Stroud District Renewable Energy Resources Assessment

A report by the Centre for Sustainable Energy and Land Use Consultants for Stroud District Council

Version: Final 1.2

Date of issue: 21st November 2019

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Executive summary

Introduction

Following the release of the IPCC Special Report 'Global Warming of 1.5°C' and subsequent recommendations from the UK Climate Change Committee, UK parliament declared a formal climate and environment emergency on 1st May 2019. This was soon followed on 12th June 2019 by the Government amending the Climate Change Act 2008 to target full net carbon neutrality (a 100% reduction of greenhouse gas emissions) in the UK by 2050. Since then, a growing number of local authorities have followed suit with declarations of climate emergencies and net zero emission targets.

Stroud District Council was ahead of national government and most other local authorities pledging in December 2018 to do everything in its power to make Stroud District carbon neutral by 2030. This will require innovative transformative action across all sectors and increasing local renewable energy generation capacity will be a key component of the solution, sitting alongside energy efficiency, energy demand reduction, heat decarbonisation and rapid growth in electric vehicles.

With Stroud District's local plan review due to reach final draft stage in November 2019, the Council wishes to incorporate policies which maximise positive local action on climate change and underpin the framework of measures needed to achieve the net zero carbon 2030 target. In addressing this need, this report from the Centre for Sustainable Energy (CSE) working in partnership with Land Use Consultants (LUC) sets out the results of a renewable energy resource assessment for Stroud District and provides a technical evidence base to underpin appropriate planning policy and mechanisms to help realise this potential.

Baseline emissions

Estimating existing energy use and associated emissions across Stroud District is important to establish a baseline from which to measure future changes and monitor progress towards targets. Total energy consumption across the industrial/commercial, domestic and transport sectors for 2017 was estimated to be almost 3,113 GWh. This corresponds to a total CO_2 emissions inventory of 785,917 tCO_2 for the year, or 539,351 tCO_2 when emissions considered to be within the scope of influence of local authorities are counted i.e. excluding large industrial sites, railways, motorways and land-use.

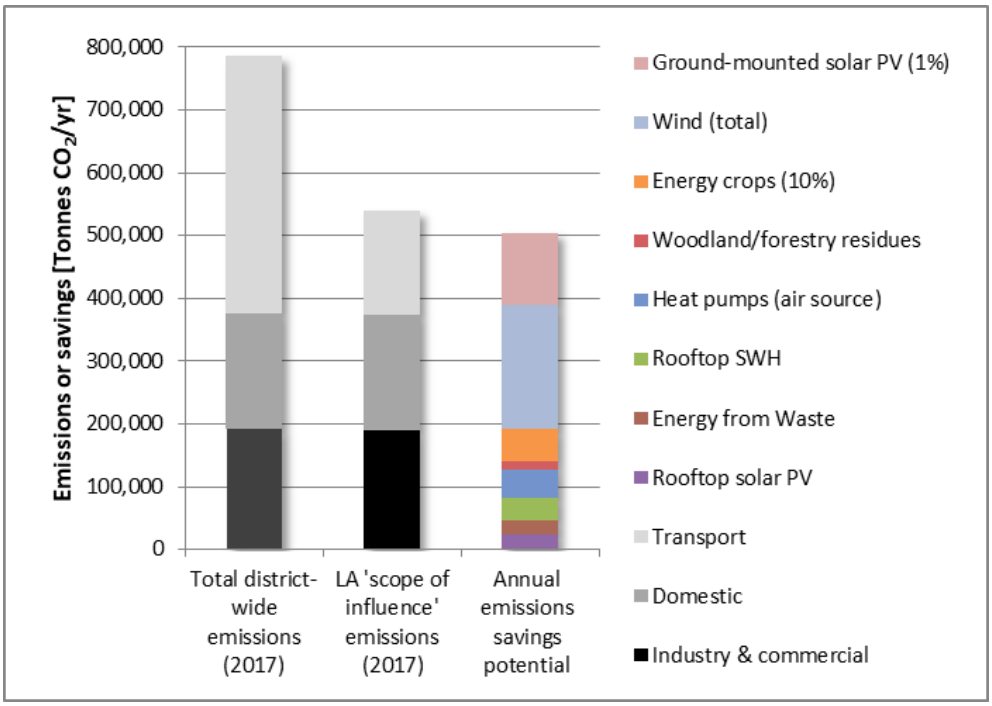
Existing renewable and low carbon energy generation

An exact figure for the amount of existing renewable energy capacity across the district is not possible to ascertain although estimates for installed electricity generation capacity are in the region of 71 MW, resulting in annual emission savings of approximately 20,314 tCO_2. This figure would increase to around 33,000 tCO_2 once the Javelin Park energy from waste facility is operating at full capacity and exporting electricity. The amount of existing renewable heat generation is not currently quantified due to a lack of accessible sub-national statistical data.

Assessment of renewable and low carbon energy resources and technologies

A range of resources and technologies have been assessed as part of a desk-based exercise involving industry-standard assumptions and calculations and/or GIS mapping to establish the potential for each type of renewable energy resource. By applying a set of constraints the renewable energy potential is expressed as generating capacity, typical annual energy yield and resulting carbon savings from offsetting fossil fuels. The approach taken has been to adopt tailored scenarios for each resource using the set of assumptions given in Appendix 1. These are largely based on establishing a theoretical resource which considers technical constraints to deployment rather than those imposed by political or financial issues. It is therefore important to realise that these resource assessments are purely illustrative and represent just one of many scenarios that could occur.

The results are expressed in the figure below in terms of potential annual emission savings compared against both total district-wide emissions and a subset of these considered to be within a local authority's scope of influence. As the full technical potential for both ground-mounted solar PV and energy crops is very large, smaller proportions of the suitable land area have been assumed to indicate the resource (1% of total suitable area for solar PV and 10% for energy crops). The 'total' wind resource assumes that the technology is deployed in all suitable areas (see Figure 26 in Appendix 3), with preference given to the largest scale turbine an area can accommodate.

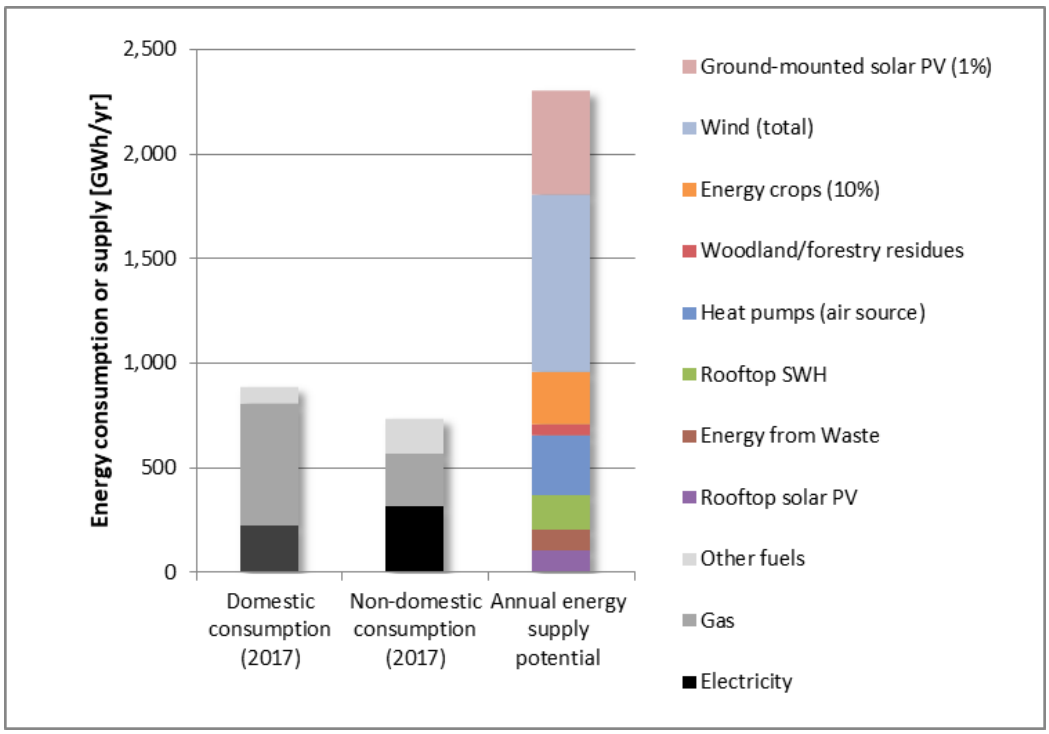


Summary of district emissions compared against potential emission savings from resource assessment technical scenarios

The figure indicates the relative scale of emission savings from each resource and the overall scale relative to total district-wide emissions and a subset of these considered to be within a local authority's scope of influence. It can be seen that, technically speaking, renewable and low carbon energy generation can make a substantial contribution to reducing overall district-wide emissions. However, as some of the estimated emission figures have been based on a static carbon emissions

conversion factor for grid electricity, it is important to note that these will change in due course; in other words, the 'value' of future renewable electricity generation in terms of resulting emission savings will gradually decrease as the electricity grid continues to decarbonise. This will not be the case however where renewable electricity is used to displace fossil fuel-fired heat, such as when gas boilers are replaced with heat pumps.

The estimated energy yields from each resource are also compared in the figure below against district-wide (non-transport) energy consumption to provide further context. For example, it can be seen that the estimated annual generation yield from the ground-mounted solar PV resource is similar to total district-wide (non-transport) electricity consumption during 2017, with the potential supply equating to approximately 93% of the consumption.



Summary of district-wide energy consumption (excluding transport) compared against potential energy supply from resource assessment technical scenarios

In practice the deployable renewable energy resource achievable by 2030 is likely to be considerably less than the technical scenarios shown above. This serves to illustrate the challenge of meeting the net-zero 2030 target with local renewables alone; there will also be a critical dependency on other measures such as energy demand reduction and the decarbonisation of the transport, electricity grid and heat supply sectors.

A key constraint with Stroud District for larger scale renewable electricity generation is grid capacity as increasing deployment of distributed generation has caused new challenges for the electricity network, with ever-larger areas of the network reaching maximum capacity. As such, the current capacity of the network to accept new generation appears relatively constrained across the District, although the level of constraint depends on the location of the generation and connection point. Energy storage technology, particularly batteries, has advanced considerably in recent years and is

well placed to help alleviate such constraints on the grid. Western Power Distribution's network reinforcement plan is normally driven by developers or generators, although there are some strategic projects planned to begin in 2023, subject to Ofgem approval.

Heat mapping

Heat mapping of Stroud District has also been undertaken using available datasets to make accurate estimates of heat demand from buildings and presenting these visually on a map, thus allowing identification of areas with high heat demand which may be suitable for district heating. An overlay analysis then identified several areas that fulfil specific criteria to identify Heat Network Priority Areas (HNPAs) within existing development, which may be worthy of further investigation (see Figure 16). These areas can then be considered alongside planned large new development sites which offer particular opportunities for heat networks.

Strategic development sites

The Stroud District Local Plan Review (Draft Plan 2019) identifies a number of emerging strategic locations for future housing and employment growth. These sites will have specific opportunities for renewable or low carbon energy generation that can be considered at the masterplanning stage, drawing on advantages of scale, location and early stage design flexibility. Although a lack of detail at this stage on energy demands, site layout and development mix limits a more in-depth exploration of viability, high level opportunities have been identified for further consideration, focusing on the Sharpness Eco-village proposal as a case study (see Table 17).

Recommendations

A key purpose of gathering evidence for this study is to help set the context and provide guidance on local policy development for Stroud District Council around decentralised renewable or low carbon energy generation. An overarching objective lies in ensuring that policies rise to the challenge of approaching net-zero carbon by 2030 whilst keeping within the bounds of the statutory planning system to ensure they are formally adopted.

A range of policy options have therefore been discussed which relate to a set of emerging policies being considered by the Council for inclusion to the draft Local Plan as follows:

- **Core Policy 1 – Delivering carbon neutral by 2030:** an overarching policy to include a reference to the energy hierarchy approach for new development;
- **Delivery Policy ES1 – Sustainable construction and design:** a policy to include an onsite low or zero carbon energy generation requirement for all development with a minimum fabric energy efficiency backstop, and include carbon offsetting as a mechanism through which developers can financially contribute in order to mitigate residual emissions that can't be addressed onsite. It should also be noted that in October 2019 a consultation was launched on Part L of the Building Regulations and changes are likely to be introduced during 2020 which may impact elements of this policy;
- **Delivery Policy ES2 – Renewable or low carbon energy generation:** a policy describing criteria for acceptable proposals, making specific reference to the Council's 2030 carbon neutral target in order to emphasise that appropriate weight will be given in this context when considering the

impact of development. The policy will also be accompanied by maps showing areas with potential for ground-mounted solar arrays and areas *"suitable for wind energy development" (*as required in the National Planning Policy Framework) and will be informed by a landscape sensitivity assessment – both of which have been produced as part of this study;

- **Delivery Policy DES3 – Heat supply:** a policy describing a heat supply hierarchy which aims to discourage the use of gas as a heating fuel and future proof developments bearing in mind Stroud District's 2030 net-zero target and the direction of travel regarding electrification of heat and use of heat pumps. This policy should also encourage heat networks and refer to Heat Network Priority Areas that have been produced as part of this study.

Further work

The Council should now consider developing a strategy and action plan which sets out in more detail the sequence of events needed to stimulate renewable energy initiatives across the district in support of the net-zero target for 2030. This should build on the evidence presented in this report and focus on actions within the Council's sphere of influence, specifying clear actions, roles, responsibilities, timescales and a plan for regular monitoring and review of progress.

The strategy and action plan should consider the following recommendations:

- **Supplementary Planning Documents (SPD)** – careful consideration should be given to material included within SPD in order to support Core Strategy policy and facilitate effective delivery. This could include further detail on criteria-based policies or areas of search, additional details on the required structure and content of proposals for sustainable energy supply (site energy strategies) submitted as part of planning applications, and details of any carbon offsetting scheme offered to developers.
- **Internal resourcing** – with the proposals for Policy ES1 on emission standards for new developments and considering the forthcoming changes to Part L Building Regulations, local authorities will need to fully understand the implications and prepare in advance for any additional resource capacity needed to manage and implement the requirements. Development Management in particular will need to understand the requirements and the most common solutions so that they can confidently enter into planning negotiations with developers and adopt systems for checking compliance. If adopted, this would need to include the logistics of a carbon offsetting scheme. Tasks that will be required in implementing policies include:
    - The provision of detailed information on the assessment process to officers in both Planning and Development Management, and other officers involved in sustainability issues;
    - The provision of detailed information on renewable energy and low carbon technologies to officers in both Planning and Development Management;
    - The provision of clear and detailed advice to developers during up-front negotiations, such as: the scope and format of an energy strategy, potential funding options and advice on market leadership and development selling points;
    - Specification of monitoring requirements for installations.

- **Facilitating partnerships** – facilitate community and business partnerships and actions across a range of stakeholders including local supply chains and installers. There are a number of options on how to develop the site, and who may end up owning the equipment. This may ultimately depend on the financial business case, but also on the Council's attitude to risk and the resources it can make available to undertake processes such as due diligence, procurement, project management and operation of the site. Collaborate with other local authorities in Gloucestershire and intermediary agencies to build capacity and technical expertise in the sector.
- **Facilitating change** – exploit the Council community leadership role in terms of communicating the arguments, raising awareness of climate change and advising on community and individual action. Also make use of effective communication channels, including social media, to clearly highlight funding opportunities and the local environmental, social and financial benefits of renewable energy projects.
- **Funding mechanisms** – establish different routes to funding for low or zero carbon developments, such as through the formation of an Energy Service Company (ESCo), identifying opportunities to use developer carbon offset funds and exploiting local authority access to low cost, long term clean energy infrastructure finance.
- **Community energy** – build on existing links to community energy groups by offering assistance to those wishing to identify, assess and develop sites for renewables. The Council could provide a facilitation role in a number of areas including helping to identify locations via the current mapping work, feasibility, partnering on share offers and publicity. Similar services could be provided to communities when developing Neighbourhood Plans.
- **Opportunities across local authority corporate estate** – lead by example by continuing to decarbonise energy use across the council estate; given the advantages conferred by local authority access to finance, property/land ownership, accessibility and knowledge of site energy consumption data.
- **Further technical studies** – expand on the renewable energy resource assessment described in this report by considering additional technical studies such as:
    - **Heat network analysis** – build on the heat mapping analysis undertaken during this study and examine in more detail the opportunities available for heat networks. An open-source online tool[1] is now available which is principally targeted at local authority officers to help them build in-house capacity in the pre-feasibility planning of heat networks;
    - **Woodfuel supply** – develop a strategic plan to establish clean and sustainable woodfuel supply chains across the district;
    - **Wind energy deployment** – facilitate further discussion within the community on interpreting landscape sensitivity constraints to different scales of wind power development. This could involve overlaying the technical wind energy assessment maps

[1] www.thermos-project.eu/home/

with the findings of the landscape sensitivity assessment to identify the areas with most potential;

- **Solar assessment** – consider commissioning a GIS-based district-wide solar energy resource assessment which maps the solar resource at rooftop level – so each household and building owner could quickly identify the suitability of their site.
- **Local authority asset survey** – undertake a survey of local authority assets within Stroud District in conjunction with Gloucestershire County Council to explore further investment opportunities for renewable energy installations such as wind, solar PV and renewable heating.

1 Introduction

1.1 Background

Following the release of the IPCC Special Report 'Global Warming of 1.5°C' and subsequent recommendations from the UK Climate Change Committee, UK parliament declared a formal climate and environment emergency on 1st May 2019. This was soon followed on 12th June 2019 by the Government amending the Climate Change Act 2008 to target full net carbon neutrality (a 100% reduction of greenhouse gas emissions) in the UK by 2050. Since then, a growing number of local authorities have followed suit with declarations of climate emergencies and net zero emission targets.

Stroud District Council was ahead of national government and most other local authorities pledging in December 2018 to do everything in its power to make Stroud District carbon neutral by 2030. Following the publication of the Gloucestershire Sustainable Energy Strategy in January 2019, Gloucestershire County Council also unanimously committed to carbon neutral targets – to reach carbon neutrality across its own estate by 2030 and to deliver a carbon neutral county by 2050. Over 85% of the current energy mix supplying Gloucestershire is still reliant on fossil fuels thus demonstrating that for Stroud District to reach carbon neutrality by 2030 innovative transformative action will be needed across all sectors. Increasing local renewable energy generation capacity will be a key component of the solution, sitting alongside energy efficiency, energy demand reduction, heat decarbonisation and rapid growth in electric vehicles.

Figure 1 shows that reductions are already underway with carbon emissions (per capita) in Stroud dropping gradually between 2005 and 2015. This mirrors the trend for Gloucestershire and the UK more widely and is largely due to significant progress in decarbonising electricity and growing the proportion of renewable energy into the grid.

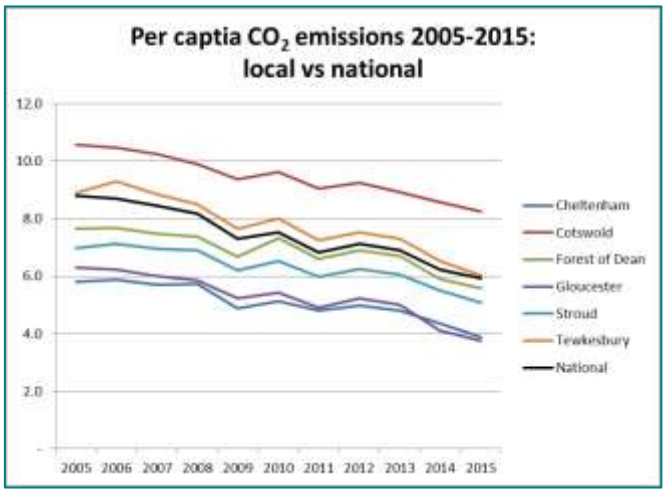


Figure 1: Historical emissions reduction across Gloucestershire

Stroud District Council has long been a champion for sustainable energy and was the first council in Europe to achieve carbon neutral status in 2015. The current Local Plan has a strategic objective on

climate change and policies on sustainable construction and design which include energy efficiency and the use of low carbon and renewable energy. The plan recognises the positive benefits of renewable energy developments such as the income source generated by the solar photovoltaic arrays at Dursley swimming pool and Cam-Winterbottom Memorial community hall. The council encourages energy generating projects that have considered the impact of the project, have consulted the local community and can prove that the benefits can outweigh adverse impacts, especially in the case of any proposals within the Cotswold Area of Outstanding Natural Beauty and the Severn Estuary. The environment committee has given its support to community energy projects that comply with the plan and can demonstrate a strong business case. A supplementary planning document, Sustainable Construction & Design Checklist covers guidance on new developments and retrofitting to reduce demand and increase energy production.

A number of significant wind and solar developments (commercial and community owned) have already received planning approval and been built including the Partnership for Renewables turbine at Sharpness, two turbines owned and operated by Resilient Energy under a community benefit society model, Ecotricity's new Alveston wind park in Stroud, the Upper Wick Solar Farm and City Work's solar array, one of Gloucestershire Community Energy Co-operative's renewable energy schemes.

With Stroud District's local plan review due to reach final draft stage in November 2019, the Council now wishes to incorporate policies which maximise positive local action on climate change and underpin the framework of measures needed to achieve carbon neutrality across the district by 2030. In June 2019, the Council's Environment Committee resolved a number of actions in this regard, including the need to identify the potential contribution that could be achieved from the deployment of renewable technologies and low carbon heat, including district heating, across the district.

In addressing this need, this report from the Centre for Sustainable Energy (CSE) working in partnership with Land Use Consultants (LUC) sets out the results of a renewable energy resource assessment for Stroud District and provides a technical evidence base to underpin appropriate planning policy and mechanisms to help realise this potential.

1.2 Objectives and scope

The overall objective of the study is to deliver an up-to-date evidence assessment of renewable energy generation potential and opportunities within Stroud district which builds on the local context, existing local capacity and takes account of the current technical and economic context for each renewable energy technology. The study is framed by Stroud District Council's and Gloucestershire County Council's latest climate change policy commitments and carbon neutrality targets and covers the period to 2040.

Specifically, the work involves mapping renewable energy generation capacity and exploring deployment scenarios that can best contribute to the 2030 carbon neutral target, and exploring policy options to achieve these. The key outputs include quantified renewable and low carbon energy resources, opportunity area maps, commentary on options/strategies for major allocation sites and policy recommendations. The study considers both stand-alone and building-integrated

renewable energy generation but does not specifically consider transport fuels apart from renewable electricity.

1.3 Assessment methodology overview

The resource assessment method used in the study considers energy resources in relation to the relevant energy generation technologies associated with each. The assessment of potential follows the standard area-based methodology that both CSE and LUC have utilised for previous studies: first a desk-based analysis involving industry-standard assumptions and calculations and/or GIS mapping is undertaken to establish the technical potential for each type of renewable energy resource, then further sets of constraints are considered (technical, economic, planning) to explore the practical or deployable potential.

The renewable energy potential for each technology is expressed as generating capacity in MW, typical annual energy yields in MWh or GWh, and resulting carbon savings from offsetting fossil fuels (see explainer below). Further details are given in Section 6 and all assumptions are included in Appendix 1.

During the research phase of the study, a stakeholder workshop was also convened in Stroud on 2nd October 2019 and was attended by a range of local stakeholders having an interest in climate change, sustainability or renewable energy generation. Interim outputs of the study were presented and participants held group discussions to the consider which local plan policy provisions would be the most important in helping to unlock Stroud District's potential for renewable and low carbon generation. Further discussions aimed to identify the most important opportunities and blockers and which areas the Council may be best placed to influence and/or facilitate. Outputs were recorded and taken into account within the study's findings. These covered a very wide range of views, topics and proposals, with community energy initiatives and renewable energy development within the Cotswold AONB featuring prominently.

MW or MWh? – explainer on energy units and Capacity Factor

Capacity and yield

In describing the energy outputs of the technologies described in this report, this report uses terms related to watts or watt-hours, for example megawatts (MW), or megawatt-hours (MWh). The key difference here is that the former refers to the **generation capacity** of the technology (i.e. its maximum instantaneous output or 'nameplate' rating), whilst the latter refers to the **generation yield** of the technology (i.e. the amount of energy it is likely to produce over a specified time period – normally a year). A domestic solar photovoltaic system, for example, might be rated at two kilowatts (its maximum instantaneous power output when light conditions are optimum), and over the course of a year it might typically generate 1,800 kilowatt-hours, which would provide around half the annual electricity needs of a typical UK household.

Depending on the scale of the energy plant, generation capacity is normally expressed in either watts (W), kilowatts (kW), megawatts (MW) or gigawatts (GW), with each unit increasing by a factor of 1,000. A large-scale wind turbine capacity of 2 MW, for example, can also be expressed as 2,000 kW (or 0.002 GW). Similarly, energy generation yield is normally stated in watt-hours (Wh), kilowatt-hours (kWh), megawatt-hours (MWh) or gigawatt-hours (GWh).

Capacity Factor

To convert from generation capacity to generation yield, an assumption needs to be made on the levels of generation at which the system will actually operate throughout the year; this will vary as it will not operate at its maximum generation capacity all the time. Industry-standard figures called 'capacity factors' are therefore used. The capacity factor (sometimes mistakenly referred to as 'load factor') takes into account the generation characteristics of a specific technology and can be defined as:

The actual energy yield produced over a period of time expressed as a proportion of the energy yield that would have been produced if the energy plant had operated at its full generation capacity continuously over the same period.

Capacity factors vary considerably between technologies; for example, solar PV may typically have a capacity factor of 0.1 whereas a large scale wind turbine may have one of 0.25. This effectively means that, in terms of energy yield, a 1 MW wind turbine is not directly comparable with a 1 MW solar PV farm. In this case, although both are capable of generating the same maximum instantaneous output of 1 MW in ideal conditions, the wind turbine will typically produce more energy over the course of a year as the wind tends to blow during day and night, whereas the sun only shines on the PV farm during the day. The use of energy generation yields in MWh or GWh will therefore provide a more meaningful measure of renewable energy deployment than simply using generation capacities in MW or GW. Additionally, any carbon savings resulting from displaced fossil fuel derived electricity are calculated directly from generation yields rather than generation capacities.

2 Policy context

2.1 National and local policy framework

The current profile of climate change on the world's stage has never been higher. The risks in failing to limit a global average temperature increase to 1.5°C have now been clearly set out in the IPCC Special Report 'Global Warming of 1.5°C'. In response to this and the 2016 Paris Agreement, the UK's Committee on Climate Change (CCC) recommended in May 2019 a new emissions target for the UK: net zero greenhouse gases by 2050. In facing up to this challenge, the need for radical changes to adapt and mitigate to the impacts of climate change is now broadly accepted in UK government and by an increasing proportion of civil society.

2.1.1 Climate Change Act

The UK's legally binding emission reduction targets were first set by the Climate Change Act 2008 and include a reduction of at least 80% by 2050 against the 1990 baseline. However, on 1st May 2019, parliament declared a formal climate and environment emergency, and on 12th June 2019 the Government amended the Climate Change Act to target full net carbon neutrality (a 100% reduction of greenhouse gas emissions) in the UK by 2050. This has been mirrored by widespread actions from local authorities and town and parish councils to adopt similar climate emergency declarations, targeting carbon neutrality by a variety of dates, backed up with emerging action plans, including Stroud District Council's declaration to make Stroud District carbon neutral by 2030.

2.1.2 National Planning Policy Framework

Whilst the political environment within which renewable energy and climate policy is set has changed radically and our high level carbon reduction commitments have been upgraded, the implications for this have yet to flow down fully into national planning policy. Aside from a revision to downgrade the support given to on-shore oil and gas development in response to a legal challenge[2] in February 2019, there has been no material change in planning policy around renewable energy since the release of the revised National Planning Policy Framework (NPPF) in 2018 when it was updated to incorporate the contents of the Written Ministerial Statement on wind[3] concerning the need for local plans to identify areas suitable for wind and that proposals should have local community backing (see Section 2.1.7). The main policies in the NPPF concerning climate change and renewables are shown below:

[2] Paragraph 209a was deleted. This said "mineral planning authorities should: recognise the benefits of on-shore oil and gas development, including unconventional hydrocarbons, for the security of energy supplies and supporting the transition to a low-carbon economy; and put in place policies to facilitate their exploration and extraction;"

[3] www.parliament.uk/documents/commons-vote-office/June%202015/18%20June/1-DCLG-Planning.pdf

"The planning system should support the transition to a low carbon future in a changing climate… should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions… and support renewable and low carbon energy and associated infrastructure" (paragraph 148)

"Plans should take a proactive approach to mitigating and adapting to climate change in line with the objectives and provisions of the Climate Change Act 2008" (paragraph 149 incorporating footnote 48);

"New development should be planned for in ways that can help to reduce greenhouse gas emissions, such as through its location, orientation and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards." (paragraph 150 b)

"To help increase the use and supply of renewable and low carbon energy and heat, plans should:

> *a) provide a positive strategy for energy from these sources, that maximises the potential for suitable development, while ensuring that adverse impacts are addressed satisfactorily (including cumulative landscape and visual impacts);*
>
> *b) consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure their development..." (Paragraph 151)*

"When determining planning applications for renewable and low carbon development, local planning authorities should:

> *a) not require applicants to demonstrate the overall need for renewable or low carbon energy, and recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and*
>
> *b) approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas" (Paragraph 154)*

"Local planning authorities should support community-led initiatives for renewable and low carbon energy, including developments outside areas identified in local plans or other strategic policies that are being taken forward through neighbourhood planning" (paragraph 152).

2.1.3 Clean Growth Strategy

The Government's Clean Growth Strategy (2017) also encourages local authorities to actively pursue a low carbon economy:

"Local areas are best placed to drive emission reductions through their unique position of managing policy on land, buildings, water, waste and transport. They can embed low carbon measures in strategic plans across areas such as health and social care, transport, and housing."[p118]

2.1.4 Planning Practice Guidance

The online Planning Practice Guidance (PPG) resource, published by the Ministry of Housing, Communities and Local Government (MHCLG) provides further interpretation of national planning policy for the benefit of local planning authorities and planning practitioners. Although the section on climate change has not been updated following the changes to the Climate Change Act and the UK Climate Emergency Declaration, it strongly asserts the centrality of climate change within the planning system and the need for adequate policies if local plans are to be found sound:

"Addressing climate change is one of the core land use planning principles which the National Planning Policy Framework expects to underpin both plan-making and decision-taking. To be found sound, local plans will need to reflect this principle and enable the delivery of sustainable development in accordance with the policies in the National Planning Policy Framework. These include the requirements for local authorities to adopt proactive strategies to mitigate and adapt to climate change in line with the provisions and objectives of the Climate Change Act 2008, and co-operate to deliver strategic priorities which include climate change." [Paragraph 1]

In respect of the approach to identifying climate mitigation measures for new development, the PPG also states:

"Every area will have different challenges and opportunities for reducing carbon emissions from new development such as homes, businesses, energy, transport and agricultural related development. Robust evaluation of future emissions will require consideration of different emission sources, likely trends taking into account requirements set in national legislation, and a range of development scenarios." [Paragraph 7]

The PPG also makes it clear with regards to renewable energy that *"When drawing up a Local Plan local planning authorities should first consider what the local potential is for renewable and low carbon energy generation. In considering that potential, the matters local planning authorities should think about include:*

- *the range of technologies that could be accommodated and the policies needed to encourage their development in the right places;*
- *the costs of many renewable energy technologies are falling, potentially increasing their attractiveness and the number of proposals;*
- *different technologies have different impacts and the impacts can vary by place;*
- *the UK has legal commitments to cut greenhouse gases and meet increased energy demand from renewable sources. Whilst local authorities should design their policies to maximise renewable and low carbon energy development, there is no quota which the Local Plan has to deliver."*

The role community led renewable energy initiatives have is outlined and states that they *"are likely to play an increasingly important role and should be encouraged as a way of providing positive local benefit from renewable energy development…Local planning authorities may wish to establish policies which give positive weight to renewable and low carbon energy initiatives which have clear evidence of local community involvement and leadership."*

In terms of identifying suitable locations for renewable energy development, such as wind power, the PPG section on 'Renewable and Low Carbon Energy'[4] states:

[4] www.gov.uk/guidance/renewable-and-low-carbon-energy This has not been updated since June 2015 but remains valid at the time of writing

"There are no hard and fast rules about how suitable areas for renewable energy should be identified, but in considering locations, local planning authorities will need to ensure they take into account the requirements of the technology and, critically, the potential impacts on the local environment, including from cumulative impacts. There is a methodology available from the Department of Energy and Climate Change's website on assessing the capacity for renewable energy development which can be used and there may be existing local assessments. However, the impact of some types of technologies may have changed since assessments were drawn up (e.g. the size of wind turbines has been increasing). In considering impacts, assessments can use tools to identify where impacts are likely to be acceptable. For example, landscape character areas could form the basis for considering which technologies at which scale may be appropriate in different types of location."

It also goes on to state that local planning authorities should not rule out otherwise acceptable renewable energy developments through inflexible rules on buffer zones or separation distances. Other than when dealing with set -back distances for safety, distance of itself does not necessarily determine whether the impact of a proposal is unacceptable.

2.1.5 Planning and Compulsory Purchase Act

Section 19(1A) of the Planning and Compulsory Purchase Act 2004 (PCPA) also requires that climate change be addressed through development plan documents and that obligations regarding annual monitoring of any targets or indicators are fulfilled:

Development plan documents (taken as a whole) include policies designed to secure that the development and use of land in the local planning authority's area contribute to the mitigation of, and adaptation to, climate change." [Section 19(1A)]

Every local planning authority must prepare reports containing such information as is prescribed as to…the extent to which the policies set out in the local development documents are being achieved. [Section 35(2)]

For the avoidance of doubt, all this means that local plans must demonstrate how their policies are in line with the legally binding carbon emission reduction targets set out in the Climate Change Act, including an understanding of both the baseline carbon dioxide emissions within the council area, the emissions inherent in future development and growth within the plan period, and the actions and policies that will reduce emissions in line with the trajectory set out in the Climate Change Act. It also means that the targets and indicators set out in local plans must be monitored on an annual basis to report on progress.

These requirements, which are all within planning policy if one reads the NPPF, the Planning and Compulsory Purchase Act 2004 and Climate Change Act 2008 together, have significant implications for local plan preparation i.e. that local plans are legally challengeable if the policies and growth commitments within them are not consistent with the legally binding trajectory for emissions reduction set out within the Climate Change Act. This has also been reiterated by the Town and Country Planning Association (TCPA) who have stated that *"Local government must also act now to ensure all its plans have clear carbon-reduction targets. Any plan which does not have a target is clearly in breach of the NPPF."*[5]

[5] www.tcpa.org.uk/news/government-must-radically-change-planning-policy-to-deal-with-climate-change

It should also be noted that under section 33A of the PCPA, local planning authorities are under a duty to cooperate with other local planning authorities in preparing local plans where strategic matters, such as "*planning measures to address climate change mitigation*", have impacts across administrative boundaries.

2.1.6 Neighbourhood plans

Neighbourhood planning offers local communities an officially recognised and legally robust opportunity to produce positive and ambitious sustainable energy plans for their local area. The PPG on Renewable and Low Carbon Energy states that *"Local and neighbourhood plans are the key to delivering development that has the backing of local communities."*

However, the large majority of the numerous plans so far adopted show little evidence of having considered the issue of climate change and energy to the level that is required to have meaningful impact. As put by the TCPA[6] *"If they are to successfully help communities deal with the future we will actually experience, they must move away from the narrow focus on accommodating housing that has blighted local planning in general, and move to an approach that plans for resilient, sustainable communities in a genuinely holistic sense."*

Given the right support, Neighbourhood Development Plan (NDP) groups can serve to convene and inform local communities and stimulate bottom-up renewable energy policies and development. This would require the local planning authority to take on a more non-traditional role of a convenor and enabler rather than that of a regulator. This may be particularly appropriate considering that the crucial factors which can cement or sway local opinion are typically around issues of:

- Place attachment (an individual's personal, emotional bond to a place);
- Distributive fairness (that the benefits of a development accrue in way that appears transparent and reasonable);
- Procedural justice (that the process by which a development has happened is fair, as well as the outcome itself).

2.1.7 Renewable and low carbon energy generation

Onshore wind power currently provides over 13GW of UK electrical generation capacity and contributed 18% of UK electricity generation in 2018, whilst being the cheapest form of new-build electricity generation available in the UK today.[7] It is also the most publicised renewable energy technology as a result of the mixed views it has garnered over its local environmental impacts. It therefore features prominently in renewable energy planning legislation and guidance at all levels. For example, the NPPF states that, other than repowering of existing wind turbines, sites can only be developed if local authorities or local communities identify suitable locations within planning policy. Outside of the identified areas, onshore wind projects are unlikely to get planning permission:

[6] Low-carbon neighbourhood planning (p3), TCPA/Esmee Fairbairn/CSE www.cse.org.uk/downloads/reports-and-publications/policy/community-energy/energy-advice/planning/renewables/low-carbon-neighbourhood-planning-guidebook.pdf
[7] Electricity Generation: Costs: Written question – 138372: www.parliament.uk/business/publications/written-questions-answers-statements/written-question/Commons/2018-04-26/138372/

"Except for applications for the repowering of existing wind turbines, a proposed wind energy development involving one or more turbines should not be considered acceptable unless it is in an area identified as suitable for wind energy development in the development plan; and, following consultation, it can be demonstrated that the planning impacts identified by the affected local community have been fully addressed and the proposal has their backing" [Paragraph 154b]

Whilst the planning regime in respect of onshore wind currently remains unchanged, and with the increased public concern around climate change and continued reductions in the cost of wind generation, there are however suggestions that the current government will be re-considering its approach to onshore wind[8].

CSE has undertaken research on the policy response of local planning authorities to the June 2015 Wind Ministerial Statement, which set out new considerations on wind energy developments so that "*local people have the final say on wind farm applications*".[9] The research was undertaken in 2017[10] and again in 2019 (unpublished). Our findings are that only a minority of authorities either have or are intending to develop land allocations for wind energy within their adopted local plans.

The research has found a range of policy approaches adopted by local planning authorities, such as:

- Policies giving in principle support but delegating the identification of suitable areas to neighbourhood plans;
- Criteria-based policies which ignore the requirement to identify suitable areas spatially;
- Policies which refer to separate landscape studies;
- Identifying unsuitable areas and proposing to support applications outside of these areas, subject to criteria.

The NPPF is clear however that local or neighbourhood plans need to *"clearly identify areas as suitable for wind energy development"* if applications are to be approved. Some of the policy approaches encountered, particularly those that rely solely on criteria-based policies which essentially ignore the requirement in national planning guidance to identify suitable areas for onshore wind, seem highly vulnerable to challenge; and if they make it through local plan examination, onshore wind proposals which rely on such policies for support seem vulnerable to challenge at planning application stage.

Of those local authorities with supportive policies for onshore wind, about a third defers the identification of suitable areas to neighbourhood plans. CSE has supported NDP groups in doing this[11] but it remains a challenging and potentially controversial area to address. Our experience suggests that without considerable encouragement and specialist support being given to NPD groups

[8] www.theguardian.com/environment/2019/jun/30/tories-urge-lifting-off-onshore-windfarm-ban
[9] https://publications.parliament.uk/pa/cm201516/cmhansrd/cm150618/wmstext/150618m0001.htm
[10] Survey of local authority wind policies (2017) Centre for Sustainable Energy www.cse.org.uk/downloads/reports-and-publications/policy/community-energy/planning/survey-of-local-authority-wind-sites.pdf
[11] How to identify suitable areas for onshore wind development in your neighbourhood plan - www.cse.org.uk/downloads/reports-and-publications/community-energy/planning/neighbourhood-planning-wind-guidance.pdf

in developing their own onshore wind policies, such policies are very unlikely to result in projects coming forward.

Given the importance of maximising renewable energy generation to achieving carbon reductions, existing and potentially deployable renewable energy resources should also be safeguarded. The Climate Change PPS from 2010 included Policy LCF15 to this effect:

Policy LCF15: safeguarding renewable and low carbon energy supplies

In determining planning applications, planning authorities should consider the likely impacts of proposed development on:

i. existing or other proposed development and their supply of, or potential for using, decentralised energy; and,

ii. existing, or proposed, sources of renewable or low carbon energy supply and associated infrastructure.

LCF15.2 Where proposed development would prejudice renewable or low carbon energy supply, consideration should be given as to how the proposed development could be amended to make it acceptable. Where this is not achievable planning permission should be refused.

2.1.8 Stroud local policy and guidance

2.1.8.1 Stroud District Council decisions

On 13th December 2018 Stroud District Council's Environment Committee[12] resolved to ask the Council to:

- Set out a plan of action for contributions from Stroud District to limit global temperature rise by 1.5 degrees celsius above pre-industrial levels in line with the Paris Agreement 2015;
- Develop a strategy for Stroud District Council to play a leadership role in achieving carbon neutrality by 2030;
- Ensure that the climate emergency is reflected in county-wide plans (for the county of Gloucestershire).

This was subsequently agreed by the Strategy and Resources Committee on the 9th January and at Council on the 24th January 2019.

A further report was brought before the Environment Committee on 6th June 2019 and from this it was resolved that the Council would set up a cross party member and officer working group and commission work to inform the local plan review of the potential contribution of renewables across the district including low-carbon heat projects.

2.1.8.2 Stroud Local Plan review

The review of the Stroud Local Plan preceded both the Council's declaration of a climate emergency and its decision to review the potential contribution from renewables. The review began with a public consultation on issues and options in 2017 with an emerging strategy of options published between 16th November 2018 and 18th January 2019. Both the issues and options and emerging strategy documents refer to mitigating, adapting and providing resilience to climate change. The

[12] www.stroud.gov.uk/media/970811/agenda-13-december-2018.pdf

vision in the emerging strategy also refers to responding to climate change through reducing our CO_2 emissions and adapting our lifestyles to living within environmental limits. It also makes reference to key issues raised in the 2017 issues and options document in terms of *"Contributing to the provision of renewable and low-carbon energy generation in the District"*. The findings of this study will inform the Local Plan Submission Draft. The next stage of consultation on the local plan review is expected to occur in autumn 2019.

2.1.8.3 Adopted Local Plan

The current Stroud District Local Plan, which was adopted in November 2015,[13] contains several references and policies which seek to promote the generation of renewable energy. 'Strategic Objective 5' specifically seeks to *"promote the generation of renewable energy"*. It is also noted that the Local Plan considered the potential for the overall development strategy to reduce contributions to climate change, seeking to promote the strategy with the least impact in relation to this.

The key relevant planning policies contained within the Local Plan are as follows:

- **Core Policy CP5** seeks to ensure that the strategic sites within the Local Plan are designed and constructed so as to maximise low or zero carbon energy generation. It also seeks to ensure that development minimises energy consumption and greenhouse gas emissions.
- **Core Policies CP8, CP11 & CP14** seek to ensure that any development "*maximises"* renewable or low carbon energy production.
- **Delivery Policy ES1** sets out that all planning applications should demonstrate how they have integrated renewable and low carbon energy.
- **Delivery Policy ES2** sets out that the council will support proposals that maximise the generation of energy from renewable or low carbon sources provided that this would not result in a significant adverse effect. The policy also sets out a number of caveats including:
    - *Renewable energy installations likely to affect the Cotswold Area of Outstanding Natural Beauty (AONB); it is necessary for developers to demonstrate that the public or national interest outweighs the protection afforded to the AONB.*
    - *The council supports the provision of small scale renewable energy developments; and*
    - *Community renewable energy schemes will be particularly welcomed.*

The policy justification states that for wind energy developments, the planning impacts identified by affected local communities should be fully addressed to ensure that the proposal has their backing.

The local plan was adopted in November 2015, which was after the Written Ministerial Statement on wind energy development was released on 18 June 2015. However, the inspectors report[14] (in relation to the examination of the extant local plan before its adoption) stated that *"SDC does not intend to identify suitable areas for renewable/low-carbon energy schemes, but sets out the criteria for considering such proposals, including their justification, impact on amenity and landscape, and engagement with local communities. With these amendments, Policy EC2 provides an appropriate*

[13] www.stroud.gov.uk/environment/planning-and-building-control/planning-strategy/stroud-district-local-plan
[14] www.stroud.gov.uk/media/1419/stroud_local_plan_inspectors_report_including_appendix.pdf

framework for considering proposals for renewable and low-carbon energy generation, which is consistent with the latest national policy".

There are no other local development documents, supplementary planning documents or guidance papers from Stroud District Council which set out areas suitable for renewable / low carbon energy schemes. Similarly, no made neighbourhood plans have included any such areas.

2.1.8.4 Climate Change Emergency Response Paper

At its meeting of 6th June 2019, the Stroud Environment Committee[15] also endorsed the recommended Council's initial response to its declaration of a climate change emergency. This sets out that a key change required to become a carbon neutral district is *"a complete shift to very low or zero carbon electricity generation, mostly renewable and much of it decentralised".* This requirement has several statements/actions including that:

- *Much of the shift will be due to the decommissioning of coal-based energy generation and the growth in offshore wind and onshore wind in Scotland, and that more needs to be done in Stroud to make a reasonable contribution to achieving national targets. Approximately 12% of energy is produced within Stroud from renewable resources, mainly solar PV, and a new target of 45% of energy consumed in Stroud would represent a quadrupling of in-district generation;*
- *Historically, the Stroud Valleys were powered by watermills. There may be opportunities for the development of more hydro-electric schemes at or near to these watermills;*
- *Whilst much of the current provision of solar PV in the district is roof mounted, there will be a need for new field-scale schemes;*
- *Subsidy-free wind turbines are likely to be viable, given sufficient grid capacity and public support, however the areas with the greatest potential are sensitive in terms of their landscape and environmental context;*
- *Current grid capacity is constrained within large parts of the district;*
- *Stroud District Council will play a key role in promoting future uptake and development of new renewable electricity generation in the district;*
- *The local plan review will be used to:*
    - introduce guidance to encourage the uptake of installation of solar PV (including within the AONB);
    - allocate areas within the local plan suitable for onshore wind energy development and field-scale solar PV;
    - develop policies to encourage hydroelectric schemes to come forward;
    - develop policies to encourage the delivery of tidal power schemes.

[15] www.stroud.gov.uk/media/1032856/item-6-progressing-carbon-neutral-2030-cn2030.pdf

During the meeting of this committee it was reported that Town/Parish Councils are beginning to form a network of their own and are contacting each other regarding the plan to become Carbon Neutral by 2030[16].

2.1.8.5 Gloucestershire County Council Climate Change Support

Following the leadership shown by Stroud District Council, Gloucestershire County Council's Full Council meeting on 15th May 2019[17] unanimously approved a motion which endorsed the climate emergency declared by the UK Government on 1st May. The motion also stated a commitment to:

- *Reduce by 80% of the council's corporate carbon emissions, striving towards 100% by including carbon offset, by 2030;*
- *Deliver a carbon neutral county by 2050;*
- *Lobby Government to commit to zero carbon aims and provide additional resources;*
- *Do all in its power to adopt, implement and strengthen the Council's Sustainable Energy Strategy.*

The Gloucestershire County Council Sustainable Energy Strategy[18] was published in January 2019. It sets out the current context of the County in its use of energy from various sources and carbon emissions. It also includes a strengths, weaknesses, opportunities and threats (SWOT) analysis of the County, which states that whilst there is appropriate technical knowledge in the County, there is a lack of initiative to deliver change within it, as this technical expertise is focussed on other locations outside of the County.

The strategy also sets out its strategic energy ambitions for Gloucestershire, which include committing to reducing carbon emissions; increasing renewable electricity generation; improving building energy performance (and tackling fuel poverty in the process); decarbonising heat demand in the County – for heating buildings and for industrial processes (i.e. not reliant on fossil fuel gas or oil) by 2040; shifting to Electric Vehicles; (EVs) and securing zero carbon new development.

In relation to the ambition to increasing renewable energy generation, the strategy suggests that 1TWh a year of renewable electricity generated within the county will be required (a quadrupling of current in-county generating capacity).

The strategy also outlines nine key building blocks, one of which is to develop a renewable energy leadership group, to bring forward scalable new business models for integrating renewables with community and other investment. This specifically refers to Ecotricity, an energy company based within Stroud, and also local, community-scale groups.

Gloucestershire County Council also hosted a climate change summit on 21 May 2019[19], which called on the local community to deliver the Gloucestershire Sustainable Energy Strategy.

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[16] www.stroud.gov.uk/media/1033865/minutes-6-june-2019.pdf

[17] www.gloucestershire.gov.uk/gloucestershire-county-council-news/news-may-2019/council-commits-to-becoming-carbon-neutral-by-2030/

[18] www.gfirstlep.com/downloads/2019/gloucestershire-energy-strategy-2019.pdf

[19] www.gloucestershire.gov.uk/gloucestershire-county-council-news/news-june-2019/county-council-leads-on-climate-action/

2.1.8.6 Neighbourhood Plans within Stroud District

A number of neighbourhood plans[20] have been made within Stroud District, and the implications for renewable energy generation are summarised below:

- Dursley Neighbourhood Development Plan 2018-2031 sets out in Planning Policy H2 that planning applications which feature energy efficiency and sustainable construction will be particularly supported and encouraged;
- Eastington Neighbourhood Development Plan 2015-2031 sets out support for all forms of renewable energy. Policy EP10 sets out community energy schemes will be strongly supported, subject to a number of planning caveats;
- Hardwicke Neighbourhood Development Plan 2015-2031 sets out ambitions to support green energy production, although it does not include any specific policies relating to this;
- Kingswood Neighbourhood Development Plan 2014-2031 does not include any specific provision for renewable energy;
- The Minchinhampton Neighbourhood Development Plan 2018-2036 does not include any specific provision for renewable energy;
- Stonehouse Neighbourhood Development Plan 2016-2031 sets out an aspiration that Stonehouse will be a thriving green town, using renewable energy, but does not set out specific policies as to how the renewable energy element of this will be achieved;
- Stroud Neighbourhood Development Plan 2015-2035 includes policy AP13 'Energy' which states that small scale and community-based renewable energy generation will be promoted and encouraged for both existing and new development. Policy AP9a 'Design: general principles' also sets out that all external lighting should use renewable energy sources;
- Whiteshill and Ruscombe Neighbourhood Development Plan 2015-2031 states that where possible new houses in the neighbourhood plan area should seek to source their energy from renewable supplies.

2.1.8.7 Cotswolds Area of Outstanding Natural Beauty

The **Cotswolds AONB Management Plan 2018-2023** includes a policy (Policy CC7) on Climate Change – Mitigation which states that:

1. *Greenhouse gas emissions should be reduced through a range of measures, including:*
    - *Improving energy efficiency, including building energy-efficient new buildings and retrofitting existing buildings;*
    - *Improving energy conservation;*
    - *Using small-scale forms of renewable energy that are compatible with the purpose of AONB designation;*

[20] www.stroud.gov.uk/environment/planning-and-building-control/planning-strategy/neighbourhood-planning

- *Reducing car use by: encouraging – and facilitating – the use of walking, cycling and public transport; encouraging home-based working (including the provision of high speed broadband); locating new development close to public transport hubs;*
- *Ensuring the provision of affordable housing to reduce the need to commute into the Cotswolds for work;*
- *Providing a network of charging points across the AONB for electric cars;*
- *Purchasing locally produced food products and services.*

2. *Climate change mitigation should be a key consideration in all new development, infrastructure and transport provision.*

3. *Climate change mitigation should be a key component of land management practices and future agri-environment, land management and rural development support mechanisms in the AONB.*

The AONB also released a **Position Statement on Renewable Energy** in 2014[21], which states that the AONB *"must play its part in reducing emissions, and this may be helped by the small-scale, local generation of energy from renewable sources. However, any schemes should ensure the conservation and enhancement of the natural beauty of the area."* Following this, the position statement also sets out that the AONB Board *"encourages the use of renewable energy in appropriate locations within the AONB or its setting, provided it is consistent with conserving and enhancing the landscape and natural beauty of the area"*.

The AONB Board considers that the following types of renewable energy development are likely to be proposed within the AONB or its setting and have the potential to result in impacts on the AONB or enjoyment of it:

- Wind turbines and wind farms;
- Biofuel, biomass and anaerobic digestion;
- Solar photovoltaic (domestic scale and solar farms);
- Solar hot water;
- Hydro-electric and Ground- and air-source heat pumps.

With specific regard to wind turbines, the Position Statement states that *"much of the AONB is unlikely to be able to accommodate wind turbine developments above 25m"*, which is assumed to refer to tip height. This is due to the potential for wind turbines to affect the character and qualities. The position statement also states that *"even with turbines below 25m there is still a risk that in many exposed locations the turbines would not be compatible with the purposes of designation (the conservation and enhancement of the natural beauty of the AONB)"*. It also sets out that wind turbines which are intended to provide electricity to the national grid and or other locations outside of the AONB will generally be objected to, suggesting that community wind-turbines and local schemes are likely to be more acceptable.

[21] www.cotswoldsaonb.org.uk/wp-content/uploads/2017/08/renewable-energy-ps-2014-final-apr2014.pdf

With specific regard to biomass, the Position Statement states that the AONB supports this, but suggests that these developments should be limited to those that are local in nature (i.e. not exporting / importing biomass), and that the design of proposals must be appropriate.

With regard to anaerobic digestion the Position Statement states that such plants may be accommodated subject to the design of the proposal being appropriate.

With regards to solar PV, the Position Statement sets out that most micro-scale projects are likely to have minimal and acceptable impacts, recognising that permitted development rights allow for some of these, for example on some existing residential buildings. The Position Statement also states that free-standing solar PV schemes, which are over 1Ha in area are unlikely to be acceptable in the AONB – and that the tests of the NPPF (set out in paragraph 172 of the February 2019 NPPF, which is unchanged from the 2012 version which was extant at the time the Position Statement was released) should apply.

With regards to solar-thermal the Position Statement states that as these are only likely to be provided at a domestic scale and that the impacts are likely to be acceptable.

Regarding hydro-electric schemes, the Position Statement sets out that medium or large scale schemes are not likely to be acceptable, and provides guidance on the design of hydro-electric schemes.

For ground and air source heat pumps the Position Statement states that these are likely to be acceptable.

The Board advises that renewable energy developments should be located where:

- They are appropriate to the landscape character;
- They would not be a dominant feature in the landscape;
- They make sympathetic use of existing buildings, tracks and other infrastructure;
- There would be no significant cumulative impacts due to other similar developments;
- There are opportunities to mitigate landscape and visual impacts and compensate for any unavoidable loss;
- They can be suitably landscaped to ensure the natural beauty of the area is conserved or enhanced;
- They are away from key amenity and heritage assets;
- They respect and are sensitive to important cultural associations;
- They are away from public views (roads, footpaths and public open spaces) if at all possible; and
- They are within existing built-up areas (a farmstead or settlement for example) where a strong functional relationship would be established, rather than in isolated locations away from other built structures.

The implication of the Position Statement is that only small-scale renewable energy projects are likely to be acceptable. Whilst the position statement does not represent development plan policy, it

will be treated as a material consideration and is likely to hold weight in the planning decision process. In addition, the AONB Board is likely to comment on renewable energy schemes of a medium and large scale, and these comments are likely to be given substantial weight by the planning authority.

2.2 Sustainable construction standards – energy and emissions

2.2.1 Building Regulations

The impact of new development also needs to be accounted for when predicting the trajectory of emissions reductions into the future. Emissions from new development have steadily decreased since the 1970s through gradually tightening requirements on energy efficiency within successive releases of Building Regulations. The current regulations, Part L (Conservation of fuel and power) came into operation in 2010 but were re-issued in 2013 and amended in 2016. The regulations apply a cap to a building's emissions through the use of a nominal Target Emissions Rate (TER) measured in $kgCO_2/m^2$/year, which must not be exceeded by the Dwelling Emissions Rate (DER) as calculated for dwellings using the Standard Assessment Procedure (SAP) methodology.

In October 2019 the Government launched a consultation on the next revision of the Building Regulations and proposed a new 'Future Homes Standard' with the message that "*We must ensure that new homes are future-proofed to facilitate the installation of low-carbon heat, avoiding the need to be retrofitted later, and that home builders and supply chains are in a position to build to the Future Homes Standard by 2025".*

The consultation considers two levels of emission reductions for new dwellings from 2020: either 20% or 31% over current 2013 Part L standards, and for the 2025 Future Homes Standard a 75-80% reduction together with low carbon heating systems (heat pumps, heat networks or in some circumstances direct electric heating i.e. they will not be dependent on fossil fuels). The 2020 31% target ('Fabric plus technology') is stated as being the Government's preferred option and would most likely comprise energy efficiency measures with onsite low carbon generation, whereas the 20% option ('Future Homes Fabric') would require higher levels of fabric energy efficiency.

The consultation also proposes that from 2020 the energy efficiency of new dwellings should be assessed in terms of 'primary energy' as the basis for the Part L performance target (alongside emission targets), and that from 2020, homes should be future-proofed for low carbon heating. This is likely to mean that, if not already fitted, homes should have a low temperature heat distribution system[22] so that they will be compatible with heat pumps. Additionally, in order to counteract existing variations in local authority-set performance standards, the consultation also proposes to remove the powers from local authorities to set their own standards above Part L.

2.2.2 Code for Sustainable Homes

A new standard for dwellings was introduced in 2006 in the form of the Code for Sustainable Homes, which provided a method of assessing and certifying the sustainable design and construction of new homes using a scale of 1-6. The code was intended to work alongside building regulations with local

[22] Low temperature heating systems typically deliver heat at 35-45°C instead of the usual 60-80 °C associated with most existing systems, and therefore use underfloor heating or extra-large radiators to compensate.

authorities able to specify mandatory levels of the code in their local plan for new developments. However, in 2014 the Government announced the Code's withdrawal and stated their intention of consolidating the standards back in to building regulations. Since then, there has been much confusion over the extent to which a local authority can set higher energy performance standards than the building regulations in their local plan – an action which was originally permitted through the Planning and Energy Act 2008. In March 2019 the issue was finally clarified in the revised Planning Policy Guidance on Climate Change:[23]

> *Different rules apply to residential and non-residential premises. In their development plan policies, local planning authorities:*
>
> *• Can set energy performance standards for new housing or the adaptation of buildings to provide dwellings that are higher than the building regulations, but only up to the equivalent of Level 4 of the Code for Sustainable Homes.*
>
> *• Are not restricted or limited in setting energy performance standards above the building regulations for non-housing developments.*

Today the Code for Sustainable Homes remains operational, with Level 4 approximately equivalent to a 19-20% improvement on current building regulations, or comparable to SAP level 86 or better.[24]

2.2.3 BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM) has traditionally been viewed as the non-domestic certification equivalent of the Code for Sustainable Homes. This standard is widely used and is specified in numerous local plans across the UK, although the emissions reduction associated with each BREEAM attainment level is not straightforward to quantify due to the weighting of scores across categories.

2.2.4 'Merton Rule'

So called 'Merton Rule' policies have proved to be a successful tool used in local plans to increase the deployment of building-integrated renewables. These require new developments to meet a proportional energy demand or emissions reduction target (typically 10-20%) from the use of onsite renewables or low carbon energy generation. They have been adopted by numerous local authorities since 2003 but are now perceived by many to have been superseded by tightening building regulations or made redundant when implemented alongside local authority policies requiring emissions reduction standards over and above those of building regulations. The power for local authorities to set such policies is enshrined in the Planning and Energy Act 2008.

Meeting emission targets such as those inherent in the Code for Sustainable Homes Level 4 will generally require a combination of onsite renewables with high levels of fabric energy efficiency, with the final choice left up to the developer when cost-effectiveness is also factored in. However, a small number of local authorities including Stockton-on-Tees Borough Council have recently

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[23] www.gov.uk/guidance/climate-change#can-a-local-planning-authority-set-higher-energy-performance-standards-than-the-building-regulations-in-their-local-plan

[24] Building for the 21st century – Stroud District Council planning requirements for sustainable development, report for Stroud District Council by Lupopia, March 2019

introduced Merton-rule style policies which will specifically require onsite renewable or low carbon generation.

2.2.5 'Net-zero carbon'

Where local authorities have followed the process of carbon auditing their plans as set out in the NPPF and PPG, they have generally concluded that it would be very difficult to achieve the required carbon reduction trajectory without new developments being built to a zero-carbon standard, due to the additional emissions growth inherent in new development commitments. This will require ambitious planning policies for new development which also ensure building energy performance is future-proofed. As stated by the RTPI: *"nothing should be planned without having successfully demonstrated it is fit to take its place in a net-zero emissions future…it makes no sense, economically, socially or environmentally, for what is planned and built today to be delivered in a form, or in places, that will require costly retrofitting tomorrow."*

A national definition of a net zero carbon building has yet to be agreed, although a framework definition has recently been proposed by the UK Green Building Council (UKGBC)[25] which is based on an *"industry consensus on how a net zero carbon building can be achieved today"*. UKGBC is currently pushing for net zero carbon in both construction and operational energy, and ultimately targets 'whole life' carbon impacts (including embodied emissions) although a detailed approach for the latter has yet to be developed.

For now, UKGBC is recommending that local authorities make plans for *"All new homes (and buildings) to be net zero carbon emissions in operation by 2030 at the latest"*, where operational energy is defined as "*When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset."* Confusingly, and depending on context, an 'operational' net zero carbon target can refer either to emissions from regulated energy use only[26], such as the Government's 2016 zero carbon homes definition (since abandoned), or to both regulated and unregulated energy use, which is considered 'true' zero carbon.

Specifically, UKGBC recommends that an appropriate trajectory towards these targets is adopted by local authorities in their local plans for new residential development, starting with an interim minimum baseline requirement of 19% emissions reduction over Part L Building Regulations 2013, with the level required by the regulations (defined by the TER: Target Emission Rate) to be met solely by energy efficiency measures BEFORE the additional 19% is addressed. This baseline target is equivalent to the energy performance standards of Code for Sustainable Homes Level 4 and so is legally sound and has been shown to be economically viable. This has already been successfully adopted in local plans by a number of local authorities including Brighton and Hove City Council, Ipswich Borough Council, Milton Keynes Council and Cambridge City Council. However, any proposed target must now be considered in the context of the Building Regulation proposals (see

[25] www.ukgbc.org/wp-content/uploads/2019/04/Net-Zero-Carbon-Buildings-A-framework-definition.pdf

[26] **Regulated energy use** refers to that controlled by Part L of the Building Regulations and includes energy used for space heating/cooling, water heating, fixed lighting, pumps and fans. **Unregulated energy use** refers to all other energy used within a building such as for cooking, appliances and small power. For non-domestic buildings, unregulated energy use also includes demands from lifts, manufacturing processes, server rooms etc.

Section 2.2.1) and any local trajectory set for net-zero carbon – this being 2030 in the case of Stroud District.

The baseline target then forms part of a hierarchical approach to a net zero carbon standard for new development (see Figure 2). Local policies are emerging which seek to impose net zero emission standards through minimum levels of onsite renewable energy generation and energy efficiency measures coupled with carbon offset funds (see Section 0), which typically allow developers to make financial contributions to offset emissions that cannot be mitigated onsite. Carbon offset funds as an 'Allowable Solution'[27] have already been in use for several years by the London boroughs, where the developer pays a specified amount per tonne of carbon to be offset – the box below summarises the latest proposals in the draft New London Plan. Similar approaches are also being taken by an increasing number of local authorities elsewhere including the West of England Combined Authorities and the Greater Manchester Combined Authorities. Such hierarchical policies also usually include set requirements for monitoring and reporting on energy performance for an initial period of operation.

Very high levels of energy efficiency have also been achieved from proprietary ultra-low energy housing construction standards that have been deployed at small scale in the UK include Passivhaus, which typically achieves 75% reduction in space heating requirements compared to standard UK practice, and Energiesprong, a refurbishment and new build standard achieving net zero operational energy. Currently however these are unlikely to be economically competitive with build solutions based on the net zero carbon hierarchical approach described above. In emission reduction terms, improving the building fabric energy efficiency levels beyond Part L 2013 can often be more expensive than onsite low or zero carbon generation options but will reduce energy costs for the occupant and lower peak demand.

[27] Allowable Solutions is the term introduced by the Government in the run-up to their abolished 2016 zero carbon homes target which allowed developers to mitigate residual onsite emissions by a range of offsite measures.

Summary of renewable and low carbon energy generation policy proposals in the draft New London Plan

SI2 – Minimising greenhouse gas emissions:

- *Major development should be net zero-carbon in accordance with 'lean; clean; green' energy hierarchy.*
- *At least 35% onsite reduction beyond building regulations (2013 issue) for major development. Residential and non-residential development to achieve 10% and 15% respectively through energy efficiency measures.*
- *Where zero carbon target can't be achieved, residual emissions to be addressed via borough carbon offset fund or offsite measures.*
- *Ensure all developments maximise opportunities for onsite electricity and heat production from solar technologies, innovative building materials and smart technologies.*
- *Boroughs are encouraged to use BREEAM targets in local plans where appropriate.*
- *Energy strategy required for major developments to demonstrate zero carbon plans, and 5-year monitoring requirement.*

SI3 – Energy infrastructure:

- *Development plans should identify need and sites for energy infrastructure requirements, and identify proposed locations for future heating and cooling networks.*
- *Energy masterplans required for large scale development locations.*
- *Major development proposals within Heat Network Priority Areas should have a communal low-temperature heating system.*

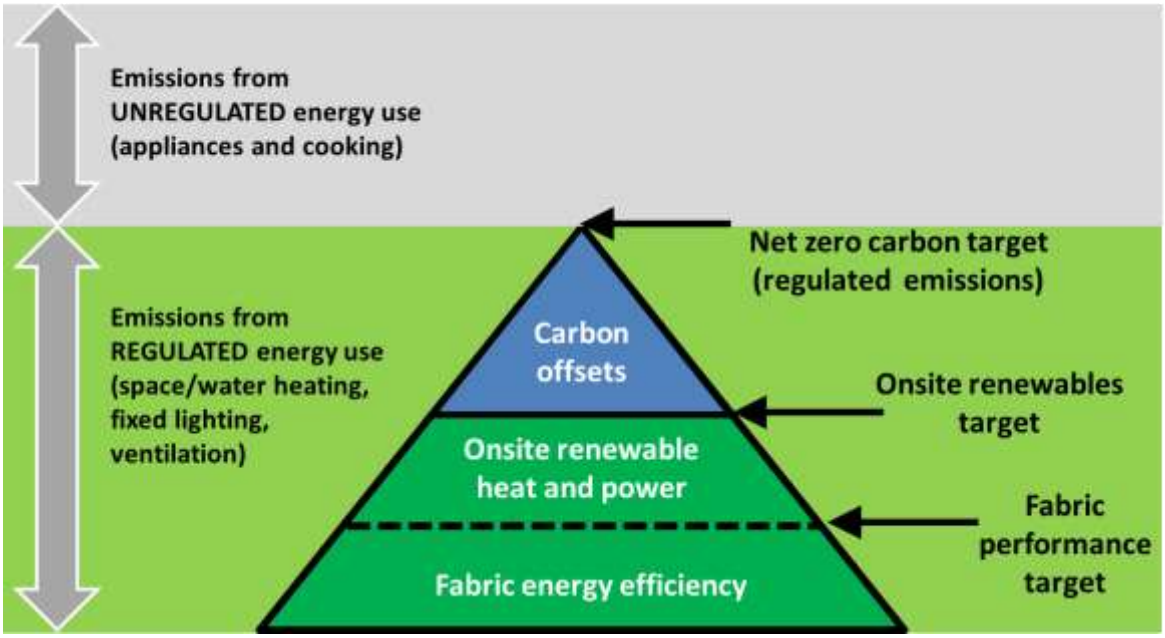


Figure 2: Hierarchy of emissions reductions for new development

In their Policy Playbook[28], UKGBC also recommends that local authorities:

[28] www.ukgbc.org/wp-content/uploads/2018/09/The-Policy-Playbook-v.-June-2019-final.pdf

- Set requirements for modelling of 'whole life' carbon impacts for new developments with a view to introducing targets and offsets in the future.
- Set requirements for monitoring and reporting energy performance of major new developments for the first years of operation.
- Set out future requirements that align with the Committee on Climate Change's recommendations for 2025 which would deliver ultra-high levels of energy efficiency as soon as possible and by 2025 at the latest, consistent with a space heat demand of 15-20 kWh/m^2/yr.

2.2.6 Carbon offsetting

Carbon offsetting is used by some local authorities in England (the most notable example being the carbon offsetting regime operated by the Greater London Authority) as an integral component of carbon reduction planning policies. It allows carbon emission reductions that cannot be achieved cost-effectively onsite to be tackled though offsite measures. In general, however, it is a controversial area of carbon management both because of the risk that it distracts from the pressing need to reduce emissions at source by seeking to make up for carbon emissions which have already been emitted, and because the claimed savings can be difficult to monitor and verify. It is important therefore that policies are designed in such a manner as to ensure that all viable onsite methods of reducing carbon emissions are exhausted first.

However, policy options for local authorities around the onsite mitigation of emissions within new developments are currently limited; whilst the Climate Change Act requires the UK as a whole to be net-zero carbon by 2050, existing national planning guidance advises that local authorities should not seek to set onsite technical standards at such high levels for the energy performance of dwellings (see Section 2.2.2). Therefore at the current time, if new developments are to be net-zero carbon, the only way for local authorities to achieve this is through a combination of the highest thermal efficiency standards possible, the incorporation of onsite renewable energy where viable and payments into a carbon offset fund, to make up the shortfall through off-site carbon abatement.

In the absence of developments which truly do not generate carbon emissions through their operation and occupation, carbon offset regimes can provide funds to create new carbon saving projects, and bring forward the rate at which carbon emission reductions are achieved. They should however be seen as temporary measures until regulatory regimes, development economics and the development industry deliver true carbon neutral or carbon positive developments on-site through use of sustainable materials, very high energy efficiency standards and integrated renewables. Care should also be taken to ensure that the emission reductions funded are genuinely additional to what would have happened otherwise and that the carbon offset regime is keeping up with the pace of emissions it is intending to mitigate for.

Although, in the case of carbon offsetting linked to zero carbon planning policies, carbon offset payments are usually calculated on the basis of abating carbon emissions for only 30 years' worth of building occupancy, there is an assumption that during this period the de-carbonisation of grid electricity and heat will be achieved through future technological and/or policy developments and therefore will account for emissions over the remaining life of the building.

3 Baseline emissions and energy needs assessment

3.1 Baseline energy demand and emissions

Estimating existing energy use and associated emissions across Stroud District is important to establish a baseline from which to measure future changes and monitor progress towards targets. According to the most recent statistics from the Department for Business, Energy and Industrial Strategy (BEIS)[29], total energy consumption across the industrial/commercial, domestic and transport sectors for 2017 was estimated to be 3,142 GWh.

Figure 3 shows the sector split of total emissions[30] during 2017, which are allocated on an 'end-user' basis where emissions are distributed according to the point of energy consumption (or point of emission if not energy related). The smaller 'LA scope of influence' emissions, totalling 539,351 tCO_2, are considered to be those within the scope of influence of local authorities and exclude large industrial sites, railways, motorways and land-use. The 'full emissions' total 785,917 tCO_2 and represent approximately 22% of the total for Gloucestershire County and 2.8% of the South West region's emissions.

Table 1 presents energy consumption statistics for 2017 which shows non-transport energy consumption across the district, mostly based on metered data, split between domestic and industrial/commercial users. Also shown are emissions data for both sectors.

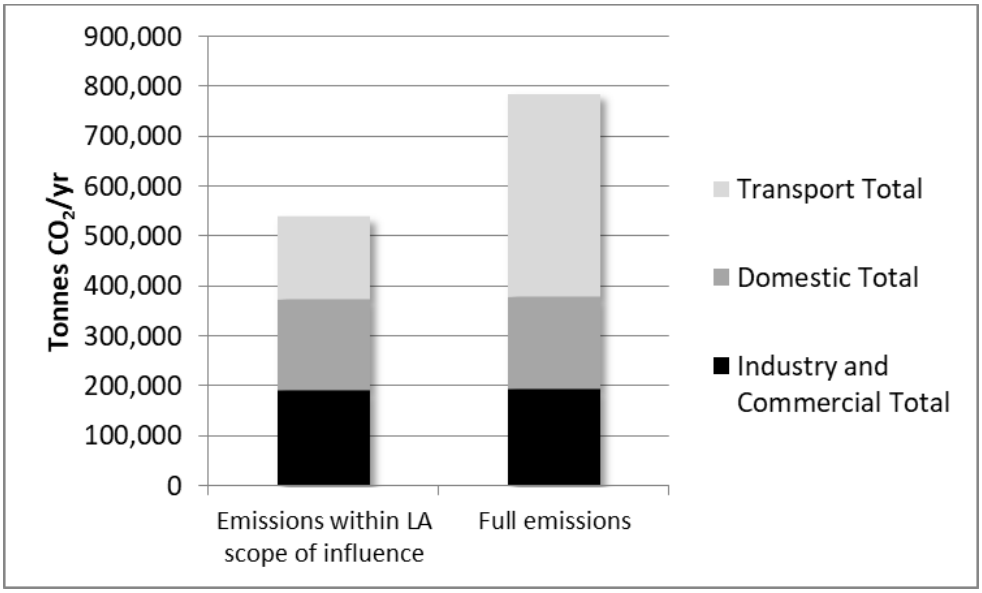


Figure 3: Local CO_2 emission sector split for Stroud District (2017 figures).

[29] www.gov.uk/government/statistical-data-sets/total-final-energy-consumption-at-regional-and-local-authority-level
[30] www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017

Table 1: Stroud District 2017 energy consumption statistics (non-transport)				
Sector	**Electricity (GWh/year)**	**Gas (GWh/year)**	**Other Fuels excl. bioenergy & waste (GWh/year)**	**CO_2 total emissions (kt/year)**
Domestic	224.7	581.7	78.9	184.7
Industrial/commercial	319.8	247.3	169.3	192.5
Total	**544.5**	**829.0**	**248.2**	**377.2**

3.2 Impact of new development

Unless new planning policies are introduced to mandate developers to deliver net-zero carbon buildings then it is inevitable that emissions across Stroud District will rise as a result of new development. As well as total emissions from regulated and unregulated operational use, whole-life cycle emissions including those resulting from construction will also need to be addressed to achieve true zero carbon.

Table 2 estimates operational emissions from different housing types built under the energy performance standards of SAP10[31]. Table 3 then estimates the emissions resulting from new housing developments predicted for Stroud District up to 2031. Currently there is insufficient data to estimate the emissions of future non-domestic development.

Table 2: Estimated CO_2 emissions from new housing types assuming SAP10 standards (tonnes/year)[32]				
Detached	**End-terrace**	**Mid-terrace**	**Large flat (low rise)**	**Small flat (low rise)**
2.58	2.02	1.91	1.35	1.13

Table 3: Estimated emissions from new housing developments in Stroud District to 2031				
Local Plan housing commitments 2006-2031	**Local Plan housing commitments 2015-2031**	**Homes built per year (assuming linear build-out)**	**Annual CO_2 emissions applying SAP10 standards (tonnes/year)**	**Total CO_2 emissions (tonnes/year)**
11,400	7,563	473	849	13,591

The forecast emissions for new housing to 2031 represents a relatively small proportion (7.3%) of current total emissions from housing across Stroud District and this figure is likely to be an overestimate if the net-zero carbon standards being proposed in Section 13 are adopted. Although these are important to implement, tackling emissions from the existing housing (and non-domestic building) stock represents a much bigger challenge to the district's net-zero carbon 2030 target and will need to be addressed urgently.

[31] SAP10 (Standard Assessment Procedure 10) is expected to become part of the next update to Part L of the Building Regulations

[32] Figures estimated from analysis undertaken for West of England Local Authorities by Currie and Brown

4 Net-zero carbon – influence of national and local policy-making

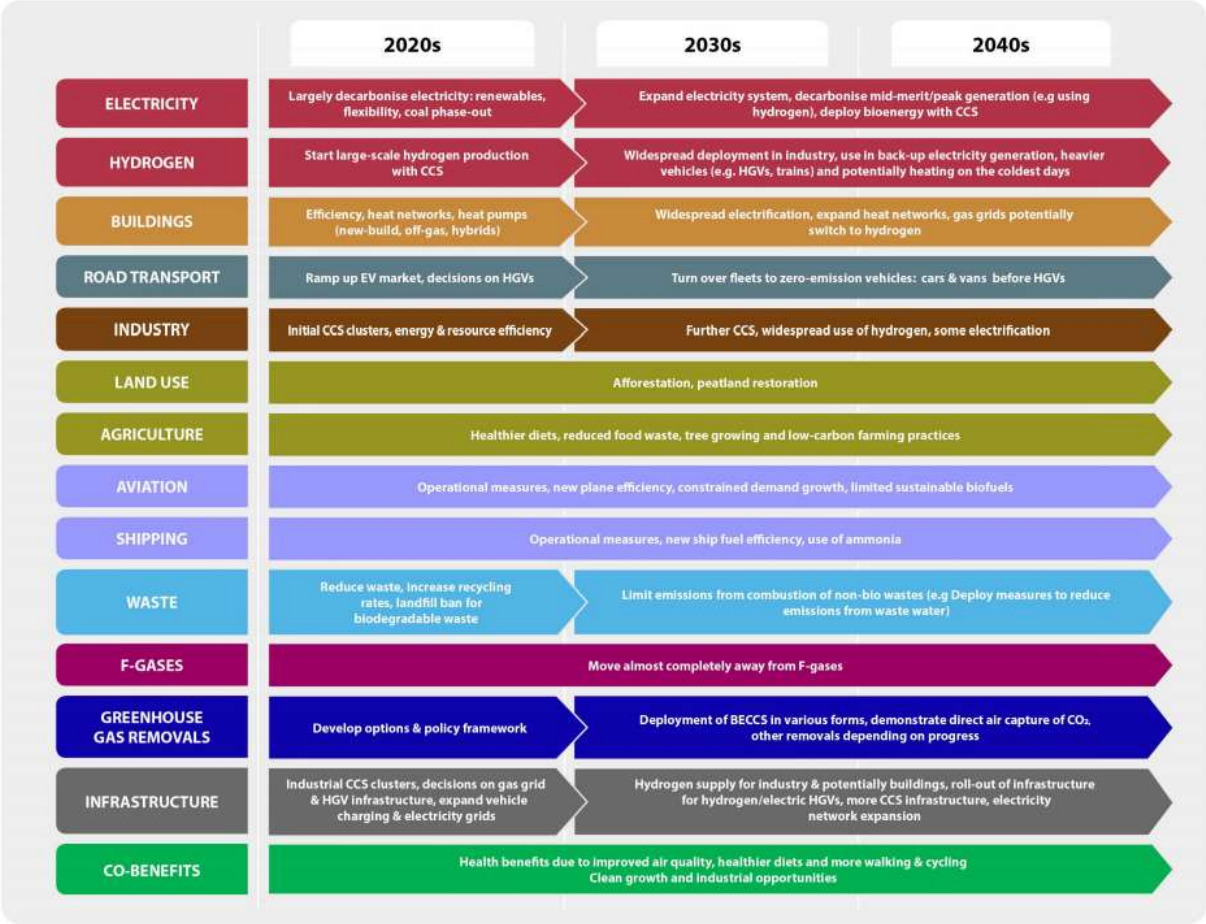
4.1 National-level policy influence

The rate of progress that will be made as a result of government policy at national level regarding emission reduction measures that fall outside the scope or influence of local authorities will clearly have a substantial impact on Stroud District's 2030 net-zero carbon target. Although this is very difficult to quantify, the most significant ongoing outcome is likely to be the rate at which the electricity grid decarbonises, which will have profound implications for both heat and electricity demand.

In their 'Net Zero' report[33] from May 2019, the Committee on Climate Change sets out the changes that would be required to put the UK on a realistic trajectory to net-zero greenhouse gas emissions by 2050. The report suggests this could result in a doubling of electricity demand (as a result of the electrification of heat and mobility), and an overall need to quadruple the supply of low-carbon electricity from current levels by 2050.

Key national initiatives to decarbonise both the electricity grid and heat supplies will need to focus on multiple approaches such as increasing wind power, carbon capture and storage (CCS), electrification of heat, transport and phasing out gas, development of hydrogen infrastructure and introducing building energy performance standards and financial incentives which encourage zero carbon technologies ultimately within self-supporting markets. Figure 4 sets out the broad actions that the Committee on Climate Change suggest will be needed.

[33] Committee on Climate Change (May 2019) - Net Zero - The UK's contribution to stopping global warming - https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf



Source: CCC analysis.
Notes: CCS = carbon capture and storage. EV = electric vehicle. BECCS = bioenergy with CCS.

Figure 4: UK net-zero GHG scenario (Committee on Climate Change, 'Net Zero' report 2019)

4.2 Local-level policy influence

Compared to the scope of influence central government has in achieving net-zero carbon, local authorities have significantly less reach and their resources are clearly more limited in being able to act. Local area binding carbon budgets are therefore less appropriate, given the multiple drivers of emissions, many of which are beyond a local authority's control. They are however well-placed to have a better understanding of the local area in terms of needs, opportunities and constraints whilst having influence through their multiple roles of social landlords, major employers, community leaders, planning authorities and service providers.

Buildings, surface transport and waste are key sectors where local authorities can exert meaningful influence in delivering emission reduction initiatives. For example, buildings offer considerable potential to reduce energy demand through local energy efficiency schemes and promote building-integrated renewables or efficient heat networks, low carbon transport can be encouraged through the provision of electric vehicle charging infrastructure and residual waste can be used to generate energy. Local authorities can also have a crucial role in facilitating grid power decarbonisation through encouraging decentralised local low or zero carbon energy generation such as wind power,

solar PV and hydro power. Lastly, it is important to realise that they can be instrumental in promoting, maximising and delivering local benefits resulting from the delivery of emission reduction measures which can include economic regeneration, reduction in fuel poverty and improved health.

5 Existing renewable and low carbon energy generation

An exact figure for the amount of existing renewable energy capacity across the district is not possible to ascertain although estimates for installed electricity generation capacity and output have been compiled in Table 4. This draws on sub-regional data regarding the Feed-in Tariff[34] scheme and BEIS' Renewable Energy Planning Database (REPD)[35], which lists all renewable electricity projects including battery storage projects and those that comprise combined heat and power (CHP) that have acquired or are subject to planning permission. The locations for known existing and consented larger-scale installations across Stroud District including those currently listed in the REPD are shown in Figure 5.

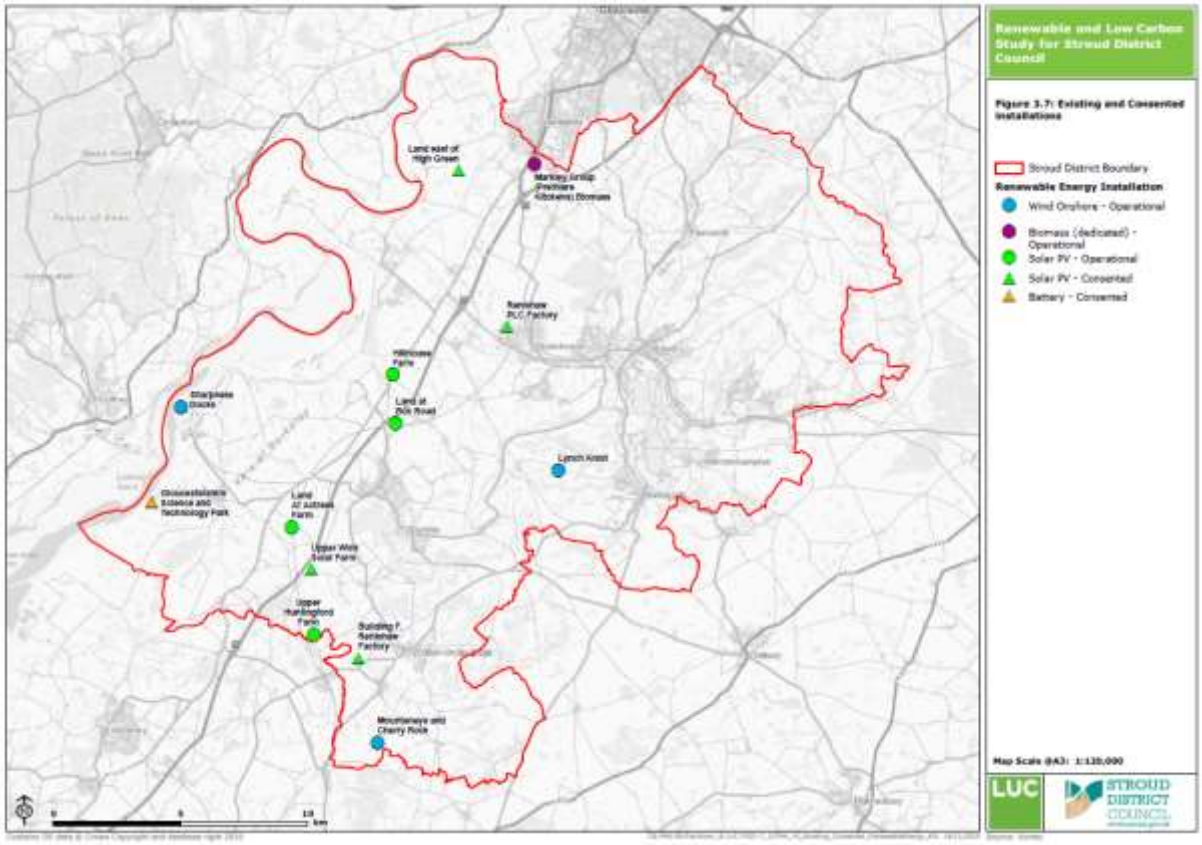


Figure 5: Existing and consented renewable energy installations

[34] www.gov.uk/feed-in-tariffs/overview

[35] www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract

Table 4 – Existing operational renewable electricity installations in Stroud District			
Technology	**Estimated total capacity (MW)**	**Electricity output (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
Solar PV	63.4	58,315	13,587
Wind	3.5	8,891	2,072
Hydro	0.1	249	58
Anaerobic digestion	1.6	8,690	2,025
Biomass (CHP, elec)	2.1	11,038	2,572
Total	**70.7**	**87,183**	**20,314**

As seen from Table 4, there is currently around 71 MW of operational renewable electricity generation across the district, with annual emission savings of 20,314 tCO_2. This figure would increase to around 33,000 tCO_2 once the Javelin Park energy from waste facility is operating at full capacity and exporting electricity.

The amount of existing renewable heat generation from anaerobic digestion, CHP, woodfuel/biomass, solar water heating and heat pumps is more difficult to quantify due to a lack of accessible sub-national data within the Renewable Heat Incentive statistics. The Microgeneration Certification Scheme (MCS) installations database is another potential source of information, but at the time of writing access restrictions had prevented analysis of this data.

6 Assessment of renewable and low carbon energy resources and technologies

A range of resources and technologies have been assessed as part of a desk-based exercise involving industry-standard assumptions and calculations and/or GIS mapping to establish the potential for each type of renewable energy resource. By applying a set of constraints the renewable energy potential is expressed as generating capacity, typical annual energy yield and resulting carbon savings from offsetting fossil fuels. The approach taken has been to adopt tailored scenarios for each resource using the set of assumptions given in Appendix 1. These are largely based on establishing a theoretical resource which considers technical constraints to deployment rather than those imposed by political or financial issues. Existing renewable energy generation installations will be inclusive within the estimates.

6.1 Wind power

6.1.1 Overview

Onshore wind power is an established and proven technology with thousands of installations currently deployed across many countries throughout the world. The UK has the largest wind energy resource in Europe.

Turbine scales do not fall intrinsically into clear and unchanging size categories. At the largest scale, turbine dimensions and capacities are evolving quite rapidly. The deployment of turbines at particular 'typical' scales in the past has also been influenced by changing factors which include the availability of subsidies of different kinds. As defined scales need to be applied for the purpose of a resource assessment, however, the present assessment has used four size categories based on a combination what turbines have been installed in the past (for smaller scales) and an awareness of current and potential future deployment (for the larger scales):

- Small (<60m).
- Medium (60m-100m).
- Large (100m-150m).
- Very large (150m-200m).

Hypothetical turbines for the purposes of the present resource assessment are based on 'typical' models (either present or past) within these categories:

Table 5 – Hypothetical turbines used for the resource assessment		
Scale	**Typical turbine installed capacity**	**Typical turbine height (maximum to blade tip)**
Small	50kW	45m
Medium	500kW	80m
Large	2.5MW	125m
Very Large	4.0MW	175m

Most turbines above the smallest scales have a direct connection into the electricity network. Smaller turbines may provide electricity for a single premises via a 'private wire' (e.g. a farm or occasionally a large energy use such as a factory), or be connected to the grid directly for export. Typically, turbines will be developed in larger groups (wind farms) only at the larger scales. The amount of energy that turbines generate will depend primarily on wind speed but will be limited by the maximum output of the individual turbine (expressed as 'installed capacity' in Table 5).

As of 2018, the UK had 13,554 MW of installed onshore wind capacity, providing 30,217 GWh electricity during the year[36]. Since the removal of financial support and restrictive modification to the national planning policy regime, onshore wind development activity has moved overwhelmingly away from England towards Wales and Scotland, where it is focusing particularly on sites with high wind speeds and the ability to accommodate large numbers of tall turbines.

LUC/CSE's review of the data available from the department for Business, Energy and Industrial Strategy (BEIS), supplemented by input from Stroud District Council, has identified only 4 turbines currently installed in Stroud District, although it is understood that there are a small number of micro-scale turbines that have been installed historically in addition to these. The identified existing wind developments in Stroud total 3.5MW and include:

- Sharpness Docs: 2MW
- Lynch Knoll: 0.5MW[37]
- Mountenays and Cherry Rock: 2 x 0.5MW

6.1.2 Resource assessment

The potential for very large, large, medium and small turbines was undertaken using GIS (Geographical information Systems) involving spatial mapping of key constraints and opportunities. The assessment identified areas with potential viable wind speeds (applying a reasonable but relatively generous assumption in this respect, bearing in mind that only the highest wind speeds are potentially viable at the present time) and the number of turbines that could be theoretically be

[36] BEIS (2019), *Energy Trends: UK renewables*, https://www.gov.uk/government/statistics/energy-trends-section-6-renewables
[37] The capacity of an additional smaller turbine located at this site was unknown at the time of writing.

deployed within these areas. A series of constraints relating to physical features and environmental/heritage protection were then removed. The remaining areas were identified for the purposes of the assessment as having 'technical potential' for wind development.

Key constraints and opportunities considered are shown in Table 24 (Appendix 1).

6.1.3 Landscape Sensitivity Assessment

Landscape and Visual Impact (LVI) has historically often been the defining consenting consideration within the context of planning applications for wind developments, and has therefore been a particularly important influence on the choice of turbine scales and locations by developers.

As the degree of acceptable landscape and visual impact is generally a matter that needs to be considered within the context of an overall planning balance, no land was excluded from the GIS technical constraints assessment on landscape or visual grounds. Instead, a separate landscape sensitivity assessment was subsequently undertaken which considered all Landscape Character Areas with technical potential for development, including those within the AONB. This can be used alongside the output of the GIS assessment, which maps and quantifies technical capacity, to determine landscape sensitivity to different scales of wind turbines.

The landscape sensitivity assessment method has been developed in accordance with the Natural England guidance[38] published in June 2019, as well as building upon LUC's considerable experience from previous and ongoing studies of a similar nature. The guidance includes the following definition:

"*Landscape sensitivity may be regarded as a measure of the resilience, or robustness, of a landscape to withstand specified change arising from development types or land management practices, without undue negative effects on the landscape and visual baseline and their value.*"

Wind turbine and solar energy development will affect different characteristics of the landscape in different ways. It is therefore important to understand the nature and sensitivity of different components of landscape character, and to set these out and assess them in a consistent and transparent fashion. In order to do this, a set of criteria have been used to highlight specific landscape and visual characteristics which are most likely to be affected by wind and solar energy development. The criteria for landscape sensitivity to wind turbines and solar PV installations are detailed in Appendix 2. A range of scales of development have been considered in the sensitivity assessment for both wind turbines and solar PV development. These align with those used for the assessment of technical potential (see Section 6.1.1).

The landscape sensitivity study is based on an evaluation of key aspects of the Stroud Landscape Character Assessment (2000) in combination with GIS data and other relevant literature. The key characteristics of each landscape character area (LCA) were assessed against each of the criteria to arrive at a judgement as to their potential sensitivity to wind turbine and solar energy development.

For each criterion, a short explanation is provided as to why it is indicative of sensitivity to the type of development proposed, and what key characteristics of the landscape will be considered. Sensitivity is judged on a five-point scale from 'high' to 'low' as set out in Appendix 2. The five

[38] An approach to landscape sensitivity assessment– to inform spatial planning and land management. Natural England. June 2019.

defined levels form stages on a continuum, rather than clearly-separated categories. Any given landscape may or may not fit neatly into one category, and an element of professional judgement is required. The relative importance of each criterion varies between LCAs; key characteristics may identify where a particular criterion is more important and should therefore be given greater weight in the judgement of sensitivity. This culminates in an overall landscape sensitivity judgement (using the five-point scale), taking account of the inter-relationships between the different criteria and the specific characteristics of the landscape being assessed.

As with all assessments based upon data and information which is to a greater or lesser extent subjective, some caution is required in its interpretation. This is particularly to avoid the suggestion that certain landscape features or qualities can automatically be associated with certain sensitivities – the reality is that an assessment of landscape sensitivity is the result of a complex interplay of often unequally weighted variables (i.e. 'criteria').

The initial stage of the assessment was a desk-based exercise, drawing on information in the 2000 landscape character assessment and other sources identified for each criterion. This was followed up with field work (undertaken in September 2019) to view each LCA in the field and make any additional observations. Field work was particularly important for criteria such as skylines and inter-visibility, which may not be consistently described in the available documentation. Field survey also assists with verification of desk-based material.

The sensitivity assessment identifies the underlying sensitivity of the landscape, as it appears at the time of the survey. It therefore considers operational development but not potential cumulative change.

Landscape sensitivity often varies within LCAs, with areas exhibiting of higher and lower sensitivity. It is therefore very important to take note of the explanatory text supporting the assessments in each LCA profile, particularly the box entitled 'Notes on any variations in landscape sensitivity'. Whilst the Landscape Sensitivity Assessment results provide an initial indication of landscape sensitivity, they **should not be interpreted as definitive statements on the suitability of individual sites for a particular development.** All proposals will need to be assessed on their own merits through the planning process, including – where required – through proposal-specific Landscape and Visual Impact Assessments (LVIAs).

During the stakeholder consultation event for this study, individual consultees raised questions concerning the variability of perception of landscape sensitivity. In particular, it was questioned whether landscape sensitivity appraisal generally gives insufficient weight to the contribution of particular landscape types to the mitigation or exacerbation of climate change, and the potential effect of this contribution upon the perception of sensitivity. It was argued specifically that landscapes that make a low or negative contribution to the mitigation of climate change might, for that reason, legitimately be perceived as of lower sensitivity.

It is acknowledged that perceptions of landscape sensitivity to particular development types do indeed vary between individuals, and even that the consensus concerning sensitivity may vary between communities and/or could vary over time. However, the present assessment has been based on an evaluative framework that is endorsed as good practice for studies of this nature, including via expression in national guidance and testing at Examination/appeal. It is considered

more appropriate to apply the environmental and other benefits of renewable energy, for example, as positive considerations within the overall planning balance, rather than for these benefits to modify the evaluation of landscape sensitivity per se.

6.1.4 Results

Table 6 below provides a summary of the technical potential for wind energy within the Stroud District. The analysis examined the potential for very large, large, medium and small turbines. Where potential existed for more than one size of turbine, it was assumed that the larger turbines would take precedence i.e. it was assumed that the largest potential turbine in each case would be installed. This was in order to calculate the maximum technical potential for wind.

The calculation of wind capacity involved applying an assumption concerning development density. Turbines are spaced within developments in practice based on varying multiples of the rotor diameter length (on different axes). Although separation distances vary, a 5 x 3 rotor diameter spacing (greater in the prevailing wind direction, taken to be southwest as the 'default' assumption in the UK) was considered a reasonable general assumption at the present time in this respect. In practice, site-specific factors such as prevailing wind direction and turbulence are taken into account by developers, in discussion with manufacturers. Bearing in mind the strategic nature of the present study, the density calculation did not take into account the site shape and minimum site size, and a standardised density was used instead:

- Very large: 2 turbines per km²
- Large: 6 turbines per km²
- Medium 20 turbines per km²
- Small: 182 turbines per km²

The calculation of potential energy yield then required application of a 'capacity factor' i.e. the average proportion of maximum turbine capacity that would be achieved in practice over a given period. Again, capacity factors vary in practice in accordance with wind speed, terrain and turbine scale. It was not possible to find suitable historic data on capacity factors taking into account these kinds of variations for the present study, and so a single capacity factor was used for all turbine scales based on regional data[39] .

The assessment results indicate that there is a technical potential to deliver up to around 336MW of wind energy capacity in Stroud District, with the greatest potential for small and medium wind turbines.

[39] BEIS FiT load factors, averaged at 28.9% for the South West region over the last 4 years: www.gov.uk/government/publications/quarterly-and-annual-load-factors

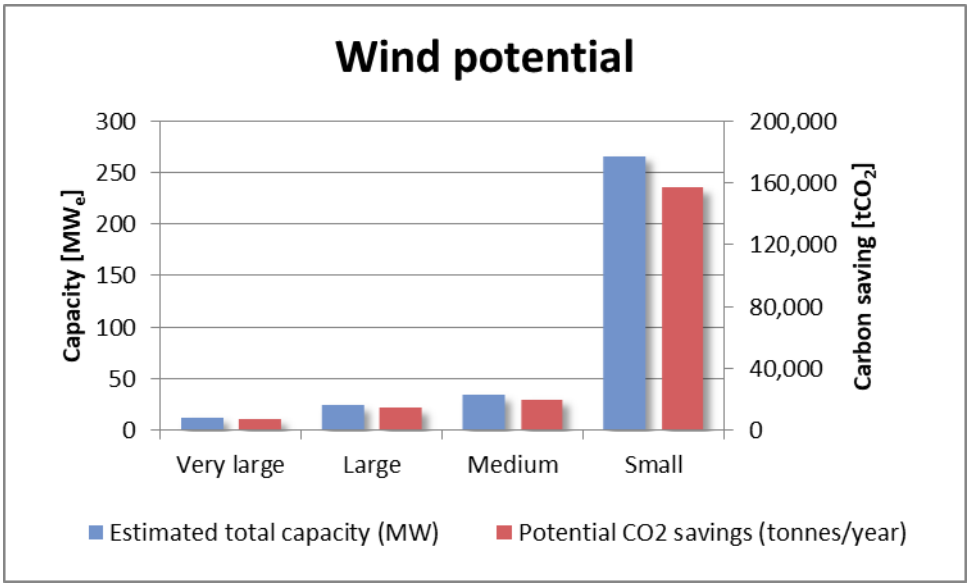


Figure 6: Onshore wind potential

Table 6 – Potential Wind Capacity and Output			
Development Scale	**Estimated total capacity (MW)**	**Electricity output (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
Small	265.55	672.28	156,641
Medium	33.69	85.29	19,873
Large	24.14	61.10	61,100
Very Large	12.32	31.19	31,190
Total	**335.7**	**849,860**	**198,017**

The maps included in Appendix 3 show the areas which have been identified via the GIS analysis to have technical potential for wind development at each considered turbine scale. These figures indicate that there are parcels of land across the District that have the technical potential for all scales of wind turbines in principle, but with opportunities being very limited at the largest scale and progressively expanding as the turbine size reduces. A particularly important influence in this respect is clearance from properties. The key role of this constraint in defining the potential wind development resource reflects a distinctive characteristic of the district in that, whilst largely rural, it does not contain significant areas that are remote from properties.

In order to illustrate the GIS tool parameters, a series of opportunity and constraints maps were also produced. Figure 20 (Appendix 3) shows the wind speed within the district at 50m above ground level (agl). This shows that the majority of the District exceeds the minimum wind speed threshold applied in the analysis, with higher wind speeds generally being in the upland areas to the east of the district on the one hand, and the open landscapes at and around the River Severn on the other. Other mapped constraints that have influenced the assessment outcomes are included within maps accompanying this report.

An assessment of this nature will necessarily have certain limitations, including:

- **Wind data** – it is important to note that the macro-scale wind data which was used for this assessment can be inaccurate at the site-specific level and therefore can only be used to give a high level indication of potential capacity and output within Stroud District. Developers will normally require wind speeds to be accurately monitored using anemometers for an extended period (typically at least one to two years) for commercial scale developments.
- **Cumulative effects** – multiple wind turbine developments can have a variety of cumulative effects. Cumulative landscape and visual effects, in particular, would clearly occur if all the identified small wind development potential was to be realised. Cumulative effects, however, cannot be taken into account in a high-level assessment of this nature and must be considered on a development-by-development basis.
- **Site-specific features and characteristics** – in practice, developments outside protected areas may potentially impact on sensitive environmental 'receptors' such as protected species. These impacts can only be assessed via a site-specific survey.
- **Aviation** – although airport safeguarding zones were identified for information, aviation interests were not used to define potentially suitable land as impacts and mitigation need to be considered on a development by development basis.
- **Proposed Allocations** – due to the timing of the resource assessment in relation to Stroud's Local Plan Review programme, it was not possible to take currently proposed allocations into account in the present assessment. These may change following consultation on the draft local plan, but in their final form will either be a further constraint upon development (in relation to built elements) but may in some cases offer opportunities for development (e.g. where they include undeveloped land).

6.1.5 Future deployment

The technical wind development potential of a district as estimated through application of reasonable constraints within a GIS tool is not the same as the development capacity that may be expected to be deployed in practice.

Certain of the limitations of the resource assessment with respect to deployable wind potential have already been noted in the previous section. For example, cumulative impacts can only be considered fully when developments come forward in practice, but would generally be expected to reduce the overall deployable capacity of a district. However, there are four particular influences on deployable wind potential that merit discrete consideration.

6.1.5.1 Landscape sensitivity

No part of the District was excluded from consideration in principle, including the Area of Outstanding Natural Beauty. However, using the established assessment methodology, large parts of the district at Landscape Character Area (LCA) scale (see Figure 21, Appendix 3) have been evaluated as having 'moderate-high' or 'high' sensitivity to wind development, with all LCAs having this level of sensitivity overall for large and very large turbines. Sensitivity rating maps are also included in Appendix 3.

LCAs shown as 'N/A' on these maps (coloured grey) were found by the GIS assessment not to have technical potential for development at the relevant scale and so were not given a sensitivity rating. However, some LCAs that have ratings may not appear to have technical potential when cross-referenced with the corresponding opportunities map. This is due to the methodology employed where any technical potential present for a given scale of development within a particular LCA, however small, will then trigger a sensitivity rating for the whole LCA according to the relevant development scale. Very small areas of technical potential may not be visible at the map resolutions used in Appendices 3 and 4.

As the sensitivity assessment notes, landscape sensitivity varies within LCAs in practice, and particular development sites may be identified within individual LCAs that have lower sensitivity than that of the LCA overall. LVI is also ultimately a consideration that needs to be weighed within the overall planning balance. The sensitivity assessment, however, can be used to guide development towards less sensitive areas in the first instance, and then to ensure that careful consideration is given to the choice of turbine locations, numbers and scales, particularly in areas of higher sensitivity.

6.1.5.2 Grid connection

Historically, it has been possible to connect a variety of wind energy development scales into the distribution network at a wide range of distances from the nearest connection point. This situation has changed dramatically over recent years due to two factors in combination:

- The distribution network, and even the transmission network, have become increasingly congested, to the point at which connections in many cases cannot take place without extremely expensive network enforcement costs (which fall to the developer) being incurred, or generation being curtailed, or both.
- The Government's cancelling of subsidies for onshore wind in 2016 has reduced wind development incomes to the point at which previously affordable reinforcement works would now render many developments unviable, particular those of smaller scale.

It is possible that, over the Stroud Local Plan period, strategic changes to the network and its management may open up new connection opportunities. In particular, District Network Operators (DNOs) are making the transition to become District Service Operators (DSOs), and as DSOs will have a greater range of tools that they will be able to use to manage the network. They may, for example, be able to facilitate an enhanced role for energy storage in balancing out the effects of increasing grid penetration of intermittent renewable generators. Further details on network capacity within the district are given in Section 7.1.

6.1.5.3 Development income

Financial support mechanisms in the form of Government subsidies previously allowed onshore wind to be developed at a variety of scales and at a variety of wind speeds. In the absence of such support, commercial developers in particular are focusing on large-scale development opportunities in areas with high wind speed, and even these may have quite tight profit margins. The resource assessment has not indicated that there are any opportunities of this kind in Stroud District, which is unsurprising considering its location and geographical characteristics. The bulk of opportunities are

instead at the medium and smaller scales, which would in the past have been supported by the Government's Feed in Tariff (FiT) regime.

Various initiatives can in theory improve wind development viability beyond the provision of subsidy. These could include, for example, establishment of local supply companies that can 'capture' the uplift from wholesale to retail energy prices. Capital costs such as turbine prices may also fall[40], potentially driven in part by the loss of subsidy itself – although the migration of demand to larger turbines in a post-subsidy context is likely to limit any effect in this regard on smaller turbine sizes. Overall, however, viability challenges, based on reduced income relative to capital costs, are a systemic challenge for wind development at all scales at the present time – to the extent that, if this challenge is not addressed at a greater than local level, the deployable wind potential within Stroud is likely to be and remain close to zero.

6.1.5.4 Community backing

The National Planning Policy Framework (NPPF), drawing on text originally contained within a Written Ministerial Statement (WMS), asserts that wind development should not be permitted unless "*following consultation, it can be demonstrated that the planning impacts identified by the affected local community have been fully addressed and the proposal has their backing*". The legitimate interpretation of this provision has not been definitively established via case law. Even to the extent that it indicates a test that has not been fully defined, however, it is a discouraging influence on developers.

[40] www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf

6.2 Solar PV (ground-mounted)

6.2.1 Overview

In addition to PV modules associated with built development, there are a large number of ground-mounted solar PV arrays or solar farms within in the UK. These consist of groups of panels (generally arranged in linear rows) mounted on a frame. Due to ground clearance and spacing between rows (and between rows and field boundary features) solar arrays do not cover a whole field and allow vegetation to continue to grow between and even underneath panels.

Ground-mounted solar project sizes vary greatly across the UK although, as with wind, developers in a post-subsidy environment are increasingly focusing on large-scale development, with the largest currently proposed scheme in England (Cleve Hill in Kent) being over 350 MW[41]. There is no one established standard for land take per MW of installed capacity, although land requirements for solar are comparatively high compared with wind – for the present assessment, an approximate requirement of 2 hectares per MW has been applied based on a combination of various existing and past guidance and recent development experience.

As of 2018, the UK had 13,118 MW of installed solar PV capacity, with this providing 12,857 GWh electricity during the year[42] (the lower energy generation relative to wind despite the similar installed capacity is due to the lower capacity factors of solar PV generation). These figures include all forms of solar PV – although according to the most recent available data, ground-mounted schemes account for 58% of overall capacity.[43] Falling capital costs are rendering solar PV increasingly viable in a post-subsidy context, although at present developers are generally focusing on large developments in order to achieve economies of scale. Grid connection costs are also critical to project viability.

LUC/CSE's review of the data available from the department for Business, Energy and Industrial Strategy (BEIS), supplemented by input from Stroud District Council, has identified the following ground-mounted solar PV projects currently consented or installed in Stroud District:

- Upper Huntingford Farm: 7.7 MW
- Hillhouse Farm: 28.5 MW
- Upper Wick Solar Farm: 5MW
- Land At Actrees Farm: 5MW
- Land at Box Road: 2.2 MW
- Land east of High Green: 20 MW

The overall installed capacity of these developments is 68.4 MW.

[41] www.clevehillsolar.com/

[42] www.gov.uk/government/statistics/energy-trends-section-6-renewables

[43] www.gov.uk/government/statistics/solar-photovoltaics-deployment

6.2.2 Resource assessment

A GIS assessment of technically suitable land for solar development was undertaken using a similar approach to that undertaken for wind development. As solar development is more 'modular' than wind (developments size is dictated by the number of panels, which themselves do not differ greatly in size) and constraints are not affected by project scale in the way that they are for wind. Therefore, the identification of available land for solar was not broken down into discrete project sizes. The GIS tool parameters are set out in Table 25 (Appendix 1).

6.2.3 Landscape Sensitivity Assessment

Although it has not generally been as contentious a matter compared to wind development, the landscape and visual impact of solar PV schemes is still often a key consenting issue, particularly at larger development scales. The landscape sensitivity assessment therefore also included consideration of solar PV, and as sensitivity varies in accordance with development scale, different development scales were considered based on land take:

- Small solar PV installation: (<5 hectares)
- Medium solar PV installation: (5-20 hectares)
- Large solar PV installation: (20-50 hectares)
- Very large solar PV installation (50-100 hectares)

Based on the application of the indicative 2ha/MW development density, the sensitivity assessment therefore encompasses development capacities up to a (generous) 50MW. This is considered a reasonable maximum for the present purposes bearing in mind the geographical characteristics of the District and the fact that any development in excess of 50MW would be considered under the national consenting framework.

The methodology applied to sensitivity appraisal for solar development was consistent with that applied to wind development and has been described above in Section 6.1.3 of this report.

6.2.4 Results

Figure 7 and Table 7 below provides a summary estimate of the technical potential for ground-mounted solar PV within Stroud District. As the full technical potential is very large, 1%, 3% and 5% of the resource is also quantified. Adopting the 3% development scale would result in a total potential technical capacity from ground mounted solar PV across the District of 1,612MW – this approximately equates to an area of 6.6 km^2 (assuming a capacity of 2.4 MW per hectare).

The 2ha/MW indicative development density applied in the estimates has already been described above. The capacity factor applied was 11%, derived from the same regional data source as was used in relation to wind.

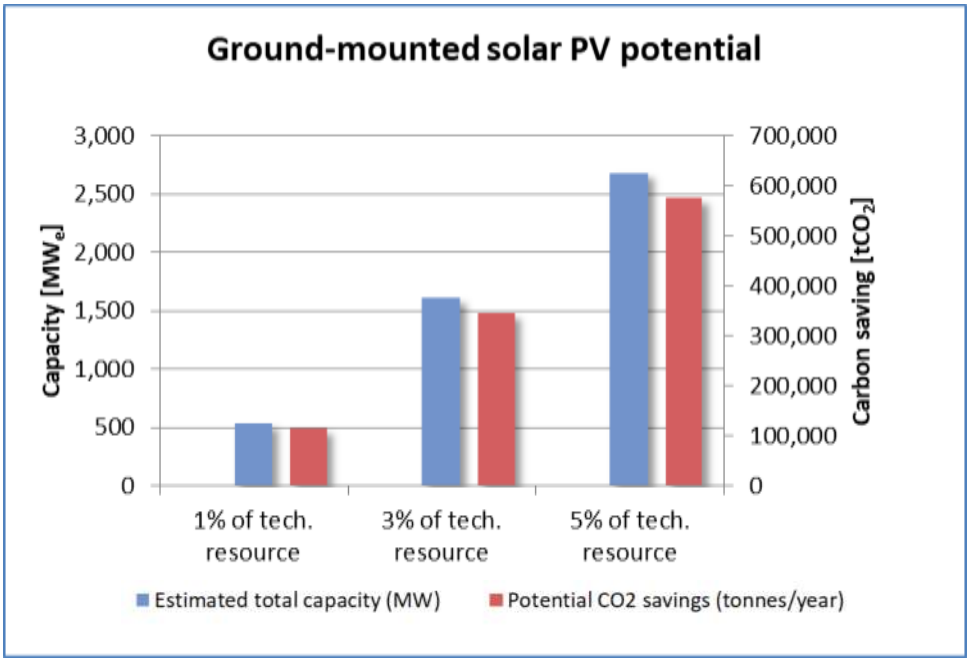


Figure 7: Ground-mounted solar PV potential

Table 7 – Potential Solar Capacity and Output			
Development Scale	**Potential Installed Capacity (MW)**	**Electricity output (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
100% of technical potential	11,193	10,295,000	2,398,735
1% of technical potential	537	494,180	115,144
3% technical potential	1,612	1,482,539	345,432
5% of technical potential	2,686	2,470,899	575,719

The key constraints and resulting potentially suitable land for solar development are presented in Appendices 1 and 3 respectively.

As with the wind resource assessment, the solar assessment has certain limitations. In particular, cumulative impact is again a key consideration that the tool cannot take into account but which would affect consideration of planning applications in practice. Due to the less constrained nature of solar relative to wind in terms of the factors that can reasonably be considered within a high-level resource assessment, a very large area of land has been identified as technically suitable for ground mounted solar; but in practice development of all or even the majority of this land would clearly not be appropriate.

6.2.5 Future deployment

Considerations other than cumulative impact would reduce the deployable potential of solar PV in practice.

As with wind, a key consideration in relation to solar PV development viability is the interaction between development income and grid connection costs. As has been noted above, at the present

time viable solar developments are generally larger scale, with it being expected that promoted schemes in the near future in Stroud would generally be in excess of around 30MW capacity. It is understood, however, that even larger scale solar developments will only generally be viable at present where a grid connection is available in relatively close proximity to the development site, and does not involve significant network reinforcement costs. Although connections can in principle be made either into existing substations or into power lines (a 'tee in' connection), proximity requirements alone would limit the deployable solar PV potential in Stroud at the present time as indicated in the electricity network map shown in Figure 13.

The generally constrained nature of the electricity network in Stroud presents a further challenge, with no substations having been identified at the present time with over 30MW available capacity. As with wind, the lack of financial support for solar PV will particularly constrain the deployable potential of smaller schemes and schemes at greater distances from potential grid connection points. The present assessment cannot, however, rule out the potential for such schemes bearing in mind that over the Stroud Local Plan period the financial context could change (including via changes to Government policy).

6.3 Solar PV/thermal (roof-mounted)

6.3.1 Overview

Both solar PV and solar water heating are well-established technologies in the UK, with uptake being significantly boosted through the Feed-in Tariff and Renewable Heat Incentive schemes. Stroud District for example saw 20MW of solar PV capacity installed between April 2010 (launch of the Feed-in Tariff) and March 2019 (when it closed), with half of this deployed on dwellings. As of August 2019 there was 13.3GW of solar PV capacity installed in the UK across 1m installations.

The breadth of uses for solar PV technology is vast and spans many diverse applications such as space vehicles, solar phone chargers, roof or ground-mounted power stations and solar street lamps. Other applications being developed in the UK include 'floatovoltaics' (floating PV arrays), for example, a 6MW floating solar PV array has now been developed on one of Thames Water's reservoirs[44]. There is also a new design for a solar PV integrated motorway noise barrier that is being considered for use by Highways England[45], and a trial of track-side solar panels being used to power trains by Imperial College[46]. Solar car park canopies also offer potential, as demonstrated by the 88.5kW system installed at the Ken Martin Leisure Centre by Nottingham City Council.

Rooftop deployment is generally limited to roofs with minimal shading and which face south-west through to south-east with a pitch of 20-60 degrees. Systems can be roof-integrated i.e. designed to form an integral part of the roof itself and therefore can offset some of the cost of conventional roofing materials using a range of PV materials including semi-transparent panels, tiles and shingles. Flats and non-domestic properties often have flat roofs and so orientation is not critical, although systems will then need tilted frames to house the solar array, with each frame suitably spaced in rows to avoid self-shading. For pitched roofs, solar PV generally needs around 7.5m^2 of roofspace per kW for high efficiency panels (e.g. monocyrstalline silicon) and grid-connected systems are able

[44] www.bbc.co.uk/news/science-environment-35868250
[45] Highways Agency Carbon Routemap (2014)
[46] www.solarpowerportal.co.uk/news/imperial_college_trialling_track_side_solar_panels_to_power_trains

to export power if there is insufficient load in the property at any one time. The rooftop size of solar water heating systems however is limited by the hot water demand of the property they are serving, with domestic systems typically requiring 1.5m^2 of flat panel per resident. Properties also need to have sufficient space to accommodate a hot water storage tank.

Standard installations of solar panels are considered to be 'permitted development' and therefore do not normally require planning consent. However, installations on listed buildings or on buildings in designated areas are restricted in certain situations and may require planning consent.

6.3.2 Resource assessment

The theoretical potential for solar technologies considers the number of roofs that could support them. For the purposes of this study a high level assessment has been undertaken which considered types and numbers of buildings across Stroud District and various assumptions on suitability.

The combined capacities of the systems were then calculated to get total installed capacity. Potential installed capacities, energy yields and savings for solar PV and solar water heating across Stroud District are presented below according to the assumptions set out in Appendix 1. For the purpose of the resource assessment both technologies are considered mutually exclusive i.e. no space restrictions are assumed as a result of locating both technologies on the same roof.

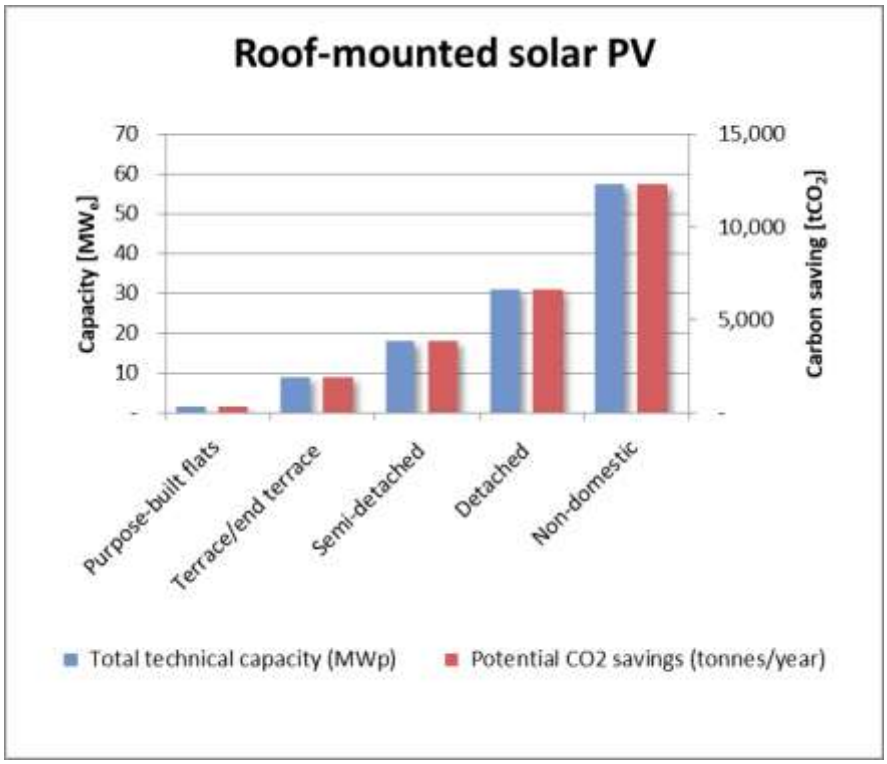


Figure 8: Solar roof-mounted PV potential

Table 8 – Assessment of rooftop solar PV			
Building category	**Estimated capacity (MW)**	**Electricity output (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
Domestic - flats	1.4	1,243	290
Domestic – terraced/end-terrace	8.9	8,191	1,909
Domestic – semi-detached	18.0	16,507	3,846
Domestic – detached	31.0	28,505	6,642
Non-domestic	57.3	52,683	12,275
Total	**116.5**	**107,129**	**24,961**

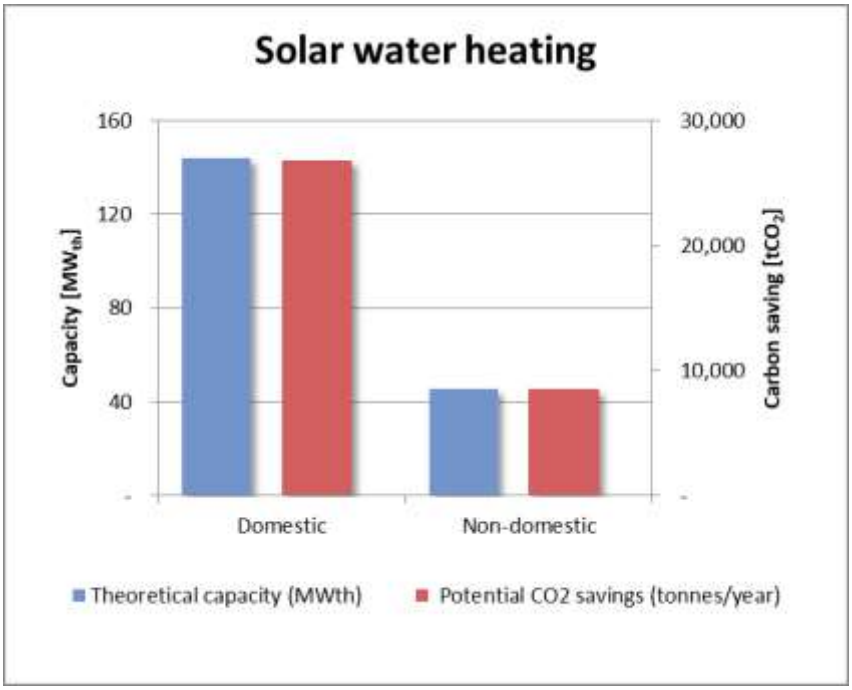


Figure 9: Solar water heating potential

Table 9 – Assessment of rooftop Solar Water Heating			
Building category	**Estimated capacity (MW)**	**Delivered heat (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
Domestic (excl. flats)	143.5	125,704	26,748
Non-domestic	45.3	39,707	8,449
Total	**188.8**	**165,411**	**35,197**

6.3.3 Future deployment

Solar PV is proving particularly attractive to developers as a relatively easy-to-install renewable energy technology which helps to meet tightening building emissions standards through offsetting high carbon mains electricity. However as seen in Section 4.1 the gradual decarbonisation of mains electricity means that the 'value' of carbon offset with solar PV will also continue to drop, although financial benefits will remain for those receiving free electricity from onsite PV systems. Additionally, the cost of solar PV has fallen dramatically over the last decade and this trend is likely to continue with UK grid parity (generation of power at or below the cost of mains power) expected in 1-3 years without the need of subsidies. Furthermore, technological advances in energy storage systems and smart power management controls, along with increasing demand from heat pumps and electric vehicles and the introduction of time-of-use tariffs to optimise benefits are also likely to act as on-going incentives for solar PV in the wake of the Feed-in Tariff.

Solar PV will therefore continue to play a vital role in the large majority of new developments and will make a significant contribution to total installed capacity. For example, deployment in 90% of Stroud District's new housing requirements up to 2040, may add around 10 MW of capacity[47]. Future uptake on existing buildings however is difficult to predict and will be more limited until non-subsidy financial viability improves.

As indicated in Section 5, solar water heating is much less common, with preference generally given to solar PV during the more lucrative Feed-in Tariff period, although installations on buildings located in off-gas areas can be financially advantageous due to the increased benefits of displacing higher cost heating fuels relative to mains gas, such as electricity and oil. Installations on non-domestic buildings are more limited as viability depends on hot water demand and competition with point-of-use hot water heating. Relative to heat pumps, the technology is likely to play a much lesser role in the decarbonisation of heat, particularly if grid electricity continues to decarbonise as predicted.

6.4 Heat pumps

6.4.1 Overview

Ground and air source heat pumps operate by using electricity to drive a standard refrigeration process to heat or cool buildings. Overall efficiency is sufficiently high in well-designed systems to make the technology a viable low carbon alternative to conventional heating or cooling systems. Space requirements for heat pumps vary according to type; ground source heat pumps require space for bore holes or a larger area for trenching refrigerant pipes, whereas air source heat pumps are physically similar to standard air conditioning units. This can mean that ground source systems are more constrained for use in retrofit projects in built up areas where space is limited. Ground conditions and the presence of groundwater can also impact feasibility and cost in a given location. Boreholes are typically installed to a depth of 70-150m but are not to be confused with those used for deep geothermal energy which often reach a depth of several kilometres. Currently, geothermal energy is only thought to be exploitable in a limited number of locations around the UK, but not in the Stroud area.

[47] Assumes 1.5kW systems supplying 7,563 dwellings

Heat pumps work best when coupled with low temperature heat distribution systems and therefore require properties to be well insulated in order for them to operate efficiently. They are often well-suited to new developments with high thermal insulation standards, but upgrades may need to be carried out with retrofit projects before heat pumps are considered a viable option.

Both ground and air source heat pumps are considered to be permitted development and therefore most installations can take place without the need for a planning application. Air source heat pumps however are subject to additional restrictions due to issues of visibility and potential noise disturbance.

Less is known about the potential for water source heat pumps. In the right locations, they have been shown to have the potential to provide efficient low carbon heating or cooling at scale as long as the buildings to be served are in close vicinity; as demonstrated by the Kingston Heights installation by the River Thames[48], which incorporates a 2.3 MW water source heat pump for space and water heating of a mixed development. Future decarbonisation of the electricity grid will increasingly benefit heat pump technologies as their overall emissions reduce.

6.4.2 Resource assessment

Theoretically, almost any building could have an air source heat pump and so the technical resource is very large. For simplicity, only air source heat pumps are considered in the capacity assessment due to the space constraints of ground source heat pumps. Ground source systems however are more efficient due to their heat being sourced from the ground which has more stable year-round temperatures. Air source heat pumps take their heat from ambient air which is subject to large temperature fluctuations; unfortunately heat demand is highest when the heat source temperature is at its lowest (winter), which means a significant drop in efficiency during this period.

The standard measure of operational efficiency for heat pumps is the Seasonal Performance Factor (SPF) which indicates year-round efficiency (as opposed to Coefficient of Performance, which usually indicates efficiency during optimum conditions only). Typical SPFs for air source and ground source heat pumps in the UK are 3.3 and 3.8 respectively.[49]

Due to the uncertainties in predicting the size of the technical resource, which is largely dependent on multiple factors relating to building suitability, an illustrative example has been modelled which assumes that 50% of properties achieve energy efficiency levels suitable for air source heat pumps.[50]. In practice however, most properties would also need to switch to low temperature heat distribution systems in order to function efficiently with heat pumps, which would involve wet systems with underfloor heating or extra-large radiators.

The potential installed capacity, heat output and CO_2 savings for air source heat pumps across Stroud District are presented below according to the assumptions set out in Appendix 1.

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[48] www.designingbuildings.co.uk/wiki/CIBSE_Case_Study_Kingston_Heights

[49] As published in domestic RHI deployment data for August 2019, which includes average SPFs for all heat pumps installed under the RHI: www.gov.uk/government/statistics/rhi-monthly-deployment-data-august-2019

[50] To put this in context, approximately 30% of UK housing currently achieves EPC Band C or above, which might generally be considered as the minimum fabric energy efficiency level for heat pumps to operate effectively.

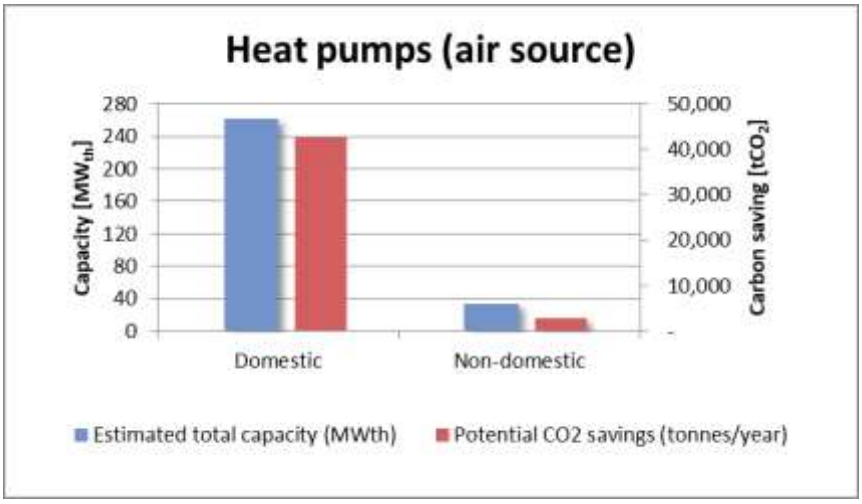

Figure 10: Heat pumps (air source) potential

Table 10 – Assessment of heat pumps (air source)			
Building category	**Estimated capacity (MW)**	**Delivered heat (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
Domestic	262.7	263,407	42,587
Non-domestic	34.4	16,497	2,876
Total	**297.2**	**279,904**	**45,463**

6.4.3 Future deployment

Heat pumps are expected to become significantly more widespread as their emissions performance increases as a result of the gradual decarbonisation of UK grid electricity, and there is a consequential shift towards the electrification of heat. They are particularly suited to new development for several reasons: they work much more efficiently with higher fabric thermal standards; low temperature heating distribution systems can be specified at the design stage; and their ability to provide 'passive' cooling can help mitigate overheating risks. Ground source heat pumps also have the added advantage of having no visible external equipment, and adequate space can usually be factored in to the footprint of larger new developments to incorporate shared ground loop arrays to serve multiple properties.

The extent to which they are retrofitted to existing development will be dependent on several factors including capital cost reductions through mass production, the rate of electricity grid decarbonisation and energy efficiency retrofits to buildings. Regarding the latter point, it is noted that the Government's Clean Growth Strategy sets out an aspiration *"for as many homes as possible to be EPC Band C by 2035 where practical, cost-effective and affordable"*, and that currently only around 30% of UK homes meet this target. Uptake in off-gas areas may be proportionally higher when competing against expensive fuels such as electricity (for direct heating) or LPG.

Although the potential for water source heat pumps has not been specifically assessed as part of the current study, the 2014 DECC water source heat map[51] identified the River Severn and the Gloucester and Sharpness Canal as having particular potential – 20MW is mentioned for the latter. Viability would largely depend on having a sufficiently high heat demand local to the heat pump location. In this respect, Sharpness docks and the proposed mixed-use development to the southeast may justify more detailed survey work to establish viability and the impact of scale for this technology.

Heat pumps can also be used to exploit sources of secondary or waste heat, such as from data centres or industrial processes. Islington Borough Council for example has developed a district heating network that uses heat supplied from the London Underground via a heat pump[52]. Other than the potential heat supply from the Javelin energy from waste plant (see Section 6.5.1.1), no further significant heat sources had been identified within Stroud District at the time of writing.

6.5 Biomass fuel

Biomass can be generally defined as material of recent biological origin, derived from plant or animal matter. It is often categorised as either 'dry' or 'wet' biomass, with the former more commonly combusted either to generate heat or to produce electricity, and the latter anaerobically digested to generate 'biogas' or used to produce a transport 'biofuel'.

Biomass is widely used in many countries as a feedstock for modern heating systems. Modern biomass heating technology is well developed and can be used to provide heat to buildings of all sizes, either through individual boilers or via district heating networks. Biomass is also increasingly being used to fuel electricity plant or combined heat and power (CHP) plant due to the low carbon emissions associated with its use.

The most common types of biomass include woodfuel from forestry sources, energy crops or wood waste, agricultural residues and the biodegradable fraction of municipal solid waste.

6.5.1 Energy from Waste

6.5.1.1 Municipal and commercial solid waste

Waste management in Stroud District comes under the framework of the Gloucestershire Joint Municipal Waste Management Strategy, developed in 2006 in partnership with the six district councils. Set against an overall objective of zero waste to landfill, Gloucestershire is achieving a recycling rate of around 52% for waste (2016/2017 figures), and has a target of 60% recycling by 2020 and 70% recycling and composting by 2030.[53]

All post-recycling residual household waste generated in Gloucestershire and collected by the District Councils or taken to Household Waste Recycling Centres will be treated by the new Javelin Park Energy-from-Waste facility, located near Haresfield in Stroud District. The facility has a capacity of 190,000 tonnes of waste per year including commercial waste and is expected to generate around

[51] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416660/water_source_heat_map.PDF
[52] www.islington.gov.uk/business/energy-services/decentralised-energy
[53] www.recycleforgloucestershire.com/recover/dealing-with-gloucestershires-waste/

14.5MW of electricity through a Combined Heat and Power (CHP) plant. It will also be capable of supplying heat or steam to be used by neighbouring heat users although this has yet to be implemented. Around 50% of the energy recovered may be called 'renewable' due to the organic composition of the waste feedstock.

However, it should be noted that the facility will remain a significant source carbon emissions. These are associated principally with the plastic content of the waste streams. Reaching net zero carbon emissions from the District's waste by 2030 will therefore require the removal of the plastic from the residual waste stream or a cessation of incineration altogether.

The energy yields and potential emission savings from the plant when fully operational are presented below according to the assumptions shown in Appendix 1. There is however some uncertainty over how much heat the facility will be able to deliver, and the size and location of the surrounding demand which is likely to depend on future development. This is considered further in Section 8.

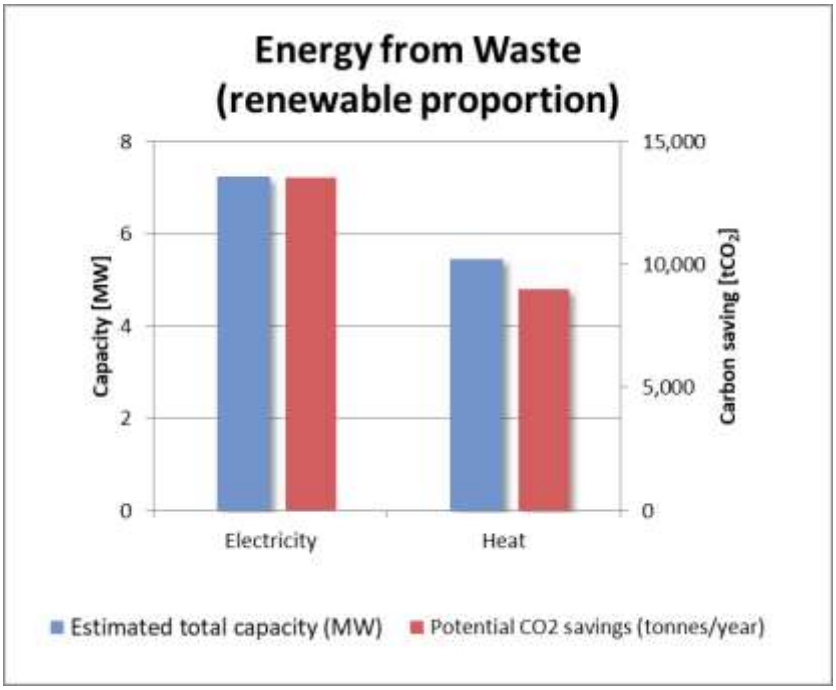

Figure 11: Energy from Waste potential (Javelin Park facility)

Table 11 – Assessment of municipal and commercial waste arisings (treated at Javelin Park EfW facility)

	Feedstock capacity (tonnes/yr)	Capacity (MW)	Delivered energy (MWh/yr)	Renewable proportion of capacity (MW)	Renewable portion of delivered energy (MWh/yr)	Potential CO_2 savings (tonnes/yr)
Electricity	190,000	14.5	116,223	7.3	58,112	13,540
Heat		10.9	87,601	5.5	43,800	9,001
	Totals		**203,824**	**12.8**	**101,912**	**22,541**

6.5.1.2 Recycled wood waste

The waste wood resource is difficult to quantify and would require a detailed survey to assess material collected at Community Recycling Centres and that present within commercial, industrial and construction waste streams. This will typically consist of clean, untreated material mixed with that contaminated with paint, preservative, fixings and other foreign materials. While clean waste wood can potentially be sourced directly from saw mills, carpenters, joineries etc, a large proportion of this resource will be mixed with contaminated material in mainstream commercial and municipal solid waste streams and so it is likely that a significant amount is currently being treated as residual waste and may therefore end up at the Javelin Park waste facility.

Due to toxic emissions and air quality concerns contaminated waste wood is generally not suitable to be used in small or medium scale thermal energy installations due to the lack of suitable exhaust gas clean-up equipment; these clean-up systems are costly and tend to be viable on large scale plant only.

Note – the wood resource from woodland and arboricultural arisings are considered in Section 6.5.2.

6.5.1.3 Food waste

Much of Stroud District's food waste, including household kerbside collections of food waste, is sent to an anaerobic digestion plant in Bishops Cleave, near Cheltenham. This takes delivery of around 34,000 tonnes of food waste annually to produce biogas, some of which is used in a CHP engine with 1.6MW generation capacity to provide all the site's power needs, with the remaining gas processed for injection to the national gas grid. This biogas is classed as a renewable source of energy although it has not been possible to quantify the annual amounts produced.

6.5.1.4 Agricultural residues and sewage

Agricultural waste also represents a potential renewable energy resource, particularly from using livestock slurry as a feedstock for the anaerobic digestion process. Using estimates from Defra statistics on animal numbers for 2016 and resulting slurry and biogas yields, an estimate has been made of the potential emissions savings in Table 12.

Table 12 – Assessment of livestock slurry

Livestock	Numbers in Stroud District[54]	Volume of slurry (tonnes/yr)[55]	Biogas yield (m^3/tonne)	Delivered energy (MWh/yr)	Potential CO_2 savings (tonnes/yr)
Cattle	32,988	131,952	20	14,145	3,446
Pigs	3,085	2,224	20	238	58
Poultry	113,423	4,424	50	1,186	289
			Total	**15,569**	**3,793**

[54] www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june
[55] www.organics-recycling.org.uk/uploads/category1060/10-010%20FINAL_Andersons_NNFCC_AD2010.pdf (table 16)

Biogas generation from anaerobic digestion of sewage is also classed as renewable form of energy with most large sites generating heat and/or electricity for the site's own needs. Stanley Downton Sewage Treatment Works currently treats much of the sewage within the Stroud/Stonehouse area but renewable energy generation capacity at the site is not currently known. Heat recovery systems can also be used with sewage or waste water infrastructure to provide heat to local users, although this application is not yet widespread.

6.5.2 Virgin woodfuel

The woodfuel resource considered here includes virgin, untreated wood residues (from forestry, arboriculture, tree surgery etc.) and the energy crops Miscanthus and Short Rotation Coppice (SRC). There is some overlap with waste where virgin wood is present in certain waste streams, but this can be difficult to segregate from non-virgin (contaminated) wood. The distinction between virgin or contaminated wood will determine the areas of legislation that will apply to its use regarding emissions permits. Woodland residues and energy crops are generally considered to be clean or 'untreated' whereas other waste wood residues may contain contaminants such as paint, preservative, etc. and would fall under stricter emission and pollution prevention controls.

Wood is considered to be a sustainable fuel if it can be shown to have been sustainably sourced, which usually means it is renewable through re-growth as part of sustainable woodland management and does not carry excessive 'embodied' carbon from processing and transport. Logs and woodchip in particular are bulky fuels and should be sourced as locally as possible to their end-use. Wood from a sustainable source is therefore classed as a low carbon energy source as the carbon emissions released when combusted are balanced by that absorbed during its re-growth. Its use as part of a zero carbon future however would require that the amount of woodfuel being burnt is replaced by re-growth or re-planting (accounting for timescales), and that carbon emissions used in growing, processing and transport processes have also been mitigated.

Various processes are used to prepare the wood feedstock prior to it becoming suitable for use as fuel in a range of forms including logs, woodchips, pellets and briquettes. These processes largely dictate the final specification of the biomass in terms of moisture content, size and form. Quality control of these parameters is vital for use in specific types of boiler and thermal conversion processes. Both woodland residues and energy crops can be used to produce either heat-only or electricity and heat (combined heat and power) via a range of energy conversion technologies including direct combustion, gasification and pyrolysis.

6.5.2.1 Forestry and woodland resource

Woodland and arboricultural residues are normally sourced as the residues of the sustainable management of existing woodland. The technically available resource can be assessed by calculating the total area of woodland in the study area and assuming a sustainable yield, which in this case is two odt/yr (oven-dried tonnes/year) – a generally accepted figure across the industry. Annual tonnage of wood can then be obtained and its heat delivery potential estimated.

The Forestry Commission's National Forest Inventory (NFI) dataset has been used for this analysis. The NFI is produced by using satellite images to identify and classify areas of woodland, alongside ground surveys of sample areas[56]. It classifies areas of woodland into the following categories:

- Broadleaved
- Coniferous
- Coppice
- Coppice with standards
- Mixed
- Shrub
- Young trees
- Felled
- Ground prepared for planting

Felled areas, shrub and young trees are excluded from the analysis because they cannot provide a sustainable source of woodfuel. They have been mentioned here because they are in the NFI, and because felled areas may be replanted in the future, while young trees will mature over time into a viable resource. Figure 12 show areas of woodland as mapped for the study area.

[56] This means that there are occasional errors where patches in photographs have been erroneously identified.

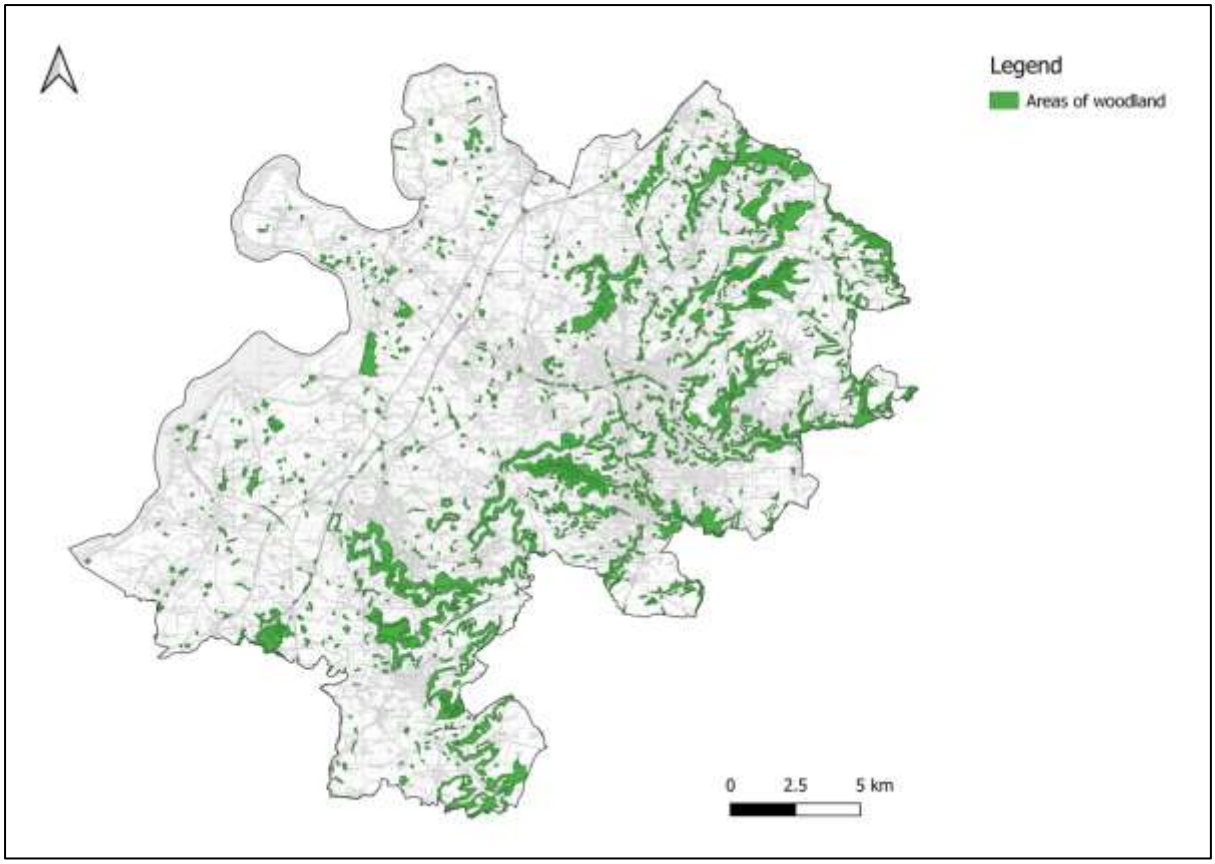

Figure 12: Areas of woodland within Stroud District

Using the GIS data behind the above map, the technically available resource by woodland category is shown in the table below. This estimates the annual tonnage of wood and its delivered heat potential – this has been assessed by using assumptions about the sustainable yield that can be obtained, heating plant efficiency and the energy content of wood. All assumptions are included in Appendix 1.

Table 13 – Woodfuel: assessment of forestry and woodland resource				
Woodland category	**Area (Hectares)**	**Sustainable woodfuel yield (odt/yr)**	**Delivered heat (MWh/year)**	**Potential CO_2 savings (tonnes/yr)**
Broadleaved	5,457	10,915	48,903	10,307
Coniferous	508	1,017	4,555	960
Felled	14	28	124	26
Mixed	256	511	2,290	483
Shrub	4	7	32	7
Young trees	99	197	884	186
Woodland (not specified)	1,210	2,420	10,843	94
Total	**7,547**	**15,094**	**67,631**	**12,062**
Total excl. felled, shrub and young trees	**7,431**	**14,862**	**66,591**	**11,843**

The above figures relate to the resource within Stroud District only, but there is potential for woodfuel to also be sourced from further afield if the cost and environmental impact of transporting the feedstock or final product is suitably assessed. The resource shown in Table 13 would nearly triple if a 40km search radius was applied from the boundary of the district. It is likely however that a significant proportion of this resource is already being utilised for the woodfuel requirements of domestic log stoves and open fires.

A further potential source of woodfuel is from the cutting of hedgerows – however it has not been possible to assess this resource because there is no reliable yield factor for the amount of woodfuel that can be obtained from a given area or length of hedgerow.

6.5.2.2 Energy crops resource

The two main woodfuel energy crops are Miscanthus and Short Rotation Coppice (SRC), which are planted specifically for heat and/or electricity production. This is usually distinct from 'biofuel' crops such as sugar cane, maize and oilseed rape which tend to be used for transport fuels.

Miscanthus cultivation has the advantages of being able to use existing machinery, is higher yielding than SRC, undergoes annual harvesting with a relatively dry fuel product when cut, but it is more expensive to establish. SRC (commonly willow) is easier and cheaper to establish, is better for biodiversity and suitable for a wider range of boilers. However, it requires specialist machinery, is harvested every three years, and produces a wetter fuel that needs to dry before it can be used. Both crops have similar lead in times with around 4 years until they produce commercial harvests. Miscanthus will reach its peak yield in year 5 and SRC will achieve its peak yield in the second rotation which is harvested in year 7.

The technical resource for energy crops assumes that they can be grown on agricultural land of grades 2 or 3 (arable land), which for Stroud District totals 32,406 hectares (around 70% of total land area). Typical constraints will preclude areas having certain types of permanent pasture and moorland, public rights of way, woodland, historic parks and gardens, and for Miscanthus, exposed areas with high average wind speeds.

Annual yields are typically around 16-18 odt/ha for miscanthus and 8-10 odt/ha for SRC. Potential energy outputs and emissions savings are shown in Table 14 below. This shows two scenarios: the resource for all suitable areas and if 10% of this (3,241 hectares) was utilised.

Table 14 – Potential yields and CO_2 savings for energy crops

Example area cultivated (Hectares)		Sustainable woodfuel yield (odt/yr)	Delivered heat (MWh/year)	Potential CO_2 savings (tonnes/yr)
Miscanthus	32,406	550,896	2,468,288	520,207
	3,241	55,090	246,829	52,021
SRC	32,406	291,651	1,306,741	275,403
	3,241	29,165	130,674	27,540

6.5.3 Future deployment of biomass

As discussed in Section 6.5.1.1, much of Stroud District's renewable biomass waste arisings in the form of municipal solid waste and domestic/commercial food waste is currently (or will soon be) treated at the Javelin Park and Bishops Cleeve waste treatment facilities, where a proportion of the energy produced can be classed as renewable. Quantities are not expected to increase significantly in the future as waste generation continues to decrease and recycling rates increase.

Assuming there is sufficient demand, the sourcing of clean recycled wood as woodfuel will depend on suitable management of waste streams and separation processes whereas the constraints on producing woodfuel from woodlands will depend on how much woodland can be brought under active management and the incentives available for landowners to extract and process woodfuel. The virgin woodfuel market is currently dominated by demand from domestic log-burners or stoves with woodchip and pellet boilers still only playing a minor role. Economic viability for the latter is better in off-gas areas due to the higher cost of predominant fuels such as oil, LPG and electricity (for direct heating), and the on-going Renewable Heat Incentive scheme. Woodfuel heating systems however will increasingly need to compete with heat pumps as the electricity grid decarbonises and will also have to contend with additional constraints such as space for fuel storage, solid fuel flue regulations and maintenance requirements.

Deployment of energy crops will be influenced by economic viability, end-use/market, land ownership, existing farming activities, potential biodiversity impacts, protected landscapes and the presence of water-stressed areas. In particular, conflicts over land use for food production and energy crops (including transport biofuels) will need to be considered in relation to the scale of energy crop production envisaged.

The production of energy crops will also be dependent on landowners and farmers being offered sufficient incentive to grow and harvest the crops, with longer-term supply contracts often needing to be arranged well in advance with end-users. As with woodland residues, the logistics of fuel processing and establishing supply chains may initially act as a barrier to the widespread take-up of this resource. Other issues that may limit exploitation include the planning and permitting of generating plant and the question of alternative markets for Miscanthus and SRC.

Particulate emissions from woodfuel combustion can be an issue in cities such as London or Bristol which have Smoke Control Areas or Air Quality Management Areas in force, particular when considering cumulative impacts in localised areas. Stroud District however does not currently have any such restrictions in place.

6.6 Hydropower

6.6.1 Overview

Hydropower is a well-established and proven technology and there are few technological constraints to its use other than ensuring that water course heads (height difference) and flow rates are adequate throughout the year, the site has adequate access and can accommodate the necessary equipment, and that the electricity generated can be transmitted to its end use. For the same reasons, energy yields can be accurately predicted and economic viability established relatively easily.

Hydropower makes use of water flowing from a higher to a lower level to drive a turbine connected to an electrical generator, with the energy generated proportional to the volume of water and vertical drop or head. Although it is an established form of renewable energy, environmental constraints on large multi-MW scale plant means that most potential exists for mainly small or micro-scale schemes. Small scale hydropower plants in the UK generally refer to sites ranging up to a few hundred kilowatts where electricity is fed directly to the National Grid. Plants at the micro-scale (typically below 100kW) may include schemes providing power to a single home.

'Low head run of river' schemes are typically sites in lowland areas, often installed on historic mill sites using the existing channel system and weir or dam. 'High head run of river' schemes are typically found on steeper ground in upland areas and the diverted water is typically carried to the turbine via an enclosed penstock (pipeline).

Small-scale hydro schemes will typically include dams, weirs, leats, turbine houses and power lines, which will have a visual impact on the locality, but which can usually be minimised by careful siting and design. Other important considerations include hydrology and the river ecology. Hydro plants may have an impact on upstream water flows and waterfalls, and fish populations can be vulnerable to changes in water flows and from the risk of physical harm from the plant equipment. Measures such as 'fish passes' are often incorporated to mitigate these impacts.

Any potential impacts of hydro installations on the status indicators of a water body as set out in the Water Framework Directive will need due consideration. Requirements will normally include abstraction licences, discharge permits and flood defence consent from Environment Agency. The cumulative impacts of hydro or other water abstraction activities along a river will need to be assessed for their impact on the protected rights of other river users. Additionally, permissions are normally issued with time limits on the abstraction period – unless these are reasonably long the developer may have concerns over the long term viability of the plant if there is a risk of these not being renewed in the future.

6.6.2 Estimated capacity

Stroud District currently has very little installed hydro power capacity, with only 71kW indicated on the Central Feed-in Tariff Register. As it has not been possible within the scope of this study to

undertake new assessment work on Stroud District's hydro resource, the assessment undertaken by Entec in 2011[57] for Gloucestershire is noted for reference. This analysis drew principally on the outputs of the Environment Agency's 'Opportunity and Environmental Sensitivity Mapping for Hydropower in England and Wales' from 2010 and considered the potential generating capacity available at each 'barrier' along a watercourse (e.g. weir, sluice, mill, etc).

The results for Stroud District are shown in Table 15 (corresponding locations are mapped in Figure 4.1 of the Entec report).

Table 15 – Hydro potential in Stroud District

Power potential range [kW]	Power potential in Stroud District [kW]
0-10	166
10-20	234
20-50	421
50-100	129
Total	**950**

6.6.3 Future deployment

The identified resource indicates that the majority is made up of small (<50kW) sites, most of which are unlikely to be of sufficient scale to be economically viable and so future deployment is likely to be significantly constrained. However, a canal water transfer scheme[58] has been proposed to transfer water from a Welsh reservoir to the River Thames via the Cotswold Canals, which could potentially create opportunities for hydro generation through a pumped hydro storage facility.

[57] www.jointcorestrategy.org/gloucestershire-renewable-energy-study
[58] www.cotswoldcanals.org.uk/2018/03/20/water-transfer-latest-update-call-to-action/

7 Energy system transmission and storage

7.1 Grid capacity

The UK distribution network was designed for a 'top down' flow of electricity, from small numbers of very large power stations. The increasing deployment of distributed generation is causing new challenges for the electricity network, with ever-larger areas of the network reaching maximum capacity. In these areas, the grid is no longer able to accept new grid connections for supply of power.

The near term opportunities for new renewable energy deployment presented by the distribution network are therefore limited to areas where there is capacity still available or an existing connection which isn't being fully utilised. Such sites offer the opportunity to host additional generating capacity without the need for a new grid connection. Identifying such sites will require engagement with site operators and/or Western Power Distribution (WPD), the Distribution Network Operator (DNO). Additionally, DNOs regularly upgrade the network to create extra capacity which can be applied for in advance, even when these upgrades take years to come online. It is therefore worth periodically checking with the DNO on capacity at a specific site of interest.

WPD maintain a network capacity map on their website[59] which provides an *"indication of the network's capability to connect large-scale developments to major substations. The colour gradings are intended to guide the user to areas of the network where a connection is more likely to be achieved without significant reinforcement."* An extract of this map is reproduced in Figure 13.

Although at present the capacity of the network to accept new generation appears relatively constrained across the District, the level of constraint depends on the location of the generation and connection point. WPD has confirmed that as of October 2019, the 33kV substations at Ryeford and Dudbridge have some capacity for distributed generation connections (possibly approaching 40MW in total) although the 33kV network at Camp and Cherington needs reinforcement. WPD's network reinforcement plan is normally driven by developers/generators, although there are some strategic projects planned to begin in 2023, subject to Ofgem approval.

[59] www.westernpower.co.uk/our-network/network-capacity-map

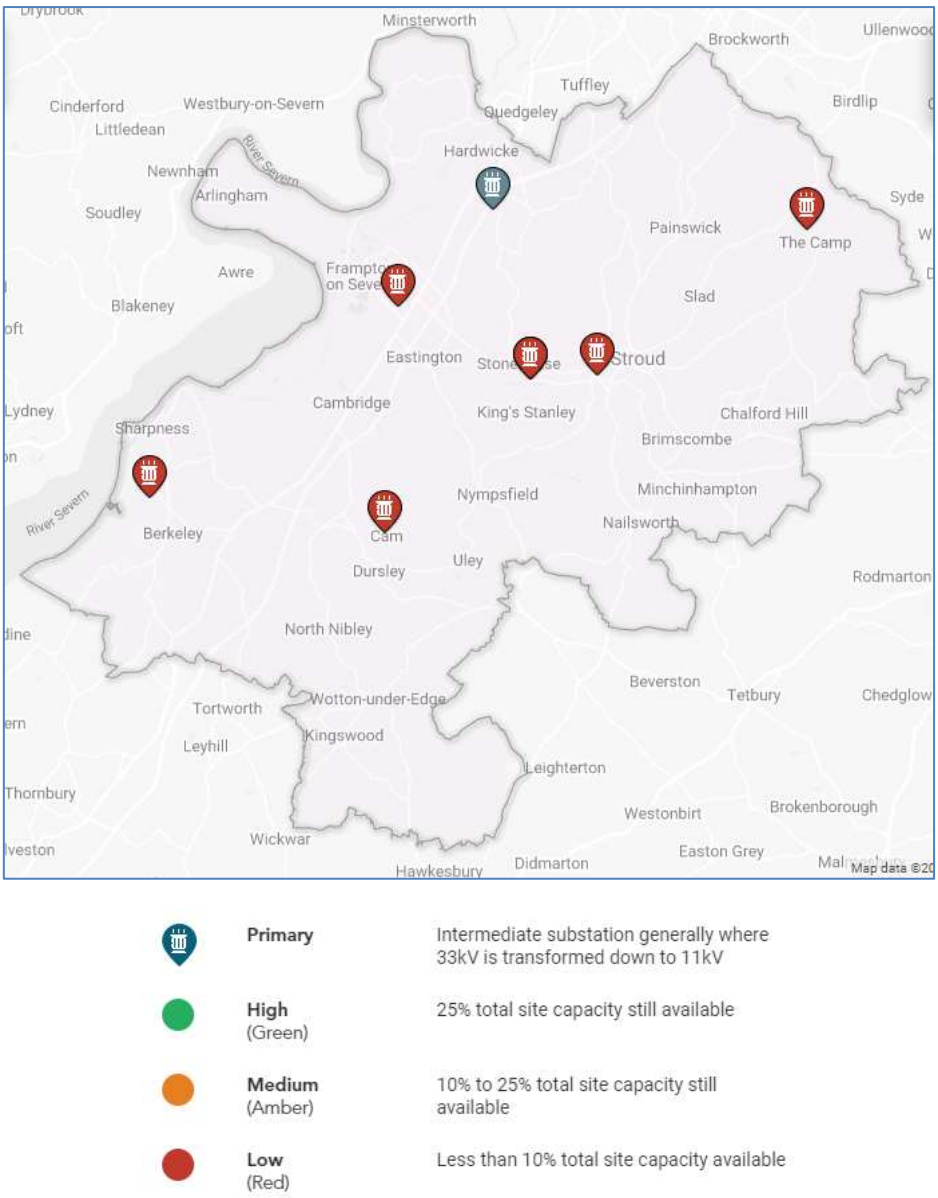

Figure 13: Extract of WPD's network capacity map – Stroud District

7.2 Energy storage and demand side response

Energy storage technology, particularly batteries, has advanced considerably in recent years and is well placed to help alleviate the constraints that currently limit connections to the grid. By co-locating battery storage with renewable energy developments developers can store excess power and sell during high demand. This also helps keep the grid 'in balance', can reduce voltage peaks and fluctuations, overheating and faults on the network and thus help to release capacity on the network for more renewable distributed generation. Detailed modelling is required to assess financial viability of investment in batteries, but initial attractiveness can be tested via engagement with WPD to determine whether the generation site sits in an area which has significant network constraints.

At the domestic level, smart control systems are now available which integrate onsite generation such as solar PV with battery storage, and optimise loads and power exports to the financial benefit of the occupant. Electric vehicles are also expected to integrate with such systems, potentially providing a significant amount of extra plug-in storage capacity.

Similar to storage, albeit 'one-way' only, provision of Demand Side Response (DSR) capacity can help relieve grid constraints by businesses reducing power demand during times of high demand, and switching back on when such peaks are over. Again, this helps keep the grid 'in balance' and release capacity on the network for more renewable distributed generation. Businesses which represent most potential for provision of DSR, such as large commercial or industrial sites, can be identified in areas with known grid constraint and options considered. Typically, such sites should be able to provide a minimum 'downturn' of power of 50 kW to represent commercially viable opportunities.

8 Potential for district heating networks

8.1 Heat mapping and district heating networks

8.1.1 Overview

District heating is a technology which uses one heat source to provide heat to two or more properties. Instead of each property having its own heating system separate from any other property, a group of properties connected to a district or 'community' heating network all receive heat (in the form of hot water or steam) from a central source, via a network of insulated pipes. This can be more efficient than each property having its own heating system, because heat generation is more efficient at larger scales.

The Committee on Climate Change's core Net Zero scenario suggests that around 5 million homes across the UK will need to be connected to heat networks by 2050. In this context, the Government's Clean Growth Strategy suggests that around one in five buildings will have the potential to access a largely low carbon district heat network by 2050.

The heat source of a district heating system is traditionally a basic boiler, although more recently higher efficiency Combined Heat and Power (CHP) systems are used. CHP produces both heat (sometimes with cooling) and electricity, so with a CHP district heating system, as well as a network of pipes distributing heat/cooling, there is also a grid connection or network of wires to distribute electricity to one or more local users. In the latter case, where the output is not grid-connected, this is referred to as a private wire network.

8.1.2 Viability of district heating

A large part of the cost of developing a district heating network is laying pipes, due to the need to excavate roads or other land, which is expensive. An energy centre, which houses the heat source, also needs to be established; this could be located within one of the buildings in the network or it could be in its own separate building. Overall costs vary widely depending on the number and type of buildings connected and the area covered. Installing a heat network in a new development is usually cheaper than installing it in an existing development because pipes can be laid at the same time as other infrastructure when roads are built. In this way, new developments often act as a trigger for a network, but with the potential to also supply existing heat demands from buildings in the vicinity which may improve economic viability.

Properties connected to a district heating network normally pay the heating network operator for units of heat delivered. Therefore the economics of a district heating system are dependent on the amount of heat provided per metre of pipe, known as the linear heat density; the higher the amount of heat delivered per metre of pipe, the better. Linear heat density is a critical factor in heat distribution economics, but this can only be calculated at the stage when a route has been defined.

As a proxy for linear heat density, spatial heat density (along with other factors) is used to find parts of the study area most likely to contain high concentrations of heat demand by means of an 'overlay analysis', which can then be investigated in more detail. Spatial density is the amount of heat per area (for example, per square metre).

8.1.3 Heat mapping

Heat mapping is a process of using available datasets to make accurate estimates of heat demand from buildings within a given area, and presenting these visually on a map. The map can then be used to find areas of high heat demand which may be suitable for district heating. This analysis uses data from the heat demand model of the THERMOS project[60], which has been produced as part of an EC Horizon 2020-funded research project led by CSE. The THERMOS model incorporates a hierarchical approach to estimating demand, with the method used depending on the available input data. This starts with a basic heat demand estimation method using a 2-D representation of a building's polygon (e.g. where only OpenStreetMap data is available) or, as in the case of Stroud District, this can be improved using a more detailed model which uses LIDAR data to estimate the 3-D shapes of buildings.

For this analysis, address-level heat demand data across Stroud District was first estimated using the THERMOS tool and a Geographic Information System (GIS) then used to analyse the spatial distribution of heat demand. All addresses in the study area, along with their associated heat demand, were mapped using their OS Grid coordinates. A heat demand density map was then produced covering the study area – see Figure 14. This is a map layer which gives the estimated heat demand per unit of land area, based on the address-level heat demand data.

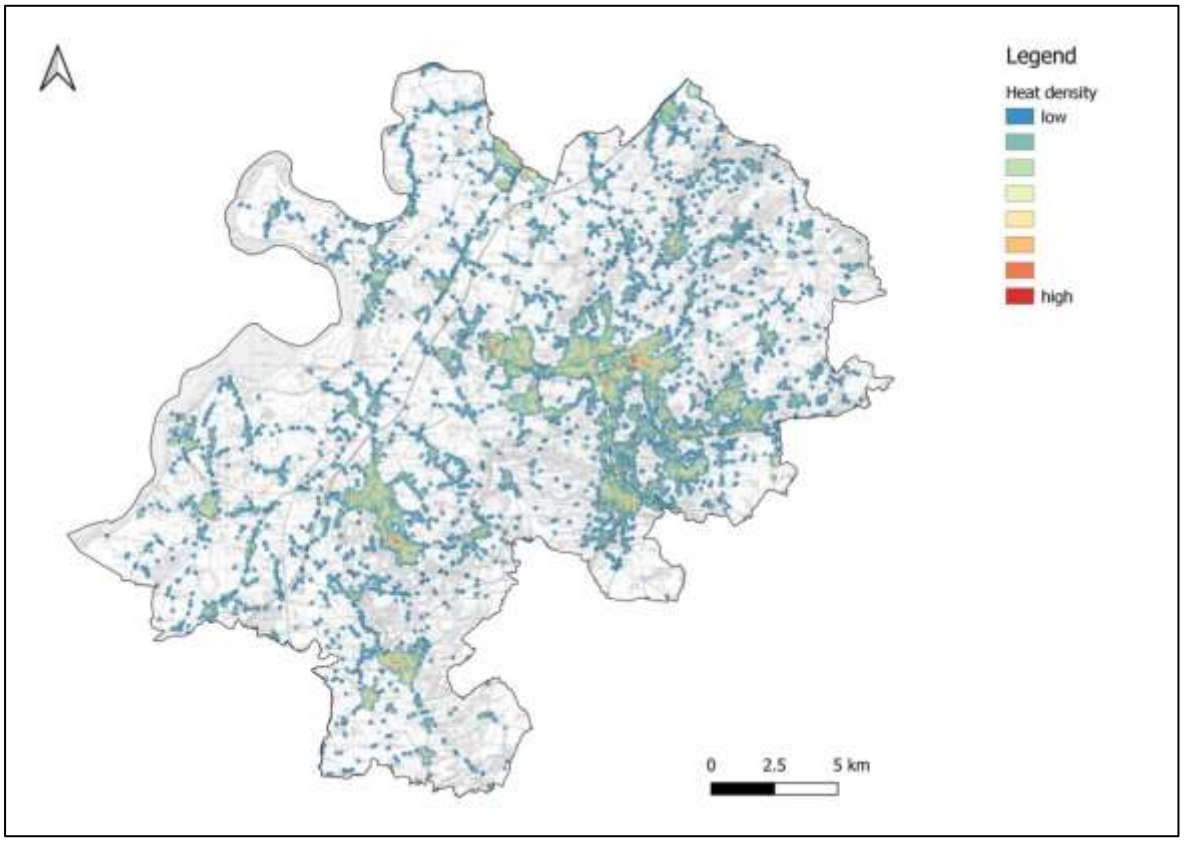

Figure 14: Heat demand map of Stroud District

[60] www.thermos-project.eu/home/

Areas with high concentrations of heat demand have higher spatial density values. Heat density is shown on the map from blue to red, with blue areas being low density and red areas high density. Linear heat density is a critical factor in heat distribution economics; however this can only be calculated once a possible pipe route has been defined.

As would be expected, the heat map shows heat demand density to be greatest in the more urban areas of the district. The most prominent clusters appear to be located in the towns of Stroud and Stonehouse, with additional smaller clusters in Nailsworth, Painswick, Dursley, Wotton-under-Edge and at the very north of the District at Hardwicke.

8.1.4 District-Wide Overlay Analysis

With a large area to explore, a useful way of initially identifying areas which are more likely to be suitable for district heating is to find areas which satisfy three conditions favourable to district heating, relating to: overall heat demand; presence of potential anchor loads; and groups of dwellings with high heat demand (normally blocks of flats). These conditions are:

- Areas must be within the 5% of land area with the highest heat demand density;
- Areas must be within 200m of residential buildings with an annual heat demand of more than 100,000kWh per year;
- Areas must be within 200m of potential anchor loads. Anchor loads are defined as the following types of buildings, which are likely to have relatively high and stable heat demands and/or be in sectors more likely to participate in heat distribution projects. For the purpose of this study, this includes all buildings with an annual demand for heat of above 100,000kWh that fall within the following categories within the THERMOS heat demand model:
    - Office
    - Commercial
    - Sport and Leisure
    - Industrial
    - Medical
    - Hotel
    - Prison

The THERMOS heat demand model uses data from a variety of sources which classify commercial buildings into different types. The categories are reasonably wide, so not all buildings in the above categories will actually be suitable as anchor loads. However, they provide a good basis for establishing the area of search. For this same reason, buildings that are classed as 'Industrial' are not included under the anchor load definition at this stage as the wide range of activities that can take place within them makes their suitability significantly more variable. When these areas are established, the locations identified and the areas around them can be checked for suitability by examining Ordnance Survey maps and Google Streetview to find out more about the types of buildings and their appropriateness (for example, high heat demand can be caused by dense

terraced housing, which is less suitable than larger loads due to the number of connections which would be required).

The overlay analysis identified several areas that fulfil all three criteria which can be considered as Heat Network Priority Areas (HNPAs) within existing development and may be worthy of further investigation (see Figure 36 and Appendix 5). These areas, however, should also be considered alongside planned large new development sites which offer particular opportunities for heat networks – this is considered in Section 9.

9 Strategic development sites

9.1 Opportunities for renewables

The Stroud District Local Plan Review (Draft Plan 2019) indicates that at least 12,800 additional homes and sufficient employment land will be developed to meet needs over the next 20 years. Much of this will be located in a number of emerging strategic locations for future housing and employment growth, as indicated in Figure 15. A selection of these with brief descriptions of type and scale is shown in Table 16.

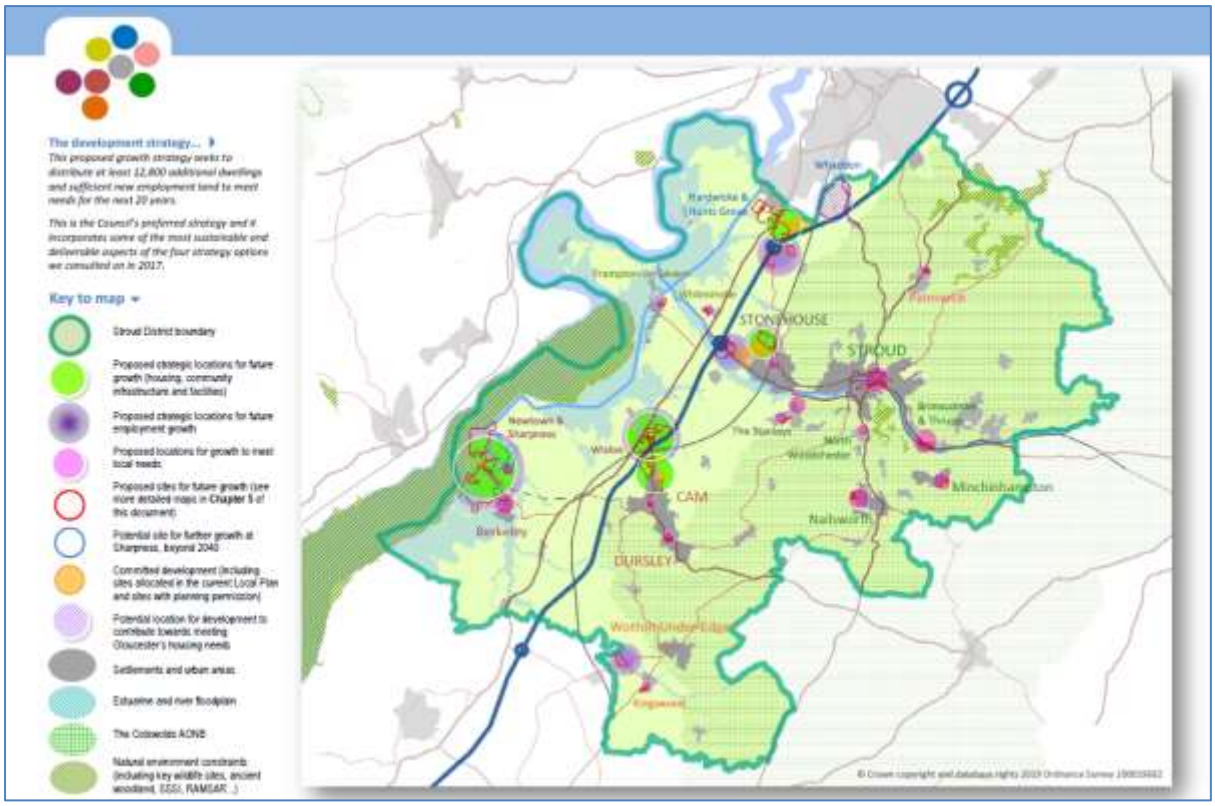

Figure 15: Extract from Stroud District Local Plan Review – Draft Plan 2019

Table 16 – Selection of emerging Strategic Site Allocations under consideration	
Site location	**Development type and scale**
South of Hardwicke	65ha site, mixed development, up to 1,200 homes.
Whaddon	2,500 homes, secondary and primary schools, community facilities, open space.
Stonehouse North West	650 homes, 5ha employment, primary school, open space.
Eco Park M5 J13	Sports stadium, 10ha green technology business park.
Wisloe New Settlement	1,500 homes, 5ha employment, primary school, local centre, community facilities, open space.
Cam North West	700 homes, primary school, community facilities, open space.
Sharpness Eco Village	2,400 homes by 2040 (5,000 by 2050), 10 ha employment, local centre, secondary and primary schools, community facilities, open space.

These sites will have specific opportunities for renewable or low carbon energy generation that can be considered at the masterplanning stage, drawing on advantages of scale, location and early stage design flexibility. Although a lack of detail at this stage on energy demands, site layout, development mix etc. limits a more in-depth exploration of viability, high level opportunities can be flagged for further consideration. The opportunity area maps included in Appendices 3 and 4 can also be checked against the site locations. Table 17 sets out some of the main opportunities while referring to the Sharpness Eco-village strategic development site as a case study.

Table 17 – Opportunities for renewable energy at Sharpness Eco-village strategic development site

Opportunity	Key factors
Energy demand reduction	• Reducing energy demand through passive solar design and advanced fabric energy efficiency can reduce the scale of onsite generation needed, potentially increasing technical feasibility and reducing costs. The 'Eco-village' ambition of the Sharpness site would suggest this is already a priority.
Decentralised energy centre	• A large site such as that planned for the Eco-village can be flexible in locating a suitable energy centre for renewable heating or CHP, for example designing in fuel storage facilities for biomass fuel. • The centre could also house energy storage facilities for either power or heat to help balance supply and demand.
Onsite low or zero carbon generation	• The potential for wind energy can be assessed through the opportunities and constraints maps referred to Section 0 of this report. The Sharpness site itself only appears to show 'technical' potential for small-scale wind turbines, although there are small areas of opportunity for larger scale turbines in the vicinity (potential for 'Sleeving' – see below) including land west of Slimbridge. The site lies within an area identified as having low to moderate landscape sensitivity to small or medium scale turbines. The turbines would, of course, need to be sited an appropriate distance from any dwellings. • Similarly the ground-mounted solar maps (Section 6.2) indicate that at least part of the site may fall within an area of technical potential for this technology and that installations up to 'large' scale would have a low to moderate impact on landscape sensitivity. However, a relatively large area of the site would be required for this option. • Buildings could be designed with roofs optimised for roof-mounted solar PV or water heating in terms of size and orientation, using building-integrated solar panels and smart energy storage systems. • Sufficient space could be allocated around buildings to incorporate shared-loop ground arrays for ground source heat pumps (more efficient than air source). • As the site is adjacent to Sharpness Docks, there could be potential for water source heat pumps located in the Severn Estuary – although this is 'offsite', depending on available capacity it could potentially provide heating/cooling to both the docks and the Eco-village.
Private wire network	• The provision of renewable electricity via private wire supply can provide low or zero carbon electricity directly to end users often at a lower price than electricity provided by the main electricity grid. At the same time, the operator of the renewable energy project can receive a greater purchase price for the electricity by selling directly to the end user. Whilst private wire supply can be used by a range of end users, wider benefits can be gained by supplying fuel poor households or businesses which are struggling with increasing energy bills. • To determine the initial viability of a scheme, it would be necessary to match the generation of power with the Eco-Village demand, although it is not necessary to use all power generated by a given renewable energy project. Note – currently a maximum of 1 MWe can be supplied by private wire to domestic customers.
Sleeving	• Also referred to as PPA Netting or Third Party Netting, sleeving is where a power purchaser (such as Sharpness Eco-village) directly enters into a contract with a generator to 'sleeve' an electricity supply (such as a nearby wind turbine) at an agreed price over a set period of time. • Under such arrangements, a power generator contracts to sells power direct to an end user (which may or may not be in the same location). This transaction, however, must be facilitated by a licensed supplier and therefore all usual grid charges and renewable energy 'levies' will usually still apply. As a consequence, the power price can usually be expected to be similar to retail prices from licensed suppliers. The benefit, however, is that generators and consumers can contract in the long-term, thus reducing the risk of power price fluctuations.
Existing development	• Adjacent existing development, such as that in and around Sharpness Docks, can offer additional energy demands which can often benefit energy generation schemes through economy of scale.
Heat networks	• See Section 9.2

9.2 Opportunities for heat networks

In considering heat networks, new development creates an additional demand for heat and power, as well as an opportunity to find a more flexible site for an energy centre and to lay heat distribution pipework. Existing development in the close vicinity can also act as additional heat demands which may improve the economic viability of a network, particularly where anchor loads may exist along with other heat demand profiles which can smooth out the overall heat demand profile.

Larger sites that have already been earmarked for new development in the Stroud area (adopted Local Plan Strategic Site Allocations) were mapped in GIS using information provided by the Council. This information was added alongside identified Heat Network Priority Areas in order to provide an indication of where new development might positively impact on the viability and layout of a heat network in the priority areas identified – see Figure 16.

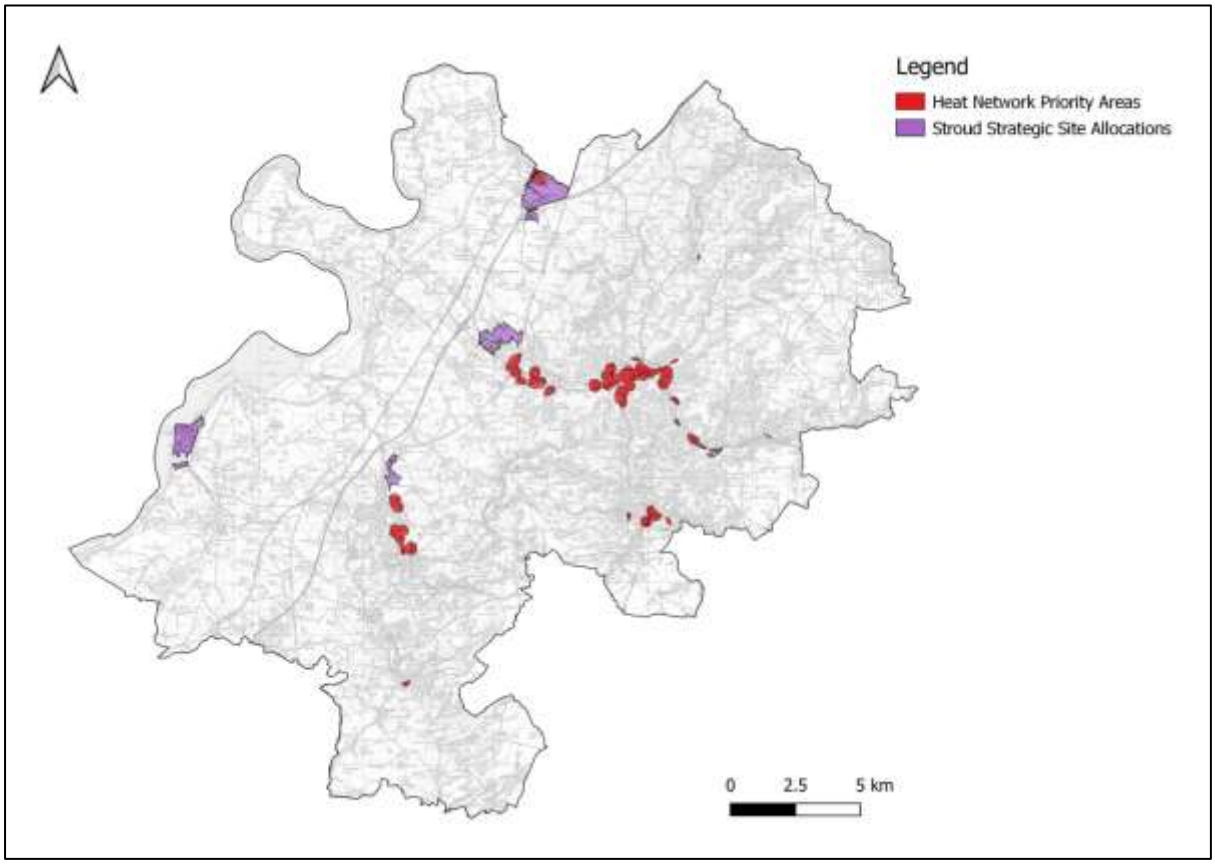

Figure 16: Heat Network Priority Areas and Strategic Site Allocations in Stroud District

It can be seen from the map that an HNPA coincides with the strategic site allocations at Hunts Grove and Quedgeley East, and that the sites at West of Stonehouse, Stroud Valleys and North East Cam also lie adjacent to HNPAs. Larger scale maps of these areas are included in Appendix 5. Although no HNPAs per se have been identified in the Sharpness locality, it is worth noting that the strategic development site near this location is situated close to Sharpness Docks which itself has potential for further development and may represent a viable energy demand.

10 Opportunities across local authority corporate estate

10.1 Options for local authorities

Although Stroud District Council's operations and activities already benefit from carbon neutral status (as achieved in 2015), opportunities remain for the development of further decentralised renewable energy generation across the corporate estate which includes both buildings and land. By considering its own estate, a local authority can take advantage of unique public sector opportunities and gain additional financial, environmental and social benefits for the district through involvement in appropriately planned renewable energy projects.

Options will typically range from larger scale standalone renewable energy projects on council-owned open land involving wind turbines or ground-mounted solar PV to smaller-scale building-integrated installations such as rooftop solar, biomass heating or heat pumps. In developing technically and financially viable projects the Council will need to identify the best-fit business model and partnering arrangement, whilst evaluating the level of development risk and financial reward that is acceptable along with the wider community benefits that are most likely to be triggered.

10.2 Opportunities for land, commercial buildings and housing assets

Stroud District Council has many property assets and interests as well as being a major landlord with approximately 5,200 Housing Revenue Account (HRA) properties to manage. Gloucestershire County Council also has significant land holdings within the district and often works closely with Stroud District Council in the assessment and promotion of sites for development. Both sets of assets, supplied as a GIS layer by Stroud District Council, are shown in Figure 17 below.

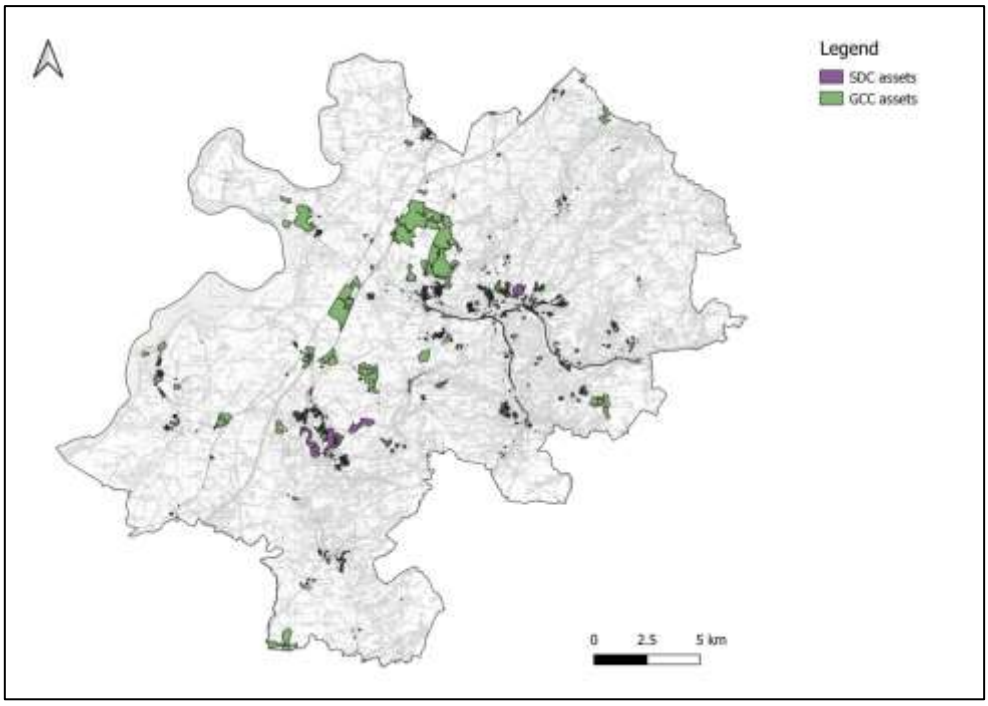

Figure 17: Assets within Stroud District held by Stroud District Council (SDC) and Gloucestershire County Council (GCC)

Opportunities for deploying renewable or low carbon energy generation across these assets are outlined as follows:

- To provide an initial indication of opportunities for wind energy and ground-mounted solar PV on local authority-owned land, the data has been overlaid with the technology opportunity maps included in Appendix 6. Although these do not distinguish between built-on and open land, there are several large area sites evident, particularly the predominantly rural sites belonging to the County Council, many of which coincide with areas of opportunity for ground-mounted solar PV and small scale wind. Being mostly urban in nature, Stroud District Council sites show less potential but warrant a more detailed analysis to explore any further opportunities.
- Considering the total amount of roof space across council-owned commercial buildings, rooftop solar certainly warrants further investigation to identify the best locations for deployment. For example, a GIS-based rooftop solar energy resource assessment can be done on selected buildings (or indeed the whole district[61]) which maps the solar resource at rooftop level to identify those locations having the best opportunities. These can then be compared against energy demand profiles within the identified properties to filter out those buildings most worthy of further detailed study. Should this result in a significant scale of deployment, the Council may also wish to consider bulk purchase of solar PV equipment/services. It could also extend this to feature a collective-purchasing scheme for the wider public.[62]
- As discussed in Sections 6.4 and 6.5, heat pumps and woodfuel heating are in terms of financial viability currently better suited to buildings in off-gas areas, as the heating fuels they may offset such as oil, LPG and electricity (for direct heating) are relatively expensive compared to gas and so are less competitive with renewable or low carbon energy technologies. However, heat pumps are likely to become cheaper and more widespread as the electricity grid continues to decarbonise over the coming years. Rural locations are also more likely to accommodate the additional space needed for ground loops with ground source heat pumps, or woodfuel storage/deliveries in the case of woodfuel heating installations. A source of self-supplied sustainable woodfuel may also be generated through local authority-managed arboricultural operations if residues can be collected, processed and distributed.
- The Council's HRA housing stock offers a number of opportunities to deploy onsite renewable or low carbon energy generation and in doing so realise multiple benefits of: reduced emissions, lower fuel bills to tenants and bulk purchasing of equipment at lower cost. Solar PV and air source heat pumps are likely to be the most feasible technology options and could be considered as part of a wider retrofit programme (for example, targeting voided properties) to increase the energy performance of the council housing stock. One such example is the Birmingham Energy Savers scheme, albeit this concluded with mixed results.[63]
- As discussed in Section 8, heat networks can offer energy efficient heating and cooling supplies and reduced emissions compared to many conventional systems such as boiler plants in individual buildings. Although not a renewable energy generation technology per se, future heat networks will need to be supplied with renewable or low carbon energy and so can act as a

[61] For example: www.cse.org.uk/projects/view/1331
[62] For example: https://www.councils.coop/case-studies/norfolk-collective-solar-scheme-norwich-city-council/
[63] www.sustainabilitywestmidlands.org.uk/news/our-comment-swm-and-members-say-goodbye-to-birmingham-energy-savers-scheme/

trigger for its development. Council buildings, particularly those located in areas with most potential for heat networks such as in town centres or adjacent to new development sites (see also Section 8.1.4), can act as stable, long term heat customers or 'anchor' loads where demand is sufficient, which can improve overall viability of the network. Furthermore, local authorities can adopt a facilitating role in heat network delivery in terms of establishing partnerships and delivery mechanisms, exploring technical and financial feasibility, accessing funding and engagement of potential customers.

- Electric vehicle charging stations could also be considered on local authority land where transport links and grid connection allow. Such facilities are also likely to include energy storage installations, which could be linked to local renewable energy generation plant.

The following sections consider the commercial opportunities and issues for local authorities wishing to exploit renewable energy generation within their own estate.

10.3 Investment and funding

10.3.1 Investment risk

The substantial reductions in local government funding in recent years, along with the prospect of the revenue support grant being phased out by 2020, has meant that local authorities are facing difficult financial challenges when trying to maintain levels of service offered prior to the cuts. This has subsequently generated an appetite for investment which brings about cost savings or an annual return of income; solar PV in particular has offered an attractive option in this respect with a number of local authorities participating in ground-mounted solar PV projects.[64]

The dramatic cut in capital costs seen in solar PV and wind products over the last decade coupled with financial incentive schemes such as Renewable Obligation Certificates and the Feed-In Tariff have enabled these technologies to offer the proposition of a low risk investment with multiple benefits. Not only are the technologies fully proven and easily deployed (where local planning constraints or grid connection are not barriers), they can deliver significant emission savings and provide a local source of zero carbon electricity with revenue options that can benefit the public sector and the local community. For these reasons, combined with what has been a relatively generous subsidy regime, such projects – solar PV in particular – have offered a commercially viable proposition for many local authorities and one that can meet their strict criteria around investment.

However, although the solar PV industry has clearly seen dramatic growth over the last few years, more recent cuts in subsidies are having an impact on the potential returns available to investors from new projects which is slowing deployment of the technology. The government is also proposing tax increases on some 'energy-saving materials' including certain renewable energy generation and storage equipment.[65] Commercial viability of projects is clearly highly sensitive to such changes and decisions on long-term investment in a low or zero subsidy environment need careful consideration, particularly when policy on future support mechanisms is unclear. The likelihood is that, in a low or zero subsidy regime, returns on investment in solar PV projects will also fall (arguably to returns

[64] For example, Swindon Borough Council has run two community investment offers to co-fund solar PV farms and Forest Heath District Council purchased a pre-developed solar PV farm in 2016.

[65] https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-8602

more appropriate for the low risks involved, one of the reasons for the government's choice to reduce subsidies).

This may reduce their attractiveness to local authorities as a potential source of future revenue or as a rewarding investment of their reserves (compared with other potential investments). Local authorities (and other public sector organisations) are therefore considering more creative commercial approaches to delivering viable projects through innovative funding mechanisms, system design, power purchase agreements and partnering arrangements. Clearly the approach taken depends on other activities that a local authority undertakes around provision of energy services and any legal entities that have been set up. These could range from managing a district heating network to forming a company that is fully licenced to supply electricity.

10.3.2 Funding

Although local authorities typically hold significant amounts of capital in reserve, they are not permitted to use these to directly plug year-on-year budget deficits; instead they need to find alternative ways of raising income from managing and investing that capital. Traditionally, capital has been invested by local authority treasurers across a range of sectors, including the fossil fuel industry, but the adoption of Socially Responsible Investment (SRI) strategies for public capital reserves is on the increase and has resulted in divestment away from unethical investments.

As discussed above, certain renewable energy projects such as solar PV installations have, with the benefit of the previously available subsidies, proven to be investable propositions capable of generating new income for a guaranteed period which easily beat current high street savings interest rates and often the returns available from other investments with similar risk profiles. In this sense, they have tended to fit well with the invest-to-save criteria of local authorities. Furthermore, such projects have triggered more direct income streams for the local community when developed as a community energy scheme, where for example a proportion of the profits are ring-fenced for other local sustainable energy initiatives. Local authorities often take a leading role in such projects as a partner and funder, with costs being supplemented by community share offers. Alternative community financing has also gained popularity via crowdfunding organisations such as Abundance and Trillion Fund (now closed), which has enabled lower cost capital and increased public engagement. However, the advent of a lower subsidy regime has now limited the ability of new projects to provide both decent returns for investors and investments supporting wider initiatives from additional profits.

Local authorities are able to acquire capital relatively cheaply through prudential borrowing, where interest rates remain historically low, and via bonds such as those from the Local Government Association's Municipal Bonds Agency. They can also consider their treasury management and how their reserves are invested, although clearly a responsible approach requires that the returns on such investments from council reserves are comparable or better than those available from other similar risk-profile investments.

Other solar PV developers in the private sector are also offering a variety of options to fund deployment of solar PV, which are open to local authorities. Typically these have followed the 'rent-a-roof' concept, where a developer will design, fund, install and maintain a system on a client's roof and receive the Feed-In Tariff and export revenues, while the client benefits from taking no development risk and receiving free, zero carbon electricity when the sun shines. These have

expanded to include buy-back schemes, where a developer purchases an existing system. In this case there is sometimes an option for the client to reinvest the released equity, together with a capital contribution from the developer, in new installations elsewhere under the same operational and revenue arrangements. However, subsidy cuts have again limited these options and are forcing developers to consider different approaches.

10.4 Sale and use of power

10.4.1 Sale of energy

The financial benefit gained from renewable power generation projects has in the past typically arisen from subsidies (i.e. Feed-In Tariff payments, Renewable Obligation Certificate sales and Contracts for Difference), payments for electricity exported to the grid or supplied to specific consumers, and from electricity bill savings from avoided imports where generated power is used on-site rather than exported for sale. The relative amount of power used on-site (self-consumption) to that exported, and the corresponding financial benefit, will vary according to the design of the system and whether there are specific arrangements for selling the power to others.

Larger scale schemes which export most or all of their power have typically sold their electricity via Power Purchase Agreements (PPAs) where projects supply to a third party for a specified period e.g. 15 years, with three years of forward fixed pricing. PPAs typically take the form of:

- Wholesale PPAs, where the power output is typically purchased by traders;
- Sleeved PPAs, where the power is typically purchased by commercial companies, with additional complex facilitating contracts signed with licensed suppliers (who will typically mark up the unit price in return for providing this service);
- Private wire PPAs, where the output can be sent direct via a dedicated wire to a nearby commercial energy user.

However, the move towards a low or zero subsidy industry for wind and solar PV (including the closure of the Feed-in Tariff subsidy scheme to new applicants from April 2019) has triggered more emphasis on self-consumption models, particularly for rooftop solar PV where technical innovation has been employed to find ways of increasing financial viability.

10.4.2 System optimisation

In the case of solar PV, a rapid decrease in manufacturing costs over recent years has complimented new approaches to system design to better optimise overall viability. This principally involves sizing a bespoke system in a way that suits the conditions of the site, and may depend on grid connection/power export constraints, size of roof and the electricity consumption profile of the host building.

For example, if export constraints are severely limited, maximising self-consumption by designing the array in such a way as to match peak output with peak demand (assuming this occurs at a suitable point during daylight hours) can still potentially make the project viable. This can be achieved by careful array orientation design i.e. not necessarily south-facing, and although it may result in a smaller array compared to the maximum roof size capacity, the resulting system may

work out as the most viable option. Additionally, export power control systems can be used to constrain the amount of power exported to the grid if necessary.

System design can also benefit from opportunities relating to Demand Side Response (DSR) [66] and smart grid control coupled with battery storage technology to allow more flexibility in terms of exporting power or using it on-site. Incorporation of battery storage should provide greater control over when the power can be used and/or sold to maximise its value. For example, output could be stored and then matched to the building electricity demand profile, which may include night time periods for example in the case of depots or warehouses. [67]

In the case of ground-mounted solar PV systems, better timed output could provide flexibility to overcome export constraints imposed by the District Network Operator, or be arranged to optimise revenue from electricity sales subject to time-of-day tariffs. However, the financial viability of such additional features needs to be carefully considered. There are the additional capital costs of battery storage to consider along with the relatively small differences between peak and non-peak prices in many tariffs currently available to commercial and public sector customers plus the impact of losses associated with charging and discharging a battery.

There are also emerging revenue-earning possibilities associated with batteries to provide system services such as enhanced frequency response (which helps ensure the electricity system stays stable) where stored electricity is released when required by National Grid. Such services are often orchestrated through contractual arrangements with third party aggregators who in turn manage the arrangements with National Grid. However, while there is much interest and enthusiasm for the new revenue streams to compensate for loss of subsidies with solar PV, there are some commercial risks associated with committing to provide such services on a PV-charged battery (compared with battery-only approaches) and the viability issues raised above still apply.[68]

That said, this is a fast developing innovative market which is geared towards the electrification of heat and transport. For example, there are now products available for domestic-scale energy storage and smart energy management of onsite generation including the integration of electric vehicles. As technology advances, costs decrease and DSR plays a greater role, there is also the option of retrofitting battery storage to existing solar PV systems and considering ways of increasing revenue by further optimising on-site use of electricity and/or export sales.

[66] Demand Side Response (DSR) or Demand Side Management (DSM) is the adjustment of consumer demand to flexibly alter consumption patterns in real-time at times of stress on the main electricity system, or in response to network operator price signals.
[67] See for example this case study by Hounslow Borough Council: www.london.gov.uk/sites/default/files/hounslow_pv.pdf
[68] Further information is available in Energy Storage - Towards a commercial model - 2nd Edition – Regen SW, November 2016

11 Policy options for Stroud District Council

There are various policy options the Council could consider to strengthen existing Local Plan policies (i.e. Policies CP5, CP8, CP11, CP14, ES1 and ES2) in relation to renewables and low carbon energy within the District. The following section provides an overview of these policy options and the strengths and weaknesses of each policy approach. The options are summarised under the following headings:

- Enhanced energy standards in new developments;
- Separation distances (for wind energy);
- Criteria based policies;
- Areas of suitability (for wind energy);
- Energy opportunity maps;
- Allocation of sites;
- Community renewables.

11.1 Enhanced standards in new development

Considering Stroud District Council's own 2030 net-zero carbon target along with the upgraded targets within the Climate Change Act and other national policy on climate change mitigation, the Council should seek to set ambitious energy performance standards for new development. The proposals from UKGBC's net zero carbon framework and the lead taken by a number of other UK local authorities strongly suggest that these should exceed the requirements of current 2013 Part L Building Regulations and comprise a hierarchical approach of high energy efficiency standards, on-site renewables and carbon offset contributions.

Policy options to consider include:

- **Energy hierarchy** – requires developers to first reduce demand ('Lean'), ensure energy is supplied efficiently ('Mean') then consider using onsite renewable/low carbon energy generation ('Green'). In the case of net-zero carbon targets, financial contributions towards carbon offsetting would be the final and least-preferred step in the hierarchy.
- **Heat hierarchy** – requires developers to follow a heat supply hierarchy such as that within the draft New London Plan:

  Major development proposals within Heat Network Priority Areas should have a communal low-temperature heating system.

  1. *The heat source for the communal heating system should be selected in accordance with the following heating hierarchy:*
     - *connect to local existing or planned heat networks*
     - *use zero-emission or local secondary heat sources (in conjunction with heat pump, if required)*

- *use low-emission combined heat and power (CHP) (only where there is a case for CHP to enable the delivery of an area-wide heat network, meet the development's electricity demand and provide demand response to the local electricity network)*
- use ultra-low NOx gas boilers.

2. *CHP and ultra-low NOx gas boiler communal or district heating systems should be designed to ensure that they meet the requirements of policy SI1 Part B*
3. *Where a heat network is planned but not yet in existence the development should be designed to allow for the cost-effective connection at a later date.*

- **Net-zero carbon target for new development** – for example:
  - Building Regulations (2013 issue) standard achieved through onsite energy efficiency plus a further minimum 19% improvement through onsite energy efficiency and/or onsite renewable energy generation; residual emissions to be offset through payments to carbon offset fund [UKGBC example];
  - At least 35% improvement on Building Regulations (2013 issue) achieved onsite, with a minimum of 10% achieved through onsite energy efficiency for residential, and 15% for non-residential; residual emissions to be offset through payments to carbon offset fund [Draft New London Plan example].
- **Merton-style policy** to specifically encourage the use of onsite renewable generation (but may be unnecessary if net-zero carbon target effectively results in a similar outcome)
- **BREEAM 'Excellent'** or above for new non-residential development – ensures high all-round environmental standards are achieved but does not provide a direct measure of emissions reduction.

In order to set out how the energy targets implied in the above standards would be met, energy statements from developers would be required based on a detailed template. Monitoring and reporting requirements on energy use and emissions during first year(s) of operation is also recommended to help evaluate the effectiveness of the policies and encourage on-going compliance.

The strengths and weaknesses of adopting these types of energy performance standards are summarised below:

Strengths:	**Weaknesses:**
• Low carbon energy efficient homes have already been built at scale and the standard can be met using traditional construction methods and materials without adding substantial development costs; • The evidence needed to confirm compliance can be prepared by the developers in a consistent easy to measure way; • Enhanced building energy performance standards represent a cost-effective way of contributing to climate change commitments; • Policies can be shaped to future-proof buildings to avoid the need for retrofitting in the future.	• To minimise the risk of challenges, developers need to be convinced of the benefits of going beyond the Building Regulation requirements and that there is no 'undue burden' or insurmountable impact on viability; • Enhanced building energy standards still incur additional development costs; • There is uncertainty over the standards that will result from the next revision of the Building Regulations due in 2020 and their compatibility with locally-set standards.

11.2 Separation distances (for wind energy)

The proximity of large wind turbines to residential properties has become an important consideration in planning decisions for wind energy developments. Several councils in England have sought in the past to impose separation distances between proposed turbines and residential properties. However, developers and climate change groups are concerned that this effectively represents an "anti-wind farm policy" that is not based on evidence.

It is important to note that there are no minimum separation distances required in English planning law or guidance. The Planning Practice Guidance which accompanies the NPPF[69] clearly states that:

"*Local planning authorities should not rule out otherwise acceptable renewable energy developments through inflexible rules on buffer zones or separation distances. Other than when dealing with setback distances for safety, distance of itself does not necessarily determine whether the impact of a proposal is unacceptable. Distance plays a part, but so does the local context including factors such as topography, the local environment and near-by land uses. This is why it is important to think about in what circumstances proposals are likely to be acceptable and plan on this basis."*

A number of local authorities have however sought to introduce separation distances. For example Wiltshire Council amended its Core Strategy Pre-Submission Document to impose minimum separation distances of 1 kilometre for turbines over 25 metres, 1.5 kilometres for turbines over 50 metres, 2 kilometre for turbines over 100 metres and 3 kilometres for wind turbines over 150 metres high. In that case, the Inspector ruled that it was contrary to the Planning Practice Guidance (PPG) and the policy was removed.

Reviews of appeal decisions have also shown that large scale wind turbines have been built with a wide range of separation distances and that they do not show any general rule, but rather judgements have been made according to the specifics of the case and local circumstances. This reflects the fact that the size of the turbines, orientation of views, local topography, buildings, vegetation and trees can all have a significant impact on what may be deemed an acceptable distance between a wind farm development and a residential property/ settlement.

As outlined in paragraph 2.7.6 of the national policy statement for Renewable Energy Infrastructure (EN-3), the two main issues that determine the acceptable separation distance between residential properties and wind energy developments are visual amenity and noise. Shadow flicker can also potentially determine the minimum acceptable separation distance. Commercial-scale wind turbines are large structures and can have an effect on visual amenity from residential properties. All wind turbines also generate sound during their operation. As such, appropriate distances should be maintained between wind turbines and sensitive receptors to protect residential amenity. The key question however is whether these safeguards are best achieved through the application of blanket district-wide separation distances or through robust criteria based policies and appropriate guidance. The provision of guidance by the Council on how residential amenity and noise issues

[69] Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/renewable-and-low-carbon-energy/developing-a-strategy-for-renewable-and-low-carbon-energy/

should be assessed arguably provides a much more robust framework which can be used to assess potential wind farm applications.

It is therefore not recommended to include a separation distance policy within the emerging Local Plan as there is a high risk that this will be rejected by the Inspector as it is contrary to the guidance provided in the PPG. If such a policy was included, it would need to be accompanied by a caveat recognising that site specific factors also need to be taken into consideration. However, with the inclusion of such a caveat, it is doubtful what purpose the policy would then be serving.

Strengths:	**Weaknesses:**
• Puts the onus on the developer to set out why the distance between the wind turbine(s) and residential property is acceptable (if the proposed development is closer than the required distance). However, an Environmental Impact Assessment (EIA) for a wind energy development should already cover these issues.	• Contrary to National Planning Policy Guidance; • Would require the inclusion of caveat to take account of local circumstances which makes the purpose of the policy questionable; • Aim of policy could be better served through the provision of guidance on how developers should consider residential amenity and noise issues in their planning applications/ EIAs.

11.3 Criteria based policies

The NPPF states that local authorities should design their policies to maximise renewable and low carbon energy development while ensuring that adverse impacts are addressed satisfactorily. The PPG provides helpful guidance for local authorities on how to develop robust criteria based policies in relation to renewable and low carbon energy projects. Key points include:

- The criteria should be expressed positively (i.e. that proposals will be accepted where the impact is or can be made acceptable);
- Should consider the criteria in the National Policy Statements as these set out the impacts particular technologies can give rise to and how these should be addressed;
- Cumulative impacts require particular attention, especially the increasing impact that wind turbines and large scale solar farms can have on landscape and local amenity as the number of turbines and solar arrays in an area increases;
- Local topography is an important factor in assessing whether wind turbines and large scale solar farms could have a damaging effect on landscape and recognise that the impact can be as great in predominately flat landscapes as in hilly areas;
- Proposals in National Parks and Areas of Outstanding Natural Beauty, and in areas close to them where there could be an adverse impact on the protected area, will need careful consideration;
- Care should be taken to ensure heritage assets are conserved in a manner appropriate to their significance, including the impact of proposals on views important to their setting;
- Protecting local amenity is an important consideration which should be given proper weight in planning decisions;

Drawing on the guidance outlined in the PPG, after expressing positive support in principle for renewable and low carbon energy development, Local Plans should list the issues that will be taken into account in considering specific applications. This should not be a long negative list of constraints but it should set out the range of safeguards that seek to protect the environment – including landscape and townscape. Other key considerations may include residential amenity, aviation, heritage etc.

It is important that policy does not preclude the development of specific technologies other than in the most exceptional circumstances and does not purely repeat national policy but is relevant to the process of decision-making at the local level and focuses on locally distinctive criteria related to local assets, characteristics and sensitivities. In the context of Stroud this could specifically relate to managing the scale and impact of renewable and low carbon developments within the setting of the Cotswolds Area Outstanding Natural Beauty. It may also be appropriate for more detailed issues and guidance to be included in a Supplementary Planning Document (SPD) on renewables.

The Inspector's report which accompanied the Blackburn with Darwen Borough Council[70] Site Allocations and Development Management Policies Plan (adopted in 2015) noted that in order for the Plan to be found sound, the Borough's criteria-based policies would need to be supported by a Supplementary Planning Document (SPD) which identified suitable areas. It is therefore recommended that any criteria-based policy designed to manage the development of renewable and low carbon technologies should also be supported by guidance on the most suitable locations (see appropriate sections relating to suitable areas, energy opportunities and allocations below), either within the Local Plan or an accompanying SPD.

Strengths:	**Weaknesses:**
• Creates greater policy certainty for developers; • Allows the Council to clearly set out the circumstances in which renewable energy proposals will and will not be permitted.	• Maybe perceived to be overly restrictive by certain stakeholders.

11.4 Identification of 'suitable areas for wind energy'

In line with the NPPF, when considering applications for wind energy development, local planning authorities should only grant planning permission if the development site is in an area identified as suitable for wind energy development in a Local or Neighbourhood Plan.

When identifying suitable areas for wind, as outlined in Section 2.1.4, the PPG does not dictate how suitable areas for renewable energy should be identified, but in considering locations, local planning authorities will need to ensure they take into account the requirements of the technology and, critically, the potential impacts on the local environment, including from cumulative impacts and views of affected local communities. It also makes reference to the former Department of Energy and Climate Change's (now part of the Department for Business, Energy and Industrial Strategy) methodology on assessing the capacity for renewable energy development. LUC was involved in the

[70] Blackburn with Darwen Borough Site Allocations and Development Management (2015), Blackburn with Darwen Borough Council

preparation of this guidance. The guidance notes the value of landscape character assessments in identifying which technologies are appropriate in different locations, including the appropriate scale of development.

The assessment of technical potential as set out in Section 0 is based on a refinement of the methodology and identifies those areas which are technically viable for wind energy – i.e. they are not constrained by infrastructure, environmental or heritage constraints.

One of the key factors determining the acceptability or otherwise of wind turbines is their potential impacts on the local landscape – this is due to their height and the movement they introduce into the landscape (i.e. rotating blades). Different landscapes present different opportunities for renewable energy, and landscape sensitivity studies can assist both planners and developers in identifying what scale of development may be appropriate in which areas. This approach is endorsed by the PPG which states that *"landscape character areas could form the basis for considering which technologies at which scale may be appropriate in different types of location."*

It is important to note that if such areas are identified in the Local Plan or Neighbourhood Plans they would be broad designations rather than allocations and would not therefore provide a definitive statement of the suitability of particular location for wind energy. Site specific assessment and design would still be required and all applications would still be assessed on their individual merits. It is also not possible at a strategic level, to take into account cumulative effects. Residential amenity, the setting of heritage assets, telecommunications, ecology and air traffic safety etc., would also need to be carefully considered at a site level.

All applications would also have to meet second test set out in the NPPF i.e. that it can be demonstrated that the planning impacts identified by affected local communities have been fully addressed and therefore the proposal has their backing. It is therefore recommended that such policies are also supported by development management criteria designed to judge individual planning applications against (see section on criteria-based policies above).

The Council may also want to give consideration to including a policy stating where proposals for wind energy development outside of the identified areas will be considered. For example, where it can be demonstrated that:

- Projects are community-led and supported schemes that meet the identified needs of local communities to offset their energy and heat demand; and
- Projects are appropriately scaled and sited to meet the demands of local utilities, industrial or commercial facilities, agricultural holdings, etc.

Examples of where identification of 'suitable areas for wind energy' has been included in local plans include Eden, Hull and Exmoor National Park – note that these are not necessarily examples of best practice, but serve to illustrate different approaches taken. The Redcar and Cleveland Local Plan[71] adopted in May 2018 includes Renewable and Low Carbon Energy Policy SD 6 which identifies areas with potential for wind and solar technologies in the Proposal Map accompanying the Local Plan.

[71] Redcar and Cleveland Local Plan (May 2018), Redcar and Cleveland Borough Council.

These areas were identified by undertaking a technical assessment of wind and solar potential overlaid with the findings of a landscape sensitivity assessment.

Strengths:	**Weaknesses:**
• Enables planners to have informed discussions with developers and communities about potential opportunities for wind– i.e. proactive rather than reactive planning; • Meets NPPF, PPG and Ministerial statement that LPAs should consider identifying suitable areas for renewable and low carbon energy sources and supporting infrastructure; • Can act as a useful tool for neighbourhood planning.	• There may be concern that it will lead to multiple wind energy applications within the areas identified as being suitable for wind. However, all applications would still need to be assessed on their own merits, in isolation and in combination with existing developments, and it would not be a replacement for detailed site studies; • It does not provide a definitive statement on the suitability of a certain location for wind turbine development – each application must be assessed on its own merits. It is not a replacement for detailed site studies.

11.5 Development of 'Energy Opportunities Maps'

The NPPF and PPG encourage local planning authorities to "*consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure.*" The Council should therefore consider identifying suitable areas for other forms of renewable and low carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources.

Clearly identifying and mapping an area's renewable and low carbon sources of energy represents a positive and proactive way to spatially plan for renewable and low carbon energy generation. With a spatial map illustrating energy opportunities it is easier for local authorities to work with local communities and developers to identify the areas that would be most appropriate for development in strategic terms, accelerating the planning and development processes and avoiding conflict.

Energy opportunities maps can provide a spatial summary of the key opportunity areas (in terms of their technical potential) for various forms of renewable energy. These can be used to inform development decisions and discussions and guide development towards the most suitable areas. This has been undertaken for both wind and ground-mounted solar PV, as described elsewhere in this report, and has also been complimented by a Landscape Sensitivity Assessment, which can be used to guide developments away from the most sensitive landscapes and, in the case of solar, away from the 'best and most vulnerable' agricultural land, in line with PPG.

With regards to heat networks, in order to encourage low carbon district heating schemes, search area maps can identify locations that have greatest potential to locate district energy schemes, based on heat mapping outputs – see Appendix 5. Opportunities in Stroud District are limited due to the mainly rural characteristics of the area, but such heat maps can nevertheless indicate the areas most worthy of further study. In London, the Mayor has identified Heat Network Priority Areas, which can be found on the London Heat Map website[72]. The draft New London Plan states that

[72] https://maps.london.gov.uk/heatmap

major development in Heat Network Priority Areas should follow the heating hierarchy in policy SI3 (see also Section 11.1).

With the introduction of neighbourhood planning, energy opportunities maps could also provide a useful tool for communities and other stakeholders to identify the key opportunities for renewables within their area. It is important to note however that it is not possible to identify locations for all types of renewable energy, as many technologies such as building integrated solar, heat pumps, farm-scale AD, and small-scale biomass can be located in nearly all areas.

Strengths:	**Weaknesses:**
• Enables planners to have informed discussions with developers and communities about potential opportunities for renewable and low carbon energy technologies – i.e. proactive rather than reactive planning; • Meets NPPF, PPG and Ministerial statement that LPAs should consider identifying suitable areas for renewable and low carbon energy sources and supporting infrastructure; • Can act as a useful tool for neighbourhood planning.	• Not possible to identify locations for all types of renewable energy technologies; • It does not provide a definitive statement on the suitability of a certain location for a particular development – each application must be assessed on its own merits. It is not a replacement for detailed site studies; • May identify potential areas for renewable energy development which are unpopular.

11.6 Allocating sites for standalone renewable and low carbon energy schemes

The local plan could allocate sites specifically for standalone renewable developments. This could provide more strategic direction to the siting of renewables for developers, investors, the local authority, statutory stakeholders and communities. It may be possible to allocate sites which have the greatest potential for sustainable energy and carbon reduction or sites that could potentially be developed for other purposes (e.g. resulting in the sterilisation of potential sites).

If sites exist that have potential for standalone renewable or low carbon energy use but are constrained in a way that would make them less attractive to commercial developers, then allocating the site is a way of promoting that site for renewable/low carbon development to a wider audience such as land owners or co-operatives. Alternatively or in addition, the Council could undertake a 'call for sites' exercise for renewable and low carbon development and consider the merits of promoted sites in isolation or in combination with other planned types of development. It should however be noted that such call for sites exercises tend to generate a relatively poor level response.

Again, it would be important that site allocations only highlight appropriate schemes/areas; site developers and communities would still be required to undertake detailed site-based assessment work to support individual development planning applications and if required Environmental Impact Assessments. Furthermore, site allocations are framed such that they do not preclude projects in other locations.

Strengths:	Weaknesses:
• Provide strategic direction to the siting of renewables; • Ensure sites with the greatest potential are identified; • May promote sites to a wider audience such as co-operatives.	• Resource intensive to gather necessary evidence to justify allocation; • Would be desirable to secure agreement of landowner which may be resource intensive; • May identify potential sites for renewable energy development which are unpopular.

11.7 Encouraging community renewables

The NPPF states that local authorities should support community-led initiatives for renewable and low carbon energy, including developments being taken forward through neighbourhood planning. Community-led renewable energy projects are increasingly being seen as an attractive option for local communities wishing to contribute to local/national climate change targets and as a way to generate local revenue to directly benefit the community.

Community groups can face considerable challenges in the pre-planning stage and there are a number of opportunities for local authorities to provide advice and guidance throughout this stage, including the provision of early advice on planning requirements and lending support to consultation activities within the community. Engaging communities for the earliest stages of plan-making to provide clear information on local issues and the decision making process.

The Council's emerging Local Plan could broaden its support for community renewable schemes by stating that the Council would actively support community renewable energy schemes which are led by or meet the needs of local communities. Such developments would normally be conceived by and/or promoted within the community within which the renewable development will be undertaken, delivering economic, social and/or environmental benefits to the community. Neighbourhood plans provide a particular opportunity to define detailed local site allocation policies for renewable and low carbon technologies.

Strengths:	Weaknesses:
• Provides support to local communities to develop renewables and low carbon energy; • Generates local revenue to directly benefit the local community; • Can secure a broad base of local support for renewable energy schemes.	• Care may need to be taken not to prescribe the process of community ownership (i.e. shared ownership etc.) as it is not the role of the planning system to do this.

12 Conclusions

12.1 Achieving net-zero by 2030

Stroud District Council's pledge to do everything in its power to make Stroud District carbon neutral by 2030 sits alongside the longer-term ambition set by the Climate Change Act 2008 to target full net carbon neutrality in the UK by 2050. Both targets are acknowledged as being hugely challenging considering the radical changes that are needed to enact the necessary innovative transformative action across all sectors. However, in their 'Net Zero' report, the Committee on Climate Change view the UK-wide target as being *"achievable with known technologies, alongside improvements in people's lives… …However, this is only possible if clear, stable and well-designed policies to reduce emissions further are introduced across the economy without delay".*

With Stroud District's local plan review due to reach final draft stage in autumn 2019, now is the time therefore to consider such policies at the local level and decide which options have the most potential to maximise positive local action on climate change and underpin the framework of measures needed whilst being acceptable within the constraints of the statutory local planning system.

One of the difficulties for local authorities in setting district-wide carbon targets which go further than those set nationally is the co-dependency on national policy measures such as those which will contribute to decarbonising both the electricity grid and heat supplies. Such measures are likely to be achieved through a mix of technologies including some which most local authorities have little or no influence over such as offshore wind power and the development of hydrogen infrastructure. The rate at which grid decarbonisation occurs will be dependent on fit-for-purpose national policies being rolled out in a timely manner, and local authorities will in turn be largely dependent on a decarbonised grid to fulfil their own policy commitments.

Local authorities are, however, well-placed to have a better understanding of the local area in terms of needs, opportunities and constraints whilst having influence through their multiple roles of social landlords, major employers, community leaders, planning authorities and service providers. Stroud District Council will therefore need to carefully examine its own sphere of influence in achieving a 2030 net-zero carbon target and be highly ambitious in tackling emissions in key sectors where it can exert meaningful influence such as power and heat generation, existing and new buildings, surface transport and waste. Increasing local renewable energy generation capacity will be a key component of the solution, sitting alongside energy efficiency, energy demand reduction, heat decarbonisation and providing infrastructure to accommodate the rapid growth in electric vehicles.

Lastly, the Council should exploit its well-placed role in promoting, maximising and delivering local benefits resulting from the delivery of emission reduction measures which can include economic regeneration, reduction in fuel poverty and improved health.

12.2 Stroud District's renewable energy resources

A broad assessment has been undertaken to quantify as far as possible the low or zero carbon energy resources across the district by examining opportunities and constraints for each energy source or technology. The approach taken has been to adopt tailored scenarios for each using the set of assumptions given in Appendix 1. These are largely based on establishing a theoretical resource which considers technical constraints to deployment rather than those imposed by political or financial issues. It is therefore important to realise that these resource assessments are purely illustrative and represent just one of many scenarios that could occur.

In order to provide context to the figures, each resource has been expressed below in terms of potential annual emission savings (Figure 18) and potential energy generation (Figure 19) with both compared against annual district emissions and energy consumption respectively. The scenarios shown in these figures are summarised as follows:

- The ground-mounted solar PV resource assumes that the technology is deployed on 1% of the total suitable area (see Figure 31 in Appendix 4), which corresponds to an area of approximately 2.2 km^2;
- The wind energy resource assumes that the technology is deployed in all suitable areas (see Figure 26 in Appendix 3), with preference given to the largest scale turbine an area can accommodate;
- The energy crops resource assumes Miscanthus is cultivated across 10% of the total suitable area, which corresponds to an area of approximately 32.4 km^2, assuming miscanthus is cultivated.
- The woodland resource assumes that 2 oven-dried tonnes/ha/yr is available across a total woodland area of 6,271 ha;
- The heat pumps resource assumes that air source heat pumps provide 85% of space and water heating demand to 50% of properties, assuming they have attained a suitable level of fabric energy efficiency and have a compatible low-temperature heat distribution system;
- The rooftop solar water heating resource assumes that the technology is deployed on 50% of dwellings and 80% of non-domestic properties;
- The rooftop solar PV resource assumes that the technology is deployed on 40% of dwellings and 80% of non-domestic properties;

[Note – the hydro power and livestock slurry resource are not included as they are too small to feature on the charts].

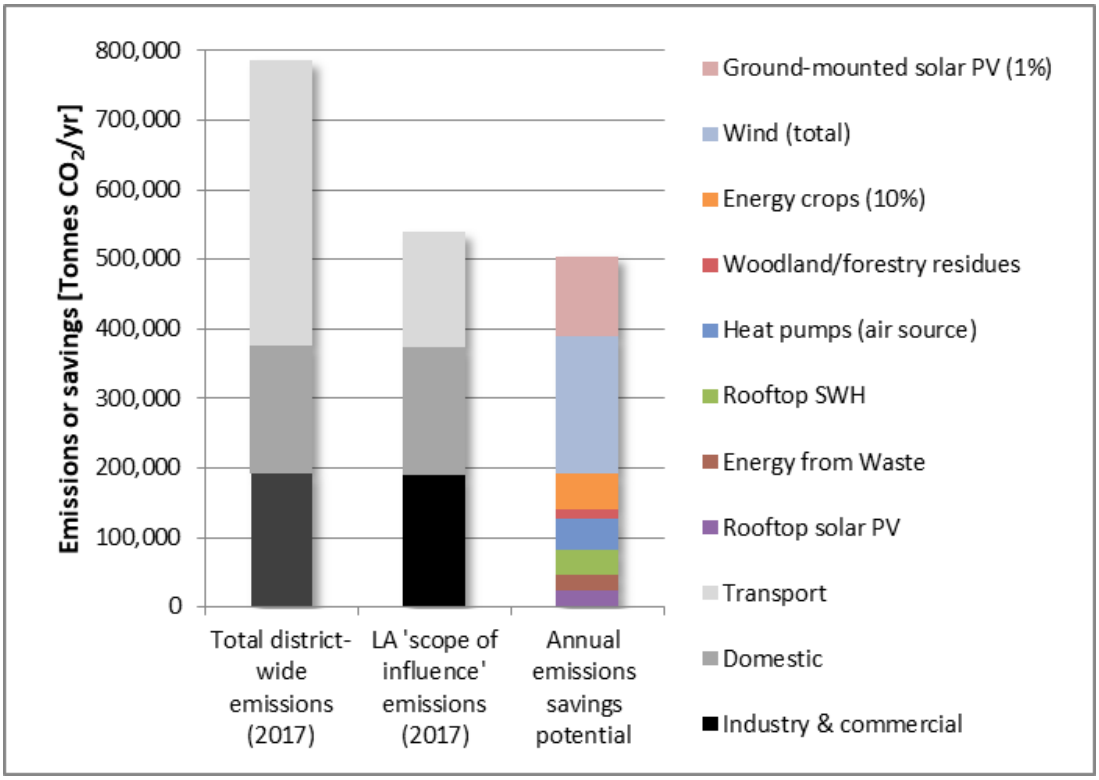

Figure 18: Summary of district emissions compared against potential emission savings from resource assessment technical scenarios

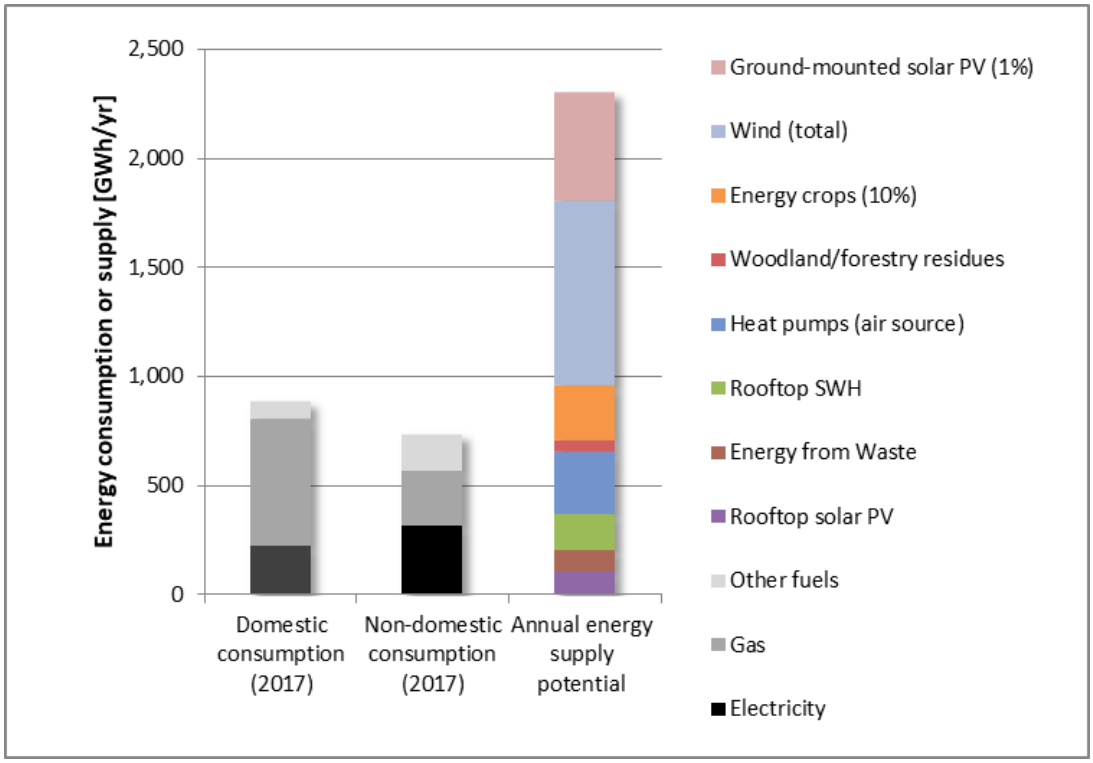

Figure 19: Summary of district-wide energy consumption (excluding transport) compared against potential energy supply from resource assessment technical scenarios

Figure 18 indicates the relative scale of emission savings from each resource and the overall scale relative to total and 'LA scope of influence' district-wide emissions. It can be seen that, technically speaking, renewable and low carbon energy generation can make a substantial contribution to reducing overall district-wide emissions. However, as some of the estimated emission figures have been based on a static carbon emissions conversion factor for grid electricity (that from SAP10[31]), it is important to note that these will change in due course; in other words, the 'value' of future renewable electricity generation in terms of resulting emission savings will gradually decrease as the electricity grid continues to decarbonise. This will not be the case however where renewable electricity is used to displace fossil fuel-fired heat, such as when gas boilers are replaced with heat pumps.

Figure 19 then compares the estimated energy yields from each resource against district-wide (non-transport) energy consumption. This is intended to provide further context to Figure 18 in terms of the scale of energy generation potential when compared to Stroud District's energy consumption. For example, it can be seen that the estimated annual generation yield from the ground-mounted solar PV resource is similar to total district-wide (non-transport) electricity consumption during 2016 – in fact, the potential supply equates to approximately 93% of the consumption.

In practice the deployable renewable energy resource achievable by 2030 is likely to be considerably less than the technical scenarios shown above. This serves to illustrate the challenge of meeting the net-zero 2030 target with local renewables alone; there will also be a critical dependency on other measures such as energy demand reduction and the decarbonisation of the transport, electricity grid and heat supply sectors.

12.3 Policy options

A key purpose of the evidence gathered by this study is to help set the context and provide guidance on local policy development for Stroud District Council around decentralised renewable or low carbon energy generation. A range of policy options are therefore discussed in Section 10 and relate to a set of emerging policies being considered by the Council for inclusion to the draft Local Plan as follows:

- Core Policy 1 – Delivering carbon neutral by 2030
- Delivery Policy ES1 – Sustainable construction and design
- Delivery Policy ES2 – Renewable or low carbon energy generation
- Delivery Policy DES3 – Heat supply

An overarching objective therefore lies in ensuring that policies rise to the challenge of approaching net-zero carbon by 2030 whilst keeping within the bounds of the statutory planning system to ensure they are formally adopted.

Policies need to be developed through drawing on a local evidence base, interpretation of national guidance such as the NPPF, PPG and Ministerial Statements, examining case law and extensive consultation. However, anticipating and awaiting future changes in what has lately been a very slow moving national environmental policy agenda can be challenging for local authorities and so many

have taken the initiative to push boundaries in their local plans to better align with their own priorities, such as climate emergency declarations and the mitigating actions that must follow.

Furthermore, the current consultation on Part L of the Building Regulations is now questioning whether local authorities will continue to have the power to set local building energy performance standards above national standards whilst proposing a 75-80% cut in emissions from new dwellings as part of a 'Future Homes Standard' from 2025. Considering the proximity of Stroud District's net-zero 2030 target, the Council should therefore look to bridge the gap to net-zero carbon new homes by enacting suitably ambitious policies as soon as possible.

13 Recommendations

13.1 Draft Local Plan policies

Recommendations with regard to the emerging delivery policies for the draft Local Plan that relate to renewable and low carbon energy generation are as follows:

13.1.1 Delivery Policy ES1 – Sustainable construction and design

This policy should include an onsite low or zero carbon energy generation requirement for all development with a minimum fabric energy efficiency backstop, and include carbon offsetting as a mechanism through which developers can financially contribute in order to mitigate residual emissions that can't be addressed onsite. This will ensure that net-zero carbon developments are achieved in terms of regulated emissions and are based on the principles behind Policy SI2 in the draft new London Plan.

A carbon offset fund should be carefully designed to incentivise developers to mitigate a maximum amount of emissions through onsite measures before resorting to offset payments. Proceeds from the fund should be used wisely to secure genuinely additional emission savings that would not have occurred otherwise. It is also suggested that a requirement is introduced to quantify and minimise unregulated emissions, at least for major developments.

It should also be noted that in October 2019 a consultation was launched on Part L of the Building Regulations and changes are likely to be introduced during 2020 (see Section 2.2.1) which may impact elements of the above policy.

13.1.2 Delivery Policy ES2 – Renewable or low carbon energy generation

This policy should make specific reference to the Council's 2030 carbon neutral target in order to emphasise that appropriate weight will be given in this context when considering the impact of development proposals.

In keeping with NPPF statements on wind energy, this policy should also be accompanied by maps showing areas *"suitable for wind energy development"* i.e. the technical constraint maps included in Appendix 3. The landscape sensitivity maps can potentially be overlaid with the technical constraint maps, or otherwise referred to, in order to identify areas which are less sensitive to the different scales of wind turbines and hence identify locations where proposals are more likely to be supported.

To avoid strictly ruling out all wind development in areas not identified in the technical constraint maps but which may justifiably under certain criteria still hold potential for wind development, it is also suggested to include wording to the effect that wind turbines may also be suitable in principle elsewhere if they are located in large new development sites, existing industrial estates or if they are proposed in neighbourhood plans or through community energy schemes. It would however need to be clearly demonstrated that the scale of the development is appropriate to the site, the benefits of the development outweigh any harm to the local community, and that the development complies with the all the remaining relevant criteria within this policy.

It is also recommended that wind turbine separation distances (i.e. proximity to occupied buildings) are not explicitly stated in the policy for reasons given in Section 11.2.

The ground-mounted solar maps included in Appendix 4 should also be referenced as identified areas where development proposals are more likely to be supported, again with reference to the corresponding landscape sensitivity maps to guide development proposals.

13.1.3 Delivery Policy DES3 – Heat supply

It is recommended that a policy on heat supply is included similar to Policy SI3 on Energy Infrastructure in the draft New London Plan. This should take the form of a heat supply hierarchy which aims to discourage the use of gas as a heating fuel and future proof developments bearing in mind Stroud District's 2030 net-zero target and the direction of travel regarding electrification of heat and use of heat pumps (also inferred in the current Building Regulations consultation).

This should assume an order of preference beginning with connection to existing or new low or zero carbon heat networks, followed by use of zero carbon renewable heat or CHP, and finally use of local ambient or secondary heat sources (in conjunction with heat pumps if required – this approach assumes that the electricity grid will continue to decarbonise at a rate that makes this option viable). As this policy encourages heat networks, the Heat Network Priority Areas map (Appendix 5) could be referenced for guidance.

Complying with this policy may in some cases automatically meet the onsite 35% emissions reduction requirement in SE1, but SE1 provides the additionality of ensuring a minimum energy efficiency standard and bridges the gap to net-zero carbon through carbon offsets.

13.2 Further work

The Council should now consider developing a strategy and action plan which sets out in more detail the sequence of events needed to stimulate renewable energy initiatives across the district in support of the net-zero target for 2030. This should build on the evidence presented in this report and focus on actions within the Council's sphere of influence, specifying clear actions, roles, responsibilities, timescales and a plan for regular monitoring and review of progress.

The strategy and action plan should consider the following recommendations:

- **Supplementary Planning Documents (SPD)** – careful consideration should be given to material included within SPD in order to support Core Strategy policy and facilitate effective delivery. This could include further detail on criteria-based policies or areas of search, additional details on the required structure and content of proposals for sustainable energy supply (site energy strategies) submitted as part of planning applications, and details of any carbon offsetting scheme offered to developers.
- **Internal resourcing** – with the proposals for Policy ES1 on emission standards for new developments and considering the forthcoming changes to Part L Building Regulations, local authorities will need to fully understand the implications and prepare in advance for any additional resource capacity needed to manage and implement the requirements. Development Management in particular will need to understand the requirements and the most common solutions so that they can confidently enter into planning negotiations with developers and

adopt systems for checking compliance. If adopted, this would need to include the logistics of a carbon offsetting scheme. Tasks that will be required in implementing policies include:

- The provision of detailed information on the assessment process to officers in both Planning and Development Management, and other officers involved in sustainability issues;
- The provision of detailed information on renewable energy and low carbon technologies to officers in both Planning and Development Management;
- The provision of clear and detailed advice to developers during up-front negotiations, such as: the scope and format of an energy strategy, potential funding options and advice on market leadership and development selling points;
- Specification of monitoring requirements for installations.

- **Facilitating partnerships** – facilitate community and business partnerships and actions across a range of stakeholders including local supply chains and installers. There are a number of options on how to develop the site, and who may end up owning the equipment. This may ultimately depend on the financial business case, but also on the Council's attitude to risk and the resources it can make available to undertake processes such as due diligence, procurement, project management and operation of the site. Collaborate with other local authorities in Gloucestershire and intermediary agencies to build capacity and technical expertise in the sector.
- **Facilitating change** – exploit the Council community leadership role in terms of communicating the arguments, raising awareness of climate change and advising on community and individual action. Also make use of effective communication channels, including social media, to clearly highlight funding opportunities and the local environmental, social and financial benefits of renewable energy projects.
- **Funding mechanisms** – establish different routes to funding for low or zero carbon developments, such as through the formation of an Energy Service Company (ESCo), identifying opportunities to use developer carbon offset funds and exploiting local authority access to low cost, long term clean energy infrastructure finance.
- **Community energy** – build on existing links to community energy groups by offering assistance to those wishing to identify, assess and develop sites for renewables. The Council could provide a facilitation role in a number of areas including helping to identify locations via the current mapping work, feasibility, partnering on share offers and publicity. Similar services could be provided to communities when developing Neighbourhood Plans.
- **Opportunities across local authority corporate estate** – lead by example by continuing to decarbonise energy use across the council estate; given the advantages conferred by local authority access to finance, property/land ownership, accessibility and knowledge of site energy consumption data.
- **Further technical studies** – expand on the renewable energy resource assessment described in this report by considering additional technical studies such as:

- **Heat network analysis** – build on the heat mapping analysis undertaken during this study and examine in more detail the opportunities available for heat networks. An open-source online tool[73] is now available which is principally targeted at local authority officers to help them build in-house capacity in the pre-feasibility planning of heat networks;
- **Woodfuel supply** – develop a strategic plan to establish clean and sustainable woodfuel supply chains across the district;
- **Wind energy deployment** – facilitate further discussion within the community on interpreting landscape sensitivity constraints to different scales of wind power development. This could involve overlaying the technical wind energy assessment maps with the findings of the landscape sensitivity assessment to identify the areas with most potential;
- **Solar assessment** – consider commissioning a GIS-based district-wide solar energy resource assessment which maps the solar resource at rooftop level – so each household and building owner could quickly identify the suitability of their site.
- **Local authority asset survey** – undertake a survey of local authority assets within Stroud District in conjunction with Gloucestershire County Council to explore further investment opportunities for renewable energy installations such as wind, solar PV and renewable heating.

[73] www.thermos-project.eu/home/

Appendix 1 – resource assessment assumptions

Table 18 – Property statistics for Stroud District (2018)	
No of domestic properties	
Terrace/end-terrace dwelling	10,120
Semi-detached dwelling	17,256
Detached dwelling	19,369
Dwelling in purpose-built block of flats or tenement	4,504
Dwelling in part of a converted or shared house (including bedsits)	1,053
Other	827
Total	**53,129**
No of non-domestic properties	
Small/medium commercial buildings <500m2 footprint	2,058 m^2
Large commercial/industrial buildings >500m2 footprint	499 m^2
Total	
Miscellaneous	
Overall proportion of 'off-gas' properties	**14.6%**
Average annual heat demand per dwelling	**11,677 kWh**
Average annual heat demand per non-domestic property	**408,101 kWh**

Table 19 – Future housing development in Stroud District	
Local Plan (to 2031)	
Housing requirements Apr 2006 - 2031	11,400
Completions up to 31st Mar 2015	3,837
Commitments as of 1st Apr 2015	3,948
Outstanding completions	7,563
No. of years to cover	16
No. of homes per year (assuming linear build-out)	473

Table 20 – Emission Factors	
Fuel	**Emission Factor [kgCO_2/kWh]**
Grid electricity	0.233
Mains gas	0.206
Heating oil	0.25
Woodfuel	0.025

Table 21 – Assumptions for roof-mounted solar resource

Solar PV	Solar water heating
• Proportion with suitable roof: ○ 40% of dwellings ○ 80% of non-domestic properties • Capacity Factor: 10% • Av. size of system[A]: ○ Detached: 4.0 kW ○ Semi-detached: 2.6 kW ○ Terrace/end-terrace: 2.2 kW ○ Flats: 0.75 kW ○ Non-domestic 28 kW • Non-domestic assumptions: ○ Average roof size 350 m^2 ○ 75% of roof area suitable for PV ○ Flat roof installation	• Proportion with suitable roof: ○ 50% of dwellings ○ 80% of non-domestic properties • Capacity Factor: 10% • Av. size of system [B]: ○ Domestic: 2.8 kW ○ Non-domestic: 17.7 kW • Heating fuel assumed to be offset: ○ Electricity: 50% of off-gas properties ○ Oil: 50% of off-gas properties ○ Gas: on-gas properties

Notes

[A] average sized domestic system in Stroud District for installations recorded on the FiT Register up to March 2019 was 3.6 m^2.

[B] average sizes taken from RHI deployment statistics Nov 2011 – Aug 2019.

Table 22 – Assumptions for heat pumps

- Uptake: 50% of properties
- Average annual dwelling heating demand: 11,677kWh[A]
- Proportion of annual average dwelling heating demand served by heat pump: 85%
- Average annual non-domestic property heating demand served by heat pump: 12,904kWh[B]
- Average size of air source heat pump[C]:
  - for dwellings: 9.9kW
  - for non-domestic properties: 26.9kW
- SPF of air source heat pump: 3.3[D]
- Main heating fuel used in off-gas areas (estimate):
  - Electricity: 50% of properties
  - Oil: 50% of properties

Notes

[A] Estimated from LSOA domestic gas consumption statistics for Stroud District (2017)

[B] Taken as the average annual heat delivered by air source heat pumps per installation as reported in non-domestic RHI deployment data up to August 2019.

[C] Taken as the average capacity for new installations as reported in domestic and non-domestic RHI deployment data up to August 2019

[D] Taken as the average Seasonal Performance Factor for new installations as reported in domestic RHI deployment data up to August 2019

Table 23 – Woodfuel – assumptions for forestry and woodland resource

• Data from National Inventory of Woodland and Trees
• Does not include 'felled', 'shrub' or 'young trees' categories
• Due to a predominance of broadleaf woodland, the sustainable woodfuel yield is assumed to be 2 odt/yr (oven-dried tonnes/year) source: www.biomassenergycentre.org.uk
• Energy content of wood assumed to be 5,150 kWh/tonne
• Boiler efficiency assumed to be 87% (converting woodfuel to delivered heat)
• Counterfactual heating fuels assumed to be:
  ○ 7.3% of resource offsetting electricity (using proportional proxy of 50% of off-gas properties)
  ○ 7.3% of resource offsetting oil (using proportional proxy of 50% of off-gas properties)
  ○ 85.4% of resource offsetting gas (using proportional proxy of on-gas properties)

Table 24 – Wind Resource Assessment Parameters

Parameter	Assumption	Data source	Justification and Notes
Wind Speed	• All areas with wind speed ≥5 m/s at 50m above ground level (agl)	• Global Wind Atlas/Vortex • Industry practice	The majority of Stroud District meets and exceeds the minimum requirement of 5m/s. Depending on the size of the turbine used the requirements for certain wind speeds change. Some turbine manufacturers produce models which may operate at lower wind speeds and the configuration of certain turbine models can be altered to improve yield in lower wind speed environments. As government policy could change in the future, and technological advances in turbines could improve, lower wind speed conditions can be considered. Therefore, a 5m/s threshold has been set to account for any future developments. Sites below 5m/s would be unlikely to be considered viable for a developer.
Wind turbine size	Four turbine sizes considered: • Very large (150-200m tip height) • Large (100-150m tip height) • Medium (60-100m tip height) • Small (<60m tip height)	• CSE and LUC • Research into turbine manufacturers • BEIS renewable energy planning database and other databases containing information on wind turbine applications	There are no standard categories for wind turbine sizes. The categories chosen are based on consideration of currently and historically 'typical' turbine models at various different scales. The approach is intended to be flexible in the light of uncertainty regarding future financial support for renewable energy. A review of wind turbine applications across the UK showed tip heights ranging from less than 20m up to 200m, with larger turbine models currently in demand from developers to as a result of the loss of financial support from Government. The majority of operational and planned turbines range between 80m and 175m. Due to the structure of the financial support system in the past, smaller turbines (those in the medium to small categories) have tended to be deployed in the past as 1-2 turbine developments.

Table 24 – Wind Resource Assessment Parameters			
Parameter	**Assumption**	**Data source**	**Justification and Notes**
Roads	• Roads with a buffer of the height of the turbine (to blade tip height) +50m. • Highways boundary.	• Ordnance Survey VectorMap District. • Highways England • Note: single and dual carriageways were extracted and separated out from main dataset. In order to create a footprint from the road centre line data, it was assumed that single carriageways were 10m in width and Motorways were 20m in width.	This buffer is applied as a safety consideration.
Railways	• Railways with a buffer of the height of the turbine (to blade tip height) + 50m.	• Ordnance Survey VectorMap District. • Note: In order to create a footprint from the railway centrelines data, it was assumed that railways were 15m in width.	This buffer is applied as a safety consideration.
Transmission lines	• Major transmission lines with a buffer of the height of the turbine (to blade tip height) +50m.	• National Grid	This buffer is applied as a safety consideration.
Public Rights of Way **Cycle Paths**	• Public Rights of Way and cycle paths with a buffer of the height of the turbine (to blade tip height) +50m.	• Stroud District Council • SusTrans • Note: In order to create a footprint from the railway centrelines data, it was assumed that Public Rights of Way and Bridleways were 2m in width.	This buffer is applied as a safety consideration.

Table 24 – Wind Resource Assessment Parameters

Parameter	Assumption	Data source	Justification and Notes
NATS Safeguarding Areas	Guidance includes the following safeguarding areas: • 30km for aerodromes with a surveillance radar facility. • 17km for non-radar equipped aerodromes with a runway of 1,100 m or more, or 5km for those with a shorter runway. • 4km for non-radar equipped unlicensed aerodrome with a runway of more than 800m or 3km with a shorter runway. • 10km for the air-ground-air communication stations and navigation aids. • 15 nautical miles (nm) for secondary surveillance radar.	• NATS	Further consultation between potential developers and NATS is required to determine if there is any impact from a proposed development.

Noise	• Residential and commercial buffer zones
	• The distance at which unacceptable noise emissions are caused by wind turbines is variable in practice. However, based on a combination of specialist advice and professional judgement /experience, residential and commercial properties have been given a buffer to exclude areas within which it would it would typically be expected that ETSU-R-97 noise limits could not be met:
	  ○ Small: 200m for residential, 150m for commercial
	  ○ Medium: 500m for residential, 200m for commercial
	  ○ Large: 600m for residential, 300m for commercial
	  ○ Very large: 750m for residential, 350m for commercial
	• For properties outside (but close to) the Borough Boundary, indicative buffers have been applied to the available property/ buildings data.
		• Stroud District Council Local Land and Property Gazetteer (LLPG) Residential and Commercial address points
		• OS OpenMapLocal Buildings layer for buildings adjacent to the Borough Boundary
		• OS_Buildings
			The two main issues that determine the acceptable separation distance between residential properties and wind energy developments are visual amenity and noise. Commercial-scale wind turbines are large structures and can effect visual amenity from residential properties. All wind turbines also generate sound during their operation. As such, appropriate distances should be maintained between wind turbines and sensitive receptors to protect residential amenity. The key question however is whether buffer distances should be applied (to take account of noise issues) when identifying suitable areas for wind energy developments.
			In order to secure planning permission, wind turbine applications must provide evidence that they adhere to the required noise thresholds set out in the ETSU Guidance – The Assessment and Rating of Noise from Wind Farms (1995) (as supplemented by the Institute of Acoustics). Based on the opinion of acoustic specialists, buffers have been defined for areas within which it would categorically not be possible to meet the ETSU-R-97 noise limits. For large and very large turbines, an additional buffer has been applied to rule out areas within which it would be highly unlikely, but not categorically impossible, to site wind turbines and still meet ETSU-R-97 noise limits.
			Shadow flicker has not been considered as a constraint in this study due to the possibility of mitigating shadow flicker effects.

Built up environment areas	• Settlements	• Stroud District council	Largely built up areas not generally suitable for wind turbine development (although there may be some limited potential for individual turbines to be developed on brownfield employment land where suitably separated from residential properties).
Future	• Strategic site allocations from adopted Stroud Local Plan	• Stroud District council	Generally unsuitable for wind turbine development.

Table 24 – Wind Resource Assessment Parameters			
Parameter	**Assumption**	**Data source**	**Justification and Notes**
developments			
Existing Renewable Energy Developments	• Land boundaries of consented and operational renewable energy installations	• BEIS • Land Registry	The quarterly BEIS Renewable Energy Planning Database[74] was used to determine the locations of operational and consented renewable energy installations, supplemented by input from Stroud District Council. This information was cross-referenced with Inspire land boundary data obtained from the Land Registry.
Natural features	• Slopes greater than 15 degrees.	• EU DEM 25m	This is a development/ operational constraint. Developers have indicated that this is the maximum slope they would generally consider feasible for development. Although theoretically possible to develop on areas exceeding 15° slopes, turbine manufacturers are unlikely to allow turbine component delivery to sites where this is exceeded.
Water Environment	• Watercourses, waterbodies and Severn Estuary with a 50m buffer.	• Ordnance Survey Rivers • Ordnance Survey VectorMap District	A 50m buffer has been applied around all rivers and waterbodies to take account of good practice such as that relating to pollution control during construction.
Woodland	• Woodland as shown on the National Forest Inventory and Ancient Woodland Inventory	• Forestry Commission • Natural England	All areas of woodland are excluded with a blade radius + 50m buffer to reduce risk of impact on bats.
Biodiversity	International designations: • Special Protection Areas (SPA) • Special Areas of Conservation (SAC) • RAMSAR	• Natural England	As protected by: • Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, commonly known as the Habitats Directive. • Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds, commonly known as the Birds Directive. • Conservation of Habitats and Species Regulations 2010 (as amended). • A blade radius buffer has been applied to avoid oversail of the protected areas/assets.
Biodiversity	• National designations: • Sites of Special Scientific Interest • National Nature Reserves	• Natural England	As protected by: • Wildlife and Countryside Act 1981. • Conservation of Habitats and Species Regulations 2010 (as amended). • A blade radius buffer has been applied to avoid oversail of the protected areas/assets.
Biodiversity	Other designations: • Local Nature Reserves • Gloucestershire Wildlife Trust Reserves • Key Wildlife Sites	• Natural England • Stroud District Council • Gloucestershire Wildlife Trust	Generally would not be suitable for renewables development based on law/policy/guidance including: • National Planning Policy Framework. • Natural Environment and Rural Communities Act 2006. A blade radius buffer has been applied to avoid

[74] www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract

Table 24 – Wind Resource Assessment Parameters			
Parameter	**Assumption**	**Data source**	**Justification and Notes**
			oversail of the protected areas/assets.
Cultural heritage	• World Heritage Sites (none within Stroud boundary) • Registered Parks and Gardens • Scheduled Monuments • Listed Buildings • Registered Battlefields (none within Stroud boundary)	• Historic England • Stroud District Council	As protected by: • National Planning Policy Framework. • The Convention Concerning the Protection of the World Cultural and Natural Heritage. • National Heritage Act 1983. • Ancient Monuments and Archaeological Areas Act of 1979. • Planning (Listed Buildings and Conservation Areas) Act 1990. A blade radius buffer has been applied to avoid oversail of the protected areas/assets.

Table 25 – Solar Resource Assessment Parameters			
Parameter	**Assumption**	**Data source**	**Justification and Notes**
Physical, Land Use and Infrastructure	• Roads • Railway • Major overhead transmission lines • Public Rights of Way and Bridleways • Severn Estuary, watercourses and waterbodies • Operational Minerals Sites with 250m buffer • Agricultural land use classifications grades 1 and 2 (Ground Mounted Solar PV projects, over 50kWp, should ideally utilise previously developed land, brownfield land, contaminated land, industrial land or agricultural land preferably of classification 3b, 4, and 5) • Common Land • Existing Green Space	• Roads: OS VectorMap District • Note: single and dual carriageways extracted and separated out from main dataset. In order to create a footprint from the road centrelines data, it was assumed that single carriageways were 10m in width and dual carriageways were 20m in width. • Railways: OS VectorMap District • Note: In order to create a footprint from the railway centrelines data, it was assumed that railways were 15m in width. • Other Datasets: • National Grid, Stroud District Council, Natural England	Physical features were taken into account which prevent the development of solar PV. There is no requirement for safety buffers in relation to these. Operational mineral sites have been buffered to account for dust emissions which will affect the generation output. Research has shown that 98% of airborne dust settles within 250m of the emission source. Agricultural Land Use is a consideration, with grade 1 and 2 land having higher value for food production. Further investigation would be required of grade 3 land to determine whether it is grade 3a or b, as available data does not distinguish these.

Table 25 – Solar Resource Assessment Parameters			
Parameter	**Assumption**	**Data source**	**Justification and Notes**
Natural environment	• Special Areas of Conservation • Special Protection Areas • Ramsar • Sites of Special Scientific Interest • National Nature Reserves • Sites of Importance for Nature Conservation • Local Nature Reserves • Ancient woodland • Other woodland areas • Gloucestershire Wildlife Trust Reserves • Key Wildlife Sites	• Natural England • Defra Spatial data layers • Stroud District Council • Forestry commission • Gloucestershire Wildlife Trust • Note: Forested areas buffered by 20m to account for shading and impacts on solar output.	As protected by: • Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, commonly known as the Habitats Directive. • Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds, commonly known as the Birds Directive. • Conservation of Habitats and Species Regulations 2010 (as amended). • Wildlife and Countryside Act 1981. • Conservation of Habitats and Species Regulations 2010 (as amended). • National Planning Policy Framework. • Natural Environment and Rural Communities Act 2006.
Historic environment	• Scheduled monuments • World heritage sites • Registered battlefields • Registered parks and gardens • Listed buildings • Conservation Areas	• Historic England • Stroud District Council	As protected by: • National Planning Policy Framework. • The Convention Concerning the Protection of the World Cultural and Natural Heritage. • National Heritage Act 1983. • Ancient Monuments and Archaeological Areas Act of 1979. • Planning (Listed Buildings and Conservation Areas) Act 1990.
Terrain	• Slope and aspect – exclude areas with north-east to north-west aspect and inclinations greater than 3 degrees, exclude all areas greater than 10 degrees	• EU DEM 25m	Although it is possible to develop Solar PV installations on slopes facing north-east to north-west, it would be generally not be economically viable to do so. However, those slopes that are north facing and below 3° are considered, as generation output will not be significantly affected.
Built up environment areas	• Settlements	• Stroud District Council	Largely built up areas not generally suitable for ground mounted solar (although there may be some limited potential for installations on undeveloped land/open space within these areas)
Future developments	• Strategic site allocations from adopted Stroud Local Plan	• Stroud District Council	Generally these will be unsuitable for ground-mounted solar, although there may be some potential for installations on undeveloped land/open space within these areas.
Existing Renewable Energy Developments	• Land boundaries of consented and operational renewable energy installations	• BEIS • Land Registry	The BEIS quarterly renewable energy database was used to determine the locations of operational and consented renewable energy installations. This was cross-referenced with Inspire Land boundary data obtained from the Land Registry

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Appendix 2– Landscape Sensitivity Assessment methodology

Approach to Assessment

1.1 The approach to the landscape sensitivity assessment has involved the following two key stages:

1. Identification of the key characteristics of wind and solar energy development and their potential effects on the landscape, to inform the development of a methodology for the assessment of landscape sensitivity;
2. Assessment of the sensitivity of the different landscape character areas in Stroud District to wind turbine and solar energy development at a range of scales.

1.2 These two stages are discussed in more detail in the following sections.

1) Potential effects of wind and solar energy development on the landscape

1.3 In order to minimise effects on the landscape through siting and design, it is important to first understand the characteristics of wind and solar energy development and how they may affect the landscape. The following section describes the features of these developments and considers the potential impacts on the landscape.

1.4 In undertaking any landscape sensitivity assessment it is necessary to acknowledge that varying attitudes to wind and solar energy development are expressed by different individuals and communities. Aesthetic perceptions can be positive or negative depending on individual attitudes to the principle and presence of renewable energy.

1.5 During the stakeholder consultation event for this study, individual consultees also raised questions concerning the variability of perception of landscape sensitivity in general. In particular, it was questioned whether landscape sensitivity appraisal generally gives insufficient weight to the contribution of particular landscape types to the mitigation or exacerbation of climate change, and the potential effect of this contribution upon the perception of sensitivity. It was argued specifically that landscapes that make a low or negative contribution to the mitigation of climate change might, for that reason, legitimately be perceived as of lower sensitivity.

1.6 Consistent with the observation above concerning varying aesthetic perceptions of wind and solar development, it is acknowledged that perceptions of landscape sensitivity to these (and other) development types do indeed vary between individuals, and even that the consensus concerning sensitivity may vary between communities and/or could vary over time. However, the present assessment has been based on an evaluative framework that is endorsed as good practice for studies of this nature, including via expression in national guidance and testing at Examination/appeal. It is considered more appropriate to apply the environmental and other benefits of renewable energy, for example, as positive considerations within the overall planning balance, rather than for these benefits to modify the evaluation of landscape sensitivity per se.

Landscape effects of wind turbines

1.7 Wind turbines can be substantial vertical structures, and larger models will inevitably be highly visible within the landscape. The movement of the blades is a unique feature of wind energy developments, setting them apart from other tall structures in the landscape such as masts or pylons. Wind energy development may affect the landscape in the following ways:

- construction of large turbines and associated infrastructure may result in direct loss of landscape features;
- wind turbines are tall vertical features that may alter the perception of a landscape, potentially affecting the apparent scale of landforms;
- movement of rotor blades may affect characteristics of stillness and solitude, as well as drawing the eye to turbines which may be a relatively small feature in the landscape;
- the presence of turbines may increase the perceived human influence on the landscape, particularly in terms of overt modern development, and this can particularly affect landscapes which have a strong sense of naturalness or wild qualities, or which form a setting to heritage assets;
- wind turbines, even at relatively small sizes, can appear large in the context of human-scale features such as domestic buildings and trees – at the largest scales, turbines can be perceived as 'overwhelming' when close to residential properties;
- turbines on skylines may compete with existing landmark features for prominence where prominent skylines or landmark features are characteristic of the landscape; and
- in order to be as efficient as possible, turbines are often placed in elevated locations, where they may affect views from wide areas.

Landscape effects of solar energy development

1.8 Solar energy developments can be substantial horizontal structures and can be highly visible and contribute to considerable change in the character of the landscape. Solar energy development may affect the landscape in the following ways:

- construction of solar panels and associated infrastructure may result in direct loss of landscape features such as hedgerows, woodland, farmland and other habitat;
- solar energy developments can cover large areas and the presence of solar panels may increase the perceived human influence on the landscape, particularly in terms of overt modern development, and this can particularly affect landscapes which have a strong sense of naturalness, or which form a setting to heritage assets; and
- at certain times of day and from certain viewing angles solar panels can reflect the sunlight, causing glint and glare which can draw the eye.

Typologies

1.9 A range of scales of development have been considered in the sensitivity assessment. The 'size' of a wind energy development can be defined by the number of turbines and/or the height of turbines. The number of turbines is an important factor in determining the suitability of a proposal in its host landscape. However, it is turbine height which is most likely to be the determining factor for the assessment of landscape sensitivity, since it is the scale of the turbine which generally defines whether it can be accommodated in the landscape. Where a large turbine cannot be accommodated due to incompatibility of scale, then this will apply whether one or many turbines are proposed.

1.10 The size of a solar energy development can also differ greatly, in terms of power output and area covered. Schemes in the UK range in area from less than 1 hectare, up to well over 100 hectares.

1.11 sets out the range of 'typologies' or 'development scenarios' considered in the assessment.

Table 26: Landscape sensitivity development scenarios

Typology
Wind
Small-scale wind turbines (<60 metres)
Medium-scale wind turbines (60-100 metres)
Large-scale wind turbines (100-150 metres)
Very large wind turbines (150-200 metres)
Solar
Small solar PV installation (<5 hectares)
Medium solar PV installation (5-20 hectares)
Large solar PV installation (20-50 hectares)
Very large solar PV installation (50-100 hectares)

2) Assessment of landscape sensitivity

1.12 The landscape sensitivity assessment method has been developed in accordance with the Natural England guidance[75] published in June 2019, as well as building upon LUC's considerable experience from previous and ongoing studies of a similar nature. The guidance includes the following definition:

"*Landscape sensitivity may be regarded as a measure of the resilience, or robustness, of a landscape to withstand specified change arising from development types or land management practices, without undue negative effects on the landscape and visual baseline and their value.*"

1.13 Wind turbine and solar energy development will affect different characteristics of the landscape in different ways. It is therefore important to understand the nature and sensitivity of different components of landscape character, and to set these out and assess them in a consistent and transparent fashion. In order to do this, a set of criteria will be used to highlight specific landscape and visual characteristics which are most likely to be affected by wind and solar energy development.

1.14 **As with all assessments based upon data and information which is to a greater or lesser extent subjective, some caution is required in its interpretation.** This is particularly to avoid the suggestion that certain landscape features or qualities can automatically be associated with certain sensitivities – the reality is that an assessment of landscape sensitivity is the result of a complex interplay of often unequally weighted variables (i.e. 'criteria').

1.15 Landscape sensitivity often varies within LCAs, with areas exhibiting of higher and lower sensitivity. It is therefore very important to take note of the explanatory text supporting the assessments in each LCA profile, particularly the box entitled 'Notes on any variations in landscape sensitivity'. Whilst the Landscape Sensitivity Assessment results provide an initial indication of landscape sensitivity, they **should not be interpreted as definitive statements on the suitability of individual sites for a particular development.** All proposals will need to be assessed on their own merits through the planning process, including – where required – through proposal-specific Landscape and Visual Impact Assessments (LVIAs).

Assessment criteria

1.16 Table 27 sets out the criteria used to evaluate the sensitivity of landscape character types to wind turbine development, and the aspects of the landscape which were considered to indicate higher or lower sensitivity. Table **28** sets out the alternative criteria used to evaluate the sensitivity of landscape character types to solar energy development, and the aspects

[75] An approach to landscape sensitivity assessment– to inform spatial planning and land management. Natural England. June 2019.

considered to indicate higher or lower sensitivity. Where the criteria for solar energy developments are very similar to that identified for wind energy development, they are not repeated.

1.17 For each criterion, a short explanation is provided as to why it is indicative of sensitivity to the type of development proposed, and what key characteristics of the landscape will be considered. Information sources are given for each criterion. The examples provide more detail as to what level of sensitivity will be assessed for landscapes displaying certain characteristics: these are examples only, based on generic descriptions. The five defined levels form stages on a continuum, rather than clearly-separated categories. Any given landscape may or may not fit neatly into one category, and an element of professional judgement is therefore required.

Wind Turbines

Table 27: Sensitivity assessment criteria for wind turbine development

Landform and scale				
A simple, smooth, gently sloping or flat landform is more likely to be able to accommodate wind energy development than a landscape with a dramatic rugged landform, distinct landform features and/or pronounced undulations. Larger scale landforms are likely to be less sensitive than smaller scale landforms since, in the latter case, turbines may appear out of scale, detract from visually important landforms and/or appear visually confusing due to turbines being at varying elevations. Information sources: Landscape Character Assessment; OS maps; fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
An extensive flat lowland landscape or elevated plateau, often a larger scale landscape with no distinctive landform features.	A simple, gently rolling landscape, likely to be of medium-large scale, without distinctive landform.	An undulating landscape, perhaps also incised by valleys, likely to be of medium scale.	A landscape with distinct landform features, and/or irregular in topography (which may be large in scale), or a smaller scale landform.	A landscape with a distinctive, rugged landform or dramatic topographical features (which may be large in scale), or a small scale or intimate landform.

Land cover pattern and presence of human scale features
Simple, regular landscapes with extensive areas of consistent land cover are likely to be less sensitive to wind energy development than landscapes with more complex or irregular land cover patterns, smaller and / or irregular field sizes, and landscapes with frequent human-scale features that are traditional to the landscape, such as red-brick villages, farmsteads, small farm woodlands, trees and hedges. This is because larger wind turbines may dominate traditional human scale features within the landscape. Information sources: Landscape Character Assessment; OS maps; aerial photography; fieldwork.

Land cover pattern and presence of human scale features				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
An open, continuous landscape with uniform land cover and lacking in human-scale features.	A landscape of large open fields, little variety in land cover, with occasional human-scale features such as trees and domestic buildings.	A landscape with medium sized fields, some variations in land cover and presence of human-scale features such as trees and domestic buildings.	A landscape with irregular or small-scale fields, variety in land cover and presence of human-scale features such as trees and domestic buildings.	A landscape with a strong variety in land cover, and complex patterns, containing numerous human-scale features.

Tracks / transport pattern				
Landscapes that are devoid of tracks will be particularly sensitive to wind energy development because it will be more difficult to absorb permanent new tracks into the landscape without change to character in these areas. In addition, if a Landscape Character Area has a rural road network which contributes to landscape character (e.g. winding narrow lanes bounded by high hedgebanks or sunken lanes), this aspect of character may be affected by access works to enable HGVs carrying turbines to a site. This characteristic therefore also influences sensitivity. Information sources: Landscape Character Assessment; Ordnance survey basemaps showing presence of tracks; fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
e.g. a landscape containing existing roads and vehicular tracks, and no restrictions in terms of narrow hedged lanes	e.g. a landscape containing existing roads and vehicular tracks, and few restrictions in terms of narrow hedged lanes	e.g. a landscape containing some existing roads and vehicular tracks, including some restrictions in terms of narrow hedged lanes	e.g. a landscape containing few lanes or vehicular tracks, and these are predominantly narrow lanes bounded by high hedgebanks	e.g. a landscape devoid of roads or vehicular tracks

Skylines / intervisibility
Prominent and distinctive and/or undeveloped skylines, or skylines with important landmark features, are likely to be more sensitive to wind energy development because turbines may detract from these skylines as features in the landscape, or draw attention away from existing landform or landmark features on skylines. Important landmark features on the skyline might include historic features or monuments as well as landforms. Where skylines are affected by development, e.g. through the presence of electricity pylons, the addition of turbines may lead to visual confusion, and as such this may not be a consistent indicator of reduced sensitivity. The relative visibility of a landscape may influence its sensitivity. An elevated landscape such as a hill range or plateau, which is viewed from other landscapes, may be more sensitive than an enclosed landscape, since any turbines will be more widely seen. Landscapes which have important visual relationships with other areas, for example where one area provides a backdrop to a neighbouring area, are considered more sensitive than

Skylines / intervisibility				
those with few visual relationships. The extent of inter-visibility may be modified by the importance of these views to appreciation of the landscape, and whether adjacent landscapes provide a setting for one another. Information sources: Landscape Character Assessment; fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		⟷		**Higher sensitivity**
e.g. A landscape in which skylines are not prominent, and there are no important landmark features on the skyline. An enclosed, self-contained landscape, or one with weak connections to neighbouring areas.	e.g. A landscape in which skylines are simple, flat or gently convex and/or there are very few landmark features on the skyline – other skylines in adjacent LCTs may be more prominent. A landscape with limited connections to neighbouring areas, and/or where adjacent landscapes are not visually related.	e.g. A landscape with some prominent skylines, but these are not particularly distinctive – there may be some landmark features on the skyline. A landscape which has some inter-visibility with neighbouring areas, and/or where relationships between adjacent landscapes are of more importance.	e.g. A landscape with prominent skylines that may form an important backdrop to views from settlements or important viewpoints, and/or with important landmark features. A landscape which is intervisible with several areas, and/or where adjacent areas are strongly interrelated.	e.g. A landscape with prominent or distinctive undeveloped skylines, or with particularly important landmark features on skylines. A landscape which has important visual relationships with one or more neighbouring areas.

Perceptual qualities				
Landscapes that are relatively remote or tranquil tend to be more sensitive to wind energy development, since turbines may be perceived as intrusive. Landscapes which are relatively free from overt human activity and disturbance, and which have a perceived naturalness or a strong feel of traditional rurality, will therefore be more sensitive. Qualities such as tranquillity can be found even in settled areas, where the influence of overtly modern development is reduced. Wind turbines will generally be less intrusive in landscapes which are strongly influenced by modern development, including settlement, industrial and commercial development and infrastructure. Information sources: Landscape Character Assessment; OS maps, fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		⟷		**Higher sensitivity**
A landscape with much human activity and modern development, such as industrial areas.	A rural or semi-rural landscape with much human activity and dispersed modern development, such as settlement fringes.	A rural landscape with some modern development and human activity, such as intensive farmland.	A more naturalistic landscape and/or one with little modern human influence and development.	A tranquil landscape with little or no overt sign of modern human activity and development.

Historic Landscape Character				
Landscapes which contain important archaeological or historic features are likely to have a higher level of sensitivity to wind energy development. Historical features may be in the form of historic land cover types and field systems, areas of buried archaeology, historic designed landscapes such as Registered Parks and Gardens or structures designated for their historical significance. Landscapes which make a significant contribution to the setting of a historical feature or landscapes may also have higher sensitivity to wind energy development. Landscapes that are primarily of modern influence and origin will have a lower sensitivity to wind energy development. Information sources: Landscape Character Assessment, Scheduled Monuments, World Heritage Sites, Registered Battlefields, Conservation Areas, Listed Buildings, Registered Parks and Gardens.				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
e.g. A landscape with relatively few historic features important to the character of the area and little time depth (i.e. large intensively farmed fields).	e.g. a landscape with a small number of historic features important to the character area and some time depth.	e.g. A landscape with some visible historic features of importance to character, and a variety of time depths.	e.g. a landscape with many historic features important to the area and a strong sense of time depth.	e.g. A landscape with a high density of historic features important to the character of the area and great time depth (i.e. piecemeal enclosure with irregular boundaries, ridge and furrow)

Scenic and special qualities				
Landscapes that have a high scenic quality will be more sensitive than landscapes of low scenic quality. Scenic qualities can include contrasts and combinations of landform and landcover which together contribute to attractive views. Scenic qualities may be recorded in the Landscape Character Assessment, or may be referenced in tourist material. Scenic viewpoints may be marked on Ordnance Survey maps. Scenic quality is also considered in the field. Information sources: Landscape Character Assessment; OS maps; tourist literature; fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
A landscape without attractive character, with no pleasing combinations of features, visual contrasts and/or dramatic elements, such as industrial areas or derelict land.	A landscape of limited attractive character, with few pleasing combinations of features, visual contrasts and/or dramatic elements.	A landscape of intermittently attractive character, with occasional pleasing combinations of features, visual contrasts and/or dramatic elements.	A landscape of attractive character, with some pleasing combinations of features, visual contrasts and/or dramatic elements.	A landscape of consistently attractive character, with pleasing combinations of features, visual contrasts and/or dramatic elements.

Solar developments

1.18 The following alternative criteria, as outlined in Error! Reference source not found., have een considered in relation to the landscape sensitivity for solar energy development. Where the criteria are very similar to that identified for wind energy development, they are not repeated here. It should also be noted that due to the horizontal nature of solar energy development, skylines are less of an important consideration when assessing landscape sensitivity.

Table 28: Sensitivity assessment criteria for solar energy development

Landform and scale				
A flat or gently undulating lowland landscape or extensive plateau is likely to be less sensitive to solar development than a landscape with prominent landforms and visible slopes, including coastal headlands. This is because arrays of solar panels will be less easily perceived in a flat landscape than on a slope, especially higher slopes. Larger scale landforms are also likely to be less sensitive than smaller scale landforms. Information sources: Landscape Character Assessment; OS maps; fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
A lowland flat landscape or extensive plateau. Larger scale landscape.	A gently undulating lowland landscape or plateau.	An undulating landscape with hidden areas as well as some visible slopes.	A landscape with many prominent, visible slopes or an upland landscape.	Very steep landform and exposed, visible slopes. Smaller scale landscape.

Land cover pattern and presence of human scale features				
Since solar panels introduce a new land cover (of built structures), landscapes containing existing hard surfacing or built elements (e.g. urban areas, brownfield sites or large-scale horticulture) are likely to be less sensitive to field-scale solar development than highly rural or naturalistic landscapes. Landscapes with small-scale, more irregular field patterns are likely to be more sensitive to the introduction of solar development than landscapes with large, regular scale field patterns because of the risk of diluting or masking the characteristic landscape patterns. This would be particularly apparent if development takes place across a number of adjacent fields where the field pattern is small and intricate (bearing in mind that the height of panels could exceed that of a hedge). Information sources: Landscape Character Assessment; OS Maps; aerial photography; fieldwork.				
Examples of sensitivity ratings				
Lower sensitivity		← →		**Higher sensitivity**
Urban or 'brownfield' landscape. Large-scale, regular fields of mainly modern origin.	Area of large-scale horticulture. Mainly defined by large, modern fields.	Rural landscape, perhaps with some brownfield sites or urban influences. Mixture of large-scale, modern fields and some smaller, more historic enclosure.	Rural landscape, perhaps with some areas of semi-natural land cover. Dominated by ancient, small-scale field patterns with a few isolated areas of modern enclosure.	Landscape dominated by semi-natural land cover. Where a field pattern exists this is characterised by small-scale, ancient fields.

Assessment method

1.19 The landscape sensitivity study is based on an evaluation of key aspects of the Stroud District Landscape Character Assessment (2000). The key characteristics of each landscape character area (LCA) were assessed against each of the criteria to arrive at a judgement as to their potential sensitivity to wind turbine and solar energy development.

1.20 Sensitivity is judged on a five-point scale from 'high' to 'low' as set out in Table 29. The process is based on professional judgement and the relative importance of each criterion varies between LCAs; key characteristics may identify where a particular criterion is more important, and should therefore be given greater weight in the judgement of sensitivity.

Table 29: Sensitivity definitions

Sensitivity Level	Definition
High	Key characteristics and qualities of the landscape are highly vulnerable to change from wind and solar energy development. Such development is likely to result in a significant change in character.
High-moderate	Key characteristics and qualities of the landscape are vulnerable to change from wind and solar energy development. There may be some limited opportunity to accommodate wind turbines/ solar panels without significantly changing landscape character. Great care would be needed in siting and design.
Moderate	Some of the key characteristics and qualities of the landscape are vulnerable to change. Although the landscape may have some ability to absorb wind and solar energy development, it is likely to cause a degree of change in character. Care would be needed in siting and design.
Moderate-low	Fewer of the key characteristics and qualities of the landscape are vulnerable to change. The landscape is likely to be able to accommodate wind and solar energy development with limited change in character. Care is still needed when siting and designing to avoid adversely affecting key characteristics.
Low	Key characteristics and qualities of the landscape are robust in that they can withstand change from the introduction of wind turbines and solar panels. The landscape is likely to be able to accommodate wind and solar energy development without a significant change in character. Care is still needed when siting and designing these developments to ensure best fit with the landscape.

1.21 The assessment was carried out initially as a desk-based exercise, drawing on information in the 2000 landscape character assessment and other sources identified for each criterion. This was followed up with field work (undertaken in September 2019) to view each LCA in the field and make any additional observations. Field work was particularly important for criteria such as skylines and inter-visibility, which may not be consistently described in the available documentation, and also assists with verification of desk-based material.

1.22 The sensitivity assessment identifies the underlying sensitivity of the landscape, as it appears at the time of the survey. It therefore will consider operational development but not potential cumulative change.

Findings

1.23 The detailed assessments for each character are set out in the supplementary annex to this report 'Assessment of Landscape Character Areas in Stroud District'.

1.24 For each area, the assessment provides:

- A map of the landscape character area and representative photographs.
- A description of the LCA against each of the assessment criteria.
- An overall judgement on landscape sensitivity for the LCA, in relation to each of the development scenarios /typologies.
- Notes on any variations in landscape sensitivity within the LCA.

1.25 Table 30 summarises the findings of the sensitivity study for each LCA and in relation to each of the development scenarios, as described in detail above. The mapped results are included in Appendices 3 and 4.

Table 30: Summary of Landscape Sensitivity Assessment findings

		Wind scenarios				Solar scenarios			
		Small-scale wind turbines (<60 metres)	Medium-scale wind turbines (60-100 metres)	Large-scale wind turbines (100-150 metres)	Very large wind turbines (150-200 metres)	Small solar PV installation (<5 hectares)	Medium solar PV installation (5-20 hectares)	Large solar PV installation (20-50 hectares)	Very large solar PV installation (50-100 hectares)
LCAs	Escarpment	H	H	H	N/A	M-H	H	H	H
	Escarpment Foot Slopes	M-H	M-H	H	N/A	M	M	M-H	H
	Frome River Valley	M	H	N/A	N/A	L-M	M	H	H
	Kingswood Vale – North	M	M-H	H	N/A	L-M	M	M-H	H
	Kingswood Vale – South	M	M-H	H	N/A	L-M	M	M-H	H
	Little Avon Basin	M	M-H	H	N/A	L-M	M	M-H	M-H
	Little Avon Mid-Valley	M	H	H	N/A	M	M	M-H	H
	Lowland Plain	L-M	M	M-H	H	L	L	L-M	M
	Lowland Ridges	M	M-H	N/A	N/A	L-M	M	H	H
	Rolling Valleys	H	H	H	N/A	M-H	H	H	H
	Sandstone Ridge	M	M-H	H	N/A	L-M	M	M-H	M-H
	Secluded Valleys	H	H	H	H	M	M-H	H	H
	Severn Vale Grazing	L-M	M	M-H	H	L	L-M	M	M-H

		Wind scenarios				Solar scenarios			
		Small-scale wind turbines (<60 metres)	Medium-scale wind turbines (60-100 metres)	Large-scale wind turbines (100-150 metres)	Very large wind turbines (150-200 metres)	Small solar PV installation (<5 hectares)	Medium solar PV installation (5-20 hectares)	Large solar PV installation (20-50 hectares)	Very large solar PV installation (50-100 hectares)
	Marshland								
	Severn Vale Hillocks	M	M-H	H	N/A	M	M-H	H	H
	Triassic Ridge	H	H	H	N/A	M-H	H	H	H
	Wold Tops	M-H	H	H	H	M	M-H	H	H
	Wooded Cambrian Ridge	M	M-H	N/A	N/A	L-M	M	H	H
	Wooded Lowlands	M	H	H	N/A	L-M	M	M-H	H

Appendix 3 – Wind maps

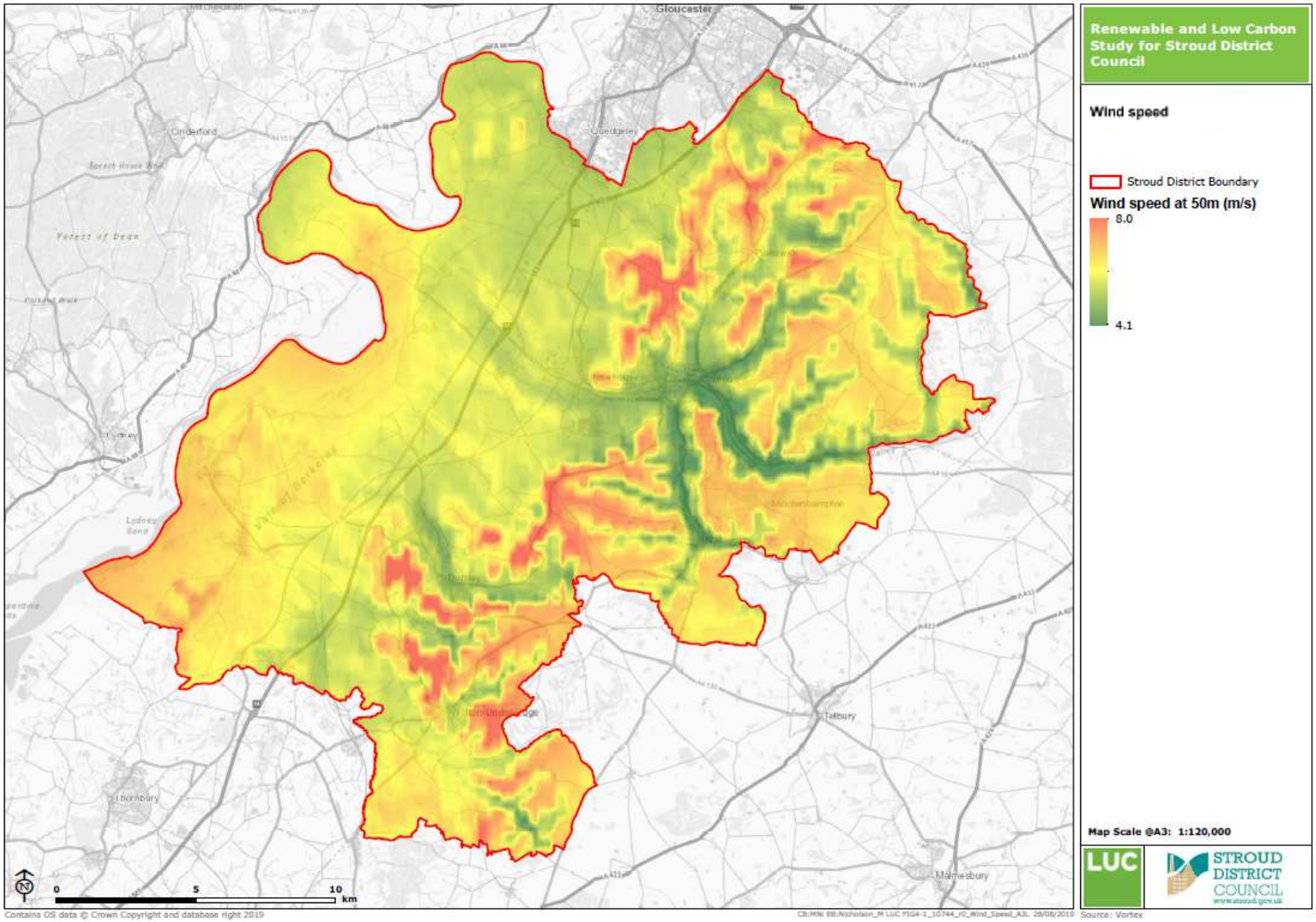

Figure 20: Wind speed across Stroud District at 50m height-above-ground

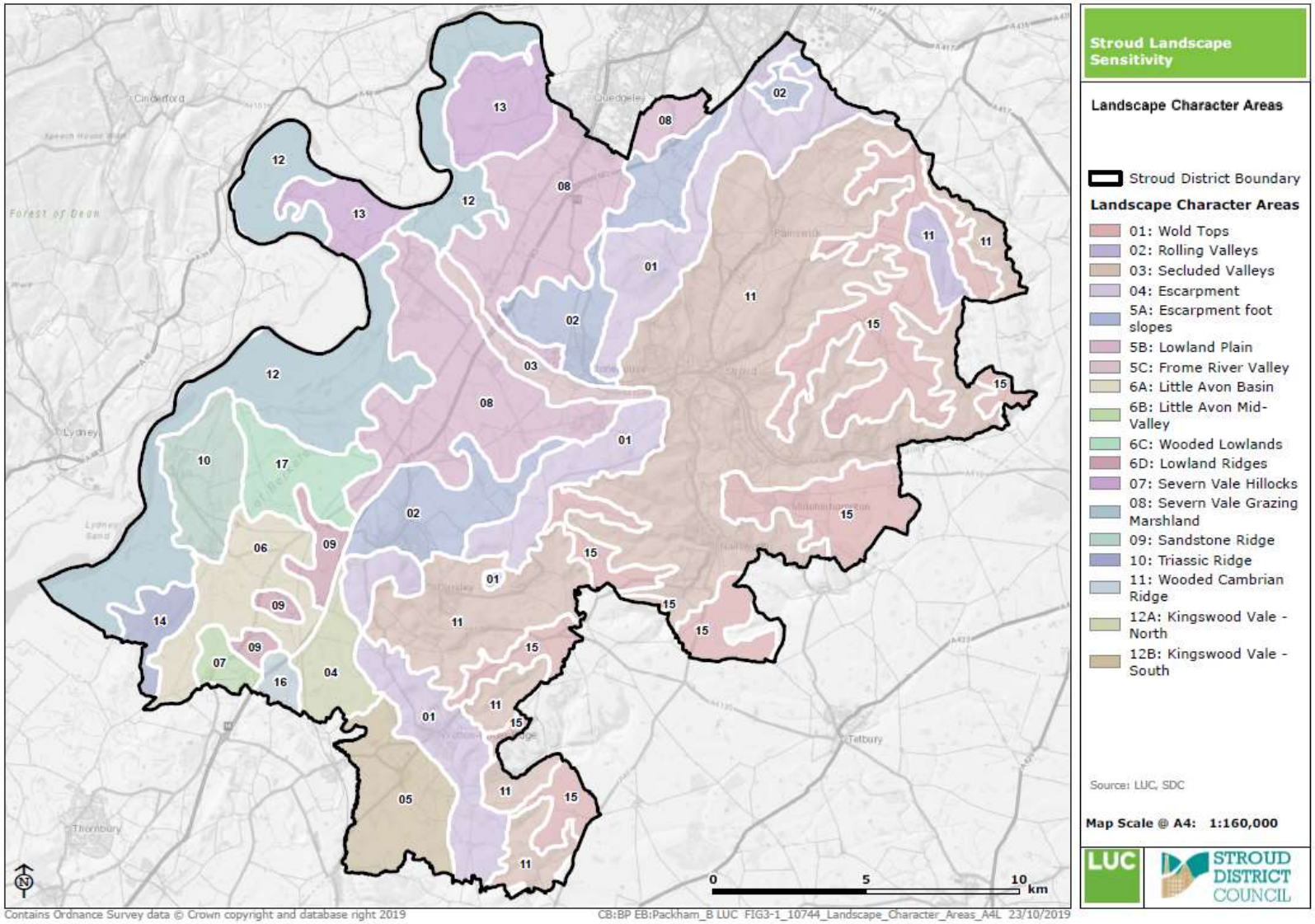

Figure 21: Landscape Character Areas

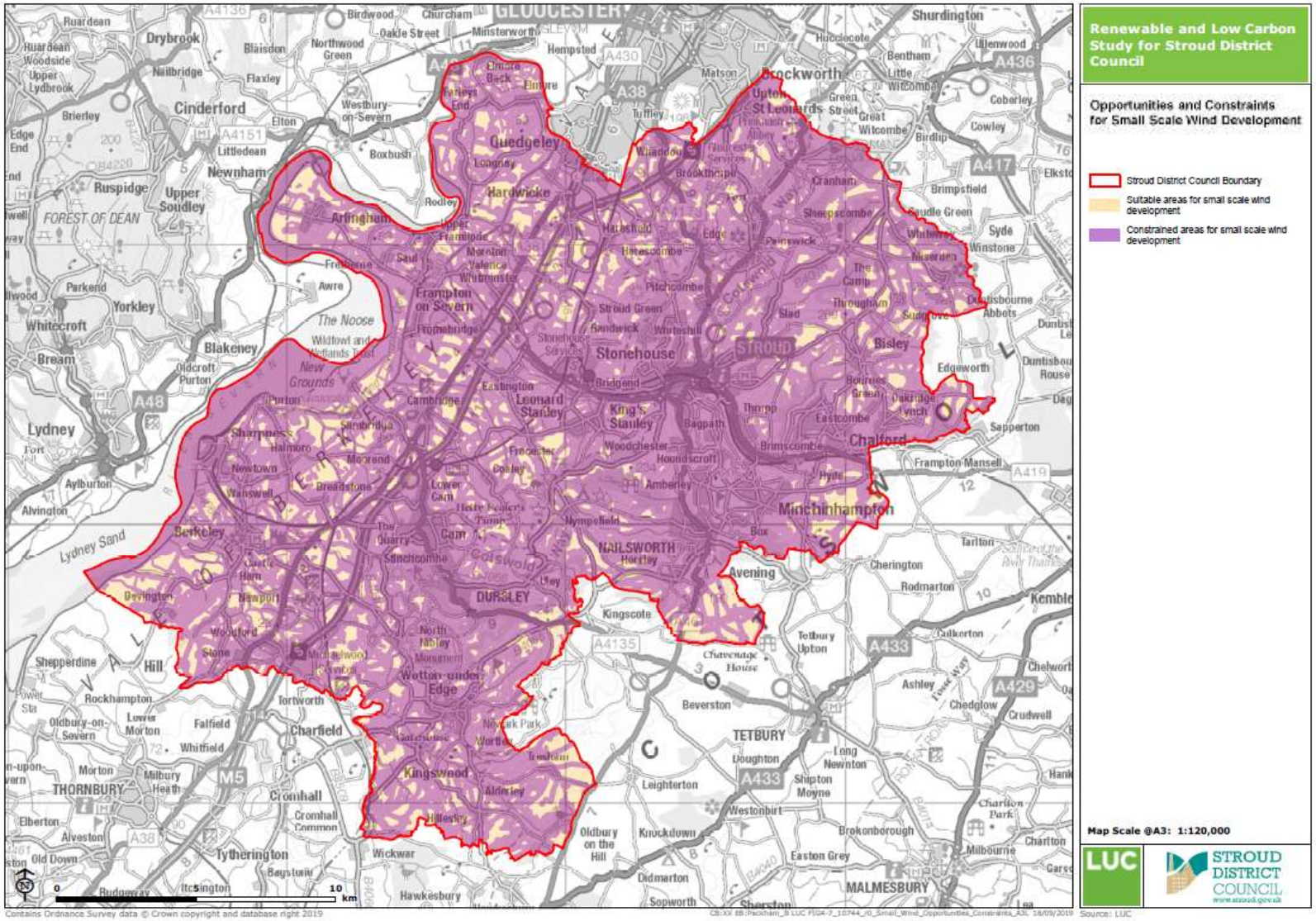

Figure 22: Opportunities and constraints for small scale wind development

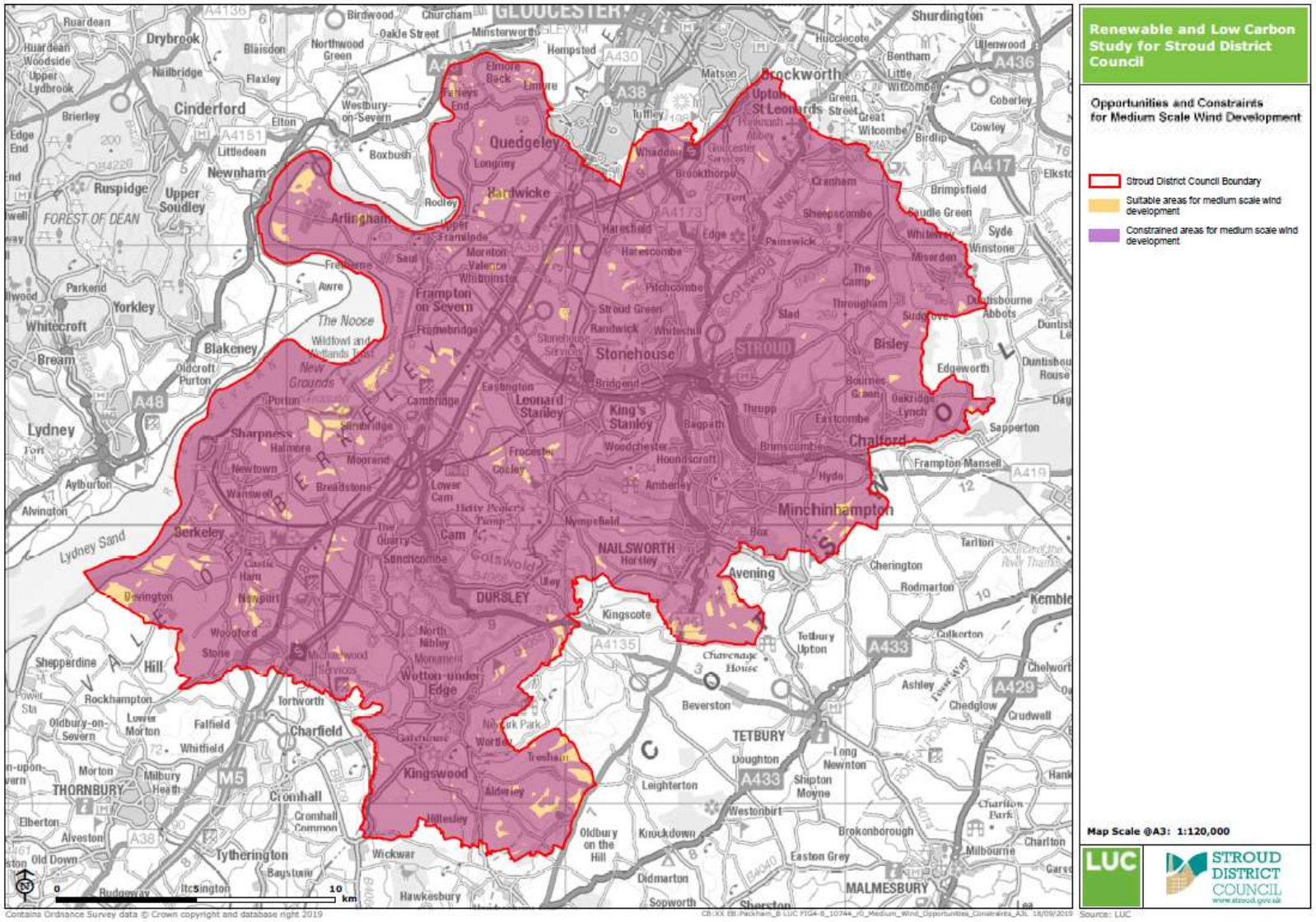

Figure 23: Opportunities and constraints for medium scale wind development

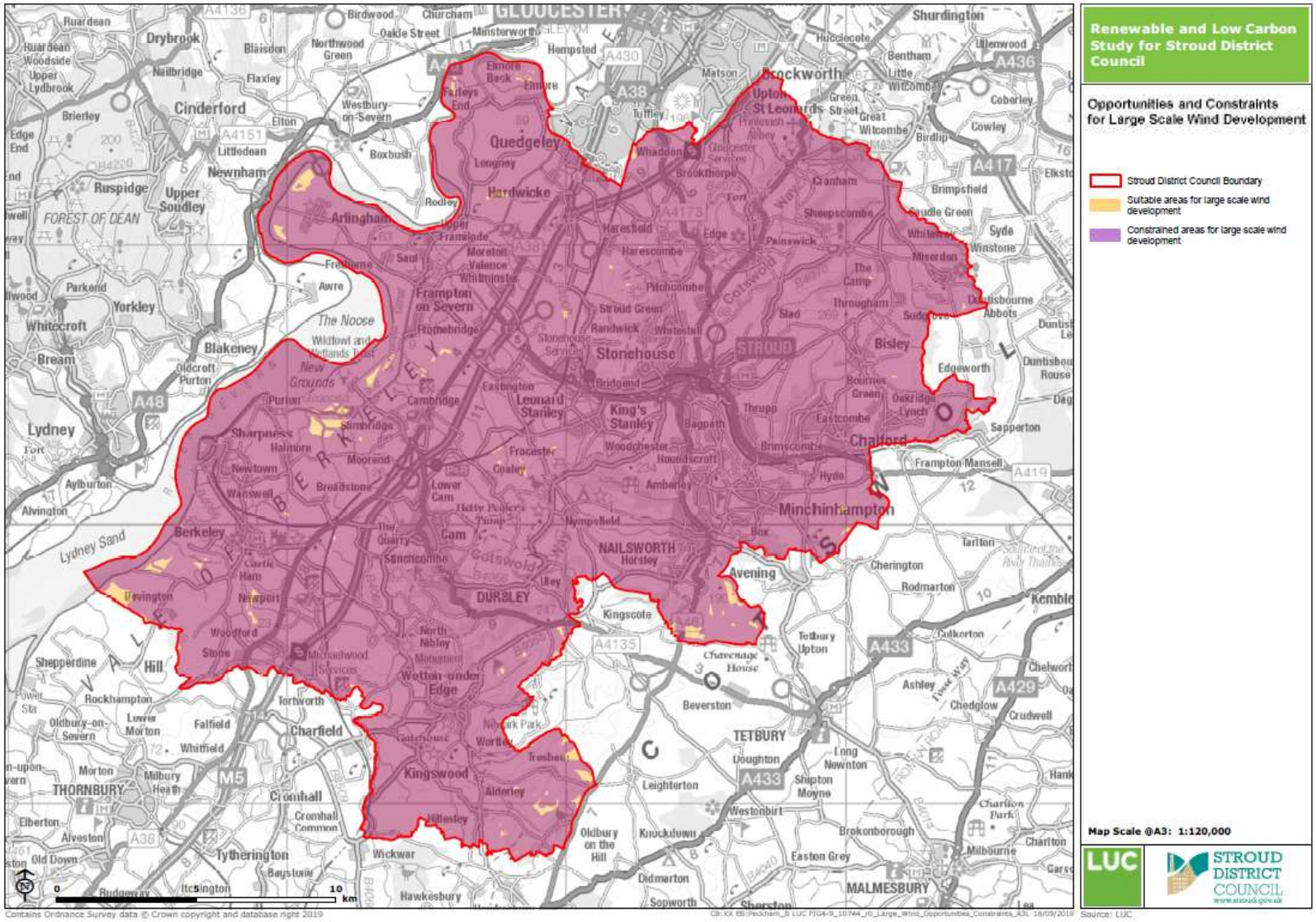

Figure 24: Opportunities and constraints for large scale wind development

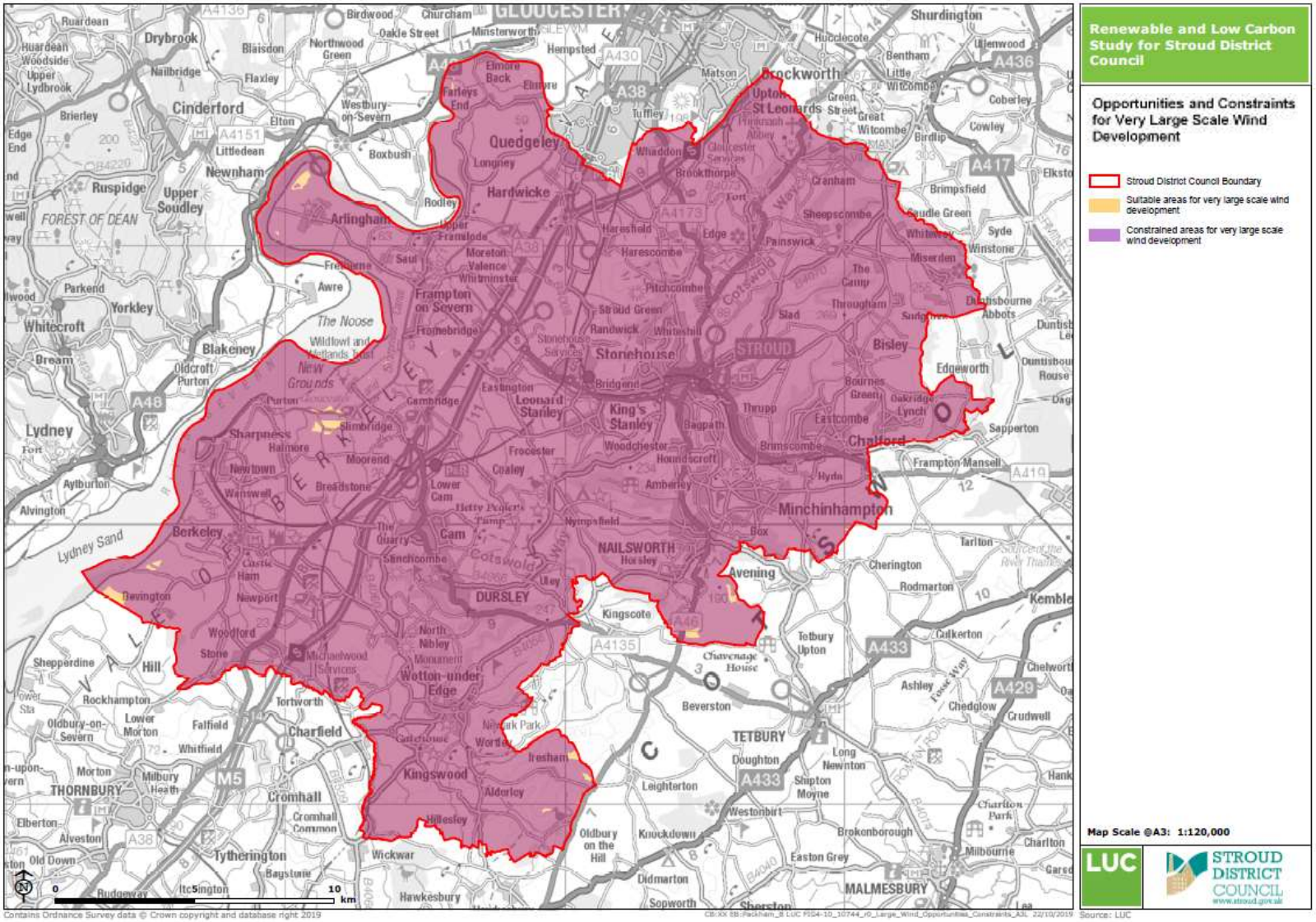

Figure 25: Opportunities and constraints for very large scale wind development

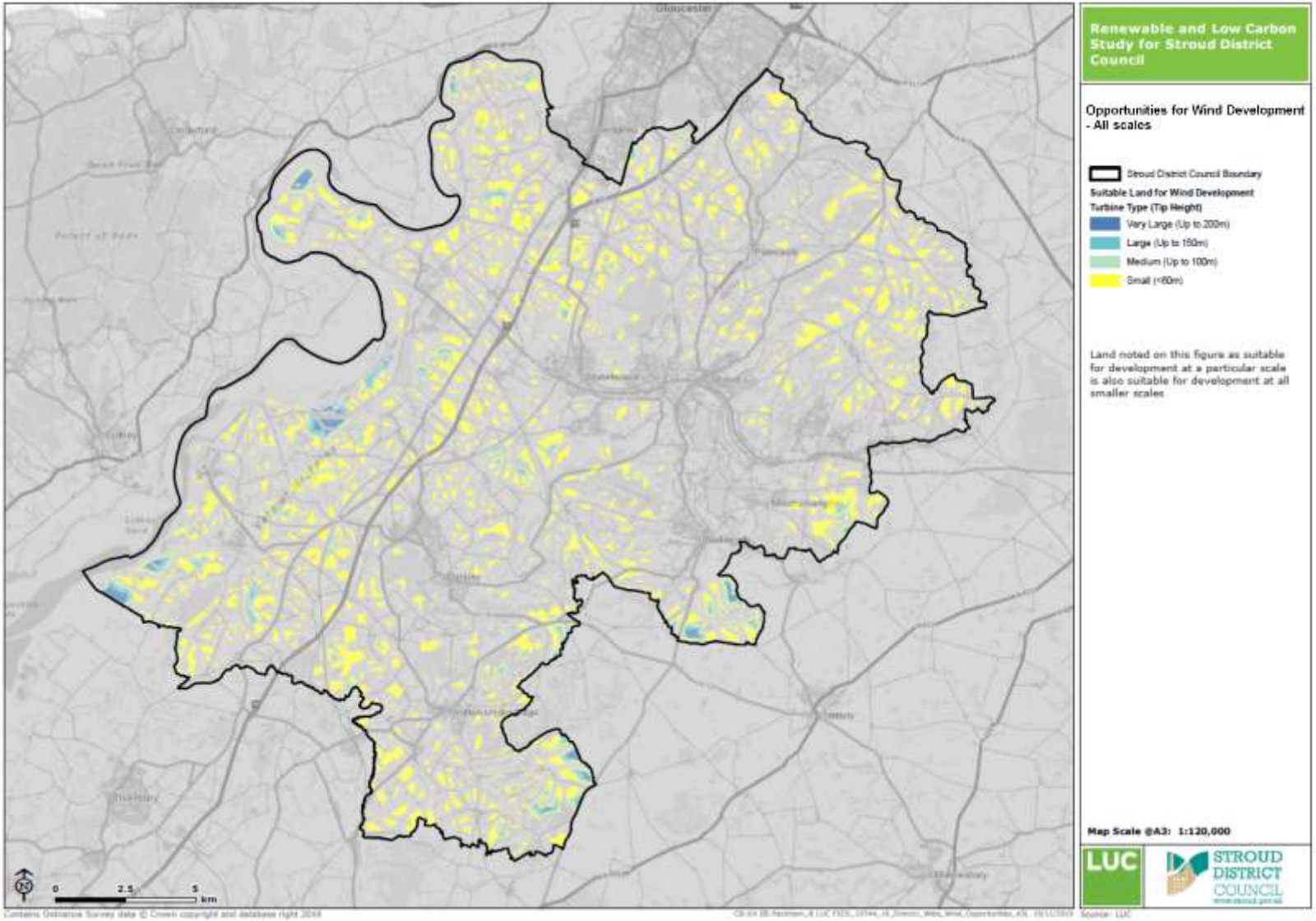

Figure 26: Opportunities for wind development – all scales

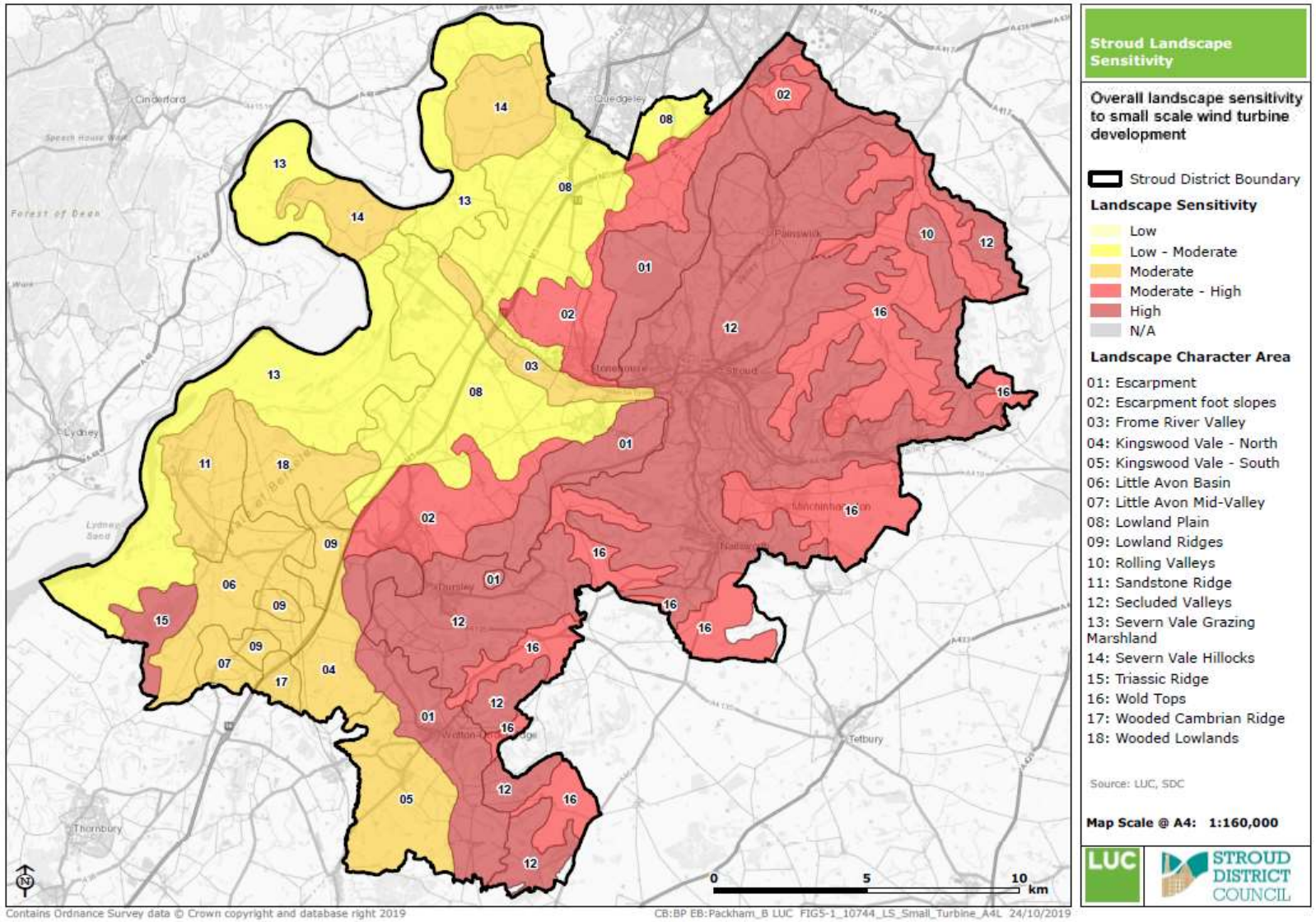

Figure 27: Overall landscape sensitivity to small scale wind turbine developments

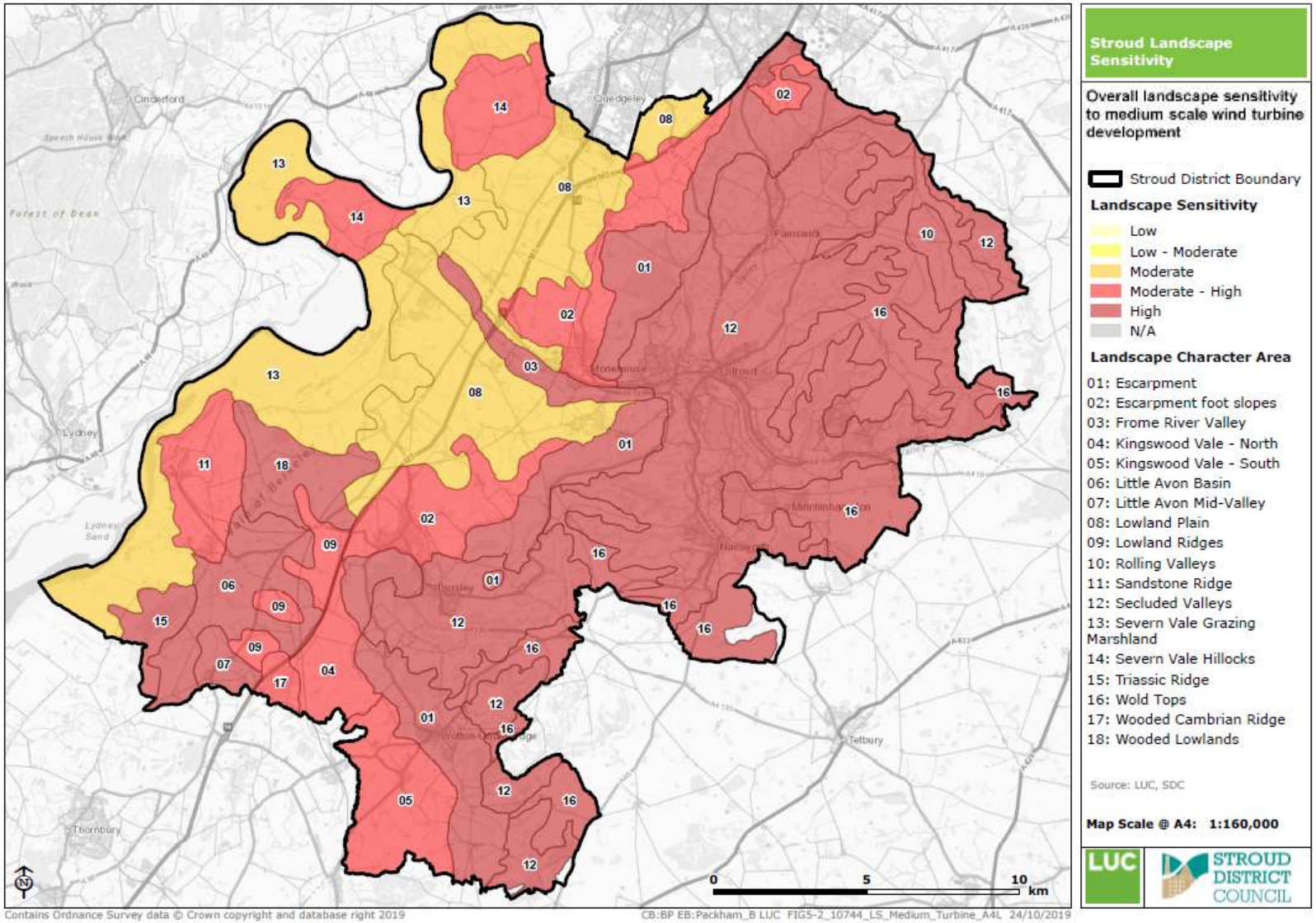

Figure 28: Overall landscape sensitivity to medium scale wind turbine developments

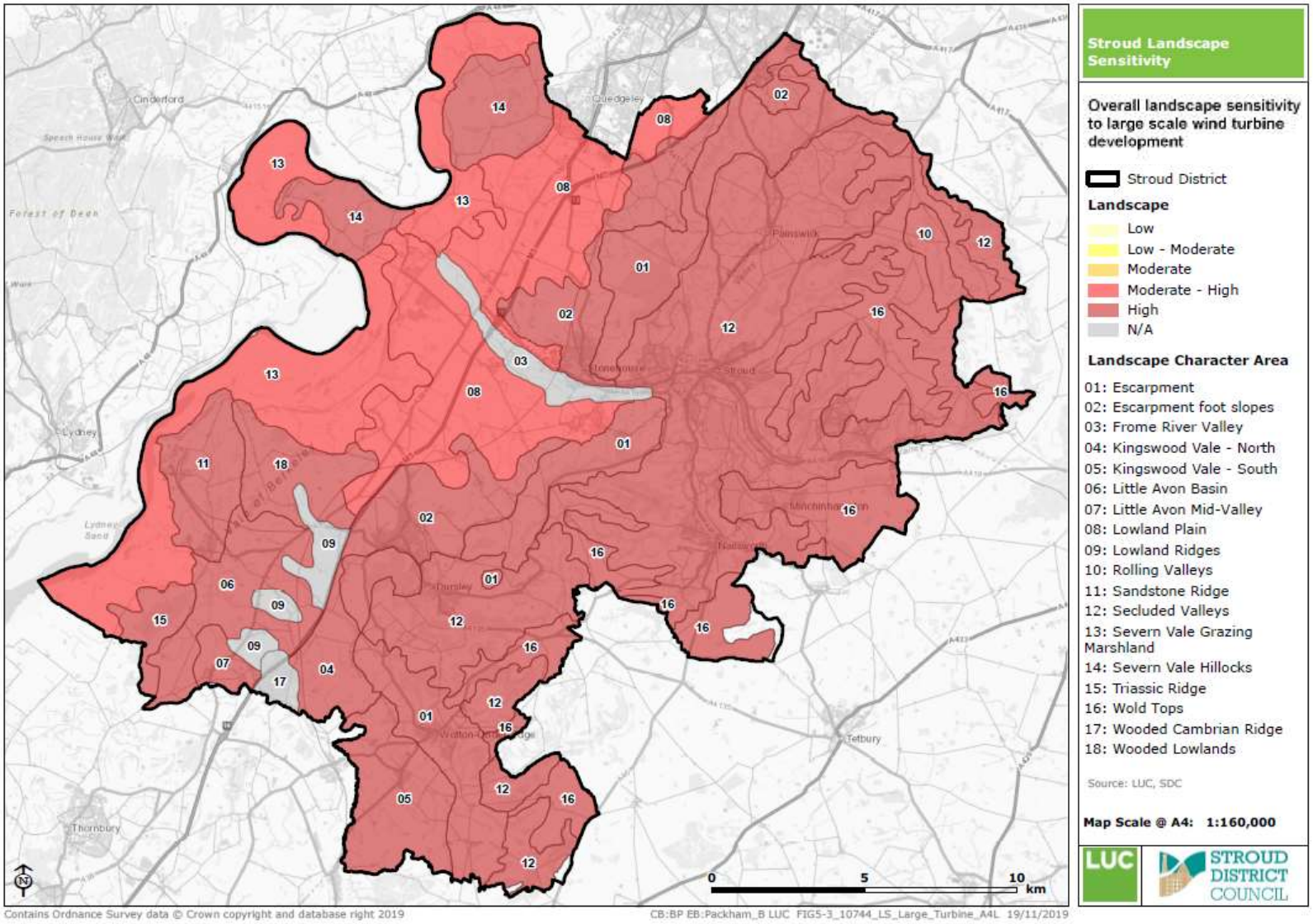

Figure 29: Overall landscape sensitivity to large scale wind turbine developments

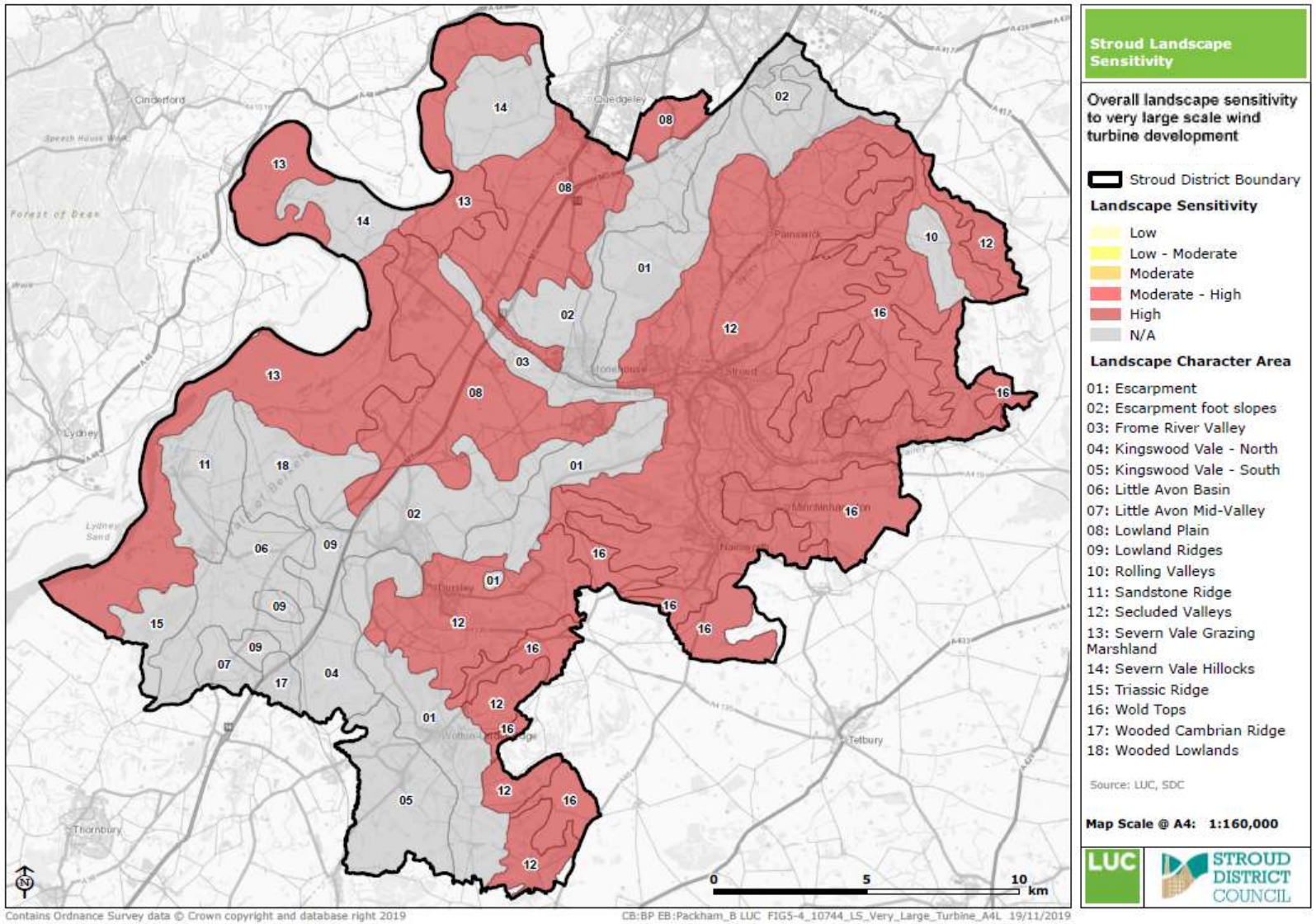

Figure 30: Overall landscape sensitivity to very large scale wind turbine developments

Appendix 4 – Ground-mounted solar maps

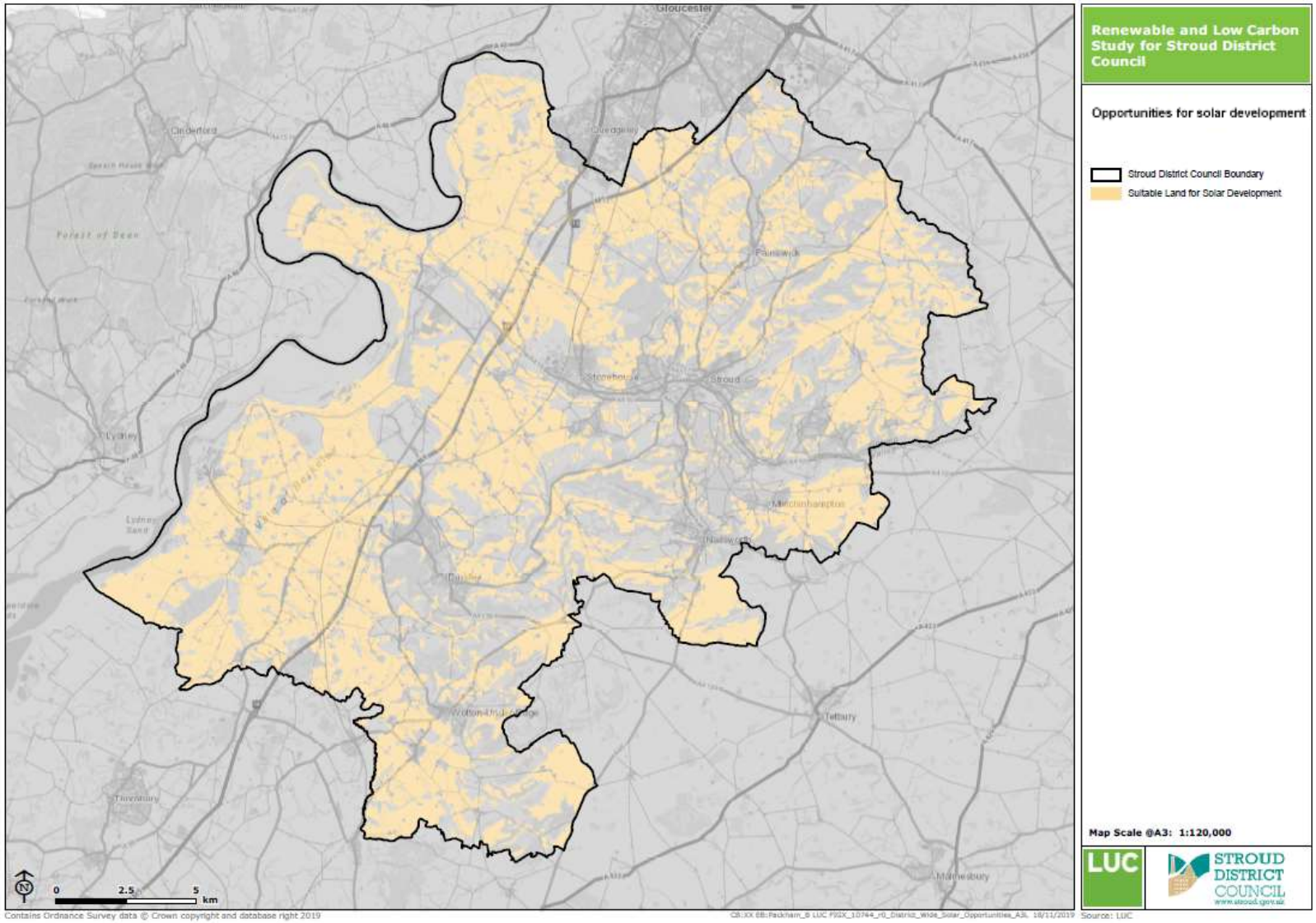

Figure 31: Opportunities for solar developments

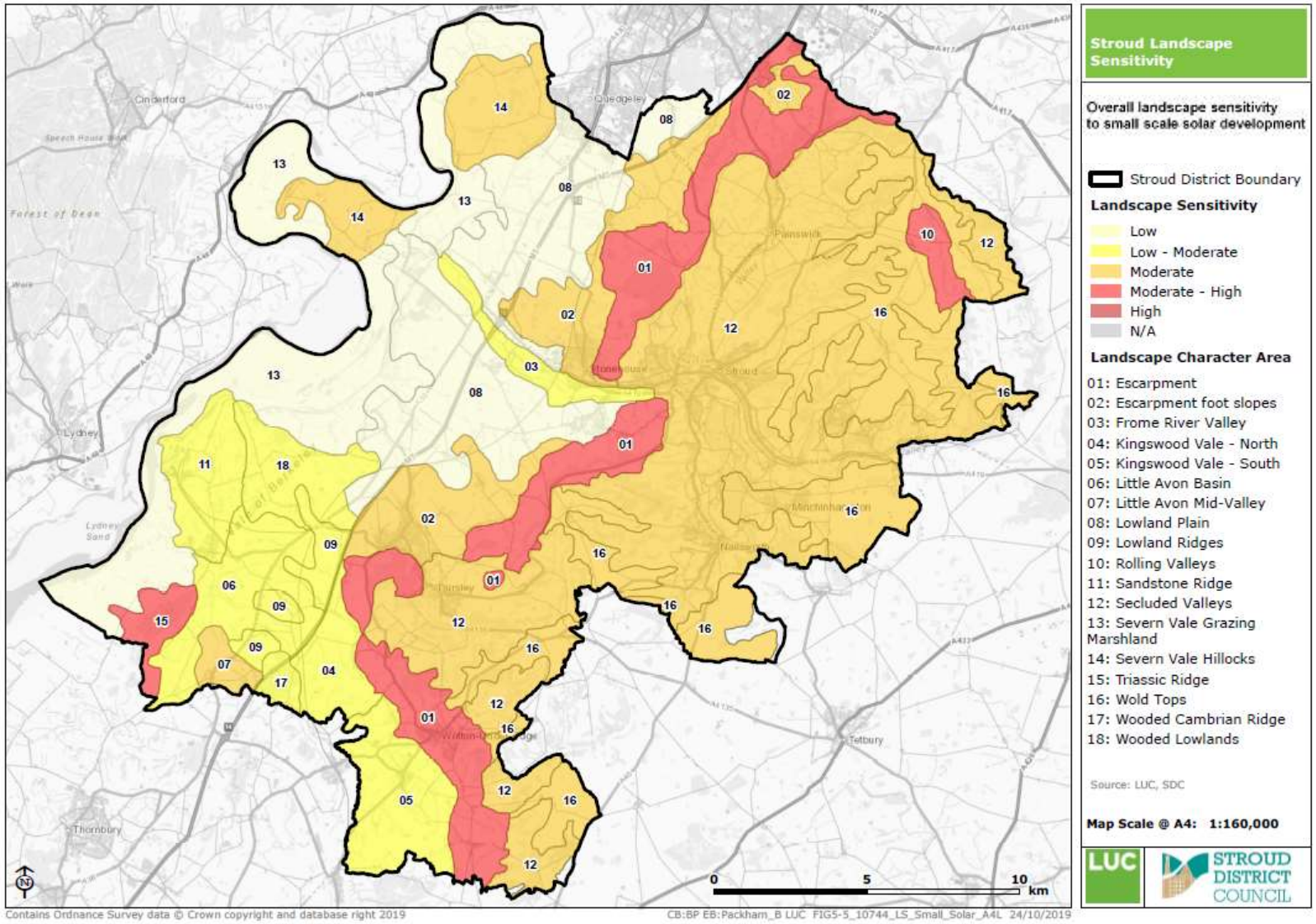

Figure 32: Overall landscape sensitivity to small scale solar developments

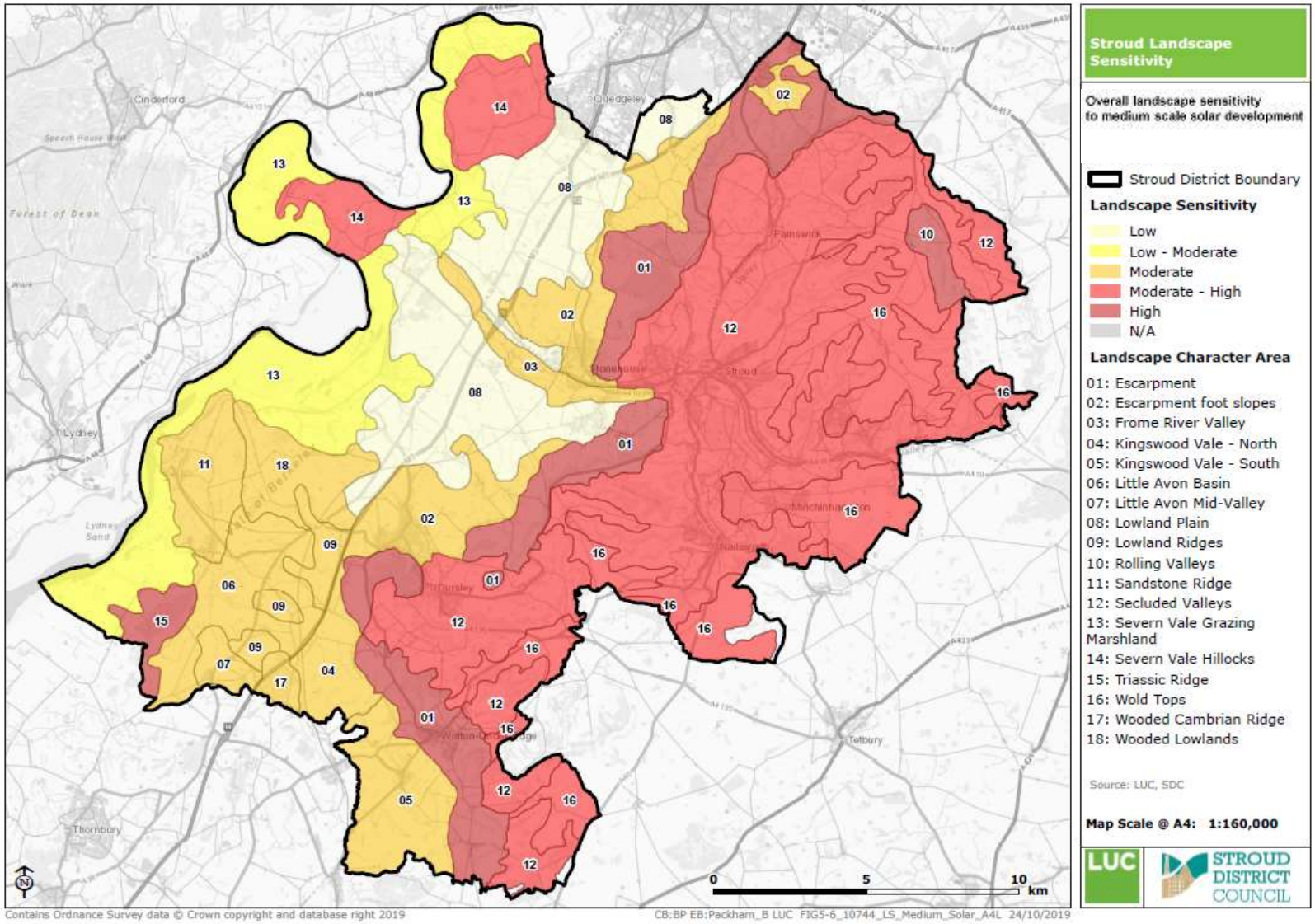

Figure 33: Overall landscape sensitivity to medium scale solar developments

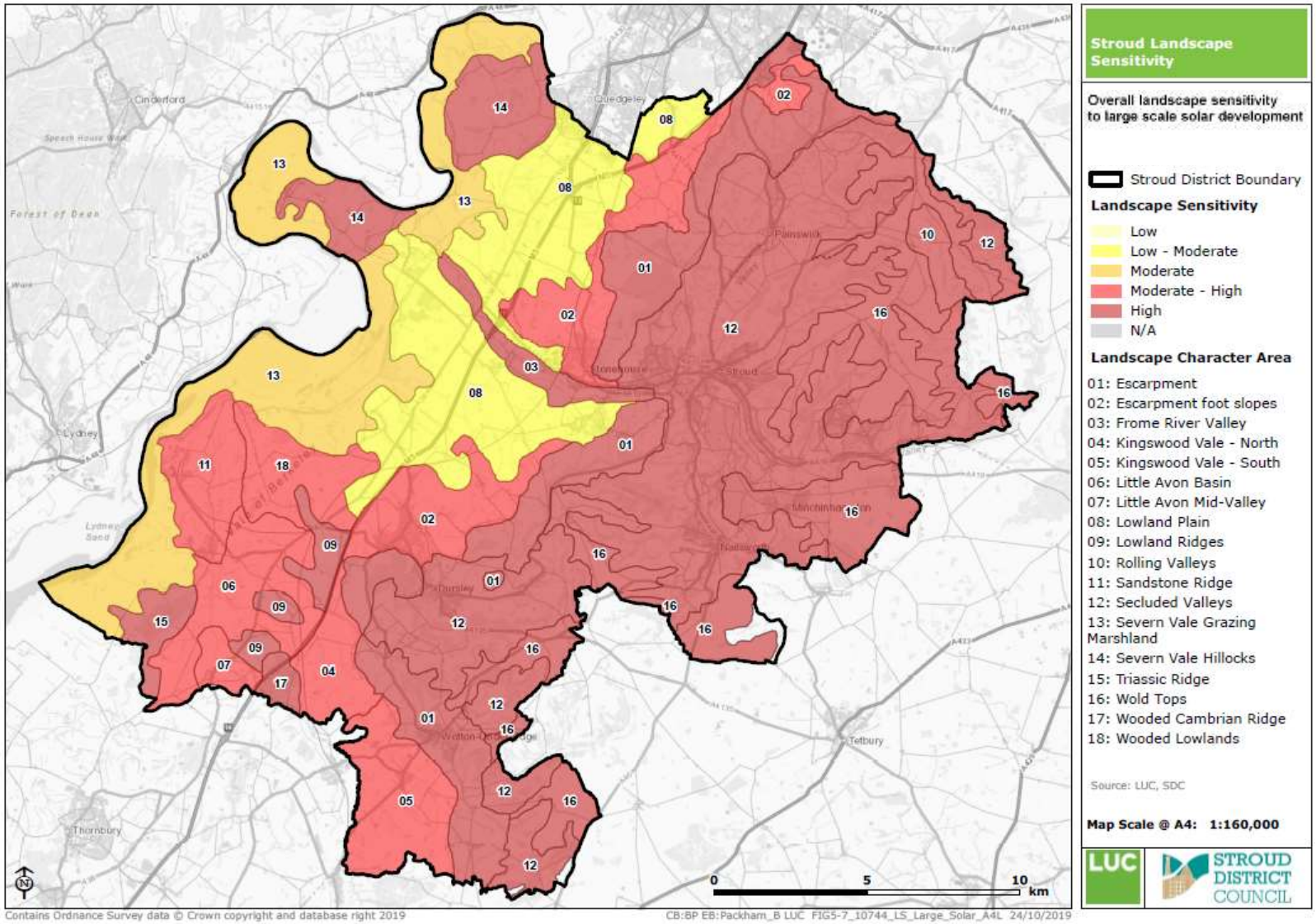

Figure 34: Overall landscape sensitivity to large scale solar developments

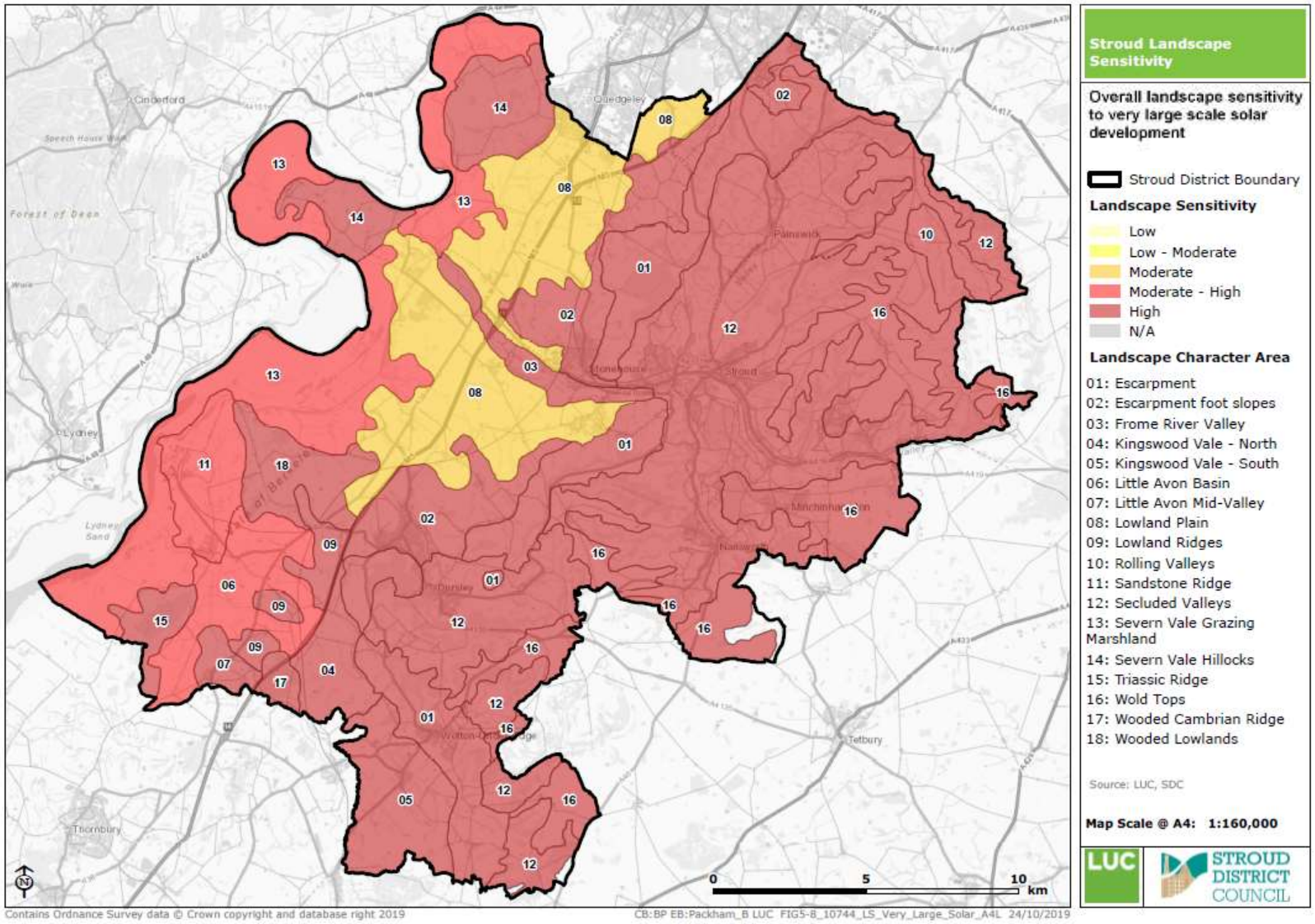

Figure 35: Overall landscape sensitivity to very large scale solar developments

Appendix 5 – Heat Network Priority Areas overlay with adopted Local Plan Strategic Site Allocations

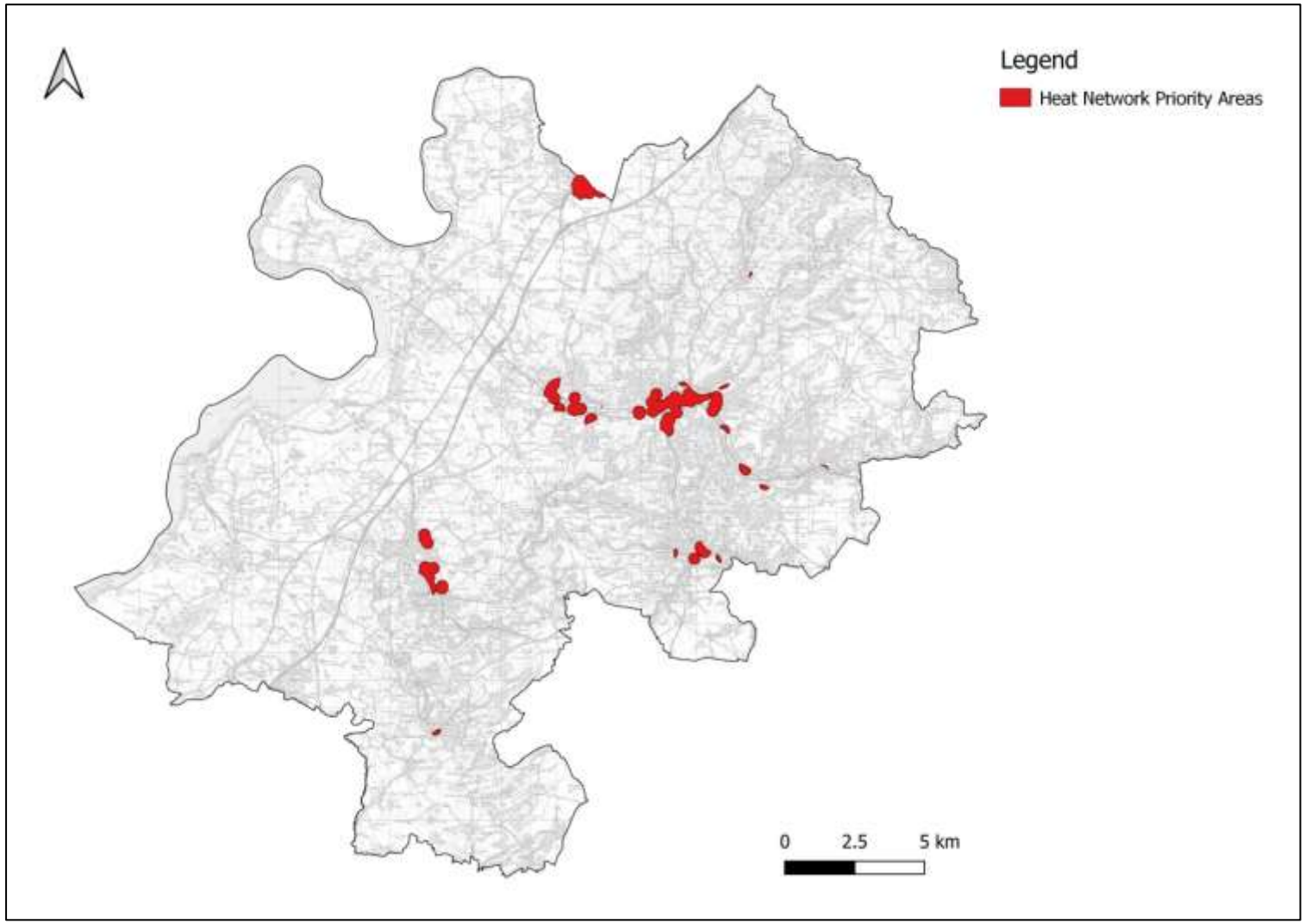

Figure 36: Heat demand overlay analysis of Stroud District showing Heat Network Priority Areas

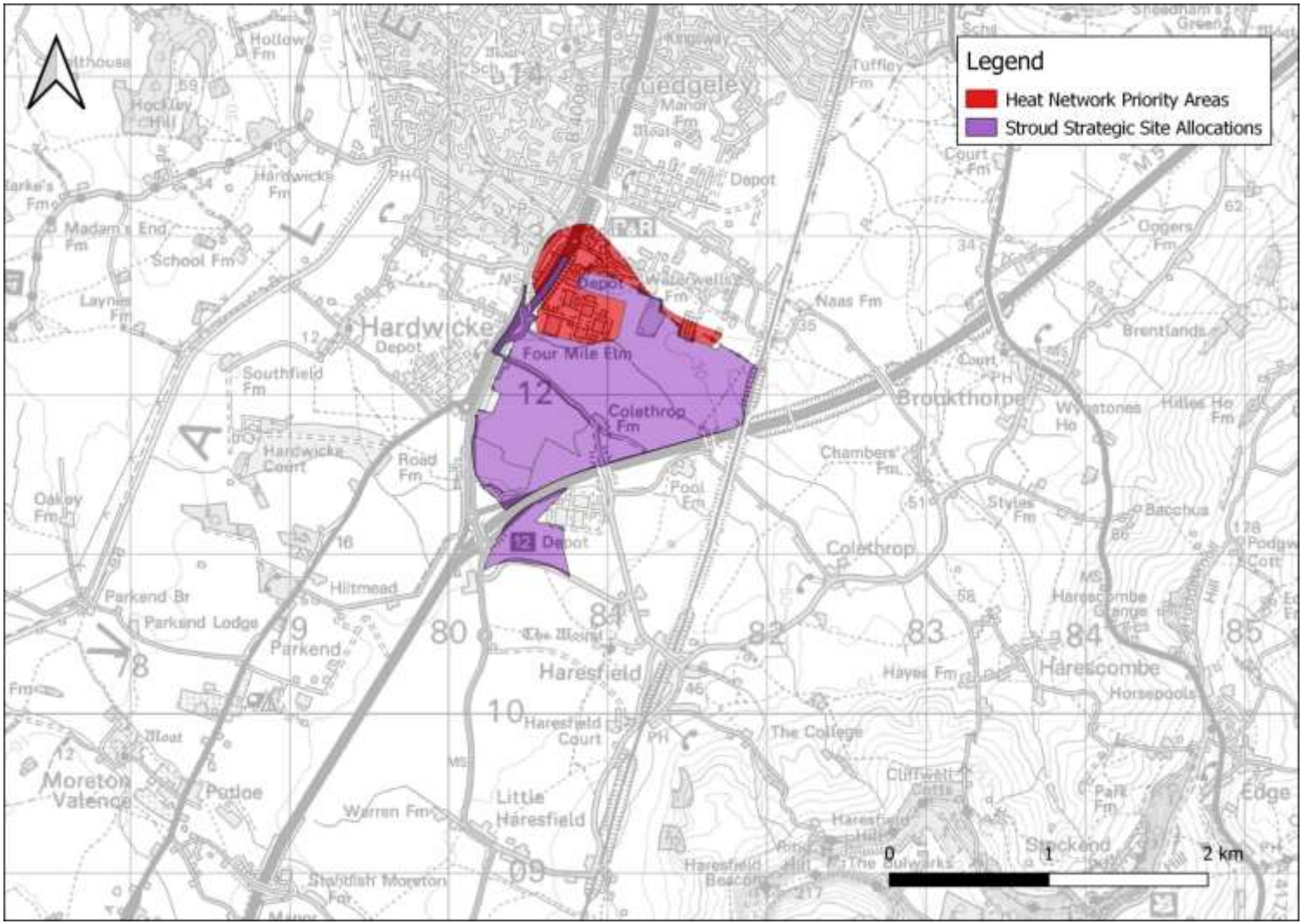

Figure 37: Heat demand overlay with adopted Local Plan Strategic Site Allocations – Hunts Grove and Quedgeley East

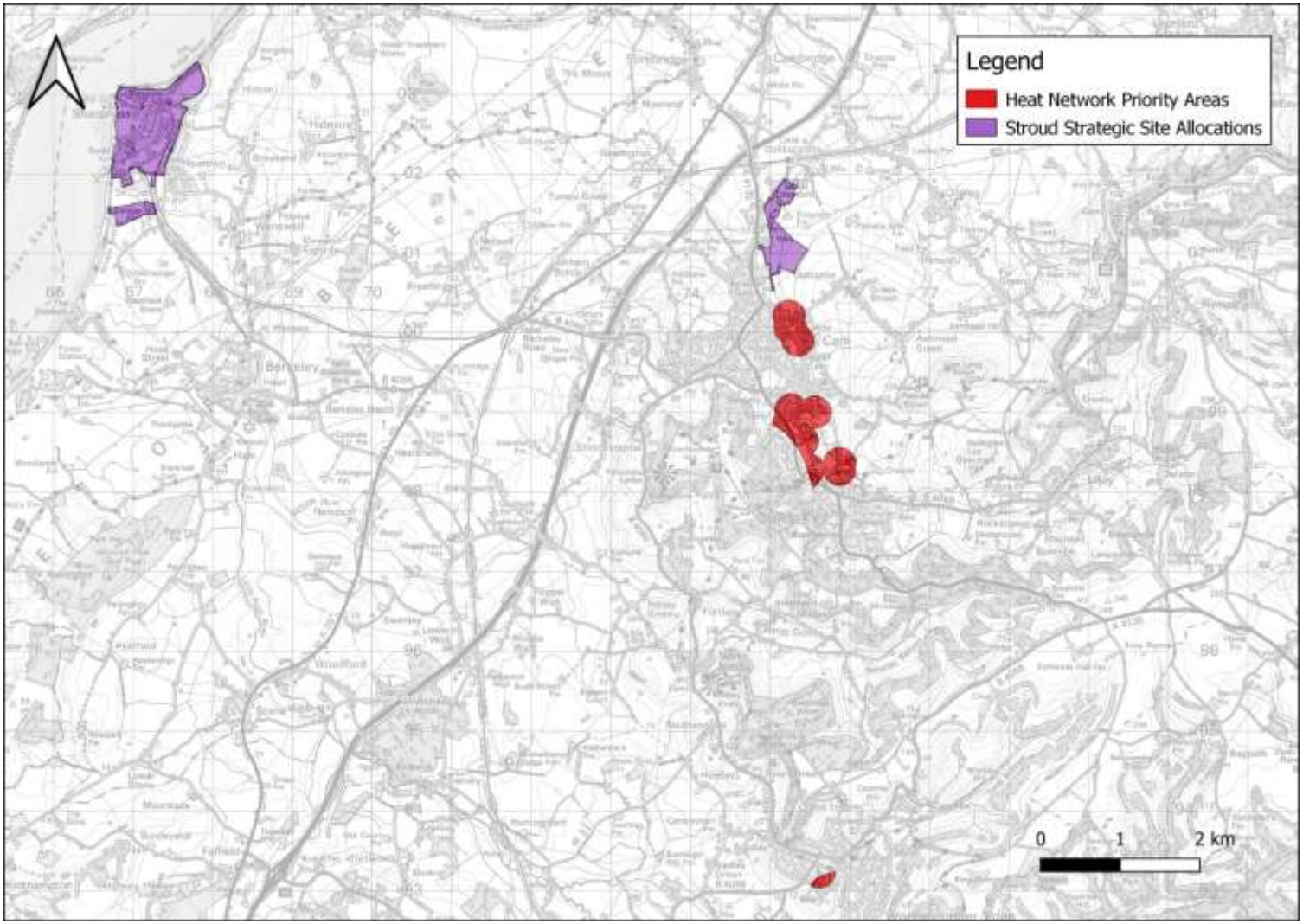

Figure 38: Heat demand overlay with adopted Local Plan Strategic Site Allocations – North East Cam and Sharpness Docks

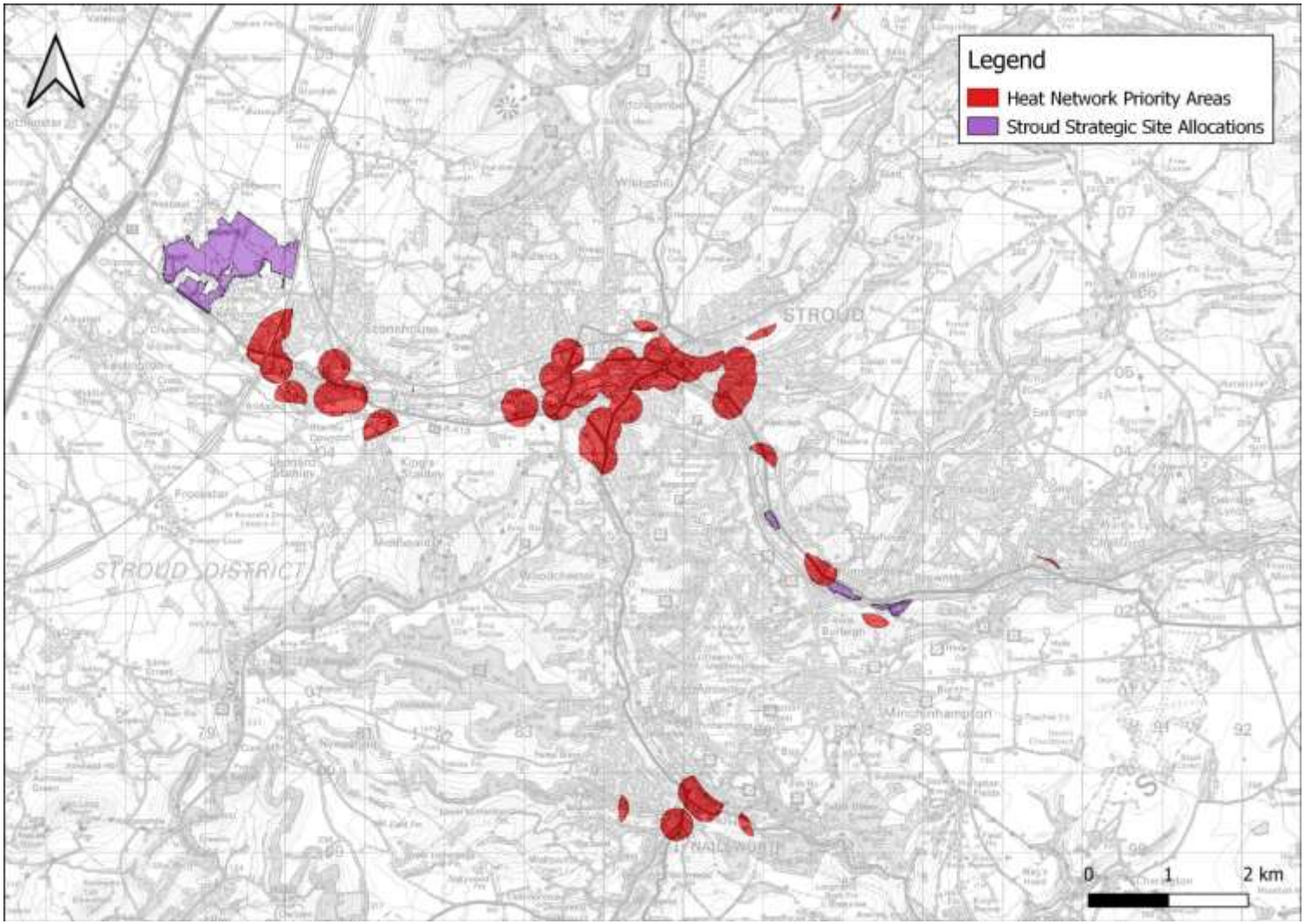

Figure 39: Heat demand overlay with Local Plan Strategic Site Allocations – West of Stonehouse and Stroud Valleys

Appendix 6 – Opportunities for wind and solar development overlay with local authority assets

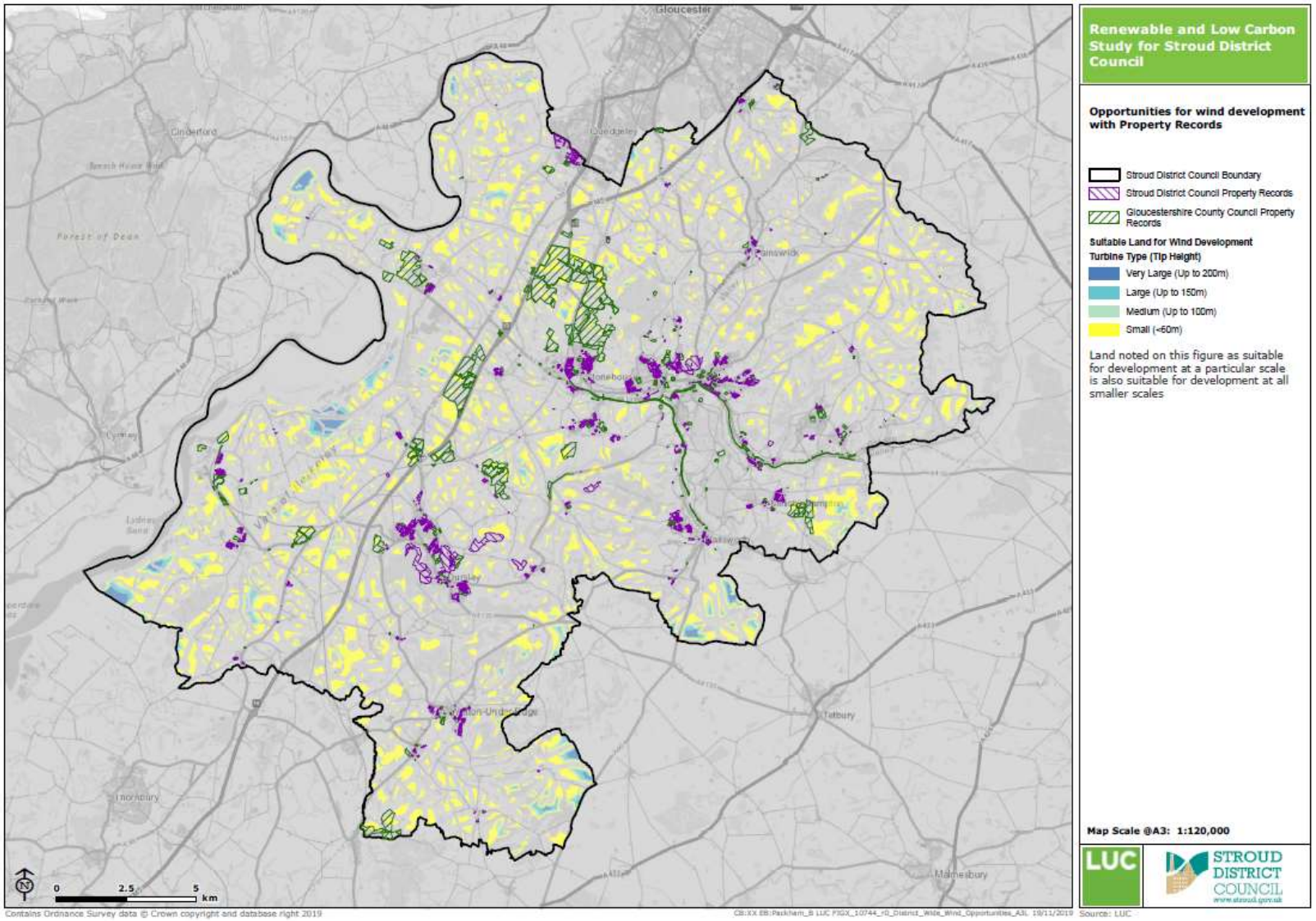

Figure 40: Opportunities for wind development overlay with local authority assets

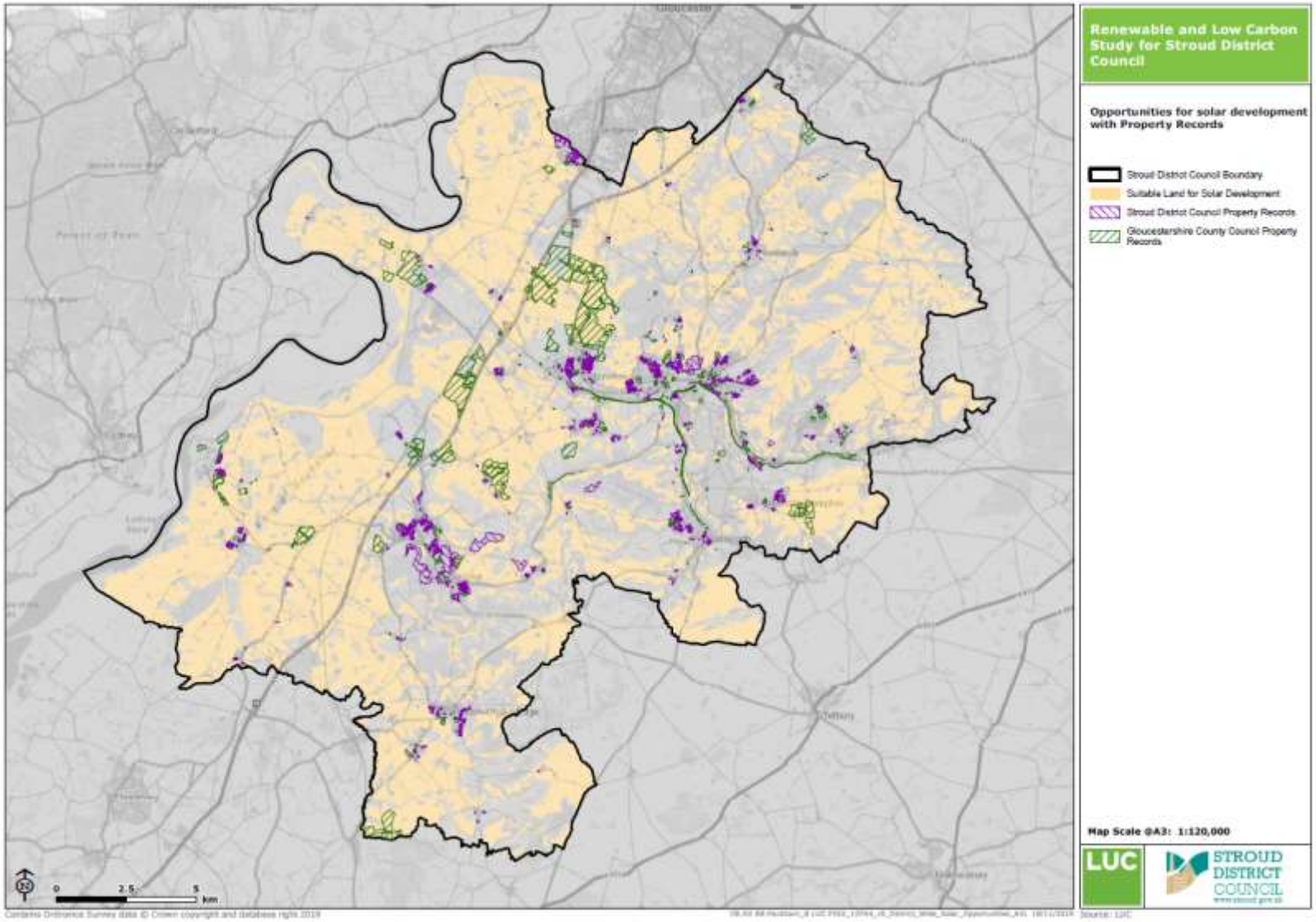

Figure 41: Opportunities for solar development overlay with local authority assets