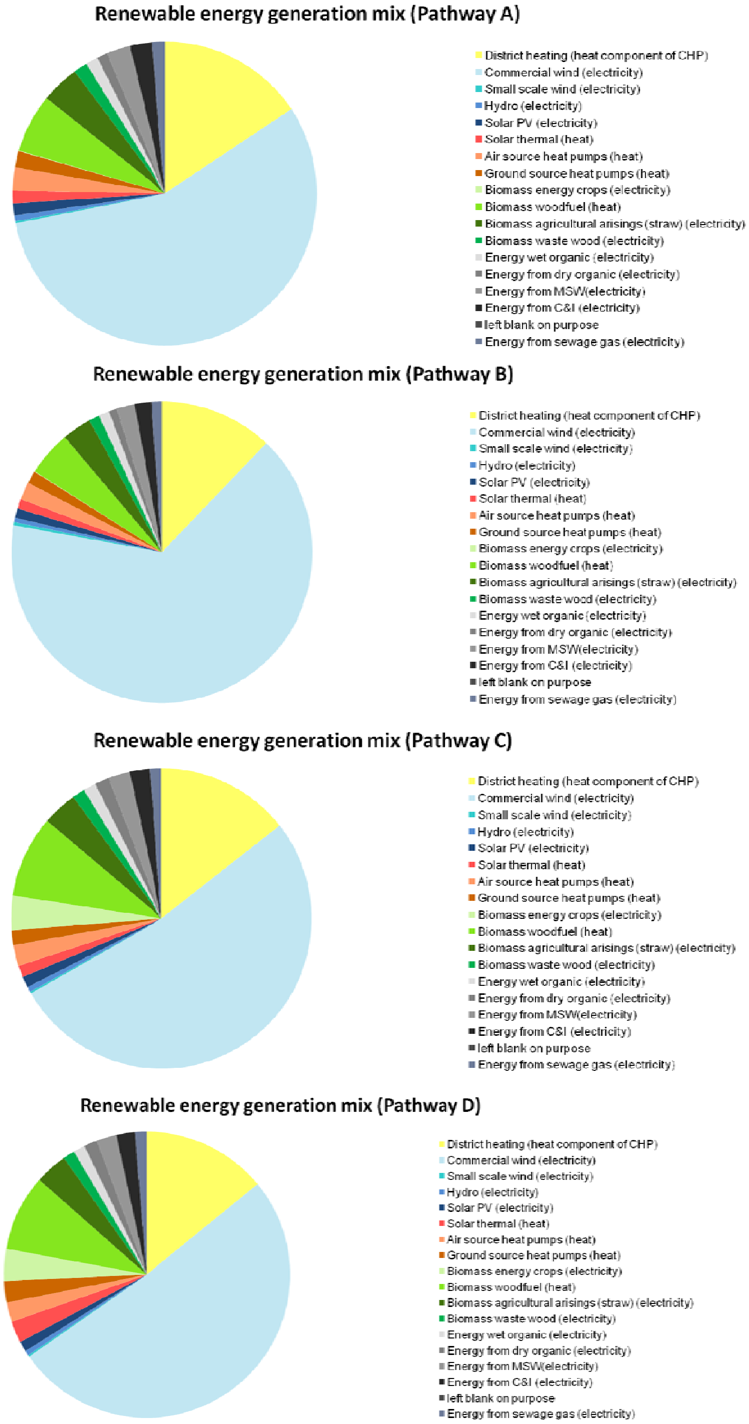

Figure 59 Breakdown of renewable energy for scenario modelling

Pathway A – EQUAL EFFORT / Technology	Maximum Potential by 2025 (MW)	Potential under scenario		Currently operational and consented (MW)
		%	MW	
Electricity				
Large wind	2702	50%	1351	427
Energy from waste				
MSW	28	100%	28	18
C&I	53	50%	26.5	
sewage gas	8	100%	7.68	8
food waste	16	50%	8	4.5
animal manures (livestock)	30	0	0	0
poultry litter	35	50%	17.5	13.5
Biomass				
co-firing	713	50%	357	104
straw	93	50%	46.5	30
waste wood	17	100%	17	31
energy crops	185	0	0	0
Hydro	26	50%	13	3
Micro generation (small/ micro wind, PV)	261	50%	130.5	??
Imported biomass (excl. Co-firing)	645	50%	322.5	65
Total			**2325**	**704**
Heat				
Heat pumps				
ASHP	149	50%	75	???
GSHP	109	50%	55	???
Solar water heating	353	50%	177	???
Wood chip boilers	450	50%	225	30
Heat from renewable CHP	868	50%	155	45
Total			**685**	**75**

Table 31 Assumptions used to model Pathway A - Equal effort across all sectors

Pathway B – HIGH WIND / Technology	Maximum Potential by 2025 (MW)	Potential under scenario		Currently operational and consented (MW)
		%	MW	
Electricity				
Large wind	2702	75%	2027	427
Energy from waste				
MSW	28	100%	28	18
C&I	53	50%	26.5	
sewage gas	8	100%	7.68	8
food waste	16	50%	8	4.5
animal manures (livestock)	30	0	0	0
poultry litter	35	50%	17.5	13.5
Biomass				
co-firing	713	50%	357	104
straw	93	50%	46.5	30
waste wood	17	100%	17	31
energy crops	185	0	0	0
Hydro	26	50%	13	3
Micro generation (small/ micro wind, PV)	261	50%	130.5	??
Imported biomass (excl. Co-firing)	645	50%	322.5	65
Total			**3000**	**704**
Heat				
Heat pumps				
ASHP	149	50%	75	???
GSHP	109	50%	55	???
Solar water heating	353	50%	177	???
Wood chip boilers	450	50%	225	30
Heat from renewable CHP	868	50%	155	45
Total			**685**	**75**

Table 32 Assumptions used to model Pathway B – Effort to increase the uptake of commercial scale, wind (onshore)

Pathway C – HIGH BIOMASS / Technology	Maximum Potential by 2025 (MW)	Potential under scenario		Currently operational and consented (MW)
		%	MW	
Electricity				
Large wind	2702	50%	1351	427
Energy from waste				
MSW	28	100%	28	18
C&I	53	50%	26.5	
sewage gas	8	100%	7.68	8
food waste	16	75%	12	4.5
animal manures (livestock)	30	0	0	0
poultry litter	35	75%	26.25	13.5
Biomass				
co-firing	713	75%	535	104
straw	93	75%	69.75	30
waste wood	17	100%	17	31
energy crops	185	25%	46	0
Hydro	26	50%	13	3
Micro generation (small/ micro wind, PV)	261	50%	130.5	??
Imported biomass (excl. Co-firing)	645	75%	483.75	65
Total			**2746**	**704**
Heat				
Heat pumps				
ASHP	149	50%	75	???
GSHP	109	50%	55	???
Solar water heating	353	50%	177	???
Wood chip boilers	450	75%	338	30
Heat from renewable CHP	868	50%	220	45
Total			**863**	**75**

Table 33 Assumptions used to model Pathway C – Effort to increase the uptake of biomass

Pathway D – HIGH HEAT / Technology	Maximum Potential by 2025 (MW)	Potential under scenario		Currently operational and consented (MW)
		%	MW	
Electricity				
Large wind	2702	50%	1351	427
Energy from waste				
MSW	28	100%	28	18
C&I	53	50%	26.5	
sewage gas	8	100%	7.68	8
food waste	16	75%	12	4.5
animal manures (livestock)	30	0	0	0
poultry litter	35	75%	26.25	13.5
Biomass				
co-firing	713	75%	535	104
straw	93	75%	69.75	30
waste wood	17	100%	17	31
energy crops	185	25%	46	0
Hydro	26	50%	13	3
Micro generation (small/ micro wind, PV)	261	50%	130.5	??
Imported biomass (excl. Co-firing)	645	75%	483.75	65
Total			**2746**	**704**
Heat				
Heat pumps				
ASHP	149	50%	75	???
GSHP	109	75%	82	???
Solar water heating	353	100%	353	???
Wood chip boilers	450	75%	338	30
Heat from renewable CHP	868	100%	440	45
Total			**1287**	**75**

Table 34 Assumptions used to model Pathway D – Effort to increase the uptake of heat generation renewable technologies

A.7 Commercial scale wind energy resource

A.7.1 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 is known to often overestimate wind speeds in comparison 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.

A capacity factor has been assumed of 30% has been assumed for commercial scale wind energy generation.

A.7.2 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.

A.7.3 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 35 and include development on roads, railways and in close proximity to high voltage, overhead power lines.

A.7.4 Economically viable resource

The economically viable commercial scale wind energy resource has been identified through engagement with stakeholders in the region. This takes into account areas where commercial scale wind turbines are unlikely to be permitted, due to concerns over their impact on highly sensitive landscapes, for example.

The constraints affecting the economically viable resource are summarised below in Table 36. It should be noted these constraints represent issues that may affect the size or scale of commercial scale wind energy deployment. These should not necessarily preclude wind energy development and all planning applications should be assessed on a case by case basis.

A number of constraints that may affect the size or scale of wind turbines but have not been included in the assessment are described in Table 37.

Constraint on physically accessible resource	Justification for applying constraint	Source of dataset
Wind speeds below 5 m/s	The DECC methodology states that this represents the wind speed below which commercial scale wind turbines will not operate efficiently.	UK wind speed database (NOABL)
Buffer of 150m either side of major carriageways	This constraint has been applied in accordance with the DECC methodology, which suggests that a buffer of "topple distance plus 10%" should be considered.	OS Strategi
Buffer of 150m either side of railway lines.	This constraint has been applied in accordance with the DECC methodology, which suggests that a buffer of "topple distance plus 10%" should be considered.	OS Strategi
Buffer of 3 rotor diameters, equivalent to 300m, either side of high voltage, overhead power lines	This constraint is 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."[55]	
Buffer of 5m to represent main rivers	This constraint has been applied in accordance with the DECC methodology.	OS Strategi
Buffer of 4m to represent secondary rivers	This constraint has been applied in accordance with the DECC methodology.	OS Strategi
Buffer of 2.5m to represent canals	This constraint has been applied in accordance with the DECC methodology.	OS Strategi
Exclusion of lakes and reservoirs	This constraint has been applied in accordance with the DECC methodology.	OS Strategi
Buffer of 5km from airports and other aerodromes	This constraint has been applied in response to consultation with the major airports in the region and with Defence Estates, who are responsible for safeguarding MoD operations.	Defence Estates CAA
Exclusion of MoD estate	This constraint has been applied in accordance with the DECC methodology and in response to consultation with Defence Estates, who are responsible for safeguarding MoD operations. The constraint has been applied to take into account possible adverse effects arising from impingement on physically safeguarded surfaces.	Defence Estates

Table 35 Issues constraining the physically accessible resource for commercial wind energy generation (considered in Part B of study).

[55] 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

A.7.5 Landscape sensitivity

The main barrier to deployment of commercial scale wind turbines is visual impact. This study has adopted the methodology in SREATS for assessing landscape sensitivity. The study used the descriptions provided by the 26 National Character Areas within and around Yorkshire and Humber to characterise the sensitivity of a landscape and its capacity to accommodate change. A sensitivity score from low to high was then applied based upon physical and perceptual criteria, including:

Physical criteria -	Landform and shape
	Settlement
	Landscape pattern
	Visual composition
	The effect of the other character areas
Perceptual criteria -	How the landscape is experienced
	Remoteness/modification/naturalness

It should be noted that although this approach takes into consideration visual composition, i.e. the nature of the views within the landscape, and an understanding of how the landscape is experienced, it does not take into consideration the scale of potential viewers.

These criteria were brought together to give an overall combined sensitivity score, which was combined with the biodiversity assessment to generate a four tier hierarchy of sensitivity zones. A cap was applied to each zone for the maximum size of wind farm that could be accommodated due to the landscape sensitivity

Zone 1 - Areas of greatest sensitivity to wind energy development and therefore least opportunity for development.

Zone 2 - Areas of high sensitivity to wind energy development, with little opportunity for development other than some very localised sites where limited proposals could be accommodated if all potential impacts on natural heritage interests were fully explored and mitigated against.

Zone 3 - Areas with some sensitivity to wind energy development. Within these areas, there is likely to be scope to accommodate development of an appropriate scale, siting and design and taking regard of cumulative impact.

Zone 4 - Areas with the lowest sensitivity to wind energy development and the greatest opportunity for development.

The Delivering Sustainable Energy in North Yorkshire study (2005) provided an assessment of wind turbine development in North Yorkshire and incorporated a sensitivity assessment based on landscape character. Although the findings of the two studies are similar, there is some variation in the sensitivity assigned to the following locations:

Teesdale Lowlands – This area is shown as low sensitivity in the SREATS study sensitivity study, but is found to be of medium or medium-low sensitivity in the North Yorkshire study due to the more localised scale of assessment.

Vale of Pickering and Yorkshire Wolds – Within the SREATS study this area was covered by two landscape units, whereas it was covered by eleven landscape units in the North Yorkshire study. As such, the North Yorkshire study has been able to refine the understanding of sensitivity in this area considerably. It found that ‘the eastern part of the Vale of Pickering and the plateau of the Yorkshire Wolds, to be of medium-high sensitivity’. ‘In the western part of the vale, the landscape is more open, and of larger scale, with a less distinctive relationship with the hills to north and south. The coastal areas are more settled, with more evidence of man’s activities and a busier character than the more tranquil inland areas. For these different reasons, the western part of the Vale of Pickering and the coastal area around Scarborough and Filey are considered to be of lower sensitivity than the National Character Areas 26 and 27 as a whole’.

Harrogate area – The area around Harrogate, from Harrogate Toto Otley and Blubberhouses is considered to be of lower sensitivity than the rest of National Character Area 22 which extends north along the eastern fringe of the Yorkshire Dales National Park. This is because there is a stronger settled influence in this area’.

Weningdale and Ribblesdale – This area has been identified as being of medium-high sensitivity to wind development in the North Yorkshire study, but of high sensitivity in the SREATS study.

A.7.6 Cumulative impact

Once the above constraints had been applied, the remaining area was subjected to a cumulative impact assessment. There is currently no nationally accepted methodology for undertaking strategic appraisals of the effects of more than one wind farm. This study has adopted a bespoke approach, which assesses the probability of a wind farm within the identified areas, and then examines the probability of neighbouring wind farms being developed.

Capabilities on project:
Building Engineering - Sustainability

Constraint on economically viable resource	Justification for applying constraint	Source of dataset
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)
Zero deployment of wind turbines assumed within areas within 600m of urban settlements	This constraint has been applied to 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 the proposed turbine, the ambient background noise and the local terrain.	OS address points database
Zero deployment of wind turbines within 500 m of existing wind turbines	Existing wind farms were assumed to cover an area $A \ in \ km2 = \frac{existing\ capacity\ in\ MW}{9MW/km2}$ This constraint has been applied to take into account the adverse turbulence effects produced by rotating turbine blades which could reduce energy output in nearby turbines.	Restats RenewablesUK Stakeholder consultation
Zero deployment of wind turbines assumed within 2km of National Parks	This constraint was applied in response to discussion with Natural England. It should be noted that this constraint was applied in order to quantitatively estimate the economically viable resource for the region. Existing planning policy makes clear that it is not appropriate to apply buffers around National Parks in assessment of planning applications.	MAGIC website
Zero deployment of wind turbines assumed within 2km of National Parks AONBs	This constraint was applied in response to discussion with Natural England. It should be noted that this constraint was applied in order to quantitatively estimate the economically viable resource for the region. Existing planning policy makes clear that it is not appropriate to apply buffers around AONBs in assessment of planning applications.	MAGIC website
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
Zero deployment of wind turbines on areas	This constraint was applied in response to consultation with Natural England.	Natural England

Constraint on economically viable resource	Justification for applying constraint	Source of dataset
designated as Heritage Coast		
Zero deployment of wind turbines assumed within areas with international and national nature conservation designations (including SPAs, SACs, RAMSARs, SSSIs and NNRs)[56]	This constraint was applied in response to consultation with Natural England.	MAGIC website
Zero deployment of wind turbines in areas defined as ancient woodland	This constraint was applied in response to consultation with Natural England.	MAGIC website
Zero deployment of wind turbines in areas defined as sites of historic interest	This constraint was applied in response to consultation with Natural England.	MAGIC website
Zero deployment of wind turbines in areas with high landscape sensitivity	Classification of landscapes was taken from SREATS. In addition, the northern Dark Peak capacity area was classified as "high sensitivity," based on the South Pennines study	SREATS South Pennines study
Lower turbine density assumed in areas of medium to low landscape sensitivity	Low sensitivity was assigned to landscape capacity area 5 (i.e. can accommodate large wind farms), with a maximum of two further large wind farms, in addition to Ovenden Moor Wind Farm. Up to 7.5 MW was allowed within landscape capacity area 6. Up to 1 large wind farm was allowed in the south east within landscape capacity area 8 Up to 12.5 MW was allowed in the west or south west within landscape capacity area 8 and in landscape capacity area 9. Up to 15 MW was allowed in landscape capacity area 10.	SREATS South Pennines study
Zero deployment of wind turbines assumed in areas of deep peat	This constraint was applied in response to consultation with Natural England.	British Geological Survey

[56] The Conservation of Habitats and Species Regulations 2010, UK Statutory Instrument, April 2010

Capabilities on project:
Building Engineering - Sustainability

Constraint on economically viable resource	Justification for applying constraint	Source of dataset
Lower turbine density assumed in areas of high sensitivity to birds (assumed to be 2.25 MW/km^2)	This constraint was applied in response to consultation with Natural England.	RSPB
Lower turbine density in areas of medium sensitivity to birds (assumed to be 4.5 MW/km^2)	This constraint was applied in response to consultation with Natural England.	RSPB
Separation distance between all wind farms (i.e. established and future schemes) of 10km	This constraint was applied to take account of cumulative impact.	n/a
Additional resource added representing potential turbines in urban areas.	It was assumed that the following local authorities had potential for an additional10 MW (equivalent to 4 turbines) in urban areas: Scarborough, York, Selby, Harrogate, Bradford, Leeds, Calderdale, Kirklees, Wakefield, East Riding, North Lincolnshire, North East Lincolnshire, Barnsley, Doncaster, Sheffield, Rotherham	n/a

Table 36 Issues constraining the economically viable resource for commercial wind energy generation

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 not been consistent. It is therefore not clear whether green belts present an absolute constraint on wind energy development.
Local nature conservation designations (e.g. 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	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.

Constraints excluded from assessment	Justification for not applying constraint
zones	
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.
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.
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.
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.[57] This constraint has not been applied in this case because we did not have a dataset that enabled us to spatially identify these areas.
Shadow Flicker	Some sources recommend that a distance of up to 10 rotor diameters from homes should be maintained to avoid shadow flicker.[58] 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	Discussion with the major district network operator (DNO) in the area and with wind farm developers implied that capacity of substations to accept incoming wind energy was a significant constraint, rather than distance of wind farm from connection point.
Areas of non-designated peat	We did not have a dataset that enabled us to spatially identify these areas

Table 37 Issues considered but not included in the assessment of the commercial wind energy resource

[57] The British Horse Society Advisory Statement on Wind Farms AROW20s08/1
[58] London Renewables/London Energy Partnership, Guidance Notes for Wind Turbine Site Suitability

A.8 Hydro energy resource

A.8.1 Natural resource and assumptions for energy generation

The natural hydro energy resource has been assessed using a recent Environment Agency study into the potential across England and Wales.[59]

A capacity factor has been assumed of 38% has been assumed for renewable electricity generation.

A.8.2 Technically accessible resource

High head schemes (above 2 metres) were excluded from the assessment.

A.8.3 Physically accessible resource

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

A.8.4 Economically viable resource

The constraints affecting the economically viable hydro energy resource are shown below in Table 38.

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.	Consultation with the Environment Agency.	Environment Agency
Reduction in deployment of schemes	Only 25% of schemes are considered to come forward.	n/a

Table 38 Issues constraining the economically viable resource for hydro energy generation

[59] Mapping Hydropower Opportunities and Sensitivities in England and Wales: Technical Report, Entec UK on behalf of Environment Agency, 2010

A.9 Biomass resource

A.9.1 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 classifications have been taken from the 2008 DEFRA Horticultural Survey. Where data is not available by local authority, land has been allocated between SRC and miscanthus according to 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.
- A yield of 11 odt/ha has been assumed for SRC crops and 16.5 odt/ha for miscanthus grown after 2020.
- All energy crops will be used in CHP plant, to maximise efficiency of use.
- 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.[60]
- 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.
- The fuel from managed woodland is used solely for heat generation.
- 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 30% has been used to estimate the likely installed capacity of wood fuel plant.

Industrial woody waste

- Industrial woody waste biomass consists of sawmill co-products from primary processing of timber and construction and demolition waste.
- Commercial and industrial waste wood has not been included in the assessment at this stage as it is excluded from the DECC methodology.
- The amount of waste wood in each local authority area has been estimated on the basis of their share of regional housing targets, using figures from the RSS.
- There will be an annual increase of 1% in the waste wood streams
- The available waste wood resource has been reduced by 50% to account for competing uses.
- 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.

[60] Renewable and Low Carbon Energy Capacity Study for Yorkshire and Humber Part B: Opportunities and Constraints Mapping – Draft Report, AECOM, April 2010

- Wheat straw yield = 58% of regional wheat yield. [61]
- Oilseed rape straw yield = 144% of regional oilseed rape yield.[61]
- Straw could be used for CHP with a typical heat to power ratio of 2:1
- 6,000 tonnes of baled straw would represent 1 MW of installed capacity.

A.9.2 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.

The medium scenario was selected to be most representative of the technically accessible resource. This assumed that energy crops could only be planted only on land no longer needed for food production. This comprises all abandoned arable land and pasture and has been defined as bare and fallow and temporary grassland.[61]

Figures provided in the DEFRA Agricultural and Horticultural Survey for England (2008) for permanent grassland were not available as a spatial dataset. In order to get an approximation of the distribution of permanent pasture and grassland, the following GIS datasets were used, available from the MAGIC website at www.magic.gov.uk. It should be noted that a number of datasets were not able to be used due to data corruption.

- Draft Coastal and Floodplain Grazing Marsh BAP Priority Habitat Inventory for England Version 1.1 Natural England;
- Draft Fen BAP Priority Habitat Inventory for England Version 1.2;
- Draft Lowland Heathland BAP Priority Habitat Inventory for England Version 1.2;
- Lowland Calcareous Grassland BAP Priority Habitat Inventory for England Version 2.0.1;
- Lowland Dry Acid Grassland BAP Priority Habitat Inventory for England Version 2.0.1 Natural England;
- Lowland Meadows BAP Priority Habitat Inventory for England Version 2.0.1;
- Millennium Greens (England);
- Traditional Orchards - Provisional (England);
- Undetermined Grassland BAP Habitat Inventory for England Version 2.0.1 Natural England;
- Upland Calcareous Grassland BAP Priority Habitat Inventory for England Version 2.0 Natural England;
- Upland Hay Meadows BAP Priority Habitat Inventory for England Version 2.0.1 Natural England.

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 in the region, up to a maximum of 50% of the total straw yield. This has been subtracted from the natural resource.

A.9.3 Physically accessible resource

The physically accessible resource has been assumed to be the same as the technically accessible resource. However, It was assumed that existing biomass boiler installations contributed to installed capacity of managed woodland.

A.9.4 Economically viable resource

The constraints affecting the economically viable resource are summarised in Table 40 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 have not been included in the assessment are provided in Table 41.

[61] Consultation with DECC, April 2010

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)	Energy crops unlikely to be permitted.	National Inventory of Woodland
Energy crops	Exclusion of roads and tracks	Landscape unable to support energy crops.	OS Strategi
Energy crops	Exclusion of areas of hardstanding	Landscape unable to support energy crops.	OS Strategi
Energy crops	Exclusion of rivers and lakes	Landscape unable to support energy crops.	OS Strategi
Energy crops	Exclusion of nature conservation areas (NNR, RAMSAR, SAC, SPA, SSSI, Local Nature Reserves)	Energy crops unlikely to be permitted.	MAGIC database
Energy crops	Exclusion of historic designations (Scheduled Monuments, Registered Battlefields, World Heritage Sites)	Energy crops unlikely to be permitted.	MAGIC database

Table 39 Issues constraining the physically accessible resource for biomass energy generation

Type of biomass	Constraint on economically viable resource	Justification for applying constraint	Source of dataset
Energy crops	Reduction in deployment based on uptake of individual biomass boilers	See section A.3 for details.	AECOM uptake modelling
Industrial woody waste	Reduction in deployment of 50%	Due to competing uses.	n/a
Straw	Reduction in deployment	Due to competing need for animal bedding requirement.	n/a
Straw	Reduction in deployment of 50%	To account for straw left on fields as fertiliser.	n/a

Table 40 Issues constraining the economically viable resource for biomass energy generation

Type of biomass	Constraint excluded from assessment	Justification for not applying constraint
Energy crops	Public rights of way (PRoW).	It has been agreed with DECC that this will not be mapped, due to the lack of a comprehensive spatial dataset.
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, although

Type of biomass	Constraint excluded from assessment	Justification for not applying constraint
		questioned the yields that may be achieved in the Moors National Park due to its altitude, which is not a landscape concern.
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.

Table 41 Issues considered but not included in the assessment of the biomass resource

A.10 Energy from waste

A.10.1 Natural resource and assumptions for energy generation

Wet organic waste

- 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 $1MW_e$ of installed CHP electrical capacity. A ratio of heat to power output of $2MW_{th}$ to $1MW_e$ has been applied.
- Wet organic waste will be used in CHP for electricity and heat production. Energy generation will be through biogas production.
- Up to 500,000 tonnes of food waste will be available for energy generation in the region, based on discussion with CO2 Sense.
- 32,000 tonnes of food waste represents $1MW_e$ 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 80% 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 0.0432 tonnes of poultry litter per year per bird.
- The fuel from poultry litter is used solely for electricity generation.
- 11,000 tonnes of poultry litter represents $1MW_e$ of installed CHP electrical capacity.
- A capacity factor of 80% has been used to estimate the likely energy generation from installed plant.

Municipal solid waste (MSW)

- 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. This takes into account the fact that approximately 35% of the MSW resource will be classed as renewable. A ratio of heat to power output of $2MW_{th}$ to $1MW_e$.
- A capacity factor of 80% 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

- 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.
- A capacity factor of 80% 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

- Any plants operational before 2000 will not be in operation by 2020.
- 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.