Renewable Energy Study: Cheltenham Borough, Gloucester City, and Tewkesbury Borough

Part 1: Strategic Potential

Contents

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1. Executive summary

1.1. Cheltenham Borough, Gloucester City, and Tewkesbury Borough councils are preparing to publish a new strategic and local plan for consultation: the Cheltenham, Gloucester and Tewkesbury Strategic and Local Plan (SLP), with the key consultation stages being undertaken between 2023 and 2026.

1.2. To support development of the SLP, CSE and LUC were commissioned to deliver a two-part study providing a detailed review of planning considerations related to climate change and renewable energy, a summary of the technical potential for renewable energy in the SLP area, and recommendations for next steps and further actions to support deployment of renewable and low carbon energy sources.

1.3. This report and its technical appendices form part one of the study, which explores renewable energy potential at a strategic level (i.e. not looking at specific sites). Part two of the study, to be conducted following the first stage of public engagement on the new plan (the first Regulation 18 Consultation), will explore area-specific opportunities, and provide recommendations for renewable energy policies.

Introduction

1.4. The UK's approach to decarbonisation[1] relies on the electrification of heat generation and transport, and the total phasing out of fossil fuel electricity generation, with a Government commitment to fully decarbonise the power system by 2035. This means all communities have a responsibility to increase the use of and supply of renewable energy if the UK is to meet its carbon reduction commitments.

1.5. The rapid scale-up of low-carbon electricity generation and the infrastructure required to deliver it must be achieved whilst also ensuring reliable, affordable and resilient supply. A whole-system approach is the most effective way to achieve that change, with an integrated approach to energy and spatial planning and a comprehensive energy plan which reflects how renewable technologies can be best tailored to deliver against local spatial development ambitions. This renewable energy study is a step towards this for the Cheltenham, Gloucester and Tewkesbury area, providing an initial evidence base to support the policy choices made in the new SLP.

[1] UK Government (2021), Net Zero Strategy: Build Back Greener, www.gov.uk/government/publications/net-zero-strategy

Planning for renewable energy

1.6. The development of the local plan is one of the most powerful tools available to a local area to shape its vision for a sustainable future. It is recommended that the SLP treats climate change related issues (both mitigation and adaptation) as central to policy formulation, visioning and strategic objective setting.

1.7. Through the Planning and Compulsory Purchase Act 2004[2] Local Planning Authorities (LPAs) have a legal duty to ensure that local plans contribute to the mitigation of, and adaptation to, climate change. The National Planning Policy Framework states that plans should include "mitigating and adapting to climate change"[3] as a core objective and is clear that the planning system "should support the transition to a low carbon future in a changing climate"[4]. National Planning Practice Guidance[5] confirms that LPAs should develop a "positive strategy for the delivery of renewable and low carbon energy" and encourages LPAs to identify suitable areas for renewable energy generation. This is particularly important for onshore wind power as, currently, for a wind farm to gain approval a scheme must be in a zone designated for wind energy in a local plan, a neighbourhood plan, or a supplementary planning document (or, alternatively, permitted through a Local Development Order, Neighbourhood Development Order or a Community Right to Build Order).

1.8. Planning policy and guidance makes clear however, that any potential adverse impacts of renewable energy development must be addressed – from ensuring that development has community backing, to undertaking suitable environmental impact assessment, and avoiding any negative impacts on designated areas. Proposals in National Landscapes (previously Areas of Outstanding Natural Beauty) and Green Belt areas will need particularly careful consideration of the balance between the benefits of renewable energy and any harmful impacts.

Current renewable energy installations in the SLP area

1.9. There are 6,775 renewable electricity sites recorded in the area with a total installed renewable capacity of 83.8 MW[6]. The bulk of this is produced by six large sites recorded

[2] UK Government, Section 19 of the Planning and Compulsory Purchase Act 2004, www.legislation.gov.uk/ukpga/2004/5/section/19
[3] UK Government (2023), National Planning Policy Framework, www.gov.uk/government/publications/national-planning-policy-framework--2
[4] Ibid.
[5] UK Government, Planning Practice Guidance, www.gov.uk/government/collections/planning-practice-guidance
[6] Figures from the 2021 renewable electricity statistics published by the Department for Energy Security and Net Zero (DESNZ) and the Renewable Energy Database – see chapter 4 for further details.

in the Renewable Energy Planning Database (REPD). There are 30 more applications recorded in the planning system. The majority of operational sites and planning applications are for solar photovoltaic (PV).

1.10. Compared to the UK average of 296 domestic PV installations per 10,000 households, Gloucester has slightly fewer installations (264 per 10,000 households) and Cheltenham and Tewkesbury have above average numbers (366 and 420 per 10,000 households respectively). Compared to the England average of 36 domestic RHI installations per 10,000 households, Gloucester and Cheltenham have fewer installations (5 and 13 per 10,000 households respectively). Tewkesbury is above average (43)[7].

1.11. There are two communal heat networks in the area, both located in Gloucester and both using heat pumps. One is operational and the other is under construction.

Renewable energy potential

1.12. Nine renewable and low carbon energy resources and technologies have been explored in detail for this study. The assessment is a desk-based exercise involving industry-standard assumptions and/or GIS mapping to establish the technical potential for renewable energy generation of each resource or technology.

1.13. 'Technical potential' in this context means the exploitable energy (electricity or heat) from a given resource, that could be theoretically deployed within a set of technical constraints. It does not consider wider constraints imposed by landscape, political or financial issues. The technologies covered include:

Power generation technologies and infrastructure:
- Onshore wind
- Ground-mounted solar
- Rooftop solar
- Hydropower
- Electricity grid constraints & battery storage

Heat sources, technologies and infrastructure:
- District heating or cooling networks
- Heat pumps
- Biomass
- Energy from waste

1.14. Figure 1 summarises the technical potential for renewable energy within the SLP area from all sources assessed. As is emphasised throughout this report, this theoretical

[7] Figures taken from UK Government published Feed-in-Tariff and Renewable Heat Incentive statistics – see chapter 4 for further details.

technical potential does not take into account any issues affecting deployment, or the fact that one technology may need to be chosen over another in some areas.

1.15. Figure 1 shows 20% of the total theoretical generation potential from wind and 20% of the total theoretical generation potential for ground mounted solar. This 20% figure has been chosen for illustrative purposes only, it is not based on any assessment of realistic deployment as we are yet to determine optimal deployment scenarios for the area (these will be developed in part two of the study).

1.16. As this shows, there is technical potential within the SLP authorities to cover the energy requirements of the area. However, based on the illustrative 20% deployment figure, there would be little headroom:

- 4,208 GWh total annual energy demand
- 4,556 GWh annual technical renewable energy potential

1.17. To realise this scale of theoretical potential would require:

- 2,692 wind turbines of different scales (for 20% of potential)
- Solar farms equating to an area of around 45km^2 (approximately 9% of the total study area)
- 44,153 rooftop solar installations and a total panel area of 140.46km^2
- Hydropower at five barriers in Tewkesbury
- The use of biomass, energy crops and biogas from animal slurry in place of natural gas heating.

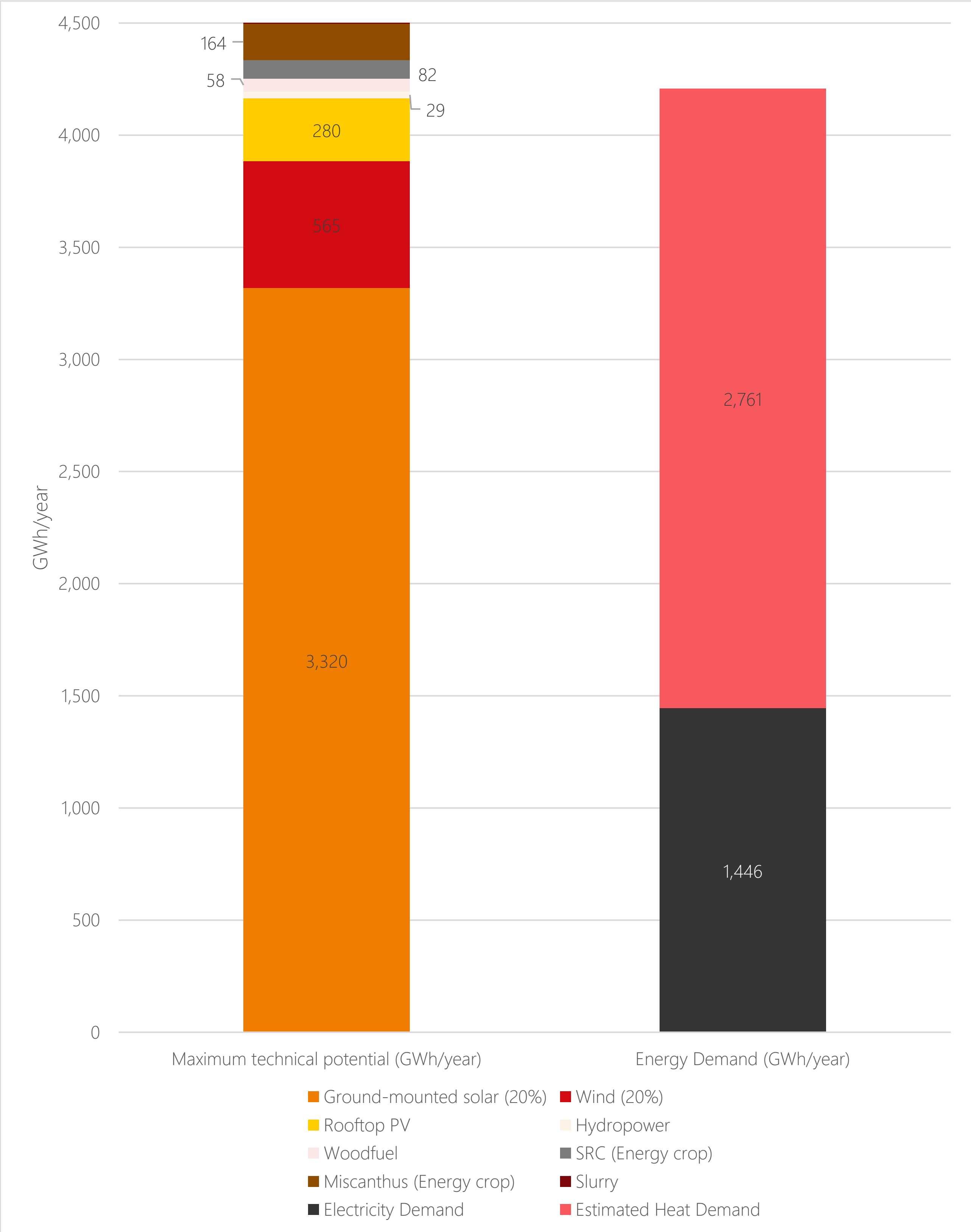

Figure 1 Summary of the theoretical technical potential of renewable energy sources compared to energy demand in the SLP authorities

1.18. To realise any scale of renewable energy potential, sufficient network capacity and timely grid connections are required. A high-level review of existing grid constraints has been undertaken as part of this study, showing that many of the substations in the area are constrained, with low generation headroom. This may hinder connections of renewables to the electricity network or require grid improvements. However, this status is likely to change with infrastructure upgrades throughout the SLP period. Policies that encourage energy storage, demand side response, and smart energy technologies will be needed and policy will have to be flexible to allow for future scenarios, changes in national policy and the grid being upgraded, or better balanced.

Next steps

1.19. Part two of this study will look in more detail at different approaches to renewable energy deployment and provide recommended wording for local plan policies. It will include:

- Identifying areas with most potential across all technologies and compiling these into a shortlist of the most promising sites.
- Undertaking a landscape sensitivity assessment to provide a more detailed evidence base for what scale of wind turbine and solar development (i.e. very large, large, medium, small) may be appropriate in areas of technical potential and where wind turbines may not be suitable (i.e. due to the potential impacts on protected or valued landscapes).
- Exploring specific opportunities for renewable energy generation that fall within the land holdings of the authorities and County Council, as well as the types of business models and delivery vehicles that may be appropriate to develop renewable energy systems on council-owned sites.
- Developing deployment scenarios with trajectories that illustrate the energy generation and carbon reduction potential of the technologies modelled and their relative roles in contributing to a future net zero system.
- Calculating a carbon baseline for each area to understand how the deployment of renewable technologies under each of the scenarios will contribute to the authorities' commitments regarding carbon neutrality.

Emerging recommendations

1.20. As the three councils move towards the new local plan over the next three years, action on climate change should be an integral part of the culture of plan-making and must be embedded and integrated into policy formulation. As is shown in the Planning for

Renewable Energy chapter of this report, only by treating climate change related issues as central to policy formulation will a Local Planning Authority have effectively discharged its legal obligations. To this end, climate change should be central to the local plan vision, objectives, and policies, and the councils should be able to demonstrate how the plan as a whole contributes to the Climate Change Act national carbon budget regime.

1.21. The following recommendations will support this, helping to shape a positive strategy for renewable energy and move closer to realising the technical potential highlighted in this report. These recommendations will be explored in more detail in part two of this study.

1. Developing policies for renewable energy. Building on the understanding of technical potential provided through parts one and two of this study, we recommend that specific targets for renewable energy are set in the local plan. These should be linked to the technical potential identified, and an overall carbon budget for the district. We recommend that the mapping produced is used to inform the local plan policies map, which is particularly important for enabling the deployment of onshore wind.

2. Developing policies for demand flexibility and energy storage features. As time goes on and more renewable energy is utilised on the grid, it will become more important to shift demand and store energy. To future-proof the local plan, we recommend development of a policy which encourages energy storage, demand side response, and smart energy technologies.

3. Developing binding net zero policies for new buildings framed around energy use intensity. We recommend the use of a fabric-first policy framed around energy (rather than a carbon percentage reduction), that provides a quantifiable, and easily verifiable way of ensuring that new development is net zero. Reducing demand in this way is an essential component in achieving an efficient low carbon energy system.

4. Carbon offsetting. The local plan should provide a framework for carbon offsetting for new development, ensuring that the electricity demand from new development is met entirely from new renewable energy generation, where possible on-site, or through additional new off-site renewable generation. This structure is like carbon offsetting, but instead of funding off-site carbon savings, contributions fund the creation of additional renewable energy to offset the impact of the development.

5. Carbon auditing the local plan and setting a carbon budget. LPAs will need a clear grasp of their area's baseline emissions to demonstrate how policies are in line with the legally binding carbon emission reduction targets in the Climate Change Act.

6. Viability considerations. It is essential that the renewable energy policies that emerge from this renewable energy study are tested as part of the local plan viability assessment. Viability will be a key area which will be tested at examination.

7. Community engagement and empowerment. To build community support for renewables deployment we recommend undertaking community engagement exercises across the areas identified as having technical potential for renewables deployment, and taking steps to enable and support community groups to engage in the planning process for renewable energy development.

8. Carbon literacy training. In local authorities that have been successful in developing ambitious policies around climate change and renewable energy generation, the prioritisation of climate change from leadership has been a key enabler. Climate literacy training for senior leadership (including Members) and all officers involved in plan making and decision making is strongly recommended.

9. Local Area Energy Plans. To inform the authorities' decarbonisation strategy it would be beneficial in future to consider developing a Local Area Energy Plan (LAEP). An LAEP would complement the renewable energy study by considering the entire energy system within the area: heat, electricity, transport, supply chains (from energy generation to transporting it into homes and businesses), systems (physical, digital, market and policy systems) and would consider the changes needed to decarbonise in the most cost-effective manner and at the fastest rate possible.

2. Introduction

Background

2.1. Cheltenham Borough, Gloucester City, and Tewkesbury Borough councils together adopted a Joint Core Strategy (JCS) in December 2017. The JCS is part of the statutory development plan and heavily influences the quantum and future location of growth in the area. To replace the JCS, the authorities are now preparing to publish a draft strategic and local plan for consultation: the Cheltenham, Gloucester and Tewkesbury Strategic and Local Plan (CGTSLP). This renewable energy study will form part of the supporting evidence base.

Objectives of the study

2.2. This study will inform development of the plan, which will ultimately govern the treatment of new local renewable energy schemes coming forward. It will:

- Provide a detailed review of planning considerations related to climate change.
- Provide up-to-date evidence of potential for renewable energy in the area.
- Recommend next steps and further actions to support development of the local plan in relation to renewable energy.

2.3. The study is being undertaken in two parts. This report forms part one of the study which is intended to provide the planning policy context around renewable energy, and identify and map the technical potential for future renewable energy provision at a strategic level (i.e. not looking at specific sites). Part two of the study, to follow the first stage of public engagement on the new plan (the first Regulation 18 Consultation), will explore area and site-specific opportunities, and provide recommendations for renewable energy policies.

2.4. This report should be read in conjunction with the Technical Appendices which provide detailed information on:

- Policy, legislation, government strategies and plans for renewable energy
- Further technical information and relevant planning case law related to onshore wind, ground mounted solar and battery storage development
- Key assumptions and emissions factors for all technologies
- Landscape sensitivity assessment methodology for wind and solar

3. Planning for renewable energy: policy and legislative requirements

3.1. Climate change is one of the greatest challenges facing our society. Mitigating and adapting to climate change is required to secure our long-term survival and must be at the heart of the vision for the future of our communities. Planning is vital to securing that vision – both directly through facilitating the delivery of renewable energy generation, and strategically, through practical solutions and design that reduces energy demand, promotes sustainable travel, and includes climate resilience measures.

3.2. The UK reduced its greenhouse gas emissions by 46% between 1990 and 2022[8], with much of the progress due to the decarbonisation of the electricity sector. Deployment of renewables has scaled up rapidly and with recent increases in gas prices, renewable technologies including onshore wind, offshore wind and solar are now the cheapest forms of electricity generation[9]. Overall, 56% of electricity generated in 2022 came from low-carbon sources[10].

3.3. Reducing emissions from electricity generation, and then using low-carbon electricity to power the economy, is a central pillar of reaching net zero[11]. This approach to decarbonisation relies on the electrification of heat generation and transport, and the total phasing out of fossil fuel electricity generation. The Government has made a strong commitment to fully decarbonise the sector by 2035[12]. The rapid decarbonisation of the electricity system is thus essential if the UK is to meet its carbon reduction commitments.

3.4. The key challenge is to ensure that these ambitions are delivered on through the rapid scale-up of low-carbon electricity generation and the infrastructure required to deliver it, whilst ensuring that this delivers reliable, resilient and affordable supply. The most effective way to do this is to take a whole-system, integrated approach to energy and

[8] Climate Change Committee (2023), Progress Report to Parliament, www.theccc.org.uk/publication/2023-progress-report-to-parliament

[9] Energy UK (2023), *UK electricity generation in 2022*, www.energy-uk.org.uk/insights/electricity-generation/

[10] UK Government (2023), National Statistics Energy Trends: UK electricity, www.gov.uk/government/statistics/electricity-section-5-energy-trends. Low carbon energy includes wind, solar, hydro, bioenergy and nuclear.

[11] Climate Change Committee (2023), Progress Report to Parliament, www.theccc.org.uk/publication/2023-progress-report-to-parliament

[12] UK Government (2021), Plans unveiled to decarbonise UK power system by 2035, www.gov.uk/government/news/plans-unveiled-to-decarbonise-uk-power-system-by-2035

spatial planning and develop a comprehensive energy plan which reflects how the various renewable technologies can be best tailored to local spatial development ambitions.

3.5. This chapter sets out the key policy and legislative requirements that influence local policy in relation to renewable energy and will therefore need to be considered as the plan is developed. These areas are explored in more detail in the accompanying appendix 1 'Planning for Renewable Energy'. Relevant planning policy and case law relating to each of the technologies covered by the resource assessment are discussed further in chapters 7 to 15 and explored in more detail in the appendices covering onshore wind and ground mounted solar.

Legal Requirements

3.6. Through the Climate Change Act 2008[13] and as a signatory of the Paris Agreement[14], the UK Government has committed to reduce emissions by at least 100% of 1990 levels by 2050; to contribute to global emissions reductions aimed at limiting global temperature rise to well below 2 degrees; and to pursue efforts to limit temperatures to 1.5 degrees above pre-industrial levels.

3.7. To meet these targets, the UK Government sets five-yearly carbon budgets. Meeting the Sixth Carbon Budget[15], which delivers three-quarters of the emissions reductions needed to reach net zero by 2050, is the only way that the UK can deliver on its contribution to the Paris Agreement. The 2023 progress report[16] published by the Climate Change Committee found that nationally we are significantly off track, and that further progress is required across all areas of policy. The Carbon Budget Delivery Plan[17] and 'Powering Up Britain'[18] both set out how the government intends to meet its legally binding climate goals – these are explored in more detail in the appendix 'Planning for Renewable Energy'.

3.8. This overarching national framework is a key consideration for local authority action and in shaping local planning policy for renewable energy, with the Planning and Compulsory

[13] UK Government (2008), Climate Change Act, www.legislation.gov.uk/ukpga/2008/27/contents
[14] United Nations Framework Convention on Climate Change (2015), The Paris Agreement, www.unfccc.int/process-and-meetings/the-paris-agreement
[15] Climate Change Committee (2020), Sixth Carbon Budget, www.theccc.org.uk/publication/sixth-carbon-budget/
[16] Climate Change Committee (2023), 2023 Progress Report to Parliament, www.theccc.org.uk/publication/2023-progress-report-to-parliament
[17] UK Government (2023), Carbon Budget Delivery Plan, www.gov.uk/government/publications/carbon-budget-delivery-plan
[18] UK Government (2023), Powering Up Britain, www.gov.uk/government/publications/powering-up-britain

Purchase Act 2004[19] setting out the legal duty on plan-making to demonstrate how policy contributes to the mitigation of, and adaptation to, climate change.

3.9. The Planning and Energy Act 2008[20] further strengthens the role of local planning to support renewable energy, setting out powers for LPAs to require a proportion of the energy for new development to be sourced in the locality of the development through renewable or low-carbon generation, and enabling LPAs to establish energy efficiency standards that exceed the energy requirements of building regulations.

National Planning Policy Framework

3.8. The National Planning Policy Framework (NPPF)[21] makes clear that "mitigating and adapting to climate change" is a core planning objective, stating that the planning system should:

- "support the transition to a low carbon future in a changing climate"
- help to "shape places that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience, encourage the reuse of existing resources and support renewable and low carbon energy and associated infrastructure".
- "take a proactive approach to mitigating and adapting to climate change".
- that "new development should be planned for in ways that can help to reduce greenhouse gas emissions", which can be achieved in part by shaping the location and design of development.
- LPAs are encouraged to "provide a positive strategy for energy from these sources" by identifying suitable areas for renewable energy generation and its supporting infrastructure, and by maximising the opportunities for community-led and decentralised energy production, whilst ensuring that adverse impacts are satisfactorily addressed.

3.9. The NPPF states that Local Planning Authorities should not require applicants to demonstrate the overall need for renewable or low carbon energy, recognising that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions.

3.10. The NPPF was updated in September 2023, making minor alterations to the renewable and low carbon development section. Applications for these uses should be approved if

[19] UK Government (2004), Planning and Compulsory Purchase Act 2004, www.legislation.gov.uk/ukpga/2004/5/contents
[20] UK Government (2008), Planning and Energy Act 2008, www.legislation.gov.uk/ukpga/2008/21/contents
[21] UK Government (2023), National Planning Policy Framework, www.gov.uk/government/publications/national-planning-policy-framework--2

its impacts are (or can be made) acceptable, with the notable exception of onshore wind: "except for applications for the repowering and life-extension of existing wind turbines, a planning application for 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 or a supplementary planning document; and, following consultation, it can be demonstrated that the planning impacts identified by the affected local community have been appropriately addressed and the proposal has community support"[22]. Wind energy development involving one or more turbines can also be permitted through Local Development Orders, Neighbourhood Development Orders, and Community Right to Build Orders.

3.11. 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.

3.12. When considering applications for the repowering and life-extension of existing renewable sites, significant weight should be given to the benefits of utilising an established site, and the application approved if its impacts are or can be made acceptable.

3.13. Industry reaction to these NPPF changes suggests that they are unlikely to materially change the rate of deployment of onshore wind in England.

National Planning Practice Guidance (PPG)

3.14. PPG[23] outlines how Local Planning Authorities can develop a positive strategy for promoting the delivery of renewable and low carbon energy:

- When developing a local plan, LPAs should first consider what the local potential is for renewable and low carbon energy generation.
- Thought should be given to the range of technologies that could be accommodated, and the policies needed to encourage their development in the right places.
- Local authorities should design their policies to maximise renewable and low carbon energy development, but there is no quota which the local plan has to deliver.

[22] UK Government (2023), National Planning Policy Framework 'Planning for Climate Change', https://www.gov.uk/government/publications/national-planning-policy-framework--2
[23] UK Government, Planning Practice Guidance, www.gov.uk/government/collections/planning-practice-guidance

3.15. It goes on to point out that although the National Planning Policy Framework explains that all communities have a responsibility to help increase the use and supply of green energy this does not mean that the need for renewable energy automatically overrides environmental protections and the planning concerns of local communities. As with other types of development, it is important that the planning concerns of local communities are properly heard in matters that directly affect them.

Community led renewable energy initiatives

3.16. The PPG sets out the role for community-led renewable energy initiatives, stating that "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."

3.17. Neighbourhood plans are seen as an "opportunity for communities to plan for community led renewable energy developments". Neighbourhood Development Orders and Community Right to Build Orders can also be used to grant planning permission for renewable energy. Local Planning Authorities should "set out clearly any strategic policies that those producing neighbourhood plans or Orders will need to consider when developing proposals" and should share any relevant evidence that may assist those producing such a plan.

Identifying suitable areas for renewable and low carbon energy

3.18. The PPG states that there are "no hard and fast rules" about how suitable areas for renewable energy should be identified, but in considering locations, LPAs should take into account the requirements of the technology, and the potential impacts on the local environment, including from cumulative impacts. The views of local communities likely to be affected should be listened to. Identifying areas suitable for renewable energy in local plans gives greater certainty as to where such development will be permitted.

Criteria based policies

3.19. Policies based on clear criteria can be useful when they are expressed positively (i.e., that proposals will be accepted where the impact is or can be made acceptable). The PPG recommends that in shaping local criteria for inclusion in local plans, the following is considered:

- The need for renewable or low carbon energy does not automatically override environmental protections.
- Cumulative impacts require particular attention.
- Local topography is an important factor when assessing effects on landscape.
- Great care should be taken to ensure heritage assets are conserved in a manner appropriate to their significance.

- Proposals in National Landscapes / Areas of Outstanding Natural Beauty (AONBs) and in areas close to them will need careful consideration.
- Protecting local amenity is an important consideration which should be given proper weight.

Use of buffer zones

3.20. LPAs should not rule out otherwise acceptable renewable energy developments through inflexible rules on buffer zones or separation distances. Distance of itself does not necessarily determine whether the impact of a proposal is unacceptable. Local context also plays a part, including factors such as topography, the local environment and nearby land uses.

Environmental Impact Assessment

3.21. Certain developments are subject to Environmental Impact Assessment (EIA). Schedule 1 developments always require EIA regardless of potential impacts. Schedule 2 developments only require assessment if they have the potential to have significant effects on the environment. This process is undertaken by the Local Planning Authority to determine whether there are likely to be significant effects on the environment.

Nationally Significant Energy Projects

3.22. Renewable and low carbon power stations of over 50 megawatts capacity and above-ground electricity power lines at or above 132 kilovolts (kV) constitute Nationally Significant Infrastructure Projects (NSIP). Applications are made to the Planning Inspectorate, rather than the LPA, which makes recommendations to ministers.

3.23. Onshore wind projects are treated differently. Since the Infrastructure Planning (Onshore Wind Generating Stations) Order 2016, onshore wind farms are no longer considered to be NSIPs under the Planning Act 2008. This means that onshore wind schemes are considered by the local authority rather than the Secretary of State. Battery storage projects above 50 MW in England are also now assessed through the Town and Country Planning Act, instead of having to go through the NSIP regime as they were prior to 2020.

Current Local Plan Policies & Climate Emergency Declarations

3.24. The current adopted JCS includes Policy INF5 (Renewable Energy/Low Carbon Energy Development) that encourages the generation of energy from renewables but only where the environmental, social and economic benefits outweigh any significant adverse impact on the local environment, and significantly with the exception of wind energy.

Adverse impacts referenced span a wide range of factors ranging from associated impacts from transmission lines, access, local amenity and biodiversity to any impact on the Cotswolds National Landscape (previously AONB)or designated Green Belt, to impacts on local users and residents covering emissions, noise, odour or visual amenity. Proposers are required to show how they have designed and sited schemes to avoid adverse impact, how they bring local economy and community benefit, how schemes can be cost-effectively removed in future to reinstate the site and how their carbon saving benefits outweigh any carbon use associated with manufacture or installation.

3.25. Cheltenham, Gloucester and Tewkesbury have all seen significant local policy shifts in the last five years towards positive local action to address climate change, specifically linked to their climate emergency declarations.

- In 2019, Cheltenham Borough Council declared a climate emergency and a commitment to be a carbon neutral council and borough by 2030. In addition to procuring 100% renewable electricity itself, it highlighted an intention to develop the business case for renewable energy, like wind and solar power, on suitable sites. Its subsequent Climate Emergency Action Plan (2022)[24] states it will encourage businesses and residents to use 100% renewable energy and will encourage developers to commit to renewable energy by stipulating requirements in a new Supplementary Planning Document.

- Gloucester City Council adopted its climate emergency resolution in July 2019, committing the Council to becoming carbon neutral by 2030 and the city as whole by 2050. Its Climate Change roadmap, published in 2020, sets out broad principles including generating clean energy – emphasising that they will be looking to maximise the use of energy sources such as wind, hydro and solar.

- Tewkesbury Borough Council declared a climate emergency in October 2019, with a commitment for the council itself to achieve carbon neutrality by 2030. The resulting action plan sets out the need for renewable energy solutions to offset consumption following demand reduction and energy efficiency measures.

Green Belt

3.26. The area covered in this renewable energy study includes the Tewkesbury Green Belt. As shown in Figure 2 the majority of the Green Belt is located within Tewkesbury Borough,

[24] Cheltenham Borough Council, Climate emergency action plan, www.cheltenham.gov.uk/info/61/climate_and_sustainability/1731/climate_emergency_action_plan_-_pathway_to_net_zero

situated between Cheltenham and Gloucester, and between Cheltenham and Bishop's Cleeve. Some areas extend into Cheltenham Borough.

3.27. The government attaches great weight to Green Belts. NPPF paragraph 151 states that when located in the Green Belt, elements of many renewable energy projects will comprise inappropriate development. In such cases, very special circumstances will need to be demonstrated if projects are to proceed. Such very special circumstances may include the wider environmental benefits associated with increased production of energy from renewable sources.

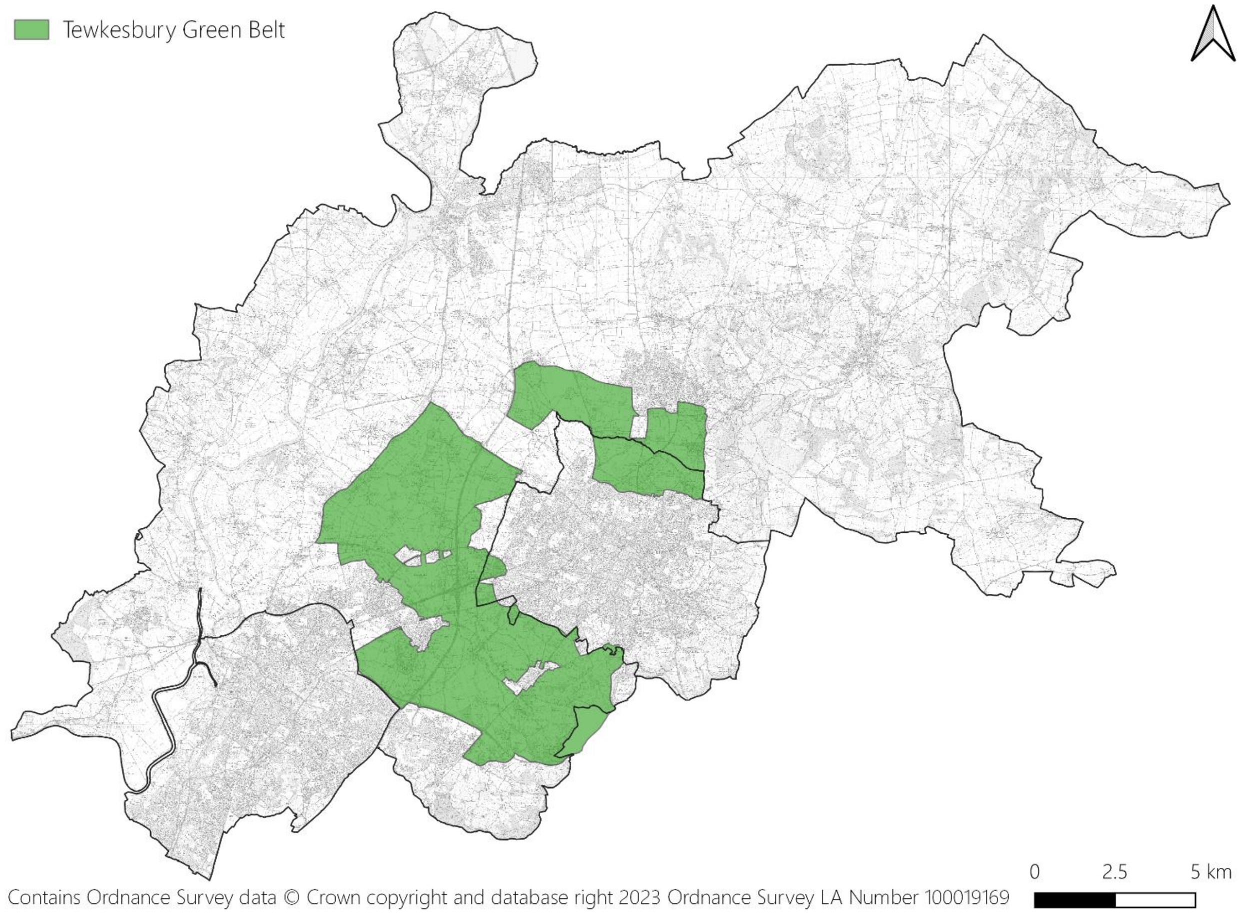

Figure 2 Tewkesbury Green Belt (National Map of Planning Data)

Areas of Outstanding Natural Beauty (AONB) / National Landscapes

3.28. The Cotswolds National Landscape (CNL) (known as Area of Outstanding Natural Beauty (AONB) until September 2023) is the largest National Landscape in the country. It has been nationally designated for its landscape importance and covers a substantial part of the study area (shown in Figure 3). The NPPF confers on National Landscapes / AONBs protection from major development, making clear that development should only be granted in exceptional circumstances.

3.29. The Cotswolds National Landscape Board's Management Plan[25] advocates "generating energy from low carbon sources in a manner consistent with the purpose of National Landscape (AONB) designation". The Renewable Energy Position Statement[26] published June 2023, confirms that the Board would be supportive of small-scale renewable energy technologies, provided that relevant considerations have been adequately addressed. The Board are of the view that large-scale forms of renewable energy deployment are unlikely to be compatible with the statutory purpose of conserving and enhancing the natural beauty of the AONB.

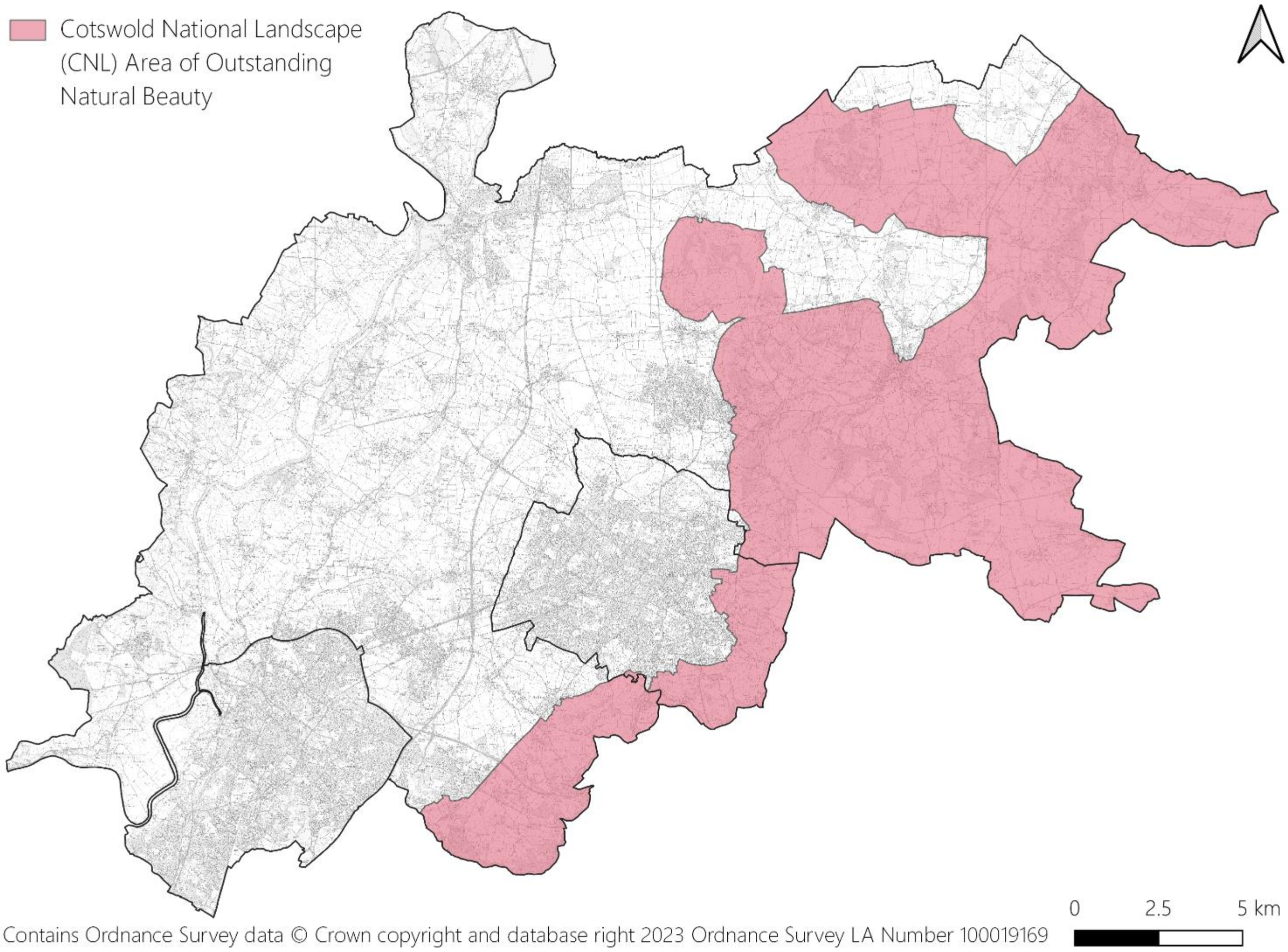

Figure 3 Cotswolds National Landscape (CNL) (National Map of Planning Data)

[25] Cotswolds National Landscape Board (2023), Cotswolds National Landscape Management Plan 2023 – 2025, www.cotswolds-nl.org.uk/wp-content/uploads/2023/09/CNL_Management-Plan-2023-25_final.pdf
[26] Cotswolds National Landscape Board (2023), Position Statement – Renewable Energy, www.cotswolds-nl.org.uk/wp-content/uploads/2023/07/Renewable-Energy-June-2023.pdf

3.30. Conclusion: Planning for renewable energy

The development of the local plan is one of the most powerful tools available to a local area to shape its vision for a sustainable future. It is recommended that the SLP treats climate change related issues (both mitigation and adaptation) as central to policy formulation, visioning and strategic objective setting.

The SLP must be able to demonstrate how it is supporting the transition to a low carbon future by contributing to the Climate Change Act national target regime and the Sixth Carbon Budget (reducing emissions by at least 100% of 1990 levels by 2050 and 78% by 2035). The SLP must develop a positive strategy for the delivery of renewables and low carbon energy, including identifying suitable areas for renewable energy development (particularly important for onshore wind).

But policy must also be designed to mitigate any potential adverse impacts – through ensuring that development has community backing, undertaking suitable environmental impact assessment, and avoiding any negative impacts on designated areas. Proposals in the National Landscape / AONB and Green Belt will need particularly careful consideration to balance between the benefits of renewable energy and any harmful impacts.

4. Existing renewable and low carbon energy generation

4.1. This chapter gives an overview of existing renewable and low carbon energy generation in the area, as contained within public records.

Renewable electricity generation

4.2. According to 2021 renewable electricity statistics published by the Department for Energy Security and Net Zero (DESNZ)[27], there are 6,765 solar PV sites in the SLP area. These total 66.2 MW capacity and generation of 55.18 GWh in 2021 (NB. generation statistics for technologies other than solar photovoltaics (PV) were suppressed to prevent the output of individual plants being revealed). Other renewables are much less prevalent in the area. There are no hydropower sites or and installed wind capacity is lower than 0.1 MW.

4.3. Units of Energy

kW, MW: Kilowatt (1,000 watts), Megawatt (1,000 kilowatts). A measurement of power; also known as capacity.

kWp: Kilowatt peak. The peak power output of a system, commonly used in solar arrays. A solar panel with a peak power of 3kWp which is working at its maximum capacity for one hour will produce 3kWh.

kWh, MWh, GWh: Kilowatt hours, Megawatt hours (1000 kilowatt hours), Gigawatt hours (1000 megawatt hours). A measurement of energy (used or generated) over time.

MWe: Megawatts of electricity (as opposed to **MWth:** Megawatts thermal)

[27] UK Government (2022), Regional Renewable Statistics, www.gov.uk/government/statistics/regional-renewable-statistics

Table 1 Renewable electricity generation technologies across the SLP authorities

Renewable Technology	Number of Sites	Installed Capacity (MW)
Solar Photovoltaics	6,765	66.2
Onshore Wind	2	<0.1
Anaerobic Digestion	2	2.8
Sewage Gas	2	2.1
Landfill Gas	3	12.3
Plant Biomass	1	0.6
Total	6,775	83.8

Renewable Energy Planning Database (REPD)

4.4. The Renewable Energy Planning Database (REPD) is published quarterly by DESNZ and records renewable energy projects over 150 kW. According to the REPD, in April 2023 there are 36 sites either operational or in the planning stages in the Gloucestershire area (shown in Table 2).

4.5. Six of these sites are operational. This includes three solar PV (ground mounted), one anaerobic digester, one battery and one biomass system. The total installed capacity is 47.4 MWe. Troughton Farm is the largest installation with a ground mounted solar farm of 30 MW. All of the operational installations are within the Tewkesbury Borough Council area (although some are covered by the planning authority Gloucestershire County Council).

4.6. The Javelin Park energy from waste facility is outside of the SLP area but worth mentioning as 36% of the waste it receives is from the study area[28]. It is operational and has a capacity of 14.5 MWe. It is shown in Figure 4 as the only energy from waste incineration site (south of the CGTSLP boundary).

[28] UK Government, 2021 Waste Data Interrogator, www.data.gov.uk/dataset/d8a12b93-03ef-4fbf-9a43-1ca7a054479c/2021-waste-data-interrogator

Table 2: Renewable Energy Planning Database Applications

Planning Authority	Number of Applications (Operational or submitted, granted, revised)
Tewkesbury Borough Council	22 (1 expired)
Cheltenham Borough Council	1
Gloucester Council	10 (1 expired)
Gloucestershire County Council	3
Total	36

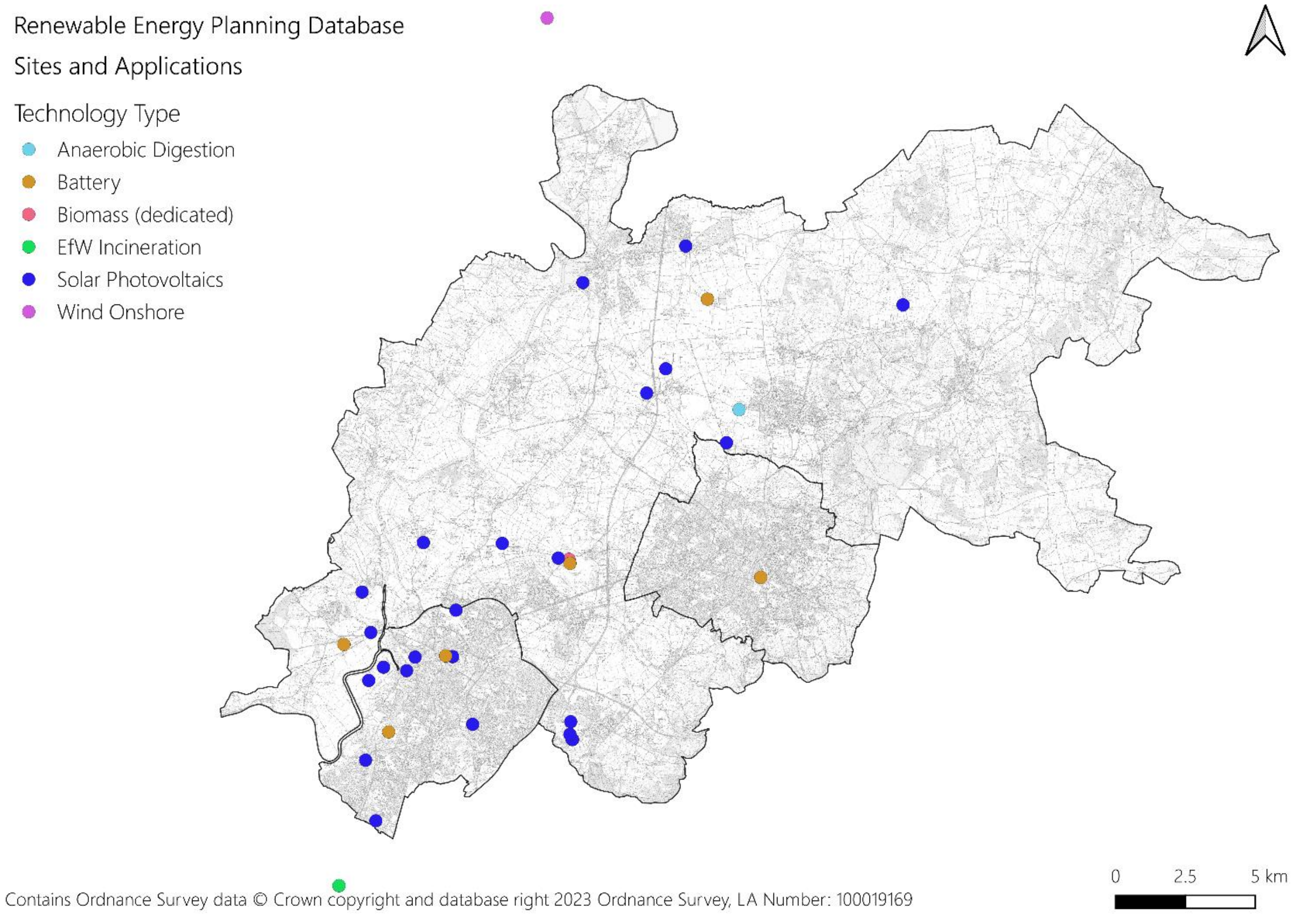

Figure 4 REPD Sites and Applications across SLP authorities and Gloucestershire County Council

4.7. As shown in Figure 4, the majority of REPD sites and applications are for solar PV. 41.7 MW is either operational or under construction, with a further 104.6 MW in the planning system either granted, submitted or revised. 14 of these installations are for ground-mounted and 12 are for roof-mounted solar.

4.8. Battery technology is also relatively common with seven applications (including one abandoned and one expired). There is one operational battery in Tewkesbury Borough Council area with 1.5 MW capacity. There is a potential for four further batteries (102 MW capacity) to be installed (granted and submitted applications).

Feed-in-tariff

4.9. Table 3 shows the domestic and non-domestic installations of renewable energy from Feed-in-tariff Statistics (2019)[29]. This data shows installations from 2010 to 2019 under the feed in tariff. The vast majority of these are solar PV. Compared to the UK average of 296 domestic PV installations per 10,000 households, Gloucester is slightly under with fewer installations and Cheltenham and Tewkesbury are over average.

4.10. The data reports some onshore (non-domestic) wind installations from 2019 (one in Cheltenham and one in Gloucester). There is one non-domestic anaerobic digestion (AD) plant at Wingmoor Farm near Bishops Cleeve in the Tewkesbury Council area (which is also reflected in the REPD). Food waste from the surrounding area is collected and digested at this site. The AD is combined heat and power (CHP) enabled and has an electric capacity of 1.6 MW. There are also anaerobic digesters and a CHP system at Netheridge Sewage Treatment Works (although not seen in the data below). There are three non-domestic microCHP's installed (two in Tewkesbury and one in Gloucester).

Table 3: Feed-in-tariff statistics across SLP authorities

Local Authority	PV Installations per 10,000 households	Total Domestic Installations	Total Non-Domestic Installations	Total
Tewkesbury	419.85	1,656	113	1,769
Cheltenham	365.97	1,970	45	2,015
Gloucester	264.30	1,464	63	1,527
Total		**5,090**	**221**	**5,311**

Renewable Heat Incentive

4.11. Table 4 shows accredited installations under the Renewable Heat Incentive (RHI) scheme (2022)[30]. In the domestic sector, the eligible technology types are biomass boilers and pellet stoves, air and ground source heat pumps, solar thermal panels.

[29] UK Government (2020), Sub-regional Feed-in Tariffs statistics, www.gov.uk/government/statistical-data-sets/sub-regional-feed-in-tariffs-confirmed-on-the-cfr-statistics

[30] UK Government (2023), Renewable Heat Incentive statistics, www.gov.uk/government/collections/renewable-heat-incentive-statistics

4.12. Some of the non-domestic RHI statistics have been redacted for Gloucester and Cheltenham due to low counts and to prevent disclosure of individual sites (see footnote 31). Within the domestic RHI installations, there are 110 air source heat pumps reported in Tewkesbury and 17 solar thermal. Data for the other local authority districts and technology types were redacted.

Table 4 Renewable Heat Incentive 2022 statistics in the SLP area

	Domestic	Non-domestic
Local Authority	Number of accredited full applications	Number of accredited full applications
Tewkesbury	177	45
Cheltenham	73	#[31]
Gloucester	30	^
Gloucestershire	*1,825*	*433*
Total (CGTSLP area)	280	

Heat networks

4.13. Although heat networks are not inherently renewable, we have included decarbonisation of heat in this study. Existing district and communal heat networks have the potential to switch to a low carbon supply (such as a heat pump). Newer networks should be set up with a zero-carbon supply. The heat network planning database[32] includes two heat networks in Gloucester. These are both communal networks, which differ from the standard definition of district heating in that the heat source in communal heating supplies heat to two or more customers within the same building rather than supplying two or more buildings. One of the networks is under construction at Kings Quarter which will supply a hotel and retail using an air source heat pump. The operational network supplies Gloucestershire College at Llanthony Road using a ground source heat pump. This site also has planning permission for a 640 kW roof-mounted solar PV array.

4.14. Conclusion: Current renewable energy installations

There are 6,775 renewable electricity sites recorded in the area with almost all of them being solar PV. The total renewable installed capacity in the area is 83.8 MW.

[31] Within the dataset the reason shown for why data has been redacted: '# refers to values between 1 and 5 inclusive which have been supressed to prevent disclosure. ^ refers to values greater than 5 which have been supressed where only one other value within the group was suppressed to prevent disclosure'.

[32] UK Government (2023) Heat Networks Planning Database, www.data.gov.uk/dataset/8a5139b3-e49b-47bd-abba-d0199b624d8a/heat-networks-planning-database

Compared to the UK average of 296 domestic PV installations per 10,000 households, Gloucester has slightly fewer installations (264 per 10,000 households) and Cheltenham and Tewkesbury have above average numbers (366 and 420 per 10,000 households respectively). Compared to the England average of 36 domestic RHI installations per 10,000 households, Gloucester and Cheltenham have fewer installations (5 and 13 per 10,000 households respectively). Tewkesbury is above average (43).

There are two communal heat networks in the area, both located in Gloucester. One is operational with a ground source heat pump and the other is currently under construction with an air source heat pump.

5. Baseline energy consumption and emissions

5.1. According to the most recent statistics[33] the total stationary energy usage in the SLP area was 4,924.3 GWh in 2020. 49% of this is domestic and 51% non-domestic. Carbon emissions factors are provided in appendix 7.

Table 5: Energy consumption statistics (non-transport)

Sector	Electricity (GWh/year)	Gas (GWh/year)	Other fuels excl. bioenergy and waste (GWh/year)	Bioenergy and waste (GWh/year)	Total (GWh/year)
Domestic	579.1	1,725.3	64.7	49.6	2,418.7
Industrial, commercial, and other	867.1	1,023.0	352.8	262.7	2,505.6
Total	1,446.2	2,748.3	417.5	312.3	4,924.3[34]

Table 6: Carbon emissions estimates for energy use (non-transport)

Sector	Electricity (thousand tonnes CO_2e/year)	Gas (thousand tonnes CO_2e/year)	Other fuels excl. bioenergy and waste (thousand tonnes CO_2e/year)	Bioenergy and waste (thousand tonnes CO_2e/year)	Total (thousand tonnes CO_2e/year)
Domestic	106.0	315.7	18.1	10.9	450.8
Industrial, commercial, and other	158.7	187.2	99.0	57.8	502.6
Total	264.7	502.9	117.1	68.7	953.4

[33] UK Government (2022), Total final energy consumption at regional and local authority level: 2005 to 2020, www.gov.uk/government/statistics/total-final-energy-consumption-at-regional-and-local-authority-level-2005-to-2020

[34] This differs slightly from the estimated annual energy demand used in the resource assessment (4,208 GWh) due to the heat demand modelled for the district heating analysis using a different methodology to the local authority statistics – see chapter 12 for more information.

6. Approach to the energy resource assessment

6.1. The following chapters explore nine renewable and low carbon energy generation resources and associated technologies in detail, providing a description of the technology, the relevant planning policy considerations, an overview of the methodology used to assess energy potential in the SLP area, and a summary of the technical potential available. 'Technical potential' means the technically exploitable energy (electricity or heat) from a given resource.

6.2. The assessment is a desk-based exercise involving industry-standard assumptions and calculations and/or GIS mapping to establish the technical potential of each resource or technology. By applying a set of tailored constraining factors to each resource, the renewable energy potential can be expressed as generating capacity (MW), typical annual energy yield (MWh or GWh) and resulting carbon savings from offsetting fossil fuels (tonnes CO_2/year).

6.3. The assessment estimates the theoretical resource that may remain after applying a set of broad constraints that are mostly technical in nature such as minimum average wind speeds and minimum distance from dwellings (for wind power), available roof space and orientation (for rooftop solar PV) and agricultural land classification (for energy crops).

6.4. Other constraints such as those imposed by landscape, political or financial issues are not considered in this part of the study, and it is important to note that the viability of any individual proposal for renewable energy generation may be subject to additional site-specific factors. Some of these factors will be considered in more detail in part two of the study, including through the landscape sensitivity assessment for wind and ground mounted solar. The approach to this assessment is set out in detail in appendix 8 'Landscape Sensitivity Assessment Methodology for Wind and Solar Developments'.

7. Onshore Wind

Introduction

7.1. 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.

7.2. Turbine scales do not fall intrinsically into clear and unchanging size categories. At the largest scale, turbine dimensions and capacities are evolving quite rapidly. As defined scales need to be applied for the purpose of the resource assessment, the assessment has used five size categories based on consideration of current and historically 'typical' turbine models:

- Very large (150-220m tip height)
- Large (100-150m tip height)
- Medium (60-100m tip height)
- Small (25-60m tip height)
- Very small (<25m tip height)

7.3. An assessment of technical potential for very small wind (<25m height) was not undertaken as it is not possible to define areas of suitability for these using the same assessment criteria. Notional turbine sizes were used for the purposes of this resource assessment. An estimated median of each class size was used (Table 7).

Table 7 Notional turbines used for the resource assessment

Scale	Typical Turbine Installed Capacity	Typical Turbine Height (maximum to blade tip)
Very large	4 MW	185m
Large	2.5 MW	125m
Medium	0.5 MW	80m
Small	0.05 MW	45m

7.4. 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 7). The majority of operational and planned turbines range between 80m and 220m, with the majority at the larger end of the scale.

Planning Policy & Deployment Considerations

7.5. Since the removal of financial support and restrictive policy requirements incorporated in the NPPF, onshore wind development activity has moved overwhelmingly away from England towards Scotland and Wales, where it is focusing particularly on sites with high wind speeds and the ability to accommodate large numbers of tall turbines. Very few onshore wind energy projects have been approved and built within England since 2015.

7.6. The Government does not have a target for onshore wind capacity, but current national deployment rates are slightly off track relative to the CCC's Sixth Carbon Budget analysis (see paragraph 0 for more detail on the carbon budget).

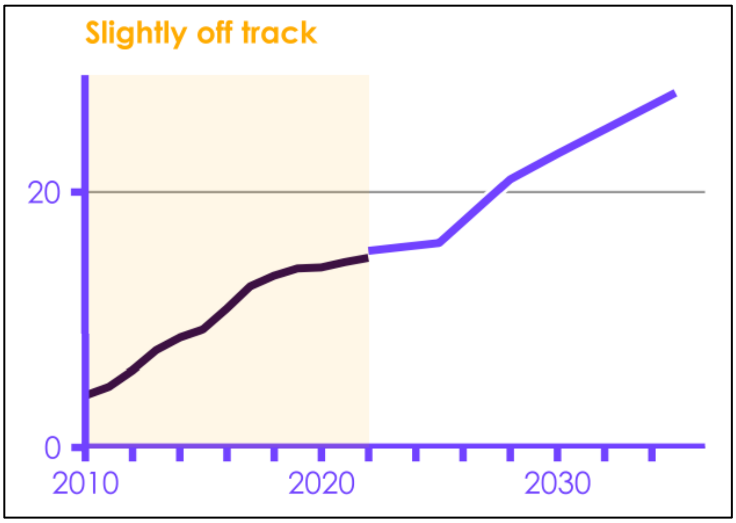

Figure 5 CCC Annual Progress Report (2023): Key indicators - onshore wind operational capacity (GW).

7.7. The technical wind development potential within the SLP area, 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. Key factors that affect deployable potential are discussed below, and explored in more detail in appendix 2 'Onshore wind – further information.

Grid connection

7.8. 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 increasing congestion on the distribution network and the transmission network[35], and the expensive network reinforcement costs (which fall to the developer). Grid connection issues in the SLP area are explored in more detail in Chapter 11 - Electricity grid constraints & battery storage.

Development income

7.9. Financial support mechanisms in the form of Government subsidies such as the Renewables Obligation (RO) and Feed In Tariff (FiT) previously allowed onshore wind to be developed at a variety of scales and at a variety of wind speeds. The RO closed to all new generating capacity in 2017 and the FiT closed to new applicants in 2019. The Contracts for Difference (CfD) scheme is now the Government's main mechanism for supporting low-carbon electricity generation[36].

7.10. CfD funding from 2017 to 2019 excluded onshore wind developments. Since Round 4 opened in December 2021 onshore wind has been included again. Nonetheless developers have found that CfDs do not make schemes financially viable in much of England where wind speeds are typically lower, and any potentially financially viable developments require a number of very large turbines to maximise the power output and make the scheme economically viable. These schemes are, however, unlikely to be acceptable in many locations in England at the present time due to planning constraints.

7.11. Overall, viability challenges based on reduced income relative to capital costs are a systemic challenge for wind development at all scales within southern England at the present time – to the extent that, if this challenge is not addressed by Government (alongside the existing planning constraints), the deployable wind potential within the SLP area is likely to be low.

7.12. Viability and funding mechanisms are discussed in more detail in the technical appendices.

National Planning Policy & Guidance

7.13. The PPG offers advice on the planning considerations that relate to wind turbines in paragraphs 14 to 33 of the Renewable and low carbon energy section. Paragraph 33

[35] The transmission network refers to the highest voltage electricity network in the UK – the 'motorway network' of the energy world - it transmits large quantities of electricity over long distances via wires carried on a system of mainly metal towers (pylons) and large substations. The lower voltage, more local, parts of the system are called the distribution network.

[36] Department for Business, Energy and Industrial Strategy (2022) Contracts for Difference, www.gov.uk/government/publications/contracts-for-difference/contract-for-difference

confirms that 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; and
- following consultation, it can be demonstrated that the planning impacts identified by affected local communities have been fully addressed and therefore the proposal has their backing.

7.14. Paragraph 33 adds that whether the proposal has the backing of the affected local community is a planning judgement for the Local Planning Authority. The legitimate interpretation of this provision has not been definitively established via case law. However, it has had a discouraging influence on developers. Larger commercial developers are currently not interested in pursuing wind farm developments within much of England, although there may be scope for small scale, single turbine installations implemented by farmers or community energy groups.

7.15. Changes were made to the NPPF in September 2023 to give more routes for LPAs to identify areas as suitable for wind energy development, with supplementary planning documents now being included alongside local and neighbourhood plans. Other routes to permitting wind turbines are now explicitly stated, with Local Development Orders, Neighbourhood Development Orders and Community Right to Build Orders included alongside the traditional planning application route. The approach to repowering and life-extension of existing wind turbines and other renewable sites has also been clarified, with the expectation that applications are granted if the impacts are or can be made acceptable, with significant weight to be given to utilising an established site (which, in the case of wind, does not necessarily need to be in an area identified as suitable for wind energy development).

Landscape sensitivity

7.16. Landscape and Visual Impact (LVI) has historically often been a 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. The approach to landscape sensitivity for wind for this study is discussed in paragraph 7.30 and 7.31.

Environmental Impact Assessment

7.17. Local Planning Authorities are required to screen applications for wind turbines for the need for EIA where the development involves the installation of more than two turbines or the hub height of any turbine or height of any other structure exceeds 15 metres.

Case law

7.18. Wind farms will always cause some environmental harm because of their scale but they will always have the benefit of providing energy from a renewable source. Appeal decisions invariably depend on the outcome of weighing the harm against this benefit. With this in mind, case law presents a mixed picture. These cases and more are discussed in detail in the appendix 'Onshore wind'.

7.19. The amount of renewable energy contributed has been found to be a material consideration[37] and the contribution to renewable energy targets has been given weight by inspectors[38]. Larger schemes have the potential to cause greater harm to landscape character and attract more significant weight against the proposal. However, the wider environmental benefits associated with increased production of renewable energy has the potential to be outweighed by harm identified to character and appearance[39].

7.20. Turbines in the Green Belt have been classed as inappropriate development[40] but significant weight can be given to renewable energy produced by wind turbines, which has the capability to outweigh Green Belt harm[41] and very special circumstances for Green Belt proposals have the potential to exist[42].

7.21. Case law also touches on community impacts - benefits in terms of job creation have been given weight by Inspectors[43], but community benefits arising from a project that do not affect the use of the land cannot be a material consideration[44]. In relation to footnote 54 of the NPPF, targeted pre-application consultation with the local community has the potential to indicate community backing of the proposal[45].

Cumulative impact

7.22. The cumulative landscape impacts are the effects of a proposed development on the fabric, character and quality of the landscape; it is concerned with the degree to which a proposed renewable energy development will become a significant or defining characteristic of the landscape. The NPPF advises that adverse effects, including cumulative landscape and visual effects must be addressed satisfactorily. The cumulative

[37] Finn-Kelcey v Milton Keynes Council 10/10/2008
[38] Land at Stowford Cross, Bradworthy (APP/W1145/A/02/1105474)
[39] Ibid.
[40] Land at Green Holes Farm, Coal Gate Lane (APP/A4710/W/15/3134617)
[41] Finn-Kelcey v Milton Keynes Council 10/10/2008
[42] Scout Moor Wind Farm, Rochdale, Lancashire (APP/P4225/V/15/3139737)
[43] Land at Stowford Cross, Bradworthy (APP/W1145/A/02/1105474)
[44] Addleshaw Goddard LLP (2019), www.addleshawgoddard.com/en/insights/insights-briefings/2019/real-estate/r-v-resilient-energy-severndale-ltd/ & Supreme Cort UK (2019), www.supremecourt.uk/cases/docs/uksc-2018-0007-judgment.pdf
[45] Land at Green Holes Farm, Coal Gate Lane (APP/A4710/W/15/3134617)

effects of wind farm proposals are of increasing significance as more have been constructed, particularly in terms of their landscape impact. More detail on cumulative impact is provided in the technical appendices.

Public attitudes, engagement and community benefits

7.23. Footnote 54 of paragraph 158(b) of the NPPF requires that wind energy schemes should only be approved if "following consultation, it can be demonstrated that the planning impacts identified by the affected local community have been appropriately addressed and the proposal has community support." However, as noted above, the lack of definition of what constitutes the "local community", or what level of "support" is required can cause issues. While there is a high level of public support for wind farms in general, actual proposals have in the past faced fierce and vocal opposition.

7.24. There is some evidence that public attitudes to the local deployment of onshore wind have softened[46], but more nuanced approaches to community engagement are required to leverage public support.

7.25. Community owned wind farms are more likely to receive backing as local people will consider themselves to be benefiting financially from the turbines rather than large corporations exploiting the community and its assets. However, local planning policy at present would not be able to refuse an otherwise acceptable renewable energy proposal because it was a commercial project, or as seen in the Severndale challenge (footnote 44), approve an application because it was community owned.

7.26. In terms of case law, lack of clear community support can persuade Inspectors to refuse plans. However, the NPPF is not clear in what constitutes a local community.[47] The requirement for sites to be identified as suitable for wind energy has been deemed to be irrelevant by Inspectors in areas where a local plan pre-dates the NPPF requirement to identify such areas.[48]

7.27. The requirement for planning impacts identified by the local community to be appropriately addressed should not be read as a requirement to wholly eliminate any detrimental impacts. The "natural meaning" of the word 'addressed' is that an Authority could find a proposal acceptable if it 'sufficiently addressed' and, as far as necessary,

[46] An ongoing research project by Oxford Brookes demonstrates majority support for wind turbines in South England - https://soole.brookes.ac.uk/prelimreport21. CSE's Future Energy Landscape project has likewise demonstrated majority support for onshore wind in 9 out of 10 communities engaged: www.cse.org.uk/my-community/community-projects/future-energy-landscapes-community-consultation-method/
[47] Hambleton 10/08/2020 (APP/G2713/W/20/3246847)
[48] Ibid.

mitigated the planning impacts identified through consultation with the local community[49].

Resource Assessment Methodology

7.28. The assessment of technical 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 suitable wind speeds (applying a reasonable but relatively generous assumption in this respect (all areas with mean annual average wind speed of <5m/s at 50m above ground level), bearing in mind that only the highest wind speeds are potentially viable at the present time) and the number of turbines that could theoretically be deployed within these areas[50]. A series of constraints relating to physical features, such as environmental/heritage protection were then removed. The remaining areas have 'technical potential' for wind energy development. The key constraints considered are set out in detail in the technical appendix.

7.29. Unconstrained areas of land were excluded if they were below a minimum developable size of 40m width and an area that varied per turbine size:

- Very large: 0.8ha
- Large: 0.6ha
- Medium: 0.4ha
- Small: 0.2ha

7.30. 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 this assessment on landscape or visual grounds. Instead, a separate landscape sensitivity assessment (LSA) will be undertaken to consider all Landscape Character Areas defined within the Gloucestershire County Landscape Character Assessment and Cotswolds AONB Landscape Character Assessment.

7.31. The LSA will be used alongside the output of this assessment of technical potential to help the councils identify which areas may be more or less suitable for onshore wind energy development. It should be noted that site specific assessments (including landscape and visual impact and residential amenity assessments) would also be needed to verify the suitability of specific wind energy development proposals in landscape terms. Careful consideration of the potential landscape impacts versus the public benefits of renewable energy would need to be weighed through the planning application process.

[49] Holder v Gedling Borough Council [2018]
[50] The wind speed data is sourced from Global Wind Atlas 3.0.

Results

7.32. Table 8 below provides a summary of technical potential for wind energy within the SLP area. Where potential exists for more than one size of turbine, it was assumed that the larger turbines would take precedence as, to ensure viability, developers usually seek to install the largest capacity turbines possible. The calculation of potential wind capacity involved applying an assumption concerning development density and the application of a 'capacity factor' i.e. the average proportion of maximum turbine capacity that would be achieved in practice over a given period – the assumptions calculations are detailed in appendix 5 'Key Assumptions: Onshore wind & Ground mounted solar'.

The assessment results indicate that there is a technical potential to deliver up to around 1,151 MW of wind energy capacity in the SLP area, with the greatest potential for small turbines as these can be located in more areas (see Figure 6 and 7).

7.33. Additional maps included in appendix 2 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 the largest areas of potential for wind generation, particularly small-scale generation, are scattered across the Borough of Tewkesbury with small pockets within Gloucester and Cheltenham.

Table 8 Onshore wind potential capacity, output and carbon savings

Development scale	Estimated total capacity (MW)	Electricity output (GWh/year)	Potential CO_2 savings (tonnes/year)	Number of turbines
Small	650	1,595	291,897	12,999
Medium	184	452	82,638	368
Large	99	243	44,468	40
Very large	218	536	98,121	55
Total	1,151	2,826	517,125	13,462

7.34. In order to illustrate the GIS tool parameters, a series of opportunity and constraints maps were produced. Figure B.1 in appendix 2 shows the wind speed within the SLP area at 50m above ground level. This shows that the highest winds speeds are predominantly located in the eastern portion of Tewkesbury and southern portions of Gloucester and Cheltenham. Other mapped constraints that have influenced the assessment outcomes are included in the appendices. Maps depicting the physical constraints are only included for small and very large turbines for illustrative purposes, showing the minimum and maximum buffer distances applied to physical features depending on turbine size.

7.35. An assessment of this nature will necessarily have certain limitations, including inaccuracy of wind data, cumulative landscape effects of multiple wind developments, site-specific features and characteristics, and the impacts of aviation which can only be considered on a site-by-site basis. These are explored in more detail in the appendix 'Key Assumptions: Onshore wind & Ground mounted solar'.

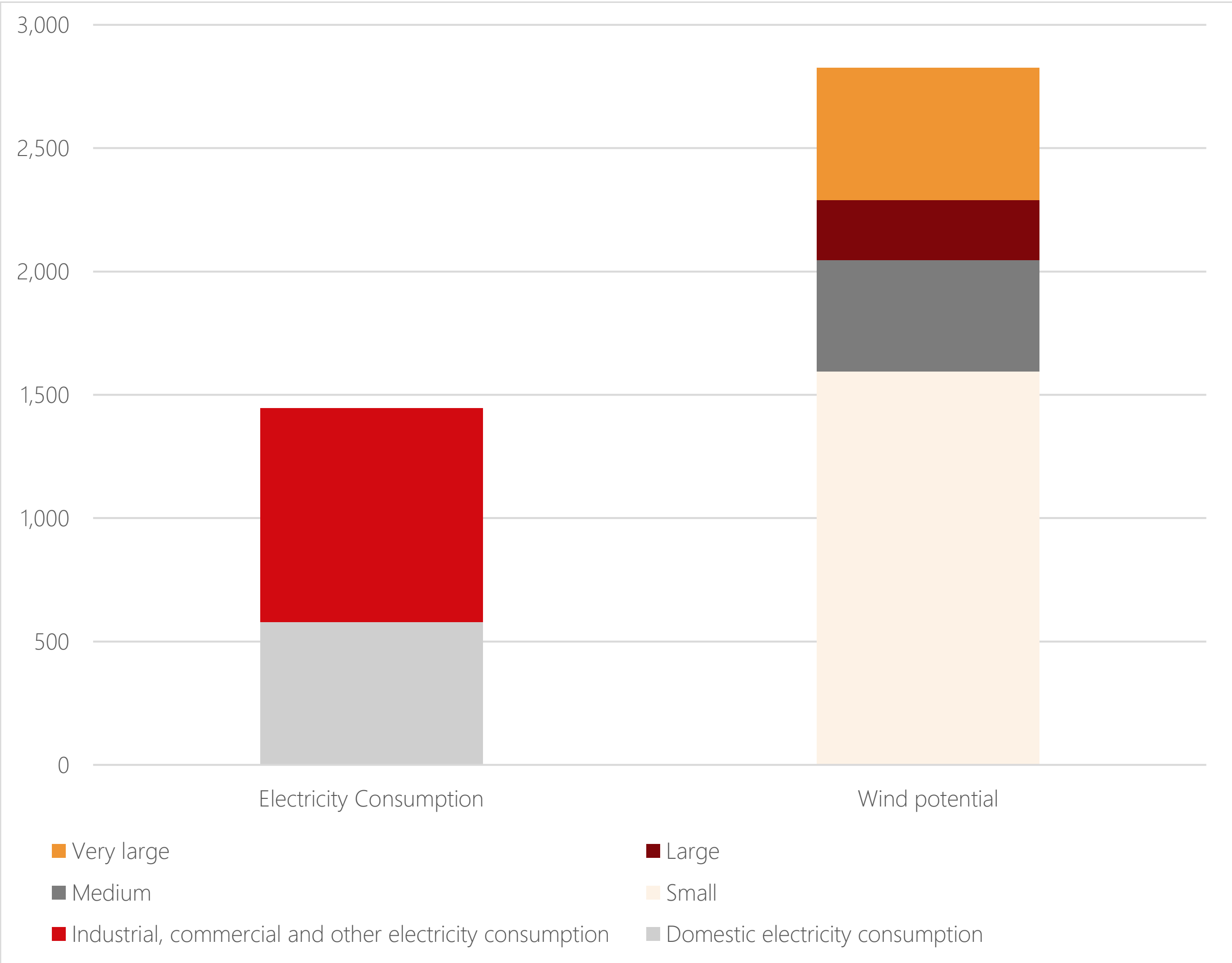

Figure 6 Onshore wind potential capacity compared to electricity consumption

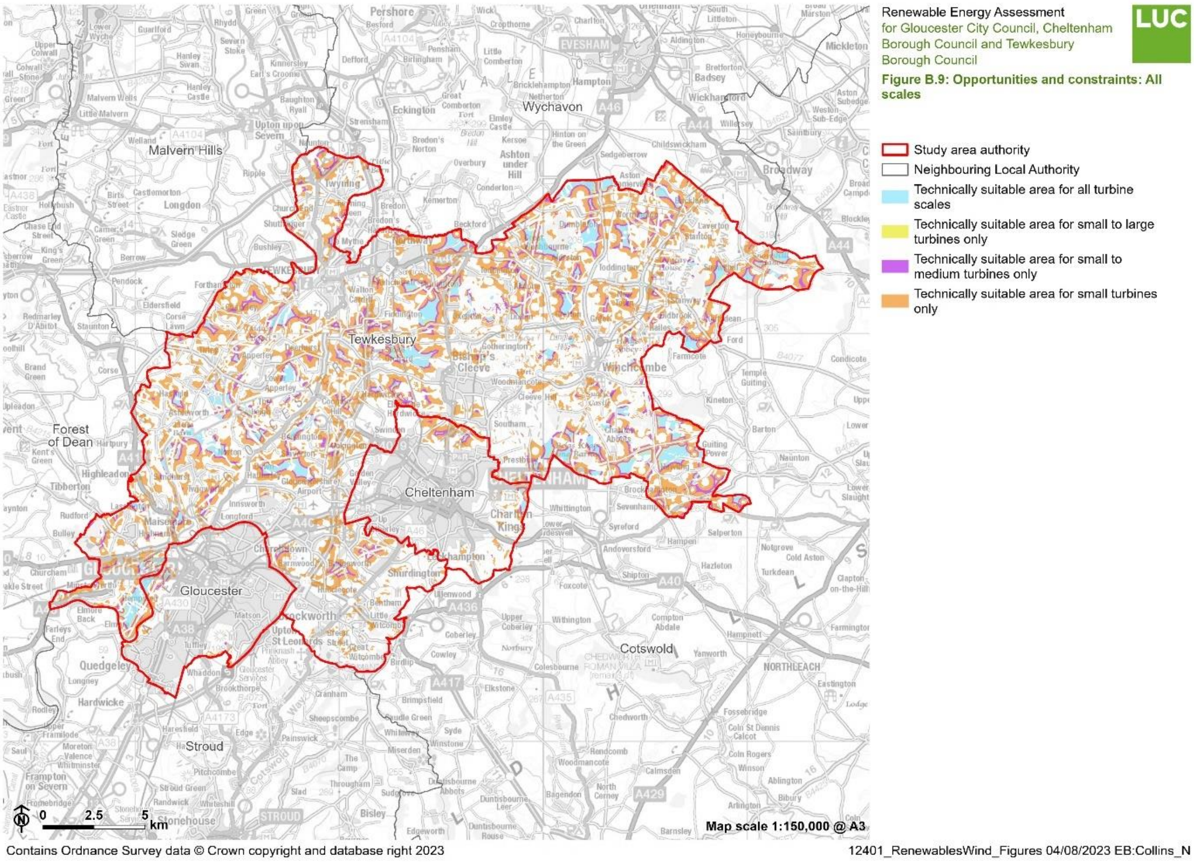

Figure 7 Opportunities and constraints - All scales

(A higher resolution version of this map is provided in the technical appendices)

7.36. Conclusion: Onshore Wind

Onshore wind has the technical potential to meet 194% of the total electricity demand for the area (2,826 GWh/year). Realising this theoretical potential would require 13,462 turbines. However, the figures presented are an indication of theoretical technical potential only. This is not the same as the development capacity that may be expected to be deployed in practice, and does not take into account any practical issues affecting deployment, or the fact that one technology may need to be chosen over another in some areas.

The potential carbon offset from installing the full potential of onshore wind is 517.1 thousand tonnes CO_2e/year. The total potential carbon saving is 54% of the total energy-related carbon emissions in the SLP area.

8. Ground-mounted solar

Introduction

8.1. There are a large number of ground-mounted solar PV arrays or solar farms within 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 the panels.

8.2. Ground-mounted solar project sizes vary greatly across the UK although developers are increasingly focusing on large-scale development, with the largest currently consented scheme in England (Cleve Hill in Kent) being over 350 MW[51]. 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 1.2 hectares per MW has been applied based on past and recent development experience.

Planning Policy & Deployment Considerations

8.3. As of 2022, the UK had 14,651 MW (14.651 GW) of installed solar PV capacity, with this providing 13,283 GWh of electricity during the year. These figures include all forms of solar PV – according to the most recent available data, ground-mounted schemes account for 51.7% of overall solar capacity. Although falling capital costs mean solar PV is increasingly viable in a post-subsidy context, at present developers are generally focusing on large developments in order to achieve economies of scale. Grid connection costs can also critically affect viability.

8.4. According to the Climate Change Committee's annual progress report, the deployment of solar capacity is significantly off track to meet the Government's target of 70 GW by 2035. An average annual deployment rate of 4.3 GW is required to deliver 70 GW by 2035 (five-times current levels of deployment). (See paragraph 0 for more detail on the CCC's carbon budgets and progress reviews).

[51] Cleve Hill Solar Park (2020), Cleve Hill Solar Park granted development consent, www.clevehillsolar.com

8.5. Key factors that affect deployable potential are discussed below, and explored in more detail in the appendix 'Ground mounted solar'.

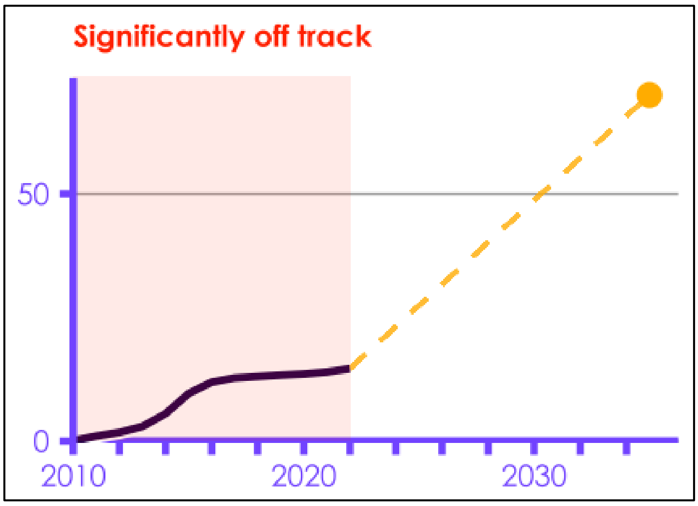

Figure 8 CCC Annual Progress Report (2023): Key indicators - solar operational capacity (GW)

Landscape sensitivity and cumulative impacts

8.6. Although the landscape and visual impacts of solar PV tend not to be as contentious as wind development, it is still often a key consenting issue, particularly for larger development scales. The approach to landscape sensitivity for solar for this study is discussed in paragraph 8.21.

8.7. The PPG states that the approach to assessing cumulative landscape and visual impact of large-scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero. Additional considerations set out in the PPG are detailed in appendix 3.

Grid connection

8.8. As with wind, a key consideration for solar PV development viability is the interaction between development income and grid connection costs. As noted above, at the present time viable solar developments are generally larger scale. 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.

Development income

8.9. The current 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 the financial context for solar is changing – for example solar is to be included in the next round of the Contracts for Difference (CfD) auctions.

8.10. Over recent years solar panel costs have decreased significantly, and as such subsidy-free solar energy schemes in the right locations are financially viable at larger scales. Solar PV module prices have dropped in price by 89% since 2010. Forecasting published by the UK Government also places solar as the cheapest source of new power generation for the coming years. Between 2025 and 2040, it is anticipated that solar parks will be more cost effective than offshore or onshore wind, gas, nuclear and other technologies[52].

8.11. With regards to smaller scale solar developments, the Smart Export Guarantee has been introduced since January 2020[53]. This could help to increase the financial viability of solar energy developments of up to 5 MW capacity. However, the obligation does not provide financial benefits equal to the previous FiT scheme.

National Planning Policy & Guidance

8.12. The NPPF states that applications for solar development should be approved if its impacts are (or can be made) acceptable.

Environmental Assessment

8.13. Large, industrial scale developments (covering over 0.5 hectares) are listed in Schedule 2 to the Town and County Planning (Environmental Impact Assessment) Regulations 2017 and would therefore require a Screening Opinion.

Case law

8.14. As with wind, case law presents a mixed picture for ground mounted solar. The cases featured below, and more, are discussed in detail in appendix 3.

8.15. The production of renewable energy[54], the associated reduction in carbon emissions and the contribution to addressing climate change may be given very significant weight in favour of solar farm proposals[55].

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[52] Solar Energy UK (2020) Solar Energy UK Impact Report 2020, www.solarenergyuk.org/resource/impact-report-2020/
[53] Ofgem (2020) Smart Export Guarantee (SEG), www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg
[54] Land at Highnam Farm, Two Mile Lane, Highnam, Gloucestershire (APP/G1630/W/16/3141634).
[55] Over Farm Market, Over, Gloucester (APP/G1630/W/16/3141824)

8.16. They may not be seen as uncharacteristic of the landscape if the pattern of hedgerows and tree cover is retained/reinforced[56]. Detrimental impacts on landscape may be significantly reduced with screening and hedgerow planting[57]. Benefits can arise from enhanced biodiversity planting and measures, which may attract significant weight[58].

8.17. The harm caused by the loss of any agricultural land will be influenced by its assessed grade. Land used for solar farms can still be used for other agricultural uses[59] and farm diversification benefits may also attract positive weight[60]. Important weight may be given to the retention of land for grazing in between the panels[61].

8.18. Solar farm proposals within the Green Belt are considered inappropriate development and may harm openness and constitute encroachment[62] and substantial weight may be attributed to Green Belt harm[63]. However, the considerable weight afforded to the benefits of producing renewable energy[64] and reducing carbon dioxide emissions may also contribute to Green Belt very special circumstances[65].

Resource Assessment Methodology

8.19. A GIS assessment of technically suitable land for solar development was undertaken using a similar approach to that undertaken for wind development. The assessment identified areas with financially viable solar irradiance levels (amount of sunlight) for PV. A series of primary constraints relating to physical features and environmental/heritage protection were then removed. The remaining areas have 'technical potential' for ground-mounted solar energy development.

8.20. Solar development is more 'modular' than wind (development 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 ground-mounted solar has not been broken down into discrete project sizes but rather any land technically suitable for development has been identified.

[56] Land to the north of Cursey Lane, Copse Green Farm, Elmstone Hardwicke (APP/G1630/W/16/3146600)
[57] Land at Highnam Farm, Two Mile Lane, Highnam, Gloucestershire (APP/G1630/W/16/3141634)
[58] Land West of New Works Lane, Telford, Shropshire (APP/C3240/W/22/3293667)
[59] Land west of the village of Scruton (APP/G2713/W/23/3315877)
[60] Land at Highnam Farm, Two Mile Lane, Highnam, Gloucestershire (APP/G1630/W/16/3141634)
[61] Ibid.
[62] Park Farm, Dunton Road, Herongate (APP/V1505/W/22/3301454)
[63] Land at East Hanningfield, Chelmsford, Essex (APP/W1525/W/22/3300222)
[64] Park Farm, Dunton Road, Herongate (APP/V1505/W/22/3301454)
[65] Land at East Hanningfield, Chelmsford, Essex (APP/W1525/W/22/3300222)

8.21. 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 this study on landscape or visual grounds. Instead, similar to wind, a separate landscape sensitivity assessment (LSA) will be undertaken to consider all Landscape Character Areas defined within the Gloucestershire County Landscape Character Assessment and Cotswolds AONB Landscape Character Assessment with technical potential for development. The LSA will be used alongside the output of this assessment of technical potential to help the councils identify which areas may be more or less suitable for ground mounted solar development within the area. Careful consideration of the potential landscape impacts versus the public benefits of renewable energy would need to be weighed through the planning application process.

8.22. The key constraints considered are set out in the appendix 'Ground mounted solar – further information', alongside additional constraint and opportunity maps.

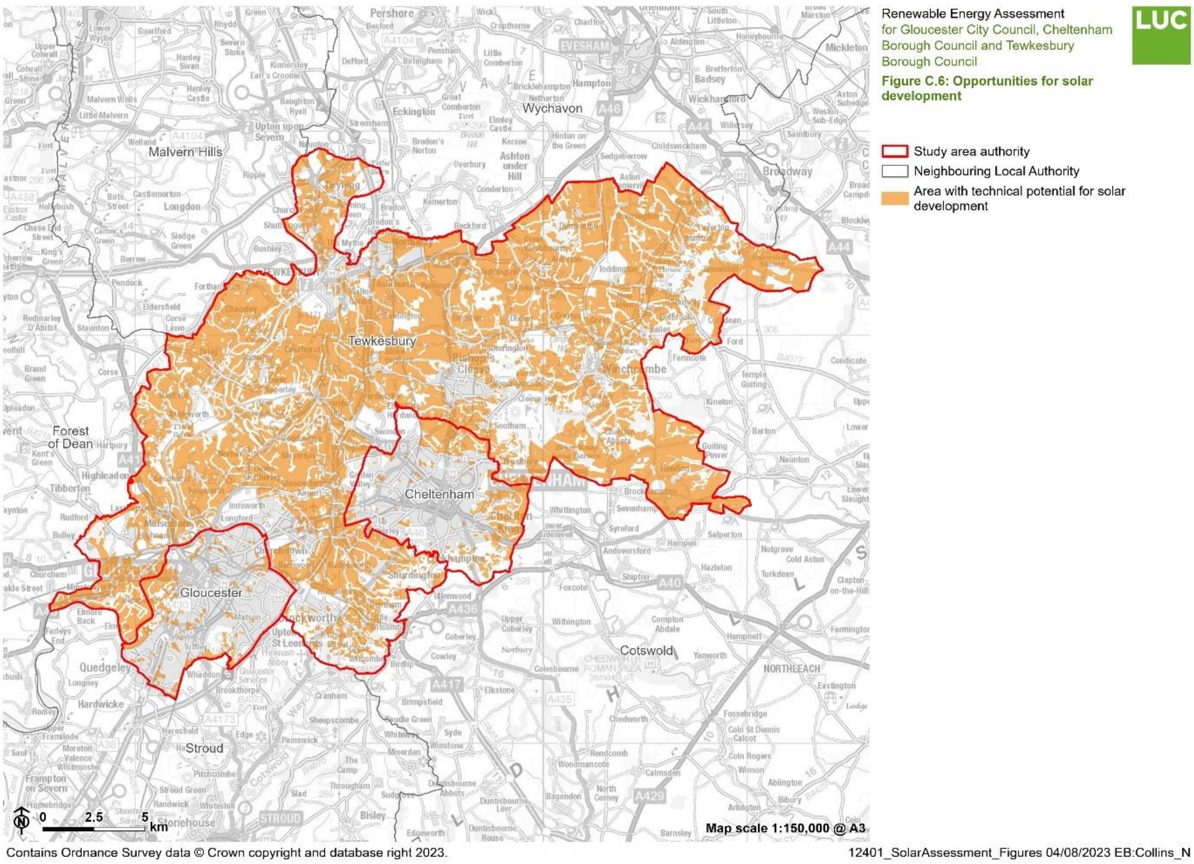

Figure 9 Area with technical potential for ground mounted solar development

(A higher resolution version of this map is provided in the technical appendices)

Results

8.23. Figure 9, Table 9 and Figure 10 provide a summary estimate of the technical potential for ground-mounted solar PV within the SLP area. As the full technical potential is very large, utilisation of 1%, 3% and 5% of the resource is also quantified. Adopting the 5% development scale would result in a total potential technical capacity from ground mounted solar PV across the area of 943.62 MW – this approximately equates to an area of 11km^2 (approximately 2% of the SLP area). The largest areas with technical potential are scattered throughout Tewkesbury with smaller pockets of potential within the west of Gloucester and the east of Cheltenham.

8.24. The calculation of potential energy yield requires the application of a 'capacity factor' i.e. the average proportion of maximum PV capacity that would be achieved in practice over a given period. Capacity factors vary in practice in accordance with solar irradiation, which in turn is affected by location, slope and aspect. It was not possible to find suitable historic data on capacity factors taking into account these kinds of factors within the SLP area for the present study, and so a single capacity factor of 10% was used, based on regional data.

8.25. The potential carbon savings as a result of generation via the identified ground-mounted solar potential was also calculated. This assumes that the electricity generated from the identified ground-mounted solar potential would result in negligible carbon emissions and would replace that currently provided by the national grid, which has an emission factor of 0.183kgCO_2e/kWh[66].

8.26. As with the wind resource assessment, the solar assessment has some key limitations. In particular, cumulative impacts are again a key consideration that the tool cannot take into account, but which would affect the suitability 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 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.

[66] National Grid (2023) Future Energy Scenarios: FES 2023 Data workbook – Key Stats; www.nationalgrideso.com/future-energy/future-energy-scenarios

Table 9 Potential ground-mounted solar capacity and output

Development scale	Potential installed capacity (MW)	Electricity output (GWh/year)	Potential CO_2 savings (tonnes/year)
100% of tech. resource	18,872	16,598	3,037,489
5% of tech. resource	944	830	151,874
3% of tech. resource	566	498	91,125
1% of tech. resource	189	166	30,375

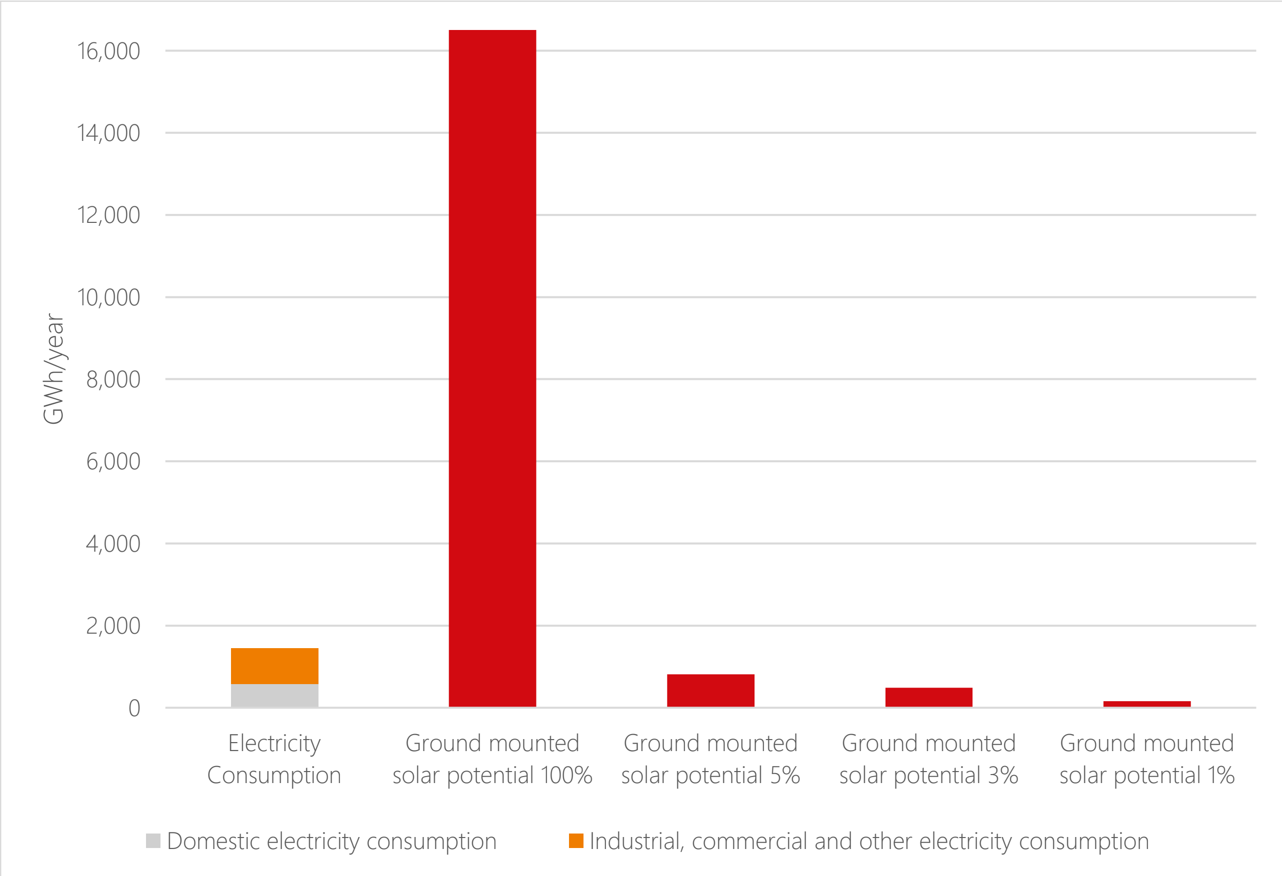

Figure 10 Ground mounted solar PV potential capacity compared to electricity consumption

8.27. **Conclusion: Ground-Mounted Solar PV**

Theoretically, should 100% of the identified technical capacity for ground-mounted solar PV be exploited, this could have the potential to meet in the region of 1,148% of the total electricity demand for the area (16,598 GWh/year). The potential carbon offset from installing the full potential is 3,037.5 thousand tonnes CO2e/year. The total potential carbon saving is 319% of the total energy-related carbon emissions.

When looking at a more realistic estimate for deployable potential of 5% of the technical capacity, this meets 57% of the total electricity demand for the area (830 GWh/year). Realising this 5% of potential equates to an area of around 11km^2 (approximately 2% of the study area). Deployment of 5% of the technical capacity saves 151.9 thousand tonnes of CO_2e/year (16% of total energy-related emissions or 57% of electricity emissions).

9. Rooftop solar

Introduction

9.1. Most rooftop systems are grid-connected, so electricity generated by the solar cells can either be exported to the national electricity grid or can be used directly in the building where it was generated via a solar inverter. Domestic-scale battery systems are available that provide storage for any excess power generated, which can then be used within the building when needed. The capital cost of a battery system is currently still relatively unaffordable for most people, but prices have been consistently falling. Other forms of solar PV technology are becoming more common in the UK, such as solar tiles, which can be integrated into new buildings or refurbishments alongside conventional roofing tiles or slates.

9.2. As well as residential and commercial buildings, rooftop solar is a popular form of community energy with local communities investing to put solar on schools and other community buildings.

9.3. Case Study: Gloucestershire Community Energy Co-op and Big Solar Co-op

Gloucestershire Community Energy Co-op are working on rooftop solar projects in the SLP area and surrounding areas. These include installing at 51 kWp array at Minchinhampton Primary Academy[67].

Big Solar Coop are investigating commercial and industrial sites larger than 250m^2 with high daytime consumption (to maximise onsite self-consumption of the generated electricity). They are working within the Gloucestershire area and engaging with sites such as schools, offering a commercial proposal and support with installation, operation and maintenance of the panels.

Planning Policy & Deployment Considerations

9.4. PPG paragraph 12 states that active solar technology (solar PV and solar water heating) on or related to a building is often permitted development (which does not require a planning application) provided the installation is not of an unusual design, or does not

[67] Gloucestershire Community Energy Co-op Ltd, https://gloscommenergy.org.uk/projects/

involve a listed building, and is not in a designated area. Where a planning application is required, the PPG gives examples of factors to bear in mind:

- The importance of siting systems in situations where they can collect the most energy from the sun.
- The need for sufficient area of solar modules to produce the required energy output from the system.
- The effect on a protected area such as an Area of Outstanding Natural Beauty or other designated areas.
- The colour and appearance of the modules, particularly if not a standard design.

Resource Assessment Methodology

9.5. CSE has developed a rooftop solar potential model that forms the core of the analysis in this section. This model uses LiDAR (Light Detection and Ranging) data where available, which can be used to measure heights of buildings and create digital elevation models (representing the shape of land surface). This data is supplemented by Ordnance Survey building footprint polygons. This process detects and models rooftops for solar panels. It follows the below process:

a) Model horizons: using LiDAR data, the model builds a horizon profile for each building. This mimics the process of an observer being stood on the roof, and reporting how much sky could be seen in each direction. This helps to calculate shadowing on the roof which may impair solar performance.
b) Detect roof planes: for each building, the model detects the “planes” that make up the roof. This gives the size and orientation of each part of the roof, with each part acting as a potential panel site.
c) Exclude unsuitable sections: the model excludes roof sections which would not suit good solar production. (i.e. if a roof is too north facing, angled too steeply, overshadowed, or the roof section is too small).
d) Fit panels: a series of panels are fitted to each viable roof section. The model selects a number and positioning and varies these until it finds the best arrangement of panels for that roof section.
e) Calculate PV output: the model then calculates the PV potential of the panels, taking into account factors such as shadowing, orientation, and location.

9.6. This model has some limitations. It cannot detect where roofs may be unsuitable due to roof weakness or type of building. It is also unable to calculate solar potential when LiDAR data is unavailable. Within the SLP area, LiDAR data covers 86% of the land area and 96.7% of buildings. This means that 3.3% of buildings will not be included in this analysis due to gaps in LiDAR data.

9.7. The model outputs also indicate buildings which might already have rooftop PV and buildings which have listed building status, where installing solar PV might not be possible.

9.8. Solar PV Cost Benefit Common Terminology

Financial assumptions are shown in the appendix 'Key Assumptions: other technologies'.

Net present value (NPV): the value of all future costs and profits over the entire life of an investment discounted to present-day money.

Internal rate of return (IRR): the rate of return on investment, technically the discount rate needed to make the NPV 0. The higher the IRR, the better the roof for solar.

Total capex: Capital expenditure of installation in £k. Calculated from £ per kW capacity and fixed cost for installation.

Results

9.9. The SLP area has the technical potential of 353.72 MW of roof-mounted solar PV capacity, which is estimated could generate 280.04 GWh/year of electricity (280,036,116 kWh/year). This would be 44,153 installations and excludes any known existing installed roof-mounted PV[68]. These results also exclude installations with IRR below 5% due to these generating less electricity and therefore being less favourable economically.

9.10. 1,036 of these installations would be on listed buildings. It may be more difficult or possibly inappropriate to install rooftop solar on some of these buildings. As the decision on modification of listed buildings sits with Local Planning Authorities, it is useful to examine the impact of enabling solar installations on listed buildings. In the SLP area, listed buildings account for only 2.4% of the total technical potential generation in the area (and 2.6% of potential capacity).

9.11. Table 10 shows the potential capacity of rooftop PV with deployment scenarios. If only 1% of the technical resource for rooftop PV is deployed then 2.8 GWh/year would be generated.

[68] Existing PV installation information will not be a complete dataset. Taken from EPC data and Stowell, D., Kelly, J., Tanner, D. et al. (2020), *A harmonised, high-coverage, open dataset of solar photovoltaic installations in the UK*, www.nature.com/articles/s41597-020-00739-0

Table 10: Rooftop solar PV potential scenarios

Scale of installations	Total installed MW potential	Total generation potential (GWh/yr)	Number of Installations	Potential CO_2 savings (thousand tonnes per year)
100% of technical resource	353.72	280.04	44,153	51.25
10% of technical resource	35.37	28.00	4,415	5.12
5% of technical resource	17.69	14.00	2,208	2.56
1% of technical resource	3.54	2.80	442	0.51

9.12. Figure 12 shows the distribution of rooftop PV potential with hotspots in all three local authority districts. Figure 11 shows the total solar PV generation potential with electricity consumption across the SLP area. If all solar panels are installed, this would cover:

- 48% of the domestic electricity consumption (although in practice a proportion of this would be used onsite and the rest exported as clean energy to the national electricity network, to offset any imported electricity).
- 19% of the total electricity demand (domestic and non-domestic).

9.13. Table 11 shows the potential carbon offset of this technical potential of rooftop PV, assuming that it offsets emissions from electricity usage. The total potential carbon saving is 11% of the domestic carbon emissions from energy use (5% of total emissions from energy use, including non-domestic).

Table 11: Carbon offset potential of roof-mounted solar PV in SLP area by building type

Tenure	Estimated generation (GWh/yr)	Potential carbon offset (thousand tonnes CO_2e/year)
Residential buildings	115.09	21.1
Non-residential buildings	104.81	19.2
Unknown tenure	60.14	11.0
Total Potential	280.04	51.2

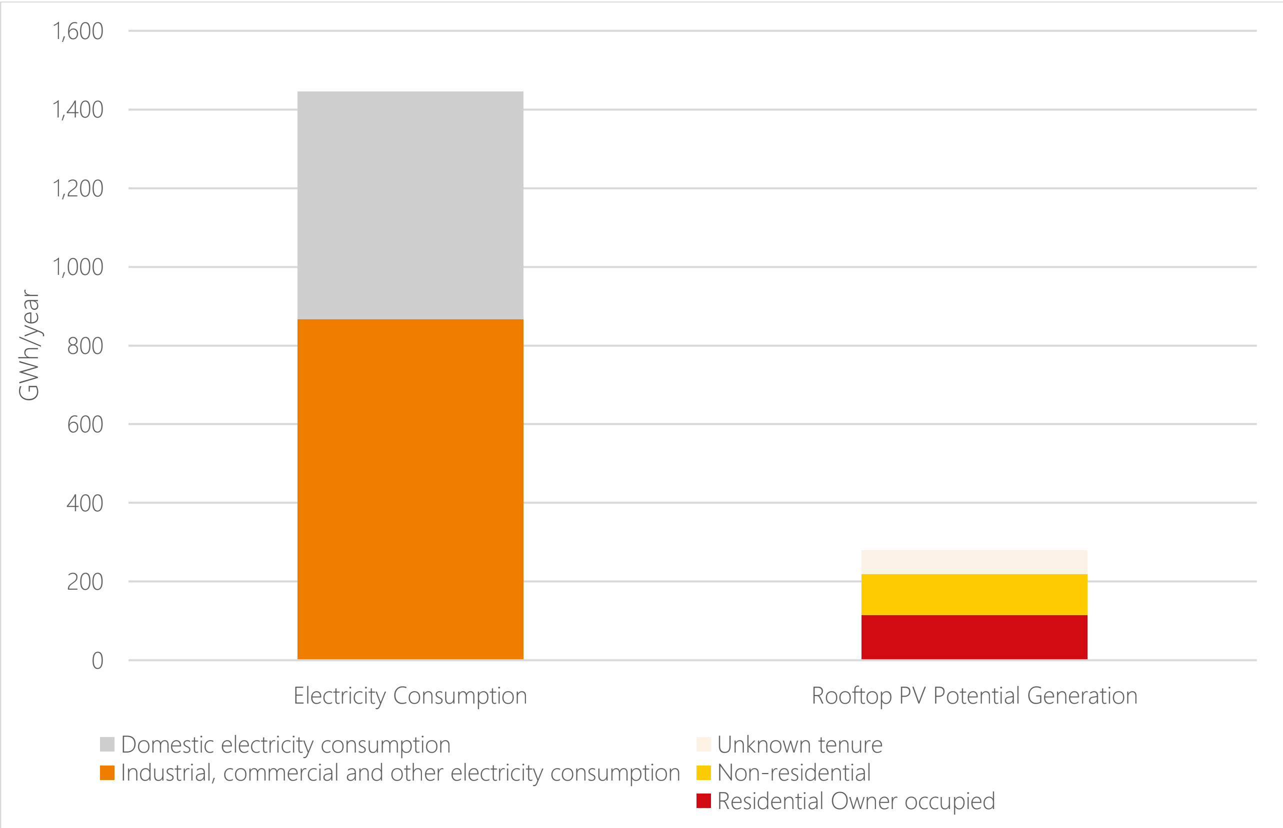

Figure 11 Rooftop solar potential (split by building type) in SLP area compared to current electricity consumption (GWh)

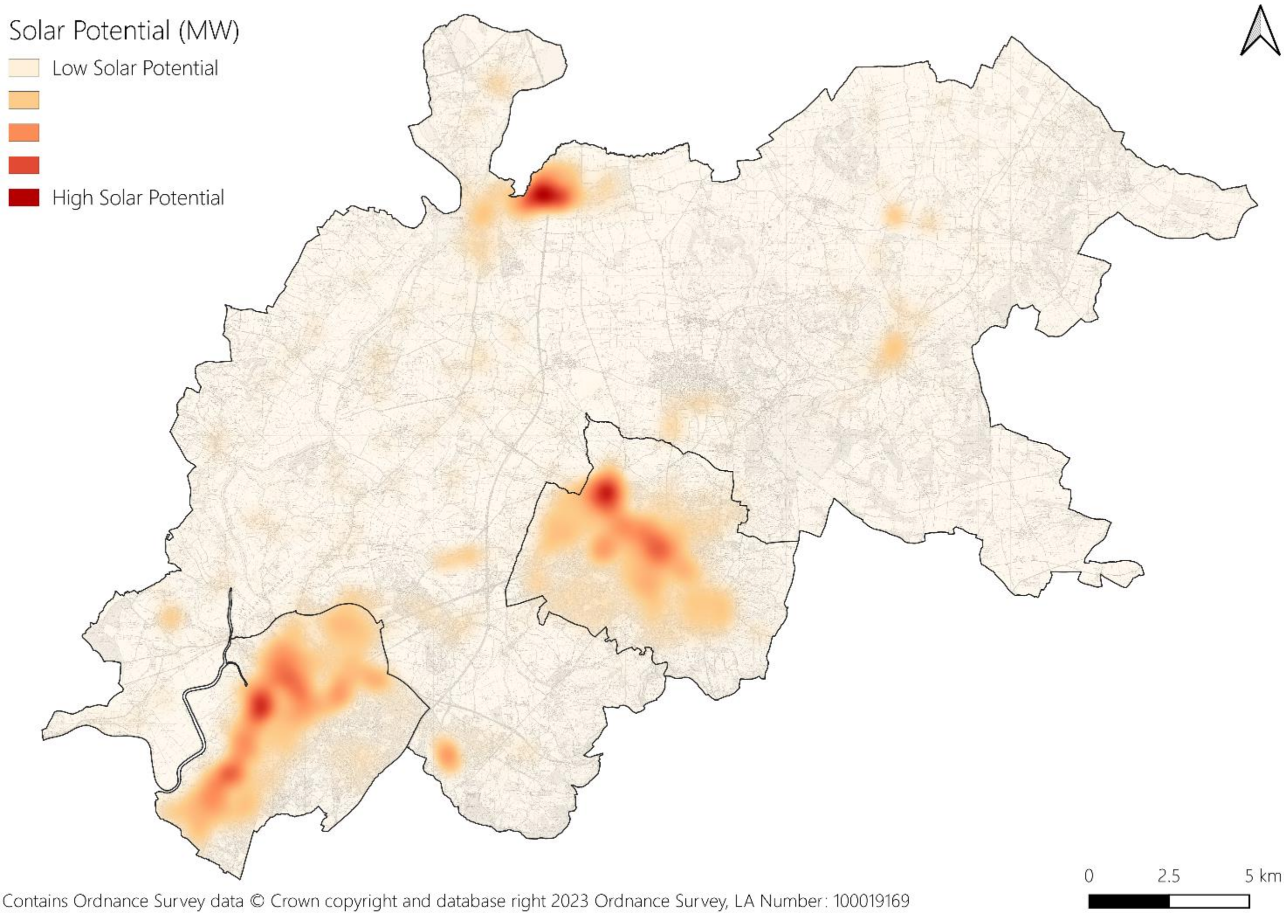

Figure 12 Heat map showing distribution of rooftop solar potential in the SLP area

9.14. Conclusion: Rooftop Solar PV

Rooftop solar PV has the technical potential to meet 19% of the total electricity demand for the area (280.04 GWh/year). Theoretically, should 100% of the identified technical capacity for rooftop solar PV be exploited, this would equate to 44,153 installations and a total panel area of 140.46km^2.

The potential carbon offset from installing the full technical potential of rooftop solar PV is 51.2 thousand tonnes CO_2e/year. The total potential carbon saving is 48% of the domestic carbon emissions from electricity consumption.

10. Hydropower

Introduction

10.1. 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. Energy yields can be accurately predicted, and economic viability established relatively easily.

10.2. 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 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 100 kW) may include schemes providing power to a single home.

10.3. '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).

10.4. 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 river ecology. Hydro plants may have an impact on upstream water flows and waterfalls. Fish populations can be vulnerable to changes in water flows and there may risk of physical harm from plant equipment. Measures such as 'fish passes' are often incorporated to mitigate these impacts.

Planning Policy & Deployment Considerations

10.5. PPG paragraph 11 states that planning applications for hydropower should normally be accompanied by a Flood Risk Assessment. Early engagement with the Local Planning Authority and the Environment Agency will help to identify the potential planning issues, which are likely to be highly specific to the location. The Environment Agency has produced advice[69] on building new hydropower schemes.

Results

10.6. According to the Feed-in-Tariff sub-national statistics[70] there are no hydropower installations in the SLP area.

10.7. An Environment Agency report[71] summarises the availability of sites, where there is likely to be little environmental impact (note that this report was produced in 2010, and therefore it is possible that some of the assumptions and outputs may be somewhat outdated). This analysis draws on those results to highlight the hydropower potential in the SLP authorities. Within the area 68 potential barriers were found, as shown in Figure 13 and described in the following tables.

Table 12: Types of barrier in SLP area

Type of Barrier	Cheltenham	Gloucester	Tewkesbury	SLP Total
Weir	26	11	24	61
Lock	0	1	2	3
Mill	0	0	1	1
Unknown	0	0	1	1
Waterfall	2	0	0	2
Total	28	12	28	68

[69] UK Government (2022), *New hydropower scheme: apply to build one*, www.gov.uk/guidance/new-hydropower-scheme-apply-to-build-one
[70] UK Government (2020), *Sub-regional Feed-in Tariffs statistics*, www.gov.uk/government/statistical-data-sets/sub-regional-feed-in-tariffs-confirmed-on-the-cfr-statistics
[71] UK government (2010), Potential Sites of Hydropower Opportunity, www.data.gov.uk/dataset/cda61957-f48b-4b75-b855-a18060302ed1/potential-sites-of-hydropower-opportunity

Table 13: Number of barriers in power categories in SLP area

Power Potential (kW)	Cheltenham	Gloucester	Tewkesbury	CGTSLP Total
0-10	28	12	20	60
10-20	0	0	2	2
20-50	0	0	0	0
50-100	0	0	1	1
100-500	0	0	1	1
500-1,000	0	0	2	2
>1,500	0	0	2	2
Total	28	12	28	68

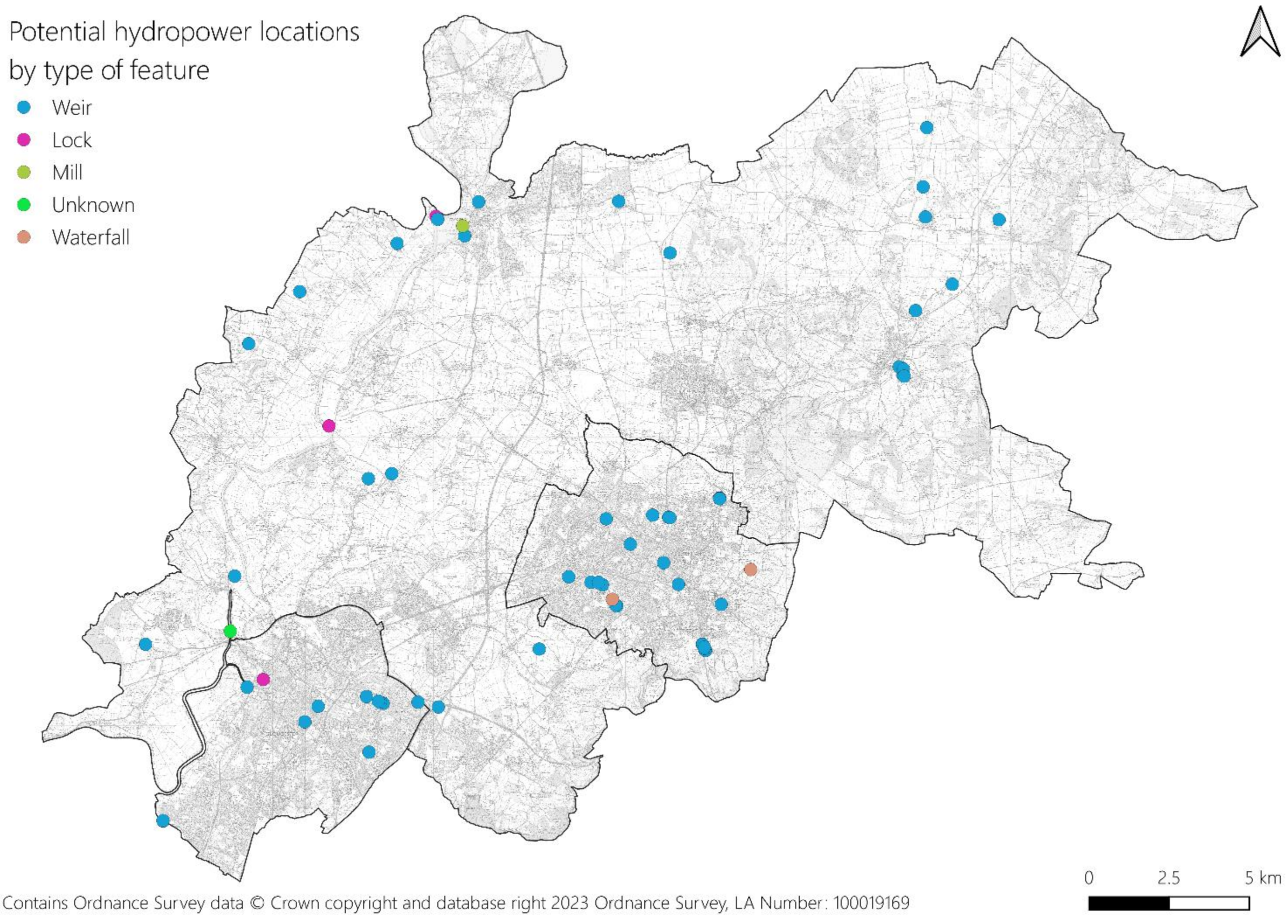

Figure 13 Potential hydropower barriers in SLP area

Table 14 Power potential of barriers in power categories in the SLP area

Power Potential categories (kW)	Cheltenham (kW)	Gloucester (kW)	Tewkesbury (kW)	CGTSLP Total (kW)	Potential generation (GWh/year)[72]
0-10	41	24	64	129	0.6
10-20	0	0	24	24	0.1
20-50	0	0	0	0	0
50-100	0	0	55	55	0.2
100-500	0	0	305	305	1.3
500-1,000	0	0	1,577	1,577	6.9
>1,500	0	0	4,839	4,839	21.2
Total	41	24	6,864	6,928	30.4

10.8. Although there is a large number of opportunities for hydropower systems across the area, the majority (91%) of sites are predicted to yield a power output of under 50 kW, which is relatively small. Many of the schemes are under 10 kW (60; 88%) and may not be a viable proposition given the very low output.

10.9. Opportunities for systems over 100 kW should be prioritised. This includes five barriers in Tewkesbury which could total 6,721 kW power potential (29 GWh/year generation potential). This would equate to less than 2% of the total electricity consumption across the SLP area (5% of the domestic electricity consumption).

10.10. There are two sites of over 1,500 kW both located on the River Severn, one with a potential of 2,154 kW located North of the Red Lion pub on Wainlode Lane and another potential for 2,685 kW which is North East of Tewkesbury.

[72] Assuming the hydropower facility could maintain its capacity year-round, which is common for hydropower

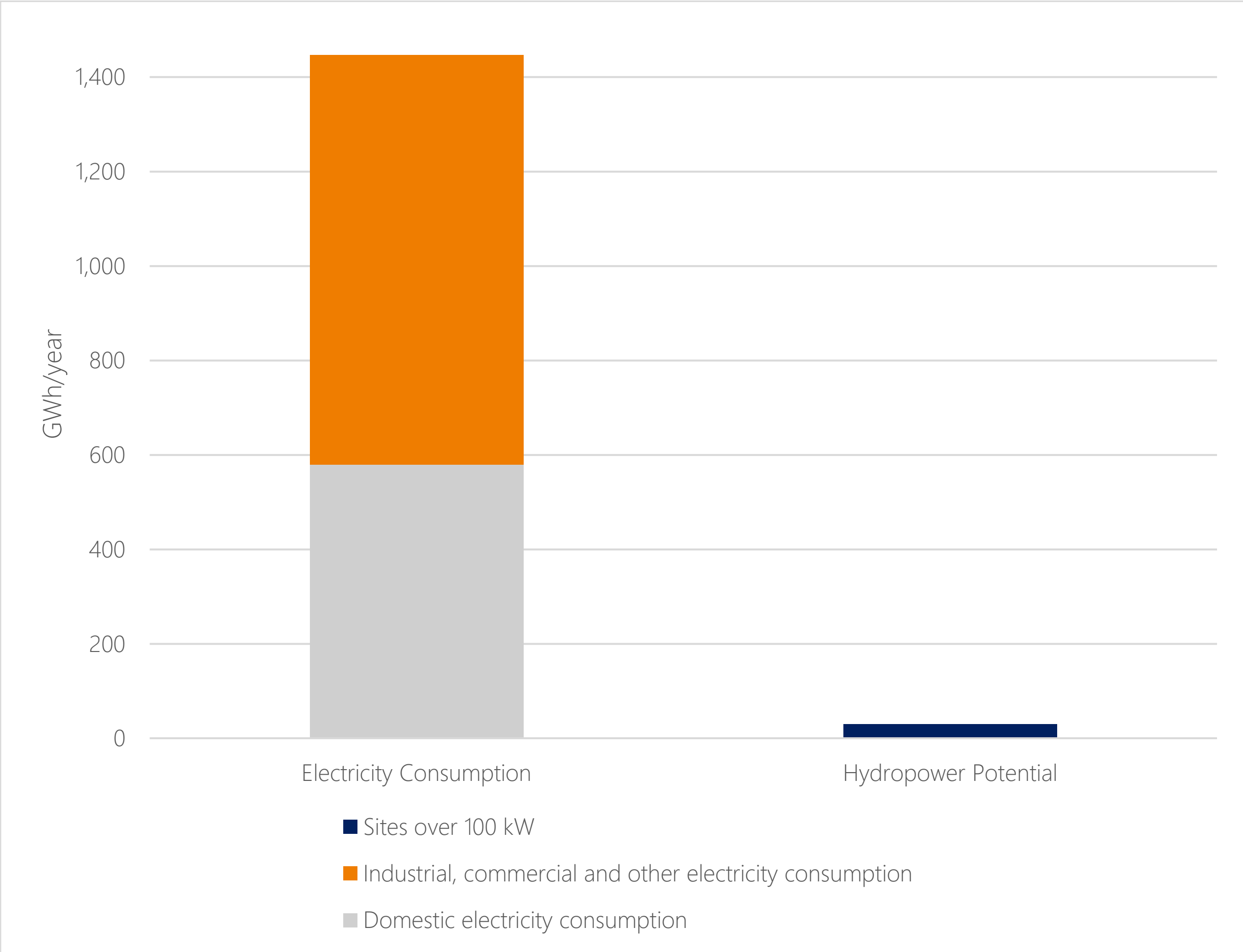

Figure 14 Hydro potential in SLP area compared to current electricity consumption (GWh)

10.11. Conclusion: Hydropower

Hydropower has the technical potential to meet 2% of the electricity consumption across the area. If deployed this would reduce energy related carbon emissions by less than 1% (savings of 4.6 thousand tonnes of CO_2e per year). The majority of sites are small (under 100kW), however there are five sites of a significant size that have a power potential of 6,721 kW and estimated 29 GWh/year generation potential.

11. Electricity grid constraints & battery storage

11.1. Ensuring sufficient network capacity and timely grid connections is a critical priority to support an increasingly electrified economy and enable available low-carbon generation to be fully utilised.

11.2. The UK electricity network has many areas of the nation that are "constrained" at a local level even when the national grid is not. Constraint happens when there is more electricity flowing through a part of the grid than it is designed to be able to accommodate. For example, if many people want too much electricity on a street at once, the local substation may overload. Similarly, if there is a large capacity of rooftop PV in an area, on a sunny day there may be too much electricity being generated. The time when demand or generation are at their highest is known as peak demand or peak generation. A location is constrained where the difference between local generation and local demand at any time is larger than the equipment can handle.

11.3. This complex system of constraints is overseen by the National Grid Energy System Operator (ESO) and the distribution network operators (DNOs). In Gloucestershire, National Grid Electricity Distribution (NGED) is the DNO responsible for equipment such as substations, which bring the electricity from the ESO's transmission network to homes and businesses. They are also responsible for any excess local generation (such as from rooftop PV) making its way to the transmission network. They will design their equipment to cope with certain peaks in demand in generation, normally with some leftover space, known as headroom. Equipment that must handle larger peaks is more expensive, as is upgrading existing equipment. Therefore, DNOs may refuse connections if a grid area is too constrained, and they deem upgrading the equipment too costly. They may also charge a connection fee to upgrade their equipment.

11.4. A high-level review of existing grid constraints has been undertaken as part of this study. NGED uses a traffic light system within its publicly available mapping data to indicate how constrained the network is at individual substation level across its area (green for unconstrained, yellow for some constraints and red for highly constrained. Figure 15 provides this information for the SLP area.

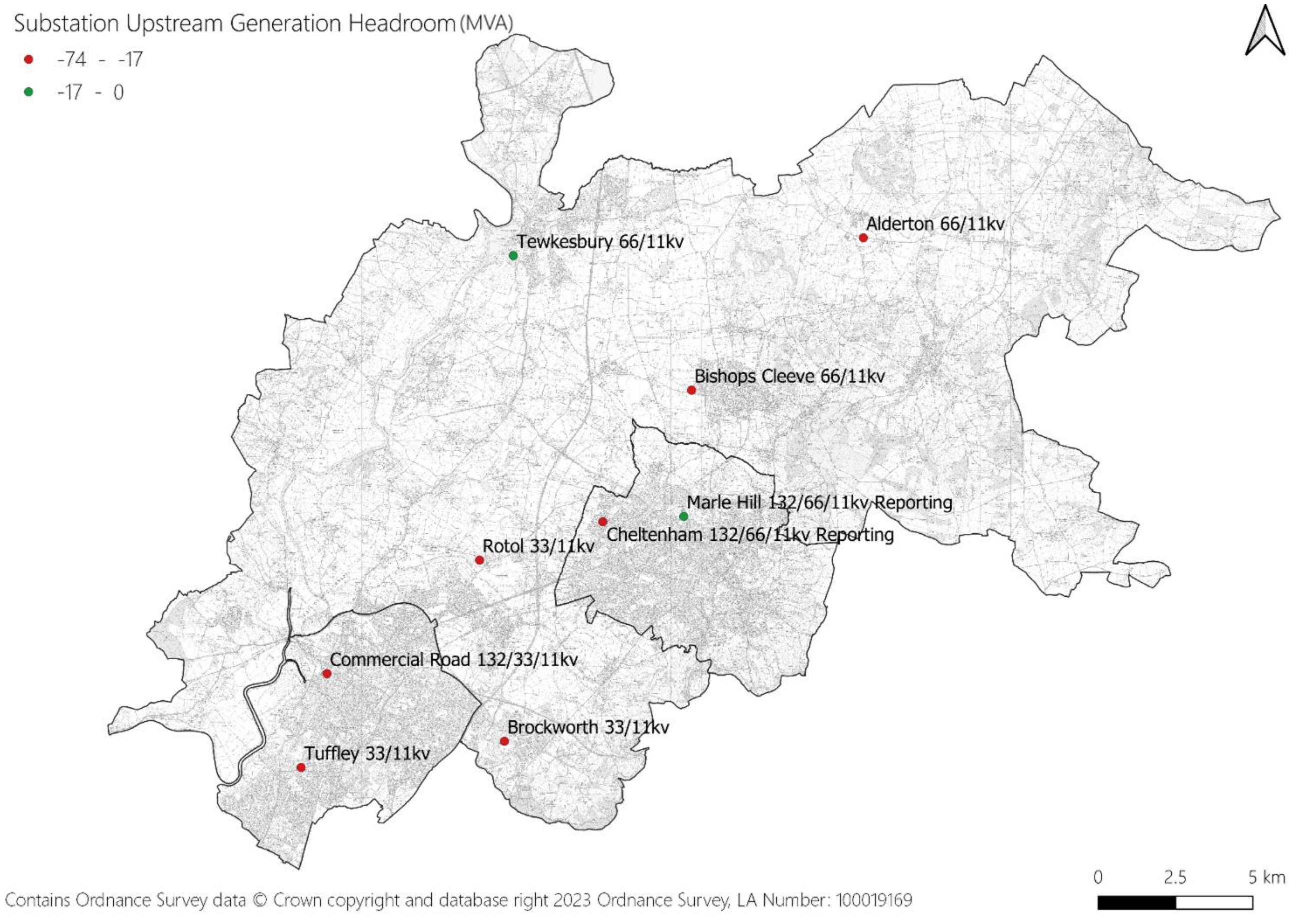

Figure 15 Constraint on substations within SLP area

11.5. There are three substations in Gloucester City (Castle Meads, Commercial Road and Tuffley), five in Tewkesbury (Tewkesbury, Alderton, Bishops Cleeve, Rotol and Brockworth) and two in Cheltenham (Cheltenham and Marle Hill)[73]. Out of the ten substations within the area, eight are designated as red meaning they have the lowest connection potential. However, two sub stations (Marle Hill and Tewkesbury) are designated as green so there is potential for new generation to connect.

11.6. The Climate Change Committee (CCC) annual progress report (2023) identifies that ensuring adequate electricity network capacity is a key enabler for decarbonising the electricity system, so that new low-carbon capacity can connect to the grid and the electricity can be effectively utilised. The CCC identify a number of key areas that need to be addressed, including strategic investments in network capacity, delivering the right transmission infrastructure and ensuring sufficient distribution network capacity, so that network development is not a barrier to the uptake of heat pumps and electric vehicles.

[73] National Grid, Network Capacity Map, www.nationalgrid.co.uk/our-network/network-capacity-map-application

11.7. The government made a commitment in the Powering Up Britain Energy Security Plan[74] to publish a grid connections action plan in summer 2023. The National Grid has proposed £936m of investment to release 22.5 giga-watts (GW) of capacity on the network due to be delivered by 2026. As such, the grid capacity is likely to remain constrained for the immediate future. As the SLP period extends past 2028, policy will have to be flexible to allow for future scenarios, changes in national policy and the grid being upgraded, or better balanced.

11.8. DNOs are generally keen to work alongside local authorities in planning their electricity networks. They make data available and often have teams to work alongside local authorities. These teams can help councils identify opportunities and challenges in the electricity system.

Battery Energy Storage Systems (BESS)

11.9. The transition to a net-zero economy will increase the pressure on electricity supply, and there will be technical challenges associated with the variable and inflexible generation of renewable electricity. As LETI (the Low Energy Transformation Initiative) make clear, as we move towards net zero grid electricity, the needs of our energy system will change:

- "Adding more renewable capacity should not continue indefinitely and adding more capacity from wind turbines and solar panels eventually just adds to the over-supply of renewable energy during peak periods without helping when the grid supply comes under pressure - when weather conditions are cold, cloudy and not windy. Other solutions including demand response and storage are needed, rather than just adding more and more renewables"[75].

11.10. Essentially as time goes on and the carbon intensity of grid electricity falls, it will become more important to incorporate technologies within new developments to shift demand and store energy, to present an energy use profile which supports wider grid decarbonisation (and minimises the need for rapidly deployable fossil fuel generation when renewable energy generation is low, or demand is high). This is likely to become readily apparent by 2030.

11.11. The integration of grid-scale batteries is in its infancy in the UK but BESS schemes will be critical to decarbonising the power system and reducing greenhouse gas emissions. Many batteries have already been deployed and are in operation across the country.

[74] UK Government (2023), Powering Up Britain: Energy Security Plan, www.gov.uk/government/publications/powering-up-britain/powering-up-britain-energy-security-plan
[75] LETI (2020), Embodied carbon primer (appendix 10 carbon offsetting), www.leti.london/ecp

Batteries can be stand-alone, or co-located with other generation, for example a solar or wind farm.

11.12. The capacity of battery energy storage is rapidly increasing and associated costs dropping. There is a role for the planning system in enabling and encouraging the deployment of such technologies.

11.13. In its annual progress report, the Climate Change Committee considers that grid storage is on track nationally due to a considerable pipeline of grid-scale battery storage in development, assuming these are able to gain network connections.

11.14. Planning guidance and case law for battery storage systems are covered in detail in appendix 4.

11.15. Case Study: Safran Landing Systems

In Tewkesbury there is an operational battery owned by Safran Landing Systems in Meteor Business Park. It became operational in 2020 and the capacity is 1.5 MW. This is likely to be used for their business operations (as an aerospace company). They have also submitted a planning application for a 260 kW roof-mounted solar PV array. If accepted, the battery may be used to store their solar PV generation and reduce reliance on grid electricity.

11.16. Conclusion: Grid Constraints and Battery storage

Many of the substations in the area are constrained, with low generation headroom. This may hinder connections of renewables to the electricity network or require grid improvements. Battery storage may be beneficial in grid constrained areas and will be important in storing renewable electricity generation during low generation periods.

12. District heating or cooling networks

Introduction

12.1. District heating is a technology which uses one heat source to provide heat to more than one building. Instead of each property having its own heating system separate from any other property, a group of buildings connected to a district heating network all receive heat (in the form of hot water or steam) from a central source (energy centre), via a network of insulated flow and return pipes. This can be more beneficial than each property having its own heating system because heat generation can be more efficient at larger scales, and the heat source can be replaced with new zero carbon technologies as they become available in the future with minimal disruption to the end-user. The term 'communal heating' differs from district heating in that the heat source in communal heating supplies heat to two or more customers within the same building.

12.2. It has been estimated that heat networks could provide 20% of the UK's total heat demand[76] compared to the 2% currently supplied by existing networks. The Climate Change Committee'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[77] suggests that around one in five buildings will have the potential to access a largely low carbon district heat network by 2050.

12.3. In October 2021 the Government launched a consultation to seek views on their approach to identifying areas in England where heat networks may offer the most appropriate solution for decarbonising heating. In responding to the consultation findings, the Government has stated their intention to "proceed with the key elements of the proposed framework" including:

- "developing a nationwide methodology for identifying and designating areas as heat network zones, within which heat networks are the lowest cost solution for decarbonising heat.
- establishing a new zoning coordinator role, which we generally expect would be fulfilled by local government, with responsibility for designating areas as heat network zones and enforcing requirements within them.

[76] UK Government (2021), Opportunity areas for district heating networks in the UK: second National Comprehensive Assessment, www.gov.uk/government/publications/opportunity-areas-for-district-heating-networks-in-the-uk-second-national-comprehensive-assessment
[77] UK Government (2018), Clean Growth Strategy, www.gov.uk/government/publications/clean-growth-strategy

- requiring heat networks developed in zones to meet a low carbon requirement, and for certain buildings and heat sources within zones to connect to a heat network within a specific timeframe[78]."

12.4. In 2023, CSE published a social research report exploring how heat network zoning policy could be developed and implemented[79]. The research engaged with several stakeholders including local authorities. The findings suggest local authorities see themselves playing a strategic role in planning and overseeing heat network zoning, whilst also raising concerns about insufficient capacity within the public sector to deliver against the scale of the challenge.

12.5. To achieve national net zero targets, heat networks that are now being fuelled by fossil fuels will need to be switched to low or zero carbon energy sources in the future, such as use of ambient heat via heat pumps. Thermal stores are increasingly used in heat network systems to provide flexibility by balancing demand swings and maintaining supply during short outages. These are typically large, insulated tanks of water that can store excess heat from generation (of electricity via CHP) at periods of low heat demand and supply heat at periods of high demand.

Planning Policy & Deployment Considerations

12.6. The planning system has a key role to play in identifying suitable locations for the installation of district heating. Through heat mapping, planners can spatially map demand, capacity and constraints.

12.7. Where there are existing, or firm proposals for, district heating supply systems with capacity to supply new development, Local Planning Authorities can expect proposed development to connect to an identified system, or be designed so that it can connect to it in the future.

12.8. LPAs need to be aware that district heating networks may not always be the right answer. A district heating network should be weighed against other heat delivery options, such as heat pumps on individual buildings, and networks should only be developed where there is a proven low carbon heat source available. Lower temperature

[78] UK Government (2022), Proposals for heat network zoning, www.gov.uk/government/consultations/proposals-for-heat-network-zoning

[79] UK Government (2023), Heat network zoning social research, www.gov.uk/government/publications/heat-network-zoning-social-research

networks provide the greatest ability to use waste and renewable heat and should be the priority[80].

Viability of district heating

12.9. Heat networks are most suited to dense clusters of buildings with high heat demands and will benefit from supplying a mix of heating requirements which result in a more even and consistent demand supply profile. For example, a mix of industrial, commercial and domestic buildings will tend to even-out the demand across a 24-hour period and make it less 'peaky'. Buildings which have continuous predictable demands ('anchor' loads) and are more likely to sign up for long term supplies of heat, such as those in the public sector, can also be beneficial to overall viability.

Resource Assessment Methodology

12.10. Heat mapping is a process of using available datasets to estimate 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, as undertaken for the SLP authorities, uses data from the heat demand model of the THERMOS tool[81], 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 annual and peak heat 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 footprint polygon (e.g. where only OpenStreetMap data is available) or, as in the case of the SLP area, this can be improved using a more detailed model which uses Ordnance Survey building outlines and LiDAR data to estimate the 3-D shape and surface area of buildings.

12.11. For this analysis, address-level heat demand data for every building across the area was first estimated using the THERMOS tool and a Geographic Information System (GIS) was 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 Ordnance Survey building outlines. A heat demand density map was then produced covering the study area – see Figure 16.

[80] RTPI (2019), Planning for a smart energy future, www.rtpi.org.uk/media/1435/planning-for-a-smart-energy-future.pdf

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

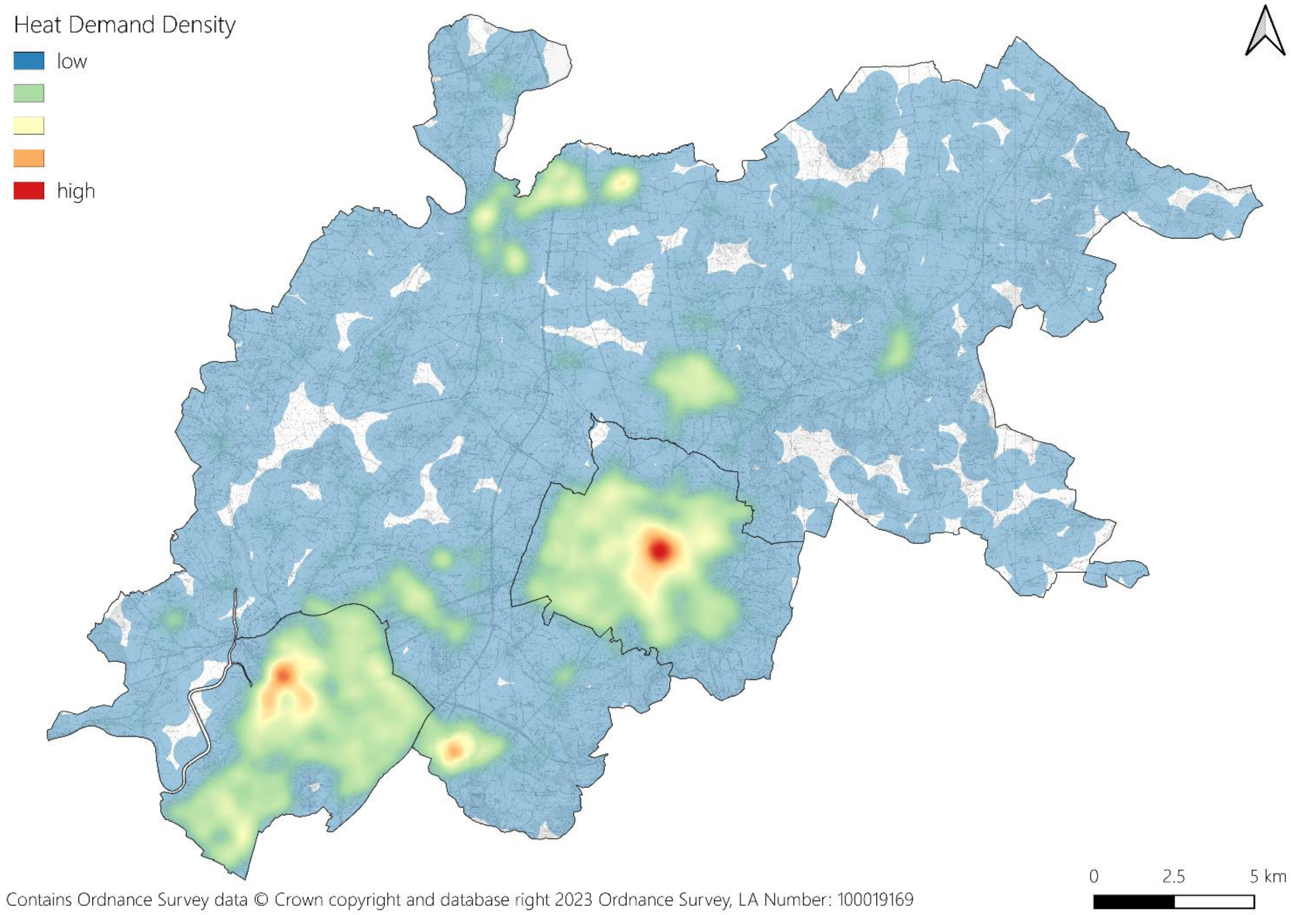

Figure 16 Heat demand density in the SLP area

(A higher resolution version of this map is provided in the technical appendices)

12.12. 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. As would be expected, the heat map shows heat demand density to be greatest in the more urban areas of the district, with clusters in Gloucester and Cheltenham.

District-wide overlay analysis

12.13. 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). Specifically, 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 100,000 kWh.

- Areas must be within 200m of potential anchor loads.

12.14. Anchor loads are defined as those types of buildings likely to have relatively high and stable heat demands and/or be in sectors more likely to participate in heat network projects. For the purpose of this study, this includes all buildings with an annual demand for heat of above 100,000 kWh that fall within the following categories within the THERMOS heat demand model:

- Office
- Commercial
- Sport and Leisure
- Industrial
- Medical
- Hotel
- Prison

12.15. Not all buildings in the above categories will actually be suitable as anchor loads (particularly in the case of industrial buildings). However, they provide a good basis for establishing the initial area of search. 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 individual larger loads due to the number of connections that would be required.

Results

12.16. In the SLP area, examples of anchor loads with high heat demands are shown in Table 15. This includes Gloucestershire Royal Hospital, Cheltenham General Hospital and Gloucestershire College. These buildings are likely to have a high, stable heat demand and projects involving these sites may be less complex as they would have fewer stakeholders than those involving many smaller individual buildings with the same overall heat demand. Examples of residential loads include Toddington Manor (detached manor house) and apartments such as St. James Walk, Century Court, and The Crescent, as well as Nazereth House, a care home.

Table 15: Potential anchor loads and residential loads identified within CGTSLP authorities

Building Name	Local Authority Area	Estimated Annual Heat Demand (kWh/yr)	OS Classification	Anchor or residential load
Gloucestershire Royal Hospital	Gloucester	4,513,222	Hospital / Hospice	Anchor load
Cheltenham General Hospital	Cheltenham	1,761,142	Hospital / Hospice	Anchor load
Gloucestershire College	Gloucester	1,380,066	Further Education	Anchor load
Cheltenham Ladies' College	Cheltenham	1,099,692	Further Education	Anchor load
Southgate House	Gloucester	991,688	Office / Work Studio	Anchor load
Holmleigh Park High School	Gloucester	941,333	Secondary / High School	Anchor load
Gloucestershire College, Cheltenham Campus	Cheltenham	861,286	College	Anchor load
Cheltenham Bournside School	Cheltenham	851,066	Secondary / High School	Anchor load
University of Gloucestershire	Cheltenham	847,201	University	Anchor load
Toddington Manor	Tewkesbury	638,675	Detached	Residential load
St. James Walk, Honeybourne Way	Cheltenham	520,988	Self Contained Flat (Includes Maisonette / Apartment)	Residential load
Century Court, Montpellier Grove	Cheltenham	485,550	Self Contained Flat (Includes Maisonette / Apartment)	Residential load
The Crescent	Gloucester	458,325	Self Contained Flat (Includes Maisonette / Apartment)	Residential load

12.17. The analysis has identified a further 169 potential anchor load buildings and 202 residential load buildings, smaller than those listed above.

12.18. For the purpose of this study, the areas identified through the overlay analysis can be termed as 'Heat Focus Areas' (HFAs). These are likely to offer the best potential for heat networks and may be worthy of further consideration. These areas should ideally be considered alongside planned large new development sites which offer particular opportunities for heat networks and any known sources of heat supply. All of the HFAs are located in Gloucester and Cheltenham (see Figure 17).

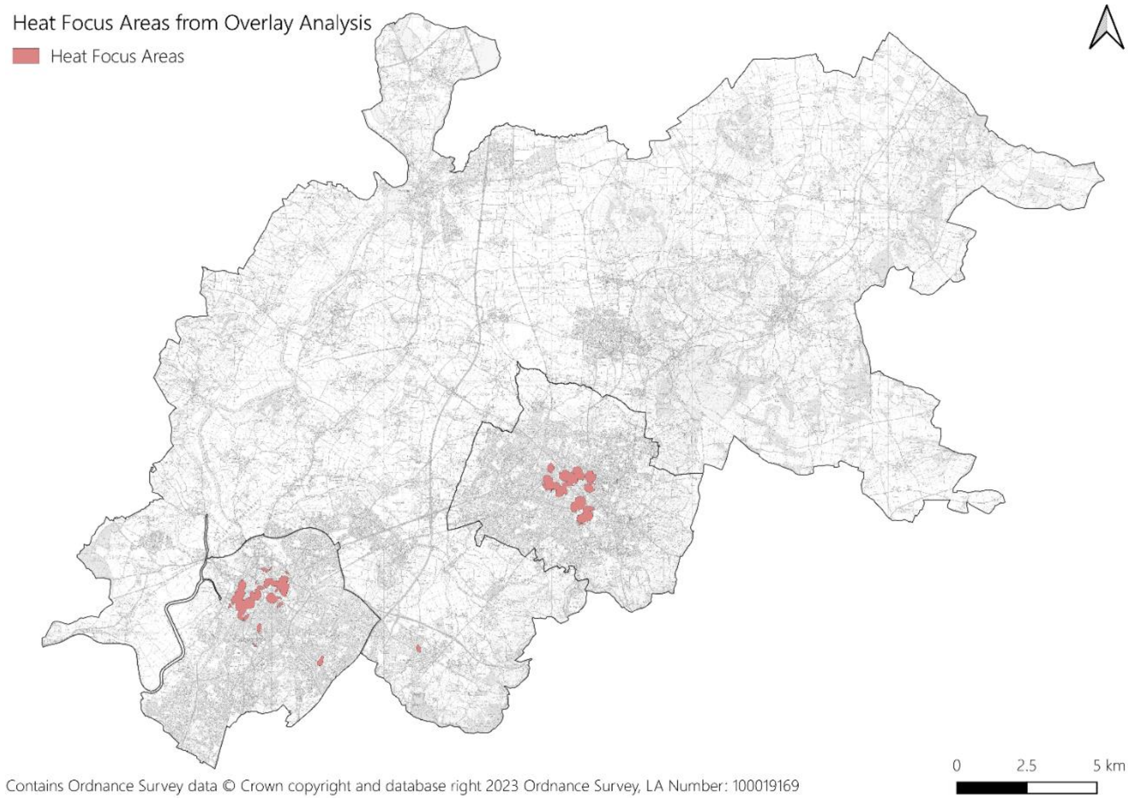

Figure 17 Heat Focus Areas in SLP authorities

(A higher resolution version of this map is provided in the technical appendices)

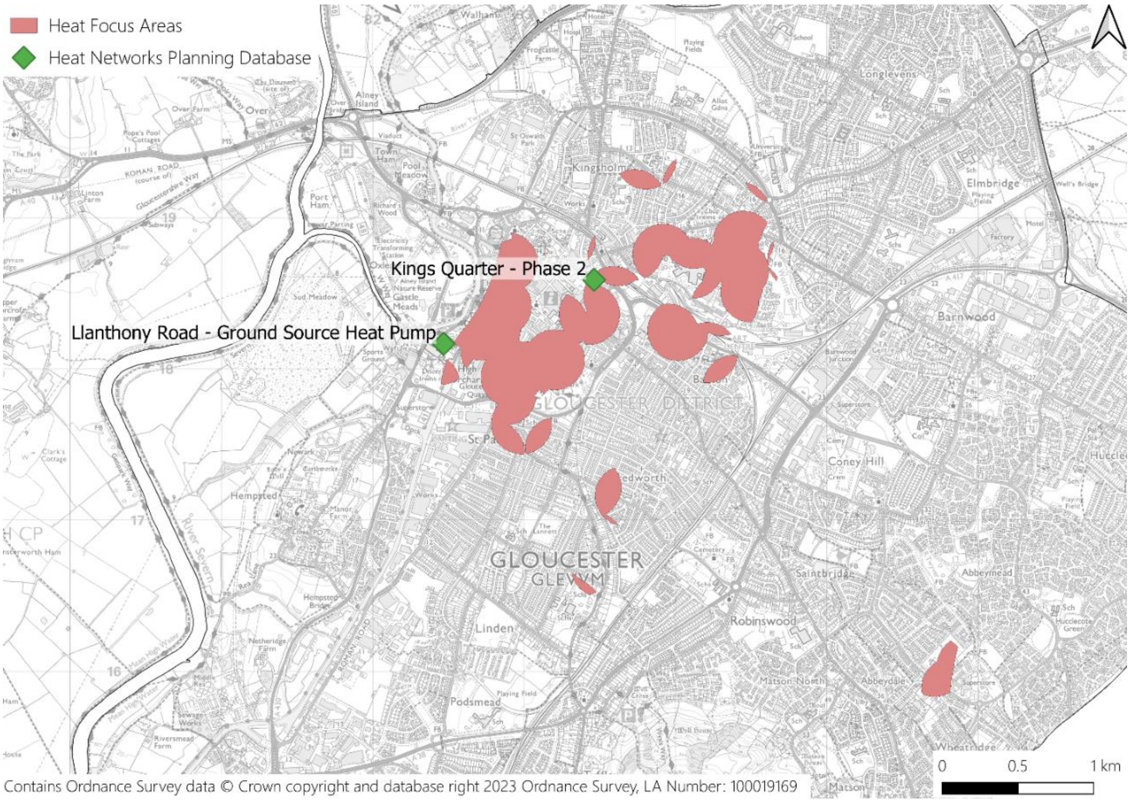

Figure 18 Heat Focus Areas in Gloucester with Heat Network Planning Database sites

12.19. Figure 18 shows the HFA's within Gloucester City Council area and the sites listed in the heat network planning database. This includes the Kings Quarter, which is still under construction. It is promising to see the heat networks co-located with the modelled heat focus areas. The Cheltenham heat focus areas are shown in Figure 19. These areas include the hospital, schools, colleges and offices.

12.20. Cheltenham is one of the 28 local authority partners in the Heat Network Zoning Pilot project[82] which aims to identify zones where heat networks may provide lowest cost, low carbon heat to the consumer through regulation, mandating powers and market support. Heat network zoning across England is expected to be introduced by 2025 using a nationwide methodology for identifying and designating heat network zones. The zoning model has been developed by CSE in conjunction with the Department of Energy Security and Net Zero, and has been run for Cheltenham. The results are provisional at this time as the model is still in development, but show three potentially network-able areas: Kingsditch trading estate (North of the centre), central Cheltenham and Cheltenham General Hospital.

[82] UK Government (2022), Heat Networks Zoning Pilot, www.gov.uk/government/publications/heat-networks-zoning-pilot

12.21. Cheltenham Borough Council is considering two networks, one in the centre and one at the new Golden Valley development (Plan A7). This development (A7) is in close proximity to the Hayden Sewage Treatment Works which could provide waste heat or energy production to the new development[83]. However, the treatment works has also been earmarked for future development and the site may be relocated.

12.22. Figure 20 shows existing development allocations, and other planning developments with the heat focus areas. New developments often act as a trigger for wider network development which can also serve existing heat demands from buildings in the vicinity and potentially improve overall economic viability.

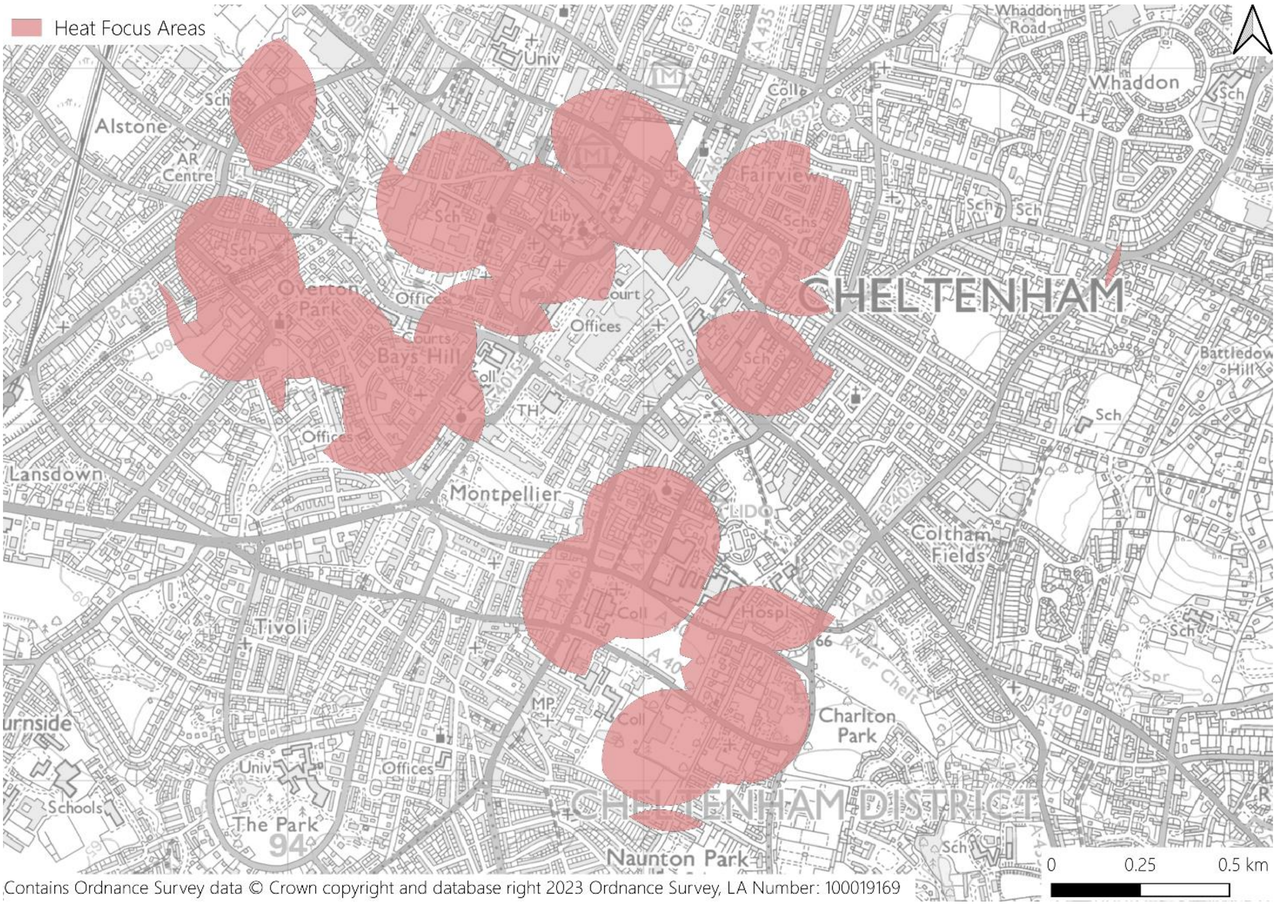

Figure 19 Cheltenham Heat Focus Areas

[83] Cheltenham Borough Council (2020), Golden Valley SPD, www.cheltenham.gov.uk/downloads/file/8188/golden_valley_spd

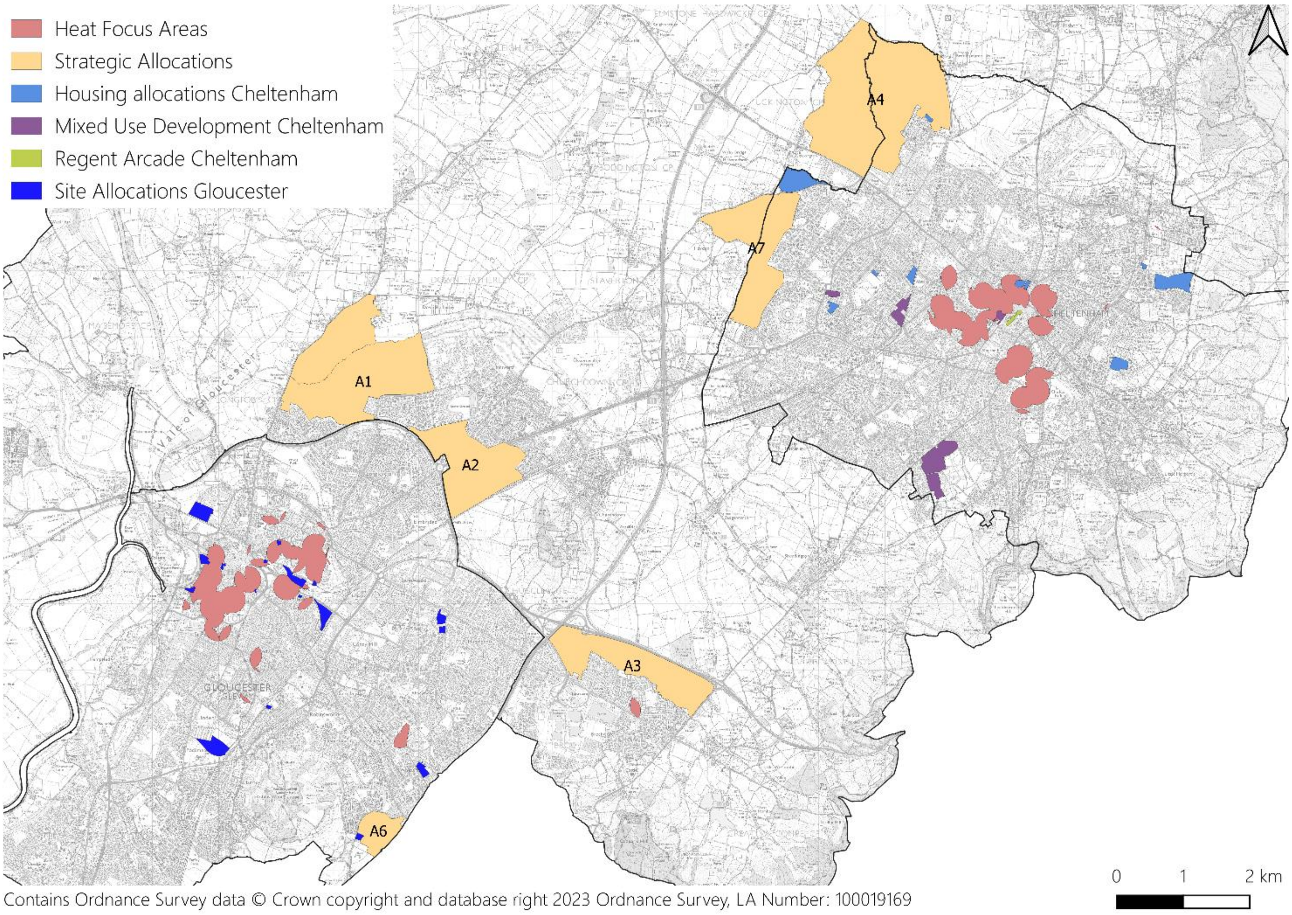

Figure 20 Site allocations, housing allocations and mixed use development with Heat Focus Areas

12.23. Conclusion: District heating

Communal heat networks are under construction and operational within Gloucester. There is good potential for further development of these networks with high heat demand density, anchor loads and residential loads nearby. There are also some good opportunities for district heat networks in Cheltenham.

13. Heat pumps

Introduction

13.1. Because of the limitations of other resources, a significant proportion of heat must be electrified. Whilst direct electric heating, immersion heaters and storage heating are an option for this, electricity is more expensive than gas per unit and so this would have an impact on household finances. It would also greatly increase the electricity demand and would therefore require costly upgrades to electricity grid infrastructure. Whilst heat pumps require electricity to run, the heating output they deliver to a building is much greater than the electricity they use.

13.2. Heat pumps have a coefficient of performance (COP) of greater than one. This means that for every kWh of electricity put into a heat pump, more than one unit of heat is generated. COPs will vary across different properties (with building age and insulation levels as factors). Generally, heat pumps are capable of COPs of three – meaning three kWh of heat are obtained for each kWh of electricity. This brings their costs into line with that of gas and means that the increased load on the electricity network would be much lower.

13.3. Heat pumps work by using electricity to draw energy from the environment, and use this to heat water, which can then be stored in a hot water tank. There are many forms of heat pump, generally divided into air source, ground source and water source. The most common is air source – these use electricity to draw heat out of the air surrounding the unit. Ground source heat pumps absorb heat from the ground, using a heat transfer fluid (normally water) heated by the ambient temperature of the soil, using either a horizontal or vertical ground loop. They have a higher coefficient of performance than air source heat pumps, but they are also more expensive and require more space. Finally, water source heat pumps also use a heat transfer fluid (normally water) to extract heat from a body of water, such as a lake or river. Generally these are also more efficient than air source heat pumps, but cost more and are very limited in where they may be deployed.

Planning Policy & Deployment Considerations

13.4. The Government has made a commitment to install 600,000 heat pumps per year by 2028[84], but current rates are around one-ninth of this and are not increasing fast enough. The UK installed 72,000 new heat pumps in 2022. The Climate Change Committee sixth carbon budget projected 130,000 installations in 2022, rising to 145,000 in 2023 (see paragraph 0 for more detail on the CCC's carbon budget). There is a concern that the number of trained retrofit assessors and heat pump installers are also off track. The Carbon Budget Delivery Plan increases the focus on heat pump delivery by 2035.

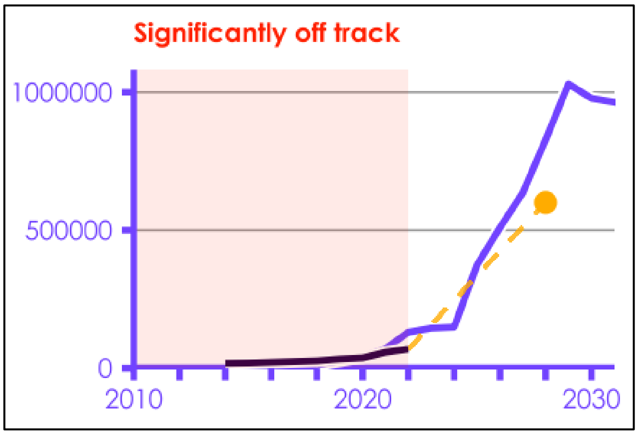

Figure 21 CCC Annual Progress Report (2023): Key indicators – heat pump installations (residential)

13.5. The average cost of installing a heat pump in a home fell by 1.9% in 2022, which followed sharp rises in 2020 and 2021 (which tracked the overall pattern of inflation for materials and labour in the construction sector). The Electrification of Heat Demonstration Project[85] has shown that heat pumps are viable in most property types, supporting the case for widespread electrification of heat.

13.6. The installation of an air source heat pump on domestic premises has been permitted development since 2011, providing limits and conditions are met. The installation of a ground or a water source heat pump on domestic premises is also usually considered to be permitted development. Permitted development rights do not apply to listed buildings. Limits may apply in Conservation Areas.

[84] UK Government (2023), Heat Pump Investment Roadmap, www.gov.uk/government/publications/heat-pump-net-zero-investment-roadmap
[85] Energy Systems Catapult, https://es.catapult.org.uk/project/electrification-of-heat-demonstration/

Results

13.7. The current heating demand is estimated at 2,761.5 GWh/yr. Table 16 compares the effect on supplied energy (in the form of natural gas or electricity) and carbon emissions under different heating scenarios.

13.8. This method assumes a coefficient of performance (COP) of three for heat pumps, and that current heating is entirely by gas, with a boiler efficiency of 85%. As can be seen, heat pumps provide the opportunity to greatly reduce energy demand for heating in the SLP area.

Table 16: Energy demands under various heating scenarios

	Current heating	Electrified with immersion heaters and direct space heating	Electrified with only heat pumps
Heating and hot water demand (GWh/yr)	2,761.5	2,761.5	2,761.5
Assumed heating efficiency	85%	100%	300%
Energy supplied for heating (GWh/yr)	3,248.8	2,761.5	920.5
Carbon emissions ($ktCO_2e/yr$)	594.5	505.4	168.5

13.9. The figures in the table above are calculated assuming that all electricity demand is met by grid electricity. The current 5-year forecast in National Grid's Future Energy Scenarios gives a carbon factor of 0.183 kg CO_2e/kWh. Current targets aim for grid decarbonisation by 2035, so emissions from electricity consumption will fall to this date. Should a portion of this demand be met by small-scale local renewable energy installations (i.e. those that not already accounted for within the assumed carbon factor) then the emissions totals would be reduced.

13.10. Conclusion: Heat pumps

The Climate Change Committee balanced pathway to reach net zero requires a dramatic increase in the uptake of heat pumps nationally and action is needed to increase uptake and improve the skills of local installers if targets are to be met.

The energy required to meet the current heating demand for the area with heat pumps would be 921 GWh per year, saving:

- 336.9 thousand tonnes of CO_2e per year compared to electric heating without heat pumps (67% carbon saving)
- 426 thousand tonnes of CO_2e per year compared to gas heating (72% carbon saving).

14. Biomass

Introduction

14.1. Biomass is 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'.

14.2. Biomass materials such as wood are widely used in many countries as a feedstock for modern heating systems. Modern biomass heating technology is well developed and has been used to provide heat to buildings of all sizes, either through individual boilers or via district heating networks. Biomass has also often been used to fuel electricity plant or combined heat and power (CHP) plant. Various processes are used to prepare wood feedstock prior to it becoming suitable for use as fuel in a range of forms including logs, woodchips, pellets and briquettes.

14.3. The types of biomass for energy production investigated in this study are:

- Forestry and woodland residues - virgin, untreated wood residues from forestry, arboriculture, tree surgery, etc.
- Energy crops - miscanthus and short rotation coppice (SRC)

14.4. 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.

14.5. Wood is generally 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 local 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.

14.6. Its use as part of a net zero carbon future however is likely to require that any adverse impacts on land use and local air quality are avoided, the amount of woodfuel being burnt is genuinely replaced by re-growth or re-planting within an acceptable timescale, and that carbon emissions resulting from growing, processing and transport processes have been mitigated.

14.7. Changes in land use from cultivating purpose-grown energy crops, also need careful consideration in terms of impacts on biodiversity and whether the activity is the most efficient use of the land compared to alternative sustainable energy or carbon reduction/sequestration measures.

14.8. The Government's Biomass Strategy was published in August 2023[86]. This outlines the role for biomass in the UK's net zero targets. This role includes renewable electricity generation, biomethane, heating, transport fuels, industry and low carbon hydrogen.

14.9. Since the 1960s, agricultural subsidy under the EU's Common Agricultural Policy (CAP) has significantly shaped farming practices in the UK, including the extent to which bioenergy initiatives have been deployed. The UK's 25-year Environment Plan and planned exit from the CAP now provide a new context for policies and strategies to scale up biomass production, not least by the Government's new Environmental Land Management (ELM) scheme[87] which will pay farmers to deliver beneficial outcomes.

Planning Policy & Deployment Considerations

Issues affecting deployment

14.10. 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. In both cases, competing alternative end-uses for wood such as for construction and building materials and any inherent carbon storage benefits will also be a factor.

14.11. Deployment of energy crops will be influenced by economic viability, end-use/market, land ownership, existing farming activities, potential biodiversity impacts, protected landscapes, the presence of water-stressed areas and net carbon reductions achieved. In particular, conflicts over land use for alternative activities such as food production will need to be considered in relation to the relative costs and benefits of each option. There may also be land use conflict when comparing the appropriateness of different

[86] UK Government (2023), Biomass Strategy, www.gov.uk/government/publications/biomass-strategy
[87] UK Government (2023), Environmental Land Management update, www.gov.uk/government/publications/environmental-land-management-update-how-government-will-pay-for-land-based-environment-and-climate-goods-and-services

renewable technology options, for example in terms of whether more benefit could be gained from the use of a particular parcel of land for the growing of energy crops compared to the installation of a ground-mounted solar array. For the purpose of comparison, the potential heat generation from one hectare of Miscanthus could be in the region of 43 MWh per year, plus 26 MWh per year electricity generation (assuming CHP), whilst a solar farm covering the same hectare of land might generate around 384 MWh per year of electricity. 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.

Resource Assessment Methodology - forestry and woodland resource

14.12. 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. Annual tonnage of wood can then be obtained and its heat delivery potential estimated.

14.13. The Forestry Commission's National Forest Inventory (NFI) dataset[88] 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[89]. It classifies areas of woodland into the following categories:

- Broadleaved
- Coniferous
- Mixed
- Shrub
- Young trees
- Felled
- Ground prepared for planting
- Low density

14.14. Felled areas, ground prepared for planting, low density, 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.

[88] Forest Research, National Forset Inventory, www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/

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

14.15. This study does not account for losses in production. For example, if the woodfuel was to be used in a thermal power plant to generate electricity, the conversion efficiency could be as low as 25%.

Results - forestry and woodland resource

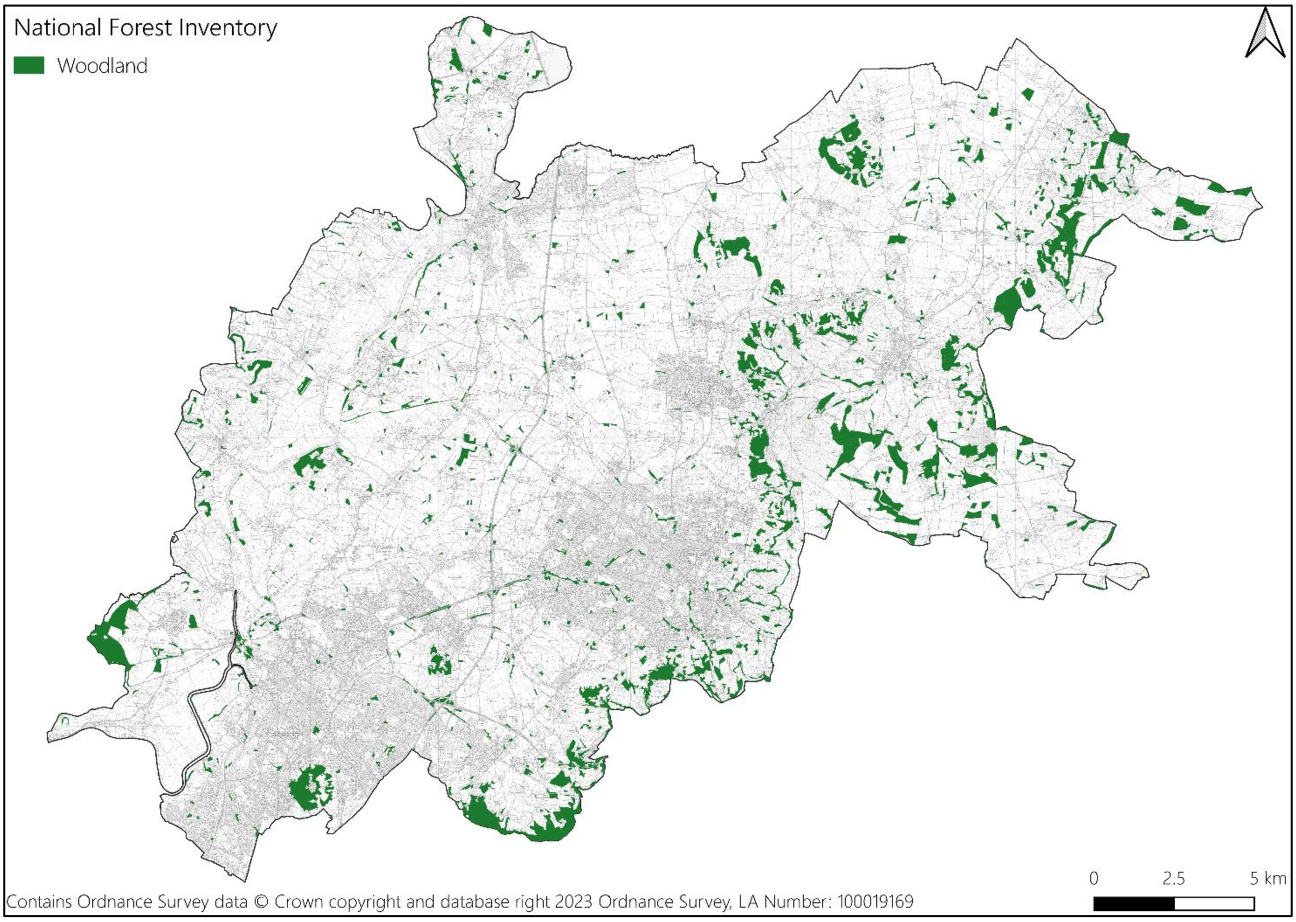

Figure 22 Areas of woodland within SLP area (all categories)

(A higher resolution version of this map is provided in the technical appendices)

14.16. Using the GIS data used in 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 the Appendix 'Key Assumptions: other technologies'.

Table 17: Woodfuel assessment of forestry and woodland resource

Woodland category	Area (Hectares)	Sustainable woodfuel yield (odt/year)	Delivered heat (GWh/year)
Assumed woodland	0.5	163.6	0.9
Broad-leaved	31.1	8,339.0	44.2
Conifer	4.1	1,607.7	8.5
Mixed - mainly broadleaf	1.3	362.5	1.9
Mixed - mainly conifer	1.3	479.3	2.5
Coppice	0.0	3.6	0.0
Total	38.3	10,955.7	58.1

14.17. The total sustainable heat potential is 58.1 GWh/year. This is dominated by broadleaved woodland (44.2 GWh/year). This would supply 4% of the residential heat demand and 2% of the overall estimated heat demand in the SLP authorities. The above figures relate to the resource within the area only, but there is potential for surplus woodfuel to also be sourced from further afield if the cost and environmental impact of transporting the feedstock or final product is suitably assessed.

14.18. The carbon offset potential is between 8.9 and 10 thousand tonnes CO_2e per year (depending on whether heat generated by electricity or gas is being displaced). If woodfuel displaces gas heating this would save 1% of the total carbon emissions from energy use (or 3.2% of domestic gas emissions).

Table 18: Carbon offset potential of woodfuel in CGTSLP area

Type of woodland	Estimated generation (GWh/year)	Carbon offset compared to gas (thousand tonnes of CO_2e/year)	Carbon offset compared to electricity (thousand tonnes of CO_2e/year)
Broad-leaved	44.2	7.6	6.8
Other woodland type	13.9	2.4	2.1
Total	58.1	10.0	8.9

14.19. 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.

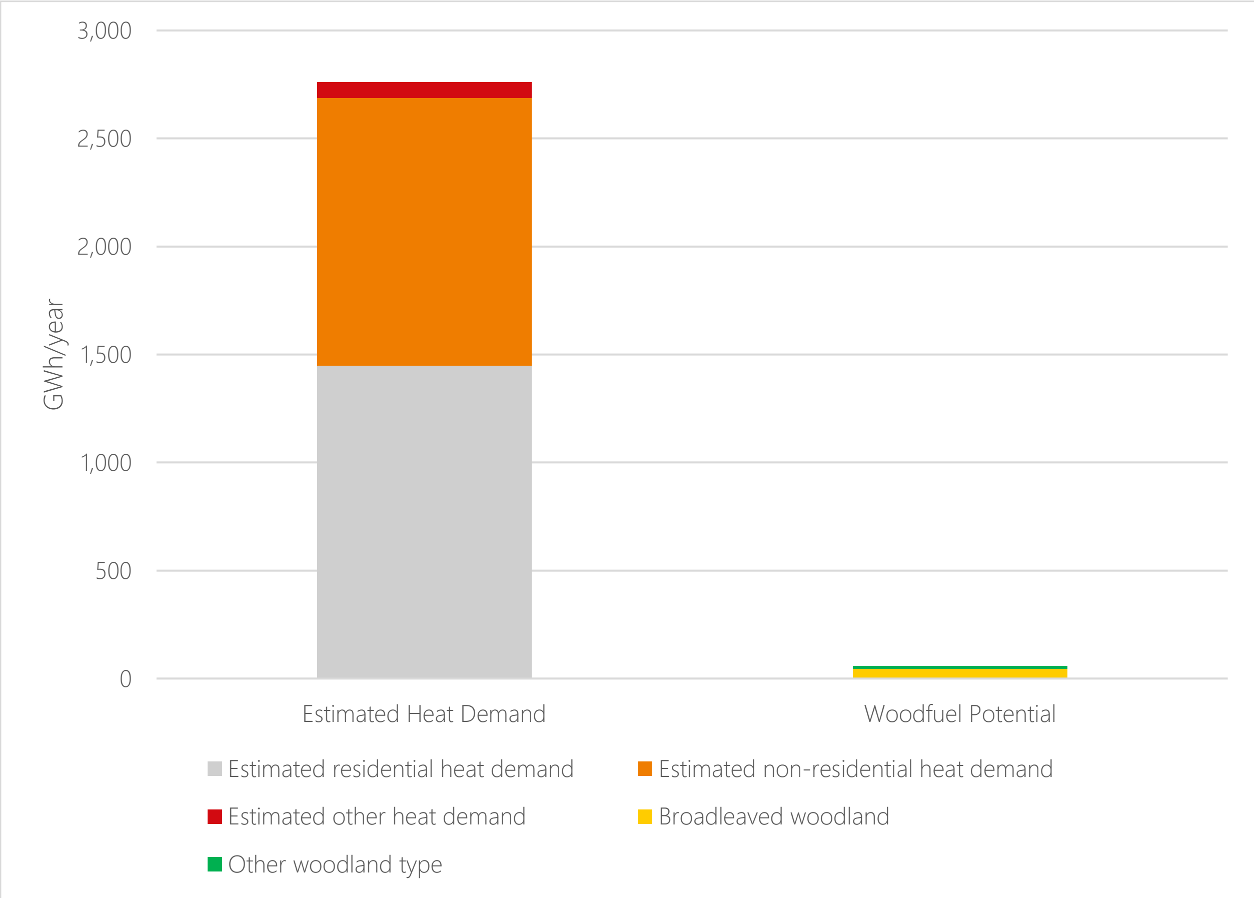

Figure 23 Estimated heat demand compared to woodfuel potential (GWh/yr)

Resource Assessment Methodology - energy crops

14.20. 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.

14.21. 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.

Results – energy crops

14.22. The technical resource for energy crops assumes that they can be grown on agricultural land of grades 2 or 3 (arable land), which for the SLP area totals 33,644 hectares (around 67% of total land area). Grade 1 land is excluded from the analysis as it is assumed that food crops will be prioritised over energy crops in these areas. Typical constraints that will preclude areas include 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.

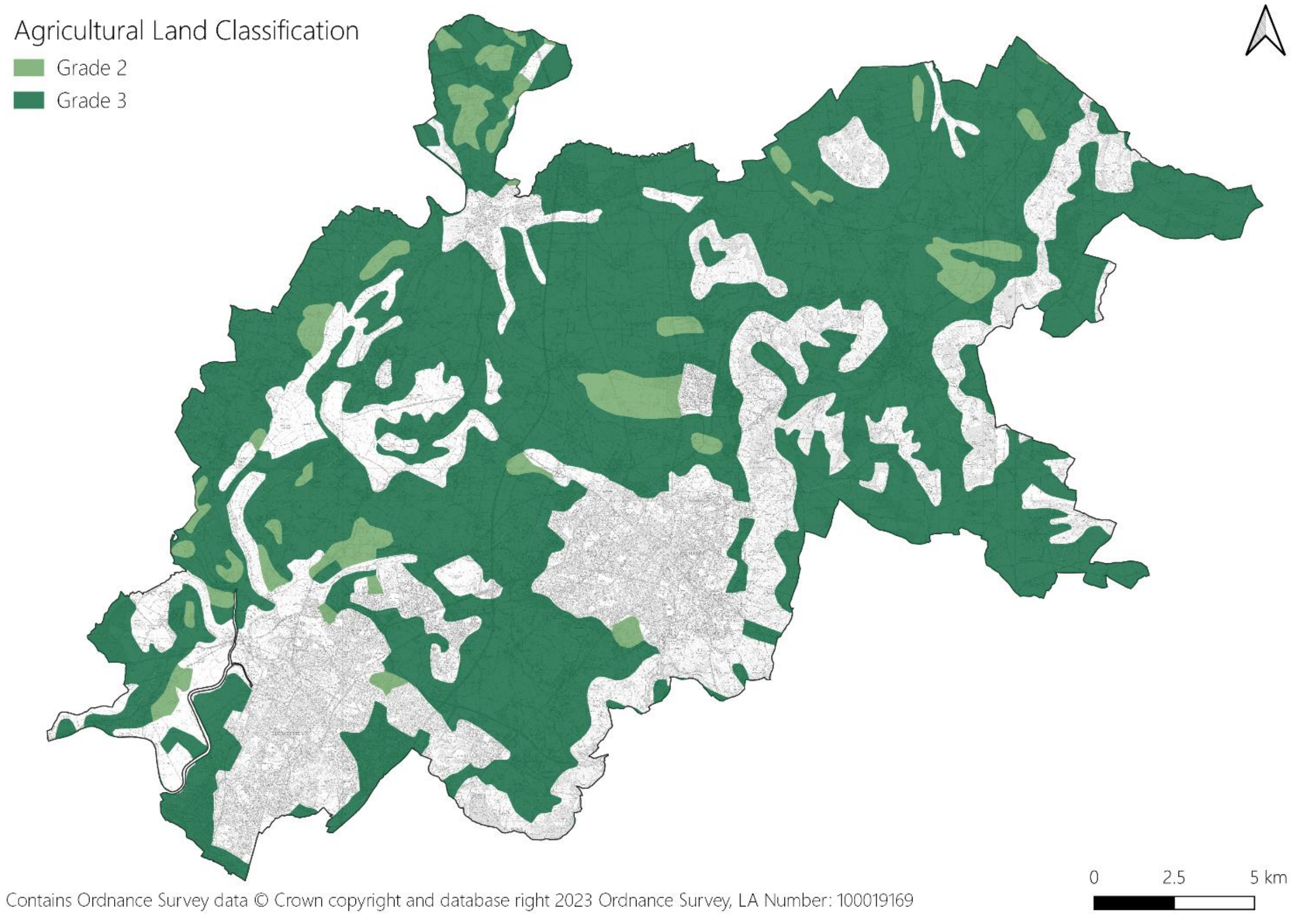

Figure 24 Agricultural land classificatiion

14.23. Potential energy outputs are shown in Table 19. This shows two scenarios: the resource if 1% (336 hectares) of all suitable areas was utilised and if 10% (3,363 hectares) was utilised. In the Miscanthus 10% scenario this could fulfil 6% of the areas estimated building heat demand (11.3% of domestic heat demand). Because the two energy crops (miscanthus and short rotation coppice) are assessed using the same land area –one must be chosen on a site over the other (this does not mean only one crop or the other).

SRC may be more suitable in some areas with concerns about conservation sensitivity. Miscanthus' better potential may make it superior where there are not such concerns.

Table 19 Potential yields for energy crops

Energy Crop	Area cultivated (Hectares)	% of all suitable areas	Delivered heat (GWh/year)
Miscanthus	336.44	1%	16.4
	3,364.40	10%	163.5
SRC	336.44	1%	8.2
	3,364.40	10%	82

14.24. The carbon offset potential is between 13.7 and 27.4 thousand tonnes CO_2e per year (depending on whether SRC or Miscanthus is grown). The emissions relating to burning energy crops or drying them have not been accounted for in the carbon saving. Growing Miscanthus would save 2.9% of the total carbon emissions from energy use (or 8.7% of domestic gas emissions).

Table 20: Carbon offset potential of energy crops

Energy Crop	Heat potential (GWh/yr)	Carbon offset compared to gas (thousand tonnes of CO_2e/year)	Carbon offset compared to electricity (thousand tonnes of CO_2e/year)
Miscanthus	163.5	27.4	27.4
SRC	82.0	13.7	13.7

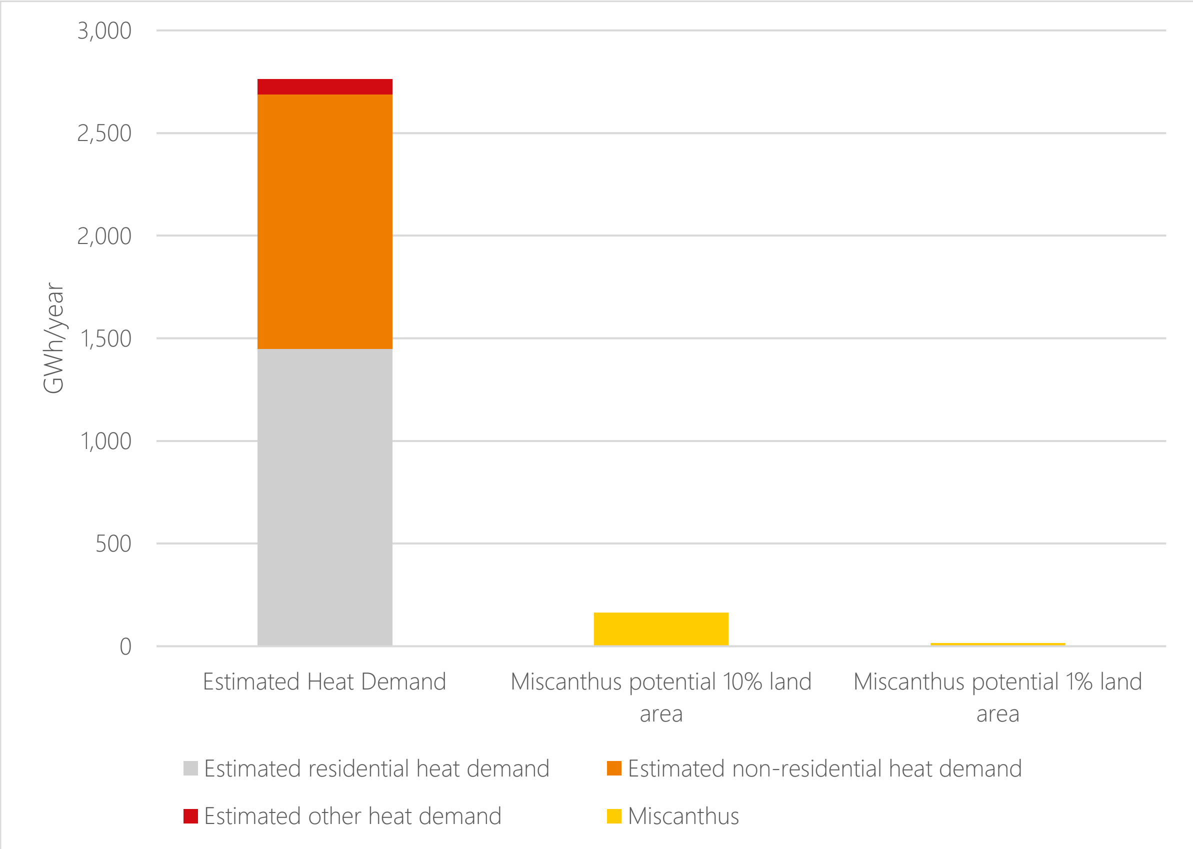

Figure 25 Estimated heat demand compared to energy crops potential (GWh/yr)

14.25. Conclusion: Biomass

Woodfuel from local sources has the theoretical technical potential to meet 4% of the residential heat demand and 2% of the overall estimated heat demand in the SLP authorities. If woodfuel displaces gas heating this would save 1% of the total carbon emissions from energy use (or 3.2% of domestic gas emissions).

Energy crops have the technical potential to generate 163.5 GWh/year (Miscanthus 10% scenario). In this scenario energy generated could fulfil 6% of the area's estimated building heat demand (11.3% of domestic heat demand). If Miscanthus displaces gas heating this would save 2.9% of the total carbon emissions from energy use.

However, the figures presented here are an indication of theoretical technical potential only, not the development capacity that may be expected to be deployed in practice. As is highlighted in this chapter - land use, impacts on local air quality, the importance of genuinely sustainable re-growth or re-planting, and the carbon emissions resulting from growing, processing and transport processes are all key considerations in the use of biomass.

15. Energy from waste

Introduction

15.1. Some organic waste streams can be processed through Anaerobic Digestion to produce biogas. This can be combusted to produce heat or electricity or injected into the gas grid. Generally, this is most commonly performed on sewage and on organic waste (for example collected food waste).

15.2. There are anaerobic digesters and a combined heat and power (CHP) system at Netheridge Sewage Treatment Works, and an anaerobic digester (AD) at Wingmoor Farm near Bishops Cleeve where food waste from the surrounding area is processed. The AD is CHP enabled and has an electric capacity of 1.6 MW.

15.3. Tewkesbury has large portions of rural land which means there is good potential for agricultural waste as a potential renewable energy resource. One key agricultural waste for which there is potential is animal slurry. This can be fed to an anaerobic digestion process to produce biogas.

15.4. Two other forms of waste have not been considered in this analysis:

- The majority of energy from municipal and commercial waste is from non-renewable resources and so cannot be considered renewable. However, some portion of the waste could be renewable dependent on its organic, non-fossil fuel content. As this is likely a very small fraction, and difficult to separate economically from other waste, it has not been considered in this report.
- Recycled wood waste is difficult to quantify and would require a detailed survey to assess material collected within the county.

Planning Policy & Deployment Considerations

15.5. National Planning Policy for Waste[90] states that waste planning authorities should identify, in their local plans, sites and/or areas for new or enhanced waste management facilities in appropriate locations. In preparing their plans, waste planning authorities should consider a broad range of locations including industrial sites, looking for

[90] UK Government (2014), National Planning Policy for Waste, www.gov.uk/government/publications/national-planning-policy-for-waste/national-planning-policy-for-waste

opportunities to co-locate waste management facilities together and with complementary activities. Where a low-carbon recovery facility is considered as an appropriate type of development, waste planning authorities should consider the suitable siting of such facilities to enable the utilisation of the heat produced as an energy source in close proximity to suitable potential heat customers.

15.6. Gloucestershire County Council are in the early stages of preparing a Waste Local Plan for Gloucestershire. This will include options for energy generation from waste such as anaerobic digestion.

15.7. The Climate Change Committee annual progress report (2023) states that continued growth in the use of energy from waste plants is undermining efforts to reduce emissions from the waste sector as emissions are already higher than the government's Carbon Budget Delivery Plan anticipates, and capacity is set to increase in the coming years. (See paragraph 0 for more detail on the carbon budget delivery plan).

15.8. Energy from waste emissions grew by 5% from 2020 to 2021. The CCC recommends a moratorium on additional energy from waste capacity until a review of capacity requirements has been completed by the government, and an updated assessment of residual waste treatment capacity requirements is published. This is because energy from waste emissions are already higher than the government's Carbon Budget Delivery Plan anticipates, and energy from waste capacity is set to increase in the coming years.

15.9. Case Study: Javelin Park Energy-from-Waste facility

Most residual household waste across the county is now treated at the Javelin Park Energy-from-Waste facility. According to 2021 Environment Agency data[91] the SLP authorities sent 68,901 tonnes to the Javelin Park Energy Recovery Facility. This is 36% of the total waste received by the facility. Gloucestershire County Council sent 20% of the waste received.

Table 21: Javelin Park Energy Recovery Facility tonnes of waste received by local authority origin of waste

Local Authority Origin of Waste	Sum of Tonnes Received	% of Waste Received
Cheltenham	43,174.12	23%
Gloucester	17,122.24	9%
Tewkesbury	8,604.44	4%
Total	**191,228.15**	**100%**

According to the website, the gross electrical output of the Facility is 17.4 MW[92]. Just under 20% of this is used to run the Facility itself and it exports the rest (equivalent to around 116,000 MWh per year, providing the equivalent electrical energy to power 25,000 homes). It is designed to be a CHP Plant, so that as well as generating electricity, it is capable of supplying heat or steam to be used by neighbouring homes or businesses.

Results

15.10. Defra statistics from 2022[93] have been used to find the number of different livestock in the area. Unfortunately, the data on number of cattle and pigs has been redacted from the data for Cheltenham and Gloucester (due to low counts) as well as, the number of poultry in Gloucester[94]. Therefore, the figures for cattle and pigs cover Tewkesbury council only and the figure for poultry covers Tewkesbury and Cheltenham.

15.11. The amount of slurry produced has been estimated. This has then been converted to the potential volume of biogas, and the potential energy contained in that biogas. These

[91] UK Government, *2021 Waste Data Interrogator*, www.data.gov.uk/dataset/d8a12b93-03ef-4fbf-9a43-1ca7a054479c/2021-waste-data-interrogator
[92] Urbaser & Balfour Beatty, The Gloucestershire Energy from Waste Facility, www.ubbgloucestershire.co.uk/faqs
[93] UK Government (2023), Structure of the agricultural industry in England and the UK at June, www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june
[94] Within the dataset the reason shown for why data has been redacted: '# - indicates that data has been suppressed to prevent disclosure of information about individual holdings, therefore totals may not necessarily agree with the sum of their components'.

results are shown in Table 22. 2.1% of heat demand in the SLP area could be met by biogas from animal slurry. This also equates to 4% of residential heat demand.

Table 22: Potential of biogas from animal slurry

Livestock	Number in SLP area	Mass of slurry (thousand tonnes/yr)	Biogas Yield (million m^3)	Energy potential (GWh/yr)
Cattle	17,886	216.30	4.33	28.98
Pigs	5,160	12.69	0.25	1.70
Poultry	1,559,002	80.69	4.03	27.03
Total	1,582,048	309.68	8.61	57.71

15.12. The carbon offset potential is between 9 and 10.5 thousand tonnes CO_2e per year (depending on whether electricity or gas is being displaced). The emissions relating to biogas have been accounted for in the carbon saving. If the full potential of animal slurry displaces gas heating this would save 1.1% of the total carbon emissions from energy use (or 3.3% of domestic gas emissions).

Table 23: Carbon offset potential of animal slurry

Livestock	Energy potential (GWh/yr)	Carbon offset compared to gas (thousand tonnes of CO_2e/year)	Carbon offset compared to electricity (thousand tonnes of CO_2e/year)
Cattle	29.0	5.3	5.3
Pigs	1.7	0.3	0.3
Poultry	27.0	4.9	4.9
Total	57.7	10.5	10.5

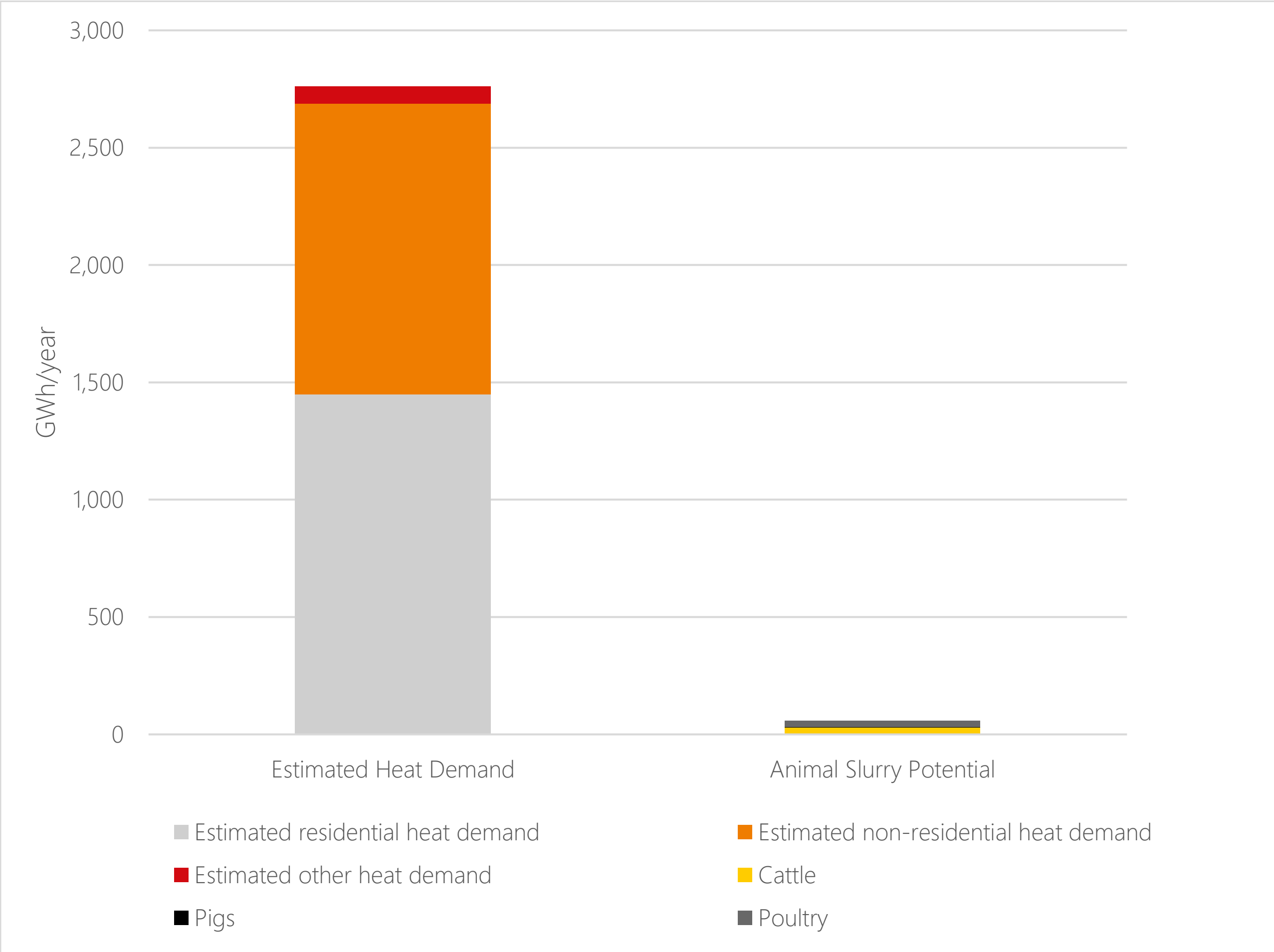

Figure 26 Estimated heat demand compared to animal slurry potential (GWh/yr)

15.12. Conclusion: Energy From Waste

2.1% of heat demand in the area could be met by biogas from animal slurry. This equates to 4% of residential heat demand. The carbon offset potential is 10.5 thousand tonnes CO_2e per year. The emissions relating to biogas release have been accounted for in the carbon saving. If the full potential of animal slurry displaces gas heating this would save 1.1% of the total carbon emissions from energy use (or 3.3% of domestic gas emissions).

However, the Climate Change Committee recommendation for a national moratorium on additional energy from waste capacity should be noted when considering the SLP. The CCC recommend a moratorium is kept in place until a review of capacity requirements has been completed by the government, and an updated assessment of residual waste treatment capacity requirements is published.

16. Other technologies

Hydrogen

16.1. In the Climate Change Committee's report on delivering a reliable decarbonised power system[95], the importance of hydrogen is apparent, as nearly one-quarter of the report is given over to its role. One of the priorities for the government is to identify a set of low-regret electricity and hydrogen investments that can proceed now. There is concern of medium-term scarcity in hydrogen supply, which would be even larger if the government prioritises using hydrogen to heat homes.

16.2. For hydrogen to be considered as a renewable energy source, it must be "green" rather than "blue". Green hydrogen comes from the electrolysis of water using a renewable energy source. Blue hydrogen is made from natural gas, and so cannot be considered renewable. Electrolysis requires large amounts of energy, and this must be met by renewable energy. Hydrogen may also be burned directly to produce heat. It has been suggested as a replacement for natural gas within heating, as well as wider applications such as an energy storage medium, for transport fuels and for high-temperature industrial processes.

16.3. Because electrolysis requires so much electricity, hydrogen is unlikely to be economical to use for most heating systems. A report by Lowes and Rosenow (2023) summarises literature on this topic. They quote that some reports say that hydrogen heating homes via the gas grid could increase heating costs by as much as 10 times[96]. Other reports they reference show that hydrogen would increase bills by 70%, not accounting for the costs of converting the gas grid, nor balancing the electrical system for producing hydrogen. This all suggests the electrification of heating will be the most economical and preferred option in most cases.

16.4. However, this does not mean that there is no use for hydrogen in decarbonising the energy system. One area of heating that electrification is not able to cover is in high temperature industrial processes. It may also find some use in transportation in applications such as heavy goods vehicles and other large vehicles, though there is also potential for other biofuels in these areas. If hydrogen is generated in centralised facilities and distributed, rather than on-site of use, centralised production would likely take a

[95] CCC (2023), Delivering a reliable decarbonised power system https://www.theccc.org.uk/publication/delivering-a-reliable-decarbonised-power-system/

[96] RAP (2023), How much would hydrogen for heating cost in the UK? www.raponline.org/knowledge-center/how-much-would-hydrogen-for-heating-cost-in-the-uk/

similar form to current petroleum products – with central "refineries" and tankers (road and rail) to distribute the hydrogen. This could lead to an increase in heavy traffic, although this is likely to be more than offset in the reduction in petroleum tankers as we move away from fossil fuels.

Geothermal

16.5. Geothermal energy is currently utilised for heat in district heat networks in three locations in England and for power generation at one project in Cornwall, with more planned in the area. However, the application of deep geothermal is not currently factored into the UK's carbon budget. The use of deep geothermal energy in the SLP area would require specialised research outside the scope of this study.

16.6. Ground-source heat pumps can take advantage of shallow geothermal energy. This energy is either through making use of the relatively stable temperature just below the surface or making use of the slightly increased temperature at that level in urban areas (and in the case of heat pumps with trenched coils solar energy contributes causing the ground surface to warm). This would allow geothermal energy to be used to heat homes.

16.7. The legacy of mining in the UK also creates opportunities for geothermal energy. Across the country there are many disused mines which have become flooded and this water may be taken advantage of in open-loop ground source heat pumps. Similarly, other sources of water underground provide this option – for example aquifers. These are however difficult to quantify without site-specific inspections of flowrates and similar.

16.8. Another potential opportunity is in existing wells and boreholes. Whilst not all will be suitable, the use of these would allow cheaper installation of shafts for ground source heat pumps. Some boreholes will already extend several hundred meters below the surface. If these can be converted to shafts for ground source heat pumps, then higher temperature water can be abstracted, improving the heat pump's performance. These would be excellent locations for a heat network energy centre (assuming there is nearby heat demand).

17. Renewable energy potential - conclusions and next steps

Summary of results

17.1. Table 24 and Figure 27 summarise the technical potential from all sources assessed. In the table these are also shown as a percentage of current electricity, heat, and stationary energy demand[97]. 'Technical potential' means the technically exploitable energy (electricity or heat) from a given resource. As is emphasised throughout this report, this theoretical technical potential does not take into account any issues affecting deployment, or the fact that one technology may need to be chosen over another in some areas.

17.2. The results include 20% of the theoretical energy generation potential from wind and 20% of the theoretical energy generation potential for ground mounted solar. This 20% figure has been chosen for illustrative purposes only, it is not based on any assessment of realistic deployment as we are yet to determine optimal deployment scenarios for the area (these will be developed in part two of the study).

17.3. As this shows, there is technical potential within the SLP authorities to cover the energy requirements of the area. However, (based on the 20% deployment) there is little headroom:

- 4,208 GWh total energy demand
- 4,556 GWh per year technical renewable energy potential

17.4. To realise this scale of theoretical potential would require:

- 2,692 wind turbines of different scales (for 20% of potential)
- Solar farms equating to an area of around 45km^2 (approximately 9% of the study area for 20% of ground-mounted solar potential)
- 44,153 rooftop solar installations and a total panel area of 140.46km^2
- Hydropower at five barriers in Tewkesbury
- The use of biomass, energy crops and biogas from animal slurry in place of natural gas heating.

[97] Though comparisons to electricity, heat, and energy use are provided to contextualise the quantity of the resource, rather than give a prediction of output.

Table 24: Summary of technical potential of renewable energy sources in the SLP area

Renewable energy source	Maximum technical potential (GWh/year)	Current electricity demand which could be met	Current heat demand which could be met	Current total energy demand which could be met
Ground-mounted solar (100%)	16,598	1,148%	601%	337%
Ground-mounted solar (20%)	3,320	230%	120%	67%
Onshore Wind (100%)	2,826	195%	102%	57%
Onshore Wind (20%)	565	39%	20%	11%
Rooftop PV	280	19%	10%	6%
Hydropower	29	2%	1%	1%
Woodfuel	58	4%	2%	1%
SRC (Energy crop)	82	6%	3%	2%
Miscanthus (Energy crop)	164	11%	6%	3%
Slurry	58	4%	2%	1%

Resource assessment - next steps

17.5. Part two of this study, will look in more detail at specific areas, approaches to renewable energy deployment, and recommendations for local policy. This will include:

- Identifying areas with most potential across all technologies and compiling these into a shortlist of the most promising sites and technologies.
- Undertaking a landscape sensitivity analysis to provide a more detailed evidence base for what scale of wind turbine and solar development (i.e. very large, large, medium, small) may be appropriate in areas of technical potential and indeed where wind turbines may not be suitable (i.e. due to the potential impacts on protected or valued landscapes). A more detailed methodology is provided in the technical appendix.
- Exploring specific opportunities for renewable energy generation that fall within the land holdings of the authorities and County Council, as well as the types of business

models and delivery vehicles that may be appropriate to develop renewable energy systems on council-owned sites.

- Developing deployment scenarios with trajectories up to 2041 that illustrate the energy generation and carbon reduction potential of the technologies modelled and their relative roles in contributing to a future net zero system.
- Calculating a carbon baseline for each area to understand how the deployment of renewable technologies under each of the scenarios will contribute to the authorities' commitments regarding carbon neutrality.

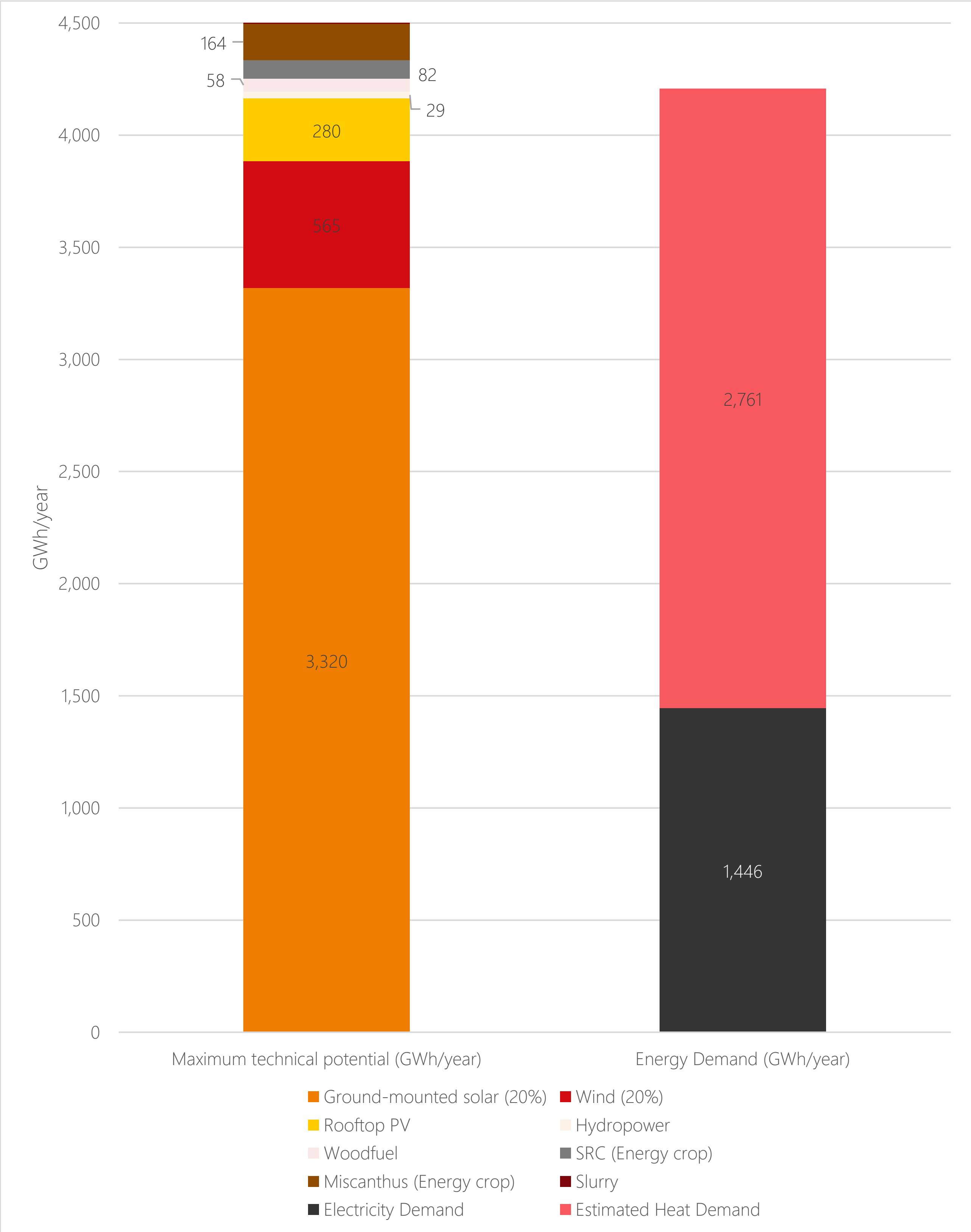

Figure 27 Summary of technical potential of renewable energy sources compared to energy demand

18. Emerging recommendations for local plan development

18.1. As the three councils move towards the new SLP over the next three years, action on climate change should be an integral part of the culture of plan-making and must be embedded and integrated into policy formulation. Only by treating climate change related issues as central to policy formulation will an LPA have effectively discharged its legal obligations.

18.2. To this end, climate change should be central to the local plan vision, objectives and policies, and the authorities should be able to demonstrate how the plan as a whole contributes to the Climate Change Act national carbon budget regime. The policy direction needs to be ambitious both in scope and timescale, to achieve Cheltenham, Gloucester, and Tewkesbury's climate emergency declaration commitments and to meet the NPPF expectations of contributing to radical reductions in greenhouse gas emissions, minimising vulnerability and improving resilience, encouraging the reuse of existing resources, and supporting renewable and low carbon energy and associated infrastructure. Renewable energy policies derived from this energy resource assessment should form a key part of this overall approach.

18.3. Strong and consistent political and corporate leadership is required to ensure that climate change is an organisational priority. An integrated approach should be adopted so that all aspects of service delivery take the climate crisis into account and that planning is used to support identified actions around mitigation and adaptation.

18.4. The following recommendations will support this, and enable a positive strategy that will help realise the renewable energy potential that this report has highlighted. These will be developed in more detail in part two of the report.

1. Developing policies for renewable energy

18.5. Building on the understanding of technical potential provided through parts one and two of this study we recommend that specific targets are set in the local plan for renewable energy production that are linked to the technical potential identified, and that are needed to achieve the overall carbon budget for the district. This would enable the local authorities to monitor delivery in their Authorities Monitoring Reports. Part two of the study will recommend policy wording for inclusion in the SLP.

18.6. We recommend that the mapping produced as part of this study is used to inform the local plan policies map, which is particularly important for enabling the deployment of onshore wind (given NPPF footnote 54, and the prerequisite for a wind farm to be in a zone designated for wind energy in a local or neighbourhood plan or supplementary planning document). This would enable community-led spatial planning and help facilitate community energy projects, and to send clear signals to developers about where renewable energy would be most appropriate to accelerate deployment and avoid conflict.

18.7. The broad policy approach taken by Cornwall Council in their Climate Emergency DPD[98] is useful as a reference point for some of the key considerations for the SLP:

- The need for site allocations versus the need for flexibility.
- The need to identify broad locations on the policies map versus the potential to create criteria-based policies.
- The development of technical criteria.
- The consideration of National Landscape / AONB and Green Belt as areas for potential renewables deployment.
- The likelihood of changes over the plan period in renewables technology, grid capacity, and the rate of grid decarbonisation on a national level.
- If/how to consider community ownership, community-led proposals or community benefits.
- How to balance land uses.

2. Developing policies for demand flexibility and energy storage features

18.8. We recommend development of a policy which encourages energy storage, demand side response, smart metering and smart heating controls and smart energy technologies, potentially allowing the energy system benefits to be counted towards policy compliance, provided that a robust methodology is provided. Any policy wording should be outcome oriented rather than fixed to one technology and should be aligned with national ambitions around smart metering and access to demand flexibility and energy storage technologies. Although classes of technology (e.g. energy storage and demand shifting) are unlikely to be superseded quickly, it is unlikely that planning policy will be able to keep up with the pace of technological development within these fields.

18.9. We would also recommend trialling the inclusion of flexibility and storage technologies within new developments with willing developers to support the development of more

[98] Cornwall Council (2023), Climate Emergency DPD guidance, www.cornwall.gov.uk/planning-and-building-control/planning-policy/adopted-plans/climate-emergency-development-plan-document

robust policies in the future, evaluating proposals which come forward, in terms of their system benefits, flexibility services offered and cost.

3. Developing binding net zero policies for new buildings framed around energy use intensity

18.10. For the energy efficiency of new buildings, we recommend the use of a fabric-first policy, framed around energy use intensity, and based on the LETI standards[99], rather than a policy based around a carbon percentage reduction. Policy based around an energy metric promises a clear, quantifiable, and easily verifiable way of ensuring that new development is net zero in terms of operational emissions. Cornwall Council[100] and Bath and North East Somerset Council[101] have both recently adopted Development Plan Documents with policies based upon the LETI approach.

18.11. As buildings become more energy efficient, (and electricity generation has decarbonised), the operational carbon of new buildings will represent a smaller proportion of a buildings overall carbon impact. This means that embodied carbon will represent a higher proportion of whole life carbon[102] and become increasingly important to address in local plans to achieve net zero developments. We therefore recommend that after focusing on renewable energy generation and energy use in new buildings, the SLP authorities also look to implement an ambitious approach to reducing the embodied carbon of new development through the local plan.

4. Carbon offsetting

18.12. The local plan should provide a framework for carbon offsetting for new development. The approach recommended by LETI aims to ensure that the electricity demand from new development is met entirely from new renewable energy generation, where possible on-site, or through additional new off-site renewable generation. The most straight forward way to achieve this is by offering free domestic rooftop solar installations to low-income households or in low-income areas where the occupier would be very unlikely to install them themselves. This structure is like carbon offsetting, but instead of funding off-site carbon savings, contributions fund the creation of additional renewable energy to offset the impact of the development.

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[99] LETI, (2020), Climate Emergency Design Guide, www.leti.london/cedg
[100] Cornwall Council, (2023) Climate Emergency Development Plan Document, www.cornwall.gov.uk/media/uxgjk4jn/climate-emergency-dpd.pdf
[101] Bath and North East Somerset Local Plan Volume 1 District-wide Strategy and Policies, (2023), https://beta.bathnes.gov.uk/sites/default/files/2023-01/1.%20Districtwide%20Composite%20plan%2018%2001%202023.pdf
[102] LETI (2020), Embodied carbon primer, www.leti.london/ecp

5. Carbon auditing the Local Plan and setting a carbon budget

18.13. LPAs will need a clear grasp of their areas baseline emissions to support reductions in them. This will require the local plan to be carbon audited in order to demonstrate how policies are in line with the legally binding carbon emission reduction targets in the Climate Change Act. The carbon auditing process would ideally inform, and be informed by, this renewable energy study, particularly the baseline carbon emissions established in part two of the study.

6. Viability considerations

18.14. It is essential that the renewable energy policies that emerge from this study are tested as part of the local plan viability assessment, which we anticipate the authorities will be commissioning separately. Viability will be a key area which will be tested at examination.

7. Community engagement and empowerment

18.15. We recommend undertaking community engagement exercises across the areas identified as having technical potential for renewables deployment in this study and taking steps to enable and support community groups to engage in the planning process for renewable energy development. The Future Energy Landscapes approach developed by CSE[103] is an open-source methodology that has been effective in supporting local planning authorities to develop ambitious planning policies for renewable deployment in their areas, while maintaining community support.

8. Carbon literacy training

18.16. In local authorities that have been successful in developing ambitious policies around climate change and renewable energy generation, the prioritisation of climate change from leadership has been a key enabler. Climate literacy training for senior leadership (including Members) and all officers involved in plan making and decision making (including planning, conservation, highways, housing and economic development), is strongly recommended.

9. Local Area Energy Plans

18.17. To inform the authorities decarbonisation strategy it would be beneficial in future to consider developing a Local Area Energy Plan (LAEP) following completion of the renewable energy study, in co-ordination with National Grid (the Electricity Distribution

[103] CSE, Future Energy Landscapes, www.cse.org.uk/my-community/community-projects/future-energy-landscapes-community-consultation-method/

Operator) and other energy stakeholders. An LAEP would complement this study by considering the entire energy system within the area: heat, electricity, transport, supply chains (from energy generation to transporting it into homes and businesses), systems (physical, digital, market and policy systems) and would consider the local changes needed to decarbonise in the most cost-effective manner and at the fastest rate possible.