LDĀ DESIGN

Renewables Capacity Study for Central Bedfordshire

Final Report
March 2014

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Summary

Introduction

This Renewables Capacity Study has been prepared to guide the application of planning policy on renewable energy development in Central Bedfordshire. It has also been used to highlight opportunities for investment in renewable energy projects on land owned by Central Bedfordshire Council.

Baseline and context

Central Bedfordshire is a predominantly rural area, with the main settlements at Leighton Buzzard and Dunstable in the south and Biggleswade, Sandy and Flitwick in the north of the area. The area has an undulating topography, with the Chilterns Area of Outstanding Natural Beauty (AONB) to the south, the historic Marston Vale in the north-west, the Greensands Ridge Nature Improvement Area running across the north of the area. There is a flatter area of fertile farmland around the River Great Ouse to the east, and there is a risk of flooding to land around the river and its tributaries. Over a third of land in Central Bedfordshire is designated Green Belt.

The economy of Central Bedfordshire is relatively strong, with strengths in engineering, manufacturing, logistics, agriculture, retail, tourism and leisure, and good links to larger towns and cities including London. Around 28,700 new homes are expected to be built in the area by 2031 along with commercial development sufficient to deliver an additional 27,000 jobs. Most of this development is expected to happen around the main existing settlements, and Green Belt boundaries may be redrawn to accommodate some of this growth.

National emissions reduction and renewable energy targets are currently driving deployment of renewable energy technologies, supported by a variety of policy, regulatory and financial mechanisms. The Feed-in-Tariff (FIT) and the Renewable Heat Incentive (RHI) provide reliable long-term subsidies for eligible technologies below 5MW in capacity, while Renewables Obligation Certificates (ROCs) granted to larger schemes can be traded to subsidise income. In time, ROCs will be replaced by Contracts for Difference as part of the Electricity Market Reform, providing a more stable basis for investors to forecast returns.

National planning policy for renewables is set out in the National Planning Policy Framework (NPPF), online Planning Practice Guidance on Renewable and Low Carbon Energy (PPG), and a series of National Policy Statements (NPSs). These include requirements to consider the potential impacts of proposed projects, including landscape, heritage, visual and ecological impacts and the cumulative impacts of multiple projects, and mitigate them to an acceptable level, in some cases through a formal Environmental Impact Assessment (EIA).

In addition to encouraging micro-generation for existing buildings through the FIT and RHI, uptake for new development is also expected to be encouraged by the inclusion of the zero carbon requirement in the Building Regulations from 2016. Local planning policy can also set targets for developers to provide for a given percentage of energy used by a new development to come from on-site renewable or low carbon technologies. Micro-generation for existing and new buildings is generally permitted development, provided that it meets certain criteria.

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Central Bedfordshire's draft Development Strategy (2013) takes a proactive approach to renewable energy development, which recognises the benefits but stresses that it must be appropriately located and designed to mitigate any impacts. A Guidance Note on wind energy development has been produced, which provides further detail on a series of planning considerations.

Energy demand and emissions

Current and future energy demands and emissions from existing buildings and new development were estimated from 2011 through to 2031, the period covered by the Development Strategy. The analysis used national data on actual energy consumption, benchmarks and projections in the Development Strategy for future development, and a series of assumptions about the rate of energy efficiency improvements and decarbonisation of electricity supplied from the national grid.

Our estimates indicate that total energy demand in Central Bedfordshire could rise over the Development Strategy period, largely due to increased electricity consumption. Emissions could fall overall as heating demand reduces and the carbon intensity of electricity supplied from the grid improves. New developments are likely to be responsible for only a fraction of total energy demand and emissions to 2031, demonstrating that efforts should be focused on improving energy efficiency in the existing building stock and increasing renewable and low carbon energy generation if significant progress is to be made.

Existing and proposed renewable energy development

A range of renewable energy projects already operational in Central Bedfordshire, including a 20MW wind farm, multiple landfill gas sites and a commercial-scale solar farm. A recent surge in the popularity of solar farms means that a number are currently being proposed in Central Bedfordshire, with 12 planning applications in the pipeline at the date of writing this report, the majority submitted in the last half of 2013. Further interest in wind turbines and biomass plants demonstrate that renewable energy development is relatively active in Central Bedfordshire.

Grid capacity

Capacity of the electricity grid for the connection of new power generation is a complex and continually changing picture. Where capacity is limited this can be a major constraint on development, along with distance from the nearest point of connection, significantly increasing costs and the time required to deliver projects and potentially rendering development unviable in some locations.

It is not possible to predict how much or where grid capacity will be available for development in Central Bedfordshire in future. However, UK Power Networks has published a map which provides a snapshot of current capacity. This indicates that the grid is highly utilised in the north and north east of the area, suggesting a significant constraint on development until upgrade works are completed to increase capacity. By contrast, capacity is understood to be available in western Central Bedfordshire, while significant capacity is shown as being available in central and southern parts of the area.

The majority of proposed new renewable energy development in the planning pipeline for Central Bedfordshire is located in areas which are currently indicated on the map as having available capacity. If these are built, they may further constrain capacity for additional development.

In the long term, major upgrades will be needed to the distribution networks and the national transmission network, managed by National Grid, to release further capacity for renewable energy generation. Improvements will also be needed to manage supply and demand on the system, including smart grid technology to monitor and control the system and additional infrastructure for storing power and releasing it at times of peak demand. On this basis, it has been assumed that grid capacity will not be a constraint on development in the long term, and may be resolved within the period covered by the Development Strategy.

Potential capacity for renewable energy development

Total potential capacity for a range of renewable energy technologies in Central Bedfordshire has been estimated with regard to a range of planning and technical considerations. Renewable energy resources and potential constraints on development have been mapped for each technology, and these figures are provided in the main report. Our approach builds on previous work in the area including the East of England Renewable and Low Carbon Energy Capacity Study (2011), itself based on the DECC Methodology for the English Regions (2010).

The results are shown in Figure 1to Figure 3, in terms of the total potential generating capacity (MW), annual electricity or heat output this capacity could produce (MWh per year) and annual carbon savings resulting from this (tonnes per year). Where relevant, a lower and higher estimate is provided, based on different assumptions about how some considerations are addressed during the planning process and the density of development which takes place.

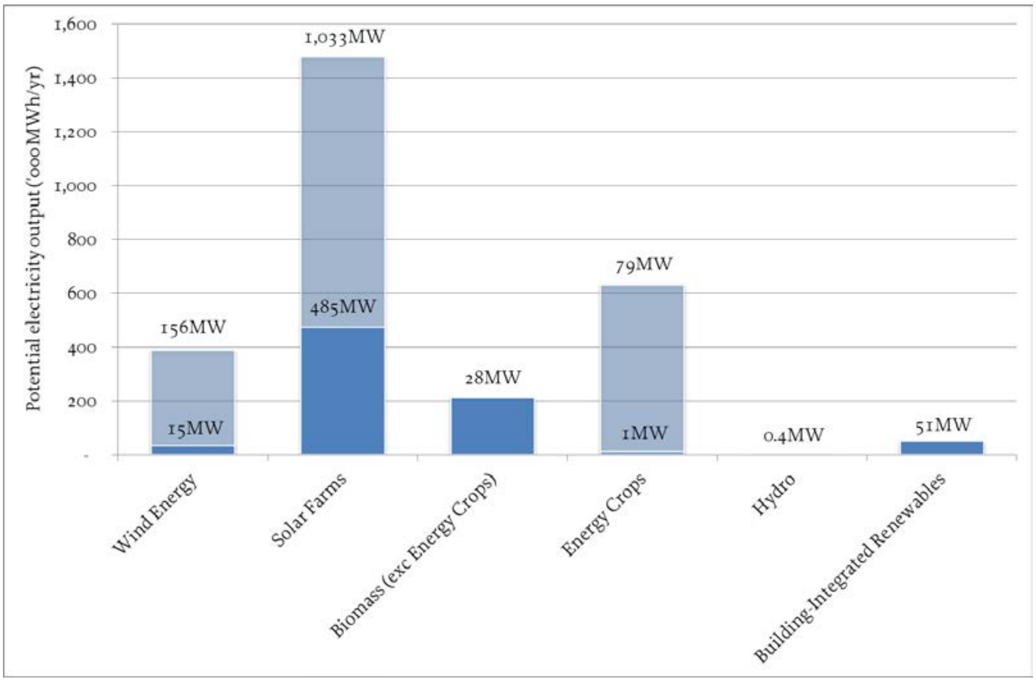


Figure 1: Total potential capacity for electricity generation in Central Bedfordshire

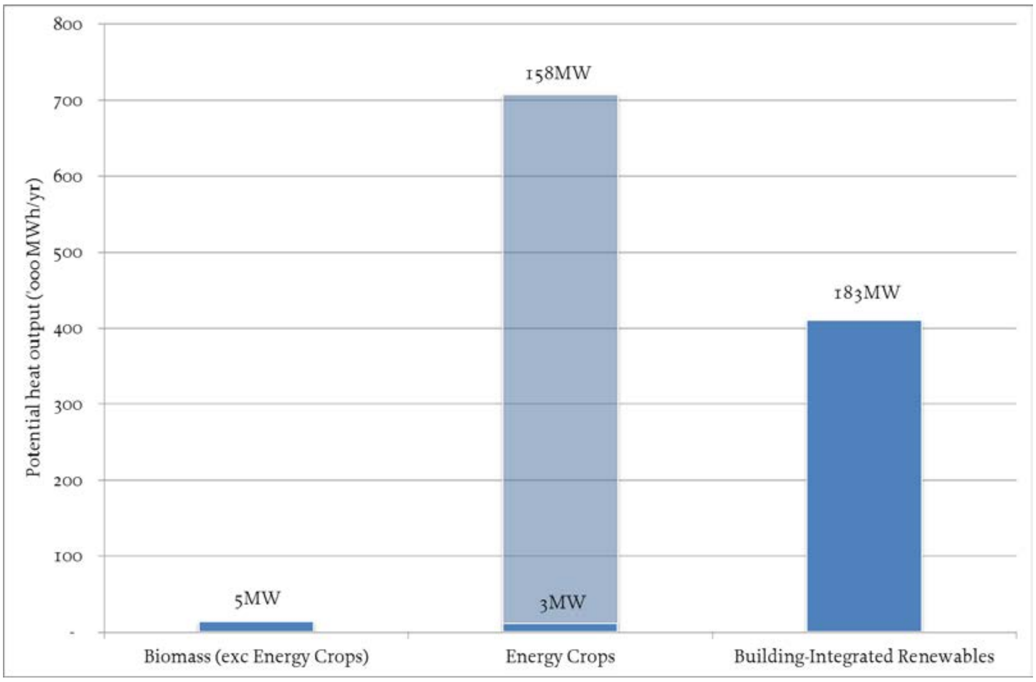


Figure 2: Total potential capacity for heat generation in Central Bedfordshire

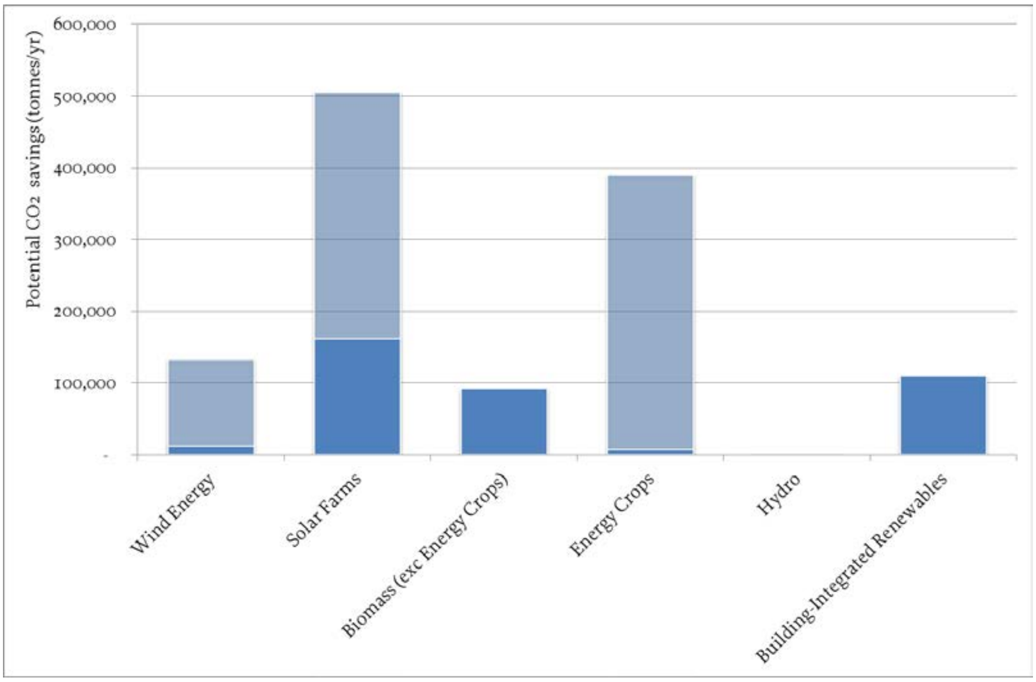


Figure 3: Total potential capacity for carbon savings from renewables in Central Bedfordshire

Overall, our assessment suggests that solar farms have the greatest potential for development in Central Bedfordshire, followed by wind energy, energy crops and other types of biomass and building-integrated renewables, with relatively negligible opportunities for hydropower. It is important to note that this is a high-level assessment of total potential capacity, and in practice the issues discussed here will need to be considered on a site-by-site basis as part of the planning process.

In estimating potential for wind energy, exclusion areas have been assumed to include urban areas, physical infrastructure, ancient woodlands, and sites with heritage and ecological designations, with buffer zones applied where appropriate. Other important issues for consideration in relation to planning applications for wind energy development include landscape and visual impact, radar impacts and the appropriateness of development in the Green Belt. The lower estimate of capacity assumes that no development takes place in the AONB, areas with radar constraints, or in the Green Belt, whereas the higher estimate assumes that the impacts can be mitigated to a level where development is allowed to take place in these areas.

The same exclusion areas have been applied in the assessment of solar farm potential, although in this case no buffer zones have been applied. Landscape and visual impact and Green Belt will also be important considerations for solar farm developments, and again the lower estimate of capacity assumes no development in the AONB or the Green Belt whereas the higher estimate assumes that impacts in these areas can be mitigated sufficiently for development to go ahead. Agricultural land quality is an important consideration for solar farm developments, with national policy encouraging local authorities to safeguard the long-term potential of the best and most versatile agricultural land. For the purpose of the assessment it has therefore been assumed that development only takes place on agricultural land which is classified as grade 3 or below, although in practice a case can be made for development on higher grade land. Grid capacity is one of the most significant constraints on solar farm development currently, and could slow down the rate of development at least in the short to medium term.

The vast majority of biomass potential is dependent on the assumptions made about the amount of agricultural land used for cultivating energy crops, which would need to be considered against competing demands for other uses including food production or development including solar farms or property. Other types of biomass considered include wood from managed woodlands, agricultural arisings, poultry litter, and animal slurry. Dry, woody biomass has been assumed to be used in combined heat and power (CHP) generation or biomass boilers, straw and poultry litter in electricity generation, and wet organic waste in anaerobic digesters to produce gas for CHP generation.

It is unlikely that there is potential for any sizable CHP and district heating networks in Central Bedfordshire, particularly with regards to retrofitting district heating to existing development. This is due to the cost and complexity of such a scheme and the lack of centres of sufficiently high heat demand density in the area to justify the investment. There could however be scope for CHP plants in a number of leisure centres, such as Flitwick, as noted in Central Bedfordshire's Carbon Management Plan, although limited progress has been made to date. The potential for CHP and district heating on major new property development sites should also be considered on a site-by-site basis as part of the planning process.

In terms of micro-hydropower potential is limited by the availability of suitable watercourses. Some opportunities do exist for projects on sites which are less sensitive in ecological terms and could provide sufficient output to justify the investment, however while these could be worthwhile projects in their own right, the overall contribution to capacity in the area is likely to be negligible.

Building-integrated renewables offer good potential for heat output, using heat pumps and biomass boilers and to a lesser extent solar thermal systems. The potential is particularly great in suitable properties which are not on the gas network, because the financial case for renewable heat technologies is strong thanks to the RHI and the relatively high costs of alternative fuels such as heating oil. Roof-mounted PV could also provide significant benefits on suitable properties, providing electricity close to the point of use.

Deployment scenarios

Finally, three deployment scenarios have been developed. These look at the extent of development which may be achieved in practice by 2031, under business-as-usual conditions, and what may be needed in order to contribute to national carbon targets or supply all of the heat and power demands in Central Bedfordshire over the same time period.

The business-as-usual scenario, based on current deployment rates, the number of applications in the pipeline and available national data indicates that around 357MW or roughly half of the lower estimate of total capacity for renewable energy technologies could be delivered within the period covered by the Development Strategy.

We have assumed that a proportionate contribution to the legally-binding national target for an 80% reduction in carbon emissions by 2050 would require a 40% reduction in local carbon emissions within the Development Strategy period, which is broadly in line with the UK's 4th Carbon Budget. To achieve this would require around 713MW of renewable energy capacity, which is double the capacity in the business-as-usual scenario, or roughly equivalent to the lower estimate of total capacity for renewables in the area. Most of this scenario and the business-as-usual scenario could be achieved in theory without development in the AONB, Green Belt or on high grade agricultural land, although this would not necessarily have to be the case.

The final scenario, which considered the potential for renewable energy sources to supply all of the energy used in buildings in Central Bedfordshire, would be significantly more challenging to achieve. Based on our assessment, this would require a quantity of development in line with the higher estimate of capacity. This could include development of a significant amount of solar farm capacity in the AONB and Green Belt and/or on Grade 1 and 2 agricultural land, and the cultivation of energy crops on higher grade agricultural land.

Achieving these enhanced deployment rates could require some compromises to be made in the planning process, intervention from Central Bedfordshire Council to facilitate development for example by offering suitable sites on its own land, a change in national policy or incentives for development, or technological developments which enable greater capacities to be achieved within the same broad quantity of development.

Conclusion and recommendations

Based on the analysis presented in this report, the development of solar farms presents the greatest potential opportunity for increasing renewable energy capacity in the area. There also appears to be potential for further development of wind energy, and significant capacity could be achieved through widespread uptake of building-integrated PV and renewable heat technologies.

There is scope for cultivation of local biomass resources to provide fuel, particularly energy crops, although this will depend on competing demand for agricultural land for food production and – increasingly – solar farm development. The contribution from hydropower and district heating to total capacity is likely to be negligible, although individual projects could certainly provide local benefits which make them viable in their own right.

Although there are some physical, technical and 'hard' planning constraints which can be used to estimate capacity, many of the planning considerations discussed in this report need to be assessed on a case-by-case basis as part of the planning process. These include the extent and nature of development in and around the Green Belt and the Chilterns AONB, the extent of solar farm or energy crop development on agricultural land, and the implications of grid constraints and whether they can be overcome in time. Assessment of these and other issues as part of the planning process will need to take into account the site context, local impacts including cumulative impacts, potential for mitigation, and the acceptability of any residual impacts. We have calculated lower and higher capacity estimates for some technologies, to indicate the broad range of capacity which could be delivered depending on the outcome of these case-by-case assessments.

In addition to considering the business-as-usual rate of deployment, our assessment indicates that it could be feasible to deliver sufficient renewable energy capacity in the area by 2031 to make a proportionate contribution to national carbon reduction targets over this same period. This is based on the assumption that the planning considerations discussed above can be satisfactorily addressed and that there is sufficient capacity in the supply chain and demand among local residents for building-integrated technologies. It is not considered likely that sufficient renewable energy capacity could be delivered locally to meet all building-related energy demands in Central Bedfordshire.

Early, positive engagement with local communities will be needed to achieve the levels of deployment outlined in this report, even for the business-as-usual scenario. Communities in Central Bedfordshire could benefit from renewable energy development in a number of ways. This could include direct 'community benefits' payments from large projects, and direct financial benefits received from having a stake in the ownership of either large projects or building-integrated technologies on their own properties.

There are a number of things which Central Bedfordshire Council could do to facilitate development of renewable energy capacity in the area. These include simplifying the planning process where possible, and providing guidance, building on the progress made with the Guidance Note for Wind Energy Development. In terms of supporting growth in micro-generation, there could be a need for the Council to raise awareness of the opportunities amongst residents, provide technical support and advice, and help to facilitate development of the local supply chain, particularly if local deployment is to exceed national expectations.

Central Bedfordshire could also get involved directly in renewable energy development, by investing in projects and/or enabling development on its own land and Council-owned buildings. In addition to supporting growth, this could generate a significant income to supplement Council budgets – an approach which a number of other local authorities are already taking. There are two particular opportunities worthy of further consideration in this regard: the development of solar farms or wind energy on County Farms land (see Figure 20, below) or investment in a programme of micro-generation installation in properties across the area.

A supplementary briefing note has been prepared on this potential, detailing the estimated capacity of wind and solar farms on County Farms land, and the possibility of employing Allowable Solutions to reduce expected emissions projected for new development in Central Bedfordshire through to 2031.

1.0 Introduction

A significant amount of work has already been done to understand opportunities and constraints for renewable energy in Central Bedfordshire and develop policy and strategy for its delivery.

The East of England Renewable and Low Carbon Energy Capacity Study (2011)[i] highlighted particular opportunities in Central Bedfordshire for wind turbines, biomass and, to a lesser extent, district heating in urban areas. Recent developments since the regional study was completed mean that a refresh of the information it contains is required to provide an up to date resource for Central Bedfordshire. These developments include changes in national and local policy, the emergence of large scale solar farms as a viable investment opportunity, newly constructed or permitted renewable energy developments in the area, and increasing constraints on the electricity grid. In addition, the amount of detail that the regional study provides on Central Bedfordshire is limited and could be improved upon.

Using the regional study and other evidence, the Council has included a policy on renewable energy development in the draft new Development Strategy (2013)[ii] and developed a Guidance Note on wind development[iii]. This Renewables Capacity Study is intended to guide the application of this policy, by identifying areas where the impacts of renewable energy development can be most effectively mitigated and made acceptable. The study is also intended to identify opportunities to develop renewable energy projects on land within Central Bedfordshire Council's own estate.

To date, there are a number of renewable energy projects which are either proposed or already operational in Central Bedfordshire. This includes a 20MW wind farm at Langford, a growing number of solar farms, landfill gas sites and the Rookery South energy-from-waste development which has a Development Consent Order. An understanding of the current level of energy development in Central Bedfordshire is used to guide this report's consideration of cumulative impact and potential locations for future development.

There are a number of issues and challenges which need to be addressed to obtain an accurate understanding of potential renewable energy capacity in Central Bedfordshire and establish an appropriate framework for policy and delivery. These issues are highlighted alongside our analysis, including a discussion of how different approaches to the interpretation of various planning considerations could influence the pace, type and location of development.

2.0 Baseline and context

2.1. Central Bedfordshire

To provide suitable context for this report's analysis, the following sections cover broad characteristics of Central Bedfordshire, including the landscape, settlements, economy, and renewable energy development in the area to date. This information has been obtained from the Development Strategy 2013[ii], Landscape Character Assessment[iv], and the latest data on renewable energy planning applications[v].

Landscape and place

Central Bedfordshire is a predominantly rural area consisting of agricultural land and open countryside, with a mixture of villages and small to medium sized towns throughout. There is a rich historic environment, with almost 11,000 records relating to designated and non-designated buildings, landscapes, archaeological sites and monuments. This includes a number of heritage assets that Central Bedfordshire is committed to protecting, conserving and enhancing.

The area has an undulating topography, with the highest point at Dunstable Downs in the south, lying on the Chilterns, a large chalk escarpment deemed an Area of Outstanding Natural Beauty (AONB) and covering a substantial area of southern Central Bedfordshire. The topography slopes down in the east of the area, where flatter land is dominated by clay geologies and the River Great Ouse drainage basin and its tributaries, providing fertile farmland.

Other major landscape designations and protected areas of importance to the UK (see Figure 21 in Appendix section 1.1) include the Greensand Ridge, an area of high biodiversity value and high-grade agricultural land that runs from east to west across the north of the area, and is a Nature Improvement Area. It supports large areas of ancient woodland due to its light sandy soils and clay deposits, and contains rare geological layers such as Fuller's Earth.

The Marston Vale, a historically important geological feature that provided material for past brick-making industries, lies in the north-west of Central Bedfordshire. The remaining southern areas between the Chilterns and Greensand Ridge are designated as Green Belt, and aim to provide a buffer to further development of the larger southern urban centres. Pockets of woodland exist across the area, with higher densities situated in the central and eastern areas, containing a mix of conifer and broadleaved trees. A number of large Registered Parks and Gardens can be found in the area, particularly north of Leighton Buzzard.

The climate of Central Bedfordshire is relatively dry, and experiences a comparatively small difference between temperatures and precipitation throughout the seasons. The presence of the Great Ouse floodplain poses potential flooding risks, and is therefore a key factor in the planning and management of the surrounding landscape.

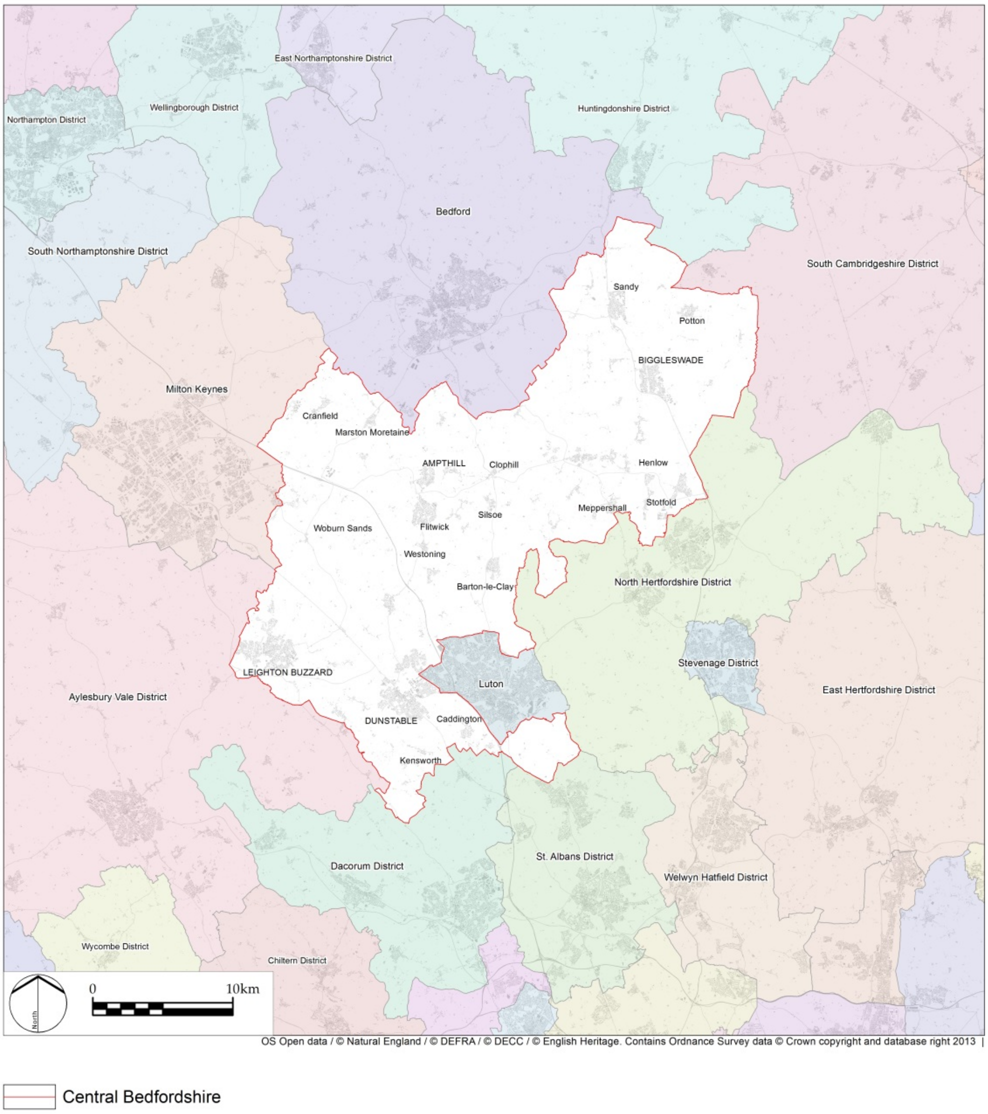


Figure 4: Central Bedfordshire and surrounding local authority areas

Population and settlements

The largest towns are Leighton Buzzard and Dunstable, located in the south of the area, whilst the smaller towns of Biggleswade, Sandy and Flitwick are located in the north. Many other smaller villages and hamlets are present amongst the remaining countryside. Just over half of the population of Central Bedfordshire lives in rural areas. It is well-connected to the major population centres of Luton, Milton Keynes and Bedford, with good access to main roads and railway lines. Multiple international airports are in close proximity, including London Luton and Stansted, alongside smaller airfields such as Cranfield.

Central Bedfordshire has a population of approximately 255,200, with a number of settlements of varying sizes. The number of people classified within the working age (16-65) equals 65% of the total population of Central Bedfordshire. The area appears to be following the national trend of significant growth in the numbers of people aged over 65, resulting in a steadily ageing population.

Economy

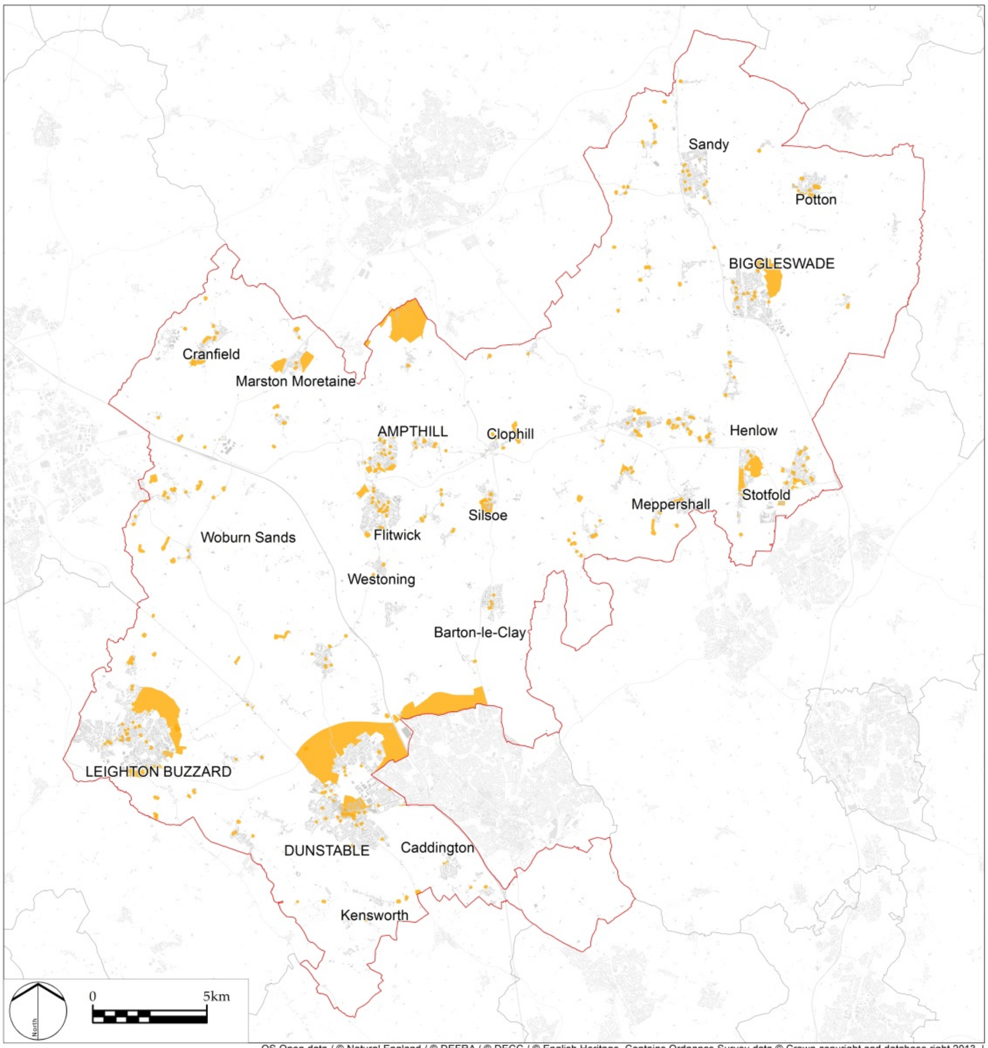
The economy of Central Bedfordshire is relatively strong compared to the national economy, and has remained resilient to the recent downturn, showing signs of higher-than-average growth in recent years. This is likely due to the diverse range of economic activity in the area, including world-leading companies such as Lockheed Martin, Amazon and B/E Aerospace, alongside a large number of small enterprises – 97% of all businesses employ fewer than 50 people. These businesses give Central Bedfordshire strengths in the engineering, manufacturing and logistic sectors, as well as an international business presence.

The town centres of the larger urban areas play an important role in both the economy and character of Central Bedfordshire, and host a wide range of retail services, including shopping centres, high street agencies and specialist retailers. Besides these employment sectors, the rural economy plays a notable role in Central Bedfordshire. Tourism and leisure are also important, and represent rapidly growing sectors that contribute directly to the local economy through zoos, parks and holiday villages. Visitor centres are becoming increasingly attractive proposals associated with existing science parks, hotels and exhibition centres, further boosting local tourism.

Proposed developments

According to the Development Strategy, 28,700 new homes are expected to be delivered in Central Bedfordshire by 2031, catering to the changing requirements of the local population and the need for regeneration of certain areas. A variety of housing types will be provided, with a focus on larger family homes, affordable housing and properties for the ageing demographic. Central Bedfordshire is also targeting non-residential growth with 27,000 new jobs across a variety of key sectors, which build upon the area's existing business strengths, such as manufacturing, tourism and the rural economy.

The majority of development is allocated to existing population centres, including Leighton Buzzard, Dunstable and Biggleswade, and along large sections of the Luton border to accommodate new urban expansion. Green Belt boundaries may be redrawn to accommodate planned growth, and the retention of large rural spaces will be required to maintain the rural economy and tranquil setting. Development sites have been mapped where possible, although GIS data was only available for new residential developments going through the planning process at the time of writing.



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Central Bedfordshire

New residential developments that have planning permission or were expected to be complete by 2013

Figure 5: Potential sites for new development as of time of writing

2.2. Policy context

This section describes the evolving national and local policy context for renewable energy development, focusing on factors affecting demand for renewable energy, and the pace and nature of development expected in future. It includes national and local strategies, policies, and targets that will influence development, including financial viability, planning, and where and how renewable energy projects are developed.

2.2.1. National policy

The national policy context for renewable energy development is rapidly evolving. Changes in policy at the national level have implications for the scale, type and choice of location of renewable energy development, viability and the rate of project delivery, the nature of community involvement in projects, and the development and application of planning policy. Some of the most relevant changes include:

- The National Planning Policy Framework (NPPF) for England (March 2012) [vi]
- The new online Planning Practice Guidance (PPG)[vii]
- Further development of the Zero Carbon Standard for the Building Regulations, including announcements on Allowable Solutions (November 2013)[viii]
- The Housing Standards Review (August 2013), which proposes to limit the ability of local authorities to apply renewables targets to new housing development[ix]
- The emerging Electricity Market Reform (December 2013), including changes to the financial incentives for different technologies[x]
- The Community Energy Strategy (February 2014)[xi]
- The Community Benefits Protocol (September 2013) and related government announcements[xii]

This section reviews the national context within three main categories, relating to national and international targets and the overall potential for growth, the financial support available for different technologies, and how planning and regulation will impact the feasibly and viability of projects.

Target-setting and growth potential

The Government has a national target for 15% of energy to come from renewable sources by 2020. A further EU-wide target has recently been agreed for 27% of energy supplies to come from renewable energy sources by 2030. Whilst onshore wind capacity is increasing rapidly, consent rates have fallen and the rate of growth is expected to slow after 2015 due to the steady development of the most suitable sites, growth of competing technologies and cumulative impacts. Being one of the most mature of the renewable technologies, onshore wind has seen a reduction in subsidies, although viable projects are still being developed. Existing capacity totals roughly 7GW of onshore wind, and recent polls exhibit positive public backing for deployment of the technology[xiii].

In relation to solar development, the UK Renewable Energy Roadmap[xiv] highlights a significant potential for further deployment, as does DECC's recent Solar PV Roadmap[xv]. Analysis indicates a potential deployment range of 7-20 GW (equivalent to 6-18 TWh), with

20 GW being the current estimate of the technical maximum level of solar PV deployment by 2020. Recent research shows that almost 500,000 UK homes have installed solar PV systems to date, demonstrating strong public support and market growth[xv].

Direct combustion of biomass for power generation appears to be of lower priority in policy terms, and such projects will only benefit from government support if they generate both heat and electricity, as informed by the sustainability principles set out in the 2012 Bioenergy Strategy[xvi]. It is likely that the most significant increase in large-scale use of biomass will be due to coal-fired power stations switching to co-firing. Otherwise, the biomass sector is expected to focus more on efficient uses of fuel such as CHP, with a preference for locally-sourced feedstock over imports from international markets. Anaerobic digestion and CHP will both continue to benefit from government support and their capacity is increasing on an annual basis. This is also the case for district heating and smaller-scale renewable heat schemes, such as biomass boilers and heat pumps for use in buildings.

Given that the UK government has targets and strategies in place for long term growth in renewable energy capacity, in addition to national and international targets for reducing carbon emissions, it is likely that renewables will continue to be an important focus for development in the coming decades.

Financial support for renewable energy technologies

There are multiple policies currently in place designed to improve the financial viability and cost-competitiveness of renewable energy technologies, and provide the market certainty that investors require. These set out the level of financial support a scheme can expect to receive, depending on technology and capacity, over a given operating lifetime. The presence of these incentives demonstrates that the UK government intends to encourage deployment of renewables at scale, but through a balanced market approach that does not favour one particular technology.

Currently two key policies support the financial viability of renewable power generation; the Renewables Obligation (RO), and Feed-in-Tariffs (FiT). These are based on incentivising renewable power generation at both the large and small scale respectively. With the RO, this is achieved by obliging energy suppliers to source a certain percentage of power from renewable power generators, in turn generating certificates (ROCs) that can be traded for a profit. FiTs offer a simple payment per unit of electricity generated, with a top up payment for any electricity not consumed by the owner of the scheme which is exported to the grid. These support policies are technology-specific and the subsidy available to new schemes is being reduced over time to account for the growing market maturity of renewables. The amount paid to schemes already registered is guaranteed for a pre-determined operational lifetime, and in the case of FiTs increases with inflation.

The Electricity Market Reform (EMR)[x] intends to replace the RO with Contracts for Difference (CfDs) and a capacity market, to provide greater long term certainty for renewables. CfDs, which are due to come in from 2017, will guarantee a fixed price per unit of electricity generated for a set contract length (the 'strike price'), removing the risk associated with the variability of wholesale electricity prices. Projects will receive a subsidy while the wholesale price is less than the strike price, although they will also need to pay money back if the wholesale price exceeds the strike price in future. The strike price, which differs for each renewable power technology, is set by the government through an independent body. The initial strike prices, which have already been published, have been designed to avoid creating a greater incentive for one technology over another. As with other incentives, it is expected that the strike price available to new schemes will reduce over time. The capacity market will ensure that back-up power generation, such as gas-fired plant, receives a guaranteed level of support to ensure capacity is available to balance out variability in the electricity supply to the grid, to maintain a balance between supply and demand, particularly as the proportion of power from renewable energy sources increases.

The EMR indicates that support for renewable energy projects at the scale studied in this report is strong going forwards, and that the financial viability of projects such as large wind or solar is now more certain. A recent adjustment downwards to onshore wind and solar strike prices suggests a potential preference for offshore renewables; however the industry view appears to be that this will have a limited impact on the current pipeline of projects.

Incentives to promote the deployment of renewable heat technologies currently include the non-domestic Renewable Heat Incentive (RHI) and the Renewable Heat Premium Payment Scheme (RHPP) for domestic properties. These cover a range of renewable heat technologies, such as heat pumps, biomass boilers, biomass CHP engines and solar thermal. The RHI pays a tariff per unit of heat generation, in a similar way to the FiT. It is differentiated by technology, capacity and the amount of heat used and helps to mitigate the relatively high upfront costs of renewable heat technologies. The RHPP offers private homeowners and private and social landlords a one-off grant to help with the installation costs of renewable heating systems, in the form of a voucher. The RHPP is due to be phased out in March 2014 and replaced with a domestic version of the RHI.

The recently published Community Energy Strategy[xi] proposes to further encourage development, by providing incentives to local communities to boost acceptance of renewables. A variety of new incentives have been proposed, which build upon existing community-based policies that have encouraged some small-scale development to date. The most important of these existing incentives is the Rural Energy Fund, which provides grants of up to £20,000 for communities to undertake initial feasibility studies and unsecured loans of up to £130,000 for further work to develop planning applications and the business case for investment. This significantly reduces the risk for communities, particularly in the early planning stages of projects.

Some key new policies include aspirational targets for community-owned renewable energy of up to 3GW by 2020, an Urban Energy Fund which will provide similar upfront funding for community projects in urban areas, and encouragement of local authorities to be more directly involved in ownership and financing. Further proposals involve adjusting current FiT capacity ceilings upwards so as to incentivise larger schemes, and bolstering the existing Green Deal for communities. Alongside policies designed to encourage community-led projects, the existing Community Benefits Protocol[xii] is an agreement by onshore wind energy developers to ensure a direct financial benefit to communities in the vicinity of their projects, designed to increase acceptance of development and reduce risk in the planning process. The typical amount paid currently equals £5,000 per MW of capacity installed. A similar approach is increasingly being adopted for other large-scale renewable energy projects like solar farms.

Planning and regulatory considerations

Aside from the financial support and target-setting outlined above, a number of planning policies are in place to encourage renewable energy development while ensuring that the impacts are minimised. The planning and regulatory considerations affecting renewable energy generation are often complex, particularly for large-scale wind or solar, and there is a need to provide guidance throughout the planning process as to assessment and mitigation.

The government's National Planning Policy Framework[vi] and supporting Planning Practice Guidance on Renewable and Low Carbon Energy[vii] outline the key constraints and considerations that should be factored into planning for renewable energy schemes. These in turn refer to the six National Policy Statements for energy infrastructure, which include specific considerations for different technologies. These policy and guidance documents cover a wide range of general and technology-specific topics, each of which is discussed in further detail in section 4.0. These include landscape designations, heritage sites, local topography and potential visual impacts, all of which must be carefully considered during the planning process.

Particular attention is paid to the cumulative impact of multiple renewable energy developments, especially of wind and solar schemes. Developments should take all possible precautions to identify and mitigate potential environmental impacts in order for the project to be deemed acceptable. This may require a formal Environmental Impact Assessment, which is determined through a Screening and Scoping process.

The majority of building-integrated renewable energy installations are permitted development, for both residential and non-residential buildings. The tightening carbon targets in the Building Regulations[viii] are expected to further encourage installation of renewable energy technologies on new development sites, particularly as the zero carbon requirements are introduced from 2016 for domestic buildings and 2019 for other types of building. As the new Building Regulations requirements are being phased in, the Government has confirmed its intention[xvii] to withdraw the Code for Sustainable Homes, as recommended in the Housing Standards Review[ix], although local authorities are still expected to be able to set targets for on-site renewable or low carbon energy supplies for new developments where feasible and viable.

Allowable Solutions will offer an alternative route for developers to achieve the Building Regulations targets, by delivering carbon-saving projects off-site or making a payment to a third party to deliver them on their behalf. Allowable Solutions could include, for example, connecting to offsite district heating networks or investing in renewable energy generation elsewhere. Local authorities and private sector companies are expected to be able to register as Allowable Solutions providers, and it is expected that they will have to compete for payments from developers, to ensure that the route to compliance is as cost-effective as possible. Allowable Solutions payments will not be able to contribute to projects supported by other government incentives, to ensure additionality and avoid duplication of subsidies.

In addition to the financial incentives described above, the Community Energy Strategy[xi] proposes further improvements to simplify the planning process for community renewable energy projects. A Community Energy Unit is being setup that will offer a 'one-stop shop' for communities to obtain advice on the benefits of renewable energy schemes and guidance on policy and regulation.

2.2.2. Local policy

Central Bedfordshire has included aspirational emission reduction targets in its 2010 Climate Change Strategy[xviii]. Its aims to see a 60% reduction in the Council's own carbon footprint by 2020 and acknowledges that renewable and low carbon energy will play a significant role in achieving this. The Council included a 10.7% reduction per capita across the area in its Local Area Agreement, which ran to 2011; up to date DECC data shows that this target was surpassed within the target period. The Carbon Management Plan sets out potential ways of the Council realising these goals, such as CHP plants in community buildings, solar PV on Council offices, and energy from waste schemes.

Central Bedfordshire Council has included a detailed policy on renewable energy development in the draft new Development Strategy (2013)[xix]. Policy 46 takes a proactive approach to renewable energy development, which recognises the benefits but also stresses the importance of ensuring that development is appropriately located and designed to mitigate any impacts. Whilst there is no presumption against renewable energy developments in Central Bedfordshire, the policy requires careful consideration of the key landscape sensitivities and assets noted in section 2.1 of this report, particularly areas such as the Greensand Ridge, the Chilterns AONB and the Green Belt.

The policy also encourages effective engagement with communities, including the provision of direct community benefits and compensation to those affected by development. Other policies outline 'significant opportunities' for the provision of on-site or near-site renewable and low carbon energy schemes as part of new property developments[xx], which could also provide an opportunity for on-going direct community involvement.

Central Bedfordshire has also produced Guidance Note 1: Wind Energy Development in Central Bedfordshire[xxi], based primarily on an analysis of the potential landscape impacts from new developments. It reflects emerging policy in the Development Strategy and national planning policy.

The Guidance Note concludes the suitability and capacity of Central Bedfordshire's landscape to host wind developments is unlikely to make medium and large projects viable. There is scope for smaller projects to be deemed acceptable, and a preference for clusters of two to three turbines separated by distances of no less than 10km rather than multiple single-turbine developments.

According to the Guidance Note the areas seen as likely to be most suitable for wind developments of small to medium scale are focused in the east of the area, where landscape impacts are potentially lesser, and nodal features could be created alongside trunk roads. This is however also where the Landscape Character Assessment identifies some of the most tranquil areas of Central Bedfordshire[iv]. The Guidance Note also states that the Council is keen for developers to include the local community in projects where possible, such as through part-ownership.

3.0 Energy demand and emissions in Central Bedfordshire

We have estimated existing and future energy demand and carbon emissions in Central Bedfordshire, to enable a comparison with the potential for renewable energy technologies to generate energy and reduce emissions in the area. This analysis covers the period up to 2031, which corresponds to the duration of the Development Strategy. The relevant assumptions for each of the following sections can be seen in section 1.1 of the Appendix.

3.1. Existing energy demand and emissions

Current domestic, commercial and industrial energy demand and carbon emissions have been calculated using the latest data from the Department for Energy and Climate Change (DECC) for Central Bedfordshire. Data from DECC's[xxii] annual sub-regional energy consumption statistics has been used to calculate electricity and heat demands for 2011.

Heat demand has been calculated using consumption data for a wide range of fuels, including gas, oil, coal and other fuels, which covers manufactured solid fuels, waste and renewables (which displace emissions). Electricity used for domestic heating has been included in the total electricity demand estimates, and it has been assumed that those customers with Economy 7 tariffs use all of their electricity for domestic heating via electric storage radiators, as opposed to gas or other fuels.

Existing CO_2 emissions have also been calculated, using the emissions factors laid out in the Standard Assessment Procedure (SAP) 2009 on the Energy Rating of Dwellings[xxiii], for the UK electricity grid, mains gas and relevant other fuels. The results of this analysis can be seen in Table 1.

	Current electricity demand (MWh/yr)	Current heat demand (MWh/yr)	Existing CO_2 emissions from energy demand (tonnes CO_2/yr)
Domestic energy consumption	479,000	1,251,000	524,200
Non-domestic energy consumption	528,000	591,000	430,600
Total	1,007,000	1,843,000	954,900

Table 1: Current (2011) annual energy demands in Central Bedfordshire due to existing building energy use. Excludes transport demands and energy used for major power generation.

3.2. Projected demand for existing buildings

Energy demand from existing development has been forecast through to 2031, in order to understand how efficiency improvements in both heating and electricity consumption could affect demand and emissions over the period. Other factors such as changing use and efficiency of appliances and increasing use of electric vehicles could also affect demand, but these have not been included due to the complexity of the analysis required and a lack of sufficient information on which to base this analysis.

The calculations were carried out by applying a number of assumptions regarding building energy efficiency and emission factors for various fuels and the UK electricity grid, and projecting this over the 20 year period (2011-2031). These assumptions are detailed in Appendix section 1.3.1. The efficiency figures represent improvements to existing buildings only, such as replacement boilers or insulation schemes – new developments are covered in the following section.

The results of this analysis can be seen in Table 2, showing a slight increase in total electricity demand by 2031 from existing buildings, but a notable decrease in heat consumption. This leads to an overall decrease in total annual emissions by the end of the study period compared to 2011.

	Projected electricity demand (MWh/yr)	Projected heat demand (MWh/yr)	Projected CO_2 emissions from energy demand (tonnes CO_2/yr)
Domestic energy consumption	529,000	1,076,000	447,500
Non-domestic energy consumption	583,000	507,000	352,100
Total	1,113,000	1,583,000	799,600

Table 2: Projected annual energy demand and emissions from existing buildings by 2031. Excludes transport demands and energy used for major power generation.

3.3. Projected energy demand and emissions from proposed new development

To assess how much new energy demand and emissions are likely to arise from the expected level of development, it was necessary to obtain data on various factors affecting this over the period 2011-2031. Firstly, the number of homes planned for development and the amount of employment and retail space were obtained from the Council and relevant planning documents to assess potential growth in the area[xxiv]. This included data on the expected timing of these developments, the planning use category they fitted into, floor areas, and total projected number of jobs to 2031.

Assumptions regarding domestic and non-domestic developments were made and agreed with the Council, based on the nature of past LDA Design project experience and data provided for Central Bedfordshire along with the planning documents. These included the likely mix of housing size and type, the split of commercial space between different B-uses including office and warehouse space, and non B-uses including high street retail and community buildings such as leisure, tourism and cultural developments. Appendix sections 1.3.2 to 1.3.4 provide more detail on the values used, and reasons for choosing them. Data was provided for each phase of planned housing allocations, whilst phasing of non-domestic developments was assumed to be even over the full 20 year period, guided by the data on allocations already complete.

This analysis is likely to represent a maximum value for new development, as not all potential sites identified and allocated are expected to come forward for construction within the period of the Development Strategy. However, given that housing data and B-use allocations have been provided by the Council and mixes agreed upon, this level of development is deemed acceptable for this report.

Energy demands for proposed new developments were calculated using benchmarks for new domestic and non-domestic buildings[xxv]. These benchmarks provide typical energy demand values for a range of building types, based on aspects such as floor area, efficiency ratings and the timing of development and therefore regulations it must comply with. This report used these values, along with updated emission factors from the SAP 2013, to calculate total energy demand and emissions over the period 2011-2031.

For simplicity, it was assumed that all new development would be built to comply with the 2016 version of the Building Regulations, with no further improvements of efficiency following construction, as owners would not be expected to renovate newly-built properties that are already highly efficient. The same emission factors to those used in projecting existing demand were applied to calculate total emissions.

For non-domestic developments, some types of building were not assessed, including hotels or leisure centres, due to a lack of sufficient information. Furthermore, given the scale at which this analysis has been carried out, the impact on total energy demand and emission forecasts from single buildings is likely to be negligible. Total estimated energy demand and emissions from proposed new developments can be seen in Table 3.

	Projected electricity demand (MWh/yr)	**Projected heat demand (MWh/yr)**	**Projected CO_2 emissions (tonnes CO_2/yr)**
Domestic energy consumption	91,000	126,000	71,500
Non-domestic energy consumption	19,000	7,000	9,000
Total	110,000	133,000	80,500

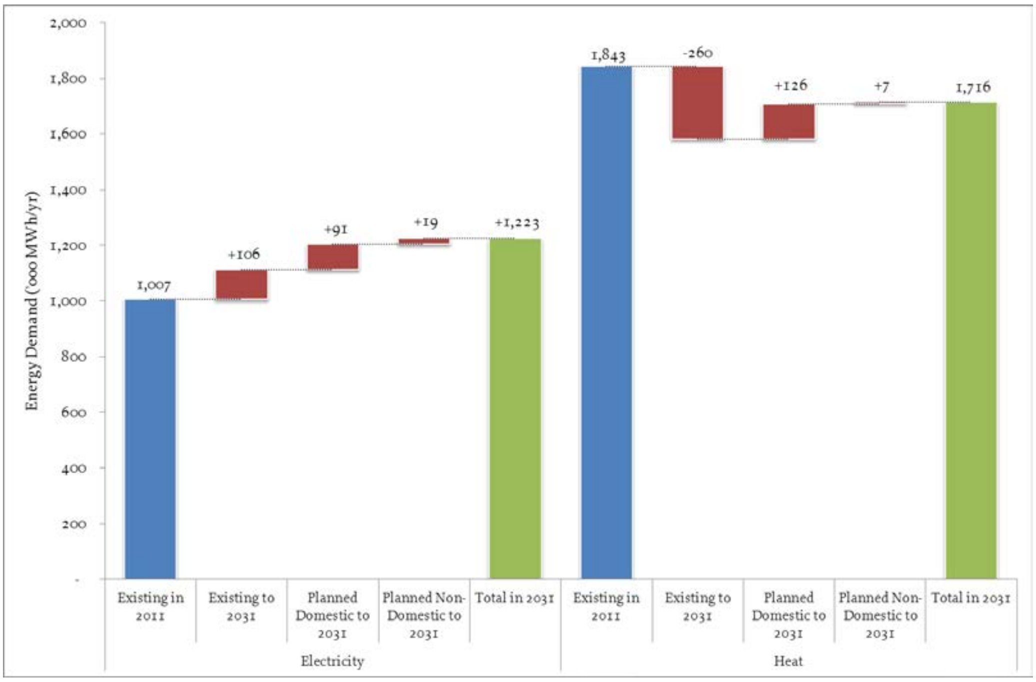
Table 3: Total projected annual energy demand and emissions in 2031 from all planned domestic and non-domestic developments over the period 2011-2031.

3.5. Total energy demand and carbon emissions

Total energy demand and associated emissions from existing and planned development in Central Bedfordshire have been calculated, using the figures described above. The results are shown in Figure 6, which illustrates the changes which could occur over the study period. Further detail is provided in Table 23 of section 1.3.5 of the Appendix.

Energy demand and emissions from all new development built by 2031 is forecast to be a fraction of that from existing buildings, accounting for around 10% and 8% of total electricity and heat consumption respectively and a similar proportion of total emissions. A focus on improving the energy efficiency of existing buildings and will therefore be important if future carbon targets are to be achieved, alongside the construction of new, energy efficient buildings and an increase in renewable and low carbon energy generation.

In Central Bedfordshire, it is estimated that total annual electricity demand will increase by 20% by 2031, whilst heat demand will fall by around 7%, leading to a total emissions reduction of 8%.



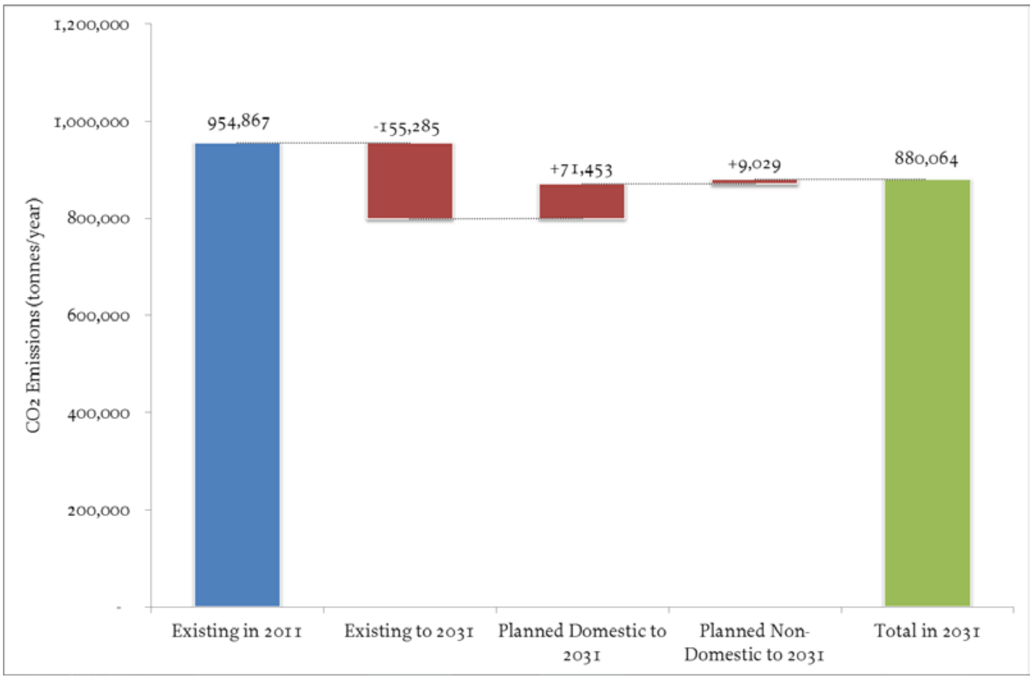


Figure 6: Total annual demand for electricity and heat (top), and emissions (bottom) due to existing and planned developments through to 2031.

4.0 Existing and proposed renewable energy development

Central Bedfordshire currently has a number of existing and proposed commercial scale renewable energy developments, including wind, solar, biomass and energy from waste plants of varying capacities.

As of this year, there are seven onshore wind projects proposed or operating in Central Bedfordshire, with a total capacity of roughly 28MW[1]. The largest of these is the 20MW Langford installation, currently fully operational, with a pre-application put forward for a further wind project adjacent to this site. The RSPB HQ site has an application pending for a 2MW turbine on its own land south of Sandy, whilst the Double Arches turbine has an installed capacity of 2.3MW and is due to begin construction soon. Whilst these projects are split between the east and west of Central Bedfordshire, there is a slight preference for development in the east, where the land is flatter, less densely populated and away from the sensitive landscapes of the Greensand Ridge and the Chilterns AONB.

Solar farms have been growing in popularity in recent years, due to falling costs and a relatively less constrained planning context compared to other major energy developments such as wind farms. Currently there are 12 ground-mounted solar projects either in the pre-application phase or approved, totalling a potential capacity of roughly 64MW. Of these only the Cotswold Farm Business Park site is operational, with an installed capacity of 4MW. The remaining sites are currently at the pre-application/EIA screening stage, and spread over a wide range of sites in the borough, with some clustering around Leighton Buzzard where grid capacity and high solar radiation offer good resource potential. Almost all pre-applications were put forward in the last half of 2013, demonstrating the recent interest in solar farms and the potential for a number of high-capacity schemes in Central Bedfordshire.

Regarding biomass and landfill gas schemes, the area has a relatively large number of sites compared to the neighbouring authorities. There are four landfill gas projects in operation, totalling 27MW installed capacity, with the Brogborough Phase III and IV developments responsible for 22MW, located east of Milton Keynes. These sites are in close proximity to urban areas to ensure a secure supply of feedstock necessary to fuel the plant. One anaerobic digestion scheme is operational in Central Bedfordshire of 1MW capacity, sited at Trinity Hall Farm to the east of Leighton Buzzard. It runs off maize waste produced onsite and is connected to a combined heat and power (CHP) engine for both electricity and heat generation.

Currently, there are no sites generating electricity in Central Bedfordshire from dedicated biomass combustion, however a 2.5MW biomass boiler is part of the planned new Centre Parcs development in Warren Wood. This scheme includes the introduction of flue systems to enable the installation of a biomass boiler and CHP engine, which will work alongside gas-fired generation to meet the sites energy needs. This will run on locally-sourced wood and aid Centre Parcs in meeting its sustainability and energy requirements.

In total, Central Bedfordshire currently has approximately 122.5MW of installed or planned renewable energy capacity. Operational developments as of 2014 total roughly 53MW of

[1] Important to note that these are totals including pre-applications, such as those currently undergoing EIA screening, and thus likely represent the maximum capacity for each scheme. Capacity data was not available for all planned projects

installed capacity, producing roughly 255GWh of electricity annually. The majority of planned capacity is in solar farms, accounting for around 59MW, with proposed wind farms totalling 8MW, followed by small amounts of biomass and landfill gas generation.

To understand the distribution and nature of renewable energy development to date, we have mapped existing and proposed sites in Central Bedfordshire and surrounding Local Authority areas (Figure 7). This is useful as it provides an indication of what developers think is viable, what is being permitted by local authorities in the area, and where cumulative impacts could potentially occur in future.

For this we have used a GIS dataset of developments that are or have been in the planning pipeline, which includes information on project type, scale and status. This was obtained by merging data from the DECC-managed *Restats* database and planning information supplied by each of the Local Authorities. The map and associated dataset was then sent back to all Local Authorities involved for verification, to ensure that it included all schemes they were aware of, with up to date details for each. Further details regarding each project shown in this map, including associated capacities, planning references and dates of application can be found in section 1.2 of the Appendix.

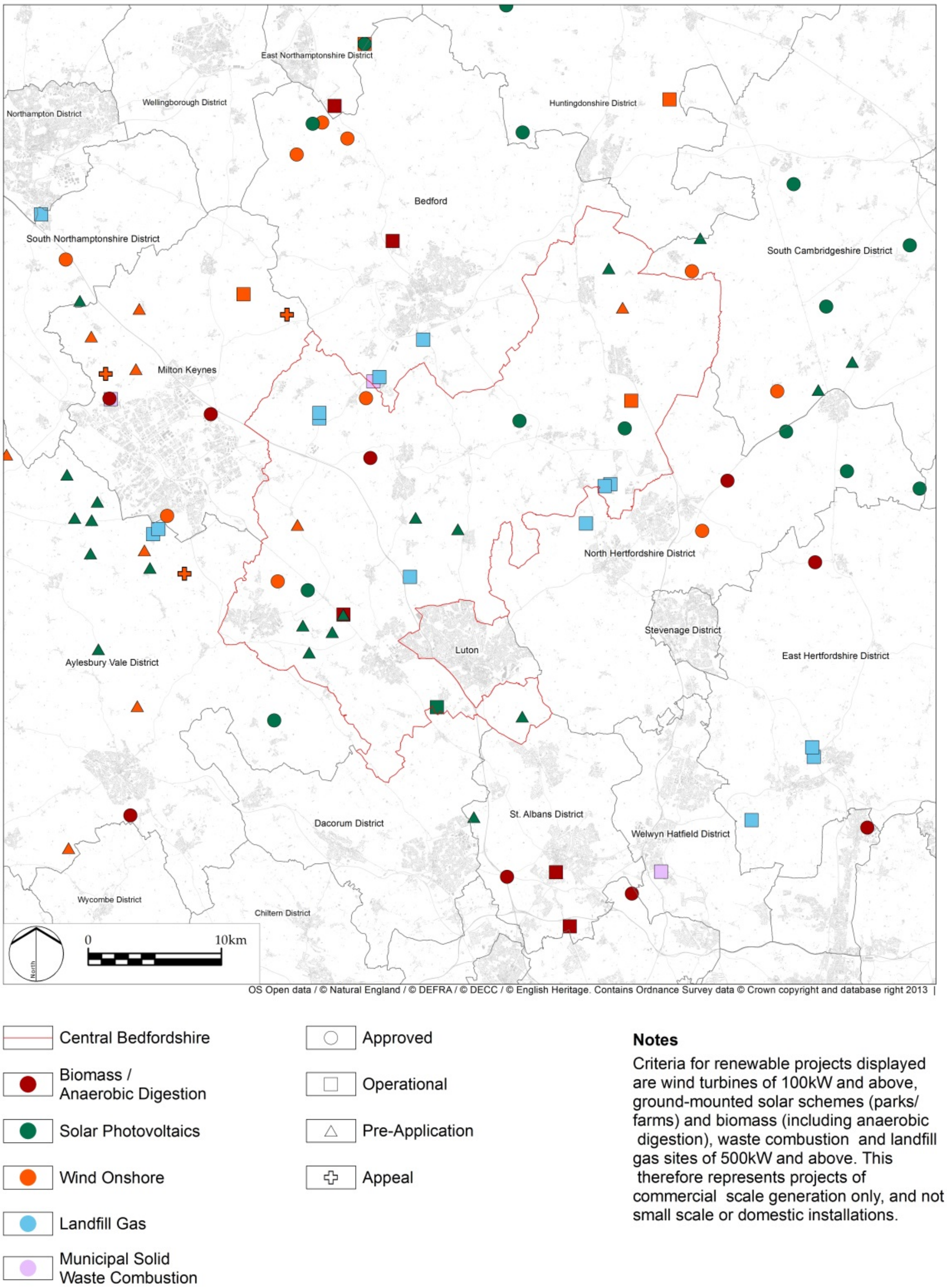


Figure 7: Existing and proposed renewable energy development

5.0 Grid capacity

The majority of renewable power projects connect to the local electricity distribution network, whether they are relatively large-scale projects such as wind farms or solar farms or small-scale building-integrated technologies. Capacity of the electricity grid for new connections is a complex and continually changing picture. The availability of capacity depends on the specification and condition of local infrastructure, the scale of local electricity demands, the amount of generation capacity connected in the vicinity, and the programme of planned upgrade works to the network.

To connect anything other than small-scale building-integrated equipment to the grid it is necessary to make an application to the local Distribution Network Operator (DNO), which in Central Bedfordshire is UK Power Networks (UKPN). Availability of capacity for connection of a new electricity generator cannot be guaranteed until a contract has been signed with the DNO.

It is therefore impossible at this stage to predict how much grid capacity will be available for new renewable energy development in Central Bedfordshire over the period covered by this study, and where this capacity will be available. We can however consider which parts of the network are more likely to have capacity for new connections, and identify where capacity constraints could be encountered which could add significantly to project costs and potentially render projects unviable, based on current and proposed patterns of development and information on existing capacity in the area.

As a starting point, we have referred to UKPN's latest Generation Capacity Map for the East of England[xxvi]. This identifies broad areas which are more or less constrained for new connections, and is updated on a regular basis. This map has been reproduced in Figure 8 with written consent from UKPN, and shows the latest available data for January 2014. It indicates that the grid is highly utilised in the north and north east of the area, suggesting a significant constraint on development until upgrade works are completed to increase capacity. By contrast, capacity is understood to be available in western Central Bedfordshire, while significant capacity is shown as being available in central and southern parts of the area.

The map provides a snapshot of current capacity on the high-voltage distribution network, which large-scale renewable energy development would be expected to connect to. It provides general information across a broad geographical area, and there are likely to be significant variations in capacity available at the local level, which would need to be considered on a site-by-site basis. Where capacity is limited, upgrades would be needed to enable new projects to connect to the grid. These can be costly and result in significant delays to projects, potentially rendering them unviable, particularly where they trigger the need for further reinforcement in higher voltage parts of the distribution or transmission network.

Close to urban areas, capacity in the local distribution network can sometimes be easier to secure because it is close to a centre of high energy demand and a higher proportion of the output from renewable energy projects in these areas will be used locally rather than being exported across a larger distance via the grid. Sites that are identified as potentially suitable for renewable energy development in planning terms are often in more remote, rural areas however, particularly in the case of large wind energy developments, where grid constraints can be more of a concern.

The majority of proposed new renewable energy development in the planning pipeline for Central Bedfordshire is located in areas which are currently indicated on the map as having available grid capacity, although some new projects are also proposed in the north of the area. While some of these developments may already be taken into account in the analysis undertaken by UKPN, others may not yet have a contract for connection and may take up available capacity in future, further constraining availability for additional development.

In the long term, major upgrades will be needed to the distribution networks and the national transmission network, managed by National Grid, to release further capacity for renewable energy generation. Improvements will also be needed to manage supply and demand on the system, including smart grid technology to monitor and control the system and additional infrastructure for storing power and releasing it at times of peak demand. This need has been recognised by the government, which has been working with the relevant organisations through the Electricity Networks Strategy Group to develop proposals for how these improvements can be delivered, although it is not yet possible to derive conclusions for how this will affect long-term development potential in Central Bedfordshire.

We have sought to organise a meeting with UKPN to review the available information on grid capacity, proposed new development and potential locations for future development, in order to discuss and refine the evidence on grid capacity and constraints in Central Bedfordshire. Although UKPN were contacted at the outset of the project and at various stages throughout, they have not been available for a meeting or to review and comment on the information prepared.

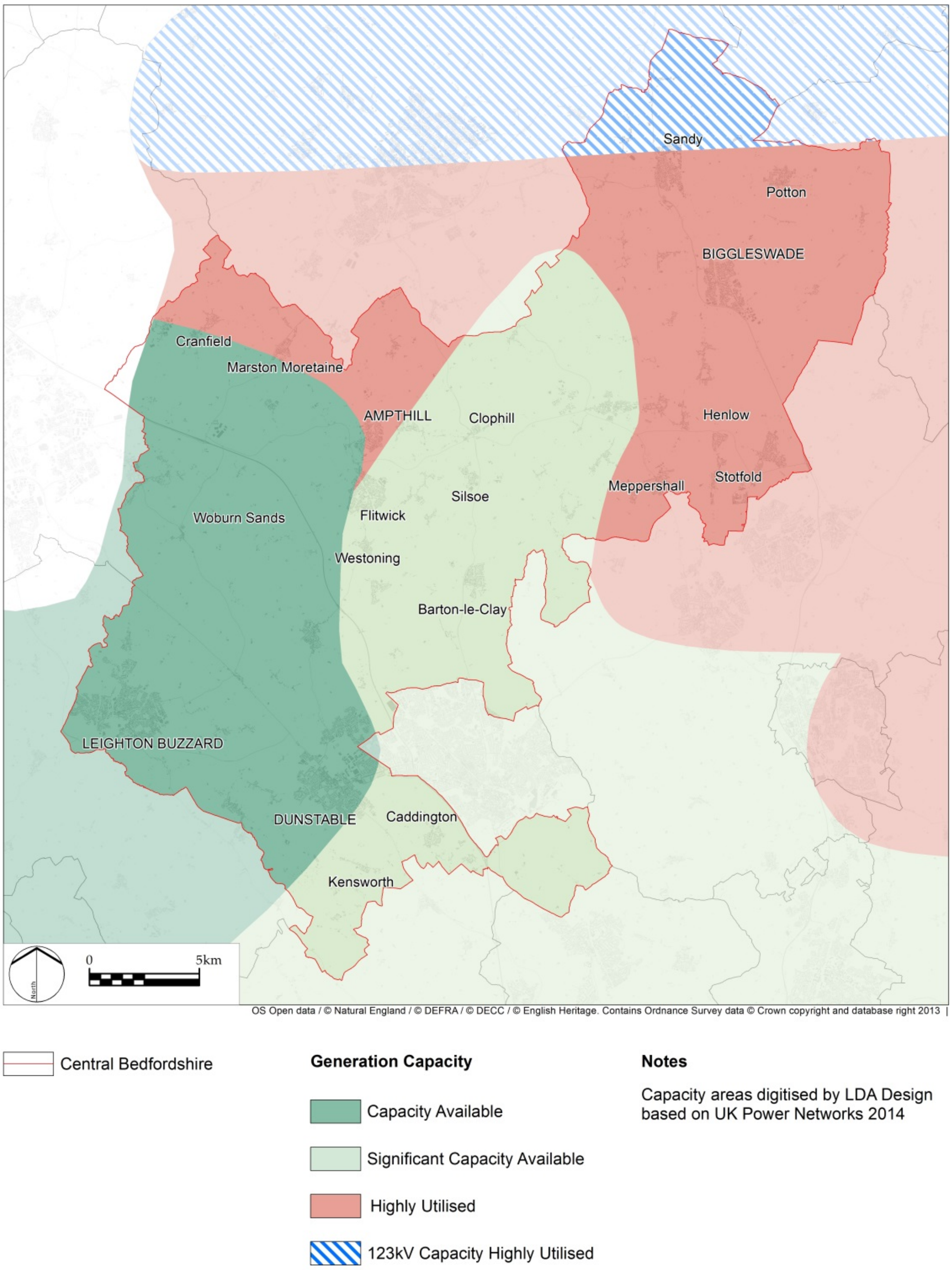


Figure 8: UKPN Generation Capacity Map for Central Bedfordshire (January 2014 version)

6.0 Potential capacity for new renewable energy development

We have undertaken an assessment of potential capacity for new renewable energy development in Central Bedfordshire including:

- Wind turbines
- Solar farms
- Locally sourced biomass
- Anaerobic digestion (non-waste)
- Hydropower
- District heating
- Building-integrated renewables (solar PV/thermal, heat pumps and biomass boilers)

Our analysis has placed greater emphasis on those technologies listed above which are likely to have the greatest scope for deployment at scale in Central Bedfordshire and which would be planned in accordance with Policy 46 of the Development Strategy. Some types of development, particularly the cultivation of biomass resources, on-farm anaerobic digestion, district heating and building-integrated renewables, could come forwards as permitted development and would therefore not require planning permission. These projects will however still contribute to total generating capacity in the area and are therefore considered in order to understand the full context for renewable energy development in Central Bedfordshire.

Our methodology for the capacity assessment builds on the approach taken in the East of England study, itself based on the DECC Methodology for the English Regions (2010). We have used data and information from the East of England study, where appropriate and current, to avoid duplicating effort. Updates and refinements have been made to the approach to ensure that the outputs meet the needs of the brief. In particular, neither the East of England study nor the DECC Methodology cover solar farms, so a new assessment of the potential for these has been included below, based on our experience of working on site-finding and planning applications on behalf of developers.

In this methodology, opportunities and constraints are mapped and considered in several stages, each of which reduces the capacity towards a more practically achievable value. The assessment starts by identifying the naturally available resource, such as areas of high average wind speeds, then applies exclusion areas based on physical constraints and 'hard' planning constraints, followed by further planning considerations. Each technology has specific requirements and key issues which can make or break a project, for example the landscape and visual impact of wind turbines, grid connections for solar farms and supply of raw materials for biomass projects and anaerobic digesters. These are described and considered for each technology in turn in the following sections.

The amount of energy which could be generated per year by each technology is based on standard industry assumptions about typical capacity factors, which are listed in each of the relevant sections. Carbon savings have been estimated relative to the alternative energy source, which for power generating technologies including wind turbines and solar PV panels is assumed to be the electricity grid. The carbon intensity of electricity supplied from the grid is expected to reduce with time, as fossil-fuelled power generation is gradually phased out and replaced with renewable and low carbon alternatives. We have therefore used an estimate of the carbon intensity of grid-supplied electricity in 2031 to calculate carbon savings from the renewable and low carbon technologies considered in the following sections, to account for this long term change and for comparison with projected carbon emissions in Central Bedfordshire at the end of the Development Strategy period. This has been derived from long-term projections of grid carbon intensity used in the SAP (2012) methodology, as described in Table 21 in Appendix 1.3.1.

The results set out in this chapter represent an estimate of total potential capacity in Central Bedfordshire in the long term. They do not account for the likely rate of deployment over the period covered by the Development Strategy. This is considered in the following chapter.

6.1. Wind energy

Wind energy is captured by turbines through the action of the wind turning the blades, with mechanical energy converted into electricity via a generator in the hub. The capacity of each turbine depends predominantly on the blade length and swept area. Different sizes are available, from micro turbines which produce around a kilowatt (kW) of output at peak capacity up to very large turbines for offshore installations which can have a capacity of 5MW (5,000kW) or more. They create no pollution during operation and have very low lifecycle carbon emissions.

Wind energy at the commercial scale is one of the most cost-effective and productive renewable technologies currently available, with onshore costs nearing competitiveness with more conventional generation plant. In the UK especially, where some of the highest winds in Europe exist, the prospect of delivering a significant share of total energy demand through onshore and offshore wind is gaining traction. Coupled with the wind industry's relatively mature market status, the expected support mechanisms to be delivered through the Government's Electricity Market Reform, and the continually falling capital and running costs, the case for wind development is strong.

We have analysed potential capacity for both large and medium-scale wind turbines in Central Bedfordshire, which may be proposed as developments of individual turbines or wind farms comprising multiple turbines. This report has not considered either small or micro turbines, as their power outputs are generally low relative to their cost and infrastructure required, limiting their viability. The following turbine sizes have been used for the assessment, although in practice a much wider range of sizes is available[xxvii]:

- **Large scale:** Turbines with an electrical capacity of 2.5MW, hub heights of up to 100m, and tip heights of up to 150m
- **Medium scale:** Turbines with an electrical capacity of 330kW, hub heights of 50m and tip heights of 67m

Compared to larger wind turbines, medium turbines, whilst generating less power individually, can potentially be accommodated in a wider range of locations due to their smaller dimensions. This may allow them to cluster together more tightly, and be sited in areas which may not be feasible for large scale turbines.

The opportunities and constraints maps for large and medium wind turbines are presented in the following section. This is followed by a discussion about the naturally available resource, exclusion areas, planning considerations, cumulative impacts, technical considerations and an estimate of the total potential capacity for wind energy development in Central Bedfordshire.

6.1.2. Opportunities and constraints maps

Four maps are presented in the following pages:

- Opportunities and constraints for large wind turbines: planning considerations
- Opportunities and constraints for large wind turbines: radar constraints
- Opportunities and constraints for medium wind turbines: planning considerations
- Opportunities and constraints for medium scale wind turbines: radar constraints

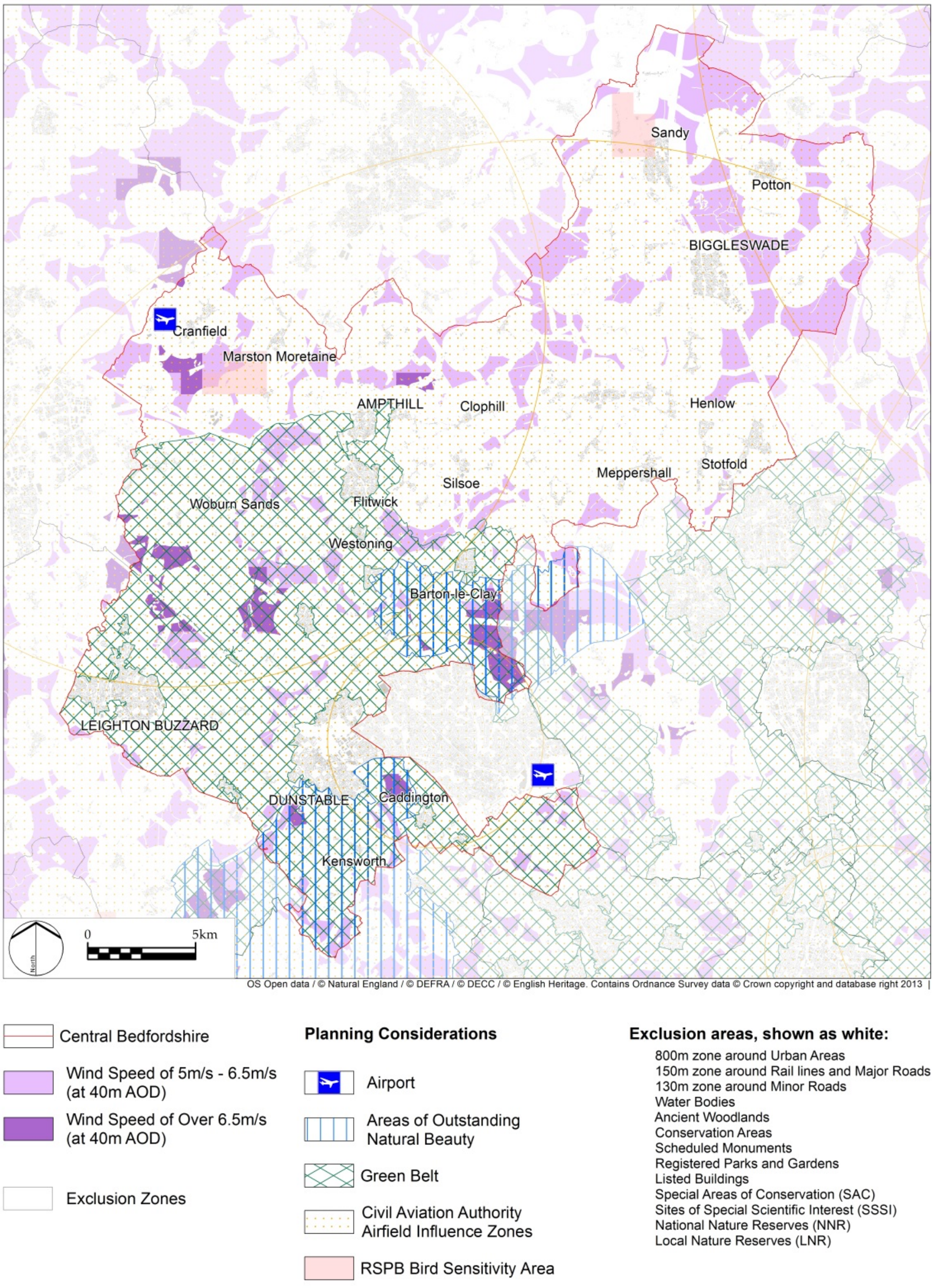
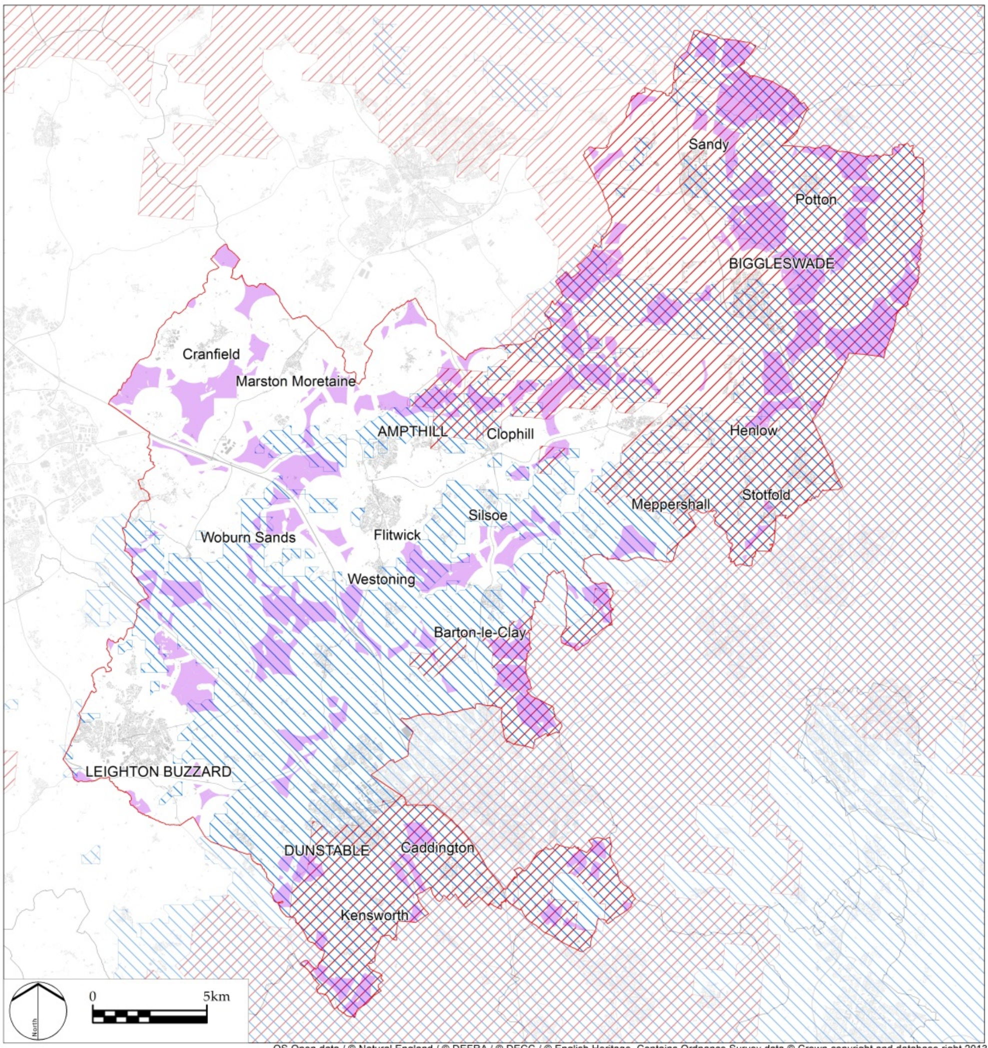


Figure 9: Opportunities and constraints for large wind turbines: planning considerations



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Central Bedfordshire

Large-Scale Wind Turbine Opportunity Areas

Civil - Primary Survellance Radar Coverage
(Turbines between 0-150m height to tip may be detected by radar)

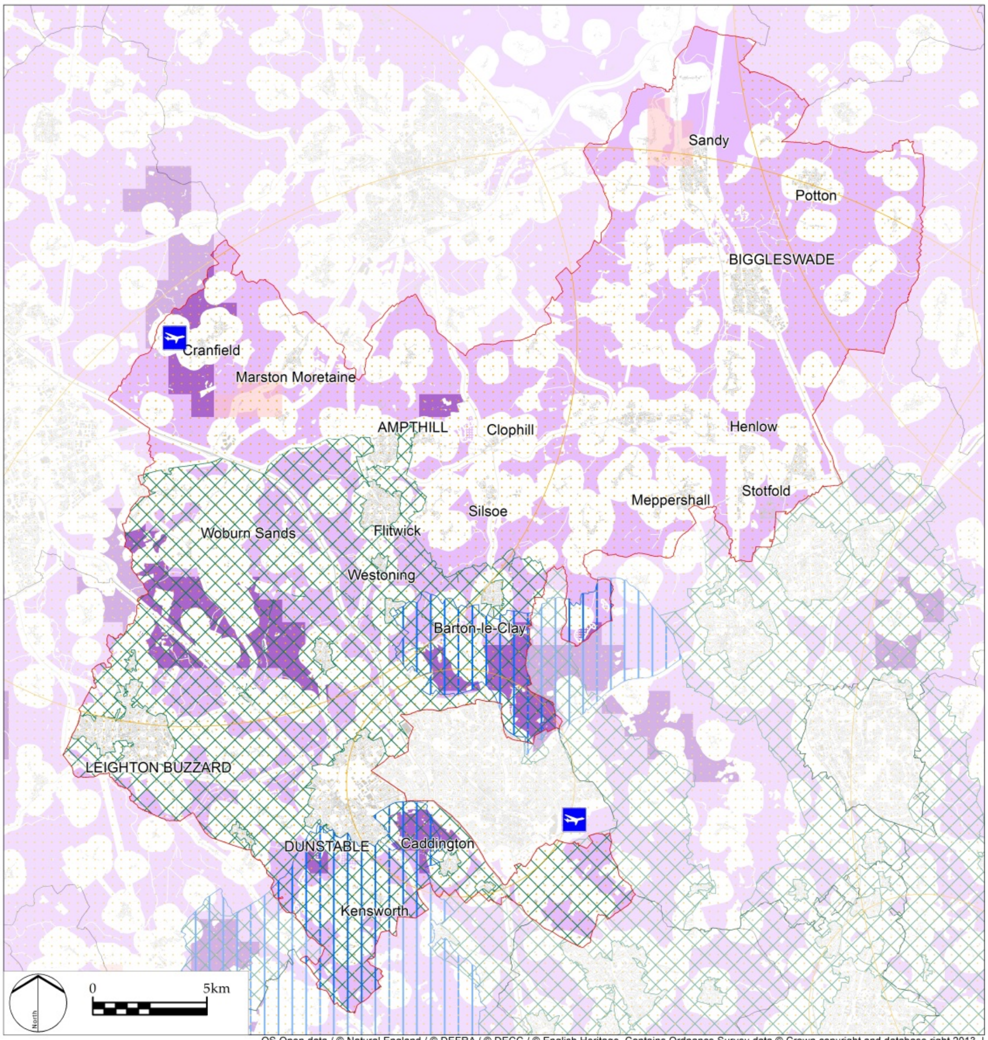
MOD Survellance Radar Coverage
(Turbines between 0-150m height to tip may be detected by radar)

Exclusion Zones

Exclusion areas, shown as white:

800m zone around Urban Areas
150m zone around Rail lines and Major Roads
130m zone around Minor Roads
Water Bodies
Ancient Woodlands
Conservation Areas
Scheduled Monuments
Registered Parks and Gardens
Listed Buildings
Special Areas of Conservation (SAC)
Sites of Special Scientific Interest (SSSI)
National Nature Reserves (NNR)
Local Nature Reserves (LNR)
Wind speeds below 5m/s

Figure 10: Opportunities and constraints for large wind turbines: radar constraints



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Central Bedfordshire

Wind Speed of 5m/s - 6.5m/s (at 40m AOD)

Wind Speed of Over 6.5m/s (at 40m AOD)

Exclusion Zones

Planning Considerations

Airport

Areas of Outstanding Natural Beauty

Green Belt

Civil Aviation Authority Airfield Influence Zones

RSPB Bird Sensitivity Area

Exclusion areas, shown as white:

400m zone around Urban Areas
150m zone around Rail lines and Major Roads
Water Bodies
Ancient Woodlands
Conservation Areas
Scheduled Monuments
Registered Parks and Gardens
Listed Buildings
Special Areas of Conservation (SAC)
Sites of Special Scientific Interest (SSSI)
National Nature Reserves (NNR)
Local Nature Reserves (LNR)

Figure 11: Opportunities and constraints for medium wind turbines: planning considerations

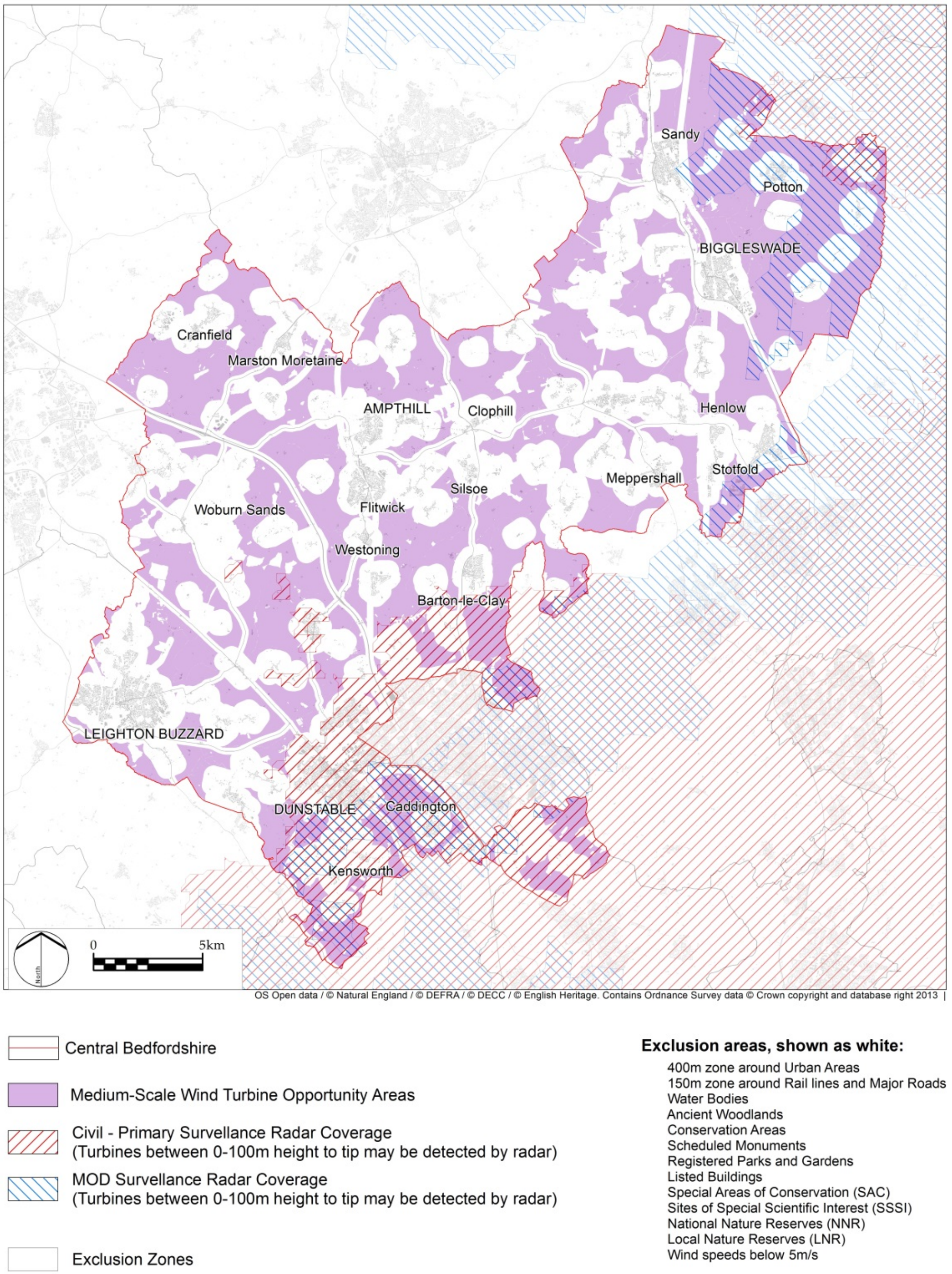

Figure 12: Opportunities and constraints for medium scale wind turbines: radar constraints

6.1.3. **Naturally available resource**

- **Local wind speeds** are the most important factor in determining site viability initially, and determines the expected electrical output of the plant, and the return on investment over its lifetime. Average wind speeds have been mapped, using data from the NOABL database. Typically, average wind speeds of at least 6.5m/s at the hub height of the turbines would be preferred for a commercial wind energy development, although developments have come forwards on sites with average wind speeds closer to 5m/s. In practice it is also important to take into account the detailed characteristics of the local wind resource, such as its turbulence, reliability, and prevailing direction, which are usually monitored over at least a year prior to development, together with the costs of developing the site.

6.1.4. **Exclusion areas**

The following physical constraints and planning constraints have been used to create exclusion areas on the wind maps, including appropriate buffer zones depending on the size of turbine:

- **Urban areas:** A minimum separation distance is typically applied between wind turbines and residential properties to reduce the potential for noise and visual impacts, including shadow flicker. For large turbines a distance of at least 800m is generally applied, and we have assumed at least 400m for medium turbines in the absence of standard industry practice. We have applied these separation distances to all urban areas on the map, as it is not possible to distinguish between residential and non-residential properties at this scale. It is important to note however that these distances are indicative, and in practice other factors such as topography, the local environment and neighbouring uses should be taken into account and the impacts assessed on a site-by-site basis.
- **New property developments:** Potential locations of new property development have also been taken into account where possible, using data provided by Central Bedfordshire, with the same separation distances applied.
- **Major roads and railways:** To mitigate the potential for turbines to fall onto major trunk roads or railways, a minimum distance from the road or railway of turbine tip height +50%, or 1.5 times the tip height (whichever is smallest), must be applied to all developments[xxviii].
- **Aviation activity:** Proximity to airports is a constraint due to the potential impact on flight paths, for both civil and defence purposes. We have assumed that turbines are not built within the boundaries of airports. Potential impact on radar also needs to be considered – this is discussed later.
- **Inland waterways:** We have assumed turbines cannot be built in these areas.
- **Ancient woodlands:** Development has been assumed not to be allowed in areas of ancient woodland due to their protected status. A buffer zone may also be applied in practice on a site-by-site basis to mitigate the potential for ecological impacts.

- **Public rights of ways and bridleways:** Similarly to major roads and railways, these may influence the layout of a wind project, and may require a buffer zone. They also require consideration from a visual impact point of view, on a site-by-site basis.
- **Heritage designations, including Scheduled Ancient Monuments, Listed Buildings, Registered Parks & Gardens, Conservation Areas:** Wind turbines have been assumed not to be built within the boundaries of sites covered by these designations. In practice, the potential heritage impacts of turbine developments on any site will need to be assessed and mitigated where necessary, including potential impacts on the setting of heritage assets in the vicinity and the potential to impact on archaeological remains on and around the site.
- **Ecological designations, including SSSIs, National Nature Reserves and the Greensand Ridge NIA:** It has been assumed that wind energy developments will not be constructed on sites covered by national and international ecological designations. In practice, it will be necessary to assess the potential ecological impacts of wind energy development on any site, whether or not it is designated or located close to designated sites, and take appropriate action to mitigate the impacts where necessary. The potential impacts on birds, bats and protected species will need particular consideration.

6.1.5. Planning considerations

The following planning considerations have been mapped, but have not been treated as exclusion areas as they are not absolute constraints on development. These need to be taken into account in a site-by-site appraisal of the context and the development proposals, as part of the planning process and there may be scope to mitigate potential impacts through appropriate siting and design of the development. Further discussion is provided below on their implications for wind energy development in Central Bedfordshire.

- **Green Belt:** As shown in Figure 9 and Figure 11, around a third of the land in Central Bedfordshire is designated as Green Belt, which covers the area in the south west between Luton, Milton Keynes, Dunstable and Leighton Buzzard. According to the NPPF, elements of many renewable energy projects will constitute inappropriate development in the Green Belt. Development is not ruled out altogether, however, as it may be permitted where the developers can demonstrate very special circumstances such as *"the wider environmental benefits associated with increased production of energy from renewable sources"*. One of the key issues will be the potential for development to impact on the openness of the Green Belt, and visual impact in this regard will need careful consideration for projects in this part of Central Bedfordshire on a site-by-site basis.

  If the Green Belt boundaries were redrawn in Central Bedfordshire to accommodate new property development, this could present an opportunity to open up areas for wind energy development in future. However, appropriate distances between sites allocated for new housing and any wind turbines would need to be taken into account.
- **Landscape, including the Chilterns AONB and areas of high landscape sensitivity:** The Chilterns AONB extends into two small areas in the south east of Central Bedfordshire, to the north of Luton and south of Dunstable, as shown in Figure 9 and Figure 11. Planning policy does not rule out wind energy development in or close

to AONBs, but the NPPF clearly states that *"great weight should be given to conserving landscape and scenic beauty"* in AONBs and they should be accorded *"the highest status of protection"* alongside National Parks. It goes on to state that *"planning permission should be refused for major developments in these areas except in exceptional circumstances and where it can be demonstrated they are in the public interest."* Factors for consideration in this respect include the need for the development, including national considerations, and the potential to develop it outside of the designated area.

The PPG notes that renewable energy development could have an adverse impact in AONBs and other protected landscapes, and the potential impacts will need careful consideration during planning. It is important that landscape character and the potential to mitigate the impacts through careful siting and design is taken into account when considering which technologies and which scale of development may be appropriate in different types of location.

Given their relative height compared to the other renewable energy technologies considered in this report, which will result in them being visible across a wider area, it is likely that the potential impacts on the Chilterns AONB will require particularly careful consideration for medium to large wind turbine developments proposed in or close to this part of Central Bedfordshire.

The Chilterns AONB Conservation Board encourages *"appropriate"* renewable energy development, but *"considers that medium- to large-scale renewable energy developments will not generally be appropriate within or beyond the Chilterns AONB or in locations beyond the AONB boundary where such development would affect its setting and character"*[xxix] In the case of wind energy, this is considered to apply to wind turbines of at least 60m height to the tip and wind farms of 6 or more turbines, which covers the scale of development considered in this study.

The position statement goes on to note that *"much of the AONB is unlikely to be able to accommodate wind turbine developments above 25m due to the topography and land cover of the area and impacts on the wind resource (of woodland for example) and the likelihood of causing real harm to the character and qualities of the AONB."* Medium to large scale wind energy developments are likely to face objections from the Chilterns AONB Conservation Board if they are considered to have the potential to impact on the natural beauty, character, amenity and/or nature conservation interest of the AONB.

The need to avoid adverse unacceptable impact on the AONB is also highlighted in Policy 46 and Policy 58 of Central Bedfordshire's Development Strategy. The approach to planning for wind energy development in and around the Chilterns and other areas identified as being of high sensitivity is described in detail in the Guidance Note.[xxx]The Guidance Note concludes that there is no capacity for medium to large scale wind energy development in the Chilterns AONB, and further to this *"the Central Bedfordshire landscape is not appropriate to accommodate large scale wind farms"*. Key areas of opportunity in landscape terms are identified for small to medium-scale development on land to the south and east of Biggleswade and North Houghton Regis, including development associated with the growth area, the M1 and A1 corridor and Stratton Business Park.

- **RSPB Bird Sensitivity Areas:** Birds are a particular consideration for wind turbines due to the potential disruption of flight paths, nesting grounds and hunting areas. The RSPB has mapped areas of particular sensitivity in terms of the potential for impacts on birds, which are shown on Figure 9 and Figure 11. As can be seen from the maps, the sensitive areas within Central Bedfordshire which are not already covered by exclusion areas for other reasons are limited to relatively small areas north west of Sandy and to the south east of Cranfield near Marston Moretaine.

  RSPB guidance in relation to these areas[xxxi] indicates that the map is not intended to indicate 'no go' areas, but areas where the potential impacts on bird populations will require particular attention during the planning process. Potential impacts on birds will also still need to be assessed and where necessary mitigated in areas outside those indicated as sensitive on the map.

- **Areas of radar coverage:** Radar coverage in an area can be a serious issue for wind energy development, as the turbines have the potential to cause interference. The significance of the impact depends on a number of factors, including the height, topography and proximity, which will determine the extent to which the turbine is visible to radar equipment. Objections from radar operators can be a make or break factor for wind energy developments.

  Maps have been published showing indicative civil and MOD radar coverage across England. Areas where medium or large turbines could be visible to the radar indicated on Figure 10 and Figure 12. Based on Figure 10, areas in Central Bedfordshire where large wind turbines are unlikely to be visible to radar are limited to central and north western areas. Opportunities for medium-scale turbines of 100m or less in height appear to be considerably less constrained in this respect, as shown in Figure 12, with radar impacts identified in the maps generally limited to the north east and south east of Central Bedfordshire. It is important to note that Cranfield airport is located in the north west of Central Bedfordshire, and its radar may not be accounted for in the maps as they only show primary radar coverage. Additional local impacts in these areas could therefore be identified.

  In practice, local variations in topography and ground cover will mean that site-specific impacts differ from the general indication given by these maps. There is no clear rule in terms of distance from a proposed turbine within which airport or radar operators should be consulted. Aviation specialists should be able to identify which airports and radar could be affected by a turbine proposal on a given site and which organisations will need to be consulted. Where radar impacts are confirmed through site-specific analysis, they can sometimes be mitigated through careful siting of turbines and design of the development. There are also potential technological solutions to radar interference, although these can be relatively costly, particularly for small to medium wind farms or single turbines, and success would still rely on negotiation with the radar operator.

Other planning considerations which are not mapped or listed above or taken into account directly in the capacity assessment, but which must be considered on a site-by-site basis for wind energy development include landscape and visual impact, heritage impacts, ecological impacts, noise, impact on telecommunications links, transport impacts and community engagement.

6.1.6. Cumulative landscape and visual impacts

In addition to considering the above points in relation to individual development sites, it is necessary to assess the potential for cumulative landscape and visual impacts as a result of multiple developments and take this into account in the planning process. The approach to taken to assessing cumulative impacts in Central Bedfordshire could have a significant impact on the total potential capacity for wind energy development in the area.

The PPG notes that cumulative impacts require particular consideration in relation to landscape and local amenity. The NPS highlights that commercial onshore wind turbines are *"large structures and there will always be significant landscape and visual effects from their construction and operation for a number of kilometres around a site."*

According to the PPG, cumulative landscape impacts and cumulative visual impacts are best considered separately. Cumulative landscape impacts relate to the potential for renewable energy development of the nature proposed to become *"a significant or defining characteristic of the landscape."* LDA Design has experience of working in an area of the country where the relatively high amount of wind energy development has led to it now being considered a 'turbine landscape'.

Cumulative visual impacts arise when a given type of development becomes a feature in particular views (or sequences of views), and this in turn has an impact on the people who experience those views. This could occur when multiple developments of the same type are visible from the same point, or shortly after each other when travelling along a given route.

There are no hard and fast rules as to what extent of development is or is not acceptable across a given area in terms of cumulative impact. This will depend on a number of factors which need to be assessed on a site-by-site basis, including local landscape character, the pattern of existing development, the location and nature of sensitive receptors such as homes, public rights of way, protected landscapes and heritage features. Perceptions of what is acceptable may also change with time.

National guidance on the approach to assessing cumulative impacts for renewable energy development is provided in the PPG and detailed local guidance for wind energy development is provided in the Guidance Note for Central Bedfordshire. Assessment will need to establish the area in which a proposed development may be visible, and identify key viewpoints, the people who experience the views and the nature of the views. It will also need to consider direct and indirect effects, cumulative impacts and temporary and permanent impacts. When assessing the significance of impacts, the sensitivity of the landscape and visual receptors should be taken into account, including views in relation to public rights of way or historic landscapes, alongside the magnitude of the proposed change.

The approach to assessment will generally include mapping existing and proposed development, analysing 'zones of visual influence' of turbines, and preparing visualisations of the proposed development in relation to other sites and key views to and from sensitive receptors. Existing and proposed wind energy development in Central Bedfordshire is shown in Figure 7, as an indication of the current pattern of development.

While there are no hard and fast rules, the Guidance Note for Central Bedfordshire provides an indication of what may the Council may consider acceptable in the area at present. This notes that *"the cumulative impact of a series of single turbines is considered to be of a greater* *consequence than a single, medium sized farm of 3-5 turbines."* The Guidance Notes also states that *"it is the Council's view that the Central Bedfordshire countryside is too populated, complex and varied in its landform to be able to successfully accommodate more than one medium or large farm within a 10km setting of another in a rural setting."*

In planning terms, as it is necessary in practice to consider cumulative impact on a site-by-site basis, it may not be appropriate to apply this spacing as a hard constraint on development in Central Bedfordshire. To derive a higher end estimate of total capacity for development in Central Bedfordshire, it has been assumed that turbines will be developed on 10% of this resulting land area, in line with the assumption in the East of England study for this purpose of this assessment.

6.1.7. **Technical considerations**

Other elements are also important in determining potential capacity, and are often factored in once the constraints and considerations discussed above are accounted for.

- **Grid capacity:** The grid connection can be a significant proportion of the overall costs of wind energy development. Large wind farms require lengthy negotiations over grid infrastructure requirements, and the cost and delay associated with obtaining a connection can be significant. The cost of connection can also be a relatively high proportion of costs for a medium scale project, particularly where capacity is constrained. The areas which are currently least constrained are located towards the centre and west of Central Bedfordshire. The northern parts of these areas have also been identified as the least constrained in physical and planning terms for wind energy development, particularly for medium turbines (Figure 11 and Figure 12), suggesting there is some potential for additional projects at least in the short term. Even if grid capacity is a short-term constraint, it is likely that in the long term, if demand for development persists, that the infrastructure will be reinforced to release additional capacity.
- **Spacing between turbines:** In order to maximise output from multiple wind turbines within a wind farm, optimum positioning and distance is required to avoid wind shading and turbulence effects. Typically it is recommended to have a distance of around five times the rotor diameter between turbines, although this may vary depending on the local wind resource and other site-specific factors.
- **Efficiency and capacity factor** – the efficiency of the turbines directly impacts electricity production, and often newer designs will have higher efficiencies and mechanisms to ensure optimum positioning. Capacity factor indicates the proportion of time a turbine is generating at full nameplate capacity, and provides a way of calculating expected output of new developments. An average capacity factor for UK onshore wind turbines of 26% was used to calculate the annual output from the resulting capacity of wind energy development considered in this assessment, as detailed in the latest DUKES report by DECC[xxxii].

Access for construction, particularly large vehicles for transporting turbine blades, will also need careful consideration on a site-by-site basis.

6.1.8. **Assessment of potential capacity**

While areas affected by the planning considerations outlined above, including Green Belt, AONB and radar constraints, should not be treated as absolute exclusion areas for wind energy development, they are likely to be a lower priority for developers than less constrained areas. To account for the range of possible outcomes, we have prepared lower and higher estimates of potential capacity as follows:

- **Lower:** The lower estimate of capacity only considers development in areas where average wind speeds are at least 5m/s and which are not affected by Green Belt, AONB or radar constraints. In these locations, it has been assumed that only clusters of up to three medium scale wind turbines will be developed at a distance of 10km apart, in line with recommendations in the Central Bedfordshire Guidance Note. Capacity factors have been assumed in line with average industry figures, as described above.
- **Higher:** The higher end of the range also includes the potential capacity for development inside areas affected by these planning considerations. This is based on the assumption that any impacts can be mitigated to the extent that they are not considered significant and that sufficient capacity can be released in the local grid through reinforcement where necessary. Again, areas where average wind speeds are greater than 5m/s have been selected. It has been assumed that only 10% of the resulting land areas will be developed in practice, to account for spacing between turbines, in line with the East of England study. While large wind turbines could be developed in principle under these conditions, the estimate for the higher end of the range is also based on the potential for medium-scale wind turbines, as it results in a higher figure for total capacity. An average density of development of 8.25MW per km^2 has been assumed across the areas included in the assessment to provide an estimate of the maximum potential capacity if all constraints were relaxed. This is based on a spacing of five rotor diameters between turbines. Capacity factors have been assumed in line with average industry figures, as described above.

For the purpose of this assessment, assumptions about the density of development in both cases have been applied equally across all areas considered, although in practice there are likely to be local variations, such as those discussed in the Guidance Note for Central Bedfordshire. The results of the assessment are presented in Table 4.

Estimate of potential capacity	Number of turbines	Potential capacity (MW)	Annual power generation (MWh/yr)	Annual carbon savings (tonnes/yr)
Lower	44	15	33,000	11,400
Higher	473	156	355,000	121,300

Table 4: Lower and higher estimates of potential capacity for wind energy development in Central Bedfordshire

6.2. Solar farms

In the UK, solar farms are large ground-mounted installations of solar photovoltaic (PV) panels. In recent years the viability of solar farms as commercial ventures has significantly increased, with a large number of sites of being consented throughout the UK. This is due to an improvement in project economics, due to falling module costs, improving efficiency and long-term government incentives, coupled with a smoother planning process compared to wind energy development.

Solar panels generate electricity when their cells are exposed to sunlight. These cells are made up of layers of semi-conducting materials, often crystalline silicon. Whilst they function in cloudy weather, direct sunlight will result in a much higher output. Solar panels are highly versatile. They can be used in a wide range of locations and require very little maintenance once installed. In some cases they can serve other purposes in addition to generating energy, including acting as a roofing material, outdoor shading or noise barriers for roads.

Solar panels produce no emissions whilst operating, and have very low emissions associated with the production of the panels compared to the amount of energy generated over their lifetime. There are however some impacts associated with the materials and chemicals used in panel manufacturing, and overall efficiency of the panels remains relatively low, with around 5 to 15% of the solar radiation which falls on the cells being converted to electrical energy, depending on their design.

As with wind energy, there are a range of factors to consider when assessing potential capacity for solar farms across Central Bedfordshire. Our assessment of potential capacity for solar farms is based on our experience of searching for sites and taking them through the planning process on behalf of developers.

The opportunities and constraints maps for solar farms are presented in the following section, followed by a discussion about the naturally available resource, exclusion areas, planning considerations, cumulative impacts, technical considerations and an estimate of the total potential capacity.

6.2.1. Opportunities and constraints map

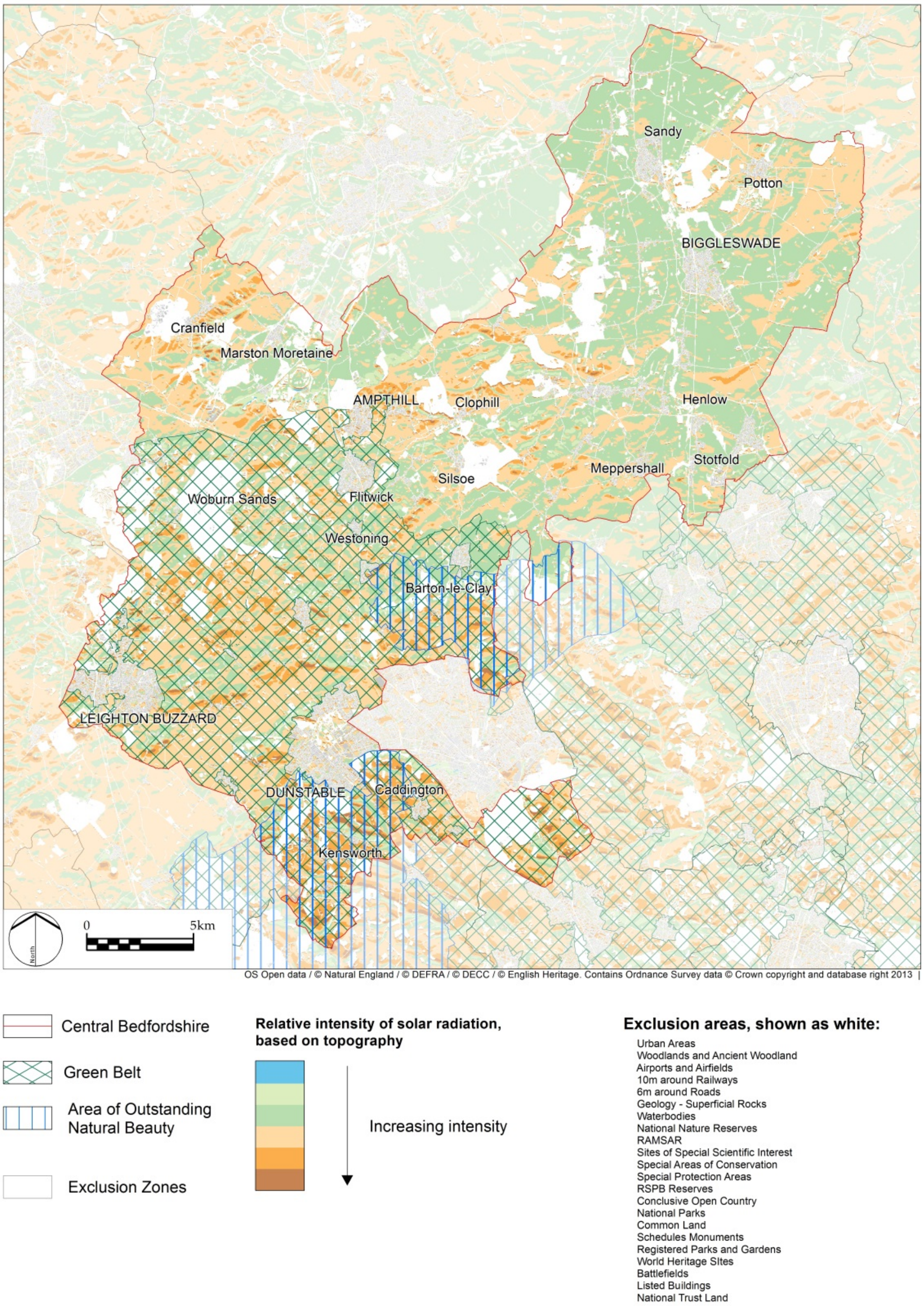

Figure 13: Opportunities and constraints map for solar farms

6.2.2. Naturally available resource

- **Solar resource:** The relative intensity of solar radiation varies across an area, due to latitude, topography and climate. These factors directly affect the power output of a solar farm, with optimum output being produced by south-facing, unshaded panels. We have modelled the relative intensity of solar radiation across Central Bedfordshire to understand where the most attractive areas for development are located (Figure 13). In general, the highest levels of solar radiation will be found on south-facing hillsides, while the lowest levels will be found on shaded, north-facing slopes or valley bottoms.

  Although the highest levels of radiation are more attractive in terms of output from the panels, there are other practical and planning considerations which might make these sites less favourable, such as greater visibility of sloping sites within the wider landscape, and access for construction or maintenance. While it is something that would need to be considered on a site-by-site basis, we have assumed for the purpose of this study that sites are developed on land which comes into the middle bands of solar radiation intensities on our mapping. This land is more likely to be flat or shallow-sloping but not north-facing, and may therefore represent a suitable compromise for development.

6.2.3. Exclusion areas

As with wind energy development, it has been assumed that solar farms will not be constructed within the following areas, although in this case no buffer zone has been applied around them:

- **Urban areas and new property development sites:** It has been assumed that solar farms of the type considered in this chapter will not be constructed in urban areas for the purpose of this assessment. Solar panels may of course be installed on roof space in urban areas, but this is considered separately.
- **Major roads and railways:** It has been assumed that solar farms will not be developed on or immediately adjacent to major roads and railways. Visual impacts arising from developments in the vicinity of roads may need to be considered however.
- **Airports:** Solar farms are assumed not to be developed within the boundaries of airports for the purpose of this assessment, although in practice this would not necessarily be ruled out. The potential for glint and glare from sunlight reflecting off the panels would also need to be assessed on a site-by-site basis for developments close to airports and mitigated where necessary.
- **Inland waterways:** It has been assumed that solar farms will not be developed on inland waterways.
- **Ancient woodlands:** It has been assumed that solar farms will not be developed on land covered by ancient woodlands.
- **Public rights of way and bridleways:** Although it has been assumed that solar farms will not be developed directly on public rights of way and bridleways, the potential for visual impacts arising from developments in the vicinity of these features would still need to be assessed and mitigated where necessary on a site-by-site basis.

- **Heritage designations, including Scheduled Ancient Monuments, Listed Buildings, Registered Parks & Gardens and Conservation Areas:** Solar farms are considered unlikely to be developed within the boundary of sites with a heritage designation for the purpose of this assessment. As with wind energy development, the potential impact of solar farms on the setting of heritage assets in the surrounding area will need to be considered in practice on a site-by-site basis and any impacts mitigated to an acceptable level.
- **Ecological designations, including SSSIs, National Nature Reserves and the Greensand Ridge NIA**: Solar farms are also assumed not to be developed within the boundaries of sites covered by ecological designations. In practice, ecological impacts will need to be assessed and mitigated where necessary even for developments outside of these areas.

6.2.4. **Planning considerations**

The following designations have been plotted for consideration in the planning process. As described above in relation to wind energy development, these are not hard and fast constraints on development but issues which should be taken into account on a site-by-site basis when assessing planning applications:

- **Green Belt:** As described above in the section on wind energy development, around a third of Central Bedfordshire is located within the Green Belt (Figure 13). The same policy will apply to solar farms, in terms of the importance of preserving the openness of the Green Belt, the principle that many elements of development will be considered inappropriate in the Green Belt in relation to this, and the need to demonstrate very special circumstances for development to be permitted. However, as solar farms are likely to be less visible beyond the site boundary compared to wind turbines, provided that sites are well screened, planning can be less constrained than for wind energy development in the Green Belt.
- **Agricultural land classification:** Once solar farms are built, the agricultural use of the land underneath the solar panels tends to be limited to sheep grazing or grassland. While the NPPF supports rural diversification, it also encourages local planning authorities to safeguard the long term potential of the 'best and most versatile agricultural land', which is defined in the same document as land in grades 1, 2 and 3a of the Agricultural Land Classification, and that developments should seek to use areas of poorer quality land in preference to that of a higher quality. Where solar farms are developed on agricultural land, the PPG encourages an allowance for continued agricultural use and/or improvements to biodiversity.

  In planning terms, it is necessary to consider this carefully on a site-by-site basis as it will be important to consider how the land is currently used, the importance of the proposed development site in relation to the overall amount of land in different grades across the area, and also the temporary nature of solar farm development, which could allow the land to be returned to a more intensive agricultural use in future.

  In Central Bedfordshire, there is a relatively high proportion of land in grade 1 or 2, as shown in Figure 14. In terms of the capacity assessment, we have excluded this land and assumed that it would not be prioritised for solar farm development. In practice, a distinction also needs to be made between grades 3a and 3b on a site by site basis, although it is not possible to do this using the national dataset. A case could also be made in practice for development on land which is technically higher grade if it is currently underused or the development is likely to have relatively little impact on the overall productivity of the area.

- **Landscape, including the Chilterns AONB and areas of high landscape sensitivity:** As described above in relation to wind energy development, although there is a need to have regard to the landscape impacts of development, particularly in areas in or around protected landscapes such as the Chilterns AONB, development in or around these areas cannot be ruled out and must be considered on a site-by-site basis.

  In addition to the sensitivity of the landscape, it will also be important to take into account topography and the potential for mitigation of any landscape and visual impacts, including screening. As mentioned above in terms of access to solar resources, we have excluded from the assessment those areas of land in the highest band of solar radiation intensity, as these are more likely to be south facing slopes and therefore more visible across the wider area, in addition to those in the lower bands which are more likely to be north facing sites or in valley bottoms.

Other planning considerations which are not mapped or listed above or taken into account directly in the capacity assessment, but which must be considered on a site-by-site basis for solar farm developments include landscape and visual impact, heritage impacts, ecological impacts, flood risk, access, site security and community engagement.

6.2.5. Cumulative landscape and visual impacts

As shown in Figure 7, a number of solar farms are already in the planning process or operational in Central Bedfordshire. A significant proportion of these sites came forward as pre-applications towards the end of 2013, demonstrating the recent increase in project viability.

The approach to assessing cumulative landscape and visual impacts of solar farms should be the same as for assessing impacts in relation to wind energy development, as described earlier. The PPG however points out that *"in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero."* In undulating landscapes, the potential for cumulative impacts of multiple developments is likely to be greater than development on relatively flat sites which can easily be screened for example by planting or improving hedgerows.

As there are no clear rules as to what should be considered acceptable in terms of cumulative impacts for solar farms, we have not taken this into account in the figures presented in the capacity assessment. For the purpose of this assessment, it has been assumed that solar farms are developed across 10% of the land area included in the assessment, to account for some separation between individual development sites.

6.2.7. **Technical considerations**

- **Grid capacity:** Grid capacity and the cost of achieving a grid connection is one of the most important factors in determining viability of a site for a solar farm at present. As described earlier, in relation to wind energy development, the north eastern part of Central Bedfordshire is currently most constrained in terms of grid capacity while there is potentially some capacity available in central and western areas. Further development, including construction of the projects which are currently in the planning pipeline if they are taken forwards, will reduce the amount of capacity available until reinforcements are made to the grid infrastructure. Although this could present a constraint on development in the short term, it is likely that in the long term further investment will be made in improving the grid to release additional capacity, provided there is sufficient demand for grid connections.
- **Land take per unit capacity of solar panels:** The land required for a solar farm will vary according to the requirements of the site, but typically it is in the region of 12ha per 5MW of capacity[xv] for an average layout of panels across a site. Sites with a better solar resource, low visibility and no shading can in practice cluster panels more tightly, reducing the land take.
- **Typical output from the panels:** PV technology covers a range of types, such as thin film and mono/polycrystalline, each with varying efficiencies and therefore varying power output per unit of capacity installed. Solar farms more often than not use crystalline panels. As the technology develops, efficiencies are likely to improve and power outputs will increase accordingly. In practice, the output from the panels will also depend on their layout, orientation and tilt, and any shading for example from trees on the site boundary, which would need to be optimised in site selection and design.

  Based on recent analysis by DECC in relation to the review of financial incentives for solar energy, we have assumed a typical output of 975MWh per year per MW of installed capacity for solar farms[xxxiii].

6.2.8. **Assessment of potential capacity**

While areas affected by the planning considerations outlined above, including Green Belt, agricultural land classification and the AONB, should not be treated as absolute exclusion areas for solar farms, they are likely to be a lower priority for developers than less constrained areas. To account for the range of possible outcomes, we have prepared lower and higher estimates of potential capacity as follows:

- **Lower:** The lower end of this range only considers development in areas which are not in the Green Belt or the AONB. In areas outside of these constraints, it has been assumed that development only takes place on land which is agricultural grade 3 or below, and which is within the middle two bands of solar radiation intensity on the opportunities and constraints map, as shown in Figure 13. Assumptions on separation between development sites, land take per unit of capacity and typical output from the panels are in line with those set out above, and no allowance has been made for grid constraints as it has been assumed that these may be resolved in time.

- **Higher:** The higher end of the range also includes the potential capacity for development inside areas of Green Belt and AONB, but still only on grade 3 land or below. This is based on the assumption that any impacts can be mitigated to the extent that they are not considered significant. Assumptions about separation between sites, land-take, output and grid constraints are the same as for the lower estimate.

The results of this analysis can be seen in Table 5. In practice, a site-by-site assessment of the various planning considerations and cumulative impacts will be required and grid capacity constraints may also result in a lower density of development, as described above.

Maximum technical potential	Suitable land area (ha)	Potential capacity (MW)	Potential electricity generation (MWh/yr)	Net CO_2 savings (tonnes/yr)
Lower	1,165	485	473,000	162,000
Higher	2,479	1,833	1,007,000	344,000

Table 5: Lower and higher estimates of potential capacity for solar farm development in Central Bedfordshire

6.3. Locally sourced biomass

Biomass which can be used for power and/or heat generation includes various forms of organic material, such as wood, straw, energy crops or organic waste from farms and industry. Whilst using biomass for energy generation releases carbon emissions, this is offset by the emissions absorbed during the growth of the original biomass, and is therefore deemed almost 'carbon-neutral', with low lifecycle emissions.

Dry or woody biomass can be combusted directly, and may first be processed into a more convenient form such as pellets or chippings, particularly for use in smaller combustion plant. Very efficient biomass combustion plant are available which can produce heat for direct use or in power generation, ranging from small boilers for domestic use with a thermal capacity of a few kilowatts (kW) up to large industrial plant with a capacity of hundreds of megawatts (MW). Biomass can also often be used in existing solid-fuel plant, as seen in the conversion of coal-burning power plants such as Drax to use an increasing proportion of wood fuel.

Aside from direct combustion, there are two other ways which dry or woody biomass can be used in power generation. Pyrolysis treats the feedstock in high temperatures and a lack of oxygen to produce a combustible gas or liquid, whilst gasification involves the part-decomposition of organic material and the creation of synthetic gas. Both are expensive and emerging technologies currently. Wet biomass, such as vegetable waste and animal slurry, can be used in anaerobic digestion (AD) to produce biogas, which can then be combusted for heat and/or power generation. The potential for AD development in Central Bedfordshire is described in section 6.3.6 of this report.

The availability of sufficient amounts of biomass in the supply chain the biggest constraint on biomass energy development, as a secure fuel source is needed to guarantee viability. The equipment also requires regular maintenance, for both domestic and non-domestic systems, and the debate over the true carbon impacts of using different types of biomass for energy generation is still ongoing. Factors which need to be taken into account include the emissions impacts of land-use changes and of transporting biomass from the locations where the resource is available to where it will be used.

An assessment of the potential for locally-sourced biomass in Central Bedfordshire has been made and is described in the following sections of this report. All data relating to agricultural land areas, uses and yields were taken from Defra's latest agricultural statistics for England, with 2010 being the most recent year for which data is available.

6.3.1. Opportunities and constraints map

Potential biomass resources and constraints have been plotted for Central Bedfordshire, as shown in Figure 14.

March 2014

Renewables Capacity Study for Central Bedfordshire

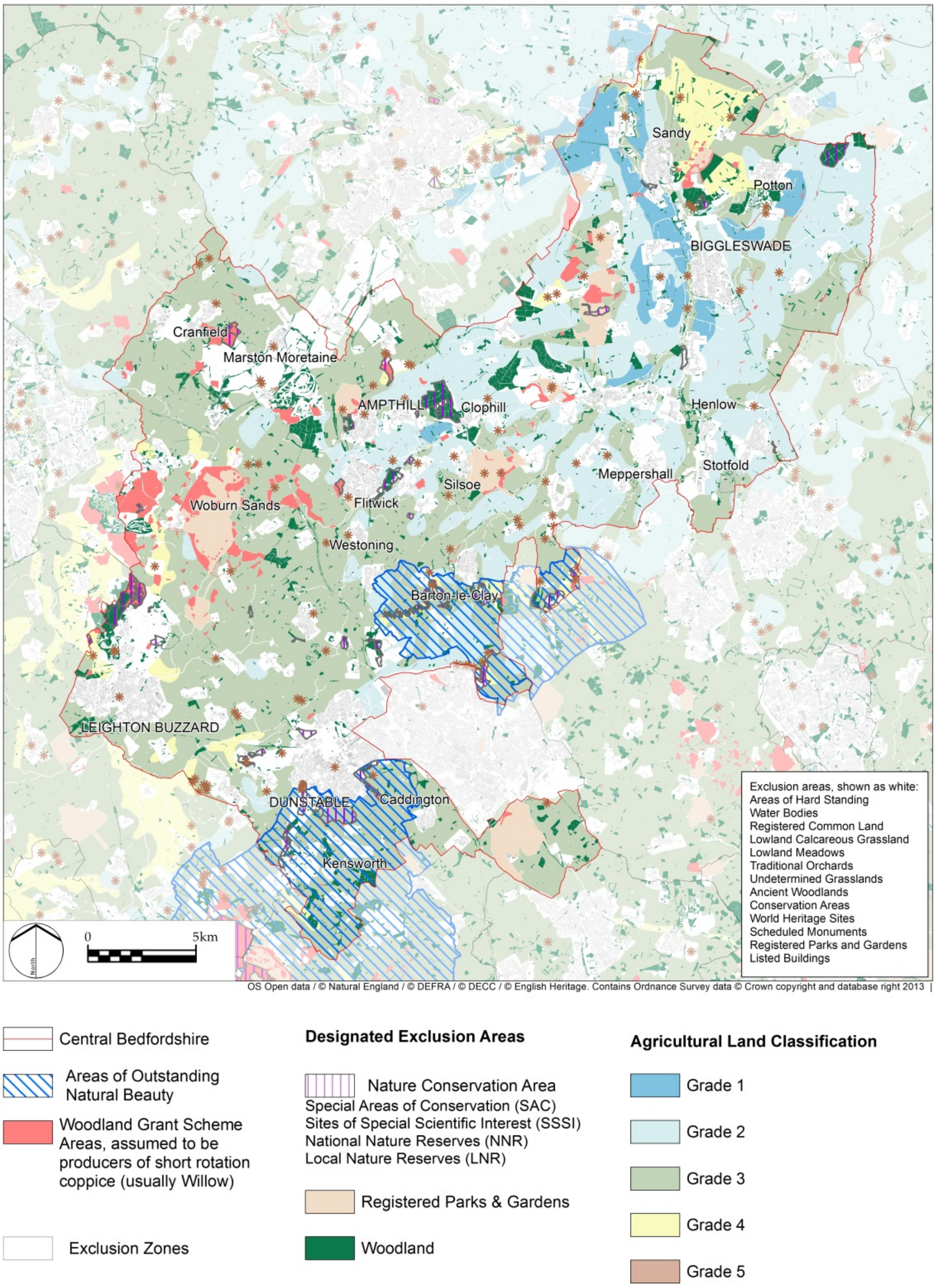

Figure 14: Opportunities and constraints for locally-sourced biomass

6.3.2. Energy crops

It has been assumed that crops grown for energy use would consist of either short rotation coppice (SRC), usually willow in the UK, or miscanthus. It has been assumed that all existing Woodland Grant Scheme Areas are used for SRC production, while any available arable land which is converted for energy crop production will be used for miscanthus. Central Bedfordshire is assumed to have a high potential yield for growing miscanthus, based on information published by Defra[xxxiv].

In line with the DECC methodology for calculating potential capacity, we have assessed the potential for energy crops in Central Bedfordshire according to the following three scenarios. All of the scenarios exclude the Chilterns AONB, Registered Parks and Gardens and designated nature conservation areas (Figure 14). The scenarios are as follows:

- **Low:** No arable, pasture or fallow land is available for miscanthus growing, and only SRC Schemes continue production at current levels.
- **Medium:** Only land that is fallow or temporary grassland is available for miscanthus growing, to avoid competition with food crops[xxxv], SRC Schemes continue production
- **High:** All grades of available arable and pasture land (1-5) are considered suitable for miscanthus growing, SRC Schemes continue production at current levels

For the purpose of this assessment, it has been assumed that all energy crops grown in Central Bedfordshire are harvested for use in combined heat and power (CHP) generation, in order to maximise efficiency of use of the resource. When calculating the energy output of these scenarios, it is assumed that the average ratio of heat-to-power output from the CHP plant is 2:1, producing $2MW_{th}$[xxxvi] of heat for every MW_e of power output. A capacity factor of 90% for electrical output, and 50% for heat output, has been used in line with assumptions made in the East of England[xxxvi] report, to account for the fact that some of the heat generated will not be used in practice.

The results of this assessment can be seen in Table 6. Further detail on assumptions is provided in section 1.4.2 of the Appendix.

Suitable land area (ha)	Potential electrical capacity (MW_e)	Potential electricity generation (MWh/yr)	Potential thermal capacity (MW_{th})	Potential heat generation (MWh/yr)	Net Co2 savings (tonnes/yr)
High scenario					
49,850	124	977,000	248	1,086,000	601,500
Medium scenario					
31,855	79	622,000	158	696,000	383,200
Low scenario					
830	1.4	11,000	2.8	12,000	6,700

Table 6: Potential energy crop resource, based on low, medium and high scenarios

6.3.3. Managed woodland

Outputs from managed woodland that are not suitable for use in other markets such as construction or industry, and which are economically viable to harvest for energy purposes, could be used as fuel. This includes brash, thinnings or "poor quality final crops in both conifer and hardwood crops", all of which hold potential for generating energy[xxxvi]. In practice, wood waste from construction and industry could also be captured and used as fuel, although this has not been taken into account in this assessment due to the limited data on availability of this resource in the area.

Within Central Bedfordshire, there is a reasonable coverage of woodland which could be managed for fuel production. This woodland comprises a range of conifer (50%), broadleaved (35%) and mixed (15%) tree types[xxxvii], all of which can be used as fuel, with conifer producing the highest energy values per oven-dried tonne. A total area of available woodland was calculated using this data and the opportunities and constraints map (Figure 14), excluding ancient woodland, nature conservation designations and Registered Parks and Gardens.

In calculating the potential capacity, this report has assumed that all wood fuel harvested from managed woodland would be used to fuel biomass boilers for heat generation only, as in practice there is limited capacity for wood-fuelled CHP plant currently in use. These are more likely to be medium to large biomass boilers, as locally sourced wood from small managed woodlands is more likely to be distributed as woodchip and domestic biomass boilers typically require commercially processed wood pellets.

The results of the analysis can be seen in Table 7, while details of the assumptions are provided in Appendix section 1.4.3.

Maximum technical capacity	Potential heat capacity (MWth)	Potential heat generation (MWh/yr)	Net Co2 savings (tonnes/yr)
Biomass boilers	3.8	10,000	2,500

Table 7: Potential capacity generated from biomass boilers fuelled by managed woodland in Central Bedfordshire

6.3.4. Agricultural arisings

Agricultural arisings which are suitable for energy generation generally consist of straw from the production of wheat and oilseed rape, and are only used for the generation of electricity. As these arisings are often in demand from other industries (such as cattle feedstock for the dairy industry), it requires a large agricultural base with low demand to be a viable fuel. This is further complicated by the requirement of large supply chains for straw resources, meaning they're likely only to be used in few, large plants[xxxvi].

To calculate the potential for Central Bedfordshire, the total farming area of wheat and oilseed rape in the area was gathered[xxxv], assuming benchmark productions of straw from each (see Appendix section 1.4.4). As with the other biomass resources a capacity factor of 90% was applied. The results of the analysis can be seen in Table 8.

It is likely this potential will be lower in practice due to other uses for the straw, particularly cattle as described earlier. It is also important to note that if any arable land was converted for energy crop production, as described above, the amount of straw produced as a by-product would be reduced.

Maximum technical potential	Potential capacity (MW)	Potential electricity generation (MWh/yr)	Net CO_2 savings (tonnes/yr)
Total	26	206,000	87,700

Table 8: Potential electrical capacity from the burning of straw from wheat and oilseed rape in Central Bedfordshire, with CO2 savings in 2031.

6.3.5. Poultry litter

Being a dry organic waste, poultry litter is most commonly burnt either for electricity generation alone, or in a CHP plant, but it can also be mixed with wet waste streams for use in anaerobic digestion. For the purpose of this report, it is assumed that poultry litter will be used for electricity generation only, due to its dry nature, relative efficiency as a fuel and the potential distance between the fuel source and the users of any heat that would be produced.

Data on the number of farmed birds in Central Bedfordshire was gathered from the Defra database[xxxv], and the amount of litter produced over a typical year applied[xxxviii]. We assumed that 100% of this resource was available for energy generation, in line with DECC expectations for 2020 onwards, and reflecting the likelihood that this resource is not currently used for any other means[xxxix]. DECC benchmarks for tonnes of poultry litter required for 1MWe of capacity were used, and the total potential calculated for the area; a capacity factor of 90% was used for an electricity-only plant[xxxvi].

Results are shown in Table 9, with the underlying assumptions available in Appendix section 1.4.5. Evidently the small number of poultry in Central Bedfordshire limits the potential resource, and this will not make a significant contribution to energy generation unless farming patterns in the area change significantly. However, this could represent a small but useful source for on-site generation at poultry farms.

Maximum technical potential	Potential capacity (MW)	Potential electricity generation (MWh/yr)	Net CO_2 savings (tonnes/yr)
Total	0.33	3,200	1,100

Table 9: Potential capacity from poultry litter fuelling a generator

6.3.6. Anaerobic digestion

In AD, wet organic material is allowed to decompose in controlled conditions and produce biogas, which can then be burnt in a gas turbine. This allows the use of sewage and other wastes that otherwise would not be a viable fuel. AD is predominantly fuelled by wet waste, including animal slurry from farms and waste from the food and drinks industry.

In this report, we have based our assessment for AD potential in Central Bedfordshire on an assessment of the amount of animal slurry only. We have excluded waste from the food and drinks industry due to a lack of available data and an assumption that this waste stream may already be captured as feedstock for an AD plant elsewhere. Other local sources of wet organic waste such as sewage treatment works, domestic food waste and green garden waste have also been excluded.

Data regarding the number of cattle and pigs in the Central Bedfordshire area was obtained from the Defra datasets[xxxv] and benchmarks for the amount of slurry produced per head were used to generate a total tonnage[xl]. Of this potential feedstock, it was assumed that 80% would be economically recoverable from the farming sites due to collection and transport constraints, and 100% of this collected slurry would be directed to a CHP plant, as per the DECC methodology.

In order for the biogas produced by AD to be used in the most efficient way, we have assumed that all of it will be used to fuel a CHP plant. In practice, biogas could also be combusted for heat or power generation only or upgraded in quality to produce biomethane and injected into the existing gas grid for use in standard gas boilers. The results are shown in Table 10, with assumptions in Appendix section 1.4.6.

Potential electrical capacity (MW_e)	Potential electricity generation (MWh/yr)	Potential heat capacity (MW_{th})	Potential heat generation (MWh/yr)	Net Co2 savings (tonnes/yr)
0.4	3,200	0.8	3,500	1,100

Table 10: Potential capacity for anaerobic digestion and CHP using animal slurry

The potential for energy generation from animal slurry seems only slightly greater than that of poultry litter, and is potentially too small and widespread to be of any realistic commercial use. Given the relatively small amount of livestock farming in Central Bedfordshire compared to other areas, the case may be limited for AD at this scale; however small-scale on-farm AD may be a viable option for larger farms in the area, particularly if they are able to supplement the feedstock with maize or other crops or farm by-products.

It is worth noting that Central Bedfordshire lies in a Nitrate Vulnerable Zone (NVZ)), with issues concerning surface water, groundwater and eutrophic zones throughout the area (Figure 24 in Appendix section 1.4.6)[xli]. This means that the traditional form of disposing of slurry by spreading it onto the surrounding land as fertiliser is not viable. As AD still produces a digestate that must also either be spread on the land, or dealt with through storage or treatment[xlii], the implications of digestate disposal for AD viability would need careful consideration. However, AD digestate has the benefit of being a more effective fertiliser than slurry where it can be spread on the land, and reduces relative methane emissions in the process[xliii].

6.5. Hydropower

Hydropower relies on running water to generate electricity, from small streams to large rivers. The potential energy of water flowing from a height is converted into kinetic energy by turbines, which drive generators and produce power. Greater heights (head heights) and faster flowing water lead to higher power outputs, making the technology highly site-specific.

There are various forms of hydropower, including the traditional run-of-river (RoR) and reservoir storage schemes, and less common pumped-storage facilities, such as Dinorwig in Wales. Hydropower is a technology that has been proven and in use for many centuries. The turbines are very reliable and the output is generally predictable, although the flow and output can vary seasonally and with weather conditions. There are no emissions during use and it can be very cost-effective at a sufficient scale and length of operation. However, there are a number of important environmental considerations. These involve potential impacts on local ecology (particularly fish) and the risk of affecting flood management for the surrounding area.

Potential sites for micro hydropower schemes in Central Bedfordshire have been mapped (Figure 15) and assessed using the Environment Agency's study on potential sites across the UK[xliv]. This identifies the location of potential sites and gives them a rating in terms of output and ecological sensitivity, split into the following categories:

- Low output, low sensitivity
- Low output, high sensitivity
- Medium output, medium sensitivity
- High output, low sensitivity
- High output, high sensitivity

Output categorisation involves studying the flow speeds, head heights and hydraulic efficiencies of potential sites, and producing an estimate of the potential power output. Sensitivity is determined by modelling expected fish populations at each site and the presence of Special Areas of Conservation, to understand the likely impacts of developing a hydro scheme in the area. For the purpose of this report, we have excluded all sites that are of 'high sensitivity', to avoid sites which are more likely to have a significant impact on the local environment.

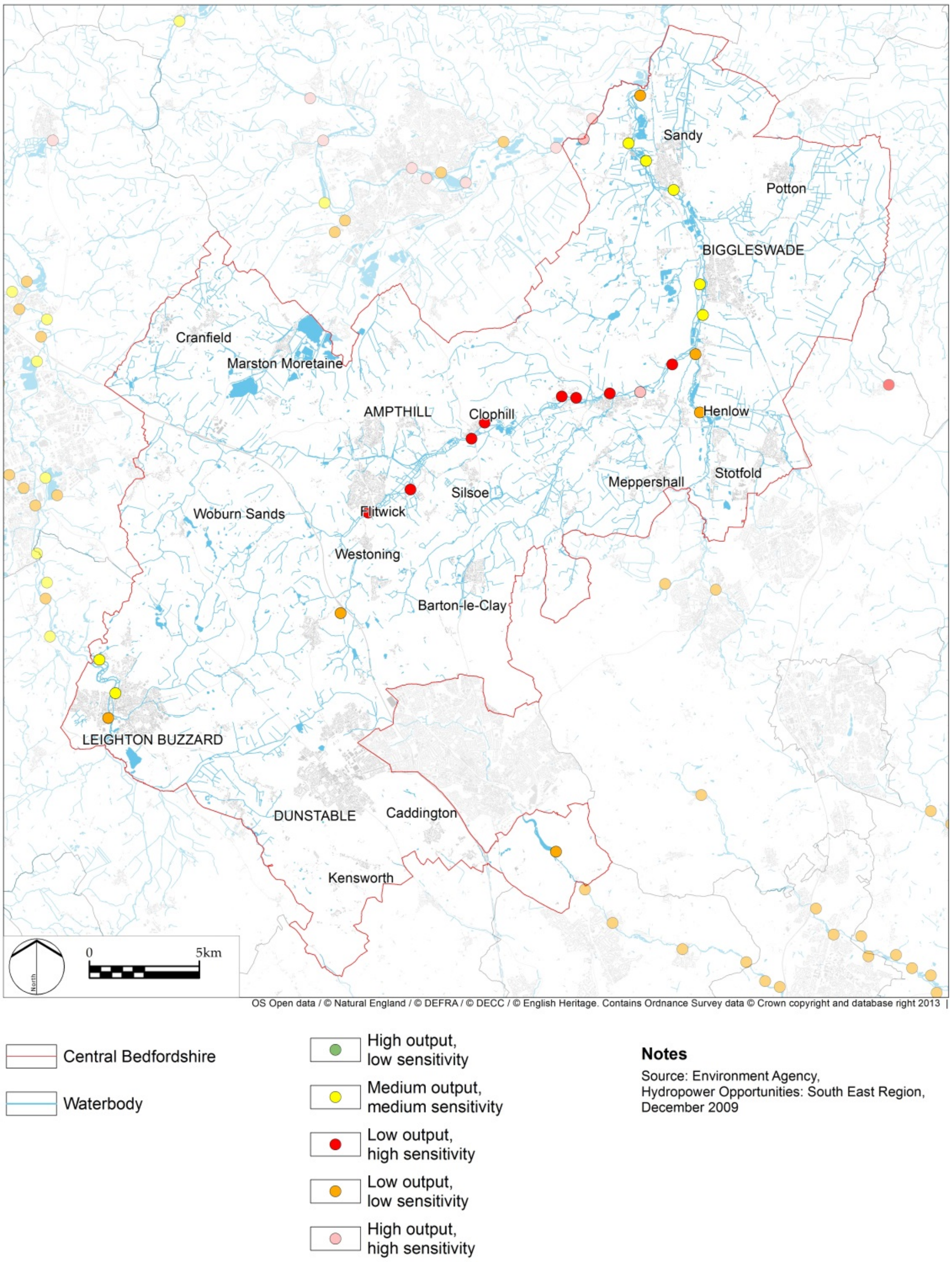

Figure 15: Hydropower opportunities and constraints

In order to calculate the technical potential for Central Bedfordshire, we counted the number of sites covering all outputs of low/medium sensitivity, and summed their power output as provided by the Environment Agency. Further details can be found in Appendix section 1.4.7 on how this was done. Electrical output was calculated using a capacity factor of 36% for the UK, based on the most recent DUKES report[xxxii]. The results are shown in Table 11.

Site category	Potential capacity (MW)	Potential electricity generation (MWh/yr)	Net CO_2 savings (tonnes/yr)
Low and medium sensitivity sites	0.38	1,980	400

Table 11: Potential capacity from micro hydropower sites in Central Bedfordshire

Whilst the majority of sites in the UK with commercial-scale hydropower potential have either been developed or deemed too environmentally sensitive to do so, there is a number of very low output, but low sensitivity sites remaining. In Central Bedfordshire, despite a maximum potential of just 0.38MW, this is spread amongst 13 sites.

Although the total potential for micro-hydropower in Central Bedfordshire is relatively low, development of some sites such as conversion of existing mills to power generation can be worthwhile in their own right. The costs of developing small sites can be high compared to the financial returns, so viability would need to be assessed on a site-by-site basis to obtain a more realistic figure for capacity.

6.6. District heating

District heating systems provide large buildings or multiple dwellings with heat and hot water from a central 'energy centre', with the heat transported through a network of highly-insulated pipes to sources of demand. A range of different heat sources can be used depending on the scale of the network, including biomass boilers, geothermal or CHP systems using a variety of fuels. District heat networks can also make use of large sources of waste heat such as industrial developments or large thermal power stations.

District heating is particularly well-suited to dense urban areas, where there is a high and relatively consistent demand for heat and good use can be made of the infrastructure to justify the relatively high installation costs for the heat network. In addition to high-density housing, it is preferable to connect a heat network to large, energy-intensive buildings or 'anchor loads' like hospitals or leisure centres and other non-residential development to get a good mix of different heat demand profiles. Although viability can vary depending on the characteristics of a local area and the specific proposals for a heat network, DECC suggests a threshold heat density of at least 3,000kW/km^2 is required to make a district heating scheme with CHP viable.

DECC's National Heat Map tool has been used[xlv] to understand heat density in Central Bedfordshire. This includes contours showing residential and non-residential heat demand and identifies larger anchor loads and potential sources of waste heat as points on a map of the UK. Figure 16 shows an extract from this National Heat Map for Central Bedfordshire, with total heat demand from all domestic and non-domestic properties. All areas that are within and above the 20-30kWh/m^2 band meet the DECC 3,000kW/km^2 threshold, with

Appendix section 1.4.8 detailing the assumptions behind the scale conversion for the purposes of this report.

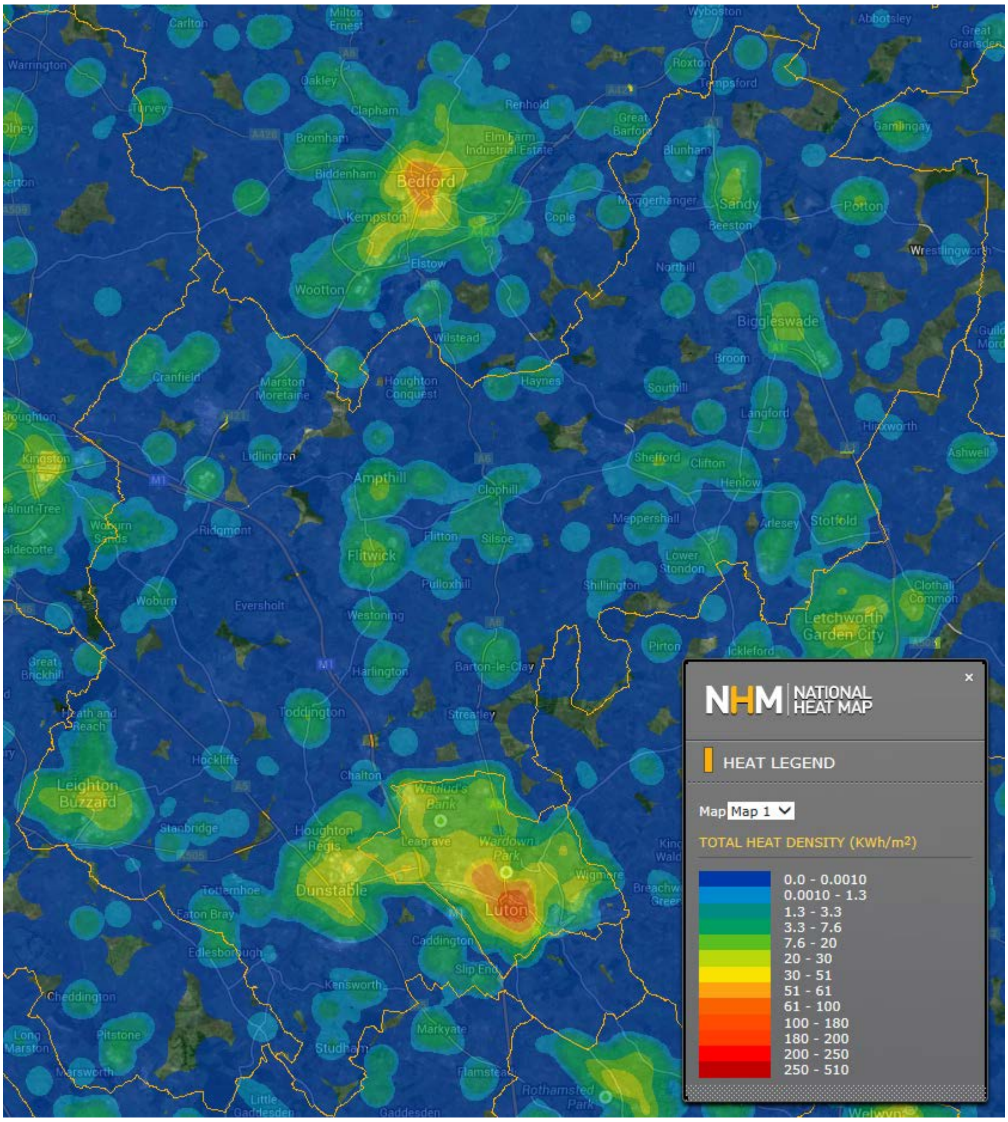

Figure 16: Total heat density map for Central Bedfordshire (boundary in yellow)

From Figure 16, it appears that there are no areas in Central Bedfordshire with particularly high heat densities. The highest values can be found in Leighton Buzzard and Dunstable, with some spill-over from Luton. Of this, only the very central areas of these towns show potential densities above the indicative viability threshold. Elsewhere, the predominantly rural nature of Central Bedfordshire, and the highly dispersed population result in very low heat densities.

It is therefore unlikely that there is potential for any sizable CHP and district heating networks in Central Bedfordshire, particularly with regards to retrofitting district heating to existing development. There could however be scope for CHP plants in a number of leisure centres, such as Flitwick, as noted in Central Bedfordshire's Carbon Management Plan, although limited progress has been made to date[xlvi]. The potential for CHP and district heating on major new property development sites should also be considered on a site-by-site basis as part of the planning process.

6.7. Building-integrated renewables

Building-integrated renewables cover a range of small scale technologies, capable of generating either electricity or heat, including roof-mounted solar PV and solar thermal systems, heat pumps and biomass boilers. They are lower output than most other renewable energy technologies, but due to their size and cost, are far more flexible in terms of siting, especially in urban areas.

Installation of building-integrated renewable energy technologies on existing buildings does not generally require planning permission, provided they meet certain conditions. Furthermore, government proposals set out in the Housing Standards Review[ix] are expected to restrict the ability of local planning authorities to set targets for new development to provide renewable energy generation on-site. Together, these points mean that building-integrated renewables rarely need to be considered by development control officers, unlike other types of development discussed above. The primary purpose of considering building-integrated renewables in this study is to inform the development of scenarios for cumulative renewable energy capacity in the area for comparison with local and national targets.

6.7.1. Roof-mounted solar PV and solar thermal

Roof-mounted solar PV works in the same way as the technology used for larger solar farms, producing electricity from sunlight. Solar thermal systems generate heat by concentrating solar radiation onto pipes carrying a heat-transfer fluid, which is passed through a heat exchanger usually in the hot water tank to provide hot water and/or heat to the building.

Both of these solar technologies can be installed on a single roof provided there is sufficient space available. They can be placed on a wide range of domestic and non-domestic roofs, although it is important to avoid shading and the panels should be as close to south-facing as possible to maximise output.

Solar PV and thermal systems are likely to be the most viable form of building integrated renewable generation, due to their mature market status, well-developed technologies and attractive economics over the medium to long term. As of 2014, nearly 500,000 homes in the UK and thousands of businesses and community sites had installed solar PV systems, totalling 2.5GW of capacity[xv]. With the publication of DECC's latest solar PV roadmap, there is a clear drive towards continuing this trend, with expectations of 10GW by 2020, and aspirations for more.

As most solar installations are integrated directly into either existing or new buildings, their distribution is likely to follow the plans laid out for development in Central Bedfordshire over time. In order to calculate the maximum potential for roof-mounted solar energy in Central Bedfordshire, information about the number of existing residential dwellings was obtained from the Bedfordshire and Luton Strategic Housing Market Assessment[xlvii]. Data on existing non-domestic developments was taken from the Employment Land Review[xlviii] and the Central Bedfordshire Council Retail Study[xlix]. These were then supplemented by the projected numbers of new housing and non-domestic floorspace calculated in section 3.3, to assess the potential solar generation capacity on new development.

Assumptions were made about the likely proportion of properties and roof space that would be able to house a solar PV or thermal system, based on the assumptions in the East of England study[xxxvi]. These assumptions allowed us to build more realistic figure for potential capacity, accounting for a number of factors, such as existing roof uses and loss of space due to orientation and angling of the panels. Further details can be found in Appendix section 1.4.9, including detail on how floorspace values for non-domestic buildings were converted to usable roof space. These are likely to be maximum assumptions for roof space utilised, as this varies considerably between buildings, but is useful as guidance for analysis at this scale.

Domestic systems were assumed to be of 2kW thermal or electrical capacity[xxxvi]. It is worth noting that a 2kW solar thermal system occupies considerably less roofspace than a 2kW solar electric system. The potential capacity for non-domestic systems was calculated using benchmarks for capacity installed per unit of roof area for an average crystalline panel[l]. A capacity factor of 8% was applied from the latest DUKEs publication[xxxii] to calculate the output of solar thermal systems, and a typical 850kWh output per kW of PV installed[xxiii] to establish potential annual generation. The results can be seen in Table 12 and Table 13.

Building type	**Potential electrical capacity (MW)**	**Potential electricity generation (MWh/yr)**	**Net CO_2 savings (tonnes/yr)**
Domestic	37	31,000	10,600
Non-Domestic	13.5	13,000	4,000
Total	50.5	44,000	14,600

Table 12: Potential capacity of roof-mounted solar PV systems in Central Bedfordshire

Building type	**Potential thermal capacity (MW)**	**Potential heat generation (MWh/yr)**	**Net CO_2 savings (tonnes/yr)**
Domestic	37	25,600	6,300

Table 13: Potential capacity of roof-mounted solar thermal systems in Central Bedfordshire

6.7.2. Heat pumps

Heat pumps use the naturally-occurring low-level heat found underground or in the atmosphere, and convert it into high-grade heat for use in space heating. They are a highly efficient way of generating heat using electricity, which can either be produced onsite by renewables or drawn from the national grid. Heat pumps operate more efficiently the lower the temperature of the output, so work more effectively with lower temperature heating systems such as underfloor heating compared to traditional wall-mounted radiators and are better suited to well-insulated properties. Ground-source pumps are more efficient than air-source heat pumps, but are often more expensive and require larger amounts of land for installation.

Given heat pumps commonly utilise electricity from the national grid, they are not strictly speaking renewable energy unless they are connected to on-site renewable energy generators such as solar panels. The carbon savings compared to electric heating or oil-fired heating are quite substantial, but compared to an efficient gas boiler the carbon savings and financial benefits of heat pumps can be negligible. They are therefore best suited to properties that are off the gas grid. Alongside this, they can be disruptive during installation and relatively expensive – the RHPP and planned domestic RHI help alleviate these upfront costs.

Due to the comparatively low space-heating demand for non-domestic buildings, and the difficulties in estimating the capacity that would be required for the variety of non-domestic buildings in Central Bedfordshire, this report has opted to study domestic potential only. The following assumptions have been applied to estimate the number of domestic properties which could be suitable for heat pumps:

- 50% of all properties off the gas grid are suitable
- 50% of all new developments

Data on the number of off gas-grid homes was obtained from DECC's subnational statistics on unmetered properties[li], with the housing mix of off-grid properties assumed from DECC's analysis of their own subnational data[lii]. This was combined with the remaining existing and planned domestic developments to calculate the total suitable number of properties.

As air-source heat pumps are of lower efficiency and higher energy consumption compared to ground-source heat pumps, this report has assumed that ground-source systems would be preferred where feasible and that 80% of suitable homes would select a ground-source heat pump, and 20% would select an air-source heat pump. This also accounts for the higher proportion of detached and semi-detached properties in Central Bedfordshire[xlvii], which are more likely to have access to sufficient land for ground source installations.

For the capacity analysis, heat pumps of $5kW_{th}$ capacity were assumed. Ground-source heat pumps were assumed to have a coefficient of performance (efficiency) of 3, with 3kWh of heat produced for every 1kWh of electricity consumed, whilst air source heat pumps were assumed to have a coefficient of performance of 2.5. An average capacity factor of 30% was applied.[liii] Carbon savings were calculated relative to traditional electric heating, and it was assumed that all heat pumps were connected to the grid, with carbon emissions associated with the electricity used deducted from the total savings. The results are shown in Table 14.

Technology	Potential thermal capacity (MW)	Potential heat generation (MWh/yr)	Net CO_2 savings (tonnes/yr)
Ground source	80	212,000	48,000
Air source	20	53,000	11,000
Total	100	265,000	59,000

Table 14: Potential capacity of air and ground source heat pumps in Central Bedfordshire

It is important to note that the DECC data and assumptions for the number of suitable properties could overestimate the potential capacity and output. The number of off-grid properties is a relatively inaccurate estimate, and the owners of dwellings that are off the gas-grid may opt out of installing a heat pump in practice. Furthermore, given the age of the properties in Central Bedfordshire, it is likely that heat pumps are likely to be less efficient in practice than assumed here.

The results show that despite the large potential capacity and output, the emissions from the grid-supplied electricity required to power the systems can suppress the benefits of air and ground source heat pumps. To mitigate this, other building-integrated renewables such as solar PV should be linked to heat pumps where possible. As the UK electricity grid is decarbonised with time, the financial and carbon benefits of heat pumps will become more obvious.

6.7.4. **Domestic biomass boilers**

The final building-integrated renewable energy technology is the biomass boiler. These tend to use wood pellets, particularly for domestic biomass boilers, or woodchip for larger non-domestic boilers. They provide only heat generation, and are a direct replacement for standard boilers. They are particularly cost-effective for properties that are off the gas grid which currently use oil-fired boilers or other fuels.

Typically, biomass boilers at the domestic scale are similar in size to other types of boiler, however they also require space for a fuel store and feed-system which could limit viability in smaller properties. Access is also required for fuel delivery, and a flue will need to be installed for the boiler.

Biomass boilers are currently roughly double the capital cost of gas boilers. However, once installed, the running costs are generally cheaper, and the introduction of the Renewable Heat Incentive means that users can receive payment for any heat generated, improving viability. Despite this, properties currently on the gas grid are still considered to be unlikely to invest in this option.

In this report, as with heat pumps and solar thermal, the much lower heat demands of non-domestic buildings and difficulty in accurately estimating the capacity of system that would be installed for the various types of uses, this analysis only covers potential capacity in the domestic sector. For the purpose of this assessment, biomass boilers are assumed to be installed in all homes which are off the gas grid, but are not assumed to be retrofitted in existing properties on the gas grid or new developments due to the space requirements and costs compared to the alternatives.

Domestic single dwelling systems are assumed to be of 8kWth capacity, with a 30% capacity factor.[liii] Results are shown in Table 15, with CO_2 savings assuming replacement of a standard gas boiler.

Technology	**Potential thermal capacity (MW)**	**Potential heat generation (MWh/yr)**	**Net CO_2 savings (tonnes/yr)**
Biomass boiler	46	120,000	30,000

Table 15: Potential capacity of domestic biomass boilers in Central Bedfordshire

As with heat pumps, this is likely an overestimate of the potential capacity in Central Bedfordshire, as it assumes they are installed in 50% of off gas-grid properties, whereas this may not be viable in practice.

The total capacity could also be limited by the availability and affordability of wood fuel. Given that managed woodland in Central Bedfordshire has the potential for roughly 10,000MWh/yr of supply (section 6.3.3), there would be a need for fuel to be imported via national or international supply chains to meet the heat requirements seen in Table 15.

6.9. Total renewable energy potential

Our estimates of total potential capacity for renewable energy technologies in Central Bedfordshire, according to the assessment outlined above, are displayed in Figure 17 - Figure 19. The height of the columns in the chart corresponds to the total annual output from each technology, in megawatt hours (MWh), while the figures shown above each column correspond to the total generating capacity installed, in megawatts (MW). Where applicable, a lower and higher estimate is shown, relating to the scenarios described in the sections on each technology above. Separate figures are shown for electricity generating potential (Figure 17), heat generating potential (Figure 18) and total carbon savings potential (Figure 19).

It is important to note that solar farms and energy crops would compete for space on lower-grade agricultural land according to the assumptions made in our assessment, and that in practice it may not be realistic to achieve the full capacity shown for both of these options. As only a maximum of 10% of a relatively small area identified as potentially suitable for wind energy has been assumed to be used, it is considered likely that this could be developed alongside the stated capacity for solar farms without any competition for land.

According to this assessment, wind energy and solar farms have the potential to provide the vast majority of Central Bedfordshire's energy generation potential, whilst the maximum resource of building-integrated PV and solar thermal, alongside hydropower and animal biomass is negligible in comparison.

Figures for potential renewable energy capacity, electricity and heat generation, and carbon savings in Central Bedfordshire across all of the technologies considered and as a total, are shown in Table 16. A range of figures is included for each to account for the lower and higher estimates provided for some technologies. Regarding energy crops and for the purposes of these totals, only the low to medium scenarios are included, due to the land competition constraints with solar farms and food in the higher scenario.

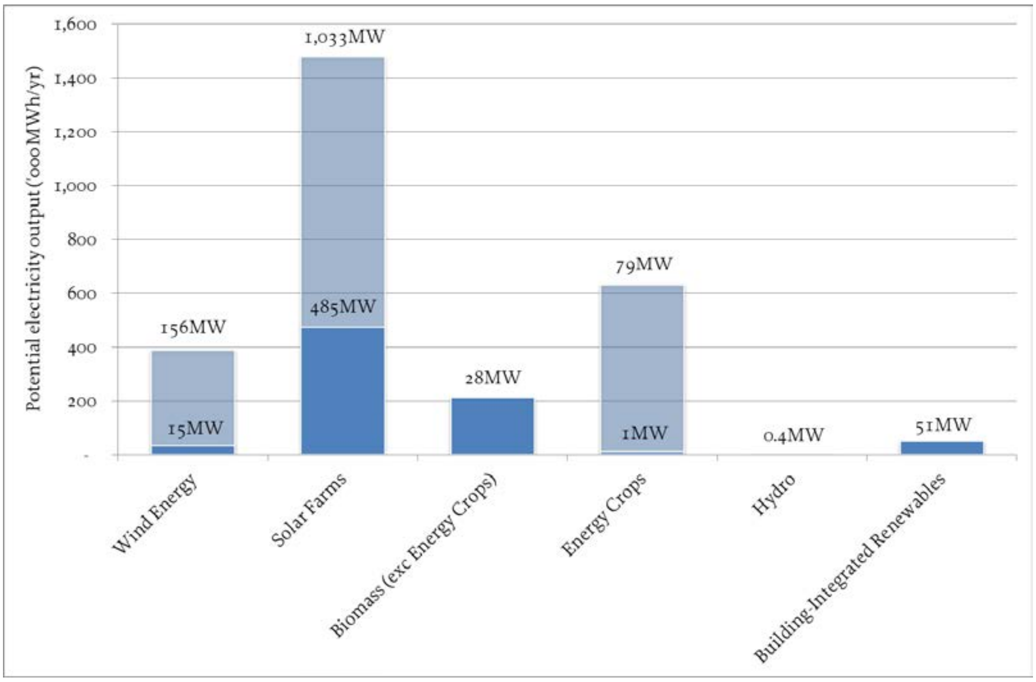

Figure 17: Total potential capacity for electricity generation in Central Bedfordshire

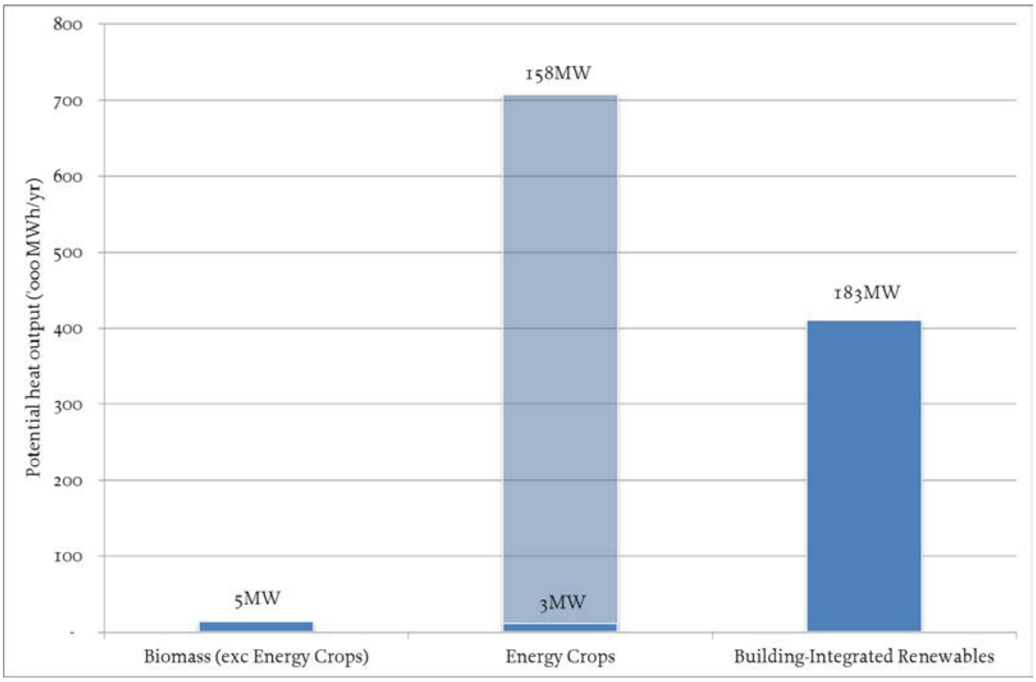

Figure 18: Total potential capacity for heat generation in Central Bedfordshire

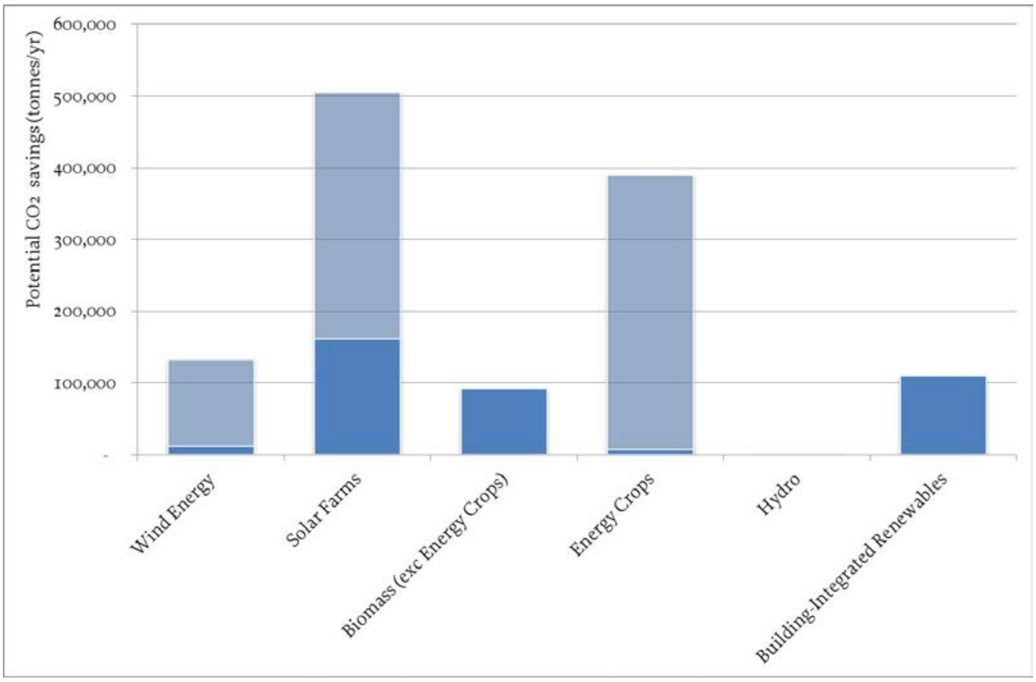

Figure 19: Total potential capacity for carbon savings from renewables in Central Bedfordshire

Total potential	Installed electrical capacity (MW_e)	Electricity generation (MWh/yr)	Installed thermal capacity (MW_{th})	Heat generation (MWh/yr)	Carbon savings (tonnes/yr)
Wind energy	15 - 156	33,000 – 355,000	-	-	11,400 – 121,300
Solar farms	485 – 1,033	473,000 – 1,007,000	-	-	161,600 – 344,000
Energy Crops	1 - 79	11,000 – 622,000	3 – 158	12,000 – 696,000	6,700 – 383,000
Managed woodland	-	-	4	10,000	2,500
Agricultural arisings	26	206,000	-	-	87,700
Poultry litter	<1	3,200	-	-	1,100
AD	<1	3,200	<1	3,500	1,100
Hydro	<1	2,000	-	-	400
Building-integrated solar	51	44,000	37	25,600	20,900
Heat pumps	-	-	100	265,000	59,000
Biomass boilers	-	-	46	120,000	30,000
Total	**581 – 1,348**	**775,400 - 2,242,400**	**191 - 346**	**429,100 – 1,120,100**	**367,800 – 1,044,700**

Table 16: Total potential renewable energy capacity in Central Bedfordshire for all technologies

7.0 Deployment scenarios

The figures presented in the previous chapter consider the total potential capacity for renewable energy development, based on the assumptions outlined in the assessment. The figures for total potential do not however take into account the rate of deployment over time. In addition, the total capacity assessment does not make any conclusions as to amount of development which might be achievable over the period covered by the Development Strategy or the extent of development in the area which may be required in order to achieve other aspirations such as targets for carbon savings.

Three scenarios have been developed which consider the potential rate of deployment in Central Bedfordshire by 2031, corresponding to the period covered by the Development Strategy. The scenarios consider deployment on a business as usual basis, and the amount of deployment which would be required to meet two defined end goals. The scenarios are described below, including a discussion of the implications for Central Bedfordshire in terms of the extent of development, and some planning and practical considerations.

7.1.1. Business-as-usual

Under a business-as-usual scenario, it has been assumed that development would be brought forwards based on current industry activity levels, typical planning consent rates and build-out rates through to 2031. It assumes that no further policy intervention is made to encourage additional development, and that political and public attitudes to renewable energy development remain relatively consistent with the current picture.

In order to analyse this, we have looked at the capacity which is already operational, data about projects which are already in the planning pipeline, a range of published research on recent developments in the market for each technology, and national projections for future uptake. The resulting projections are shown in Table 17.

Technology	Existing capacity (MW)	Total potential new capacity (MW)	Business-as-usual: Total by 2031			
			Capacity (MW)	Power output (MWh/yr)	Heat output (MWh/yr)	Carbon savings (tonnes/yr)
Wind energy	20	15 – 156	35	77,000		26,640
Solar farms	4	485 – 1,033	247	240,400		82,125
Biomass	1	34 - 279	7	27,840	30,950	17,140
Hydropower	Negligible					
District heating	Negligible					
Building-integrated PV	6.6	51	37	31,875		10,580
Building-integrated renewable heat	0	183	32		71,800	16,700
Total	**31.6**	**768 – 1,457**	**357**	**377,115**	**102,750**	**153,185**

Table 17: Business as usual scenario for deployment to 2031 [2]

The projection for onshore wind assumes the lower end of our capacity estimate will be built out by 2031, adding a further 15MW to the existing wind energy capacity in the area. This would appear reasonable given that 4.6MW of additional capacity has been approved already and a further 3.5MW is in the planning pipeline currently. In support of this, the UK has seen strong growth in the medium wind sector in the last couple of years, according to a study by Renewable UK[liv].

The projection for solar farms assumes that 50% of the lower end of the capacity estimate will be built out by 2031, adding just over 240MW to existing capacity. This seems achievable in terms of demand from developers, given that 5.25MW additional capacity has already been developed and a further 96MW of capacity are in the planning pipeline. It is likely that the development rate will slow somewhat compared to the rapid pace seen in the last year or two, as the optimum sites are taken and it becomes more challenging to identify further sites and take them through the planning process. It is likely that major investment would be needed in grid infrastructure to achieve this level of capacity in Central Bedfordshire. The cost of this could be achieved by contributions from a number of

2 Total potential new capacity refers to thermal capacity if a CHP engine is involved (e.g. energy crops). The total figures only take into account the lower estimate for biomass, to avoid double counting of land used for solar farms and energy crops.

developers although the need for grid upgrades is likely to slow down the pace of development or delay it while work is undertaken.

Growth in the biomass sector has slowed considerably in the last couple of years nationally and in the East of England[lv]. Existing capacity is based on the capacity of the anaerobic digestion plant which is understood to be now in operation, based on the latest statistics from DECC[lvi]. Growth is based on the assumption that a further two reasonable sized projects come forwards in the period up to 2031, in addition to the new biomass CHP site which already has planning permission. These further sites could be linked for example to the existing leisure centres which have been identified as having potential for CHP and/or suitable major new development sites.

Existing figures for building-integrated PV are based on data on uptake of the FiT in Central Bedfordshire to date, which demonstrates that 99% of the existing micro-generation capacity in the area is roof-top PV[lvi]. National figures for small-scale rooftop PV systems shows that growth has slowed over the last couple of years, as initial demand has been taken up and financial incentives have been reduced to slow growth and control subsidies. Growth over the last year was around 20%. It has been assumed that growth will slow further to an average of around 10% per year in future years, which takes the total by 2031 close to the total potential capacity estimated for the area.

Other than what may be achieved in relation to the biomass capacity discussed above, installed capacity of district heating by 2031 has been assumed to be negligible as potential is limited and build-out rates are likely to be slow for projects of any significant scale. Installed capacity of hydropower by 2031 has also been assumed to be negligible, due to the limited potential in Central Bedfordshire, particularly in relation to the opportunities presented by the other technologies.

We have not found any record of existing building-integrated renewable heat installations in Central Bedfordshire. Although there may be some solar thermal, biomass and heat pump systems installed in practice the total capacity is still likely to be negligible compared to the other figures presented here. The introduction of the domestic RHI is likely to drive growth in future. A forecast of the number of domestic renewable heat installations across the whole of the UK by 2021[lvii] has been used to develop an estimate of the number of installations in Central Bedfordshire, assuming this is proportionate to the number of households in the area relative to the rest of the UK and a steady growth rate year on year through to 2031.

7.1.2. Contributing to national targets

This scenario considers the total amount of renewable energy capacity that would be needed in Central Bedfordshire to make a proportionate contribution to the achievement of national renewable energy and emission reduction goals. As the UK currently has a number of legal obligations to boost renewable energy deployment and reduce carbon emissions, this scenario is useful in understanding what level of development Central Bedfordshire will need to bring forward if it is to support the national ambition.

We have based the target for 2030 on the emissions target currently in place under the UK's 4th Carbon Budget. This states a nationwide reduction in annual carbon emissions of roughly 40% will be needed by 2030 compared to 2010 levels, in order to stay on track to achieve the legally binding target of an 80% reduction by 2050. This is more ambitious than the newly announced EU target for emission reductions, which requires a 40% reduction by 2030 on 1990 levels for each Member State. As the Carbon Budget relates to the legally binding framework adopted by the UK government and is more challenging, we have used this target as the lead assumption for this scenario.

In order to simplify this analysis, we have applied this same target to all local authorities in the UK, so as to achieve an overall emissions reduction of 40% nationally by 2030. In practice, it may be more realistic to assume that a higher target will be achieved in places where there is greater scope for savings to be made, for example where there is a large amount of old housing suitable for refurbishment or significant potential for renewable energy generation, or where emissions are less likely to grow, for example due to new development.

Table 18 details the associated reduction in annual emissions that would be required on this basis in Central Bedfordshire. For the purposes of this report, it is assumed that our study period of 2011-2031 is equal to the period covered by the national target of 2010-2030.

Target	Emissions based on energy demand in 2011 (tonnes/yr)	Target emissions for 2031 (tonnes/yr)	Projected change due to energy efficiency and new development (tonnes/yr)	Required saving from renewables by 2031 (tonnes/yr)
40% emission reductions	955,000	573,000	-75,000	-307,000

Table 18: Target emissions savings in Central Bedfordshire by 2031 to contribute to 40% national target in the 4th Carbon Budget

The total annual carbon saving required from renewables by 2031 to achieve this target is approximately double the carbon savings which would be achieved according to the business-as-usual scenario described in the previous section. It would therefore be necessary to roughly double the overall rate of deployment set out in the business-as-usual scenario to achieve this target by 2031. An approximate breakdown of what this could mean by technology is provided in Table 19, below.

Technology	Existing capacity (MW)	Total potential new capacity (MW)	40% carbon target: Total by 2031			
			Capacity (MW)	Power output (MWh/yr)	Heat output (MWh/yr)	Carbon savings (tonnes/yr)
Onshore wind	20	15 – 156	70	154,000	-	53,280
Solar farms	4	485 – 1,033	510	497,380	-	169,900
Biomass	1	34 - 279	14	55,150	61,300	33,950
Hydropower	Negligible					
District heating	Negligible					
Building-integrated PV	6.6	51	51	44,430	-	14,750
Building-integrated renewable heat	0	183	68	-	143,600	35,430
Total	**31.6**	**768 – 1,457**	**713**	**750,960**	**204,900**	**307,310**

Table 19: 40% carbon target scenario for deployment to 2031[3]

In carrying out this analysis, we doubled the deployment rates assumed under the business-as-usual scenario for each technology, provided the figures remained within the overall potential capacity estimates for Central Bedfordshire. As Table 19 indicates, this was possible for all technologies with the exception of building-integrated PV, where the total potential capacity according to the assumptions made in this study would be exceeded. Our assumptions for building-integrated renewables are relatively conservative, and it is possible in practice that it may be possible for additional capacity to be installed on rooftops.

However, for the purpose of this scenario, we have assumed that the shortfall is made up by additional ground-mounted solar farm capacity, as indicated in Table 19, given that they are considered to offer the greatest scope in terms of potential capacity. This amount of solar farm development is just over our lower estimate for the range of potential capacity. Achieving it could therefore mean relaxing some of the assumptions made in our analysis in terms of allowing some development in the Green Belt or the AONB, allowing some

3 Total potential new capacity refers to thermal capacity if a CHP engine is involved (e.g. energy crops). The total figures only take into account the lower estimate for biomass, to avoid double counting of land used for solar farms and energy crops.

development on grade 1 or 2 agricultural land, or allowing for a greater density of development and a reduced distance between development sites.

To deliver this amount of wind energy development would require either larger turbines or clusters of a greater number of medium turbines than currently recommended in the Guidance Note for Central Bedfordshire, or it would require the delivery of some capacity in the Green Belt or the AONB. In addition, further significant investment in grid capacity is likely to be required to facilitate this additional capacity for solar farm and wind energy development.

Based on our analysis, there is in theory the potential in Central Bedfordshire to double the capacity of biomass and other renewable heat installations in the area compared to what is assumed in the business-as-usual scenario. However, this would mean that the rate of uptake per household would need to be significantly greater than national projections for this to be achieved. Central Bedfordshire Council may therefore need to find additional ways of encouraging local deployment, for example by raising awareness of the opportunities amongst building owners, providing technical support and advice, or facilitating the development of the local supply chain for installation.

7.1.3. Meeting local energy needs

This scenario considers the amount of installed renewable energy capacity that would be required to entirely meet all electricity and heat demands for buildings in Central Bedfordshire by 2031. This would go some way beyond the amount required to meet national carbon targets over the same period, and would indicate significant ambition in terms of the amount of capacity being developed.

In order for local renewables to meet 100% of local building-related energy demands by 2031, it will be necessary to produce around 1,223,000 MWh of electricity per year to meet demand for power consumption and 1,716,000 MWh of heat per year, as calculated in section 3.4. Our analysis indicates that even if the higher estimates of capacity for every technology considered in this report were delivered, it would still not be possible to achieve this level of output within Central Bedfordshire, particularly within the timescale considered, due to a number of issues including competing land-uses, planning constraints and technical limitations.

A breakdown of how maximum potential capacity based on our assessment compares to the total energy demand which would need to be met in this scenario is provided in Table 20.

Technology	Existing Capacity (MW)	Total potential new capacity (MW)	100% renewable energy: Total by 2031		
			Capacity (MW)	Electricity (MWh/yr)	Heat (MWh/yr)
Onshore wind	20	15 – 156	156	355,000	-
Solar farms	4	485 – 1,033	1,033	1,007,000	-
Biomass	1	34 - 279	112	549,000	14,000
Hydropower	Negligible				
District heating	Negligible				
Building-integrated PV	6.6	51	51	42,000	-
Building-integrated renewable heat	0	183	183	-	411,000
Total	**31.6**	**768 – 1,457**	**1,535**	**1,954,000**	**425,000**
2031 demand				**1,223,000**	**1,716,000**
Proportion of 2031 demand				**160%**	**25%**
Proportion of 2031 demand if surplus electricity used to supply remaining heat demand				**100%**	**67%**

Table 20: 100% of energy demand scenario for deployment to 2031[4]

Although in theory there is sufficient capacity to be able to supply more than enough electricity from renewable energy sources to meet projected power demands in 2031, the theoretical capacity for renewable heat technologies identified in our assessment would only supply around 25% of heat demand. This is assuming the upper estimates for all technologies we assessed, and therefore represents a large deficit in meeting future heating demand from renewable technologies alone. To address this deficit, we have assumed that all remaining surplus electricity output is used to supply heat, via 100% efficient electrical heating such as storage heaters. When this is calculated, up to 67% of heat demand can be met but there would still be a shortfall.

4 Total potential new capacity refers to thermal capacity if a CHP engine is involved (e.g. energy crops). The total figures only take into account the lower estimate for biomass, to avoid double counting of land used for solar farms and energy crops.

In order to achieve this very challenging target, all of the potential solar farm capacity estimated for this study would need to be delivered, both inside and outside the Green Belt and AONB. Solar farms have still only been assumed to be developed on agricultural land which is grade 3 or below, although in practice development could be delivered on higher grade land, where appropriate on a site-by-site basis. In addition, there is scope to increase the density of development by reducing the distance between solar farms, to further increase the potential contribution from solar farms.

The higher estimate of potential capacity for wind energy development would also need to be delivered to supply the amount shown above. While this still accounts for hard physical and planning constraints and allows for spacing between individual projects, significant compromises would need to be made compared to the assumptions in the Guidance Note for Central Bedfordshire. In particular, development would be needed in the Green Belt, AONB and areas of radar constraint, assuming that any potential impacts could be mitigated to an acceptable level. This would also require either larger turbines or clusters of a greater number of medium turbines than currently recommended in the Guidance Note, with a reduced spacing between project sites.

To avoid double counting with land used for solar farms in this scenario, we have assumed that energy crops would only be grown on grade 1 or 2 land across Central Bedfordshire, which puts an overall limit on the contribution they can make to this scenario. To achieve the quantities shown in Table 20 would require all of the grade 1 and 2 land in the area to be used for energy crops, which would clearly have implications for local food production and may not be achievable or desirable in practice. It is also not necessarily feasible that this quantity of energy crops could be used locally in practice, as a large number of biomass-fuelled power generation, CHP or non-domestic biomass boilers would need to be installed in addition to the domestic-scale biomass boilers which are taken into account within the building-integrated renewable heat figures. Alternatively it is possible that some energy crops could be cultivated in the area and exported for use elsewhere.

The full capacity of building-integrated micro-generation technologies would also need to be installed in order to achieve the figures set out in Table 20, on a rapid timescale, compared to nationally-projected deployment rates. Significant intervention would be required to encourage and facilitate this extent of development, over and above that described in the 40% carbon reduction scenario, above.

The potential impacts and practical challenges associated with achieving this scenario would be significant, and the rate of deployment required to achieve this capacity by 2031 may also outstrip what could be delivered by the supply chain even if the demand could be created locally. In addition, this assessment only takes into account building-related energy demands, and energy demand would be far greater if transport and other uses are also taken into account. It is therefore very unlikely that it will be achievable in practice for Central Bedfordshire to provide for all of its energy demands within the boundaries of the local authority area, without much greater improvements in energy efficiency and significant compromises on a number of planning considerations.

8.0 Conclusions and recommendations

The purpose of this report is to help provide an indication of potential capacity and some of the issues which need to be considered in delivering renewable energy development in Central Bedfordshire. In practice, many of the opportunities and constraints described here need to be considered on a site-by-site basis and addressed through the planning process.

Based on the analysis presented in this report, the development of solar farms presents the greatest potential opportunity for increasing renewable energy capacity in the area. There also appears to be potential for further development of wind energy, and significant capacity could be achieved through widespread uptake of building-integrated PV and renewable heat technologies.

There is also scope for cultivation of local biomass resources to provide fuel, particularly energy crops, although this will depend on competing demand for agricultural land for food production and – increasingly – solar farm development. The contribution from hydropower and district heating to total capacity is likely to be negligible, although individual projects could certainly provide local benefits which make them viable in their own right.

Although there are some physical, technical and 'hard' planning constraints which can be used to derive estimates of capacity, many of the planning considerations discussed in this report need to be assessed on a case-by-case basis as part of the planning process. These include the extent and nature of development in and around the Green Belt and the Chilterns AONB, the extent of solar farm or energy crop development on agricultural land, and the implications of grid constraints and whether they can be overcome in time. Assessment of these issues as part of the planning process will need to take into account the site context, local impacts including cumulative impacts, potential for mitigation, and the acceptability of any residual impacts. We have therefore calculated lower and higher estimates of potential capacity for some of the technologies, to indicate the broad range of capacity which could be delivered depending on the outcome of these case-by-case assessments.

We have also developed scenarios for the total rate of deployment through to 2031, which is the period covered by the Central Bedfordshire Development Strategy (2013). In addition to considering the business-as-usual rate of deployment, our assessment indicates that it could be feasible to deliver sufficient renewable energy capacity in the area by 2031 to make a proportionate contribution to national carbon reduction targets over this same period. This is based on the assumption that the planning considerations discussed above can be satisfactorily addressed and that there is sufficient capacity in the supply chain and demand among local residents for building-integrated technologies. It is not considered likely that sufficient renewable energy capacity could be delivered locally to meet all building-related energy demands in Central Bedfordshire.

Early, positive engagement with local communities will be needed to achieve the levels of deployment outlined in this report, even for the business-as-usual scenario. Communities in Central Bedfordshire could benefit from renewable energy development in a number of ways. This could include direct 'community benefits' payments from large projects, and direct financial benefits received from having a stake in the ownership of either large projects or building-integrated technologies on their own properties.

There are a number of things which Central Bedfordshire Council could do to facilitate development of renewable energy capacity in the area. These include simplifying the planning process where possible, and providing guidance, building on the progress made with the Guidance Note for Wind Energy Development. In terms of supporting growth in micro-generation, there could be a need for the Council to raise awareness of the opportunities amongst residents, provide technical support and advice, and help to facilitate development of the local supply chain, particularly if local deployment is to exceed national expectations.

Central Bedfordshire could also get involved directly in renewable energy development, by investing in projects and/or enabling development on its own land and Council-owned buildings. In addition to supporting growth, this could generate a significant income to supplement Council budgets – an approach which a number of other local authorities are already taking. There are two particular opportunities worthy of further consideration in this regard: the development of solar farms or wind energy on County Farms land (see Figure 20, below) or investment in a programme of micro-generation installation in properties across the area.

A supplementary briefing note has been prepared on this potential, detailing the estimated capacity of wind and solar farms on County Farms land, and the possibility of employing Allowable Solutions to reduce expected emissions projected for new development in Central Bedfordshire through to 2031.

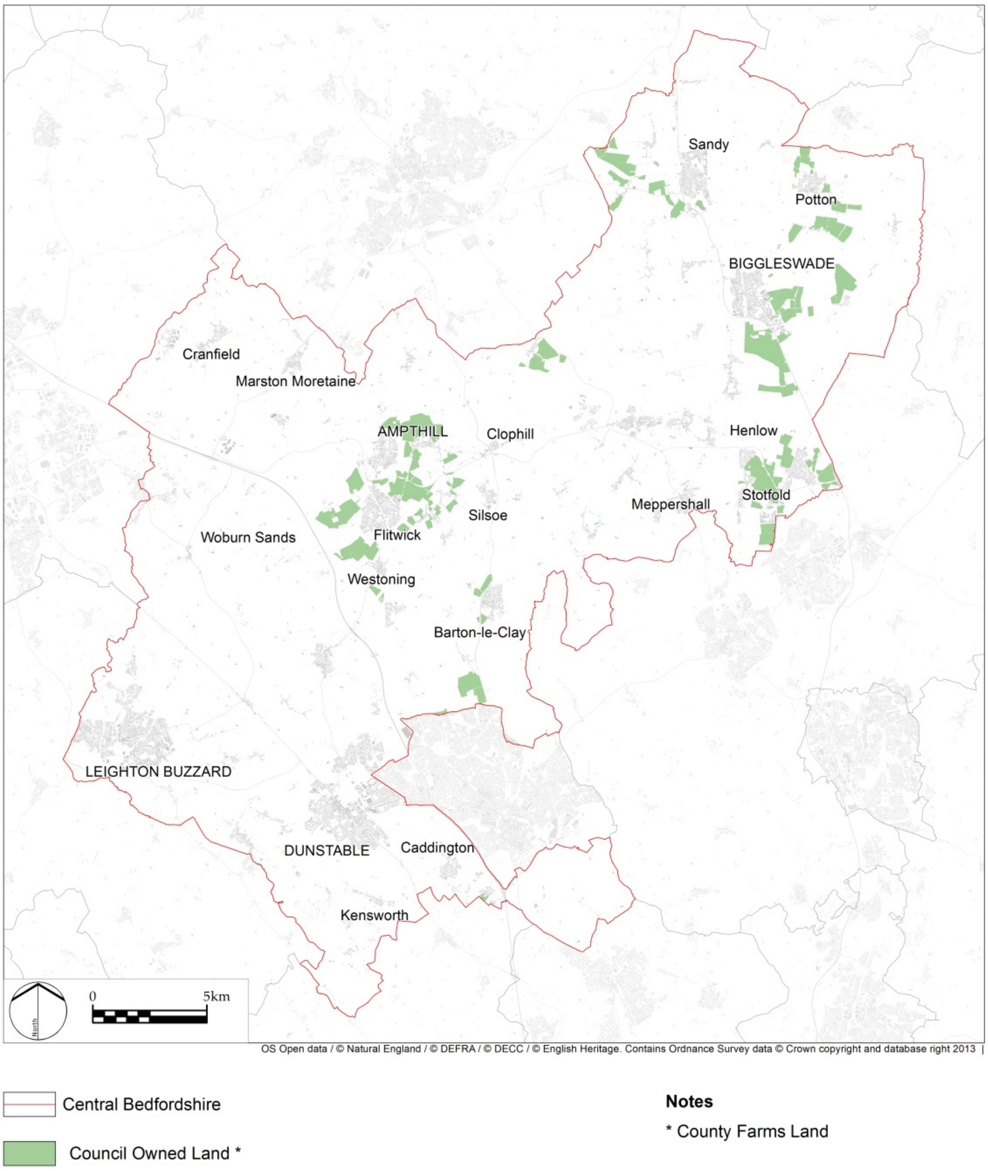

Figure 20: Land owned by Central Bedfordshire Council

1.0 Appendices

1.1. Central Bedfordshire context

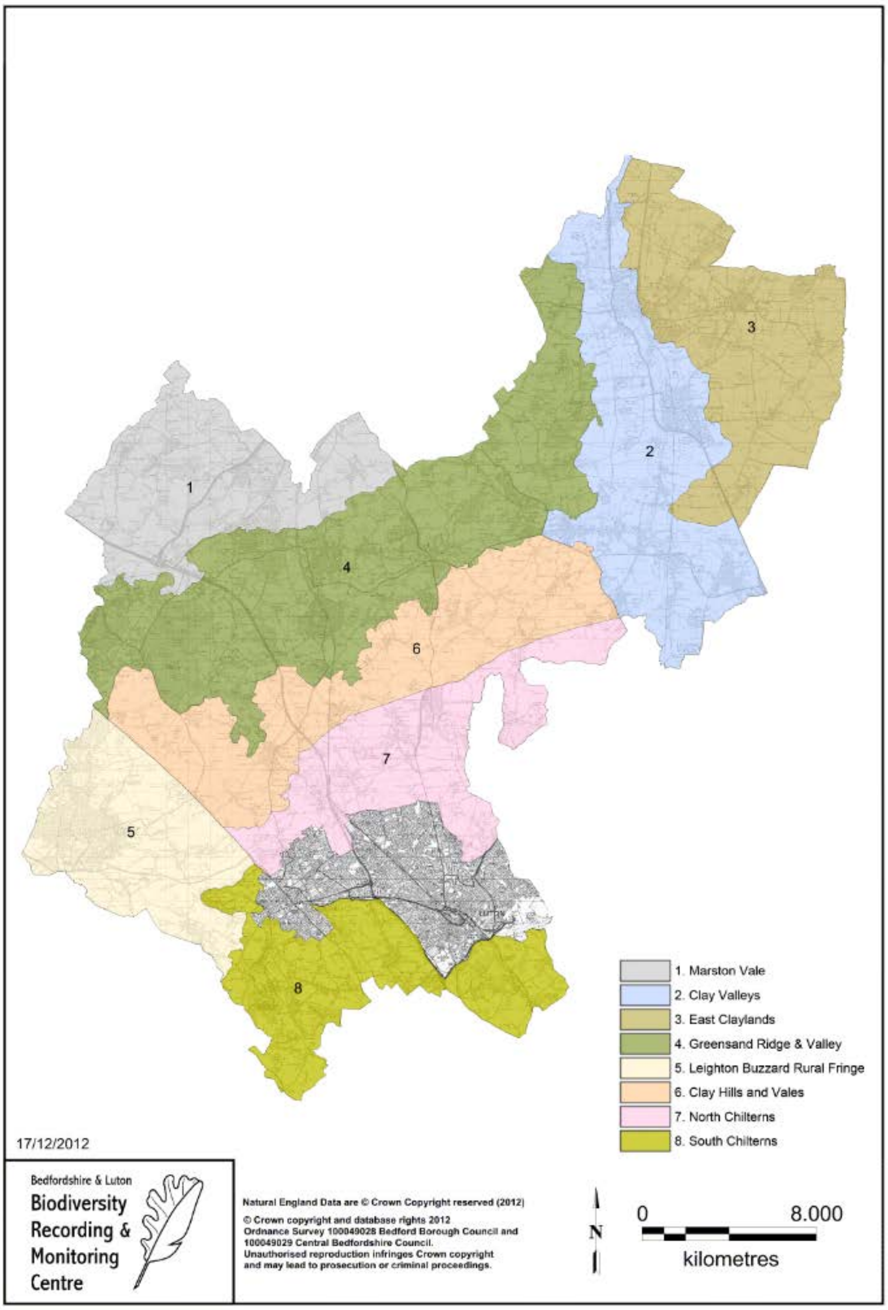

Figure 21: Map of Landscape Designations in Central Bedfordshire, obtained from Wind Guidance Note

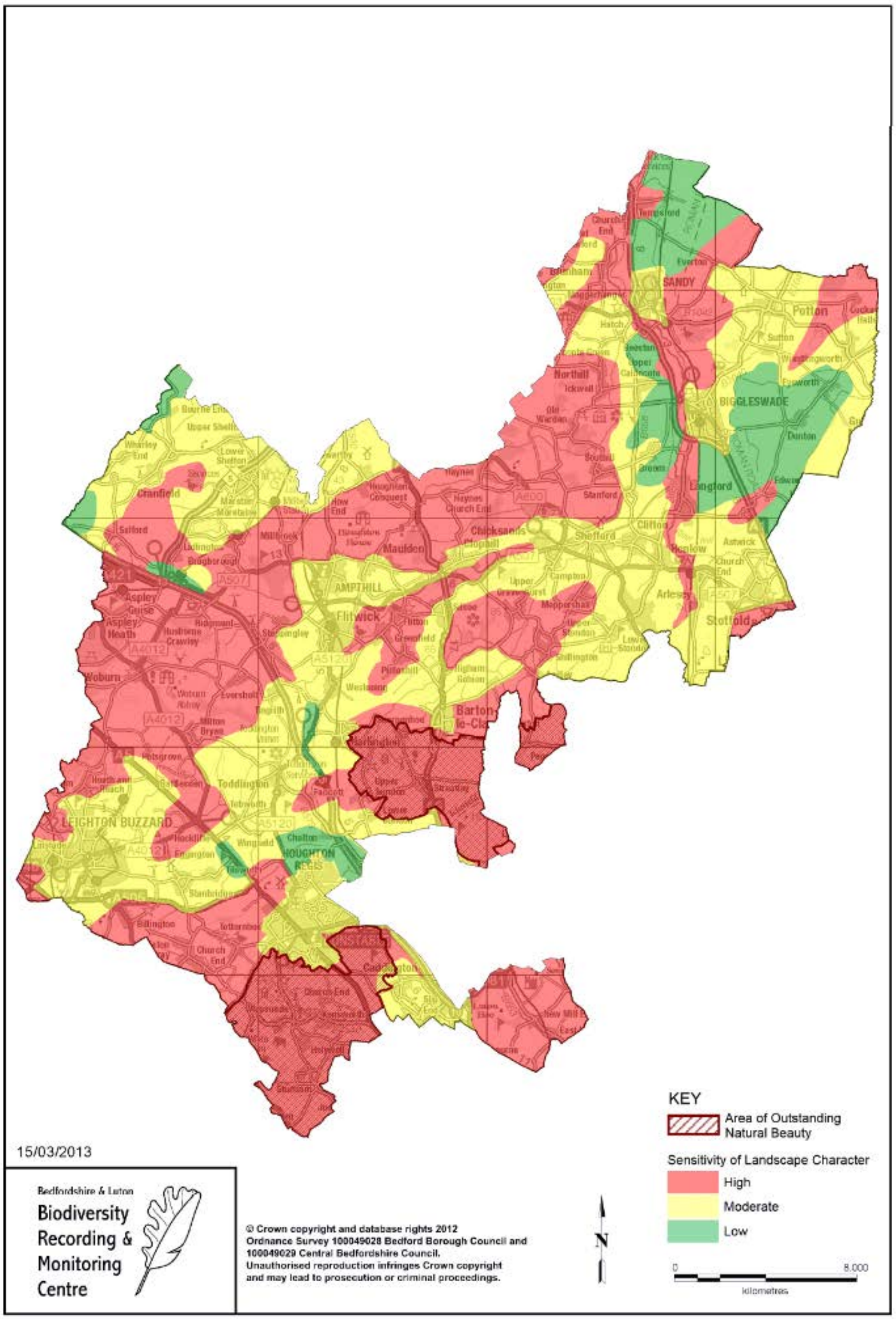

Figure 22: Map of landscape sensitivity areas in Central Bedfordshire, obtained from Wind Guidance Note

1.2. Existing and proposed renewable energy developments

This section contains detailed planning information on all proposed and existing renewable energy projects shown in Figure 7, as gathered from DECC *Restats* data and further communication with all relevant neighbouring Local Authorities. This data is up to date as of the time of writing this report, and has been verified by each Local Authority concerned.

1.2.1. Wind

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
11/60001/SO	Aylesbury Vale	18/02/2011	Burston Hill Farm, Weedon Road, Aston Abbotts, Buckinghamshire, HP22 4NQ	Pre-Application	Proposed wind turbine at Burston Hill Farm - Request for screening opinion	-
11/60005/SO	Aylesbury Vale	05/05/2011	Weatherhead Farm, Barretts End, Leckhampstead, Buckinghamshire, MK18 5NP	Pre-Application	Proposed medium scale wind turbine	-
11/60009/SO	Aylesbury Vale	29/06/2011	Land At Dorcas Lane, Newton Road, Stoke Hammond, Buckinghamshire	Appeal	5 turbine (125m each) wind farm	10
12/60000/SO	Aylesbury Vale	09/03/2012	Isom Fordham & Elgin Lower Waldridge Farm, Owlswick Road, Ford, Buckinghamshire, HP17 8XW	Pre-Application	Scoping Opinion - proposed wind turbine	-
12/60012/SO	Aylesbury Vale	27/03/2013	Cowpasture Farm, Drayton Road, Newton, Longville, Buckinghamshire, MK17 0BU	Pre-Application	Request for scoping opinion relating to the installation of 4(no) wind turbines	10
10/00484/MAF	Bedford	29/06/2012	Chelveston Airport, Chelveston	Operational	9 turbines total (4 Bedford, 5 E Northants) approved on appeal	22.5
08/02692/MAF	Bedford	13/08/2013	Land at Airfield Farm, Podington	Approved	3 turbines approved on appeal	6
13/00663/FUL	Bedford	27/01/2014	Middle Farm, Back Lane, Souldrop	Approved	1 turbines	0.5
12/00713/FUL	Bedford	30/01/2013	Winsey Farm, Park Lane, Sharnbrook	Approved	1 turbine	0.225
CB/13/01466/OAC	Central Bedfordshire	25/04/2013	Bletchley Landfill Site, Newton Road, Bletchley	Approved	Erection of single wind turbine	-
CB/10/03034/FULL	Central Bedfordshire	08/09/2010	Double Arches Quarry, Eastern Way, Heath And Reach, Leighton Buzzard, LU7 9LF	Approved	Erection of single wind turbine (108m high to top of hub, 149m high to tip of rotor)	2.3
CB/11/04077/FULL	Central Bedfordshire	11/11/2011	The Marston Vale Millennium Country Park, Station Road, Marston Moretaine, Bedford, MK43 0PR	Approved	Erection of single wind turbine up to 120.5 metres in height, and ancillary infrastructure	2.3

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
CB/13/03021/SCN	Central Bedfordshire	05/09/2013	Land at Tilsworth, near Leighton Buzzard	Pre-Application	Construction of a solar PV park covering 12-15ha and/or 3 wind turbines with hub height >75m, tip height >102m and rotor diameter >54m	1.5
-	Central Bedfordshire	09/09/2013	The RSPB Reserve, Potton Road, Sandy, SG19 2DL	Pre-Application	RSPB Lodge Nature Reserve Wind Turbine	2
-	Central Bedfordshire	23/08/2013	Edworth Road, Langford, Biggleswade, Bedfordshire, SG18 9PJ	Operational	-	20
12/01927/CONS	Central Bedfordshire	29/08/2012	Speedwell Cottages, Speedwell, Woburn	Pre-Application	1 'mid-size' turbine of tip height 67m	
-	Huntingdonshire	08/10/2013	Land between Graveley, Offord Darcy and Great Paxton	Operational	Cotton Farm	20
-	Milton Keynes	01/09/2010	Petsoe Manor, Olney	Operational	7 turbine farm	14 - 21
-	Milton Keynes	17/10/2013	Malt Mill Farm Castlethorpe Road Hanslope	Pre-Application	Malt Mill Farm	0.8
-	Milton Keynes	04/09/2013	Stoke Goldington, Milton Keynes, Buckinghamshire	Pre-Application	Stoke Heights Wind Farm	30
-	Milton Keynes	25/10/2013	Hill Farm, Little Linford Lane, To Haversham High Street, Haversham, Milton Keynes	Pre-Application	Orchard Way Wind Farm	15
13/00195/FUL	Milton Keynes	04/02/2013	Lodge Farm House, Wolverton Road, Castlethorpe, Milton Keynes, MK19 7ES	Appeal	Installation of 3 wind turbines (max tip height 99.5m)	0.5 – 0.8
12/02611/FUL	Milton Keynes	14/01/2013	Dovecote Farm, Turvey Road, Astwood, Newport, Pagnell, MK16 9JX	Appeal	Erection of single turbine (hub height 50m, tip height 78m)	0.5
08/00047/1	North Hertfordshire	04/09/2008	Weston Hills Wind Turbines, Hatch Lane, Weston, SG4 7EB	Approved	Change of use of agricultural land and siting of 3 120m wind turbines	2
12/00946/ADJ	North Hertfordshire	24/04/2012	Land at Highfield Farm, West of Royston Road, Litlington	Approved	Installation of five wind turbines of maximum tip height 100m	5
S/2564/11	South Cambridgeshire	29/12/2011	Castle Farm, Hatley Road, Gamlingay, Sandy, SG19 3HH	Approved	Installation of single wind turbine (53.7m to tip)	0.33
S/1018/06/F	South Cambridgeshire	17/05/2006	Wadlow Farm, West Wratting	Pre-Application	13 wind turbines and all associated works	-
-	South Northamptonshire	04/09/2013	Land between Roade Courteenhall Hartwell and the M1	Approved	M1 Wind Farm	11.7

1.2.2. Solar farms

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
13/60005/SO	Aylesbury Vale	14/03/2013	Prospect Farm, Highway Drayton, Parslow, Buckinghamshire, MK17 0JW	Pre-Application	Request for screening opinion (EIA)	-
13/60006/SO	Aylesbury Vale	22/05/2013	Ridge Hill Farm, Little Horwood Road, Nash, Buckinghamshire, MK17 0EH	Pre-Application	Request for screening opinion (EIA)	-
13/60007/SO	Aylesbury Vale	17/04/2013	Huntsmill Farm, Finmere Road, Shalstone, Buckinghamshire, MK18 5ND	Pre-Application	Request for screening opinion (EIA)	-
13/60009/SO	Aylesbury Vale	22/05/2013	Home Farm, Mursley Road, Little Horwood, Buckinghamshire, MK17 0PG	Pre-Application	Request for screening opinion (EIA)	-
13/60008/SO	Aylesbury Vale	22/05/2013	The Old Sawmill, Nash Road, Beachampton, Buckinghamshire	Pre-Application	Request for screening opinion (EIA)	-
13/60010/SO	Aylesbury Vale	31/05/2013	Hurdlesgrove Farm, Hurdlesgrove Hill, Hoggeston Buckinghamshire, HP22 4EJ	Pre-Application	Request for screening opinion (EIA)	-
13/60011/SO	Aylesbury Vale	29/05/2013	Park Hill Farm, Bletchley Road, Great Horwood, Buckinghamshire, MK17 0NT	Pre-Application	Request for screening opinion (EIA)	-
13/60014/SO	Aylesbury Vale	31/07/2013	Land Adjacent To Radclive Road, Gawcott, Buckinghamshire	Pre-Application	Request for screening opinion (EIA)	-
13/60015/SO	Aylesbury Vale	06/08/2013	Churchill Farm, Church Hill, Whaddon, Buckinghamshire, MK17 0LZ	Pre-Application	Request for screening opinion (EIA)	-
13/02392/APP	Aylesbury Vale	02/09/2013	Long Meadow Farm, Horton Road, Ivinghoe, Buckinghamshire	Approved	Ground mounted solar farm	3
13/00218/MAF	Bedford	06/06/2013	Glebe Farm, Forty Foot Lane, Souldrop	Approved	-	15.51
12/02408/MAF	Bedford	25/04/2013	Chelveston Airfield, Chelveston	Approved	-	14
CB/13/02421/SCN	Central Bedfordshire	21/08/2013	Land at Faldo Farm, Faldo Road, Barton-le-Clay, Bedford, MK45 4RF	Pre-Application	EIA Screening Opinion	10
CB/11/00455/FULL	Central Bedfordshire	09/02/2011	Cotswold Farm Business Park, Millfield Lane, Caddington, Luton, LU1 4AJ	Operational	Construction of a solar energy farm and associated works	4

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
CB/13/00251/FULL	Central Bedfordshire	29/01/2013	Lodge Farm, Sandy Lane, Chicksands, Shefford, SG17 5QB	Approved	Installation of a ground mounted farm on one corner of farmland	0.25
CB/13/01958/PAPC	Central Bedfordshire	02/07/2013	Land adjoining sewage work, south of the A505, Stanbridge	Pre-Application	Option 1: 1MW site Option 2: 5MW Site	1 – 2.5
CB/13/02171/PAPC	Central Bedfordshire	02/08/2013	West of Fernbury Farm, Tempsford Road, Everton	Pre-Application	Waterloo Solar Farm - installation of solar farm & associated works across 34.6ha	-
CB/11/03829/FULL	Central Bedfordshire	26/01/2012	The Grange, Church End, Hockliffe, Leighton Buzzard, LU7 9NL	Approved	Agricultural land (Cattle grazing) to Installation of Free standing Solar Panels	-
CB/13/03043/SCN	Central Bedfordshire	12/09/2013	Land adj to Chiltern Green Road Newmill End, Lower Harpenden Road, Hyde, Luton LU1 3TS	Pre-Application	EIA Screening Opinion	-
CB/13/01185/SCN	Central Bedfordshire	14/05/2013	Wood Farm, Dickens Lane, Tilsworth, Leighton Buzzard, LU7 9PX	Pre-Application	EIA - Screening Opinion	34
CB/12/03978/SCN	Central Bedfordshire	24/04/2013	Trinity Hall Farm, Near Tilsworth	Pre-Application	EIA - Screening Opinion	-
CB/13/03021/SCN	Central Bedfordshire	05/09/2013	Land at Tilsworth, near Leighton Buzzard	Pre-Application	Construction of a solar farm covering 12-15ha and/or 3 wind turbines with hub height >75m, tip height >102m and rotor diameter >54m	-
CB/13/02899/SCN	Central Bedfordshire	04/09/2013	Clayhill Farm, Westoning, Bedford, MK45 5HH	Pre-Application	EIA Screening Opinion	-
	Central Bedfordshire	20/09/2013	Worth Road, Biggleswade, Bedfordshire, SG18 9PJ	Approved	-	13
1300644FUL	Huntingdonshire	17/05/2013	The Old Wayre, Spaldwick Road, Stow Longa, Huntingdon, PE28 0TL	Approved	Installation of solar photovoltaic panels on a ground mounted system	0.003
1300473FUL	Huntingdonshire	04/06/2013	Hamerton Zoo Park, Hamerton Road, Steeple Gidding, Huntingdon, PE28 5RE	Approved	Installation of ground mounted solar PV array	0.005
1301100FUL	Huntingdonshire	11/07/2013	The Airfield Industrial Estate, Little Staughton Airfield, Little Staughton	Approved	Installation of 208 solar PV panels and associated works to generate 950kWh/kW annually	-
1301218FUL	Huntingdonshire	05/08/2013	Land West Of Railway Line And South Of Brooklands Farm, Rectory Lane, Abbots Ripton	Approved	Development of renewable energy solar farm and all associated works	2.5
1301787FUL	Huntingdonshire	25/11/2013	Land North Of Wiggin Hill, Old Ramsey Road, St Ives	Pre-Application	Proposed solar farm and all associated infrastructure	4.06
1301517FUL	Huntingdonshire	13/12/2013	Padley Chicken Farm, High Street, Old Weston, Huntingdon, PE28 5LA	Pre-Application	Ground mounted solar array provide renewable energy to the associated buildings on the poultry site	0.25

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
13/02504/FUL	Milton Keynes	02/12/2013	Bulls Head Farm, Eakley Lanes, Stoke Goldington Newport Pagnell MK16 8LP	Pre-Application	-	5.8
13/01816/FUL	Milton Keynes	10/09/2013	Oakgrove School Venturer Gate Middleton Milton Keynes MK10 9JQ	Pre-Application	Removal of Existing Wind Turbines and erection of ground mounted PV panels 50kWp	-
13/02114/1SO	North Hertfordshire	28/08/2013	Nuthampstead Aerodrome, Nuthampstead, Royston	Approved	-	10
13/00237/1SO	North Hertfordshire	01/02/2013	Thrift Farm, Baldock Road, Therfield, Royston, SG8 9NN	Approved	Proposed solar farm	-
12/02850/1SO	North Hertfordshire	19/12/2012	Wisbridge Farm, High Street, Reed, Royston, SG8 8AH	Approved	Change of use of land from (1) agriculture to (2) mixed use for agriculture and use for the generation of renewable energy	6
S/2198/10	South Cambridgeshire	15/12/2010	Land at Radical Farm, Chittering Drove, Chittering, Cambridgeshire	Approved	Construction of solar farm	5
S/0154/11	South Cambridgeshire	31/01/2011	Land to West of Cantelupe Road, Cantelupe Farm, Haslingfield, Cambridgeshire	Approved	Continued use as agricultural land and a new solar farm	5
S/1611/12/FL	South Cambridgeshire	14/08/2012	Caxton Road, Bourn, Cambridgeshire, CB23 2SU	Approved	Construction of solar energy farm and all associated works	5
S/0841/13/E1	South Cambridgeshire	10/04/2013	Land to the west of Radical Farm, Chittering Drove, Chittering, Cambridgeshire	Pre-Application	EIA Screening Opinion request for 27 hectare site for 20 MW solar farm	-
S/1042/13/E1	South Cambridgeshire	15/05/2013	Great Wilbraham, Weston Colville, Little Wilbraham	Pre-Application	EIA Screening Opinion request for solar farm	-
S/1765/13/E1	South Cambridgeshire	12/08/2013	Land adjacent Highfield Farm, Bassingbourn, Cambridge	Pre-Application	Solar farm construction	-
S/1786/13/E1	South Cambridgeshire	14/08/2013	Land north of Long Lane, Gamlingay, St Neots, SG19 3ES	Pre-Application	Solar farm construction	-
S/1883/13/E1	South Cambridgeshire	30/08/2013	Land at Manor Farm, Church Street, Thriplow, Royston, Cambridgeshire, SG8 7RE	Pre-Application	EIA Screening Opinion	14
S/2007/13/EI	South Cambridgeshire	16/09/2013	Land to the West of Railway, Melbourn Bypass, Meldreth, Cambridgeshire	Pre-Application	EIA Screening Opinion	-
S/0155/13/FL	South Cambridgeshire	15/07/2013	81 Cambridge Road, Wimpole, Royston, Cambridgeshire, SG8 5QB	Approved	Construction of solar farm and all associated works	13
S/1542/12	South Cambridgeshire	24/07/2012	Land at, Radical Farm, Chittering Drove, Chittering, Cambridgeshire	Approved	Extension to existing solar farm	-
-	South Northamptonshire	17/10/2013	Stonepit Farm, Hanslope Road, Hartwell	Pre-Application	-	20

5/2013/226 9	St Albans	19/11/2013	Land Bounded By Tullochside Holtsmere End Lane Little Revel End Lane and, Hemel Hempstead Road, Redbourn,	Pre-Application	EIA screening opinion	8

1.2.3. Biomass - dedicated and AD

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
07/00275/A GN	Aylesbury Vale	08/02/2007	Moat Farm, Marsh Lane, Stoke Mandeville, Buckinghamshire, HP22 5UZ	Approved	Installation of AD plant	-
12/20001/A WD	Aylesbury Vale		Westcott Venture Park, Westcott, Buckinghamshire, HP18 0NX	Approved	Various in vessel composting and AD facilities and ancillary developments	-
BC/CM/200 3/14 BC/CM/200 9/7	Bedford		Biogen, off Twinrood Road, Clapham	Operational	Check Bedfordshire Minerals & Waste team for more info	2.1
	Broxbourne	09/09/2013	Rattys Lane Sustainable Energy Facility, Hoddeston, Hertfordshire, EN11 0RG	Approved	Waste AD plant	3
CB/10/0320 0/FULL	Central Bedfordshire	15/09/2010	Trinity Hall Farm, Watling Street, Hockliffe, Leighton Buzzard, LU7 9PY	Operational	Construction of Biogas Plant - development proposes a farm based AD using maize feedstock grown locally	1.06
CB/10/0459 6/FULL	Central Bedfordshire	22/12/2010	Warren Wood, Fordfield Road, Millbrook	Approved	Energy Centre approved under CB/10/03096/RM, incorporating 6 flues to allow for biomass and CHP energy sources - wood-fuelled biomass plant alongside improving existing gas-fired	2.5
-	East Hertfordshire	13/02/2013	Buttermilk Farm, Baldock Road, Buntingford, SG9 9RH	Approved	-	1.07
-	East Northamptonshire	16/08/2012	Biogen UK Ltd Westwood AD Plant, Higham Park Farm, Bedford Road, Rushden, Northamptonshire	Operational	Farm AD plant	2
-	Hertsmere	26/06/2013	Agrivert, Coursers Farm AD Plant, St Albans, Hertfordshire, AL4 0PD	Approved	Farm AD plant	2
13/00861/F ULEIS	Milton Keynes	29/04/2013	Former Fiege, Merlin Dickens Road, Old Wolverton, Milton Keynes, MK12 5QF	Approved	Demolition of existing buildings and erection of new building and associated infrastructure for the mechanical treatment, AD and in-vessel composting and advanced thermal treatment of 140,000 tonnes a year of household, commercial and industrial waste	7

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
10/01181/MIN	Milton Keynes		Land To The Right of Portway, Pineham, Milton Keynes	Approved	Erection of an Organics Treatment Facility including Combined In-Vessel Composting, Dry AD Treatment Systems for the production of renewable electricity and supply of mains quality gas into the local supply network	-
11/00333/1CC	North Hertfordshire	11/02/2011	Bygrave Lodge Farm, Wallington, Baldock, SG7 6QX	Approved	Farm based AD Plant for the digestion of food chain waste to produce bio-fertiliser and biogas for use in on-site heat and power generation for exportation to the local distribution network	1.5 - 2
	St. Albans	05/11/2013	Navitas Environmental Ltd, EQ Waste, Appspond Lane, Potters Crouch, Hertfordshire	Approved	Resubmission application	6
5/2011/2905	St. Albans	24/09/2012	J Sainsbury Plc, Everard Close, St Albans, AL1 2QU	Operational	Installation of biomass boiler to service yard (restrospective)	0.3 – 1
5/2009/0076	St. Albans	13/03/2009	Land adjacent to 4 Victor Way, Colney Street, St Albans, Hertfordshire	Operational	Liquified Bio Methane CHP	1.5 thermal, 1.4MW electrical

1.2.4. Municipal solid waste combustion

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
A0336	Bedford	13/10/2011	Rookery South, a former brick clay pit, near Stewartby, Bedfordshire	Approved	Rookery South Resource Recovery Facility	65
B0576	Milton Keynes	07/12/2013	Dickens Road, Old Wolverton, Milton Keynes MK12 5QQ	Approved	Milton Keynes Waste Recovery Park (ACT - Gasification)	7
AA610	Welwyn Hatfield	25/10/2012	New Barnfield, Travellers Lane, Hatfield, Hertfordshire	Approved	New Barnfield ERF	30

1.2.5. Landfill gas

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
02001L3	Aylesbury Vale	10/02/1994	Newton Longville Landfill Site, Newton Longville, Bletchley, Buckinghamshire	Operational	Newton Longville Landfill	0.99
02042L5	Aylesbury Vale	07/10/1996	Newton Longville Landfill, Bletchley Road, Bletchley, Buckinghamshire	Operational	Bletchley Phase II	2.2
01026L3	Bedford	23/06/1995	Elstow Landfill Site, Wilstead Road, Elstow, Bedfordshire	Operational	Elstow Landfill Site	1.76

Planning reference	Borough	Date received	Address	Planning status	Details	Capacity (MW)
01099L3	Bedford	15/07/1994	L'Field Stewartby Landfill Site, Adjacent to Stewartby Village, Green Lane, Stewartby, Bedfordshire	Operational	-	10.66
01027L3	Central Bedfordshire	23/06/1995	Sundon Landfill Site, Common Lane, Sundon, Bedfordshire	Operational	Sundon Landfill Site	2.64
01039L5	Central Bedfordshire	08/07/1990	Woburn Road, Brogborough, Bedfordshire	Operational	Brogborough Phase III	11
01040L5	Central Bedfordshire	04/01/1999	Brogborough Landfill, Woburn Road, Brogborough, Bedfordshire	Operational	Brogborough Phase IV	11
EN00021	Central Bedfordshire	21/01/2006	Mill lane, Arlesey Landfill, Arlesey, Bedfordshire	Operational	Arlesey Landfill Gas (Extension)	2.3
N00051L	Central Bedfordshire	04/11/1994	Arlesey Landfill Site, Arlesey, Bedfordshire	Operational	Arlesey Landfill Site	1.08
01008L4	East Hertfordshire	05/08/1997	Ware Quarry, Westmill Road, Ware, Hertfordshire	Operational	Brazier Landfill Scheme	3.88
EN00268	East Hertfordshire	16/03/2000	Waterhall Farm, Bayfordbury, Hertforshire, 181 High Street	Operational	Waterhall Farm	0.5
EN00269	East Hertfordshire	19/07/1999	Westmill Landfill, Westmill Quarry, Westmill Road, Ware Herts	Operational	Westmill Qaurry	2.6
N00040L	North Hertfordshire	15/11/2004	Holwell Sandpit, North Herts, SG5 3RT	Approved	Hitchin	1.5
S/02438/06 /CW	South Cambridgeshire	20/12/2006	Land at Waste Management Park, Ely Road, Waterbeach, Cambridge, CB5	Operational	Facility for the mechanical and biological treatment of waste	-
S/02441/03 /CW	South Cambridgeshire	21/11/2003	Land at Milton Landfill Site, Butt Lane, Milton, Cambridge, CB4	Operational	Extension of existing gas utilisation compound	-
N00024L	South Northamptonshire	13/12/2002	Northampton	Operational	Wooton	2

1.3. Energy demand and emissions in Central Bedfordshire

1.3.1. Demand and emission forecasting assumptions

The assumptions in Table 21 are those used throughout the forecasting of energy demand and emissions, for new and existing domestic and non-domestic uses. They were taken from the SAP 2009 and 2012 procedures, with the changes in annual domestic electricity and heat demand obtained from the AECOM East of England study, and adjusted for this report. Emission factors increase in the latest version of the SAP guidance due to the inclusion of methane and NO_X.

Category	Values used in report	
	SAP (2009) – used for 2011-2013	SAP (2012) – used for 2013-2031
UK grid emission factor (electricity displaced by renewables used same values)	0.517	Linear annual reduction from 0.519 in 2013, to 0.342 by 2031 – SAP assumed 0.381 by 2027
Heating oil emission factor	0.274	0.298
Coal emission factor	0.301	0.394
Dual fuel emission factor	0.206	0.226
Mains gas emission factor	0.198	0.222
Existing boiler efficiency	76%	
New boiler efficiency	90%	
Electric heating efficiency	100%	
Annual reduction in domestic electricity use for existing buildings, inc efficiency	+0.5%[xxxvi]	
Annual change domestic heat use for existing buildings, inc efficiency	-0.75%[xxxvi] (AECOM used 10% by 2020 - we applied 15% by 2031)	

Table 21: Assumptions used for forecasting existing and planned building demand, taken from a range of sources.

1.3.2. Residential demand and development

Through interpretation of the Development Strategy and further supporting planning documents, it was seen that Central Bedfordshire is aiming to increase the amount of 2/3 bedroom housing, both in town centres and in the rural areas, and to better accommodate an ageing population.

Given the rural setting of the borough, it is also likely that larger housing will be preferred on the urban fringe developments and in smaller villages/hamlets, alongside large and small flat provisions in the planned town centre regenerations.

The housing mix therefore assumed for all new planned developments is as followed, and has been agreed upon with our Council client:

- Small apartment/flat – 10%

- Large apartment/flat – 15%
- Terraced house – 20%
- Semi-detached – 27.5%
- Detached – 27.5%

1.3.3. B-use projected demand and development

The development of B-use sectors was calculated using the data provided by our clinet for hectares of allocated land, and the total number of jobs projected to 2031 (12,150) in the Development Strategy Report 2013.

An indicative mix of B1-B8 uses was agreed, and applied to the number of jobs stated. The employment spaces already allocated indicate a preference for business and industrial developments, to enhance the already strong presence of business in the area and promote job growth.

The mix of all new planned B-use developments assumed is as follows, agreed upon with our Council client:

- B1 (offices, business) – 50%
- B2 (industrial, workshops) – 30%
- B8 (storage, warehouses) – 20%

Using a guidance note on calculating employment densities for new developments[lviii], benchmarks for areas of floorspace (m^2) per full time employee (FTE) were applied, providing the total amount of employment space expected to be developed to 2031. All jobs projected in Central Beds were assumed to be of FTE status, as suggested in the guidance note. This approach produces a final floorspace value that is very similar to the latest projections in the Employment and Economic Study for Central Bedfordshire, and is therefore a valid method for this report[lix].

These numbers were spread evenly over the 2011-2031 period due to lack of phasing timing data, with benchmarks from the CIBSE, SAP and Zero Carbon Hub reports used to calculate the total heat and electricity demand, and emissions expected over the entire period.

Table 22 shows the employee density benchmarks per full-time employee (FTE) used in the forecasting of B-use floorspace in this report.

Use class	Use description	Area per FTE (m^2)	Comments
B1	General office	12	Incudes HQ, admin and client facing types
	Call centres	8	
	Business parks	10	A blended rate of above B1 uses for use when out of town
	Serviced offices	10	
	Data/IT centres	47	
B2	General	36	Range of 18-60m^2
B8	General	70	Range of 25-115m^2 Higher capital intensity equals a lower density
	Large scale and high bay warehousing	80	Wide variations arising from scale and duration of storage

Table 22: Floorspace benchmarks for all B-uses, including comments on the range of values. Taken from OffPAT Home and Communities Agency report (2010)

1.3.4. Non B-use demand and development

This report used the retail floorspace figures taken from the Development Strategy 2013, which outlined 34,500m^2 of development needed to meet future demands over the study period – this was split equally between general retail and high street agency.

For the remaining uses, typical figures were taken for the floorspace of large supermarkets, retail warehouses etc[lx], and using assumptions and needs laid out in the Development Strategy, likely developments were calculated. Considering that Central Bedfordshire is expected to see a preference for town centre regeneration, urban fringe development and some rural farming retail growth, it is reasonable to assume that high street retail and agency will be the majority development type.

This report included further considerations for developments other than pure high street retail, based on current demand, future plans and the limited data available on allocations of large single public buildings. This report did not allocate specific community or tourism buildings, such as hotels or hospitals, due to a lack of data on these sectors, and their negligible overall impact on our demand forecasting. We were also informed by our Council client that Central Bedfordshire is currently well served by the neighbouring boroughs, and will likely not see much new development.

The following building floorspaces were assumed alongside the 34,500m² of pure retail listed in the Development Strategy 2013. These include typical floorspaces for each[lx]:

- 5,000m² of large supermarkets – 2,500m² each
- 8,500m² of small food stores - <2,500m² each
- 2,500m² of large non-food stores/retail warehousing – 2,500m² each
- 5,000m² of restaurants – based on demand from rural economy and tourism

Altogether this report has assumed a total retail floorspace of 55,500m² to be built by 2031.

1.3.5. Total energy demand and carbon emissions

Year	Projected Electricity Demand (MWh/yr)	Projected Heat Demand (MWh/yr)	Projected CO_2 Emissions from Energy Demand (tonnes CO_2)
2011	1,010,000	1,844,000	958,400
2016	1,058,000	1,802,000	985,100
2021	1,119,000	1,782,000	958,500
2026	1,175,000	1,756,000	925,600
2031	1,223,000	1,716,000	880,100

Table 23: Total annual energy demand and emissions from all existing and planned developments over the period 2011-2031

1.4. Renewable energy resource

1.4.1. Wind

Turbine size	Minimum hub height (m)	Minimum tip height (m)	Minimum separation distance (m)	Minimum buffer distance (m)
2.5MW	75	125	500	800
330kW	37	53.7	167	400

1.4.2. Energy crops

Up to date Defra data on the agricultural land use and areas of arable, fallow and temporary grassland does not exist for Central Bedfordshire alone, and is only available for the wider

Luton and Bedfordshire Authority. As this data was needed to carry out the medium scenario energy crop analysis, we estimated values from the Luton and Bedfordshire database.

This was achieved by comparing the land areas that were available for both Authority areas, such as total farmed land and amount of cereal being grown, and observing the differences. It was seen that Central Bedfordshire is responsible for ~50% of all agricultural land uses in Luton and Bedfordshire. This seems reasonable, given the relatively equal sizes and highly rural landscapes observed in both Central Bedfordshire and Bedfordshire. Luton is unlikely to host notable amounts of agricultural land, and is therefore ignored.

Therefore, we halved the relevant data taken from the Luton and Bedfordshire database to obtain values for our analysis. Assumptions regarding yield and output of energy crops are as follows, taken from the AECOM East of England report:

- SRC crops (willow) produce 10 oven-dried tonnes (odt)/ha
- Miscanthus produces 15 odt/ha
- 6,000 odt is required to power a 1MW$_e$ system

1.4.3. Managed woodland

Forestry Commission data on the mix of trees in local woodlands is available at the county scale for the whole of Bedfordshire. The data has also been published as a map, which is shown in Figure 23 of this report. This was used to estimate the mix of tree types in Central Bedfordshire.

When calculating the potential feedstock available for use in energy generation, we have assumed that:

- 50% of total woodland resource is either uneconomical or physically unviable to retrieve
- 50% of this subsequent value goes to other markets as a priority over energy generation, such as construction, industry or other biomass plants operating in the area
- The calorific value of managed wood fuel is 12.5GJ/odt with a conversion efficiency to heat of 80%
- For each tree type available, the odt yields for fuel are:
  - 12 odt/ha for conifer
  - 4 odt/ha for broadleaved
  - 6 odt/ha for mixed woodland
- 6,000 odt required for 1MW$_e$ capacity

These assumptions are in line with the DECC methodology and updated assumptions used in the AECOM report[xxxvi], and reflect the high demand for managed wood resource currently.

For biomass boilers generating heat only, conversion efficiencies of 80% and capacity factors of 30% were assumed as per the Cheshire East report and AECOM report.

For CHP use, AECOM assumptions were again applied, with conversion efficiencies of 80%, and capacity factors of 50% and 80% for heat and electricity production respectively.

1.4.4. Agricultural arisings

The assumptions regarding typical yields and amount required for power generation are as follows:

- Wheat straw yield – 8 odt/ha for a typical wheat field
- Oilseed straw yield – 3.5 odt/ha for a typical oilseed field
- 6,000 odt required for 1MW_e capacity

In the AECOM report, it is assumed that up to 50% of this total straw resource is used in other markets such as for cattle feedstock and bedding. It is also possible that 50% of the total resource could be left as fertiliser on the fields. These assumptions were not used in this report, due to the smaller total yields expected from Central Bedfordshire's reasonably small animal farming industry, and a desire to produce values for maximum potential capacity.

1.4.5. Poultry litter

Data on the number of birds producing litter was obtained from the Defra agricultural database for Central Bedfordshire, and the following assumptions applied to calculate the potential capacity available:

- 1,000 birds produce 16.5 tonnes of litter per year
- 100% of the resource is available currently – DECC methodology assumes 50-100% from 2015 onwards – our update reflects the analysis of maximum potential capacity and the likelihood that poultry litter is currently not being used for other means
- 11,000 tonnes of litter are required to fuel 1MW_e capacity plant

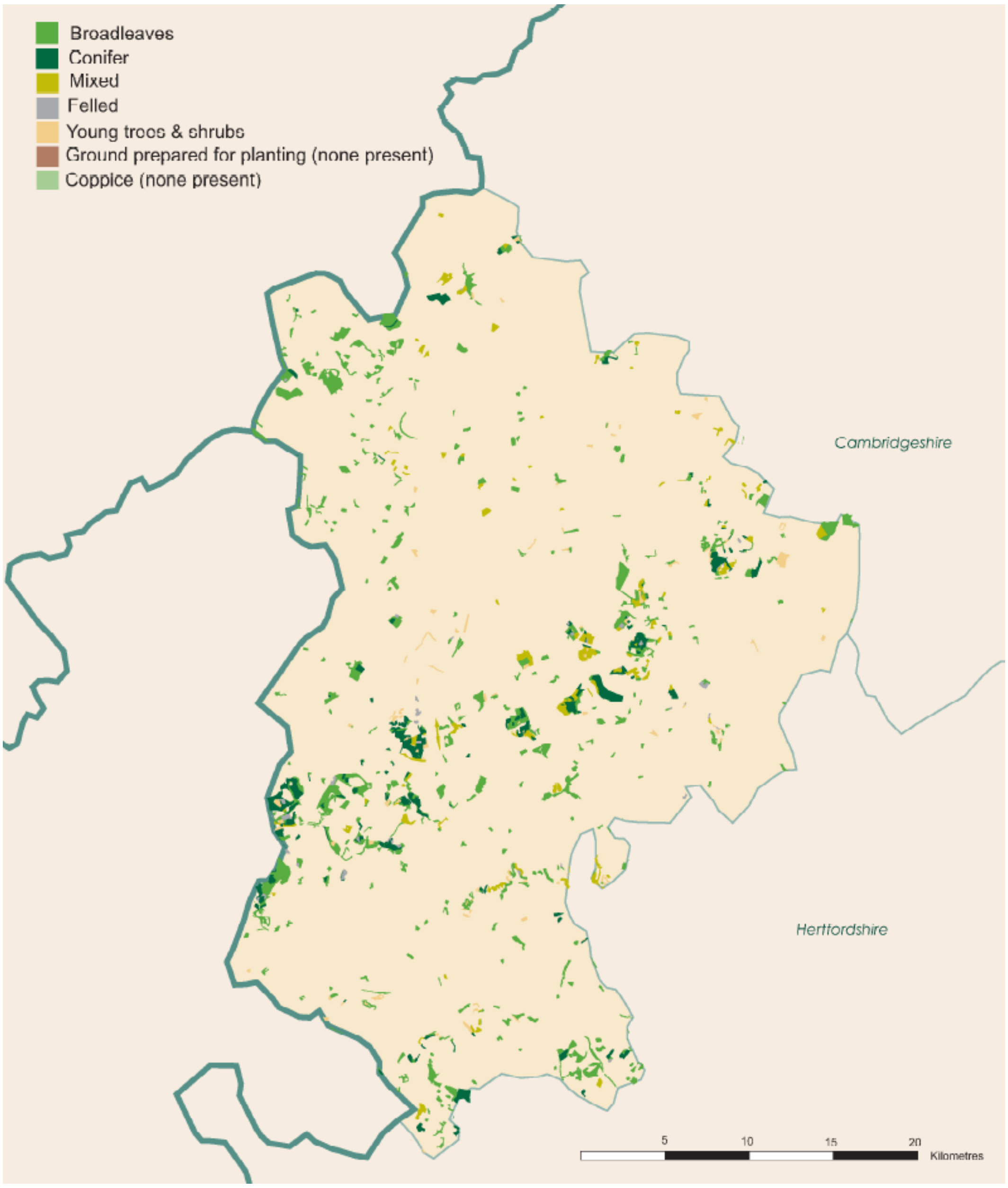

Figure 23: Distribution of woodland over 2 hectares by forest type in Bedfordshire County. Obtained from Forestry Commission[xxxvii]

1.4.6. Anaerobic digestion

Figure 24 shows the Nitrate Vulnerable Zones present in Central Bedfordshire, as per Defra's dataset and Magic Map online tool. This demonstrates that Central Bedfordshire is exposed to all three forms of vulnerable area, with surface and groundwater issues present throughout the area, and eutrophic zones in the north western tip within the Marston Vale. This limits the spreading of slurry or digestate due to possible ecological impacts.

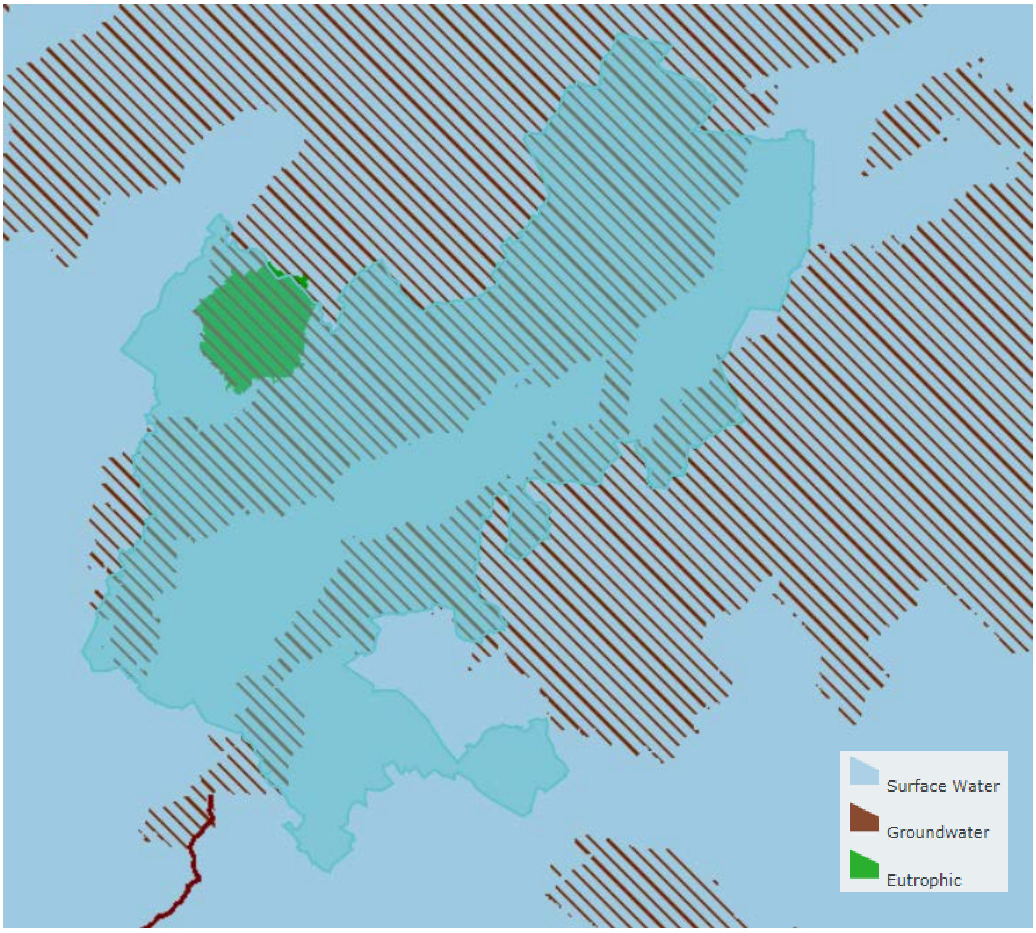

Figure 24: Nitrate Vulnerable Zones in Central Bedfordshire, obtained from the Defra Magic Map tool

For the capacity analysis, benchmarks for slurry production and tonnes required for power generation were applied from DECC and AECOM reports:

- Wet waste from the food and drinks industry was ignored for the reasons stated in the main body
- Each wet tonne of slurry produces $20m^3$ of biogas, with $1m^3$ equating to 5.8kWh
- 225,000 tonnes of wet animal slurry is required to fuel a $1MW_e$ plant

1.4.7. Hydro

As the Environment Agency does not provide an explicit breakdown on the actual power outputs of their low/medium/high categories, this report took the EA report's separate scale for output based on seven categories, and applied these to the low/medium/high sites. This was weighted depending on the frequency of outputs across the UK. For example, the majority of sites lie within the 0-10kW output category, so we took an average of 5kW for the low output sites. These assumptions are as follows:

- Low output sites – 5kW average based on high frequency of 0-10kW sites in UK

- Medium output sites – 50kW average based on 2nd highest frequency of 10-100kW sites nationwide, and weighted to lower end of range to reflect EA data
- High output sites – as there were no high output sites of low/medium sensitivity in Central Bedfordshire, we did not attempt to estimate an average from the EA report

1.4.8. District heating

DECC's National Heat Map scale is quoted in units of kWh/m^2. For the purpose of comparison, the nominal threshold of $3{,}000kW/km^2$ equates to around $26kWh/m^2$, assuming both are based on average heat demand per unit of area over the course of a year. This would suggest that all areas within and above the 20 - 30 kWh/m^2 banding are potentially viable.

1.4.9. Building integrated solar PV

In this report, the potential capacity of roof-mounted solar PV was established by estimating the total number of domestic properties, and total roofspace of non-domestic properties, that may be available for installation.

Firstly, a basic set of assumptions were applied to determine the proportion of buildings realistically viable for solar PV development, based on the likely uptake and willingness to install them. These were:

- 25% of all existing domestic properties
- 50% of all new domestic properties
- 40% of all existing and new non-domestic properties

In order to calculate the value of non-domestic roofspaces, which is necessary to assess potential solar PV capacity, the following calculations were carried out:

- B-use developments:
  - Total existing floorspace was provided by the Employment Land Review[xlviii]
  - The total of Mid and South Bedfordshire was summed from this report to calculate Central Bedfordshire floorspace in 2008
  - It was assumed that 2008 floorspace was the same in 2010, the point at which this report's analysis is dated from (projected new development begins in 2011)
  - Of this total floorspace, 33% was assumed to be equal to the total roofspace of B-use properties, based on estimation of the building heights/floor numbers in Central Bedfordshire – we assumed that the majority would be 1-3 storeys high on average, as the borough contains no major HQs, business parks or high rise centres
- Non B-use developments:
  - Data on existing floorspace for retail, leisure and other developments is relatively sparse, and figures for an area-wide total could not be found
  - This report used the Council Retail Study[xlix] to obtain values for 2008, again assuming the same values in 2010 for this report

- – The Retail Study contains a breakdown of retail floorspace in each of the notable settlements in Central Bedfordshire, as well as insights into the mix of community buildings in each
- – The total floorspace figures given in this report were summed; however data was not given for Ampthill, Houghton Regis or Flitwick, nor was it given for the rural areas of Central Bedfordshire, meaning that this report excludes some retail developments and their potential for renewable capacity
- – However, given that the study provides data on the largest of Central Bedfordshire's settlements, it likely covers the majority of floorspace known
- – It was then assumed that 33% of this total floorspace translates into roofspace, as with B-use developments – whilst some retail sites are likely to be more low-rise than offices or business centres, it is reasonable for the scale of analysis this report has undertaken

Once subsequent roofspace had been calculated through the process detailed above, these figures were reduced further to account for existing roof uses, such as access points, plant or pitched roofs:

- 80% of domestic roof space
- 60% of non-domestic roof space

Finally, a 50% reduction was applied to these viable roof spaces, to account for loss of usable space when building the solar panels themselves, such as orientating them to the optimum position and loss of area due to shading from the solar structures themselves.

Endnotes

[i] AECOM (2011) East of England Renewable and Low Carbon Energy Capacity Study.
[ii] Central Bedfordshire Council (2013) Development Strategy for Central Bedfordshire: Pre-submission Version
[iii] Guidance Note 1: Wind Energy Development in Central Bedfordshire (2013)
[iv] Central Bedfordshire Council (2013) Landscape Character Assessment on p14-22 of Wind Guidance Note 1
[v] Obtained from Central Bedfordshire Planning Portal Application Search and data received from Central Bedfordshire Council
[vi] DCLG (2012) National Planning Policy Framework
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[x] DECC (2013) Electricity Market Reform: Delivery Plan
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[xiii] RenewableUK Onshore Wind information page - http://www.renewableuk.com/en/renewable-energy/wind-energy/onshore-wind/index.cfm
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[xvii] DCLG (2014) Written Ministerial Statement: Building Regulations, 13th March 2014
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[xx] Paragraph 11.71 of Development Strategy, including policies 60-62
[xxi] Guidance Note 1: Wind Energy Development in Central Bedfordshire (2013)
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[xxiv] Data on planned and allocated developments was obtained from Central Bedfordshire Council, the Development Strategy for Central Bedfordshire (2013) and the Strategic Housing Market Assessment Update 2012
[xxv] Data taken from Zero Carbon Hub 'Defining A Fabric Energy Efficiency Standard for Zero Carbon Homes report (2009) for domestic buildings, and CIBSE TM46 (2008) for non-domestic.
[xxvi] Generation Capacity Map for the Eastern Region, version dated 14 January 2014. The latest version of the map can be downloaded from

www.ukpowernetworks.co.uk/internet/en/connections/electricity-generation/generation-capacity-maps/

[xxvii] DECC (2010) Renewable and Low Carbon Energy Capacity Methodology: Methodology for the English Regions.

[xxviii] Department for Transport (2013) The Strategic Road Network and the Delivery of Sustainable Development: New Trunk Road Guidance relating to Wind Turbine Offset Distances. Whilst this policy does not apply to private or local authority roads, it is likely objectors may push for higher standards on this, and therefore should be considered a risk by developers

[xxix] Chilterns Conservation Board – Position Statement: Renewable Energy, Chilterns AONB Conservation Board (2013)

[xxx] Guidance Note 1: Wind Energy Development in Central Bedfordshire, Central Bedfordshire Council (2013)

[xxxi] Mapped and Written Guidance in Relation to Birds and Onshore Wind Energy Development in England, RSPB (2009)

[xxxii] DECC (2013) Digest of UK Energy Statistics 2013

[xxxiii] Renewables Obligation Banding Review for the Period 1 April 2013 to 31 March 2017, DECC (2012)

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