



**Loch Lomond & The
Trossachs National Park
Authority**

**Decarbonising
Energy
Generation within
the National Park:
Identifying
Opportunities for
Suitable
Renewable
Energy
Technologies**

Final report
Prepared by LUC
February 2025



Loch Lomond & The Trossachs National Park Authority

Decarbonising Energy Generation within the National Park Identifying Opportunities for Suitable Renewable Energy Technologies

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Executive Summary

Purpose of this study

Loch Lomond and the Trossachs National Park Authority (LLTNPA) are currently gathering evidence to prepare a new Local Development Plan (LDP). This will guide sustainable land use and development within the National Park and facilitate the aim of significantly scaling up efforts to address the climate emergency.

LUC was appointed by LLTNPA to provide support for the identification of opportunities for renewable and low carbon technologies within the National Park, contributing to the wider evidence base required for the preparation of the LDP and informing an update to the LLTNP Renewable Energy Supplementary Planning Guidance (published 2017). This study seeks to help support the ambition of the LLTNPA's recently approved National Park Partnership Plan (NPPP) (2024-2029) which sets the goal for the National Park to be net zero by 2035 by outlining the high-level scope and key considerations for renewable and low carbon energy development within the National Park. National and local policy context

National policy context demonstrates the importance of delivering a coordinated approach to climate change mitigation and deployment of renewable energy and low-carbon technology across all sectors and areas of the country. In planning, NPF4 provides high-level support for climate change mitigation and the development of renewable and low-carbon energy.

The unique context of the National Park and its special qualities provide additional context for the appropriate deployment of technology. National planning policy, and the requirement to meet the four statutory aims of National Parks, places limitations on the scale of renewable energy development which can take place. The LLTNPA's existing Local Development Plan and renewable energy guidance provide guidance on the development of renewable technology in the park but pre-date NPF4 and currently only provide technology specific advice for hydro, wind and biomass.

The NPPP includes objectives for creating a low carbon place and designing a greener way of living and identifies targets for increasing micro-generation technologies in the National Park.

This study builds on the findings of the greenhouse gas emissions assessment and target scenario for the National Park, published in 2023¹. The report identifies renewable energy generation as part of the mix of approaches to achieving net zero in the National Park by 2033, while also recognising the limitations of what can be achieved within the context of a National Park. The report identifies planning as one of the tools the LLTNPA can use to address greenhouse gas (GHG) emissions. This includes informing the types of renewable energy technology that will be appropriate and where within the National Park, facilitating communities and business switching to non-fossil fuel sources of power and heat. In addition to extensive references to heat pumps, solar and small-scale wind, the report specifically identified the strong hydro-electric presence within the National Park which could be further capitalised. The identification of these technologies within the report informed those taken forward for assessment in this study.

Approaches to renewable the low-carbon technologies

This study was informed by an analysis of existing planning regulations, case study analysis, consultation with the four LLTNP constituent authorities, analysis of recent and historic planning applications within the National Park, and stakeholder engagement. Key opportunities, challenges and current demand trends for renewable and low-carbon development within the LLTNP context. The findings demonstrate the need for updated and expanded guidance for renewable energy development, with a particular need for guidance relating to solar, heat pump and battery storage technologies which are not currently represented.

The following list of technologies were taken forward for further assessment to determine their technical capacity within the National Park, as well as the key planning, landscape and heritage constraints and considerations to their development:

¹ Small World Consulting (2023) Greenhouse gas emissions assessment and target scenario for the National Park. Available at: <https://www.lochlomond-trossachs.org/wp-content/uploads/2025/01/Loch-Lomond-NP-GHG-Assessment-Report.pdf>

- Solar (rooftop solar photovoltaics (PV) and solar thermal, and ground-mounted solar PV);
- Heat pumps (air source heat pumps (ASHP) and ground source heat pumps (GSHP));
- Battery storage;
- Run-of-river hydro;
- Small-scale wind; and
- Biomass.

Renewable energy opportunities, technical capacity and constraints

Using spatial data, a high-level assessment of the technical capacity for the deployment of each technology within the National Park was carried out where possible, subject to several data limitations and assumptions. Consideration of the technical and environmental constraints to development are outlined, with generic guidance relevant to all technology types, as well as specific considerations for each technology. A high-level summary for each technology is provided below.

Solar

Rooftop solar: Solar PV has become an increasingly affordable option in recent years in UK markets, and the integration of solar with whole-house systems, such as electric vehicle charging and heat pumps, could further encourage the adoption of these technologies. The total technical capacity within the National Park is estimated to be 19.07MW for rooftop solar photovoltaics (PV) and 24.22MW for rooftop solar heating (though mutually exclusive due to usage of roof space). If full technical capacity was achieved, there is potential for 2,764.25 tonnes of carbon of emissions to be saved per year. While this represents a relatively small percentage of overall carbon emissions, the role of rooftop solar should not be discounted in the National Park's energy mix, due to the important role it plays in reducing emissions from buildings.

Ground-mounted solar: Assessing the technical potential for ground-mounted solar at a strategic level was not feasible within this assessment. However, there may be opportunities for individual ground-mounted installations to offer greater capacity as they are not limited to individual buildings.

Heat pumps

There is significant potential for the deployment of heat pumps within the National Park, within new and existing building stock. There is recognition at national level that heat pumps will play an important role in decarbonising household heating emissions and high-level policy direction to support this.

Air source heat pump (ASHP): Almost any building theoretically has the potential for an ASHP to be installed, although they are generally deployed on detached, semi-detached and terraced houses with the physical space requirement. The findings of the technical capacity assessment in this study suggests that if all domestic properties in the National Park were to install an ASHP, this could secure the majority of emissions reductions required from household fuel. If full technical capacity was achieved, without limitation, across all domestic and non-domestic building stock, there is potential for 32,463.73 tonnes of carbon of emissions to be saved per year in the National Park.

Ground source heat pump (GSHP): GSHPs require more space than ASHP, with a horizontal system requiring around 700 square metres, or a vertical system requiring around 11 square metres for an average of three boreholes located away from foundations of a property. It was not possible to estimate the technical potential for GSHP deployment as part of this assessment, as it was not possible to determine the number of properties with these space requirements.

Subject to certain criteria, many heat pump installations will fall under permitted development rights and do not require planning permission. Key environmental considerations for the implementation of ASHP include, but are not limited to, landscape and visual impacts, cultural heritage impacts, and noise. GSHP may have additional considerations such as ecological, hydrological and archaeological impacts. However, the environmental impacts of most domestic-scale heat pump installations are expected to be minimal, subject to appropriate siting and design. Overall, there is considerable scope for heat pump technology to support the decarbonisation of heating within the National Park, with the appropriate installation of heat pumps.

Battery energy storage systems (BESS)

The technical potential of battery storage did not form part of this assessment, as demand is dependent on the amount of renewable energy generation in the National Park and the

existing capacity of the grid. BESS are typically located near to an energy generating source (such as a wind or solar development) and their scale proportionate to the power output of the generating source. They can range from small domestic scale units to larger-scale batteries housed in shipping-like containers. Environmental and locational considerations for battery development include general natural heritage impacts, landscape and visual effects, and noise, proportionate to the scale of the proposal.

BESS play an important role in increasing efficiency of the grid in the transition to renewables, and broader trends have shown the sharp rise in demand for BESS across the country. Within the National Park, there is likely to be scope for the co-location and deployment of batteries proportionate to the scale of renewable energy development, to improve the efficiency and reliability of generating sources.

Hydro

While there have been fewer recent developments within the National Park, hydro remains an important part of the existing renewable energy mix in the National Park. The potential for landscape and natural heritage impacts is significant for this technology. The existing LLTNP Renewable Energy Planning Guidance provides detailed guidance relating to hydro development and assessment of environmental impacts.

The scope of the technical potential for additional hydro installations within the National Park was beyond the remit of this assessment. A bespoke study by hydropower specialists would be required to fully understand the technical potential within the National Park, alongside ecological, landscape and cultural heritage constraints. It is anticipated that schemes coming forward in the National Park are likely to be relatively small-scale 'run-of-river' schemes.

Wind

Only small-scale wind development is supported by planning policy in the National Park, constituting a single turbine with a height to blade tip of no more than 30m. Assessing the full technical capacity of wind energy within the National Park is beyond the scope of this assessment. Single turbines can be carefully micro-sited to consider nearby technical and environment constraints. The assessment presented within this study maps the physical constraints to wind development within the National Park at a strategic level (i.e. wind speed, physical infrastructure, technical and natural heritage constraints). Areas of with the least physical constraints are in the northern part of the National Park.

Key environmental considerations are likely to include, but are not limited to, ecological impacts on habitats and protected species (in particular, birds and bats), landscape and visual impacts, cultural heritage impacts, and other amenity impacts such as noise. Impacts of building-mounted turbines are likely to be similar to rooftop solar installations.

As supported by existing planning policy, there is a place for small-scale wind development within the National Park and evidenced demand for this to be part of the energy mix, including co-located with other technologies. Most small-scale wind turbines can be sited and designed to have minimal adverse environmental impacts, and all proposals should be assessed on a case-by-case basis and cumulatively with other developments.

Biomass

Demand for biomass technologies has reduced over time as other technologies become more popular and lower cost. National policy direction indicates that the role of biomass in a domestic setting going forward is likely to be limited to existing properties that are not currently suitable for clean heating systems. Where scaling-up bioenergy is supported, the focus in the long-term should be on Bioenergy with carbon capture and storage (BECCS).

With regard to the technical potential for biomass within the National Park, it is assumed that most properties could incorporate a domestic-scale biomass boiler. Larger scale proposals may require a dedicated boiler room or separate fuel store. Biomass development is covered by the existing Renewable Energy Planning Guidance and key environmental considerations include, but are not limited to, landscape and visual and air quality impacts.

Overall, future role of biomass within the National Park is likely to align with the Scottish Government's position that bioenergy should only be used in those applications where its carbon reduction is maximised and where alternative options are not available.

Biomass fuel

This study includes an assessment of the total technical potential for biomass resource within the National Park i.e. the production of both wood fuel and energy crops. However, while considerable amounts of land within the National Park are considered technically suitable for biomass fuel, this assessment must be understood within the broader land use context of the National Park (including food production, forestry, nature restoration, etc.). As such, while the production of biomass fuel within the National Park could provide local

sources of biofuel, this must be balanced with other land use objectives for nature restoration and carbon sequestration.

Recommendations for Renewable Energy Planning Guidance

The culmination of this work is a set of detailed recommendations for updates to the National Park Authorities renewable energy planning guidance.

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Chapter 1

Introduction

1.1 Loch Lomond and the Trossachs National Park Authority (LLTNPA) are currently gathering evidence to prepare a new Local Development Plan (LDP). This will guide sustainable land use and development within the National Park and facilitate the aim of significantly scaling up efforts to address the climate emergency.

1.2 LUC was appointed by LLTNPA in July 2024 to provide support for the identification of opportunities for suitable new renewable and low carbon technologies within the National Park.

1.3 This report will feed into the wider evidence required for the preparation of the new LDP, which will be required to align with Scotland's Fourth National Planning Framework (NPF4)², adopted in February 2023. The evidence base will also inform an update to the LLTNP Supplementary Renewable Energy Planning Guidance³ (published 2017). Planning guidance does not form part of the development plan but forms a material consideration for decision-making on planning applications. An update to the National Park's Renewable Energy Planning Guidance will provide the necessary interim guidance to developers and decision makers until the next LDP is adopted.

1.4 This study will help maximise opportunities to support renewables in the National Park supporting the ambitions outlined in LLTNPA's recently approved National Park Partnership Plan (2024 -29)⁴. This sets a goal for the National Park to be a net-zero place no later than 2035, while recognising the additional landscape and ecological constraints in meeting the statutory aims of the National Park. This is supported by the greenhouse gas emissions assessment (2023) which identified a target scenario of 2033 for net zero emissions in the National Park.

² Scottish Government (2023) National Planning Framework 4. (see <https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/02/national-planning-framework-4/documents/national-planning-framework-4-revised-draft/national-planning-framework-4-revised-draft/govscot%3Adocument/national-planning-framework-4.pdf>)

³ LLTNPA (2017) Renewable Energy Planning Guidance. (see <https://www.lochlomond-trossachs.org/wp-content/uploads/2016/07/PG-Renewables-2017-Approved.pdf>)

⁴ LLTNPA (2024) National Park Partnership Plan 2024-29. (see <https://www.lochlomond-trossachs.org/wp-content/uploads/2024/04/Final-NPPP.docx>)

1.5 Recognising the constraints of a National Park in delivering large scale renewable energy development, this study mainly focuses on maximising the potential energy generation opportunities from micro-renewables and small-scale low carbon technologies, although larger schemes are considered.

1.6 It is important to understand the purposes of this study within the context of the energy hierarchy which is explained further in chapter 2. This study focuses on actions the NPA can take to increase renewable energy production; the third tier of the energy hierarchy. The primary focus is on actions which Planning can take, however, recommendations are also incorporated for the wider NPA where appropriate.

Methodology

1.7 LUC worked in collaboration with LLTNPA to establish the project objectives, priorities and scope for this work and agree project outputs. A high-level overview of the methodology for this work is provided below.

Literature review and evidence gathering

1.8 A literature review was carried out to establish the policy context relevant to renewable energy planning guidance. It explored the range of renewable and low-carbon technology to be included in the study, and the specific requirements of these individual energy technologies regarding related infrastructure and landscape/design issues. Case study examples were identified both within the LLTNP and other National Parks to better understand existing planning requirements for these technologies.

Local authority engagement

1.9 Engagement was carried out with each of the four Local Authorities whose areas fall within the National Park. This provided a clear picture of the progress they had made in developing their Local Heat and Energy Efficiency Strategies (LHEES) and the associated Local Heat and Energy Action Plan (LHEAP). It also identified the priorities they have for renewable and low-

carbon development in their areas, as well as any opportunities and challenges they were facing.

Stakeholder engagement

1.10 Engagement with key stakeholders took place at an early stage to ensure a full understanding of stakeholder appetite, plans and perceived constraints to renewable and low-carbon energy development within the National Park. Stakeholder engagement was carried out with businesses, a land manager and a community group, all of whom had previously developed or had plans to develop community, micro-renewable and low-carbon projects.

Review of National Park Authority data and reports

1.11 Further development of the evidence base took place with a review of LLTNPA data and reports including the current Renewable Energy Planning Guidance (2017)³, the draft National Park Partnership Plan 2024-29⁴ and adopted LDP 2017-21⁵. LLTNPA data on the existing capacity of renewables technologies within the National Park was also collated.

1.12 The literature review included a detailed review of the Greenhouse Gas Assessment undertaken for the National Park⁶. It identified the role and limitations that the planning system in the LLTNP has in delivering renewable technologies which will assist the park in meeting targets to become net zero by 2033.

1.13 The literature review, stakeholder engagement and established evidence base informed the short-listing process for the technologies to be included in the study.

Assessment of environmental and landscape sensitivities for identified technologies

1.14 This stage of the project was led by LUC's team of landscape, ecological and heritage specialists who ensured that these considerations were clearly reflected in the analysis of opportunities. This work stage included a review of the National Park's landscape character types (LCTs) and special landscape qualities (SLQs).

⁵ LLTNPA (2017) Local Development Plan 2017 – 2021 (see <https://www.lochlomond-trossachs.org/planning/planning-guidance/local-development-plan/>)

⁶ LLTNPA (2023) LLTNPA Carbon footprint assessment and proposed pathway to Net Zero. (see <https://www.lochlomond-trossachs.org/wp-content/uploads/2023/04/Loch-Lomond-NP-GHG-Assessment-Presentation.pdf>)

1.15 It is not possible to provide definitive advice on where development might be appropriate within the National Park, as all proposals will need to be determined on a case-by-case basis. The review of landscape and heritage considerations therefore focuses on siting / design advice to minimise environmental impacts. This includes generic and technology-specific siting / design advice, as well as siting/design advice which is specific to the key characteristics of each LCT.

Assessment of potential opportunities for renewable energy technologies

1.16 A high level assessment of the potential opportunities for renewable energy development in the National Park was carried out, utilising spatial data where possible. The technical potential for energy generation from rooftop solar, air source heat pumps and biomass creation was calculated. LUC's specialist GIS team also undertook constraints mapping for some of the identified technologies to establish areas where development could be possible.

1.17 The theoretical potential from this task was compared against the landscape constraints identified previously, outputting locations with greater potential and greater constraint for various technologies, and where there may be a requirement for additional detail in the updated Renewable Energy Planning Guidance.

Development of recommendations

1.18 Based on the findings of the process above, a list of suggested updates to be made to LLTNPA's Renewable Energy Planning Guidance (published 2017)³ was developed and is provided within Chapter 13 of this report.

Structure of the report

1.19 This report presents the findings of the study and is structured as follows:

- **Chapter 1** (this chapter) introduces the project, its scope and provides a high-level overview of the methodology.
- **Chapter 2** covers the findings of the literature review, including the national and local policy context. It includes a summary of national climate policy context, relevant NPF4 policies, the adopted LDP and Renewable Energy Planning Guidance, National Park Partnership Plan 2024-29 and LLTNPA Greenhouse Gas Assessment. The chapter concludes with a discussion of the influence the planning system has in the development of renewables in the National Park. It identifies where the NPA and its partners may need to develop additional actions to promote the wider uptake of renewables.
- **Chapter 3** summarises case study examples and provides a summary of potential renewable energy and low-carbon technologies which could be delivered in the National Park. It also provides an overview of findings of consultation with the four constituent local authorities.
- **Chapter 4** provides a summary of the findings of stakeholder engagement and a review of recent planning applications, establishing demand trends, priorities and challenges for renewable energy development within the local context.
- **Chapter 5** sets out the details of the short-list of renewable and low-carbon technologies where there is evidenced demand and a potential need for planning guidance or further support from the NPA and partners to maximise energy generation through these technologies within the National Park.
- **Chapter 6** provides a summary of the opportunities and constraints identified for solar energy generation in the National Park.
- **Chapter 7** provides a summary of the opportunities and constraints identified for air and ground source heat pump energy generation in the National Park.
- **Chapter 8** provides a summary of the opportunities and constraints identified for battery energy storage systems in the National Park.

- **Chapter 9** provides a summary of the opportunities and constraints identified for run-of-river hydro energy generation in the National Park.
- **Chapter 10** provides a summary of the opportunities and constraints identified for wind energy generation in the National Park.
- **Chapter 11** provides a summary of the opportunities and constraints identified for biomass energy generation in the National Park.
- **Chapter 12** provides an assessment of the potential biomass resource in the National Park.
- **Chapter 13** provides a list of recommendations for updating the LLTNPA Renewable Energy Planning Guidance, reflecting the findings of this study.
- **Appendix A:** provides an overview of assumptions used in the assessment of technical potential and constraints for each technology.

Chapter 2

Background and policy context

2.1 This chapter establishes the background and policy context for this project. It provides a high-level overview of the national policy context, including national legislation and policy and local policy and strategy. The chapter concludes with a detailed discussion of the greenhouse gas emissions assessment for the National Park and identifies the remit of the planning system in supporting renewable energy development which will contribute to meeting emission reduction targets for the National Park.

National policy context

Climate change targets

2.2 The Scottish Government declared a global climate emergency on 28th April 2019. Following this, national climate legislation set a target date for net zero emissions of all greenhouse gases (GHG) by 2045. The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 strengthened Scotland's climate change targets for the reduction of emission levels from an 80% reduction by 2050 (as set out in the Climate Change (Scotland) Act 2009) to 100% by 2045. This made the statutory emission targets placed on Scotland the most stringent of any country in the world at the time.

2.3 The importance of climate change has therefore never been more prominent than in recent years and there is a clear national focus to ensure a green recovery for Scotland. Nevertheless, Scotland missed its annual decarbonisation target for 2021 and, on the current path, the target of a 75% reduction in GHG emissions by 2030 is considered no longer credible by the Climate Change Committee⁷. It is therefore considered to be a crucial time for Net Zero in Scotland and strong action is needed to reduce emissions, across all areas of society and the economy.

⁷ Climate Change Committee (20 March 2024) 'Scotland's 2030 climate goals are no longer credible' (see: <https://www.theccc.org.uk/2024/03/20/scotlands-2030-climate-goals-are-no-longer-credible/>)

2.4 In September 2024, the Climate Change (Emissions Reduction Targets) (Scotland) Bill was lodged in light of missed targets. The Bill was passed on 5th November 2024 and amends the Climate Change (Scotland) Act 2009 with the aim of providing a more reliable framework for emissions reduction. Scotland will now move to using five year carbon budgets to set climate targets, based on recommendations from the independent Climate Change Committee. This approach aims to take into account that previous emissions targets are vulnerable to year-to-year fluctuations (such as colder winters or global events such as the pandemic)⁸.

Draft Energy Strategy and Just Transition Plan

2.5 In January 2023, the Scottish Government published their Draft Energy Strategy and Just Transition Plan 2023⁹ (SESJTP), setting out their priorities and policy direction for realising their climate change and Net Zero ambitions with regards to energy. This looks to transform the way that Scotland generates and uses energy until 2030 and sets out a number of key ambitions, including:

- Deploying more than 20 GW of additional renewable electricity on and off-shore by 2030.
- At least the equivalent of 50% of Scotland's energy across heat, transport and electricity demand will come from renewable sources by 2030.

2.6 The draft SESJTP does not include any policy that specifically relates to small-scale renewable energy. However, it does support communities to ensure they derive maximum benefit from the energy transition, including outlining support for regional hydrogen hubs, community ownership and supporting schemes such as Community and Renewable Energy Scheme (CARES).

2.7 The SESJTP document remains in draft form following a consultation period from January to May 2023 and is yet to be adopted but it illustrates the key priorities and policy direction of the Scottish Government on the energy transition.

National Planning Framework 4

2.8 NPF4 was adopted February 2023 and sets out a clear message regarding the climate emergency and the important role that renewable energy generation can play in tackling both the biodiversity and climate crises.

2.9 NPF4 superseded both NPF3 (2014) and Scottish Planning Policy (SPP) (2014), which set out the national spatial framework for planning and the context for development planning in Scotland. Unlike its predecessors, NPF4 combined the spatial framework and national policy into the one document and has elevated status, forming part of the statutory development plan¹⁰ alongside the relevant LDP. Like LLTNP, many planning authorities throughout Scotland are in the process of updating their LDPs and associated supplementary guidance (SG) to align with NPF4, while taking into account the local context. Local planning policy across Scotland is still to be updated to fully align with national climate change policy, government priorities for renewable energy, Net Zero targets and what this means in practice.

2.10 NPF4 sets out the strategic spatial vision for Scotland for the coming decades. The Ministerial Foreword makes clear the centrality of tackling climate change to this document, with clear and strong messaging. It states: "Planning carries great responsibility – decisions about development will impact on generations to come. Putting the twin global climate and nature crises at the heart of our vision for a future Scotland will ensure the decisions we make today will be in the long-term interest of our country". At the forefront of the document, Policy 1 (tackling the climate and nature crises) states that: "when considering all development proposals significant weight will be given to the global climate and nature crises" and Policy 2 (climate mitigation and adaptation) aims to encourage, promote and facilitate development that minimises emissions and adapts to the current and future impacts of climate change.

2.11 Policy 11 (energy) aims to encourage, promote and facilitate all forms of renewable energy development onshore and offshore. This includes energy generation, storage, new and replacement transmission and distribution infrastructure and emerging low-carbon and zero emissions technologies including hydrogen and carbon capture utilisation and storage (CCUS).

⁸ Scottish Government (2024) Climate Change Bill passed (see: <https://www.gov.scot/news/climate-change-bill-passed/>)

⁹ Scottish Government (2023) Draft Energy Strategy and Just Transition Plan. (see: <https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/01/draft-energy->

[strategy-transition-plan/documents/draft-energy-strategy-transition-plan/draft-energy-strategy-transition-plan/govscot%3Adocument/draft-energy-strategy-transition-plan.pdf](https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/01/draft-energy-strategy-transition-plan/documents/draft-energy-strategy-transition-plan/draft-energy-strategy-transition-plan/govscot%3Adocument/draft-energy-strategy-transition-plan.pdf))

¹⁰ When determining planning applications, Councils are legally required to have regard to the statutory development plan, comprising NPF4 and the relevant LDP. In this case, NPF4, the adopted LDP (2017-21) and any statutory supplementary guidance (SG) form the development plan for LLTNP.

The policy provides high-level support for the expansion of renewable, low-carbon and zero emissions technologies, including small scale renewable energy generation technology.

2.12 LDPs should aim to provide their area's full potential for electricity and heat from renewable, low-carbon, and zero-emission sources by identifying a range of opportunities for energy development without grid capacity being a constraint. However, this should be done with the understanding that development proposals will only be supported where they maximise net economic impact, including local and community socio-economic benefits. Policy 11 does not support some major renewable energy development in National Parks, with Policy 11(b) stating "development proposals for wind farms in National Parks and National Scenic Areas will not be supported".

2.13 Policy 11 recognises that certain impacts are inherent to some renewable energy forms. These include impacts on residential amenity (visual, noise, shadow flicker), public access routes, aviation, telecommunications, road traffic, historic sites, water resources, biodiversity, forestry, as well as the need for robust decommissioning and restoration plans and consideration of cumulative impacts. These impacts will need to be addressed by project design and mitigation measures to ensure they are minimised as far as practicable.

2.14 The Special Landscape Qualities of the National Park make it sensitive to new development, including renewables, and this is one of the most important considerations when assessing proposals for renewable energy development. Policy 4 (natural places) aims to protect, restore and enhance natural assets making best use of nature-based solutions and outlines restrictions for developments which affect designated areas including National Parks. It states that development in such areas will only be supported where the objectives of designation and the overall integrity of the areas will not be compromised; or any significant adverse effects on the qualities for which the area has been designated are clearly outweighed by social, environmental or economic benefits of national importance.

2.15 Additionally, NPF4 Policies 18 (infrastructure first), 19 (heat and cooling), 13 (sustainable transport) and 29 (rural development) also generally support the development of renewable energy low or zero-emission technologies in Scotland, with Policy 29 requiring development to be appropriately scaled to location.

Overall, NPF4 provides high-level support for climate mitigation and renewable and low-carbon energy development, whilst also setting policies to manage development within the context of a range of social, environmental and economic considerations.

2.16 The unique context of the National Park and its special qualities provide additional context for planning and development within the National Park. Development must be in line with national planning policy and the requirement to meet the four statutory aims of National Parks.

Four statutory aims of National Parks in Scotland

- Conserve and enhance the natural and cultural heritage of the area
- Promote sustainable use of the natural resources of the area
- Promote understanding and enjoyment (including enjoyment in the form of recreation) of the special qualities of the area by the public
- Promote the sustainable economic and social development of the area's communities.

Existing local policy and guidance

2.17 This section provides an overview of existing LLTNPA policy and guidance relevant to renewable energy and low-carbon planning. To further support the evidence base and provide context for the development of recommendations, each of the following documents were reviewed in detail with the key elements summarised below: the documents include the adopted LDP 2017-21, Renewable Energy Planning Guidance (2017), National Park Partnership Plan 2024-29 and LLTNPA Greenhouse Gas Assessment and Net Zero Report (2023). The role of Local Place Plans is also covered. The section concludes with a discussion on the role of the planning system in the delivery of renewable technology in the National Park which is required to meet the Parks net zero emission targets.

Adopted Local Development Plan 2017-21

2.18 The statutory development plan for the National Park area comprises NPF4 (2023), the adopted LDP (2017-2021)¹¹, and adopted supplementary guidance. LLTNPA's current LDP is dated 2017-2021, however, the planning authority has revised their timescales for the next plan and the current plan will remain in place until the new LDP is adopted.

2.19 Part 1: 'Introduction and Vision' of the LDP states that the National Park's move towards low carbon energy generation should be delivered, in part, through support for smaller renewable energy developments across a range of technologies.

2.20 Part 4 of the LDP outlines the policies. Overarching Policy 1 states that all development should contribute to the National Park being a low carbon place by reducing greenhouse gas emissions through sustainable design; use of energy efficient materials, passive solar design, landscaping and micro renewables, connecting or creating opportunities to a shared heating scheme.

2.21 In addition, the LDP outlines two policies specific to the development of renewable energy. Renewable Energy Policy 1 addresses renewable energy within the National Park. It sets out specific policy requirements relating to wind energy development (defined as proposals consisting of no more than one turbine with a height to blade tip of less than 30 metres), hydro energy and biomass and biogas energy (proposals will be supported where they are located in close proximity to the source of demand for generated heat and power and use a sustainable source of fuel). This policy states that *"proposals for renewable energy development within the National Park will be supported where the siting, design, access and scale of the proposal will not have a significant adverse impact either individually or cumulatively on:*

- *Landscape or visual amenity*
- *Woodlands/forestry*
- *Biodiversity*
- *The water environment*
- *Cultural heritage*
- *Air quality*
- *Traffic and transport*

- *Recreation and access*
- *Residential amenity"*.

2.22 Additionally, it states that large-scale commercial wind turbines are incompatible with the special qualities of the National Park and are not considered to be appropriate within the National Park or where they are located outside the National Park that they affect its landscape setting.

2.23 Renewable Energy Policy 2 addresses renewable energy developments adjacent to the National Park, outlining the conditions where the NPA will support renewable energy developments adjacent to the Park. This states that they must not individually, or cumulatively with other developments or proposals, have a significant adverse visual impact on the landscape setting of the National Park and its principal gateways.

2.24 The policy states that development proposals should not conflict with nearby land uses and should include Climate Friendly Designs. This should demonstrate how proposed buildings will achieve a reduction in greenhouse gas emissions through; a) Minimising overall energy requirements through conservation measures, and b) Incorporating on-site low and zero carbon generating technologies to meet 10% of the overall energy requirements of the building, rising to 20% by December 2021.

Current Renewable Energy Planning Guidance

2.25 LLTNPA planning guidance (PG) does not form part of their statutory development plan, but it still supports the delivery of the LDP and forms a material consideration in decision-making. The LDP is supported by LLTNPA's current Renewable Energy Planning Guidance (published 2017)¹², which sets out more detailed guidance on LLTNPA's requirements through the planning process and a summary of typical considerations for each technology. It also provides guidance on best practice mitigation measures for the potential impacts of different types of renewable energy.

2.26 The Renewable Energy PG focuses on three main technologies – hydro, wind and biomass – and provides a spatial framework for these. This includes guidance on appropriate locations, types and scales of development within the National Park, specific considerations

¹¹ LLTNPA (2017) Local Development Plan 2017 – 2021 (see <https://www.lochlomond-trossachs.org/planning/planning-guidance/local-development-plan/>)

¹² LLTNPA (2017) Renewable Energy Planning Guidance. (see <https://www.lochlomond-trossachs.org/wp-content/uploads/2016/07/PG-Renewables-2017-Approved.pdf>)

and good practice that should be taken into account when preparing a proposal, and the recommended procedure for submitting a planning application. For hydro, wind and biomass, the PG outlines guidance related to technical feasibility and scope, locational guidance, planning considerations, landscape and visual impact considerations, cumulative impact assessment and topic advice.

2.27 The PG outlines that the LDP provides support for 'small scale' renewable energy development (defined as: "a development which has a low impact on the landscape, natural or built heritage, rather than its generation capacity"¹³). The aim is not to solely provide energy for 'export', rather sustaining the National Park's communities and businesses through locally generated less expensive electricity or heat, and the opportunity for raising funds for their development.

2.28 In terms of wind energy, large scale commercial wind development is defined as "more than one turbine and over 30m in height". With regard to this guidance, 'small scale' is interpreted to be (a) no more than 1 turbine and (b) any single turbine less than 30m in height (to blade tip). Above this threshold is considered large scale and is not supported.

2.29 The PG also highlights that neither the LDP nor the NPPP define 'small scale' for hydro or biomass energy developments. In terms of hydro, run of the river schemes up to 2MW are likely to provide the greatest opportunity whilst still considered to be small scale. Each application is assessed against its impacts and these will include cumulative impacts in combination or in sequence with other developments.

National Park Partnership Plan 2024-29

2.30 The purpose of the National Park Partnership Plan (NPPP)¹⁴ is to guide all those with a role to play in looking after the Park in working together to do so and achieve a shared vision for the area. Following the approval of the NPPP by the LLTNPA in December 2023, Scottish Ministers issued their formal approval for the adoption of the plan.

2.31 The adopted NPPP sets a shared vision for the area that *'by 2045 the National Park is a thriving place that is nature positive and carbon negative'*. It sets a goal for the National Park to become a net zero place no later than 2035.

2.32 The Plan outlines the Authority's ambitions, along with their partners, to tackle climate change through mitigation measures including reducing peatland emissions, increasing tree cover and restoring the water environment. The LLTNPA also plans to reduce carbon emissions by facilitating and encouraging the use of low carbon travel modes by visitors and residents. This includes the provision of a multi-use path network for active travel, the installation of more EV charging points and better integrating the public transport network.

2.33 The NPPP aims to support thriving rural communities, including making rural communities more resilient, by enabling more local living and working. A key action outlined to achieve this is increasing community scale energy and heat generation, including opportunities for district heat networks and retrofitting renewable micro-technology to community buildings. The NPPP sets out that "living well locally" means people can meet their daily needs as close as possible to where they live or work. This includes having a good range of rural services and facilities, more local food growing and energy generation along with active travel or public transport options. In addition, it highlights current community-led action in the National Park on local energy generation via community-owned run of the river hydro schemes. It aims to build on such an example to encourage and empower all communities in the National Park to take action towards living well locally, adapting to the Climate Emergency and delivering for nature. The NPPP also supports the energy industry in increasing local green skills to fill new jobs in the environmental sector.

Local Place Plans

2.34 Local Place Plans form part of the Scottish Government's wider work on planning reform and implementation of the Planning (Scotland) Act 2019. The development of Local Place Plans aims to improve community engagement, support community-led, collaborative approaches to planning and reduce conflict. Local Place Plans may identify community aspirations for renewable energy development or identify locally-specific constraints related to their development. Since legislation to support the preparation, submission, and registration of Local

¹³ Ibid. p15.

¹⁴ LLTNPA (2024) National Park Partnership Plan 2024-29. (see <https://www.lochlomond-trossachs.org/wp-content/uploads/2024/04/Final-NPPP.docx>)

Place Plans was introduced in 2022, a number of communities within Loch Lomond and the Trossachs National Park have been in the process of developing Local Place Plans. Local Place Plans within the National Park will inform the next LLTNPA Local Development Plan.

Greenhouse Gas Assessment and Pathway to Net Zero Report

2.35 Small World Consulting (SWC) produced a greenhouse gas emissions assessment and target scenarios for the LLTNP in May 2023. This is in line with similar assessments produced for all other UK National Parks and several AONBs. The report contains a consumption-based assessment of the greenhouse gas emissions attributable to residents and visitors, including travel to and from the National Park. It provides a set of Paris-aligned target recommendations for transitioning to a low-carbon economy. The report presents annual emission estimates from residents, from visitors while in the National Park, from visitors travelling to/from the National Park and annual industry emissions.

2.36 The report notes that the per capita footprint of residents in the National Park is estimated to be 17.6% higher than the UK average. This includes household fuel emissions that are around 12% higher than the UK average and household electricity emissions which are 61% higher than the UK average. However, these emissions didn't consider renewable energy solutions as the share of these technologies across households was comparatively low and no suitable data with sufficient geographical detail was available.

2.37 The high number of visitors to the National Park means that the residents greenhouse gas footprint only accounts for around half of the footprint of all visitors. 42% of the greenhouse gas footprint for visitors time in the area comes from food and drink and another 18% from accommodation.

2.38 There are no large industrial emitters in the National Park. Accommodation businesses account for 41% of the footprint of industries and agriculture, forestry and fishing account for 19%.

2.39 The report projects that if every sector implements decarbonisation and land use change efforts recommended a realistic timescale to meet net zero emissions in the National Park is by 2033 (taking into account the unique characteristics of the landscape, land use types, the number of residents and visitors and their consumption patterns and the level and type of industrial activity).

2.40 To reduce household energy consumption, the report recommends the replacement of oil or gas boilers with alternatives such as an electric heat pump, especially for off-gas-grid properties which use oil heating. Meeting increased electricity demand in rural areas could be met by local renewable energy production and/or improved grid connections which are particularly relevant where local people will be using electric heat pumps and electric vehicles. It is recognised that affordability can affect the take-up of these technologies so government grants and other funding will be important. Reducing GHG emissions from visitor accommodation and food services could similarly be reduced by consumers switching to renewable energy suppliers or installing renewable electricity sources (such as solar and wind) for electricity and installing a renewable heat source such as a heat pump.

2.41 The report identifies planning as one of the tools the LLTNPA can use to address GHG emissions. This includes informing the types of renewable energy technology that will be appropriate and where within the National Park, facilitating communities and business switching to non-fossil fuel sources of power and heat. In addition to extensive references to heat pumps, solar and small-scale wind, the report specifically identified the strong hydro-electric presence within the National Park which could be further capitalised. The identification of these specific technologies within the Greenhouse Gas Assessment report informed the selection of technologies for assessment. Further specific reference is provided in chapter 5 where this formed part of the decision to short-list a technology for assessment.

2.42 The report also recognises the limitations of renewable energy generation in the National Park and states that one of the key ways that householders and businesses can reduce their emissions from electricity and heating is by switching their energy supplier to one which is divesting away from fossil fuels and actively sourcing a supply derived from genuinely renewable energy (e.g. solar, wind, tidal and/or hydro-electric power). This will be supported by increased renewable energy generation elsewhere in Scotland and enhanced grid connections.

2.43 Reductions in energy use will be one of the key ways that the LLTNP can meet net zero targets by 2033. The report recognises that the biggest contribution the LLTNP can make to GHG emissions reduction in the long term will be land-use changes including peatland restoration and woodland creation.

The energy hierarchy

2.44 It is important to understand the purposes of the study in the context of the energy hierarchy. The energy hierarchy is a framework used to guide decision-making in energy use and efficiency. It prioritises actions based on their environmental impact, focusing on reducing energy demand and minimising carbon emissions. The hierarchy is structured in the following order:

- Reduce energy demand: This is the most effective and sustainable approach, achieved through measures such as, changing travel behaviour, or optimising processes to use less energy.
- Use energy efficiently: Once energy demand is reduced, the next step is to use the available energy as efficiently as possible, maximising the output per unit of energy consumed. This involves adopting energy-saving technologies, more efficient appliances, and better design.
- Use renewable energy: If energy demand cannot be reduced or made more efficient enough, the next step is to switch to renewable energy sources such as solar, wind, or hydropower, which have a lower environmental impact compared to fossil fuels.
- Use low-carbon and conventional energy: As a last resort, when renewable options are not feasible, energy from low-carbon sources (like nuclear or natural gas) can be used. Conventional fossil fuels (coal, oil, etc.) are the least preferred due to their high carbon emissions.

2.45 The energy hierarchy encourages reducing energy consumption first and foremost, making better use of resources, and then transitioning to cleaner, renewable energy sources. It is often applied in areas such as urban planning, building design, and policy development for sustainability.

2.46 In Scotland, the energy hierarchy is closely integrated into the broader Energy Strategy and Just Transition Plan, which is focused on achieving a net-zero energy system by 2045. The plan prioritises reducing energy demand, improving energy efficiency, and scaling up the use of renewable energy sources. It seeks to ensure that Scotland's transition to cleaner energy maximises social, economic, and environmental benefits. A key aspect is fostering a just transition for workers and communities, ensuring equitable access to energy while reducing reliance on fossil fuels.

2.47 Outside of this study it is important that the National Park continues to pursue actions to reduce energy demand and increase energy efficiency as priorities. The planning system has influence in decarbonising the built sector through the sustainable design of new buildings and encouraging the uptake of low/zero carbon transport in new development. Outside of the remit of the planning system, the Loch Lomond and the Trossachs National Park Authority can have wider influence on the reduction of energy demand and increased energy efficiency across different sectors. This includes encouraging the wider uptake of sustainable transport modes and the retrofit of existing buildings which already form actions within the National Park Partnership Plan (NPPP).

The role of planning in the integration of renewable energy and low carbon technology

2.48 NPF4 sets national policy for large scale renewables in Scotland. Applications for consent for the constructure, extension and operation of electricity generating stations with capacity in excess of 50 megawatts are made to the Energy Consents Unit and determined by Scottish Government Ministers. Applications for the installation of overhead electric lines and associated infrastructure and associated wayleaves and compulsory purchase orders are also made to the Energy Consents Unit.

2.49 Applications for renewable energy developments below this 50MW threshold are made to the relevant local planning authority, who are responsible for setting local policy and determining planning applications.

2.50 Many micro-renewable technologies (equipment with an output of up to 50 kilowatts of electricity or 45 kilowatts of thermal energy) are covered by householder permitted development rights (PDRs), meaning they can be developed without submitting a planning application. While limitations exist, such as for dwellings within a conservation area and listed buildings, these provide broad permissions for flues for biomass heating systems, flues of combined heat and power systems, ground and water source heat pumps, free standing wind turbines, air source

heat pumps and solar panels¹⁵. Non-Domestic PDRs cover most solar panel installations but exclude development of these technologies within a National Park¹⁶. Further details for the PDRs of specific technologies are provided within chapters 6-10.

2.51 Acknowledging the remit of national policy, the energy consents unit and renewable technologies covered by PDRs, of the renewable technologies directly mentioned within the SWC report, the LLTNPA therefore has direct influence over the development of hydro power, non-domestic and ground mounted solar, singular turbines and battery storage systems of less than 50MW. Maximising the development of these technologies should therefore be a focus for any revisions to the renewable energy supplementary planning guidance.

2.52 The LLTNPA has received further advice on priority decarbonisation measures for buildings in the National Park, in order to meet decarbonisation targets. These focus on heat pumps in existing and new homes, and floor, roof, cavity wall and solid wall insulation. The planning system, in combination with building regulations have an important role in securing these measures in new buildings. It is essential that these measures are not only implemented in new development however and the retrofit of existing buildings will be critical. Beyond some works in listed buildings, the planning system has a limited role to securing these measures, however other departments and partner organisations will be able to play a significant role in encouraging and supporting the uptake of these measures and this should be reflected in the National Park Partnership Plan.

2.53 The remainder of this report focuses on the role that planning in the National Park can make in the delivery of renewable energy and low carbon technologies which will assist in meeting greenhouse gas emission reduction targets.

Summary of policy context

National policy context demonstrates the importance of delivering a coordinated approach to climate change mitigation and deployment of renewable energy and low-carbon technology across all sectors and areas of the country. In planning, NPF4 provides high-

level support for climate change mitigation and the development of renewable and low-carbon energy.

However, the unique context of the National Park and its special qualities provide additional context for the appropriate deployment of technology. National planning policy – and the requirement to meet the four statutory aims of National Parks - places restrictions on the scale of renewable energy development which can take place.

The LLTNPA's existing LDP and renewable energy guidance provide guidance on the development of renewable technology in the park but pre-date NPF4 and currently only provide technology specific advice for hydro, wind and biomass.

The NPPP includes objectives for creating a low carbon place and designing a greener way of living and identifies targets for increasing micro-generation. Targets in the NPPP were informed by the 2023 greenhouse gas emissions assessment which established a target of 2033 for meeting net zero emissions and identifies the means by which planning can contribute to meeting these targets.

The rest of the report will focus on the role which planning can have specifically on the development of renewable energy and low carbon technologies in the National Park.

¹⁵ <https://www.gov.scot/publications/householder-permitted-development-rights-guidance-updated-2021/pages/8/>

¹⁶ <https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2024/05/circular-2-2024-non-domestic-permitted-development-rights/documents/circular-2-2024->

[non-domestic-permitted-development-rights/circular-2-2024-non-domestic-permitted-development-rights/govscot%3Adocument/circular-2-2024-non-domestic-permitted-development-rights.pdf](https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2024/05/circular-2-2024-non-domestic-permitted-development-rights/documents/circular-2-2024-non-domestic-permitted-development-rights/circular-2-2024-non-domestic-permitted-development-rights.pdf)

Chapter 3

Renewable energy and low carbon technologies

3.1 This chapter presents the renewable energy and low-carbon technologies considered as part of this study, providing case-study examples of the technologies which could be delivered within the National Park. Additionally it provides an overview of engagement carried out with the four constituent local authorities – Stirling, Perth and Kinross, Argyll and Bute and West Dunbartonshire.

Introduction to renewable and low carbon technologies

3.2 The field of renewables and low carbon technologies is rapidly evolving and expanding and any renewable energy policy and guidance must be responsive to this to ensure that the implementation of a full range of technologies can be supported where sensitivities permit. Additionally, many micro-generation developments in the National Park are likely to be classed as permitted development. The PDRs within National Parks vary somewhat to overall PDRs in Scotland, particularly for non-domestic buildings. The full list of PDRs for domestic and non-domestic buildings can be found in the references in footnotes 18 and 19.

Permitted Development Rights for micro-renewables and low carbon technologies

Permitted Development Rights (PDR) grant permission for certain forms of development, allowing them to be carried out without a planning application under the Town and Country Planning (General Permitted Development) (Scotland) Order 1992 ('the GPDO'). In some cases, PDR are disappplied (or limited) in certain sensitive areas, such as in conservation areas, World Heritage Sites and National Parks.

The Scottish Government is implementing a phased update of PDR to facilitate deployment of micro-renewable and low-carbon technologies. For example, recent changes which came into force in May 2024 saw the easing of PDRs for rooftop solar, removing the upper limit of 50kW of total energy output. This means that many more

rooftop solar projects (aside from certain cases such as in World Heritage Site or on listed buildings) no longer require planning permission¹⁷.

Circular 1/2024: Householder Permitted Development Rights¹⁸ provides a summary of PDR for domestic development, setting out the specifications for several types of microgeneration equipment covered by PDRs. These include ground- and water-source heat pumps, air source heat pumps, free-standing wind turbines, roof-mounted wind turbines on detached houses, solar panels on a dwelling/a building within the curtilage of a dwelling, flues for biomass heating systems, combined heat and power systems and free-standing solar panels within the curtilage of a dwelling.

Circular 2/2024: Non-Domestic Permitted Development Rights¹⁹ explains what non-domestic works can be undertaken without planning permission. This includes specifications for PDR covering building-mounted solar panels²⁰. PDR for non-domestic ground-mounted solar and solar canopies do not apply in National Parks.

Where PDRs do not apply, planning permission is required. Some PDR development will also be subject to the process of prior notification/prior approval, meaning the local authority must be notified and has opportunity to indicate whether specific aspects of the development are acceptable.

3.3 An important aspect of this study to inform recommendations for National Park guidance is learning from best practice examples elsewhere, particularly where renewables have been effectively integrated into other National Parks. The section therefore provides a series of renewable, low carbon and zero emission technology case study examples, which focus on technologies that planning can influence the delivery of. The case studies set out a summary of the technologies considered in this study, a high-level description of each, key planning requirements and a summary of any planning conditions placed on the decision notice. While the planning policy frameworks for other National Parks will differ, the learning from these can

assist in the identification of planning requirements and guidance that LLTNP can adopt to ensure their guidance will facilitate the appropriate development of these technologies.

Case study examples

Solar – ground mounted

Installation of 42 ground mounted solar photovoltaic panels at Dalrachney Lodge Hotel, Carrbridge²¹

Description

Planning permission was approved in 2023 for the installation of 42 ground mounted solar panels in the rear garden area of Dalrachney Lodge Hotel, within the Cairngorms National Park. The lodge is a two and a half storey sandstone former Edwardian Hunting Lodge, dating from 1845 and set within 2 acres of grounds adjacent to the Dulnain River.

The plans outline that the panels will sit at a 45 degrees angle and the overall height, including the mounting ground anchors, will be approximately 1.3 metres from ground level to the top of the panels. The total area taken up by the panels is approximately 82 sqm and they will be located adjacent to the north-eastern corner of the rear grounds.

Planning requirements from relevant park LDP/SPG

The Cairngorms National Park Local Development Plan 2021 outlines in policy 7: Renewable energy that proposals for renewable energy generation will be considered favourably where:

- a. they contribute positively to the minimisation of climate change;
- b. they complement the sustainability credentials of the development;
- c. they conserve and enhance the special qualities of the Park, including wildness;

¹⁷ Savills (2024) Unpacking changes to the planning process for solar energy in Scotland – 5 April 2024. (see: <https://www.savills.co.uk/blog/article/358468/commercial-property/unpacking-changes-to-the-planning-process-for-solar-energy-in-scotland.aspx>)

¹⁸ Scottish Government (2024) Planning circular 1/2024: householder permitted development rights (see: <https://www.gov.scot/publications/circular-1-2024-householder-permitted-development-rights>)

¹⁹ Scottish Government (2024) Planning circular 2/2024: non-domestic permitted development rights (see: <https://www.gov.scot/publications/circular-2-2024-non-domestic-permitted-development-rights/documents/>)

²⁰ This PDR does not apply to buildings on/in the curtilage of a listed building, within 3km of an aerodrome or technical site, within a National Scenic Area, within a historic garden or designed landscape within a National Park or within a World Heritage Site.

²¹ The Highland Council (2023) Planning – Application Summary: 23/00026/FUL | Installation of 42 ground mounted solar photovoltaic panels. Available at: <https://wam.highland.gov.uk/wam/applicationDetails.do?activeTab=summary&keyVal=RO0V97IHL6800>

Solar PV – roof mountedLady Manners School's rooftop solar panels²²

roof. Each panel is intended to be a Bifacial Double Glass Module (Black Frame) and measure some 1.13m wide and 1.72m high. No panels are proposed on the front, road facing roof slopes of the original school building.

Planning requirements from relevant park LDP/SPG

The Peak District National Park Development Framework²³ outlines in Policy CC2: Low carbon and renewable energy development that proposals for low carbon and renewable energy development will be encouraged provided they can be accommodated without adversely affecting landscape character, cultural heritage assets, other valued characteristics, or other established uses of the area. In addition, it requires that the cumulative impacts of low carbon and renewable energy development within the National Park and visible beyond its boundary must be taken into account, and that where proposals do not compromise the valued characteristics of the National Park the Authority will also take into account the economic, social and wider environmental benefits of renewable and low carbon development.

The National Park's climate change and sustainable building supplementary planning document²⁴ highlights that regarding solar PV there is considerable variation in appearance, and care should be taken to choose those with the least visual impact. It also advises that large scale ground mounted solar arrays are not appropriate, and that to meet National Park policies, ground mounted solar arrays outside the curtilage of a building should be avoided, and in any case are likely to require an application for change of use.

In addition, it outlines that solar PV or solar thermal equipment shall, so far as practicable, be sited so as to minimise the effect on the external appearance of the building, be sited so as to minimise its effect on the amenity of the area and when no longer needed for micro-generation shall be removed as soon as reasonably practicable.

The guidance also outlines the four key factors in minimising the impact of solar panels on National Park values:

- a. Choose the least obtrusive location

Solar PV – roof mountedLady Manners School's rooftop solar panels²²

- b. Choose the least obtrusive type of panel
- c. Decide if reroofing is required
- d. Select the simplest configuration of panels

Summary of outcome / decision

As identified in the delegated report, key issues for consideration of this application were focused on the impact of the proposed solar panels on the character and appearance of the buildings. The issues also included impacts on the wider landscape within which the school is located, while having regard to the benefits of addressing climate change and advocating such measures. Key issues weighed up in the Delegated Report relate to the policy principle (including climate change mitigation and improvement of community facilities), the character and appearance of solar panels, amenity (including glint and glare), sustainability, and ecology.

The proposed development was considered against NPPF and the relevant policies of the Core Strategy. Other material considerations include the NPA's Design Guide and Climate Change and Sustainable Building Supplementary Guidance. The latter document promotes the positive role that low carbon and renewable energy can play in reducing greenhouse gas emissions, providing support for the proposed development, subject to other material considerations.

Design mitigations proposed by the applicant included the positioning of solar panels closer to roof verges. If being proposed for a domestic property, a similar proposal would fall under permitted development rights. The panels were not proposed on the front facing roofscape of the original school building and are only proposed on modern buildings or more recessive roofscapes of the original building. The proposed black panels set within a black frame were considered to be acceptable in appearance.

The NPA's climate change and sustainable building supplementary planning guidance was cited by both the applicant and case officer in consideration of the design of the proposed development.

²³ Peak District National Park Authority (2011) Peak District National Park Local Development Framework. Available at: https://www.peakdistrict.gov.uk/data/assets/pdf_file/0016/49021/LDF-CoreStrategyFinal.pdf

²⁴ Peak District National Park Authority (2013) Climate Change and Sustainable Building: Supplementary Planning Document. Available at: https://www.peakdistrict.gov.uk/data/assets/pdf_file/0042/492999/3401-EF-Sustainable-Planning-Doc.pdf

Solar PV – roof mounted

Lady Manners School's rooftop solar panels²²

With regard to ecology, a bat survey and preliminary roosting assessment were submitted alongside the planning application, as well as a Bat Risk Assessment and Mitigation Strategy. Consultation with Peak District National Park Authority ecologist raised no objections, subject to the proposed Bat Risk Assessment (BRA) and Mitigation Strategy being adhered to. The BRA and Mitigation Strategy demonstrated that the initial design had been amended to exclude areas of the roof identified with roosts. It also set out proposed mitigation measures relating to the timing of installation works, avoidance of certain areas of roof features, and minimised impacts to the roof structure generally. The proposed mitigation measures were considered acceptable by the NPA Ecologist.

As such, the conditions within the decision notice for the planning application include that the solar panels to be installed should be the Bifacial Double Glass Module (Black Frame), as detailed in the submitted documents, unless as otherwise agreed in writing by the National Park Authority. In addition, the development shall be undertaken having full regard to the recommendations in the Bat Risk Assessment and Mitigation Strategy unless otherwise agreed in writing by the National Park Authority. A footnote is included in the Decision Notice relating to the discovery of nesting birds during the implementation of works.

District heat network / ground source heat pump

Installation of an underground heating system to supply district heating to chalets at Lishman House Chalet Site, Glenridding²⁵

Description

Planning was approved in 2022 for an underground heating system which supplies heating to all nine chalets at Lishman House Chalet Site, Glenridding in the Lake District National Park. The application outlines the development of pipe work situated 1.2 metres underground from an adjacent field north west of the site running into a pump house then dispersed to the nine chalets on site. Planning permission was also sought for the pump house approximately 3.30 metres high, 4.02 metres wide and 2.50 metres deep situated at

District heat network / ground source heat pump

Installation of an underground heating system to supply district heating to chalets at Lishman House Chalet Site, Glenridding²⁵

the north of the site and be flat roofed structure where the walls would be covered in timber cladding and would feature double UPVC doors on the north east elevation.

Planning requirements from relevant park LDP/SPG

The Lake District National Park Local Plan 2020-2035 outlines under Policy 20: Renewable and low carbon energy that they will support district heating, decentralised, renewable and low carbon energy developments, including buildings or infrastructure directly related to the renewable energy proposal. In addition, when assessing proposals for decentralised or renewable energy schemes, they will take into account the cumulative impacts both within the Lake District and that which is visible beyond its boundary, and that where the requirements of the Policy are deemed to make a development unfeasible or unviable this must be demonstrated by the applicant through an independent viability assessment.

The associated guidance states that LDNP policy supports all forms of renewable and low carbon energy, for example, air and ground source heat pumps and energy storage proposals. The proposals have to take into account the impact on the landscape and other environmental considerations in line with the other policies in this document and some cases an environmental appraisal may be required to assess and mitigate any adverse impacts on the natural environment²⁶.

Summary of outcome / decision

The proposed development was considered against the relevant policies of the Lake District National Park Local Plan 2020-2025 including Policy 01: National and international significance of the Lake District, 02: Spatial strategy, 03: Development and flooding, 06: Design and development and Policy 28: Minerals safeguarding areas. NPPF is also a material consideration in the determination of planning applications in England.

The proposed development was afforded support from the local planning policy and associated guidance, as set out above. The main issues considered in the assessment related to appearance and impact on the character of the area, flood risk and minerals safeguarding. As the pipe work was located underground, no associated effects were

²⁵ Lake District National Park Authority (2022) Application details: 7/2021/3197. Available at: <https://planning.agileapplications.co.uk/ldnpa/application-details/77297>

²⁶ Lake District National Park Authority (2021) What we're trying to achieve: Policy 20: Renewable and low carbon energy. Available at : <https://www.lakedistrict.gov.uk/planning/planningpolicies/local-plan/policies/policy-20-renewable-and-low-carbon-energy>

District heat network / ground source heat pump

Installation of an underground heating system to supply district heating to chalets at Lishman House Chalet Site, Glenridding²⁵

expected on the character of the surrounding area. The pump house itself was considered to be well screened from views due to its location and its position, small size, form and design and was deemed to be acceptable.

Alongside a site plan, elevations and specifications of the system, only a flood risk assessment was submitted in support of the planning application. Flood risk effects were considered acceptable. Impacts on the Minerals Safeguarding Area were considered acceptable as the proposal was not considered to affect the overall value of the minerals resource.

The Environment Agency raised no objections to the applications and no representations were received in response to the proposal. The decision notice did not require any changes to the original application.

Battery storage

Battery storage unit to provide zero emission back up power to Plas Dol-y-Moch Outdoor Education Centre²⁷

Description

Advances in battery storage capabilities have now enabled Plas Dol-y-Moch Outdoor Education Centre in Eryri (Snowdonia) National Park to develop an alternative hybrid power solution for the site to reduce the emissions associated with their site. The planning application, approved in 2022, outlines the co-location of a containerised battery storage system with the existing diesel generator. This aims to enable short term back up power to the building to be provided without the need for the diesel generator. The battery unit also supports the future potential for decarbonising heating by providing the potential for load management of electrical demand for the site as a whole. In the plans the containerised battery is located at ground level adjacent to the existing generator to minimise the need for

Battery storage

Battery storage unit to provide zero emission back up power to Plas Dol-y-Moch Outdoor Education Centre²⁷

long runs of cabling and for access and the fencing around the battery mimics the fence around the backup power compound of the site.

Planning requirements from relevant park LDP/SPG

Development policy 3: Energy in the Snowdonia Local Development Plan²⁸ outlines that where appropriate, planning applications should be accompanied by an Energy Statement either separately or as part of the Design and Access Statement. In addition, development should not cause harm to landscape, amenity, nature conservation and heritage interests. The supplementary planning guidance (SPG) on renewable and low carbon energy does not outline any guidance relating specifically to battery storage.

Summary of outcome / decision

Alongside site layout plans, elevations and battery storage specifications, a Design and Access Statement and standalone Heritage Impact Statement were submitted alongside the planning application. The proposed development is in the curtilage of a Grade II listed building and therefore its appearance and impact on the designated asset was a key consideration in the planning process. The proposed development was limited to the side of the building and were not visible from the primary viewpoints of the front of the listed building.

The Design and Access Statement states that proposed battery containers will be plain white in colour. However, planning permission was granted subject to the condition that the battery storage unit is painted throughout a light to mid grey within 3 months of its installation and thereafter be maintained in that colour.

This colour specification requirement was not set out in any specific planning policy or design guidance, however, it was intended to reduce the visual impact of the battery unit on its surroundings (i.e. the listed stone building). Consideration of the detailed design, including preferred colour/materials, of proposed technology components (such as battery units) and associated infrastructure (such as fencing), would be helpful to include in renewable energy

²⁷ Snowdonia National Park Authority (2022) Application details: NP5/73/LB74Q. Available at: <https://planning.agileapplications.co.uk/snowdonia/application-details/18367>

²⁸ Snowdonia National Park Authority (2019) Eryri Local Development Plan 2016-2031. Available at: <https://snowdonia.gov.wales/wp-content/uploads/2022/01/Cynllun-Datblygu-Lleol->

[Saesneg.pdf?_gl=1*1689a3g*_ga*MzgzNjM5NDE1LjE3Mjg5MjA3MDk.*_ga_2SRYPWD50*MTcyODkxODAxOC4yLjAuMTcyODkxODAxOC4wLjAuMA..](https://planning.agileapplications.co.uk/snowdonia/application-details/18367/Saesneg.pdf?_gl=1*1689a3g*_ga*MzgzNjM5NDE1LjE3Mjg5MjA3MDk.*_ga_2SRYPWD50*MTcyODkxODAxOC4yLjAuMTcyODkxODAxOC4wLjAuMA..)

Battery storage

Battery storage unit to provide zero emission back up power to Plas Dol-y-Moch Outdoor Education Centre²⁷

design guidance. This would encourage applicants to consider this early in the design process rather than post-consent. Colour specifications are likely to be dependent on site context and surroundings, as well as the technical requirements of technologies and industry standards, and guidance should be accommodating of this.

Hydroelectric

Buchanan community hydro²⁹

Description

In 2019 planning permission was approved for the construction of a 100kW run of river hydro power scheme for export to the national grid on the Burn of Achlais near Milton of Buchanan on the east side of Loch Lomond in the Loch Lomond and the Trossachs National Park. The project consists of a single intake, penstock, powerhouse and tailrace and takes water from the Achlais Burn and returns it to the same watercourse just above the public road bridge over this burn at the B837.

The main components of the scheme outlined in the plans include permanent elements of an intake structure (approximately 2.5m high x 9.5m wide), 2.2km of buried pipeline, powerhouse (measuring 7m x 5.5m x 6.5m with white rendered walls and slate roof), new access from B837 to powerhouse, buried tailrace and outlet structure and grid connection. Temporary elements outlined include 180m track from existing access track to intake location, 20m wide construction corridor and 3no. material laydown and construction compound areas.

Hydroelectric

Buchanan community hydro²⁹

The scheme went live in 2022. Surpluses are paid into the local Community Benefit Fund which supports local projects such as Scouts and youth groups. The Hydro project focusses on climate change impact and community benefit^{30,31}.

Planning requirements from relevant park LDP/SPG

The Loch Lomond and the Trossachs National Park Local Development Plan 2017-2021³² outlines in Renewable Energy Policy 1 the considerations for all forms of renewable energy development, providing support for proposals which will not have significant adverse impact (individually or cumulatively) on landscape or visual amenity, woodlands/ forestry, biodiversity, the water environment, cultural heritage, air quality, traffic and transport, recreation and access and residential amenity.

Policy 1 states that for hydro energy schemes, engineering works, the siting, design or scale of all components (including the powerhouse, headponds, weirs, penstocks and tailraces other ancillary buildings or works, access requirements and other support infrastructure) do not generate significant landscape and visual effects.

In addition, development should not alter the river profile and the water supply to the powerhouse would not result in an inadequate flow of water in any stream which would reduce its ecological value or visual attractiveness as a natural feature. Pipes to, and power lines from, the powerhouse should be placed underground, and sufficient landscape measures should be included to integrate the proposal into the landscape setting and reinstatement measures should be taken to restore the physical conditions of the site when construction is complete.

Proposals are also assessed with regard to Loch Lomond and the Trossachs National Park's renewable energy planning guidance³³. For hydro, this states that considerations should particularly be made regarding the National Park's Special Landscape Qualities, wildland characteristics, biodiversity, habitats and species, as well as cumulative impacts on landscape, ecology, water quality and quantity, and recreation and access.

²⁹ Loch Lomond and the Trossachs National Park Authority (2019) Planning – Application Summary: 2019/0018/DET Construction of a hydro scheme. Available at: <https://eplanning.lochlomond-trossachs.org/OnlinePlanning/applicationDetails.do?activeTab=summary&keyVal=PLOY8TSILCQ00>
³⁰ Development Trusts Association Scotland (2024) The transformative impact of community owned energy. Available at: <https://dtascot.org.uk/sites/default/files/Energy%20Case%20Studies%202024.pdf>

³¹ Buchanan Community Hydro Society (undated) Welcome to Buchanan Community Hydro Society. Available at: <https://buchananhydro.coop/>

³² Loch Lomond and the Trossachs National Park Authority (2017) Local Development Plan 2017-2021.

Available at: <https://www.lochlomond-trossachs.org/planning/planning-guidance/local-development-plan/>
³³ <https://www.lochlomond-trossachs.org/wp-content/uploads/2016/07/PG-Renewables-2017-Approved.pdf>

HydroelectricBuchanan community hydro²⁹**Summary of outcome / decision**

In addition to site plans, elevations, and component specifications, several supporting documents were submitted alongside the planning application. These included EIA Screening, Access and Traffic Report, Desk-Based Archaeological Survey, Bryophyte Survey, Ecological Appraisal, Environmental Risk Assessment and Mitigation, Turve Management Plan, Construction Method Statement, Noise Survey and Analysis, Fish Habitat Surveys, Freshwater Pearl Mussel Survey, Hydrology Report, and Landscape and Visual Impact Assessment.

The proposed development was assessed against the relevant policies of the LDP. Material considerations included the statutory aims of the National Park and the relevant outcomes of the National Park Partnership Plan (2018-2024).

Key considerations considered in the Delegated Report included landscape and visual impacts, ecology, public access, residential amenity and traffic, with considerable consideration of the ecological effects of the proposed development.

The decision notice included 21 separate conditions for the development. These included requirements for a detailed construction method statement, breeding birds protection plan, appointment of an ECoW and a submitted scope of works for them, a landscape restoration plan, provision of design details for intakes, powerhouses, outfall and all over above ground structures, a micro-siting plan detailing the final widths of the construction corridor within the development, protections for archaeology, adherence to access specifications, signage specifications, visibility sightlines specifications, the provision of a background noise survey, implementation of noise mitigation measures, noise impact assessment, monitoring report submission, and a public access management plan. The decision notice also required the development to ensure that the lower section of the West Highland Way remains open and ensure right of way priority to cyclists along the Drymen to Balmaha cycleway.

This planning application was supported by detailed information, and illustrates the level of information required to fully assess hydro-electricity proposals in comparison to other technologies (albeit dependent on the scale of development and site sensitivities). The

HydroelectricBuchanan community hydro²⁹

existing LLTNPA renewable energy planning guidance provides a detailed overview of the likely considerations and assessment work required to make a determination and this is likely to continue to be required.

Small scale wind – singular turbineErection of 15 metre high, 6.1 kW wind turbine at Swarthghyll Farm, Buckden³⁴**Description**

The application for the installation of a 15m high turbine in farmland behind a tree belt at Swarthghyll Farm, Oughtershaw, Buckden, within the Yorkshire Dales National Park was approved in 2018.

Planning requirements from relevant park LDP/SPG

For wind energy developments, the Yorkshire Dales National Park Local Plan 2015-2030 refers to the Written Ministerial Statement on wind energy development (2015)³⁵ which states that 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. As the Local Plan does not identify areas suitable for wind development, Yorkshire Dales LPA can find proposals acceptable if, following consultation, they are satisfied it has addressed the planning impacts identified by affected local communities and therefore has their backing.

The LPA's Design Guide allows for wind turbines up to 15m in height that have limited impact on the landscape quality of the National Park.

³⁴ Yorkshire Dales National Park Authority (2018) Application details C/13/127G. Available at: <https://planning.agileapplications.co.uk/yorkshiredales/application-details/2171>

³⁵ Department for Communities and Local Government (2015) House of Commons: Written Ministerial Statement (HCWS42) made by the Secretary of State for Communities and Local Government 18 June

2015. Available at : <https://www.parliament.uk/globalassets/documents/commons-vote-office/June-2015/18-June/1-DCLG-Planning.pdf>

Small scale wind – singular turbine

Erection of 15 metre high, 6.1 kW wind turbine at Swarthghyll Farm, Buckden³⁴

Summary of outcome / decision

Key issues in the decision delegated report focus on landscape and visual impacts. Locating the wind turbine closer to the farm to help mitigate its visual impact was considered to be a suitable design mitigation. The turbine can only clearly be seen from immediate views along the public right of way nearby. Intermediate and longer views of the turbine are lessened by the existing farm buildings, trees and topography, and the turbine was considered to be well hidden in the landscape. Additional, planting undertaken by the applicant as part of a flood alleviation scheme was considered to mitigate the visual impacts the turbine once established.

As the LPA's Design Guide clearly indicates that turbines up to 15m in height (with limited impact on the landscape quality of the National Park) would be considered acceptable, this likely provided the applicant with certainty and clear direction when developing their proposal and selecting a suitable technology.

No other environmental considerations were considered in detail in the report and the principle of development is supported by local planning policy relating to renewable energy development, in conjunction with the Written Ministerial Statement and Design Guide.

The decision notice did not require any changes to the original application.

Biomass

Installation of Biomass Boiler and erection of shed, Semeil Farm, Strathdon³⁶ in the Cairngorms National Park.

the existing farm hub and existing farmhouse, behind the existing agricultural steading buildings in the yard area.

The planning application outlines that the agricultural shed is to measure approximately 10m by 8m and the total height of the agricultural shed will be 5m with eaves of 3.5m. Roof and walls are to be clad in juniper green box profile metal sheeting. The proposed woodchip boiler will be 2,105mm by 1,570mm by 1,840mm with 130 kW max capacity and the height of the exhaust stack will be 199mm diameter and 6m high from the ground, extending approximately 900mm from the roof slope of the agricultural building. The shed will also hold a 3,000 litre buffer tank (1,500mm by 2,710mm) and a woodchipper hopper enclosed by concrete panels (90mm (D) by 4572mm (L) by 3500mm (H)). The access to the farm site is unaltered and fuel (woodchip) will be transported by agricultural machinery to the biomass store for dry storage.

Planning requirements from relevant park LDP/SPG

In the Cairngorms National Park, all biomass proposals must include sufficient storage capacity to minimise the need for delivery of the fuel to the site. Biomass energy should be located to avoid having adverse effects from/on traffic, noise, odour, water and air quality from energy production, delivery and storage of biomass. In addition, there is support for biomass energy schemes that are able to make use of local sources of biomass and can demonstrate a long-term biomass supply³⁷.

Summary of outcome / decision

In addition to proposed site plans and elevations, a supporting statement (outlining the reason for the proposed biomass boiler), details of the woodchip boiler specification and an Inventive Renewable Emission certificate were provided in support of the application. An Aberdeenshire Council 'Biomass Boiler Information Request Form' was also completed by the applicant, setting out details of the boiler and its systems, its operation and maintenance, stack details, fuel details (including adequate fuel storage on site) and building details. This information request form ensured all necessary details and technical specifications were

Biomass

Installation of Biomass Boiler and erection of shed, Semeil Farm, Strathdon³⁶ in the Cairngorms National Park.

Description

In 2024 planning permission was granted for the erection of an agricultural building and installation of a biomass boiler at Semeil Farm which is 300 metres east of the hamlet of Heughhead, Strathdon, in the Cairngorms National Park. The site is located to the north of

³⁶ Aberdeenshire Council (2024) Planning – Application Summary: Erection of Shed Including Installation of Biomass Boiler. Available at: <https://upa.aberdeenshire.gov.uk/online-applications/simpleSearchResults.do?action=firstPage>

³⁷ Cairngorms National Park Authority (2021) Local Development Plan 2021. Available at: <https://cairngorms.co.uk/planning-development/ldp-2021/>

Biomass

Installation of Biomass Boiler and erection of shed, Semeil Farm, Strathdon³⁶ in the Cairngorms National Park.

provided and that policy requirements were met (such as availability of sufficient storage capacity).

Consultation was carried out with Environment and Infrastructure Services (Environmental Health) who had no objections to the proposal subject to conditions on emissions from the biomass boiler and height of the exhaust stack/flue. The Cairngorms NPA provided no comments.

The proposed development was considered against the relevant policies of NPF4 and Cairngorms LDP 2021, with discussion in the Report of Handling relating to the principle of development, the scale of the building and potential visual and amenity impacts (including noise and emissions). The small-scale proposal was considered to be appropriate in relation to surrounding agricultural buildings and the proposal compatible with the existing use of the site as a working farm. The principle of development is supported due to policy support for renewable energy development and climate change mitigation.

The conditions within the decision notice for the planning application include that the biomass boiler system shall be permanently operated and maintained in accordance with the completed Biomass Boiler Information Form. At the request of the Planning Authority, the biomass plant operator shall provide the maintenance log/s for the approved biomass system within one month of the date of request. Should the maintenance log indicate that the biomass system is not being operated or maintained in accordance with manufacturers specification or should the biomass system not be operating in accordance with the details contained within the approved Biomass Boiler Information Form the developer shall, at their expense, and at the request of the Planning Authority, provide a mitigation statement to the Planning Authority which shall identify and detail actions to be implemented (including timescales for implementation) to address the issue(s). The biomass system shall thereafter operate in accordance with the measures detailed within the agreed mitigation statement.

In addition, it specified that the 6m high exhaust stack should not be varied in height or design from the approved plans without a separate express grant of planning permission by the planning authority.

Summary of case study findings

The case studies outlined above demonstrate renewable energy proposals within UK National Parks that were considered acceptable when considered against the relevant planning policies and material considerations. The following key learning points can be drawn from the analysis of these case studies.

- Landscape and visual considerations are key in the majority of renewable energy applications, at all scales. Other key considerations depend on site characteristics and sensitivities but may include ecological impacts (including impacts on protected species and designated sites), amenity (including visual amenity and noise impacts), and heritage impacts (direct and indirect). As is evidenced by the case study examples above, the appropriate level of information required to assess planning applications will vary significantly dependent on the scale and location of development proposals.
- Detailed design guidance, such as detailed specifications of suitable locations for rooftop solar panels, provides applicants with greater certainty about what will be considered acceptable from an early stage in the development of their design. Sketch drawings provide useful tools to visualise detailed design guidance and ensure clarity.
- Local policy and design guidance may benefit from including detailed design considerations (such as colour of renewable energy components and associated infrastructure). Applicants are therefore more likely to consider these details at pre-application stage, rather than post consent.
- Certain types of development, such as hydroelectricity proposals, are likely to require more distinct and specialised assessment work and supporting information to be submitted with the planning application. Planning guidance should provide a list of all potential environmental considerations, ensuring that applicants consider these from early in the development of their proposals.
- Information request forms (such as Aberdeenshire Council's 'Biomass Boiler Information Request Form') may provide useful tools to ensure all relevant technical specifications of the proposed technology are provided in one place. This may provide additional certainty to applicants about the level of information required and ensure that they are in line with planning policy.

Approach by constituent local authorities

3.4 LLTNPA spans across parts of four local authority areas - Stirling, Perth and Kinross, Argyll and Bute and West Dunbartonshire. It was therefore considered important to engage each local authority, to avoid the duplication of efforts and to gain a full understanding of any progress being made with regard to renewable and low-carbon energy at a local level. While LLTNPA planning policy is separate from those of its constituent local authorities, meeting decarbonisation targets requires joined up working across different scales. Therefore, enabling cross-boundary knowledge-sharing and ensuring collaboration and cohesion is important to the development of policy and guidance for the National Park.

3.5 The Scottish Government has recently introduced a requirement for all local authorities to prepare Local Heat and Energy Efficiency Strategies (LHEES)³⁸ and Delivery Plans. The strategies underpin a locally based approach to heat and energy efficiency planning and delivery. They set out long-term plans for decarbonising heat in buildings and improving their energy efficiency across a local authority area. It is therefore important for this study to consider these four strategies, which are at various stages of development.

3.6 Engagement was carried out with key contacts at each of the four constituent local authorities to gain understanding of LHEES progress, their local policy context, any key priorities they have in the delivery of renewable energy and the challenges they are facing. A summary of the engagement findings for each local authority is set out below.

Stirling

3.7 Stirling has integrated much of its renewable and low-carbon energy strategy into the Regional Energy Masterplan (REM), which outlines key areas for decarbonisation, particularly for heat networks, fulfilling the requirements of an LHEES.

3.8 In Stirling, the current focus for renewable energy initiatives is on heat networks. In particular, the development of shared boreholes for ground source heat. Two key projects are being progressed. The council sees the development of heat networks as the most effective method to decarbonise the area.

3.9 Alongside this, the council is investigating ways to unlock funding for community-led renewable projects while addressing the energy efficiency deficiencies within its council-owned buildings, particularly considering upcoming regulatory changes from the Heat in Buildings Bill.

3.10 Stirling is exploring various renewable energy options, such as solar energy, wastewater recovery, and ground source heating. They are also looking at hydrogen technologies, although any proposals remain in the pre-application phase. Additionally, the University of Stirling has its own heat network, which it aims to expand, complementing the council's efforts. The council has identified potential funding avenues from both the Scottish Government and private investments, particularly for renewable projects that can improve energy efficiency and contribute to community benefits.

3.11 Stirling Council noted several challenges in advancing its renewable energy agenda, the main one indicated was limited grid capacity. Additionally, there is uncertainty surrounding the viability of hydrogen-converted boilers, with local investment decisions on hold as they await Scottish government direction. Financial constraints also pose a challenge, as many residents seek funding to implement energy efficiency measures but find that available resources primarily target council housing, leaving private homeowners with fewer options. Addressing these issues will be crucial for Stirling to achieve its decarbonisation goals effectively.

Perth and Kinross

3.12 The LHEES for Perth and Kinross was developed in summer 2024 and is currently being integrated into the LDP to align with the new NPF4. This integration is crucial as it ensures that local energy efficiency and renewable energy policies reflect national goals and directives.

3.13 In terms of renewable energy priorities, Perth and Kinross Council has identified several key areas for development. Battery storage and improvements to transmission networks are at the forefront being essential for managing the variability of renewable energy sources. The council is also focusing on larger solar farm schemes on agricultural land and exploring co-location opportunities, where technologies like wind or solar can be integrated with battery storage. Additionally, the council is considering a district heating policy to enhance energy

³⁸ Scottish Government (2022) Local heat and energy efficiency strategies and delivery plans: guidance (see: <https://www.gov.scot/publications/local-heat-energy-efficiency-strategies-delivery-plans-guidance/>)

efficiency in local communities, although they noted the impracticalities of this in more rural areas.

3.14 Perth and Kinross Council are also witnessing applications for micro-hydro, small-scale solar, and small-scale wind. The local topography is conducive to small-scale hydro projects, yet constraints and sensitivities, such as environmental designations, limit the number of proposals coming forward.

Argyll and Bute

3.15 Argyll and Bute Council is actively progressing towards meeting its obligation to develop a LHEES, with the goal of finalising these by the end of the year. A key focus within the strategy is the implementation of heat networks, specifically micro heat networks where small clusters of homes, typically three to four, would share a borehole ground source heat pump.

3.16 Historically, Argyll and Bute has seen the development of several micro hydro schemes, mostly on private estates and farms, serving the needs of landowners. However, despite its long history, the council noted that these schemes contribute relatively little to overall energy production. Additionally, there are growing concerns over the impact on the water environment and water quality, which has led to scepticism about the future scalability of micro hydro as a significant energy source in the region. Similarly, micro wind developments are not widely seen as a potential growth area.

3.17 Looking ahead, Argyll and Bute intend to focus more heavily on solar energy storage technologies, seeing them as key opportunities to meet energy demands and reduce reliance on traditional power sources. However, a significant limitation they noted is grid capacity and therefore battery storage is also being prioritised. The existing infrastructure cannot accommodate large-scale renewable projects without substantial upgrades, which poses a major barrier to expansion in the near future.

3.18 The local authority is also paying attention to community benefits. They recognise the importance of ensuring that renewable energy projects not only contribute to environmental goals but also deliver tangible benefits to local residents. There is a desire to move beyond traditional financial compensation for communities, and instead, focus on generating green jobs and other long-term employment opportunities. This approach is seen as a way to enhance the overall impact of renewable energy developments, ensuring that local communities are fully engaged and benefiting from the projects.

West Dunbartonshire

3.19 Engagement with West Dunbartonshire Council published their LHEES in 2024 . This serves as the most relevant and up-to-date document guiding their approach to renewable energy in line with NPF4.

3.20 Engagement feedback found that historically, solar and wind energy have been the primary focus in West Dunbartonshire, as both technologies are well-established and relatively straightforward to implement. However, there is increasing interest in novel technologies.

3.21 Battery storage, in particular, has seen a steady growth in applications, reflecting its growing importance as a complementary technology to manage intermittent energy sources like wind and solar.

3.22 Changes in permitted development rights have reduced the need for certain technologies such as heat pumps to go through the LPA's planning process. This has decentralised the adoption of these technologies, allowing homeowners and businesses to implement them more easily without direct oversight from the local authority.

3.23 Engagement feedback found that hydrogen energy is another area being explored, although the project in question is still at pre-application phase. This aligns with broader national ambitions to develop hydrogen as a key component of Scotland's future low-carbon energy mix. However, it is too early to predict the outcome of this project or its potential scale within the local authority.

Summary of findings from local authority engagement

3.24 Feedback from each local authority highlighted grid capacity and expansion of the electricity transmission network as a key challenge and constraint for the deployment of renewable energy.

3.25 There is a clear focus on understanding newer technologies, or technologies where there have been a recent increase in demand, particularly solar and battery storage but also a growing exploration of heat networks. Due to the recent emergence of Battery Energy Storage Systems (BESS) they are not as widely understood as more established technologies such as wind and solar. Rapid technological advancement in BESS models is likely to mean that planning guidance and decision-making needs to keep up with this progress.

3.26 Beyond the planning system the importance of securing community benefits through renewable energy development was raised by all local authorities. This included integrating training and employment opportunities into the delivery of renewable energy projects as well as the subsequent community benefit contributions associated with ongoing energy generation. While community benefits are more often attributed to larger scale development, this should be considered by other departments within the LLTNPA and could include signposting and/or provision of training opportunities to allow local communities to access employment opportunities arising from development.

Summary of approaches to renewable and low-carbon technologies

This chapter provided an overview of existing approaches to renewable and low-carbon energy development planning within National Parks.

Many domestic and some non-domestic micro-generation development proposals will fall under national permitted development rights and therefore will not require planning permission. The circumstances in which PDR apply vary (such as being located within a National Park for certain types of development) and therefore careful consideration of PDR in relation to micro-renewable energy developments is important for those bringing forward development proposals and navigating the planning system.

Case study evidence is important to informing planning guidance, particularly where policy and guidance elsewhere has aided the effective integration of renewables into National Parks. Findings from the case studies in this chapter are summarised on page 23 and identify some of the key considerations in the planning decision-making process. They also highlight some specific factors for consideration in the development of future planning guidance.

Stakeholder consultation carried out with the four constituent local authorities highlighted some of the challenges and focus areas for renewable energy development in their local areas. Key issues included developing an understanding of newer technologies which have experienced an uptake in demand, such as solar as well as considerations related to grid capacity, and an associated demand for the development of Battery Storage. Other issues for consideration by the NPA more widely included securing community benefits from renewable energy proposals.

Chapter 4

What are the priorities and challenges in the National Park?

4.1 In order to develop relevant policy and guidance regarding renewable energy and low-carbon development in the National Park, it is essential to understand what the current demands and recent development trends are. Stakeholder engagement with businesses, a land manager and a community group - all of whom had previously developed or had plans to develop community, micro-renewable and low-carbon projects - took place and is summarised below. Additionally, a review of recent planning applications within the National Park was carried out.

Stakeholder engagement

4.2 This section presents the results of the stakeholder engagement, for each stakeholder it covers:

- A description of the stakeholder/project, what the ambitions were and what the challenges were for the technologies they tried to implement.
- A summary of how can planning guidance can respond to the challenges identified.
- Short commentary on how the findings can inform the work of the LLTNPA more generally.

Stakeholder 1

4.3 'Stakeholder 1' was a key representative from a community development trust which has explored options for several different renewable technologies at an individual and community scale. Their main priorities revolve around solar energy (both roof and ground-mounted installations), micro-hydro projects, and battery storage solutions.

4.4 The community has explored various small-scale projects. These include a community hydro scheme and building-level initiatives including installing air source heat pumps and solar

PV on rooftops. These have been undertaken on/adjacent to public buildings, such as the local school as well as some private installations by local residents. The community is also interested in exploring battery storage and the electrification of transport as future developments.

4.5 Several site-related challenges limit renewable energy developments. This included the need to install ground mounted solar panels next to the school as its listed building status prevented them from being installed on the roof. Local landscape sensitivity has impacted the viability of larger projects such as the proposed micro-hydro scheme. For this SEPA regulations also posed a challenge due to concerns about negative impacts on the watercourse and flooding.

4.6 The group expressed a strong interest in more detailed and mapped guidance that highlights eligible areas for specific technologies while ruling out areas where developments are not viable. They also feel that National Park guidance should complement existing resources from organisations like Community Energy Scotland, particularly in areas like early-stage feasibility assessments for renewable energy projects.

4.7 Financial barriers in the absence of the Feed-in Tariffs, and willingness of communities to take on projects with a 10 year payback time have posed larger constraints to delivery than any planning or other regulatory requirements. If projects were to be delivered beyond individual buildings, further support would be required to develop local community capacity and a fuller understanding of the risks and benefits.

Stakeholder 2

4.8 'Stakeholder 2' was the owner of a large estate within the National Park. Their biggest land use was hill farming for sheep and cattle. However, they are actively exploring and undertaking land use changes including peatland restoration and woodland creation on parts of their estate. They have implemented different types of renewable technologies across their estate over several years and have investigated the viability of others. Their ambitions for future renewable energy development focus on expanding hydro capacity and implementing solar PV on building rooftops.

4.9 The estate currently operates two hydro schemes harnessing local water resources for energy generation. The stakeholder is interested in a third scheme, although this is hindered primarily by challenges related to water supply and landownership.

4.10 The landowner made a previous planning application for solar PV panels on the roof of an agricultural building but this was refused due to the visual impacts from an adjacent road. They have installed two biomass boilers but discussed the increasing difficulties in sourcing the wood chip required for these. As a result this is not something that they would pursue again.

4.11 The stakeholder had not previously consulted the LLTNPA's planning guidance and has relied on early engagement with planning officers to discuss requirements and likely constraints considering the unique landscape and ecological characteristics of their estate, rather than relying on generic documentation. They emphasised the value to them of this approach previously and would want to continue to do this for any possible future developments.

Stakeholder 3

4.12 Stakeholder 3 represents an organisation that has been actively engaged in renewable energy projects in the National Park, particularly rooftop solar, for over a decade, successfully establishing significant operational capacity. They are interested in expanding their renewable energy portfolio by adding heat pumps and battery storage, contingent on these technologies being powered by solar energy.

4.13 The stakeholder emphasised the need for tailored guidance regarding specific technologies, notably solar and battery storage, identifying gaps in existing regulations that lack clarity on what constitutes 'small scale'. They also advocated for clearer guidance concerning noise levels, visual impacts, and ecological considerations. They also expressed interest in guidance for areas with archaeological significance.

4.14 Additionally, they stated that mapping which identifies suitable areas for renewable energy development would be beneficial. The identification of designated areas for battery storage systems would also be beneficial, which must be factored into grid connection considerations.

4.15 The guidance should also account for the decarbonisation needs of buildings, suggesting flexibility should be provided in locating renewable energy sources near buildings that can benefit from them.

4.16 While the stakeholder noted interest in installing heat networks, they find the high costs impractical for the National Park context, given that dense urban areas are required to make such systems economically viable. They see individual air source heat pumps as a more viable option in less densely populated areas.

4.17 Beyond planning and other regulatory requirements, the stakeholder faces significant challenges relating to grid capacity and navigating the complexities of import and export agreements.

Stakeholder 4

4.18 Stakeholder 4 was an independent consultant focused on establishing telecommunication stations in underserved areas. They are interested in integrating renewable energy solutions to replace traditional diesel generators for these stations. As part of their role, they are involved in drafting planning applications and guidance for telecom infrastructure, and are prioritising renewable energy options such as solar and potentially wind energy.

4.19 They stated that they encounter challenges related to visual impact and land requirements, as the addition of solar panels requires significantly more space than the station's small footprint (10x10 metres). The consultant stressed the importance of developing guidance that considers the unique environmental and visual impacts associated with telecom station establishments, particularly in sensitive landscapes.

4.20 Beyond planning and regulatory requirements, the stakeholder also highlighted budget constraints as a major limitation in implementing renewable energy solutions. Overall, they advocated for exploring hybrid solutions, such as the combination of solar and wind energy with battery storage, to minimise reliance on diesel generators while effectively addressing coverage needs.

Summary of stakeholder consultation

4.21 The stakeholder consultation was important to understand the current ambitions of different stakeholders for renewable development, existing challenges and barriers to development and views on how restrictive or supportive the planning system is currently perceived as being for potential planning applicants.

4.22 A range of technologies were being pursued by the stakeholders. While the most common were solar PV and battery storage, stakeholders were supportive of additional planning guidance on a wide range of technologies. Some stakeholders maintained a preference to have

early conversations with planning officers so that the specific requirements related to their development could be understood. It is therefore important that the guidance is suitable for use by planning officers to inform their pre-application discussions with developers.

4.23 Grid capacity and financial constraints were the most common issues identified for the implementation of renewable energy beyond planning and other regulatory requirements. This should be reflected by the LLTNPA and their partners when providing wider support for the integration of renewables.

Current demand trends

4.24 A review of planning applications in the National Park was carried out to establish an overview of key development trends and current demands. The search covered all renewable energy development planning applications up to September 2024³⁹. The analysis below therefore gives a summary of the technologies and types of development of most relevance to LLTNPA's updated renewable energy planning policy and guidance.

4.25 The analysis below summarises applications submitted, indicating applicant demand, and does not provide commentary on the status of applications, with several recent applications decision status pending.

Wind

4.26 There have been a total of nine applications for the development of sole wind turbines in the National Park since 2005, with six of these applications submitted for small-scale turbines prior to 2014. The remaining three applications were submitted within the past year, in 2024, and are all co-located with ground-mounted solar development. Other applications have been received for wind co-located with other technologies but the data available did not allow these to be fully assessed.

³⁹ Many microgeneration proposals will be covered by PDR and therefore are not required to apply for planning permission (see **Chapter 2**). This analysis therefore gives an overview of applications requiring

planning consent and not a full overview of the deployment of these technologies throughout the National Park, as many cases do not require planning permission.

4.27 The three applications⁴⁰ received in 2024 illustrate a recent uptake in demand for small-scale wind development in the National Park, particularly when combined with other technologies:

- Erection of a 20m high wind turbine and 42 ground-mounted solar panels (2024/0027/DET)
- Erection of two 15m high wind turbines and 36 ground-mounted solar panels (2024/0137/DET)
- Erection of two 15m high wind turbines and 42 ground-mounted solar panels (2024/0155/DET).

Solar

4.28 To date there have been 65 planning applications for solar PV development in the National Park. 24 of these applications relate to ground-mounted solar proposals and 41 are for roof-mounted solar. More than half of the total number of applications have been submitted in the past few years (since 2021), highlighting the growing popularity of these technologies. The majority of planning applications for solar PV development have been approved.

4.29 Several solar PV application proposals are co-located with other technologies, including 12 with wind turbines and three with battery storage. Ten of these applications were approved, with two pending decision.

4.30 Whilst the majority of applications relate to smaller-scale renewable energy development, such as domestic solar installation, there were several medium- and larger-scale applications submitted in recent years, particularly for ground-mounted solar development. These trends indicate a potential requirement for additional planning guidance for both roof- and ground-mounted solar development at varying scales.

Hydro

4.31 To date there has been a total of 55 planning applications for the construction of hydro schemes in the National Park between 2005 and 2024, at varying sizes and energy capacities.

Several of these are run-of river micro hydro schemes at less than 100kW however, there are a number of larger hydro schemes, with capacities in their hundreds and thousands (kW).

4.32 Since 2020 there have only been two planning applications relating to hydro schemes, both submitting amendments to previous consents. There have been no planning applications for new schemes submitted in recent years. Reasons for this decrease may include the closure of the Feed-In Tariff incentive scheme in 2019, and/or the number of remaining opportunities for this technology is limited.

Biomass

4.33 To date there have been 32 planning applications for the construction of biomass plants/systems in the National Park, all of which have been approved. The majority of these cases relate to domestic-scale biomass installations. No new biomass applications have been submitted since 2019.

Heat pumps

4.34 There have been ten planning applications for the installation of air source heat pumps in the National Park, all submitted between 2021 and 2024. Three of these applications are combined with the installation of solar photovoltaic (PV) panels.

4.35 There have been no planning applications for the installation of ground source heat pumps in the National Park.

4.36 As the installation of heat pumps largely fall under PDRs it is not possible to comment on the overall take-up of these technologies by residents and businesses across the National Park.

Battery storage

4.37 There have been four planning applications for battery storage in the National Park to date. All four applications were submitted in 2023 and 2024, showing the very recent emergence of this technology. If national trends (and those reported by the adjoining local authorities) are followed, demand for this technology will likely continue to grow.

⁴⁰ Each of these applications are pending decision at the time of writing.

4.38 Three of the proposals also include small-scale solar PV installation. One application relates to a standalone BESS development but forms part of a larger site containing a biomass facility (granted permission in 2011).

Summary of demand trends

4.39 A high-level overview of trends shows that the number of applications for solar, battery storage and air source heat pumps is increasing, along with wind to a smaller extent, while applications for biomass and hydro are decreasing.

4.40 Wind energy development has seen a recent re-emergence in demand in the past year, following limited new wind development over the past decade. Small-scale solar PV has seen a steady increase in popularity over time, however, only very recently have larger-scale applications come forward in the National Park. Battery storage is a relatively new technology, with planning applications only coming forward in the past two years. Similarly, applications for air source heat pumps have witnessed a sharp increase in recent years. On the other hand, no planning applications relating to new biomass or hydro development have come forward in recent years.

4.41 Going forward, micro-generation proposals for some technologies similar to those described will no longer require planning permission due to recent Scottish Government updates to permitted development rights (see **Chapter 2**).

Summary of stakeholder consultation and demand trends

This analysis gives an overview of historic and recent demand trends for the renewable and low-carbon technologies within the specific local context of the National Park, informing the next stages of this study. Overall, consultation with local stakeholders and a review of recent planning applications within the National Park demonstrates the need for updated and expanded guidance for renewable energy development. The findings highlight a particular need for guidance relating to solar PV and battery storage technologies, of which there is evidenced demand but are not covered within existing planning guidance.

Chapter 5

Short-list of technologies and generic guidance

Existing operational and consented renewable energy generation in the National Park

5.1 The information from the baseline desk research and stakeholder engagement informed a shortlist of technologies requiring additional assessment for both their technical potential and likely constraints in order to identify recommendations for planning policy which supports their development. These are described below, along with their reason for selection.

5.2 It is important to reiterate at this point that renewable energy sits third in the energy hierarchy as described in chapter 2. As such, maximising the benefits of many of these technologies is reliant on a reduction of energy demand and an increase in the energy efficiency of buildings through a fabric first approach. While outside of the remit of the planning system, this should be prioritised as an action for the NPA and partners in the NPPP to support any changes in planning policy which facilitate greater uptake of these technologies. The following paragraphs describe each of the renewable energy technologies:

5.3 Solar: this was the most commonly mentioned renewable energy technology by stakeholders. This was also noted as the most common planning application received by the LLTNPA, with 65 applications received and over half of these since 2021, and similarly by each of the other local authorities consulted. Solar PV is relatively easily to implement and which can be installed at a range of scales from individual rooftop panels to a solar farm. The Greenhouse Gas Assessment identified solar as an important part of the renewable energy mix in the National Park to meet net zero emissions. While many solar PV installations will be covered by permitted development rights, the increasing number of applications for larger scale ground mounted solar show that this technology has the potential to play a significant role in scaling up renewable energy generation in the National Park and therefore the impact of this technology needs to be assessed so that it can be accommodated within the environmental constraints of the National Park.

5.4 Heat pumps: the demand for heat pumps is rapidly increasing and this was reported by all of the local authorities and stakeholders consulted. Ten applications for air source heat pumps have been received but the number of heat pumps installed is likely to be much greater as many will be covered under permitted development rights. Given the relative low cost of these technologies and ease of implementation, especially for air source heat pumps, the technical potential of these was assessed. These technologies are anticipated to have a relatively minor natural heritage, landscape and cultural heritage impacts and will largely fall under permitted development rights. However, heat pumps are likely to play a significant role in the renewable energy mix in the National Park. Due to their specific identification as a key technology to reduce emissions within the Greenhouse Gas Assessment, it was considered important to assess any potential constraints to implementation. Take up of ground source heat pumps is currently of a lesser scale than air source heat pumps, and all domestic installations are covered by permitted development rights. However these were also considered within the assessment due to their potential role.

5.5 Battery energy storage systems: as more energy is generated from renewable sources and due to constraints on the capacity of the grid there is an increasing need for battery storage which are generally delivered alongside a renewable energy development. Domestic battery storage which would support the installation of micro-renewables is generally covered under permitted development rights. Each of the local authorities consulted reported an increasing number of planning applications for battery storage and demand for this was also reported by two of the stakeholders. The LLTNPA has received four applications for battery storage in the last year alone and therefore it was considered important that this technology was assessed.

5.6 Hydro: while there haven't been any planning applications for hydro development since 2020, it remains an important part of the existing renewable energy mix in the National Park (Figure 5.1 shows existing renewable developments in the National Park) and some interest was expressed by one of the stakeholders consulted, if current barriers could be overcome, such as the closure of feed-in tariffs and landowner support. The Greenhouse Gas Assessment report specifically identified the strong hydro-electric presence within the National Park which could be further capitalised. The potential for natural heritage and landscape impacts is also significant for this technology and therefore it was considered important that this technology was assessed.

5.7 Wind energy: while only singular turbines can be accommodated in the National Park, the natural heritage, landscape and cultural heritage impacts of wind energy development is still

significant. One of the stakeholders consulted reported a potential interest in wind energy development alongside other technologies and there have been three recent planning applications for wind energy to be co-located with solar development, representing possible cumulative impacts. The Greenhouse Gas Assessment report identified small scale wind as an important part of the renewable energy mix in the National Park. It was therefore considered important to assess this technology.

5.8 Biomass: guidance for biomass boilers is incorporated into the existing guidance. The stakeholders who mentioned this technology stated that they would not use this technology again and there is less demand for it as heat pumps become a more popular, and lower cost, technology. No applications have been received by the LLTNPA since 2019, although domestic scale boilers are largely covered by permitted development rights. Given it is still a technology in active use in the National Park, this was included in the assessment, however, it may be that specific guidance is not required going forward.

5.9 The subsequent chapters of this report (chapter 6-11) set out the findings of our analysis on the technical potential and constraints for the technologies identified and explores the natural heritage, landscape and heritage constraints to their development. For each technology the chapter covers:

- A description of the technology, key considerations and associated infrastructure, including analysis of the extent to which the technology is addressed in the existing planning guidance.
- An assessment of the theoretical technical potential of different renewable energy technologies in the Park (where this was possible).
- The locational, planning and other environmental constraints (e.g. landscape, heritage) to the development of each of the technologies in the National Park.
- Capacity for the different renewable energy technologies including their likely location or association with buildings.
- Advice on siting and design of each technology type to minimise their environmental and visual impact.

5.10 The limitations of data available and the applicability of assessment methodologies for smaller scale renewables mean that only certain technologies could be assessed for their

technical potential. A full list of assumptions used in the assessment of technical potential for the technologies which were assessed can be found in Appendix A.

5.11 Additional policy considerations for the biomass resource assessment and hydrogen technologies are considered below.

Policy considerations for the biomass resource assessment

5.12 The future role of biomass within Scotland and LLTNP's energy mix will be informed by national policy direction and demand. In 2024, the Scottish Government published their Draft Bioenergy Policy statement for consultation⁴¹, which sets out their current position on the role of bioenergy as the country moves towards a net zero future. In the short to medium term (to 2035) it is expected that biomass as fuel may be the only solution for existing properties that are currently not suitable for clean heating systems. There should be a focus on the use of locally available resources to meet the demands of an area. In the longer-term (i.e. post-2035) the use of bioenergy should prioritise bioenergy with carbon capture storage (BECCS) where possible, and the majority of biomass uses should deliver negative emissions. This will be dependent on how technologies develop. However, the policy recognises that biomass or biofuels may be the only solution for existing properties that are not currently suitable for clean heating systems.

5.13 Regarding planted biomass resource (i.e. the potential for biomass generation from forestry and woodland in the National Park), this must be considered within the wider land use context of the National Park. Scotland's Third Land Use Strategy (2021) sets out sustainable land use as *'fully contributing to the fight against climate change and biodiversity loss, benefiting the wider natural environment, supporting our communities socially and economically, and underpinning the health and wellbeing of the population'*. There is limited land suitable for growing bioenergy crops and so this requires consideration of other land use priorities (such as food production, housing, woodland creation, peatland restoration, nature restoration and protection of ecosystems). An additional time and cost constraint to biomass planting is that Scottish Forestry would require an Environmental Impact Assessment (EIA) be

carried out if planting Short Rotation Coppice (SRC) in a sensitive area, such as a National Park.

5.14 Notwithstanding this context, in addition to the technologies list above, an assessment of the potential planted biomass resource in the National Park was undertaken, the results of which are presented in chapter 12. The assessment represents the technical potential for biomass fuel within the National Park. However, this must be interpreted within its broader land use context.

Policy considerations for hydrogen technologies

5.15 This study has not considered hydrogen in further detail. National policy supports Scotland's renewable energy resource and deployment of hydrogen production technologies, with hydrogen expected to play an important part, alongside renewables, in the national energy system. The Scottish Government published the Hydrogen Policy Statement⁴² in 2020 and Hydrogen Action Plan in 2022⁴³, which set the ambition for 5GW of hydrogen production capacity by 2030 and 25 GW by 2045. NPF4 Policy 11 provides high level planning policy support for the development of emerging low-carbon and zero emissions technologies, including renewable and low-carbon hydrogen production.

5.16 National policy focuses on industrial scale hydrogen development, 'hydrogen hubs' (in other areas of Scotland) and focus on its use in heavy industry. It is not considered that hydrogen will play a central role in the overall decarbonising of domestic heat, although this is being trialed in some areas of the country (such as Fiife's H100 project).

5.17 Demand for the development of hydrogen technologies in the National Park was not identified through the literature review, consultation with constituent local authorities, stakeholders or review of planning application history. Renewable and low-carbon hydrogen technologies are ideally located close to large-scale renewable resources and therefore, opportunities for hydrogen production are likely to be more limited in the National Park than in other areas of Scotland.

⁴¹ Scottish Government (2024) Draft Bioenergy Policy Statement – consultation (see: <https://www.gov.scot/publications/draft-bioenergy-policy-statement/>)

⁴² Scottish Government (2020) Hydrogen Policy Statement (see: <https://www.gov.scot/publications/scottish-government-hydrogen-policy-statement/>)

⁴³ Scottish Government (2022) Hydrogen Action Plan (see: <https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2022/12/hydrogen-action-plan/documents/hydrogen-action-plan/hydrogen-action-plan/govscot%3Adocument/hydrogen-action-plan.pdf>)

5.18 There may be opportunities to develop small-scale hydrogen production facilities within the National Park in the future, this will depend on the availability of other low-carbon and renewable energy sources, water availability, grid capacity and other technical constraints. Subject to demand trends and the integration of hydrogen technologies in other parts of the country, the National Park Authority may need to consider planning implications for the development of hydrogen technologies in the future.

5.19 Within the context of the National Park and this study, the production of guidance relating to hydrogen technologies has not been considered further in this study.

Existing operational and consented renewable energy installations in the National Park

5.20 There are already several larger scale renewable energy developments in the National Park. Hydro schemes have the highest electricity output, providing over 90,000 MWh per year. Existing developments must be considered when assessing the potential cumulative impacts of development. It is not possible to identify an exact figure for the amount of existing renewable energy generation across the National Park, and there are numerous datasets available providing information on renewable energy deployment across the UK. As such, the mapping of existing renewable developments within the National Park included within Figure 5.1 at the end of this chapter is not exhaustive.

5.21 Further sources of information could be referred to as part of further study, but caution should be taken so as not to double-count installations that are included within multiple data sources.

5.22 Existing and consented renewable energy developments are presented in Figure 5.1. This draws on:

5.23 Department for Energy Security & Net Zero's (DESNZ) July 2024 Renewable Energy Planning Database (REPD)⁴⁴.

- This data lists all renewable electricity projects over 150kW and was accessed at the start of the study and used to estimate the current deployment of larger-scale renewable developments within the National Park.

- Note however that the minimum threshold for installed capacity was 1MW until 2021, at which point it was lowered to 150kW. This means that projects below 1MW that were going through the planning system before 2021 may not be included.

5.24 Loch Lomond & The Trossachs National Park Authority Small Scale Hydro Renewable Energy Developments (2024)⁴⁵.

- This data lists hydroelectricity projects within the National Park, and was provided by the National Park Authority.

- It was assumed that this data was more accurate than the DESNZ, and was used to represent all small hydro developments within the National Park for this study.

5.25 Local Energy Scotland Projects Index (2024)⁴⁶.

- This data includes community benefit, shared ownership and community & local owned renewable energy projects.

- This data was used to supplement the above two datasets.

5.26 Figure 5.1 only includes projects that were registered as operational and consented at the time of preparing this report using the sources listed above. To note, operational and consented developments have been included in the figure because consented development will be operational in the future, so it provides the most up to date information on emerging renewable energy developments within the local planning authority.

⁴⁴ Department for Business, Energy and Industrial Strategy (2014, updated 2024) Renewable Energy Planning Database: quarterly extract [online]. Available at: <https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract>

⁴⁵ Loch Lomond & The Trossachs National Park Authority Small Scale Hydro Renewable Energy Developments, as sent to LUC on 19/08/2024, and additional information provided via email on 07/01/2025.

⁴⁶ Local Energy Scotland (2024) Projects Index[online]. Available at: https://localenergy.scot/projects-overview/map/?project_type=&project_stage=&local_authority_id=&area_of_benefit-la=&area_of_benefit-cc=&colo=&project_owner=

Table 5.1 Existing operational and consented renewable development in the National Park, including capacity, output and CO2 savings.

Source	Technology	Estimated total capacity (MW)	Electricity output (MWh/year)	Potential CO2 savings (tonnes/yr)
Operational				
REPD and Local Energy Scotland	Biomass (dedicated)	5.98	29,722	3,953
LLTNPA data and Local Energy Scotland	Hydro (LLTNPA data and Local Energy Scotland)	27.59	92,312	12,278
Consented (permitted/under construction)				
REPD	Solar Photovoltaics - Roof	0.18	142	19
	Total operational and consented	33.76	122,176	16,249
Abandoned				
REPD	Hydro	2.00	6,691	890
Withdrawn				
REPD	Wind Onshore	4.00	8,924	1,187
Planning permission refused / appeal refused				
REPD	Wind Onshore	20.00	44,621	5,935

Generic design guidance

5.27 The initial assessment led to the identification of a series of generic design siting and design guidance for all technologies which covers landscape, landscape character types (LCTs) and cultural heritage. These are presented in the table below which is referred to throughout the subsequent chapters (6-11). Figure 5.2 shows the location of the main LCTs across the National Park.

All technology types	
Generic siting and design guidance (landscape)	<p>The following siting and design guidance is applicable to all Landscape Character Types (LCTs):</p> <p>Evaluate and assess all development proposals to ensure that they do not adversely affect the Special Landscape Qualities (SLQs) of the National Park, as set out in <i>NatureScot Commissioned Report 376: The Special Landscape Qualities of the Loch Lomond and The Trossachs National Park</i>;</p> <p>Evaluate and assess all development proposals to ensure they reinforce and, where possible enhance, local distinctiveness and local landscape and settlement character;</p> <p>Reinforce and enhance the sense of place through careful design (including siting, massing, scale and materials) to minimise the impacts of any new development;</p> <p>New structures should respond to the existing topography and avoid large earthworks that contrast with landform and may make the structures appear more conspicuous;</p> <p>Materials and colours should be simple and reflect the landscape and geology around them, as well as the vernacular building style;</p> <p>Protect and enhance key views within, to and from the National Park;</p> <p>Retain existing vegetation along site boundaries where possible, and supplement with new tree and hedgerow planting to enhance landscape patterns where appropriate;</p>

All technology types	
	<p>Utilise existing roads and tracks for site access wherever possible. For new roads and tracks, consider how these can fit in with the landscape character and complement the pattern of existing road networks;</p> <p>To minimise the effects of light pollution, minimise the use of lighting in particular blue light emissions and use shielding and sensors effectively to direct lighting downwards; and</p> <p>Consider how the scheme fits with other similar proposals in the area in terms of cumulative effects and in-combination effects.</p>
LCT-specific siting and design guidance	<p>Siting and design guidance is provided below for each LCT within the National Park, with reference to the key characteristics described in NatureScot's National Landscape Character Assessment (2019).</p> <p>LCT 215 – Open Ridgeland – Glasgow & Clyde Valley:</p> <p>Retain and protect important habitats including broadleaved woodland; and</p> <p>Retain and protect the “<i>undeveloped character</i>” of the LCT.</p> <p>LCT 250 - Steep Ridges and Hills:</p> <p>Retain and protect “<i>views along the sea lochs</i>” to hills which form key landmark features; and</p> <p>Retain and protect the relative sense of remoteness within the LCT.</p> <p>LCT 251 Highland Summits:</p> <p>Retain and protect important habitats including the “<i>semi-natural grassland with patchy heather and ground-hugging alpine species</i>”, bog on glen floors, rare broadleaf woodland and “<i>fragments of oak and birch</i>”;</p> <p>Retain and protect the ‘<i>distinct sense of wild character of the summits</i>’ away from hydro-electric infrastructure and forestry;</p> <p>Retain and protect the “<i>extensive views</i>” from high summits which are popular with hill walkers; and</p>

All technology types	
	<p>Retain and protect views towards the “<i>Instantly recognisable mountain forms such as the Cobbler and Ben Lomond</i>” and “<i>important landmark features</i>” of Ben Ledi, Ben Vorlich and Ben Lomond.</p> <p>LCT 252 – Upland Glens:</p> <p>Retain and protect important habitats including the “<i>Notable ancient and semi-ancient woodlands of oak and birch in some glens</i>” and “<i>Relict wood pasture and Caledonian pine woodlands</i>”;</p> <p>Retain and protect the “<i>Significant cultural features in more open glens, including shielings and abandoned field systems</i>”; and</p> <p>Retain and protect the “<i>Classic views channelled up and down the Glens</i>”.</p> <p>LCT 253 - Straths and Glens:</p> <p>Retain and protect important habitats including the “<i>Scattered trees and remnants of native woodland</i>”, “<i>riparian woodland</i>” and “<i>Mixed policy woodlands and avenues of trees</i>”;</p> <p>Retain the current pattern of built development whereby “<i>Settlements and farms are located on lower side slopes, raised above the floodplain, and often tucked between knolls. Settlements tend to be sited at bridging points or at the junction with side glens</i>”; and</p> <p>Retain and protect views along the open strath and glen floors “<i>...along and across the traditional farmed landscapes, attractive river landscapes and lochs, as well as the dramatic Highland setting of the surrounding rugged slopes and mountain summits</i>”.</p> <p>LCT 254 - Straths and Glens with Lochs:</p> <p>Retain and protect the appreciation of “<i>Subtle promontories and narrow beaches...on loch shorelines</i>” in long views down the lochs;</p> <p>Retain and protect the “<i>variety of structures including dams and aqueducts – many of these comprise distinctive 19th Century structures</i>”;</p> <p>Retain the current pattern of built development comprising “<i>Scattered traditional dwellings or clusters of buildings usually located close to alluvial</i></p>

All technology types	
	<p><i>pastures at the intersection with side glens and water courses on some loch shores</i>”; and</p> <p>Retain and protect the long views “<i>across open water to the Highland Summits</i>”.</p> <p>LCT 255 – Parallel Ridges – Loch Lomond & the Trossachs:</p> <p>Retain and protect views towards the Parallel Ridges, which are described as “<i>Highly visible and important landmarks in local and wider landscapes, contributing to the highly scenic character of the Highland Boundary Fault Zone</i>”;</p> <p>Retain and protect important habitats including broadleaf woodland on some hill faces and species-rich grassland in the narrow channels between ridges;</p> <p>Retain and protect “<i>Historic and prehistoric features</i>”.</p> <p>LCT 256 – Rolling Forested Plateau:</p> <p>Retain and protect the “<i>Dramatic views from the Duke’s Pass over the intensely rugged Ben Venue and Loch Ard at the heart of the scenic and celebrated Trossachs</i>”.</p> <p>LCT 257 – Plateau Moor and Forest – Loch Lomond & the Trossachs</p> <p>Retain and protect important habitats including blanket bog which overlies the rounded summits and plateau landforms; and</p> <p>Retain and protect the “<i>Elevated views to Conic Hill and Loch Lomond from Moor Park</i>”.</p> <p>LCT 258 – Ridges and Knolls with Estates</p> <p>Retain and protect important habitats including “<i>Diverse mixed policy woodlands and some remnant parkland</i>” and “<i>Ancient and semi-natural woodlands</i>” covering the prominent isolated knolls; and</p> <p>Retain and protect the “<i>highly scenic composition</i>” of the landscape resulting from its “<i>Complex landform and intricate land-cover pattern</i>” as seen on the approach to the National Park.</p>

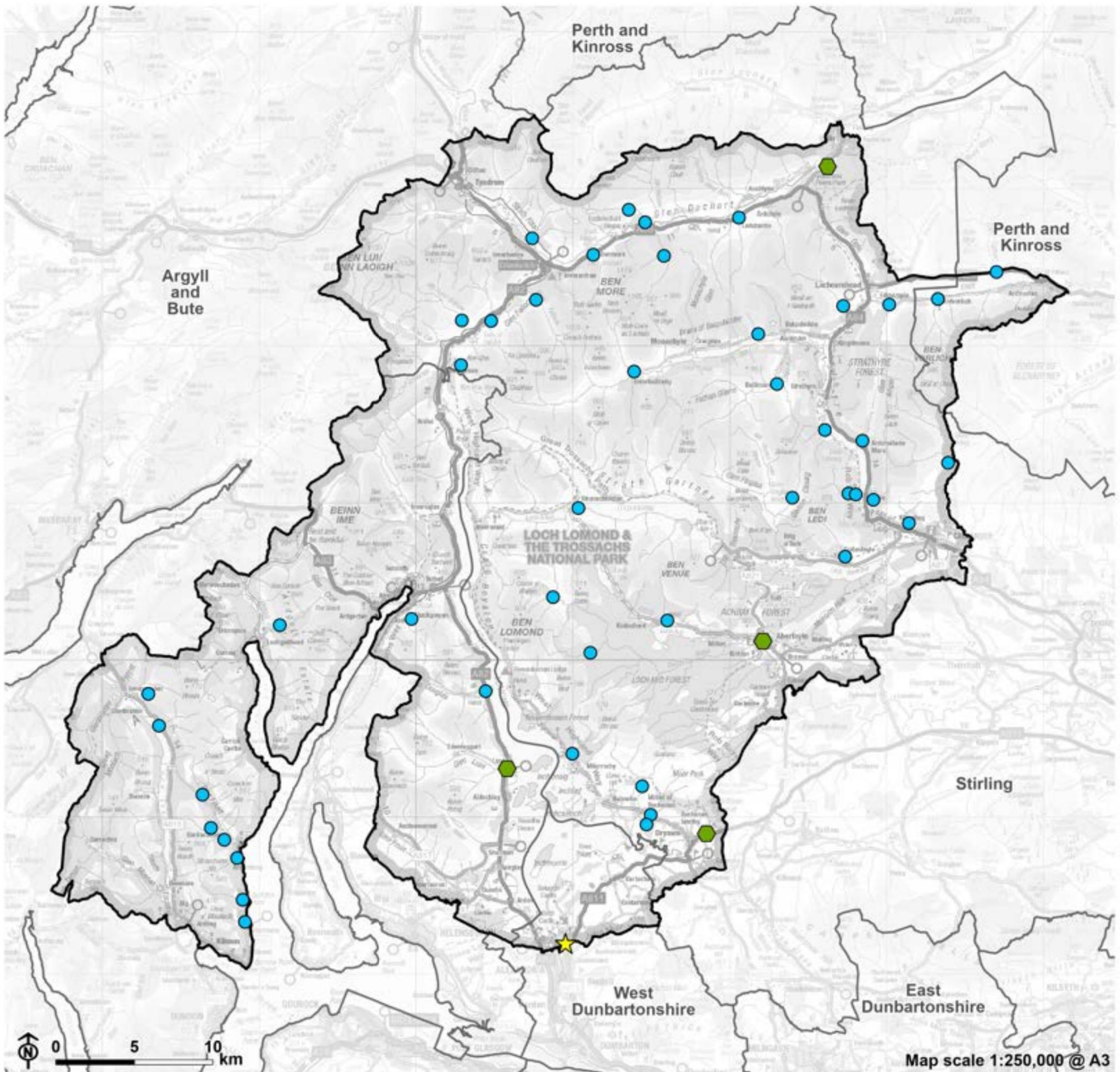
All technology types	
	<p>LCT 260 – River Valley Farmland and Estates:</p> <p>Retain and protect the character of “<i>Estates and their wooded policies</i>” including boundary walls, gates and lodges; and</p> <p>Retain and protect important habitats including “<i>Occasional mature broadleaf trees</i>” along roads and field boundaries and “<i>boundary trees of ash, oak and beech</i>” on upper slopes west of Drymen.</p> <p>LCT 261 - Rolling Farmland - Loch Lomond & the Trossachs:</p> <p>Retain and protect views towards the “<i>Small hill of Duncryne, a key landmark feature</i>”;</p> <p>Retain and protect important habitats including the ash and beech trees which line some roads, as well as “<i>rush-patterned damp pastures and small remnant moss with stands of birch</i>”; and</p> <p>Retain and protect the “<i>Breathtaking views of Loch Lomond and the high peaks which surround it from more open and elevated areas</i>”.</p> <p>LCT 262 – Lowland Peatland and Loch Basin</p> <p>Retain and protect important habitats including “<i>Lowland raised bog, interspersed and contrasting with semi-improved grazing land</i>” and broadleaf woodland around the Lake; and</p> <p>Retain and protect the “<i>extensive views to the dramatic scarp of the Parallel Ridges – Loch Lomond and the Trossachs and the Highland landscapes of the National Park</i>” from the Lake of Menteith.</p> <p>LCT 263 - Lowland Loch Basin - Loch Lomond & the Trossachs:</p> <p>Retain and protect important habitats including “<i>Extensive native oak dominated woodlands</i>” and “<i>wisps of birch threading up through narrow gullies</i>”;</p>

All technology types	
	<p>Retain and protect the “<i>designed landscapes with mixed policy woodlands and parkland</i>”; and</p> <p>Retain and protect the “<i>Highly scenic landscape composition of island, water and indented shoreline, especially when viewed from surrounding hills and the south of the loch</i>”.</p> <p>LCT 264 – Lowland Loch Basin Islands:</p> <p>Retain and protect important habitats including “<i>broadleaf, oak-dominated woodland</i>” and Yew trees at Inchlonaig;</p> <p>Retain and protect the “<i>many archaeological features</i>”; and</p> <p>Retain and protect the “<i>unique and highly scenic composition particularly appreciated from elevated views</i>” which results from the pattern of water, islands and indented shoreline of Loch Lomond.</p>
Generic historic environment guidance	<p>Historic buildings, places and archaeological sites, known collectively as historic assets, largely derive their significance from their physical remains and the contribution their setting can make to the way they are understood, appreciated and experienced. It is important to understand the significance of a historic asset or assets to determine their likely sensitivity to the proposed change, and the impacts from the introduction of renewable technologies.</p> <p>While all historic assets evidence past human activity, contribute to our sense of place and are given consideration in the planning system, some historic assets are provided by a higher level of protection through designation. These include scheduled monuments, listed buildings, conservation areas and Gardens and Designed Landscapes.</p> <p>Changes to designated historic assets may require specific consent. In the first instance seek advice from Historic Environment Scotland in relation to scheduled monuments,⁴⁷ and the local planning authority for listed buildings, changes within a conservation area and Gardens and Designed Landscapes.</p>

⁴⁷ It should be noted that scheduled monument consent (SMC) is unlikely to be granted for any development with likely physical effects on such an asset.

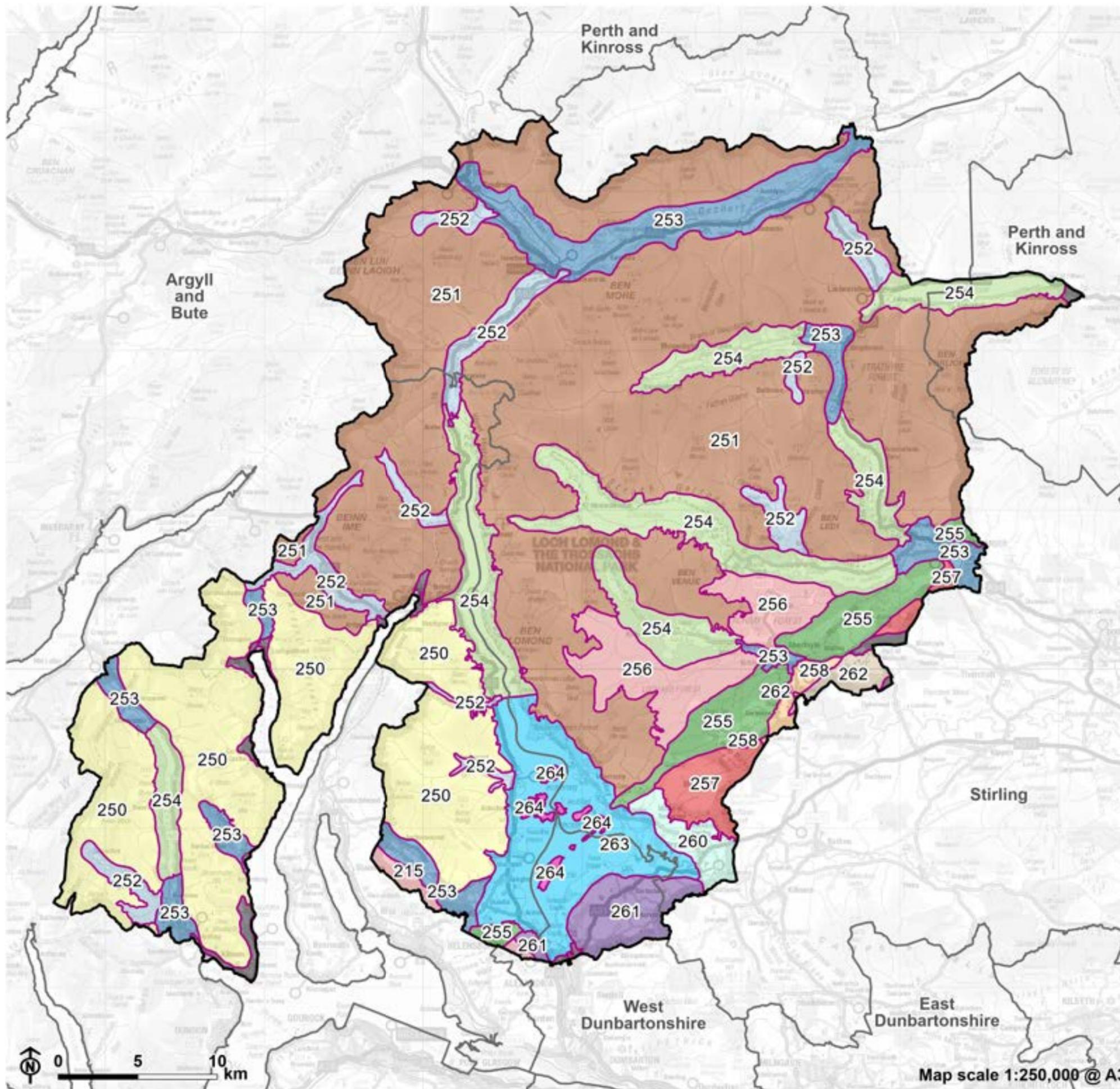
All technology types	
	<p>Historic buildings and places are often capable of accepting sensitively sited and designed micro-renewable technologies, such as air source heat pumps, without affecting their significance. However, the installation of micro-renewable technologies may have impacts on the fabric of historical buildings and this should be a key consideration during installation.</p> <p>By their nature larger renewable projects, such as solar farms and battery energy storage, are more likely to adversely affect historic assets. Where planning consent is required, historic environment sensitivities need to be understood at an early stage, and involve engagement with the planning authority's archaeological and conservation advisers. Impacts will be considered as part of the consenting process.</p> <p>Renewable projects of any size should seek to avoid, reduce or minimise historic environment impacts through careful siting and design, preserving a historic asset's significance, and the character of historic buildings and conservation areas. This specifically should include:</p> <ul style="list-style-type: none"> ■ Locating away from historic buildings or avoiding installation on principle elevations or visibly dominant roofs. ■ Considering the installation of equipment on the internal features of historic buildings and structures which may result in harm. ■ Consider any ground disturbance during the construction of technologies including small-scale domestic installation, such as the excavation of cable trenches, which have the potential to remove or truncate buried archaeological remains that may be present. <p>For micro-renewables affecting a designed historic asset, such as a listed building, or for large projects requiring planning consent, advice may be available from the local planning authority. Further speciality historic environment advice may be required to understand the significance of historic assets, the potential for archaeological remains and identify potential historic environment impacts. They can also provide advice on how to avoid, reduce, minimise or mitigate historic environment impacts.</p>

Figure 5.1 Existing and consented renewable energy installations within Loch Lomond and The Trossachs NPA



Loch Lomond and The Trossachs NPA
Figure 5.1: Existing and consented renewable energy installations within Loch Lomond and The Trossachs NPA

- Loch Lomond and the Trossachs National Park
- Local Authority
- Technology**
- Biomass (dedicated)
- Solar photovoltaics
- Small scale hydroelectric



- Loch Lomond and the Trossachs National Park
- Local Authority
- Landscape Character Type**
- 215: Open Ridgeland - Glasgow & Clyde Valley
- 250: Steep Ridges and Hills
- 251: Highland Summits
- 252: Upland Glens - Loch Lomond & the Trossachs
- 253: Straths and Glens
- 254: Straths and Glens with Lochs
- 255: Parallel Ridges - Loch Lomond & the Trossachs
- 256: Rolling Forested Plateau
- 257: Plateau Moor and Forest - Loch Lomond & the Trossachs
- 258: Ridges and Knolls with Estates
- 260: River Valley Farmland and Estates
- 261: Rolling Farmland - Loch Lomond & the Trossachs
- 262: Lowland Peatland and Loch Basin
- 263: Lowland Loch Basin - Loch Lomond & the Trossachs
- 264: Lowland Loch Basin Islands
- Other

Overview of the technology

Solar power works on the principle of taking energy from the sun and using that to generate power. There are two different types of solar technology - solar photovoltaics (solar PV) and solar thermal.

Solar PV turns sunlight into electrical energy. It can be useful for domestic use (providing electricity to the home including to run other low-carbon technologies such as heat pumps). At a commercial/industrial scale it can substantially reduce the carbon emissions of businesses. At a large-scale (i.e. solar farms) it can generate energy to supply the national grid. Technologies are commonly found in the following forms:

- Roof-mounted solar PV can come in the form of solar panels, PV roof tiles and flexible panels. Wall-mounted panels can also be installed on south-facing walls.
- Ground-mounted solar PV can range from domestic scale to large-scale solar farms. Technologies can come on rack-mounted metal framing which is driven into the ground to hold solar panels at a fixed upwards angle. Some of these arrays can be adjusted manually several times a year, allowing operators to account for seasonal shifts in the sun. Other examples can be found on pole-mounted systems which support multiple panels on a single pole. These can elevate panels higher off the ground than standard mounts and can include tracking systems allowing panels to tilt automatically, maximising sun exposure throughout the day.

Solar thermal panels turn sunlight into heat. They can be used to generate thermal energy for use in industry, in commercial sectors and for domestic use. They can be used with a heat exchanger to supplement hot water or central heating system. Solar thermal panels are most commonly roof mounted and are similar in appearance and construction impacts to solar PV.



Top: Roof-mounted solar PV (Freepik) Bottom: Ground-mounted solar (LUC)

Size/scale

Roof-top systems can vary in size and scale depending on the needs of the home or business. Typical domestic solar panel dimensions are approximately 1x2m, however they can come in a range of sizes and solar arrays could be anything between a few panels to a system covering the entire roof of a large building.

The scale of solar farms will depend on the size of the available land parcel, but panels will generally be mounted on structures a few metres off the ground. Due to the requirement for relatively flat, open and unobstructed land, solar farm development is typically found on agricultural land.

Power output / storage	<p>The energy output of solar installations will depend on the number of panels installed, their position and orientation (including any shading) and the level of solar irradiance. A system can be designed to meet the energy needs of the home, business or operation, assuming sufficient suitable space is available. Therefore, solar can be developed at a broad range of capacities.</p> <p>Domestic systems may range from 2kW to 5kW+ depending on the size and needs of the home, and the roof space available⁴⁸. Industrial and business needs will likely require higher energy capacities. Larger-scale solar developments such as solar farms can produce up to around 5MW of energy on approximately 25 acres of land⁴⁹.</p>
Colour	<p>Solar panels are typically blue / black in colour. Selecting solar panels in a matte or non-reflective finish which relates as closely as possible to the material, colour and finish of the existing roof covering can ensure they are less visible.</p>
Positioning	<p>Rooftop installations are generally suitable on unshaded south-west to south-east facing roofs, pitched between 20-60°. On flat roofs, panels are pitched on tilted frames.</p> <p>For larger ground-mounted solar farms, the most suitable sites for development are likely to be in proximity of a grid connection (i.e. a substation with suitable capacity), have suitable road access for transportation of materials, be located away from 'prime' agricultural land, be generally flat or on a gentle south-facing slope and be unshaded.</p>
Construction / operation impacts	<p>Building-mounted solar installations will likely require the erection of scaffolding to install solar panels on the roof. Preliminary assessments for a householder/business intending to install rooftop solar installations may include structural surveys, ensuring the roof can accommodate the weight of panels. It will also require confirmation that there is sufficient solar irradiance to achieve the required levels of energy generation, and an inspection of the roof to determine the presence of bats or roosts which are protected by law. There may be landscape and visual impacts including glint and glare depending on the visibility of the rooftop installations from the surrounding area. Additionally, direct and indirect cultural heritage impacts will likely require assessment, particularly when installations are in sensitive areas such as a conservation area or on a listed building.</p> <p>Ground-mounted installations will require metal frames to hold the solar panels up. Depending on the location and scale of the development, construction impacts may include construction noise, traffic impacts, and impacts on surrounding residential amenity and land use. Key environmental considerations for the assessment of solar PV applications are likely to include landscape and visual impacts including glint and glare in visible locations. Other considerations such as the quality of agricultural land, archaeological sensitivity, hydrological or ecological impacts will need to be factored in depending on the location of the development and site-specific context. Solar farm proposals at a particular scale, or within a sensitive area, may require Environmental Impact Assessment (EIA).</p>
Infrastructure / access	<p>For domestic solar installations an inverter is needed to produce an alternating current to run household lighting, heating, appliances and devices.</p> <p>Ground-mounted installations will require mounting structures, fencing, lighting and CCTV, cabling, transformers and suitable road access. Cabling usually needs to be trenched into the ground to prevent damage. Solar installation may benefit from being co-located with a battery storage system to maximise the efficiency of the scheme.</p>

⁴⁸ Green Match (see: <https://www.greenmatch.co.uk/solar-energy/solar-panels/sizes>)

⁴⁹ Solar Fast (see: <https://solarfast.co.uk/blog/solar-farms/>)

Scope of existing guidance	Solar PV and solar thermal (both domestic/building mounted or ground mounted) are not covered within the existing planning guidance document.
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Technical Potential in the National Park

Ground mounted solar

6.1 The technical potential of ground mounted solar could not be assessed due to the number of variables. It is beyond the scope of this project to map all potential constraints, such as buffer distances between solar developments and different width of road. Moreover, as the National Park is primarily focusing on micro-scale technologies, these have the ability to be carefully micro-sited to consider nearby constraints. As such it is not appropriate for this strategic-scale study to merge all constraints to identify an area of "unconstrained" land with potential for solar development, as it has for biomass virgin wood fuel technologies. Although it should be noted that ground mounted solar has the potential to generate larger quantities of energy than roof mounted solar which tends to produce energy for individual domestic use.

Roof mounted solar

6.2 Analysis was undertaken to identify the theoretical extent that rooftop solar can be accommodated in the National Park.

6.3 The total potential capacity of roof mounted solar was estimated based on typical system sizes and the estimated percentage of suitable roof space within the study area. Roofs that have potential to deliver solar PV panels also have the potential to deliver solar water heating generation. However, this was treated as being mutually exclusive with solar PV potential, i.e. the same roof space can only be utilised for one of the technologies. Generation potential was therefore calculated for each technology for separate comparison. Appendix A provides a full breakdown of the methodology for these calculations.

6.4 It was assumed that 40% of domestic properties would be suitable for rooftop solar PV, combined with an estimated 75% of non-domestic properties. In total these would have an estimated capacity of 19.07 MW⁵⁰.

6.5 Based on the same estimates of rooftop suitability, domestic and non-domestic properties could provide an estimated rooftop solar heating capacity of 23.22 MW. However, it should be noted that a single area of roof space can only be used for either solar PV panels or solar water heating panels. For example, a 10m² roof space can either be used for 10m² of rooftop solar PV panels, or 10m² of rooftop solar water heating panels, or a combination e.g. 5m² of solar PV panels and 5m² for solar water heating panels. As such, this assessed total potential capacity for solar water heating is mutually exclusive with the assessed potential for rooftop solar PV.

6.6 Figure 6.1 shows the technical potential for rooftop solar photovoltaics. It shows the average system size by property type. This shows that areas with potential for rooftop solar PV are concentrated within the main settlements. It also shows wider potential on detached and non-domestic buildings out with the main settlements and along the main transit routes where detached homes and non-domestic buildings which can accommodate a larger solar array (such as farm buildings) are more common.

6.7 It is noted that this study does not account for potential constraints to rooftop solar developments, such as the presence of listed buildings and conservation areas. Most standard installations of solar panels on existing buildings are considered to be permitted development and therefore do not normally require planning consent. An overview of permitted development rights (PDR) is provided in **Chapter 3** of this report and, with specific regard to solar, within the 'planning considerations' section of this chapter. Further study would be required to assess the

⁵⁰ Equivalent of the power output of EDF Energy Renewables Pearie Law wind farm, comprising six turbines in West Lothian.

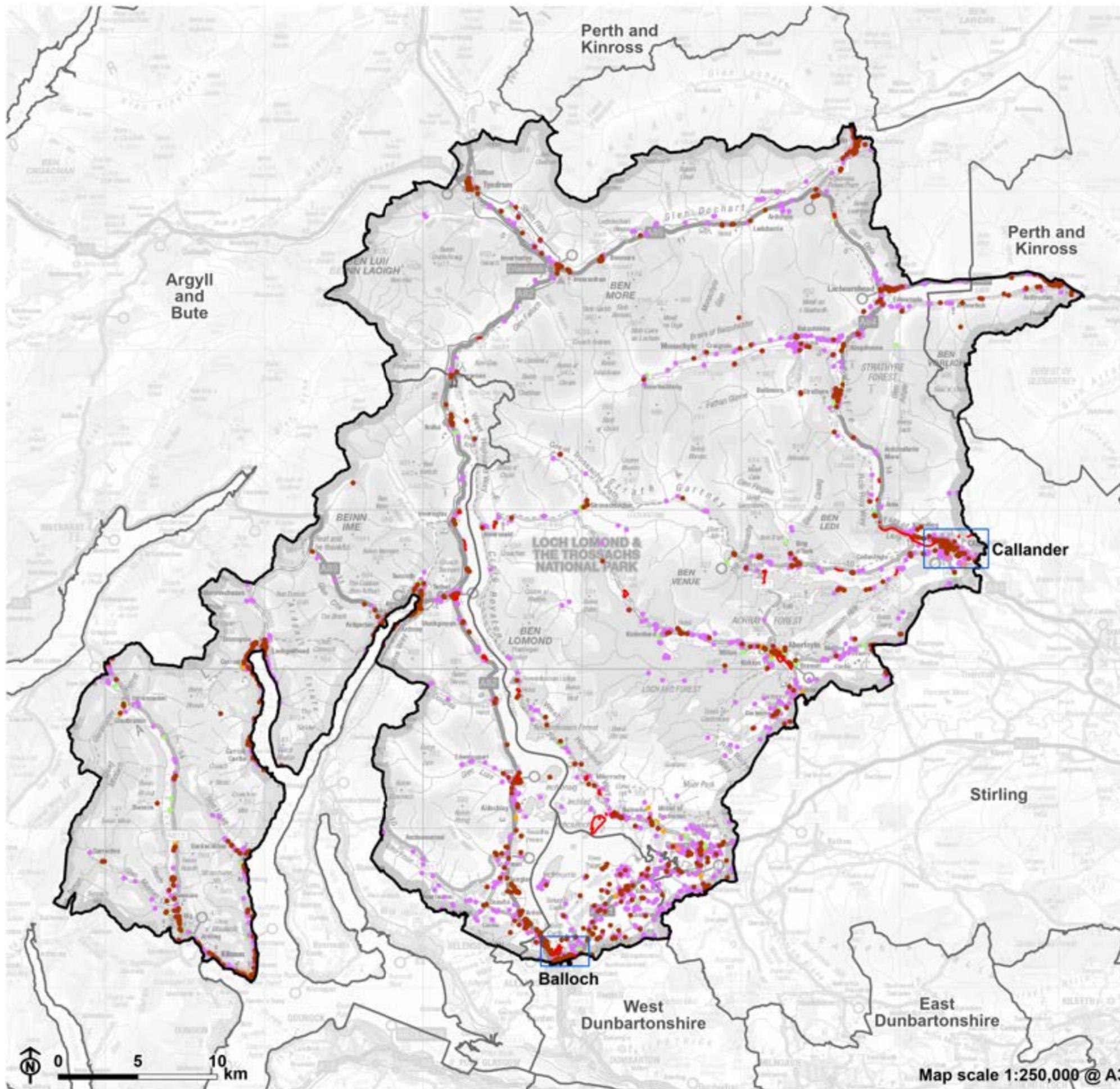
suitability of roof space for solar panel installations on listed buildings and within conservation areas, as well as to consider other constraints to rooftop solar development, such as:

- Landscape impacts;
- Roof surface material/construction;
- Roof structure and loading capacity;
- Protected species – bat roosts;
- Protected species – bird nests; and
- Grid connection (for larger developments).

6.8 Figure 6.2 and Table 6.1 summarise the estimated technical potential for roof-mounted solar PV in Loch Lomond.

6.9 If the full technical capacity of rooftop Solar PV in the National Park was to be achieved there is the potential for 2,764.25 tonnes of carbon emissions to be saved per year. This is a relatively small contribution to overall carbon emissions in the National Park, especially those associated with domestic electricity. However, the role of rooftop solar PV in assisting reducing emissions from buildings should not be discounted, especially where this is a suitable and easily implemented technology for a particular property.

Figure 6.1: Technical potential for rooftop solar photovoltaics (PV)



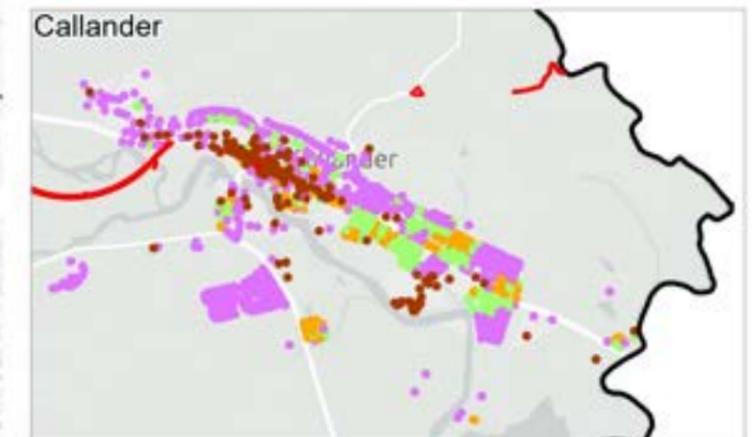
Loch Lomond and the Trossachs National Park

Local Authority

Loch Lomond and the Trossachs National Park Authority estate

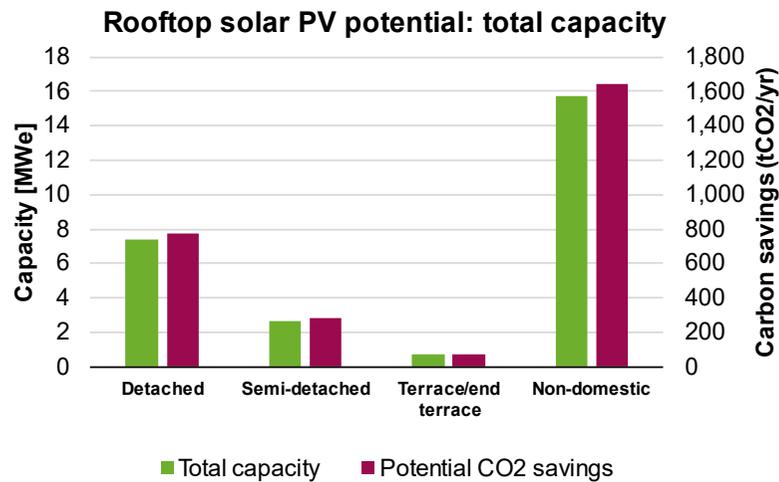
Solar PV potential - average system size by property type

- Terraced: 1.7 kW
- Semi-detached: 3.4 kW
- Detached: 5.2 kW
- Non-domestic: 12.8 kW



Notes:

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Figure 6.2 Estimated total capacity (MWe) and potential CO₂ (tCO₂/yr) savings for rooftop solar PV

(tonnes/yr) savings for rooftop solar PV

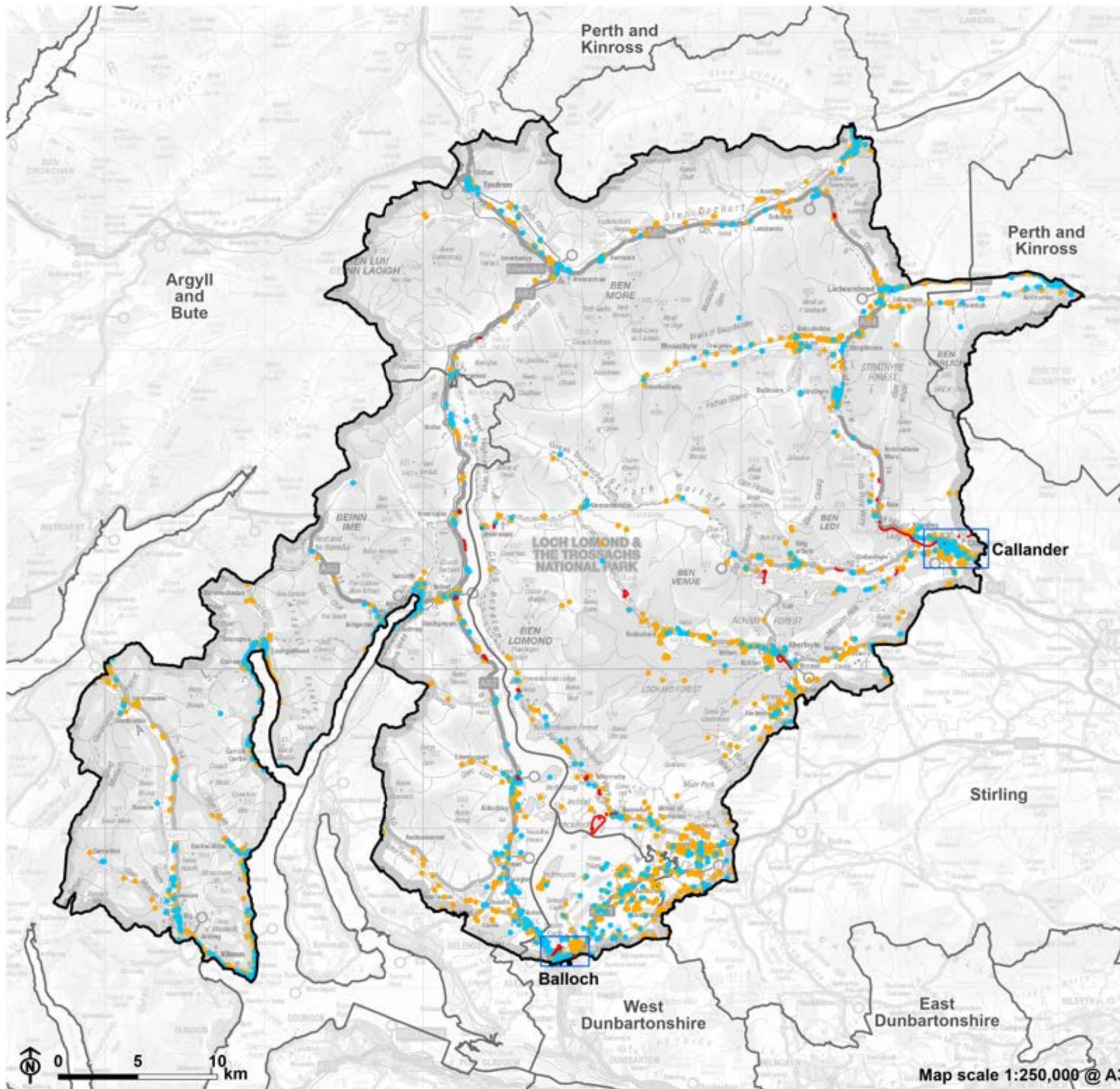
Building Category	Estimated capacity (MW)	Electricity output (MWh/year)	Potential CO ₂ savings (tonnes/year)
Detached	7.36	5,785.58	769.48
Semi-detached	2.66	2,094.11	278.52
Terrace/end terrace	0.69	543.82	72.33
Non-domestic	15.72	12,360.37	1,643.93
Total	19.07	20,783.88	2,764.26

6.10 Figure 6.3 shows the potential for rooftop solar water heating within the National Park. It shows that there are similar amounts of both the larger 18.8 kW non-domestic and the smaller 2.8 kW domestic rooftop solar water heating systems concentrated within the main settlements

as well as along the main transit routes. Figure 6.4 and Table 6.2 summarise the estimated technical potential for roof-mounted solar water heating in Loch Lomond.

6.11 The greenhouse gas emission assessment identified much greater carbon emissions associated with household fuel than household electricity. The identified carbon emission saving from achieving the full technical potential of domestic rooftop solar water heating is much lower than those for rooftop solar PV. The contribution this technology can make towards meeting emission reduction targets for household fuel is therefore relatively minimal. This technology may have more benefit if installed on non-domestic properties, however, its contribution towards overall emissions targets is still small. Despite this it is important that the technology is not discounted, especially where it is a suitable and easily implemented technology for a particular building.

Figure 6.3: Technical potential for rooftop solar water heating



- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate

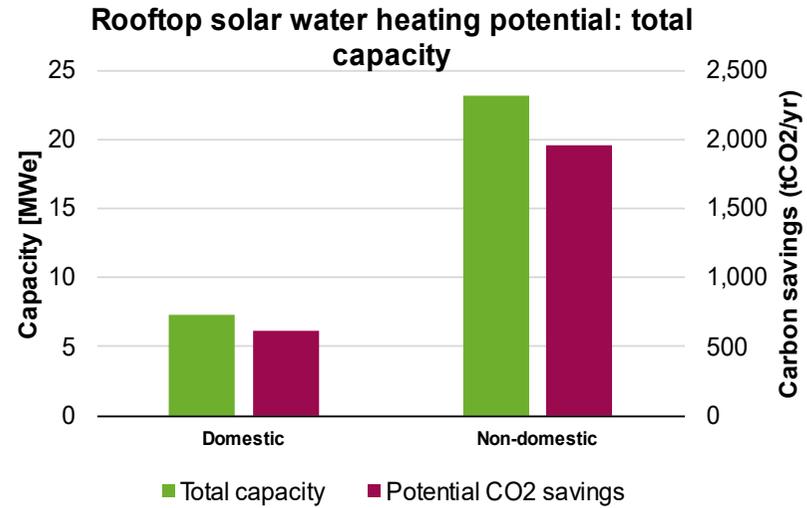
Solar water heating potential - average system size

- Non-domestic: 18.8 kW
- Domestic: 2.8 kW



Notes:

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Figure 6.4 Total estimated capacity (MWe) and potential CO₂ savings (tCO₂/yr) for rooftop solar water heating in Loch Lomond.Table 6.2 Estimated capacity (MWth), electricity output (MWh/year) and potential CO₂ savings (tonnes/yr) for rooftop solar water heating.

Building Category	Estimated capacity (MWth)	Electricity output (MWh/year)	Potential CO ₂ savings (tonnes/year)
Domestic	7.28	2,871.54	615.79
Non-domestic	23.22	9,152.73	1,962.77
Total	23.22	12,024.28	2,578.56

Locational considerations and constraints

6.12 Figure 6.5 demonstrates locations of annual solar irradiance. Higher annual solar irradiance levels will have the potential to generate larger yields of solar power and therefore be more attractive to developers. The highest concentration of these locations is along the eastern edge of the National Park and towards the south.

Ground mounted solar PV or solar thermal

Planning considerations

6.13 Householder PDR under Class 3B allow for the carrying out of works within the curtilage of a dwellinghouse, which includes free-standing solar panels or solar thermal. Class 3B PDR do not apply in conservation areas or within the curtilage of a listed building. As outlined above, non-domestic PDR do not apply within the National Park for building or ground mounted solar PV or solar thermal.

6.14 The following sections outline the issues that need to be considered before a planning application for rooftop or ground mounted solar PV or solar thermal is submitted.

6.15 In particular for ground mounted solar, the size of solar array will influence the type of ancillary infrastructure required. Consideration should be given to the impacts of access tracks, security fencing and components such as substations and power lines.

Environmental considerations

Natural heritage considerations

6.16 The introduction of NPF4 requires all development to contribute to the enhancement of biodiversity, integrating nature-based solutions where possible. Policy 3(c) requires that local development proposals 'include appropriate measures to conserve, restore and enhance

biodiversity, in accordance with national and local guidance. Measures should be proportionate to the nature and scale of development'. This policy requirement does not apply to individual householder development. NatureScot has produced 'Developing with Nature' guidance⁵¹ to support the delivery of Policy 3(c).

6.17 All renewable energy developments within the National Park need to be screened to determine whether an EIA is required. All developments requiring an EIA, are covered by NPF4 policy 3(b) which requires development to ensure that nature networks are in a 'demonstrably better state' than without intervention and 'significant biodiversity enhancements' are provided. The Scottish Government has published draft planning guidance⁵² on the delivery of the cross-policy outcome of 'improving biodiversity'. The draft guidance is intended to be a living documentation and provides guidance on the implementation of policy 3 and policy 4, including use of an appropriate biodiversity metric for measuring enhancement⁵³. In addition NatureScot provide general pre-application advice and scoping advice for solar farms⁵⁴.

6.18 Figure 6.6 shows the natural heritage constraints for ground-mounted solar PV development. It shows that one of the largest constraints is the Great Trossachs Forest NNR in the centre of the National Park, another large area of constraint is the Glen Etive and Glen Fyne SPA in the north west of the National Park. Other key constraints in the National Park are the numerous SSSIs and SACs. The largest areas with fewer constraints to the development of solar energy are located in the north-east, south-west and south-east of the National Park.

6.19 The generic natural heritage considerations outlined in the existing guidance in relation to the habitat and species designations will apply (paragraphs 4.9 - 4.12). Ecological impacts from ground-mounted solar PV installations will often depend on site-specific factors. Proposals, including any associated infrastructure and access, may result in loss, fragmentation and modification of habitats. However, they also provide significant opportunity for habitat creation and biodiversity enhancement.

6.20 Design considerations for infrastructure should avoid impacts on trees, hedgerows, and areas of higher ecological sensitivity and habitat connectivity. Assessment of proposals should

⁵¹ NatureScot (2023) Developing with nature guidance (see: <https://www.nature.scot/doc/developing-nature-guidance>)

⁵² Scottish Government (2023) Biodiversity: draft planning guidance (see: <https://www.gov.scot/publications/scottish-government-draft-planning-guidance-biodiversity/>)

⁵³ A metric for Scotland has not been approved for use at the time of writing.

⁵⁴ <https://www.nature.scot/doc/general-pre-application-and-scoping-advice-solar-farms>

include consideration of how construction works (e.g. piling for mounting poles/frames), lighting installations, security fencing and changing land management practices may affect local ecology. The scale and scope of ecological surveys required will be proportionate to the scale and location of development and the site-specific context.

6.21 Potential impacts on protected and notable species – through potential habitat loss, displacement and disturbance - may include impacts on breeding, foraging and roosting birds, bats, and other protected species. The potential impact of security fencing may influence the movement of larger mammals, including protected species such as badgers. Collision risk for birds and bats for solar PV development is considered to be low.

6.22 Figure 6.7 shows soil constraints for the development of ground-mounted solar PV development. This includes the national soil map of Scotland, which demonstrates areas of peatland and high carbon soils across the National Park. The map demonstrates that there is a high concentration of vulnerable bare peat towards the northwest of the National Park.

6.23 Loss of carbon-rich soils, peat, and best and most versatile agricultural land should be minimised in accordance with NPF4 Policy 5. However, it should be noted that construction and operation of ground-mounted solar will not lead to long-term degradation or loss of soils.

6.24 There are many opportunities to enhance the natural capital value of ground-mounted solar development and contribute to biodiversity enhancement. Implementable measures are likely to be site-specific and proportionate to the scale of development. However, appropriate interventions may include enhancement and improved habitat connectivity of hedgerows and field margins, tree planting, and sowing of native species rich grassland communities.

Landscape and visual considerations

6.25 Figure 6.8 shows where the physical constraints to the development of ground-mounted solar PV are located in the National Park. Physical constraints include infrastructure such as roads and railways, as well as buildings, open space and watercourses / bodies. It shows that larger settlements in the National Park, such as those to the south of Loch Lomond, near Callendar, Aberfoyle and Lochearnhead in the east of the National Park, Killin in the north and near Tyndrum, Arrochar and Lochgilphead in the west, tend to have the highest concentration of physical constraints, especially buildings and open spaces. Watercourses / bodies and roads run throughout the National Park and a railway line runs through the north-west of the National

Park. Areas with the least physical constraints are located in the northern part of the National Park.

6.26 Figure 6.9 shows landscape constraints for the development of ground-mounted solar PV development, including National Scenic Areas (NSAs) and Wild Land Areas (WLAs) within the National Park. Loch Lomond is the largest NSA which includes the Loch Lomond basin, with the smaller Trossachs NSA centred on Ben Venue. WLAs are primarily located in the north of the National Park, and are focused on Ben Lui, Ben More and Ben Ledi.

6.27 Ground mounted solar arrays can range in scale from domestic to large-scale. The components of a solar array may include different mounting structures, fencing, lighting and CCTV, cabling, transformers and suitable road access. Ground mounted solar therefore has the potential to result in significant landscape and visual effects, including effects on SLQs and the key attributes and qualities of WLAs. There is also the potential for cumulative landscape and visual effects to occur.

6.28 As noted in the existing renewables guidance, location and design will influence the extent of likely landscape and visual effects. Generic landscape siting and design considerations to reduce effects relating to all technology types are set out in chapter 5. In addition to the generic guidance, siting and design guidance specific to solar farms may include:

- Use of non-reflective surfacing to reduce glare where possible;
- Continuation of current land management practices (e.g. grazing) beneath the solar panels where possible; and
- Minimising landscape and visual impacts through design of any buildings required (e.g. electrical switchgear, inverters) and use of construction materials that reflect the local landscape context.

6.29 As noted, the most suitable sites for development are likely to be in proximity to a grid connection (i.e. a substation with suitable capacity), have suitable road access for transportation of materials, be located away from 'prime' agricultural land, be generally flat or on a gentle south-facing slope and be unshaded (see Figure 6.8). This is likely to guide development towards lowland landscapes within the National Park, and away from the more remote upland landscapes.

6.30 Some LCTs are likely to be less susceptible⁵⁵ to development of the nature proposed. These LCTs are more likely to be able to accommodate ground mounted solar without significant landscape effects, subject to appropriate siting, design and mitigation.

6.31 Landscapes that are flat or gently sloping, with a simple and regular pattern, and limited intervisibility with surrounding landscapes, are likely to be less susceptible to change. Landscapes with a higher proportion of field boundary vegetation, woodland and / or forestry may also be able to accommodate development as existing vegetation will help to integrate the development with its landscape setting as well as helping to filter/screen views. LCTs which exhibit these key characteristics⁵⁶, include LCT 260 – River Valley Farmland and Estates, LCT 253 - Straths and Glens and LCT 254 - Straths and Glens with Lochs.

6.32 Landscapes that have strong topographical variety or distinctive landform features, are complex or rugged, are remote from signs of human activity or have highly visible skylines are more likely to be susceptible to change. Landscapes that are open, with limited tree cover, are also likely to be more widely visible and therefore more susceptible to change. LCTs which exhibit these key characteristics^{Error! Bookmark not defined.} include LCT 215 – Open Ridgeland – Glasgow & Clyde Valley, LCT 251 Highland Summits and LCT 255 – Parallel Ridges – Loch Lomond & the Trossachs.

6.33 All proposals should be assessed on a case-by-case basis. For ground mounted solar farms requiring planning consent, a landscape and visual assessment is likely to be required in accordance with GLVIA3.

Cultural heritage considerations

6.34 Figure 6.10 shows the cultural heritage constraints for ground-mounted solar PV development. It shows that larger settlements in the National Park, such as those to the south of Loch Lomond, near Callendar and Aberfoyle in the east of the National Park and near Rashfield in the south west, tend to have the highest concentration of cultural heritage constraints, especially Inventory-listed gardens and designed landscapes, and conservation areas. Both scheduled monuments and listed buildings tend to be more concentrated in more

populous areas and along transport routes, though are relatively more dispersed throughout the National Park. Western, north-western and central areas of the National Park tend to have the least amount of cultural heritage constraints to the development of solar energy.

6.35 Solar panels mounted on the ground are generally secured in one of two ways:

- Concrete ‘pad’ foundations that sit on the ground surface; or
- Anchors or pilings driven into the ground.

6.36 Both of these means of construction have the potential to result in physical effects to archaeological remains – obscuring, compressing or damaging in situ deposits.

6.37 For ground-mounted schemes, it is necessary to understand the archaeological potential of the proposed site. This will require specialist input, and early engagement with the National Park archaeological advisers, West of Scotland Archaeology Service.

6.38 Where a proposal lies within a scheduled monument, planning permission is unlikely to be granted. The designation requires additional consent, via the Scheduled Monument Consent (SMC) process administered by Historic Environment Scotland (HES). Undertaking unauthorised works to a scheduled monument is a criminal offence, and SMC is generally only granted for works directly related to the management and maintenance of the asset – not for development.

6.39 Ground-mounted schemes can also give rise to effects as a consequence of setting change to offsite heritage assets. An idea of the scope and scale of the local historic environment can be obtained from PASTMAP⁵⁷, but specialist advice should be sought from the planning authority and their archaeological advisers. Broadly, the larger the scheme, the more likely it is to have effects – with it being more visible across a wider area and representing a larger-scale change within the landscape (which may, in itself, be of historic interest). Understanding how these effects might arise and manifest themselves requires specialist advice, and applications will need to be supported with an appropriate heritage statement or

⁵⁵ Susceptibility is defined by the Guidelines for Landscape and Visual Impact Assessment, Third Edition (GLVIA3) as “the ability of the landscape receptor (whether it be the overall character or quality/condition of a particular type or area, or an individual element and/or feature, or a particular aesthetic and perceptual aspect) to accommodate the proposed development without undue consequences for the maintenance of

the baseline situation and/or the achievement of landscape planning policies and strategies” (GLVIA3 paragraph 5.40).

⁵⁶ Described in NatureScot’s National Landscape Character Assessment (2019)

⁵⁷ <https://pastmap.org.uk/>

HIA to understand the likely effects and available means of avoiding, reducing or offsetting their impact.

Assessing cumulative effects

6.40 With regard to solar farms in particular, the NPA will need to consider other local solar farms when considering new applications, focusing on the cumulative effects from multiple schemes on the landscape and/or historic environment.

Roof mounted solar PV or solar thermal

Planning considerations

6.41 Householder permitted development rights (PDRs) apply to Solar Panels (or solar thermal) on Dwellings (Class 6HA), with the following exemptions:

- Development is not permitted on a listed building or within the curtilage of a listed building.
- In a conservation area, development is permitted provided the solar panels and equipment are mounted on a rear elevation or a side elevation if that side elevation does not front a road.

6.42 For solar panels (or solar thermal) mounted on outbuildings within the curtilage of a dwelling (Class 6HB) PDR do not apply to listed buildings or buildings within the curtilage of a listed building or within a World Heritage Site.

6.43 Non domestic PDR do not apply within the National Park for building or ground mounted solar PV⁵⁸.

6.44 Planning applications will therefore primarily be forthcoming in relation to listed buildings, conservation areas and non-domestic solar PV.

Environmental considerations

Natural heritage considerations

6.45 Paragraphs 6.16 and 6.17 which set out the requirements of NPF4 policy 3(c), EIA screening and policy developments on improving biodiversity also apply to roof mounted solar. Roof mounted solar installations are unlikely to have significant effects on natural heritage receptors. However, consideration should be given to the presence of bat roosts and bird nests, particularly for larger scale proposals (e.g. covering an entire roof). Installation activity could temporarily disturb birds or bats within roof spaces, and the relevant statutory consents should be applied.

Landscape and visual considerations

6.46 Roof mounted solar installations are likely to be small in scale and located on the roofs of existing buildings. Roof mounted solar is therefore unlikely to have a significant or widespread effects on landscape and visual receptors, or on the SLQs of the National Park. However, developments would have to be considered on a case-by-case basis, and a landscape and visual assessment may be required in line with the Landscape Institute's Guidelines for Landscape and Visual Impact Assessment, 3rd Edition (GLVIA3).

Cultural heritage considerations

6.47 Where roof-mounted solar panels are proposed on historic buildings, it is important to understand the status of that building. If it is listed, additional permissions are required for development that could affect its 'character as a building of special architectural or historic interest' – in the form of Listed Building Consent (LBC).

6.48 Broadly, any roof-mounted solar panels should be considered as having the potential to affect the character and significance of historic buildings as a result of physical changes. They will, inherently:

- Be affixed to historic fabric – i.e. screwed, bolted or clamped to historic roof timbers;

⁵⁸ The Town and Country Planning (General Permitted Development) (Scotland) Order 1992
<https://www.legislation.gov.uk/ukxi/1992/223>

- Require change to historic roof coverings (e.g. removal of slates or pantiles to facilitate access to roof structures, with replacement flashings); and
- Change the character and appearance of the building, introducing a clearly modern and reflective set of materials that will often alter the roofline of the building.

6.49 A heritage statement or heritage impact assessment (HIA) may be required for buildings considered to be non-designated heritage assets by the planning authority. Applicants should refer to relevant Historic Environment Scotland 'Managing Change' publications for targeted advice, and consult the National Park Authority at an early stage to understand the likely level of effect, and whether accompanying information will be required.

6.50 For listed buildings, LBC applications must be made in parallel with the application for planning permission to the National Park Authority in its capacity as planning authority. In addition to a heritage statement and/or HIA, the authority will require detailed information on the proposed changes to historic fabric and clear justification for any adverse effects identified.

6.51 In addition to changes to individual historic buildings themselves, roof-mounted solar has the potential to affect the setting of other heritage assets, and to change the character and appearance of historic places.

6.52 Where proposals lie within a conservation area, close attention will need to be paid to the potential to affect the 'character and appearance' of the historic place. Avoiding front elevations (i.e. those meant to be seen, and with particular aesthetic qualities) and those that address roads or public spaces should be a key principle. Maintaining historic rooflines, and avoiding introducing alien elements in sensitive vistas that enable understanding and appreciation of the significance of historic settlements should inform siting and design.

6.53 Applicants, even where the building directly affected is not of heritage significance, will need to understand the potential for effects to designated and non-designated assets. Where a proposal has the potential to affect the setting of a scheduled monument, Category A-listed building or Inventory-Listed Garden or Designed Landscape, HES will also need to be consulted.

6.54 Just because a building is historic, or even designated, need not mean that roof-mounted solar is unacceptable – but it does mean that a greater level of information and understanding of the building itself and its surroundings is required.

Assessing cumulative effects

6.55 Cumulative impacts may be a consideration in relation to incremental changes to the character of conservation areas.

Other issues affecting deployment

6.56 It is important to note that it is not only the planning system which will impact the ability for the NPA to maximise its renewable energy generation potential. Other factors impacting the deployment of solar energy generation include the following:

Grid decarbonisation and reduced electricity bills

6.57 Rooftop solar PV is becoming an attractive option for developers as a renewable energy solution that helps offset high-carbon mains electricity and meet stricter building emission standards. While the value of this carbon offsetting will decrease as the grid decarbonises, those with onsite solar PV will continue to benefit financially from reduced electricity bills. Over the past decade, solar PV costs have fallen significantly, with further reductions expected and UK grid parity (when the cost of electricity from solar PV is less than or equal to the cost of power from the grid) anticipated within 1 – 3 years, even without subsidies. Recent advancements in smart power management and energy storage systems enhance solar PV efficiency by automating power usage, storage, or export. Additionally, integrating solar PV with whole-house systems, including electric vehicle charging, could further encourage the adoption of rooftop solar technologies.

Lack of financial incentives

6.58 The closure of the Feed-in Tariff (FiT) scheme in March 2019, which provided payments for both energy generation and export from small-scale renewable installations, marked a substantial reduction in financial incentives for the deployment of renewable energy. Whilst it was applicable to all forms of renewable generation, its impact was ultimately most felt in the solar sector. The Smart Export Guarantee (SEG) introduced in January 2020 to replace FiT only compensates small-scale low-carbon generators for the electricity they export to the grid, making it less financially attractive than its predecessor. As SEG does not reward total energy generation, it offers fewer incentives for installing new systems. Although the UK government has taken steps to encourage renewable energy adoption, such as reducing VAT to 0% on

energy-saving materials (including solar PV and solar thermal) from April 2022 to March 2027, this measure alone may not fully offset the financial gap left by the FIT scheme.

6.59 The lack of robust financial incentives, particularly for technologies like solar water heating, has contributed to slower adoption rates. Solar water heating is less common than PV and often only financially viable for off-gas properties due to higher fuel costs. Furthermore, non-domestic solar water heating installations face additional challenges due to variable hot water demand and competition from other heating solutions such as point-of-use hot water heating.

Summary of solar power opportunities and constraints

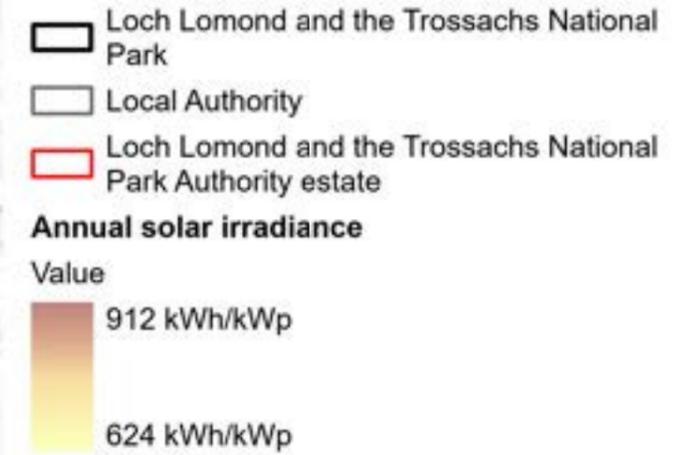
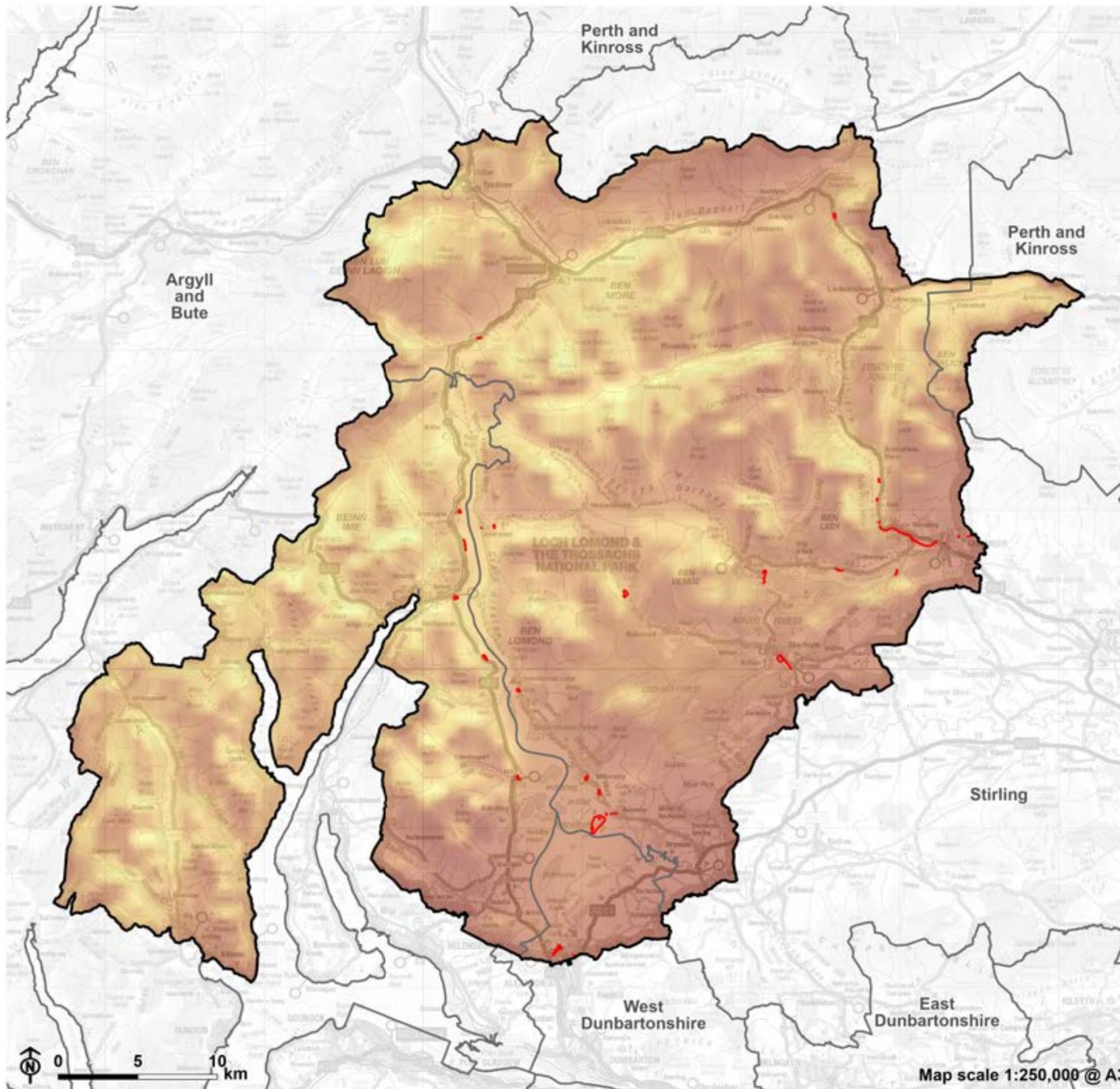
There is evidenced demand for both rooftop and ground-mounted solar at varying scales within the National Park. Solar PV has become an increasingly affordable option in recent years in UK markets, and the integration of solar with whole-house systems, such as electric vehicle charging and heat pumps, could further encourage the adoption of these technologies. Many small-scale solar developments will qualify as permitted development and do not require planning permission.

In terms of maximum technical capacity, it is estimated that 40% of domestic roofs and 75% of non-domestic roofs could accommodate panels within the National Park. The total capacity is estimated to be 19.07MW for solar PV and 23.22MW for solar heating (mutually exclusive due to roof space usage). If full technical capacity was to be achieved, there is potential for 2,764.25 tonnes of carbon emissions to be saved per year. Whilst this represents a relatively small percentage of overall carbon emissions, the role of rooftop solar in reducing emissions from individual building should not be discounted.

Assessing the technical potential for ground-mounted solar at a strategic level was not feasible within this assessment. However, individual ground-mounted installations may offer greater capacity as they are not limited to individual buildings. The scale of solar farm development would be subject to suitable siting, design and environmental impact.

Environmental considerations for solar development vary for rooftop and ground-mounted installations. For rooftop installations consideration should be given to the presence of bat roosts and bird nests. They are unlikely to have significant or widespread landscape and visual effects, and impacts on historic buildings or heritage assets need to be considered. on landscape and visual receptors or on SLQs of the National Park. Ground mounted solar may include additional infrastructure including fencing and ground fixings

with associated ecological impacts. Other considerations include glint and glare, cumulative landscape and visual impacts and varying scales of development location-based environmental sensitivities but key considerations are likely to include landscape and visual impacts, glint and glare, direct cultural heritage impacts and impacts on setting.

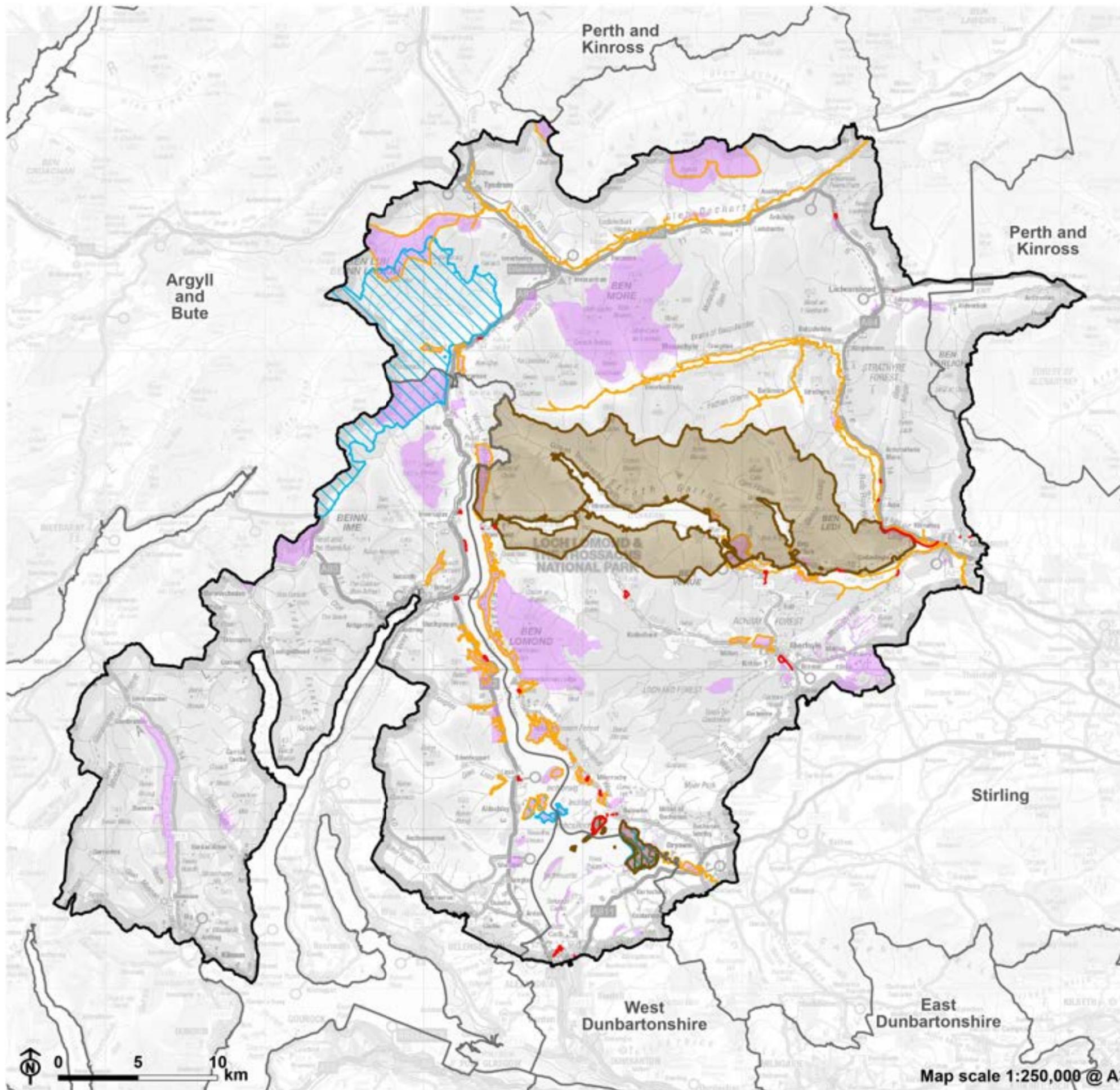


Notes:

Global Solar Atlas 2.0 is a free, web-based application, developed and operated by the company Solargis s.r.o on behalf of the World Bank Group, utilising Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: <https://globalsolaratlas.info>.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Figure 6.6: Solar constraints - Natural heritage constraints

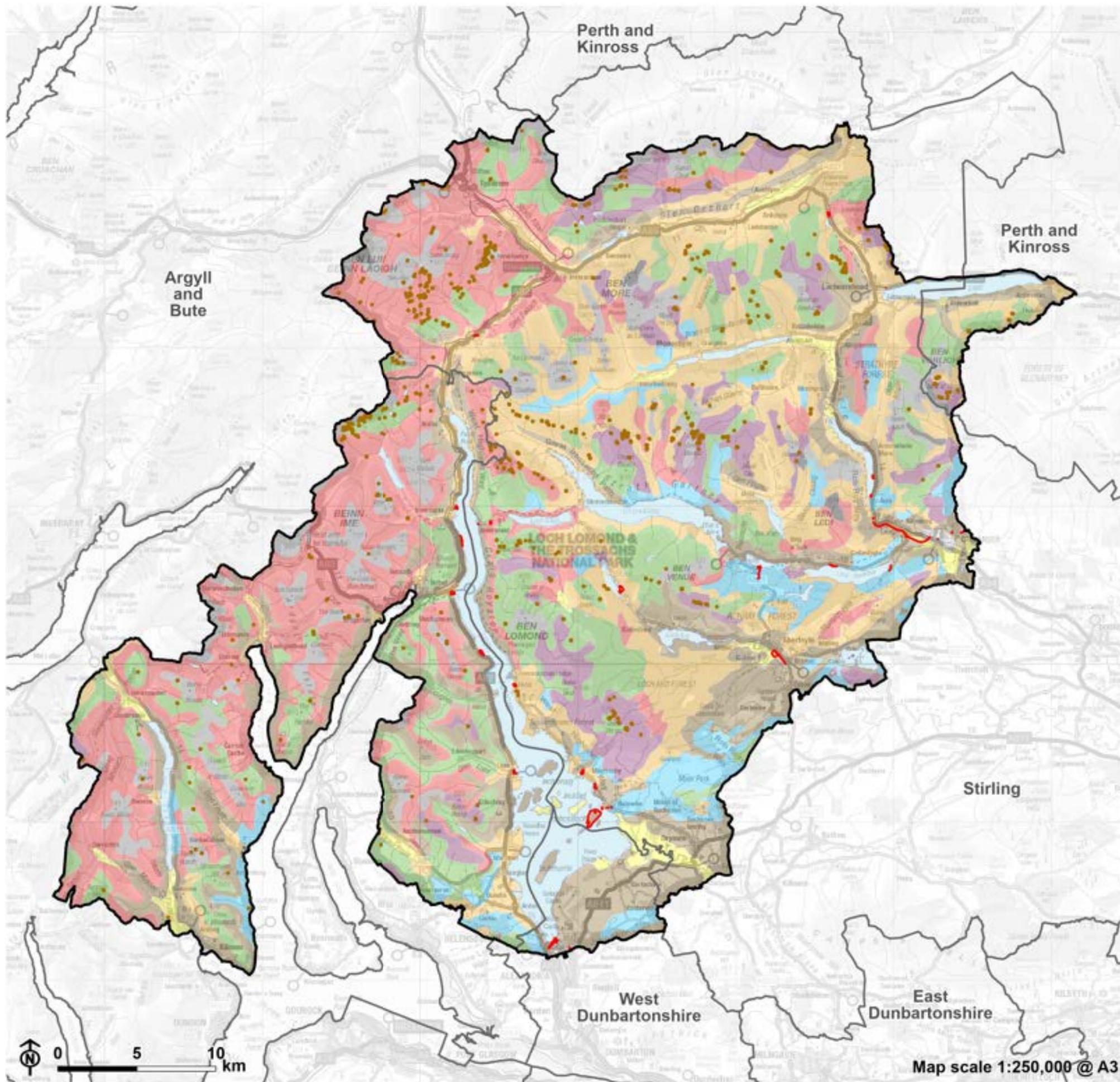


- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- National Nature Reserve
- Ramsar site
- Special Protection Area
- Special Area of Conservation
- Site of Special Scientific Interest

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.



Loch Lomond and The Trossachs NPA:
Decarbonising Energy Generation within
the National Park



Loch Lomond and The Trossachs NPA

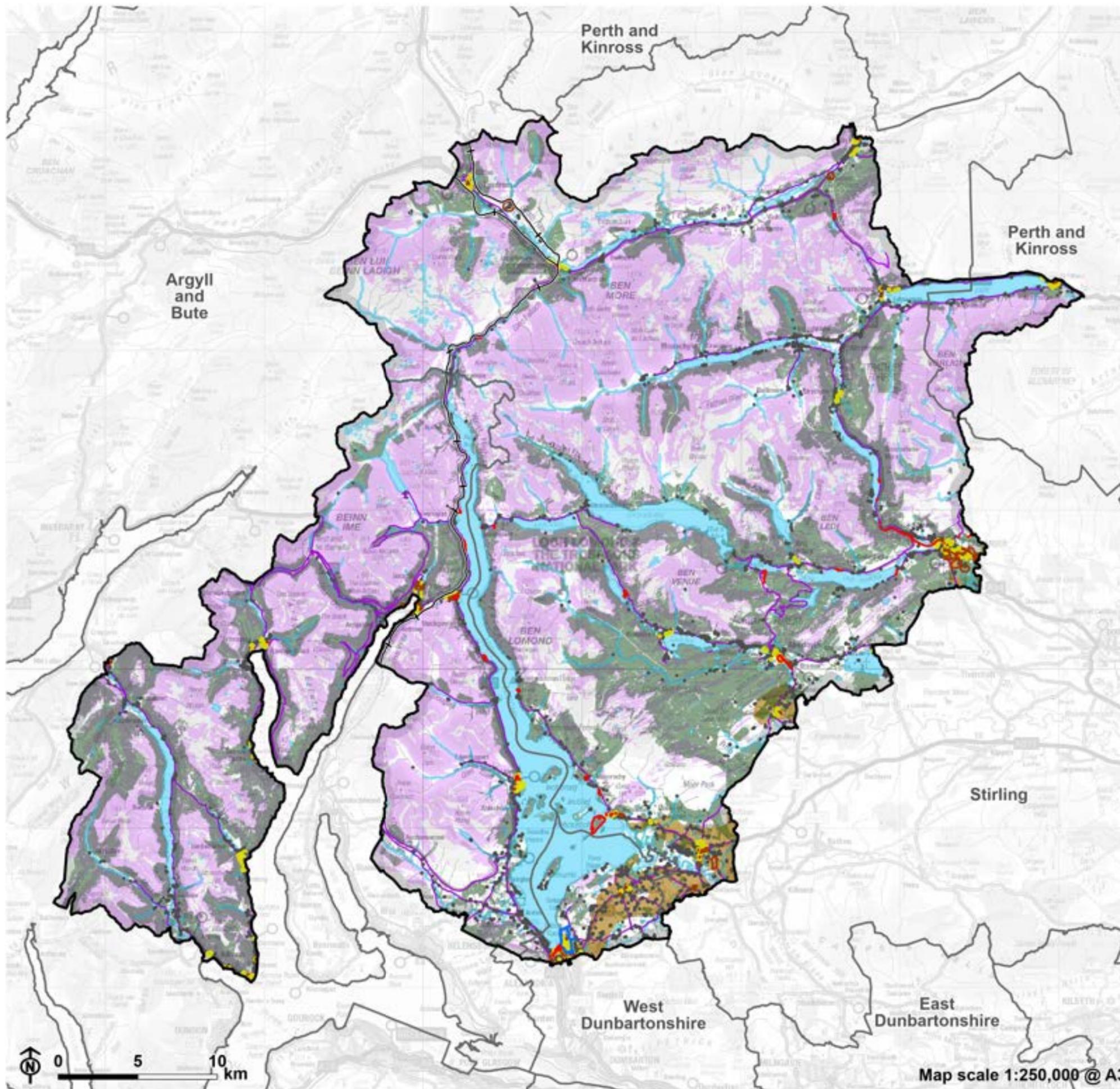
Figure 6.7: Solar constraints - Soil constraints

- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Bare peat area
- National soil map of Scotland**
- Alluvial soils
- Brown soils
- Immature soils
- Lochs
- Mineral gleys
- Mineral podzols
- Montane soils
- Peat
- Peaty gleys
- Peaty podzols

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.



Loch Lomond and The Trossachs NPA:
Decarbonising Energy Generation within
the National Park



Loch Lomond and The Trossachs NPA

Figure 6.8: Solar constraints - Physical, land use and infrastructure

- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Road
- Railway
- Country park
- Site allocation
- Building
- Open space
- Watercourses and water bodies
- Woodland
- Slope above 15° or slope above 7° and north-east to north-west aspect
- Land capable of agriculture: classes 1-3.2

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

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The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

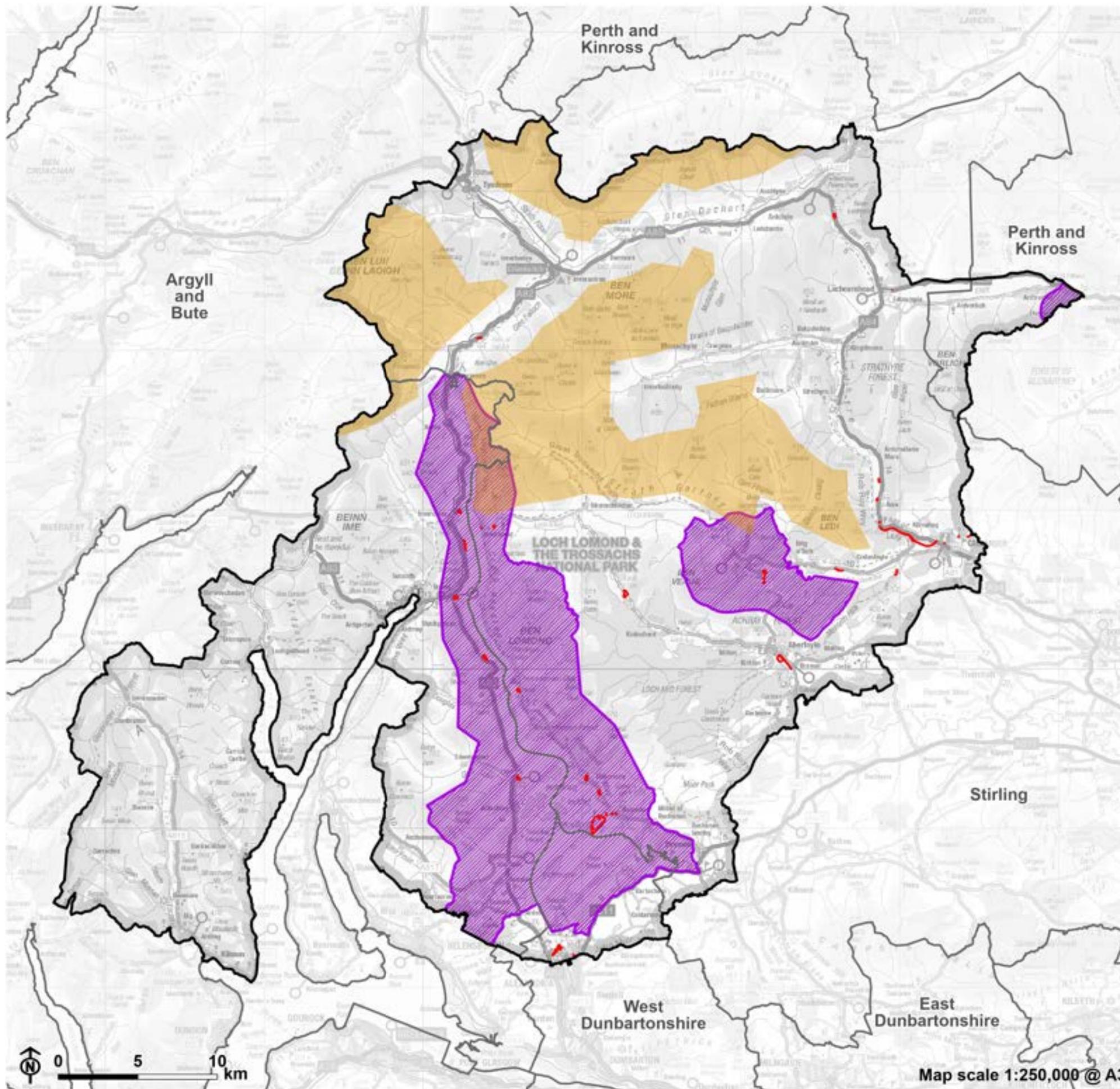


Figure 6.9: Solar constraints - Landscape constraints

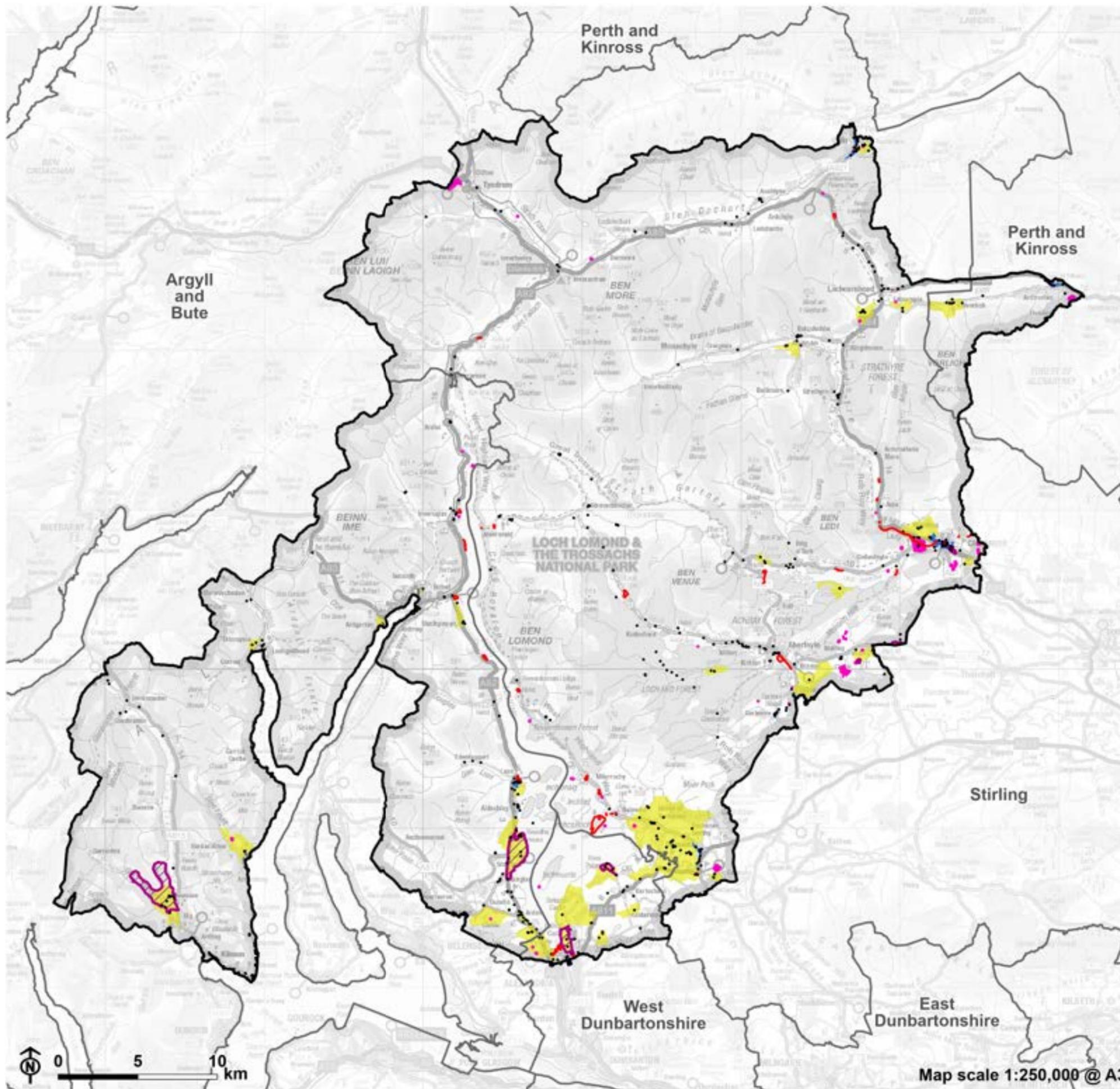
- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- National Scenic Area
- Wildland Area

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Figure 6.10: Solar constraints - Cultural heritage constraints



- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Listed building
- Gardens and Designed Landscapes
- Scheduled monument
- Conservation area
- Historic Designed Landscape

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Chapter 7

Heat pump opportunities and constraints

Overview of the technology

A heat pump is a device that can transfer low-temperature heat from a renewable source such as air, water, or the ground and raise it to a higher temperature using a refrigerant cycle. This then heats a home via radiators or underfloor heating.

- An **air source heat pump (ASHP)** transfers heat from the outside air to water. A monobloc system has all the components in a single outdoor unit, with pipes carrying water to the central heating system and a hot water cylinder inside a home. A split system separates the components between indoor and outdoor units, usually used when there's quite a distance between the external unit and house.
- A **ground source heat pump (GSHP)** utilises geothermal energy and extracts heat found in the ground, with installation involving a bore hole up to 100m deep or a trench.
- A **heat network**, or district heating, is a system that supplies heating from a central source (e.g. a combined heat and power plant) to multiple consumers through a network of underground pipes carrying hot water.



Air Source Heat pump (Freepik)

<p>Size/scale</p>	<p>ASHP outdoor units are generally compact, around the size of an air conditioning unit (e.g. 1 x 1.5 x 0.5m). Indoor units are smaller, usually mounted on walls or floors, an engineer will be required to advise on the best location for this within a property to prevent any structural issues. Monobloc systems take up less space than split systems. If used for hot water, then a hot water cylinder is also needed (approximately 80 x 80cm).</p> <p>GSHP require a suitable area of land near a house for digging and trenching. They require either a deep vertical borehole (50 – 100m deep) or horizontal loops which require room for two 30-40 metre long trenches. The heat pump unit is usually compact and mounted indoors.</p> <p>Heat networks can vary in size and scale, covering a large area such as a town or city, or can be fairly local, providing heat to a cluster of buildings. There may be cases where small-scale heat networks are suitable within the National Park. Where this is the case, it is likely to be a shared ground source heat pump serving a small number of homes. As such this chapter subsumes the opportunities and constraints for micro-scale heat networks into those for GSHP.</p>
<p>Power output / storage</p>	<p>ASHP typically generate between 5 – 20 kW of energy. The capacity needs of individual homes will depend on the size and energy usage of the home; however it is estimated a 5kW system would be required for 100sqm of floor space.</p>

	GSHP have a higher output compared to ASHP, especially suited for larger buildings or more extensive heating demands. GSHP offer more stable temperatures than ASHP as they use the stable temperatures in the earth to supply a property with heat and hot water.
Colour	Standard heat pump outdoor units come in neutral colours, typically white, grey, or beige, to blend with building exteriors.
Positioning	Outdoor ASHP units need to be installed on a solid, stable surface (e.g. concrete pad or mounted to a wall), with some space around it to allow a good flow of air. Indoor units are usually installed in utility rooms or less occupied spaces. A GSHP demands more space and suitable geology for digging and trenching, alongside the heat pump unit.
Construction / operation impact	<p>Construction impacts for ASHPs will be limited to the property. There may be some landscape and visual impacts for outdoor units depending on the location on the property and visibility from the surrounding area/public highway. Additionally, direct and indirect cultural heritage impacts may require assessment, particularly when installations are in sensitive areas such as a conservation area or on a listed building.</p> <p>For GSHPs, additional considerations such as the suitability of land for ground loops and boreholes is required. Environmental considerations are likely to include impacts on soil and geology, ecological impacts, and impacts on the water environment, specifically in relation to groundwater. Short-term and temporary construction impacts will include excavation or drilling.</p> <p>ASHP and GSHP generate noise during operation and there may be some potential adverse impacts on neighbouring residential receptors if poorly located on a property.</p>
Infrastructure / access	Installations will require a suitable place for indoor or outdoor units, as well as the associated infrastructure such as pipework and electrical connections. Properties should be well insulated to ensure that the system functions most efficiently, as they produce heat at a lower temperature than traditional boilers. A heat pump system will typically require a radiator 2.5 times larger than a traditional radiator. If connected to a domestic water system, the heat pump will need suitable pipework to integrate with the building's hot water system. Heat pumps run on electricity and are therefore most effective when combined with other micro-renewable technologies, such as solar PV systems, to generate power onsite.
Scope of existing guidance	Heat pumps are not covered by the current guidance document.

Technical potential in the National Park

Ground source heat pumps

7.1 Ground source heat pumps require more space than air source, requiring pipes to be buried vertically in a deeper system or horizontally in a shallow, wider system. Due to these significant space constraints, this study did not estimate the potential capacity of ground source heat pumps across the study area, as it was not possible to estimate how many properties have access to the required space. It is noted however that a horizontal system would require around 700 square metres, or 2.5 tennis courts making them unviable for most homes. A vertical ground source heat pump is likely to be more viable, requiring around 11 square metres of space for an average of three boreholes, although these must be situated away from the foundations of the house and there must be enough space to accommodate the machinery required to install the boreholes⁵⁹

Air source heat pumps

7.2 Almost any building theoretically has the potential for an air source heat pump to be installed. The majority of air source heat pumps in the UK are deployed on detached, semi-detached and terraced houses, as they commonly meet the requirements for heat pumps to be suitable, such as having the physical space requirements to install such devices⁶⁰ Therefore, the assessment considered the potential for air source heat pumps to be delivered in all buildings. Although heat pumps can also be deployed within flats and other dwellings, their suitability can be highly variable. As such, dwellings classed as 'flats' and those classed as 'other dwellings' were not included within the assessment. The average size of a system was estimated to be 10.2kw for a domestic property and 46.52kw for a non-domestic property⁶¹. For off-gas properties, it was assumed that 45% of the heating fuel offset was electricity and 55% was oil.

7.3 Figure 7.1 shows the technical potential for air source heat pumps. It shows that there are similar amounts of both the larger 46.5 kW non-domestic and the smaller 10.2 kW domestic rooftop air source heat pump systems concentrated within the main settlements as well as along the main transit routes. Detailed assumptions made in the production of this figure can be found in Appendix A. Figure 7.2 and Table 7.1 below provide a summary estimate of the technical potential for air source heat pumps within the National Park.

7.4 As previously stated the carbon emissions associated with household fuel are much higher than those associated with household electricity. The Scottish Government has previously indicated that they anticipate the installation of heat pumps to be a major factor in reducing emissions⁶², this was reflected in the greenhouse gas emissions assessment for the LLTNP. Recommended decarbonisation measures for the Park state that by 2027 48% of new homes should have heat pumps installed, as well as 51% of existing homes off the gas grid and 28% of homes on the gas grid, in order to meet emissions reductions targets. This increases to 82%, 86% and 69% respectively by 2032. The technical capacity assessment suggested that if all domestic properties were to install an air source heat pump, this could secure the majority of emissions reductions required from household fuel. This is therefore in line with wider recognition that the installation of this technology should be prioritised.

7.5 Additionally, the Scottish Government are in the process of developing regulations to deliver a 'Scottish equivalent to the Passivhaus standard', improving the energy standards of new buildings⁶³. Published guidance and approved calculation tools are expected in 2026 and the implementation date for regulations to be March 2028. This will likely have impacts for the planning applications coming forward and the deployment of heat pumps within the National Park.

⁵⁹ <https://heatpumphouse.com/guides/space-ground-source-heat-pump/#:~:text=You%20will%20need%20around%20700%20square%20metres%20of, is%20around%20the%20size%20of%202.5%20tennis%20courts.>

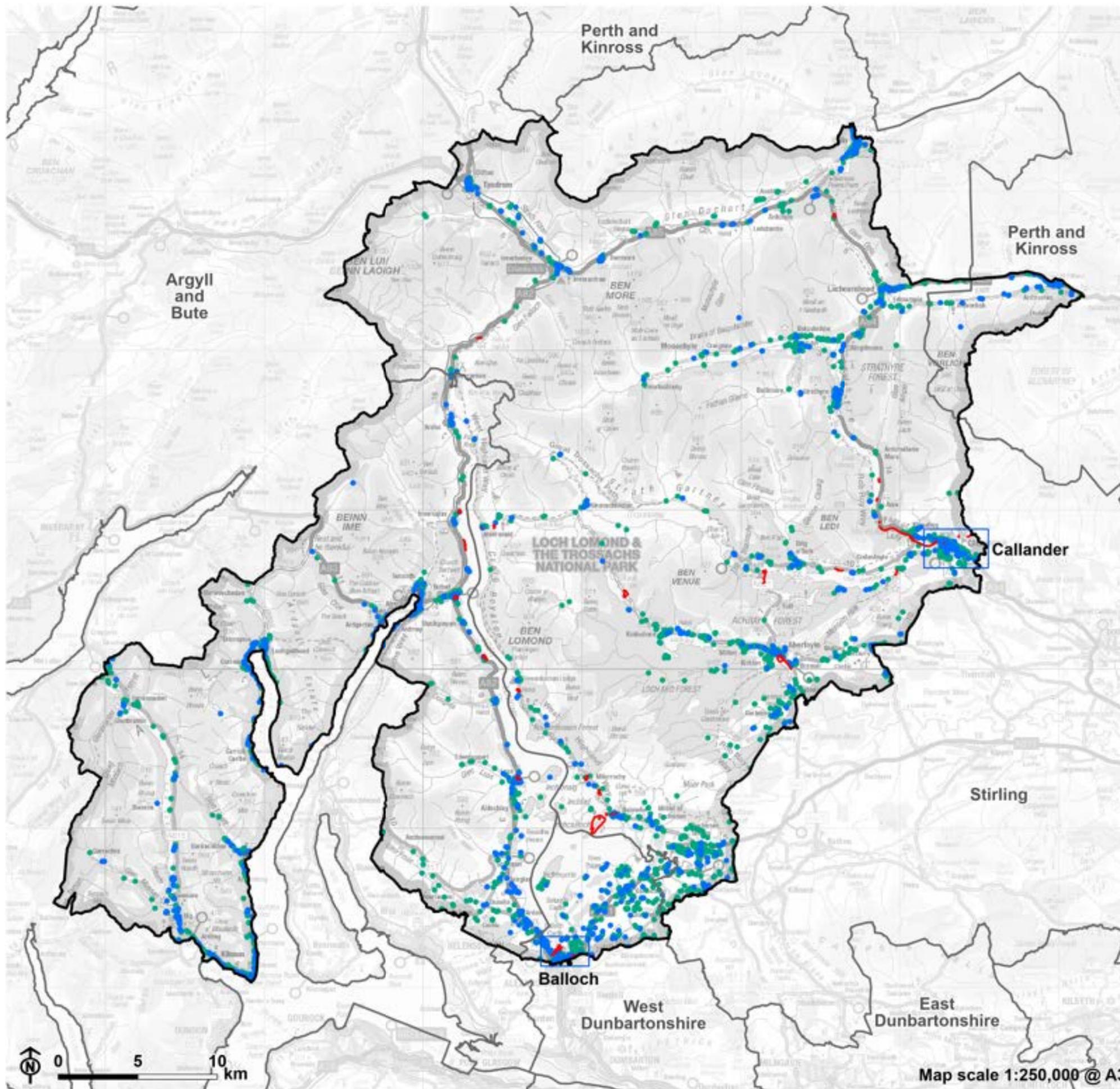
⁶⁰ EnergySavingTrust (2024) Heat pumps for flats, terraced houses and other property types. Available at: <https://energysavingtrust.org.uk/from-flats-to-terraced-houses-heat-pumps-are-suitable-for-all-property-types/>. Accessed on: 09/12/2024).

⁶¹ DESNZ (2024) RHI monthly deployment data: March 2024 (Annual edition). Available at: <https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-march-2024-annual-edition>

⁶² <https://www.gov.scot/publications/developing-scotland-wide-section-3f-planning-policy/>

⁶³ Scottish Government (2024) Energy Standards Review – Scottish Passivhaus Equivalent: Working Group. Available at: <https://www.gov.scot/groups/energy-standards-review-scottish-passivhaus-equivalent-working-group/>

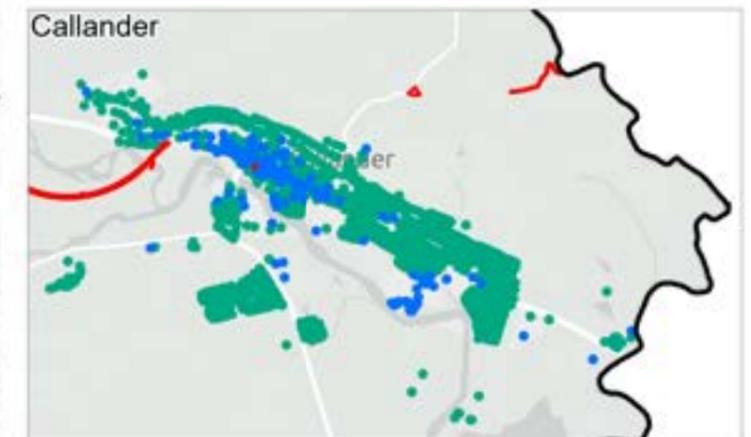
Figure 7.1: Technical potential for rooftop air source heat pumps



- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate

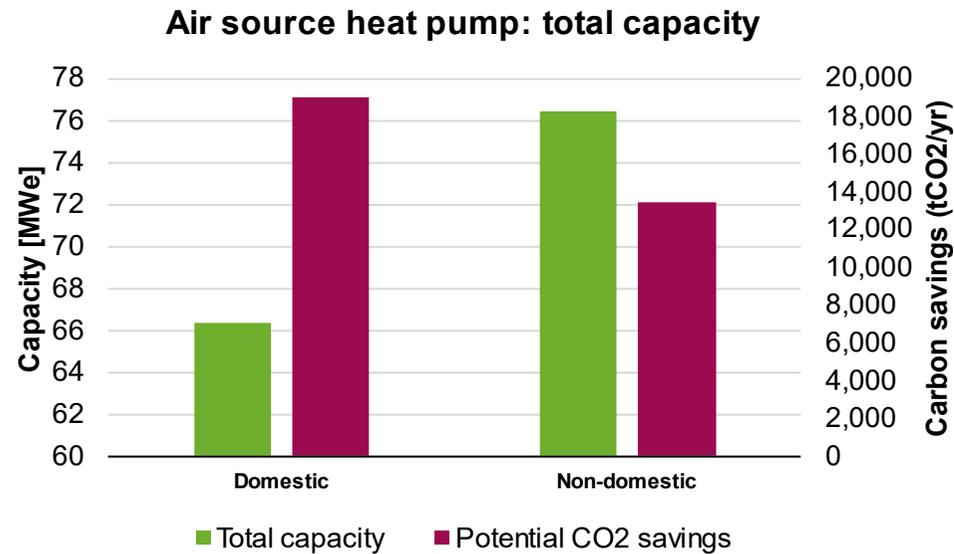
Air source heat pump - potential average system size

- Non-domestic: 46.5 kW
- Domestic: 10.2 kW



Notes:

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Figure 7.2 Total estimated capacity (MWe) and potential CO₂ savings (tCO₂/yr) for air source heat pumps.Table 7.1 Estimated capacity (MWth), delivered heat (MWh/yr) (not inc SPF) and potential CO₂ savings (tonnes/yr) (including SPF) for air source heat pumps.

Building category	Estimated capacity (MWth)	Delivered Heat (MWh/yr) (not inc SPF)	Potential CO ₂ Savings (tonnes/yr) (including SPF)
Domestic	66.34	22,930.86	18,980.36
Non-domestic	76.48	26,435.92	13,483.36
Total	76.48	49,366.78	32,463.73

Locational guidance

7.6 Suitable locations for GSHPs would need more detailed assessment which is beyond the scope of this strategic study. It has been assumed that ASHPs could be provided on almost any building and therefore there is no additional locational guidance provided for heat pumps.

Key planning considerations

7.7 At present, householder permitted development rights allow for the installation of ASHPs on or within a dwelling. However, these do not apply if the pump protrudes more than 1 metre from the outer wall, if the property is located within a conservation area (in which case the ASHP has to be at ground level to the rear of the building), or within the curtilage of a listed building. More than one ASHP also cannot be installed on the same building or within the curtilage of a building; this means that where buildings are flats, only one flat can benefit from these permitted development rights. Non-domestic heat pumps are not covered by non-domestic PDR.

Environmental considerations

7.8 Heat pumps generate noise and can have potential effects on neighbouring properties, if poorly located on a property. Consideration for the residential amenity of adjacent residential properties should be made when determining the location for units, including locating units as far away as possible from neighbour's openable windows or noise sensitive rooms such as living rooms or bedrooms. However, adverse impacts on residential amenity are generally considered to be avoidable and mitigable. Manufacturers have also recognised the market value in quieter models and these have become available in recent years.

Natural heritage considerations

7.9 Heat pump installation is unlikely to give rise to significant natural heritage concerns. ASHPs are located adjacent to buildings and therefore adverse effects are expected to be minimal.

7.10 For GSHPs, underground construction works may have some local impacts dependent on the scale and location of installations. The construction of boreholes or ground loops may cause disturbance to habitats and species and may affect local hydrogeological conditions. There will

also be impacts on soil from excavation. In operation, heat pumps can contribute to environmental noise.

Landscape and visual considerations

7.11 Air-source and ground-source heat pumps are typically small in scale and therefore unlikely to have a significant or widespread effect on landscape and visual receptors, or on the SLQs of the National Park. However, developments would have to be considered on a case-by-case basis, and a landscape and visual assessment may be required in accordance with GLVIA3.

Cultural heritage considerations

Air-source heat pumps

7.12 ASHPs can often be accommodated in historic contexts with comparatively few problems, however there are some key issues that need to be considered.

7.13 Where machinery is to be affixed to the exterior of a historic building, the position, colour and materiality of the installation will necessarily have an effect on the character and appearance of that building. It is therefore advisable to avoid principal elevations and frontages addressing streets or public spaces to minimise both perception of change to the building itself and erosion of the wider historic character (particularly if located in a conservation area). Similarly, the method of fixing can be important where this has the potential to damage historic fabric. Consequently, there may be a need to ground-mount the machinery and ensure that pipe runs avoid sensitive fabric when drilling/cutting into the building. For larger historic buildings, choosing inconspicuous locations, ideally on or adjacent to secondary/later built elements is advisable. For split systems, there is the potential for impacts as a consequence of setting change from larger machinery, but generally these can be sensitively located to minimise effects.

7.14 For listed buildings, options where the machinery does not need to be mounted directly on the building are advisable to minimise potential loss of or damage to historic fabric. (If the installation is not directly mounted to the building, LBC may not be required.) It should also be noted that the installation of Air Source Heat pumps in historic buildings is likely to require work to improve insulation to make them effective as a source of heat. This must be managed

effectively to ensure there are no negative impacts on the building fabric. Not managing this effectively has the potential to impact the breathability of a building and lead to poor moisture management and possible fabric defects such as stone decay/timber rot.

Ground-source heat pumps

7.15 As a development type requiring either vertical drilling or extensive open-area excavation to install loops of pipework, there is potential for damage to the archaeological resource.

7.16 It is therefore necessary to understand the archaeological potential of the proposed site. This will require specialist input, and early engagement with the National Park archaeological advisers, West of Scotland Archaeology Service. They will be formal consultees on any eventual application and can provide applicants with information on the known archaeological resource, and a clear understanding of the necessary work that may be required in support of an application.

7.17 It is likely that in areas of higher archaeological potential, some pre-consent investigation will be required, particularly for larger schemes where trenches, rather than boreholes, are required. Boreholes require a smaller surface area to be disturbed and can be more appropriate in areas of higher archaeological potential – minimising the area of deposits damaged or lost. In addition to the physical damage caused by cutting trenches, ground source heat pumps also have the potential to cause further damage to in situ deposits through freeze-thaw action and dewatering by mobilising groundwater between previously impermeable layers of soil stratigraphy.

7.18 Where a proposal lies within a scheduled monument, planning permission is unlikely to be granted. The designation requires additional consent, via the Scheduled Monument Consent (SMC) process administered by Historic Environment Scotland (HES). Unauthorised works to a scheduled monument is a criminal offence, and SMC is generally only granted for works directly related to the management and maintenance of the asset – not for development.

Assessing cumulative impacts

7.19 There are unlikely to be cumulative impacts from heat pumps.

Other issues affecting deployment

7.20 Beyond the planning system, several other issues have been identified which may affect deployment.

High investment costs

7.21 Costs for an individual to install a domestic ASHP fall in the range of £8,000-£16,000 depending on the size and efficiency required, which can be an expensive upfront cost for a private homeowner. ASHP's also require good insulation to maximise their efficiency and therefore fabric upgrades to improve the energy efficiency of a home which will increase costs further. The Home Energy Scotland scheme provides up to £15,000 for private homeowners to invest in an ASHP to support individuals looking to make the shift to cleaner energy and make their homes more energy efficient, however this is subject to availability and meeting eligibility criteria⁶⁴.

Skills shortage

7.22 A rapid upskilling will be required to adapt from installing fossil fuel heating systems to heat pumps, including plumbers, system designers, engineers, other building traders, and more widely the sales and administrative staff required to develop the supply chain. The Scottish Government are working with the sector to ensure up-skilling in renewables is provided within the current apprenticeship schemes, and more widely in the industry.

Practical considerations

7.23 Practically, air source heat pumps are understood to be noisy, and therefore may be a concern or a disincentive for individuals where they do not want to cause a noise nuisance. Concerns with the technology have also been raised about the compatibility with existing heat systems in Scotland. Therefore, installing a heat pump may also require a plumbing upgrade to the property to accommodate the technology. As mentioned previously, higher levels of insulation are also recommended due to the lower running temperature of a heat pump.

⁶⁴ <https://www.homeenergyscotland.org/home-energy-scotland-grant-loan>

Summary of heat pump opportunities and constraints

There is significant potential for the deployment of heat pumps within the National Park, within new and existing building stock. There is recognition at national level that heat pumps will play an important role in decarbonising household heating emissions and high-level policy direction to support this.

Almost any building theoretically has the potential for an ASHP to be installed, although they are generally deployed on detached, semi-detached and terraced houses with the available physical space.

The findings of the technical capacity assessment in this study suggests that if all domestic properties in the National Park were to install an ASHP, this could secure the majority of emissions reductions required from household fuel. If full technical capacity was achieved, without limitation, across all domestic and non-domestic building stock, there is potential for 32,463.73 tonnes of carbon of emissions to be saved per year in the National Park.

GSHP require more space than ASHP, with a horizontal system requiring around 700 square metres, or a vertical system requiring around 11 square metres for an average of three boreholes located away from foundations of a property. It was not possible to estimate the technical potential for GSHP deployment as part of this assessment, as it was not possible to determine the number of properties with these space requirements.

Subject to certain criteria, many heat pump installations will fall under permitted development rights and do not require planning permission. Key environmental considerations for the implementation of ASHP include, but are not limited to, landscape and visual impacts, cultural heritage impacts, and noise. GSHP may have additional considerations such as ecological, hydrological and archaeological impacts. However, the environmental impacts of most domestic-scale heat pump installations are expected to be minimal, subject to appropriate siting and design.

Overall, there is considerable scope for heat pump technology to support the decarbonisation of heating within the National Park, with the appropriate installation of heat pumps in the right locations.

Chapter 8

Battery storage opportunities and constraints

Overview of the technology

Battery Storage or Battery Energy Storage Systems (BESS) are devices that collect energy from renewable energy sources, or from the electricity network, and store it for later use.

BESS offer a solution for providing a steady flow of electricity at all times, allowing energy from renewables - such as solar and wind - to be stored during times of peak production and then released at times of low production. Utilising battery storage improves the efficiency of the grid, allowing for energy to be captured when demand is low and then providing backup supply when demand is high, improving the day-to-day flexibility and resilience of the energy system.

Based on current UK and international markets, the most commonly used battery type is lithium-ion. Other technologies include lead acid batteries, flow batteries and nickel-iron batteries. BESS can range significantly in scale:

Utility/domestic-scale systems can be used in a domestic setting to support the energy efficiency of individual homes, facilitating the efficiency of micro-renewables such as rooftop solar.

Commercial/industrial-scale systems are designed for bigger operations or industrial use and are generally installed on-site to allow businesses to store and discharge electricity at specific times. In most cases, they are integrated with commercial solar panel systems.

Large/grid-scale systems are generally co-located with a generating resource, such as a wind or solar farms. They can also be placed on the transmission and distribution system, near substations, to help balance local electricity supply and demand.



Large/grid-scale battery energy storage systems. Source: Wikimedia Commons.

<p>Size/scale</p>	<p>Utility/domestic-scale battery storage systems are typically compact, with dimensions similar to a large suitcase or small refrigerator. For example, a 10kWh system dimensions may be approximately 100x70x15cm.</p> <p>Commercial/industrial-scale batteries are largely dependent on the energy needs of the business, including the scale of operations, the variability of their energy demand/supply. Models vary across the market and can be found in sizes comparable to domestic/utility-scale systems, up to large/grid scale units (see below) depending on the storage capacity.</p> <p>Large/grid-scale can also vary significantly in size however, individual units are generally housed in large containers, comparable to shipping-containers. Generally, for large/grid-scale BESS, multiple containers are located together, with the number of units dependent on the overall storage capacity requirements, the size of the site and other planning/environmental considerations.</p>
<p>Power output / storage</p>	<p>Utility-scale home systems support the electricity usage of an average household, which uses between 8-10kWh of electricity per day. Smaller systems start at around 2.5-5kWh, but typically range from 5-20kWh.</p> <p>Commercial/industrial-scale have higher capacity than residential systems but lower capacity than grid-scale systems. The power output of the system can vary significantly depending on the scale and needs of the business but can range from a few dozen to hundreds of kWh.</p>

	Large/grid-scale systems provide significantly higher storage capacities, measures in megawatts/megawatt hours (MW/MWh). Developments in the planning system generally range between 20-100MW. The most common grid-scale battery solutions today are rated to provide either 2, 4 or 6 hours of electricity, however, efforts are underway to advance the technology and develop BESS with abilities to store energy for longer.
Colour	Neutral colours, including white, grey and black.
Positioning	Small-scale units can be wall mounted or floor standing. They are typically installed in a garage, utility room or outside in weatherproof enclosures. Batteries should be installed in a cool, dry location away from direct sunlight or heat sources. Depending on the intended function of larger-scale (i.e. container sized) BESS, they may be best located near the generation source or near an existing substation to support the functioning of the grid. Often, a BESS development will comprise multiple battery packs (i.e. multiple containers) and associated infrastructure.
Construction / operation impact	Small-scale battery storage installation is likely to have minimal construction and operation impacts, limited to the property. For larger development, short-term and temporary construction impacts associated with the development of larger-scale BESS may be related to site levelling, construction traffic and construction impacts such as noise, air quality and residential amenity. BESS units are generally compact and landscape and visual impacts may be easily mitigated with suitable landscaping, but will likely require assessment. Other site-specific effects may include direct and indirect cultural heritage impacts, ecological impacts, hydrology and flood risk and fire risk considerations. Battery storage technologies generate noise and therefore an assessment of noise impacts in relation to surrounding land uses is likely to be a key consideration.
Infrastructure / access	BESS developments are relatively compact compared to other technologies but still require additional infrastructure. Depending on size and location this may include security fencing, electrical cabling and a suitable grid connection, as well as appropriate access for construction and maintenance. Battery storage is increasingly found co-located with other renewable technologies or grid infrastructure.
Other considerations	Battery storage technologies at all scales are developing quickly, in response to the rapidly evolving international market and increasing demand. Therefore, planning policy and guidance must be flexible to adapt to likely developments in the size, scale and storage capacity of battery systems in coming years.
Scope of existing guidance	Battery storage is not covered by the current guidance document.

Technical potential and locational guidance

8.1 The technical potential of battery storage wasn't assessed as demand is dependent on the amount of renewable energy generation in the National Park and the existing capacity of the grid.

8.2 No locational guidance is available, however battery storage is typically located close to an energy generating source and the scale of battery storage will be proportional to the power output of the energy generating source.

Planning considerations

8.3 NPF4 supports the need for increased energy storage technology and capacity.

8.4 Domestic battery storage does not require planning permission but may require listed building consent if alterations are required to the building fabric. Domestic batteries are typically located within a property or outbuilding.

8.5 There are no PDR rights for non-domestic battery storage within a National Park⁶⁵.

8.6 The Scottish Government considers that a battery installation generates electricity and is therefore to be treated as a generating station. As a result, a battery installation should be treated as any other generating station for the purposes of deciding whether Section 36 consent is required for its construction and operation⁶⁶. Section 36 of the Electricity Act 1989 (“the 1989 Act”) applies to proposals for the construction, extension or operation of an onshore electricity generating station whose capacity exceeds (or, when extended, will exceed) 50 megawatts (MW). Applications to construct or operate electricity generating stations below this threshold which do not require section 36 consent are made to the local planning authority under the Town and Country Planning (Scotland) Act 1997.

8.7 It is anticipated that the majority of applications for battery energy storage within the National Park will typically be of smaller scale, reflecting the scale of energy generation infrastructure. They would therefore require planning permission but be below the threshold for Section 36 consent.

Environmental considerations

Natural heritage considerations

8.8 The generic natural heritage considerations outlined in the existing guidance in relation to the habitat and species designations will apply (paragraphs 4.9 - 4.12). Battery storage technologies are usually compact, but some larger proposals may include lighting, security fencing and access infrastructure. There may be potential to cause loss, fragmentation and modification of habitats but ecological impacts will depend on the scale and location of

development and site-specific sensitivities. Design mitigation should ensure avoidance of areas of higher ecological sensitivity and prevent loss of habitat connectivity.

8.9 The effects of lighting, noise and fencing on local ecology should be considered, and where appropriate the impacts of access tracks, parking areas or other site infrastructure (depending on the scale of the battery storage). The scope of ecological surveys required should be proportionate to the scale and location of development and the site-specific context. Similarly, the identification of opportunities for onsite biodiversity enhancement will depend on the size of the scheme and existing site features.

Landscape and visual considerations

Small-scale Battery Storage

8.10 Landscape and visual effects (including effects on SLQs) for small-scale community/business battery storage schemes are expected to be negligible and are therefore not considered further. The majority of BESS within the National Park are anticipated to be in support of domestic or community scale technologies.

Large-scale Battery Storage

8.11 Large-scale battery storage developments vary in size, but individual units are generally housed in large containers comparable in size to shipping-containers. Ancillary infrastructure may include access tracks, security fencing and grid connections. Large-scale battery storage has the potential to result in significant landscape and visual effects, including effects on SLQs and the key attributes and qualities of WLAs. There is also the potential for cumulative landscape and visual effects to occur.

8.12 As noted in the existing renewables guidance, location and design will influence the extent of likely landscape and visual effects. Generic landscape siting and design considerations to reduce effects relating to all technology types are set out in chapter 5.

⁶⁵ <https://www.legislation.gov.uk/ssi/2024/102/made>

⁶⁶ <https://www.gov.scot/publications/battery-storage-consents-and-variations-to-planning-permission-for-energy-generating-ancillary-uses-chief-planner-letter-august-2020/>

8.13 As noted, for larger-scale battery storage, the most suitable development sites are likely to be located near a generation source or near an existing substation to support the functioning of the grid.

8.14 Some LCTs are likely to be less susceptible to development of the nature proposed. These LCTs are more likely to be able to accommodate large-scale battery storage without significant landscape effects, subject to appropriate siting, design and mitigation.

8.15 Landscapes that are flat or gently sloping, with a simple and regular pattern, and limited intervisibility with surrounding landscapes, are likely to be less susceptible to change. Landscapes with a higher proportion of field boundary vegetation, woodland and / or forestry may also be able to accommodate development as existing vegetation will help to integrate the development with its landscape setting as well as helping to filter/screen views. LCTs which exhibit these key characteristics, include LCT 260 – River Valley Farmland and Estates, LCT 253 - Straths and Glens and LCT 254 - Straths and Glens with Lochs.

8.16 Landscapes that have strong topographical variety or distinctive landform features, are complex or rugged, are remote from signs of human activity or have highly visible skylines are more likely to be susceptible to change. Landscapes that are open, with limited tree cover, are also likely to be more widely visible and therefore more susceptible to change. LCTs which exhibit these key characteristics include LCT 215 – Open Ridgeland – Glasgow & Clyde Valley, LCT 251 Highland Summits and LCT 255 – Parallel Ridges – Loch Lomond & the Trossachs.

8.17 All proposals should be assessed on a case-by-case basis. For large-scale battery storage requiring planning consent, a landscape and visual assessment is likely to be required in accordance with GLVIA3.

Cultural heritage considerations

Small-scale battery storage

8.18 It is not anticipated that utility or domestic-scale storage will present any particular issues for the historic environment. It is likely that the majority of such technologies would be located within garages, outbuildings or other ancillary structures and would be unlikely to result in adverse effects.

Commercial/industrial-scale battery storage

8.19 It is anticipated that any such scheme would be accommodated within a business's operational land and buildings, and would therefore be unlikely to give rise to meaningful effects to the historic environment. However, the larger-scale 'shipping container' format BESS are likely to give rise to visual effects and setting change if improperly located with regard to heritage assets.

Large/grid-scale battery storage

8.20 It is unlikely that schemes of this scale would come forward within the National Park. However, given their extensive surface area and clearly modern, industrial form they have the potential to result in both physical effects to buried archaeology and setting change to upstanding features.

8.21 Any development of this nature is likely to require screening for EIA. To inform this process, it will be necessary to understand the archaeological potential of the proposed site. This will require specialist input, and early engagement with the National Park archaeological advisers, West of Scotland Archaeology Service. They will be formal consultees on any eventual application and can provide applicants with information on the known archaeological resource, and a clear understanding of the necessary work that may be required in support of an application. Similarly, where the proposal has the potential to affect the setting of a scheduled monument, Category A-listed building, Inventory-listed Garden and Designed landscape, or Inventory Battlefield, HES would need to be consulted via its pre-application service.

Cumulative impacts

8.22 There is potential for cumulative landscape and visual effects to occur for large scale battery storage, including when the location of battery storage is in proximity to other renewable energy generation infrastructure.

Other issues affecting deployment

8.23 Barriers to the development of battery energy storage systems (BESS) in the UK include a lack of manufacturing capacity for batteries in the UK and the UK's reliance on international markets for critical minerals that are used in batteries (such as lithium). Development might also

be hindered by the cost of establishing BESS and delays to grid connections and the ease of access to sites to install and service units. Due to potential fire risk it is also likely that Network Grid Managers may become consultees for any future BESS applications which are close to grid infrastructure. Barriers to the development of BESS and other energy storage systems also include high upfront capital costs, uncertain revenue streams and delays to grid connections.

8.24 The lifespan of batteries is limited by the number of charge-discharge cycles they can endure. Degradation over time can reduce system efficiency and increase maintenance costs. In addition, the use of large-scale battery systems raises safety concerns, including the risk of thermal runaway and fires, and robust safety measures and advancements in battery technology are essential to mitigate these risks. As the roll-out of BESS grows, so does the need for effective recycling and end-of-life management solutions to address environmental and resource concerns.

Summary of battery storage opportunities and constraints

The technical potential of battery storage did not form part of this assessment, as demand is dependent on the amount of renewable energy generation in the National Park and the existing capacity of the grid. BESS are typically located near to an energy generating source (such as a wind or solar development) and their scale is proportionate to the power output of the generating source. They can range from small domestic scale units to larger-scale batteries housed in shipping-like containers. Environmental and locational considerations for battery development include general natural heritage impacts, landscape and visual effects, and noise, proportionate to the scale of the proposal.

BESS play an important role in increasing efficiency of the grid in the transition to renewables, and broader trends have shown the sharp rise in demand for BESS across the country. Within the National Park, there is likely to be scope for the co-location and deployment of batteries proportionate to the scale of renewable energy development, to improve the efficiency and reliability of generating sources.

Chapter 9

Run-of-river hydro opportunities and constraints

Overview of the technology

Hydro energy generation involves the extraction of energy from moving water. Water flowing from a higher to a lower level powers a turbine that is connected to an electrical generator. The amount of energy generated depends on the amount of water, the flow rate and the height the water falls from.

Most applications in the National Park are expected to be small scale 'run-of-the river' developments, where water is taken from a river, passed through a turbine and then flows back into the river.



Run-of-river hydro scheme (LUC)

Size / scale	The size and scale of hydro developments is likely to depend on site-specific factors including size of the watercourse and power needs. The power house is usually the largest structure capable of housing a turbine, generator and transformer.
Power output / storage	On average, the power output for small scale run-of-river schemes ranges between 15kW and 2MW.
Colour	Components come in a range of colours including silver, grey, black, white, blue and green.
Positioning	Schemes are located on suitable rivers or burns with fast flowing water.
Construction / operation impact	<p>The construction of small-scale run-of-river hydro schemes can have several potential impacts on the environment, local communities, and ecosystems, though these are generally less severe than large-scale hydro projects. Key environmental considerations include:</p> <ul style="list-style-type: none"> ■ Ecological disturbance: construction can disrupt aquatic habitats, affect fish migration, and cause bank erosion, leading to habitat loss and fragmentation. ■ Water quality: increased sedimentation, turbidity, and the risk of chemical spills can temporarily degrade water quality. ■ Flow and hydrology changes: temporary alterations to river flow may affect downstream ecosystems and water availability.

	Other site-specific sensitivities, such as cultural heritage and land use impacts will depend on the specific site context and local sensitivities. Other short-term and temporary construction impacts may include construction noise, traffic impacts, and other impacts on amenity depending on the surrounding land uses.
Infrastructure / access	The components of an installation will vary depending on location and vertical drop (head) and may require penstocks (pressure pipes), lades, weirs, and water drawn from multiple sources. Before descending to the turbine, the water passes through a settling tank or 'forebay' in which the water is slowed down sufficiently for suspended particles to settle out. The forebay is usually protected by a rack of metal bars (a trash rack) which filters out water-borne debris. A pressure pipe, or 'penstock', conveys the water from the forebay to the turbine, which is enclosed in the powerhouse together with the generator and control equipment.
Scope of existing guidance	Technology specific guidance for hydro is provided in the existing guidance.

Technical potential and locational guidance

9.1 Assessment of the potential for additional hydropower installations within the National Park is beyond the scope of this assessment. This would require a bespoke study by hydropower specialists to identify locations along waterways where suitable yearly flow characteristics are present and could feasibly support hydropower sites. Further assessment would then be required to determine the suitability of such sites for development, taking consideration of constraints such as ecological factors and landscape and cultural heritage impacts. A high-level strategic assessment, such as this study, cannot address such considerations.

Planning considerations

9.2 Planning considerations are outlined in the existing renewable energy planning guidance. No significant changes have been identified and no changes have been made to consenting regimes.

Environmental considerations

Natural heritage considerations

9.3 The generic natural heritage considerations outlined in the existing guidance in relation to the habitat and species designations will apply (paragraphs 4.9 - 4.12). Existing guidance specifically relating to the water environment remains applicable for hydro scheme proposals (paragraphs 4.13 – 4.16). With regard to paragraph 4.16, specific guidance relating to development affecting designated sites should be signposted. For example, recent guidance was produced and adopted in 2020 by Perth and Kinross Council, Angus Council, SEPA and NatureScot for planning applications within the catchment of the River Tay SAC, or which could affect the water quality of the River Tay SAC⁶⁷. Any similar site-specific guidance produced for other designated sites within the National Park (such as the River Teith SAC, Endrick Water SAC, etc.) should also be signposted within updated planning guidance.

9.4 Interactions between hydro schemes and changes in water availability due to climate change should be taken into account. This should include consideration of impacts on biodiversity, private water supplies and cumulative impacts from development. Potential impacts of hydropower developments upon the status indicators of a water body, as set out in

⁶⁷ https://www.pkc.gov.uk/media/46816/River-Tay-SAC-Guidance-Adopted-2020/pdf/River_Tay_SAC_2020_Adopted.pdf?m=1607092292013

the Water Framework Directive, may require abstraction licences, discharge permits and flood defence consent from SEPA.

9.5 As set out in the existing planning guidance, impacts on hydrology and river ecology require consideration in determining the suitability of sites for hydropower developments. For example, aquatic plants may impact the performance of a hydropower scheme by impacting water flows. Moreover, river fish populations may be sensitive to changes in water flows, as well as risk physical harm from the hydropower equipment installed. Impacts on land based habitats resulting from penstock/track construction will also need to be considered.

Landscape and visual considerations

9.6 The size and scale of hydro developments are likely to depend on site-specific factors including size of the watercourse and required generation capacity. The power house is usually the largest structure capable of housing a turbine, generator and transformer. Hydro developments have the potential to result in significant landscape and visual effects, including effects on SLQs and the key attributes and qualities of WLAs. WLAs and NSAs within the National Park are shown on **Figure C5**. There is also the potential for cumulative landscape and visual effects to occur.

9.7 As noted in the existing renewables guidance, location and design will influence the extent of likely landscape and visual effects. Generic landscape siting and design considerations to reduce effects relating to all technology types are set out in chapter 5. In addition to the generic guidance, siting and design guidance specific to hydro developments may include:

- Minimising landscape and visual impacts through micro-siting and design of structures required (e.g. forebay/tank, penstock/pressure pipe, lades, weirs, generator); and
- Minimising landscape and visual impacts through sensitive design of temporary and permanent access tracks.

9.8 As noted, run-of-river hydro developments will be located on suitable rivers or burns with fast flowing water. This is likely to guide development towards strath and glen landscapes within the National Park, although upland landscapes may contain suitable watercourses.

9.9 Some LCTs are likely to be less susceptible⁶⁸ to development of the nature proposed. These LCTs are more likely to be able to accommodate hydro developments without significant landscape effects, subject to appropriate siting, design and mitigation.

9.10 Landscapes which contain contemporary structures (e.g. transmission lines or other utilities), are close to other signs of human activity and have limited intervisibility with surrounding landscapes, are likely to be less susceptible to change. LCTs which exhibit some of these key characteristics⁶⁹, include LCT 252 – Upland Glens - Loch Lomond & the Trossachs and LCT 253 - Straths and Glens.

9.11 Landscapes that are complex or rugged, have an absence of modern development, are remote from signs of human activity and have a strong sense of place or local distinctiveness are more likely to be susceptible to change. Landscapes that are open, with limited tree cover, are also likely to be more widely visible and therefore more susceptible to change. LCTs which exhibit these key characteristics include LCT 250 Steep Ridges and Hills, LCT 251 Highland Summits and LCT 255 – Parallel Ridges – Loch Lomond & the Trossachs.

9.12 All proposals should be assessed on a case-by-case basis. For run-of-river hydro developments requiring planning consent, a landscape and visual assessment is likely to be required in accordance with GLVIA3.

Cultural heritage considerations

9.13 It is anticipated that schemes coming forward in the National Park are likely to be relatively small-scale. However, even small run-of-river schemes are substantial engineering works, depending on the techniques employed.

⁶⁸ Susceptibility is defined by the Guidelines for Landscape and Visual Impact Assessment, Third Edition (GLVIA3) as “the ability of the landscape receptor (whether it be the overall character or quality/condition of a particular type or area, or an individual element and/or feature, or a particular aesthetic and perceptual aspect) to accommodate the proposed development without undue consequences for the maintenance of

the baseline situation and/or the achievement of landscape planning policies and strategies” (GLVIA3 paragraph 5.40).

⁶⁹ Described in NatureScot’s National Landscape Character Assessment (2019)

9.14 From a cultural heritage perspective, avoiding watercourses with historic features on or adjacent to the channel is a useful principle. This is also a consideration in the vicinity of penstock and track working corridors. Equally, historic mill buildings can sometimes present opportunities to accommodate machinery and/or re-use lade features to transport water.

9.15 Given the complex interactions between environmental effects for even very small hydro schemes, prospective applicants should be advised to seek advice from the planning authority and archaeological advisers at the earliest opportunity.

Cumulative impacts

9.16 Significant cumulative effects may arise from small-scale hydro development if other schemes are affecting the same catchment, and this should be taken into account in assessment.

Other issues affecting deployment

9.17 As well as the assessment of potential impacts from individual hydropower installations upon waterways, the cumulative impacts of hydropower and any other water abstraction activities along a waterway on the protected rights of other river users (such as recreational access rights) will require assessment.

9.18 Moreover, as permissions on use of waterways for hydropower are commonly issued with a time limit on the permitted abstraction period, this must also be considered. Unless such time periods are sufficiently long, the long-term viability of hydropower developments may be at risk if these permissions are not renewed in the future.

Summary of hydro opportunities and constraints

While there have been fewer recent developments within the National Park, hydro remains an important part of the existing renewable energy mix in the National Park. The potential for landscape and natural heritage impacts is significant for this technology. The existing LLTNP Renewable Energy Planning Guidance provides detailed guidance relating to hydro development and assessment of environmental impacts.

The scope of the technical potential for additional hydro installations within the National Park was beyond the remit of this assessment. A bespoke study by hydropower specialists would be required to fully understand the technical potential within the National Park, alongside ecological, landscape and cultural heritage constraints. It is anticipated that schemes coming forward in the National Park are likely to be relatively small-scale 'run-of-river' schemes.

Chapter 10

Wind opportunities and constraints

Overview of the technology

A wind turbine turns wind energy into electricity. The types of wind turbines potentially acceptable in the National Park include:

- **Standalone wind turbines**, also referred to as freestanding or pole-mounted turbines. These are designed to capture wind at higher altitudes.
- **Building-mounted turbines**. These are generally small turbines located on the roof of a building.



Pole-mounted wind turbine. (© Albert Bridge (cc-by-sa/2.0))

Size/scale	<p>Within the National Park, only small-scale wind development is supported. LLTNPA policy provides support for single turbine developments with a height to blade tip of no more than 30m.</p> <p>Micro-generation turbines are also increasingly popular technologies. These could be standalone turbines located on top of a 5m pole or building-mounted turbines designed to be fitted on rooftops on the gable end of properties.</p>
Power output / storage	<p>Power output is dependent on turbine size and wind speed/resource, which can vary significantly from site to site. Wind speed requirements vary with turbine scale and model, with some manufacturers producing models which may operate at lower wind speeds. Most turbines require minimum wind speeds of 2-5m/s, reaching peak generation between 10-13m/s. Turbines will shut off in high speed conditions to prevent damage.</p> <p>Micro-generation turbine models are available for domestic use, with electricity generation limited to a few hundred watts. Smaller pole-mounted turbines may generate a few kilowatts of electricity and roof mounted domestic turbines are usually around 1kW-2.5kW in capacity⁷⁰.</p> <p>Small wind turbines for domestic use are usually between 400 watts and 20kW. Small commercial wind turbines may have a power rating up to 5kW, which with an average wind speed of 6m/s could generate 13Mwh per annum, covering the energy needs of a typical business or four homes. Larger standalone turbines of suitable scale to be developed within the National Park may have a generation output of 50kW+, however, this will depend on turbine model and technology.</p>
Colour	<p>Turbines are usually white, light grey, metallic grey, silver, off-white or cream in colour. Colour choice for turbines is likely to be a judgement based on design objectives, which could be to reduce visual impact and integrate with the landscape.</p>

⁷⁰ Eco Energy Consultants. Wind Power for Residential (see: <https://ecoenergyconsultants.co.uk/wind-power-for-residential/>)

Positioning	To ensure optimum performance, the siting of a wind turbine will be largely dependent on ensuring good wind resource. Topography, surrounding buildings and other obstacles will influence wind resource. There must be suitable access for installation and maintenance. The siting of a wind turbine should take landscape and visual considerations into account, as set out in NatureScot's Siting and Designing Wind Farms in the Landscape Guidance, Version 3A (August 2017).
Construction / operation impact	<p>Standalone turbines are likely to have short-term and temporary construction impacts associated with construction noise, traffic, residential amenity and other short-term effects during installation. There would be ongoing intermittent traffic associated with the maintenance of the turbine once installed.</p> <p>Environmental factors relating to the operation of the scheme are likely to include noise, landscape and visual effects, and ecological impacts. These will all likely be key considerations in determining the suitability of the proposal. Other site-specific sensitivities may include indirect or direct cultural heritage impacts, hydrology and ground conditions. Due to the noise produced by wind turbines, they tend not to be suitable for use in areas where there are noise sensitivities. However, with advances in technology, quieter models with reduced vibration are constantly in development.</p> <p>Building-mounted turbines are likely to have more limited impacts, similar to the installation of rooftop solar PV. Preliminary assessments for a householder/business intending to install building-mounted turbines may include structural surveys, ensuring the roof can accommodate the technology. There may be landscape and visual impacts depending on the visibility of the turbine installations from the surrounding area. Additionally, direct and indirect cultural heritage impacts will likely require assessment, particularly when installations are in sensitive areas such as a conservation area or on a listed building.</p>
Infrastructure / access	<p>Pole-mounted turbines may require some additional infrastructure. Depending on the scale, this may include:</p> <ul style="list-style-type: none"> ■ Turbine foundations i.e. strong concrete or steel foundations to support the turbines weight. ■ Adequate tracks/roads for transporting construction materials and facilitating maintenance. ■ Electrical infrastructure including electrical wiring and inverters for AC/DC conversion. ■ Monitoring and control systems for performance oversight and safety. ■ Grid connection infrastructure, including cable-route, transformers and metering equipment for safe connection to the electricity grid. <p>Turbines benefit from being co-located with a battery storage system to maximise efficiency.</p>
Scope of existing guidance	Technology specific guidance for wind turbines is provided in the existing guidance.

Technical potential and locational guidance

10.1 It is beyond the scope of this project to map all potential constraints, such as buffer distances between homes and suitable locations for turbines of varying height. As the National Park is only able to accommodate single wind turbines, these have the ability to be carefully

micro-sited to consider nearby constraints. As such it is not appropriate for this strategic-scale study to merge all constraints to identify an area of "unconstrained" land with potential for wind development and therefore calculate overall generation potential.

10.2 Figure 10.1 shows the wind speed constraints for wind energy generation. Wind speed requirements change with turbine scale and model, however, the figure shows that higher wind

speeds can generally be found on higher elevations across the north and west of the National Park.

10.3 Figure 10.2 shows where the physical constraints to the development of wind energy are located in the National Park. Physical constraints include infrastructure such as roads and railways, as well as buildings, open space and watercourses / bodies. It shows that larger settlements in the National Park, tend to have the highest concentration of physical constraints, especially buildings and open spaces. Watercourses/ bodies and roads run throughout the National Park and a railway line runs through the north-west of the Park. Areas with the least physical constraints are in the northern part of the National Park.

Planning considerations

10.4 As set out in **Chapter 2**, at a high level, NPF4 does not support some larger scale renewable energy development within the National Park. NPF4 Policy 11(b) states “development proposals for wind farms in National Parks and National Scenic Areas will not be supported”.

10.5 As per existing local planning policy, only small-scale wind development is supported in the National Park which constitute single turbine developments with a height to blade tip of no more than 30m. The NPA requires all applications for wind energy development to be accompanied by a Landscape and Visual Impact Assessment (LVIA).

Environmental considerations

Natural heritage considerations

Standalone wind turbines

10.6 Figure 10.3 shows the natural heritage constraints for wind energy development. It shows that one of the largest constraints is the Great Trossachs Forest NNR in the centre of the National Park, another large area of constraint is the Glen Etive and Glen Fyne SPA in the

north-west of the National Park. Other key constraints in the National Park are the numerous SSSIs and SACs. The largest areas with fewest natural heritage constraints to the development of wind energy are located in the north-east, south-west and south east of the National Park.

10.7 The natural heritage considerations set out in existing planning guidance for small-scale wind energy proposals remain relevant (paragraphs 5.36 – 5.45). Most small scale wind turbine development, of the scale to be delivered in the National Park, can be sited and designed to have minimal impact on natural heritage. NatureScot has produced a range of updated guidance on planning for renewable energy including onshore wind development. Much of this guidance is oriented towards large-scale wind farm development however, general guidance regarding wind turbine impacts on protected species such as birds⁷¹ and bats, avoidance of peatlands and carbon-rich soils, and other natural heritage considerations⁷² are relevant to proposals of all scales.

10.8 Wind farms present three main risks to birds: 1) death through collision or interaction with turbine blades, 2) direct habitat loss through construction and 3) displacement through indirect loss of habitat if disturbance causes birds to avoid the wind farm and surrounds (i.e. if bird populations are deterred from using their normal routes to feeding or roosting grounds)⁷³. Similarly, risks to bats include collision mortality, barotrauma and other injuries, loss or damage of foraging habitat, direct loss of or damage to roosts, and displacement of individual or populations of bats (for example, due to construction activity)⁷⁴. These risks are applicable to single turbine development at a smaller scale.

10.9 Figure 10.4 demonstrates soil constraints for the development of wind energy. This includes the national soil map of Scotland, which demonstrates areas of peatland and high carbon soils across the National Park. The map demonstrates that there is a high concentration of vulnerable bare peat towards the northwest of the National Park.

Building mounted turbines

10.10 Installation activity for rooftop micro wind installations could disturb birds or bats within roof spaces, and the relevant statutory consents should be sought. NatureScot advise that

⁷¹ <https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/onshore-wind-energy/wind-farm-impacts-birds>

⁷² <https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/onshore-wind-energy>

⁷³ <https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/onshore-wind-energy/wind-farm-impacts-birds>

⁷⁴ <https://www.nature.scot/doc/bats-and-onshore-wind-turbines-survey-assessment-and-mitigation>

micro turbines are sited at least 30m from potentially suitable bat habitat. Additionally, if a turbine is installed on or near a building, design mitigation should ensure that it is located as far from regular bird nest sites as is practicable to minimise risk of collision and avoidance of disturbance⁷⁵.

Landscape and visual considerations

10.11 Turbines at the upper end of the size potentially acceptable in the National Park may require some additional infrastructure, e.g. access tracks, substation and grid connection. Wind turbines therefore have the potential to result in significant landscape and visual effects, including effects on SLQs and the key attributes and qualities of WLAs. WLAs and NSAs within the National Park are shown on Figure 10.5.

10.12 Siting and design considerations for turbines of 15-50m in height are set out in Annex 1 of NatureScot's Siting and Designing Wind Farms in the Landscape Guidance, Version 3A (August 2017). A good practice guide to track construction is provided in Scottish Natural Heritage's (now NatureScot) Constructed tracks in the Scottish Uplands, 2nd Edition (2013, updated in 2015). Further design advice is provided in the current renewables guidance.

10.13 As noted, the siting of wind turbines will be largely dependent on ensuring good wind resource, and wind turbines are usually best located on top of a hill or property in a suitably windy location.

10.14 Some LCTs are likely to be less susceptible⁷⁶ to development of the nature proposed. These LCTs are more likely to be able to accommodate wind turbines without significant landscape effects, subject to appropriate siting, design and mitigation.

10.15 Landscapes which are large in scale, have an absence of topographical variety, are simple and regular in pattern and the presence of contemporary structures are likely to be less susceptible to change. LCTs which exhibit some of these key characteristics⁷⁷, include parts of

LCT 257 Plateau Moor and Forest – Loch Lomond & the Trossachs and parts of LCT 251 Highland Summits.

10.16 Landscapes that are small in scale, with strong topographical variety, distinctive undeveloped skylines and remote from human activity are more likely to be susceptible to change. Landscapes with strong inter-visibility with sensitive landscapes, or which form an important part of the view from sensitive viewpoints, are also likely to be more susceptible to change. LCTs which exhibit these key characteristics include LCT 263 Lowland Loch Basin - Loch Lomond & the Trossachs, LCT 254 Straths and Glens with Lochs and LCT 250 Steep Ridges and Hills.

10.17 All proposals should be assessed on a case-by-case basis. The current renewables guidance states that all applications for wind energy development within the National Park will need to be accompanied by an LVIA undertaken in accordance with GLVIA3.

Cultural heritage considerations

Standalone wind turbines

10.18 With appropriate information, it should generally be possible to avoid physical effects on archaeological assets when constructing smaller-scale standalone turbines. Seeking early advice from the National Park archaeological advisers, West of Scotland Archaeology Service⁷⁸ will provide the necessary understanding. They will be formal consultees on any eventual application, and can provide applicants with information on the known archaeological resource, and a clear understanding of the necessary work that may be required in support of an application.

10.19 Wind turbines have the potential to introduce modern infrastructure, noise and movement to the setting of heritage assets, and therefore specialist advice is required to identify, avoid and reduce such effects. Where the proposal has the potential to affect the setting of a scheduled

⁷⁵ <https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/micro-renewables>

⁷⁶ Susceptibility is defined by the Guidelines for Landscape and Visual Impact Assessment, Third Edition (GLVIA3) as "the ability of the landscape receptor (whether it be the overall character or quality/condition of a particular type or area, or an individual element and/or feature, or a particular aesthetic and perceptual

aspect) to accommodate the proposed development without undue consequences for the maintenance of the baseline situation and/or the achievement of landscape planning policies and strategies" (GLVIA3 paragraph 5.40).

⁷⁷ Described in NatureScot's National Landscape Character Assessment (2019)

⁷⁸ <https://www.wosas.net/>

monument, Category A-listed building, Inventory-listed garden and designed landscape, HES should be consulted via its pre-application service.

Building-mounted turbines

10.20 Mounting turbines on historic buildings is potentially more problematic. They are inherently incongruous, obviously modern pieces of machinery that introduce movement, noise and vibration to historic buildings and places.

10.21 At a physical level, it is important to understand whether the structure of a historic building is sufficiently strong to bear the additional weight, wind-loading forces and vibrations arising from the installation of a turbine. The method of fixing must also conserve historic fabric and minimise change – which can be challenging when having to uprate structures to cope.

10.22 In addition to changing the character and appearance of the building itself, roof-mounted turbines can also change the character and appearance of historic places, conservation areas in particular, and affect the setting of other heritage assets (including where the building itself is not of historic interest). Appropriate advice should be sought from the planning authority conservation officer and, if necessary, HES, to ensure that sufficient information is provided in applications.

10.23 However, the evidence suggests that roof-mounted turbines generally perform poorly, as surface roughness effects of neighbouring buildings, gardens and other features result in weak, irregular and gusty wind profiles that do not provide optimal wind resource or energy recovery. Focusing on other renewables solutions and energy efficiency measures are likely to be more effective and offer stronger return on investment.

Cumulative impacts

10.24 Where several singular turbines are permitted within a local area, there is the potential for cumulative landscape and visual effects to occur.

Other issues affecting deployment

Standalone turbines

10.25 The disadvantages of small wind turbines include high initial cost, effective placement, wind fluctuation, change in wind direction and also aero-acoustic noise.

10.26 Optimal wind speeds are usually found at higher elevations, but small wind turbines are often installed at lower heights, reducing their efficiency and energy output. Small wind turbines need a sufficient amount of open space around them to reduce wind obstruction, which isn't always available, especially in residential areas.

10.27 In addition, small wind turbines require significant upfront investment, including the cost of the turbine, installation, foundation (for ground-mounted units), and possible connection to the grid. Furthermore, small wind turbines have a lower power output relative to their size, especially when compared to larger turbines or other renewable sources like solar panels. This makes them less efficient in delivering meaningful energy output, particularly when wind speeds are low or variable.

10.28 Even small wind turbines can generate noise, which can be a concern in residential areas or locations near other occupied buildings. The noise can be disruptive to neighbours and can deter installations in populated areas. In addition, small turbines are visible and may be seen as unattractive or intrusive by both property owners and neighbours, limiting social acceptance in communities where aesthetics are a priority.

Building-mounted turbines

10.29 Turbine roof vents and rooftop wind turbines need strong, sustained winds to be cost-effective. However, the top of a house is close to ground level, and obstacles like trees and other buildings can cause turbulence. This can reduce the turbine's output and shorten its life. Roof-mounted turbines are cheaper than freestanding ones but are not as powerful.

10.30 Turbines add weight and produce vibrations, which can cause structural strain on roofs. Many homes would require reinforcement to handle the added load and avoid damage over time.

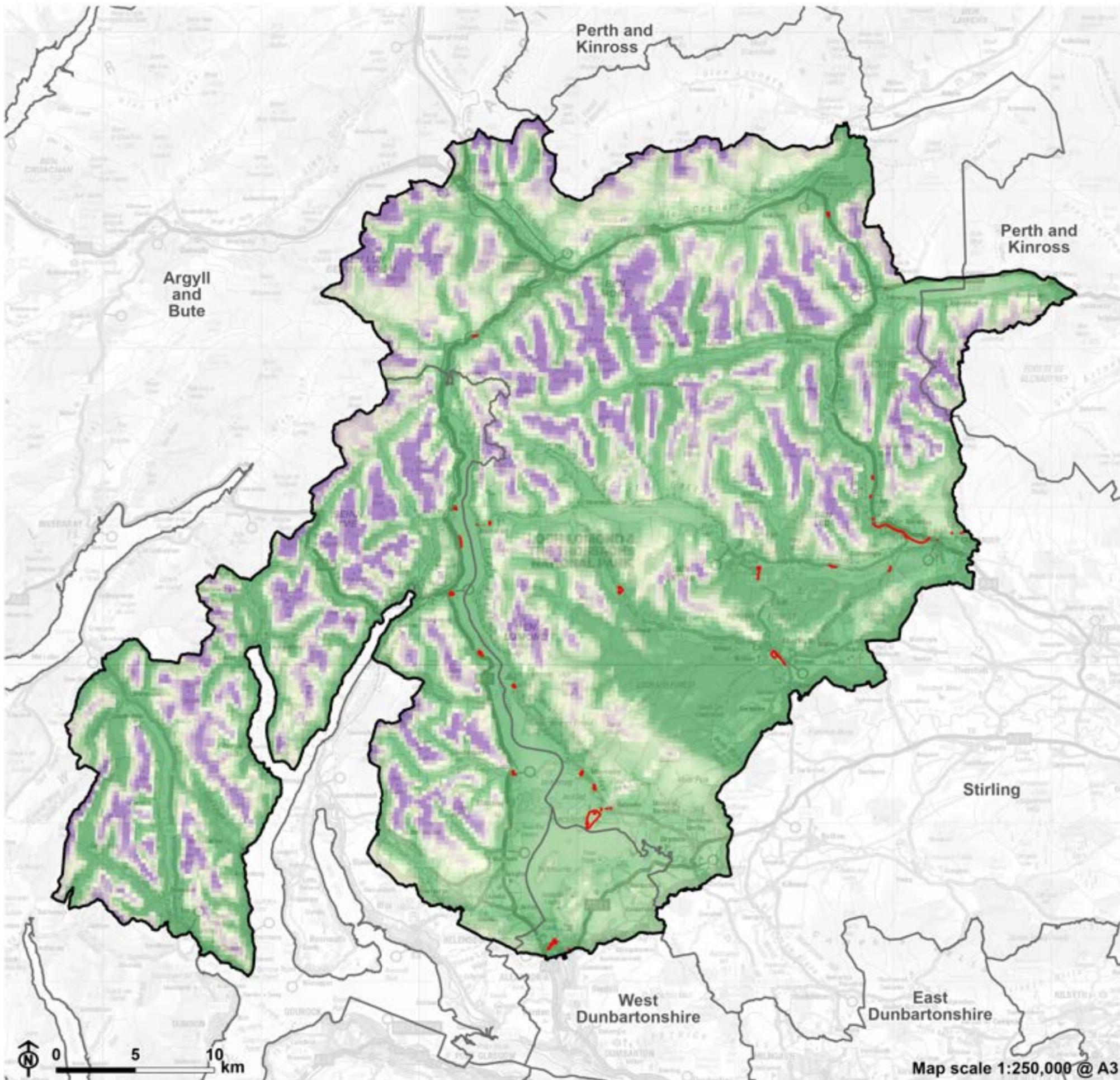
10.31 Roof-mounted turbines can be seen as intrusive or unattractive by homeowners and neighbours, which can deter adoption in residential neighbourhoods where aesthetics are a priority. In addition, even small wind turbines can produce noticeable noise during operation, especially in windy conditions. This noise can be disruptive to residents, particularly in densely populated areas.

Summary of wind opportunities and constraints

Only small-scale wind development is supported by planning policy in the National Park, constituting a single turbine with a height to blade tip of no more than 30m. Assessing the full technical capacity of wind energy within the National Park is beyond the scope of this assessment. Single turbines can be carefully micro-sited to consider nearby technical and environment constraints. The assessment presented within this study maps the physical constraints to wind development within the National Park at a strategic level (i.e. wind speed, physical infrastructure, technical and natural heritage constraints). Areas of with the least physical constraints are in the northern part of the National Park.

Key environmental considerations are likely to include, but are not limited to, ecological impacts on habitats and protected species (in particular, birds and bats), landscape and visual impacts, cultural heritage impacts, particularly on setting, and other amenity impacts such as noise. Impacts of building-mounted turbines are likely to be similar to rooftop solar installations.

As supported by existing planning policy, there is a place for small-scale wind development within the National Park and evidenced demand for this to be part of the energy mix, including co-located with other technologies. Most small-scale wind turbines can be sited and designed to have minimal adverse environmental impacts, and all proposals should be assessed on a case-by-case basis and cumulatively with other developments.

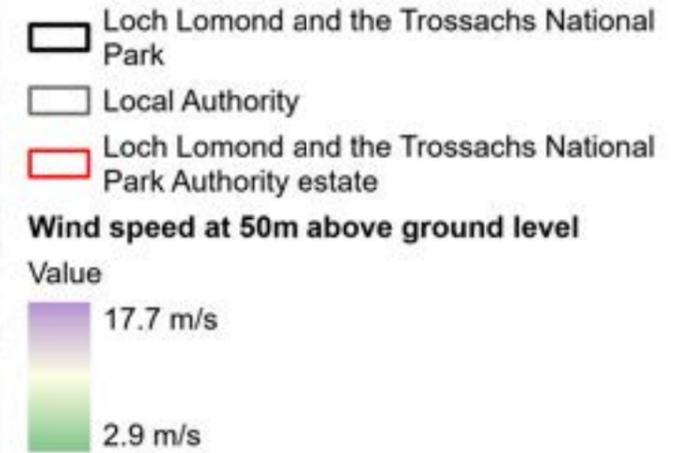


Loch Lomond & The Trossachs NPA:
Decarbonising Energy Generation within
the National Park



Loch Lomond & The Trossachs NPA

Figure 10.1: Wind Constraints - Wind speed at 50m above ground level

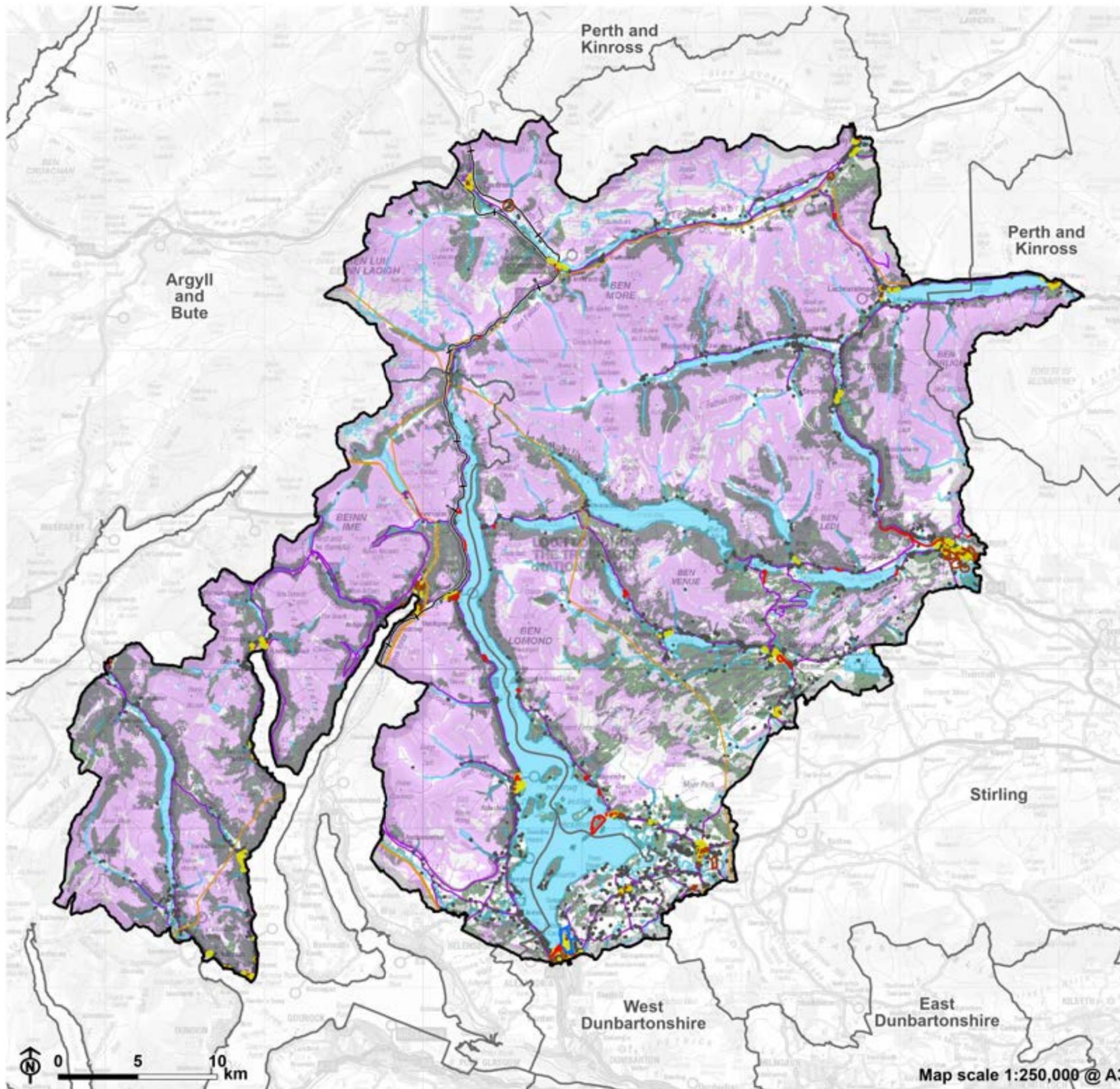


Notes:

Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: <https://globalwindatlas.info>.

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

Figure 10.2: Wind constraints - Physical constraints



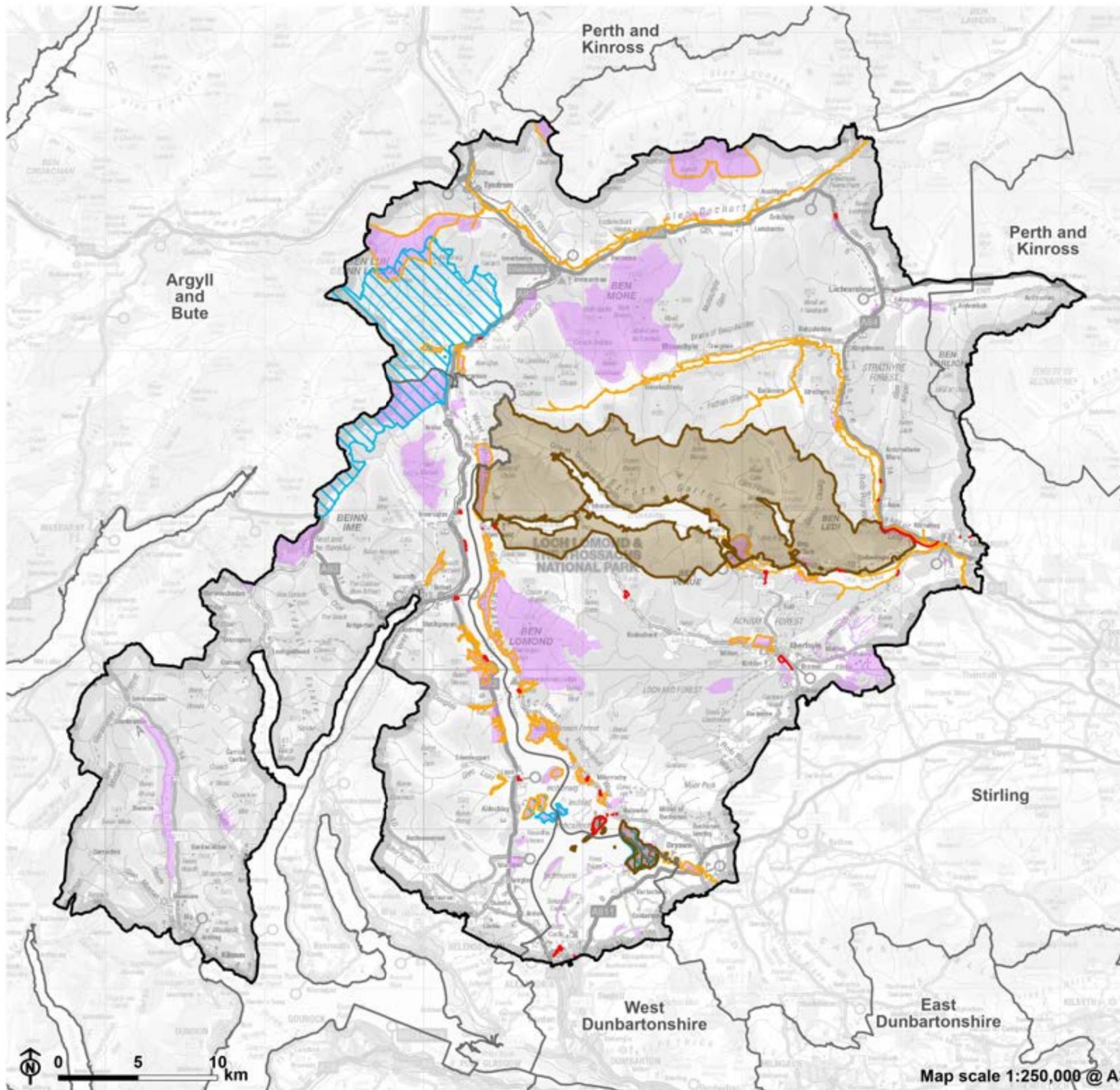
- Loch Lomond and the Trossachs National Park Authority
- Neighbouring Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Road
- Railway
- Transmission line
- Country park
- Site allocation
- Building
- Open space
- Watercourses and water bodies
- Woodland
- Slope above 15°

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

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The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

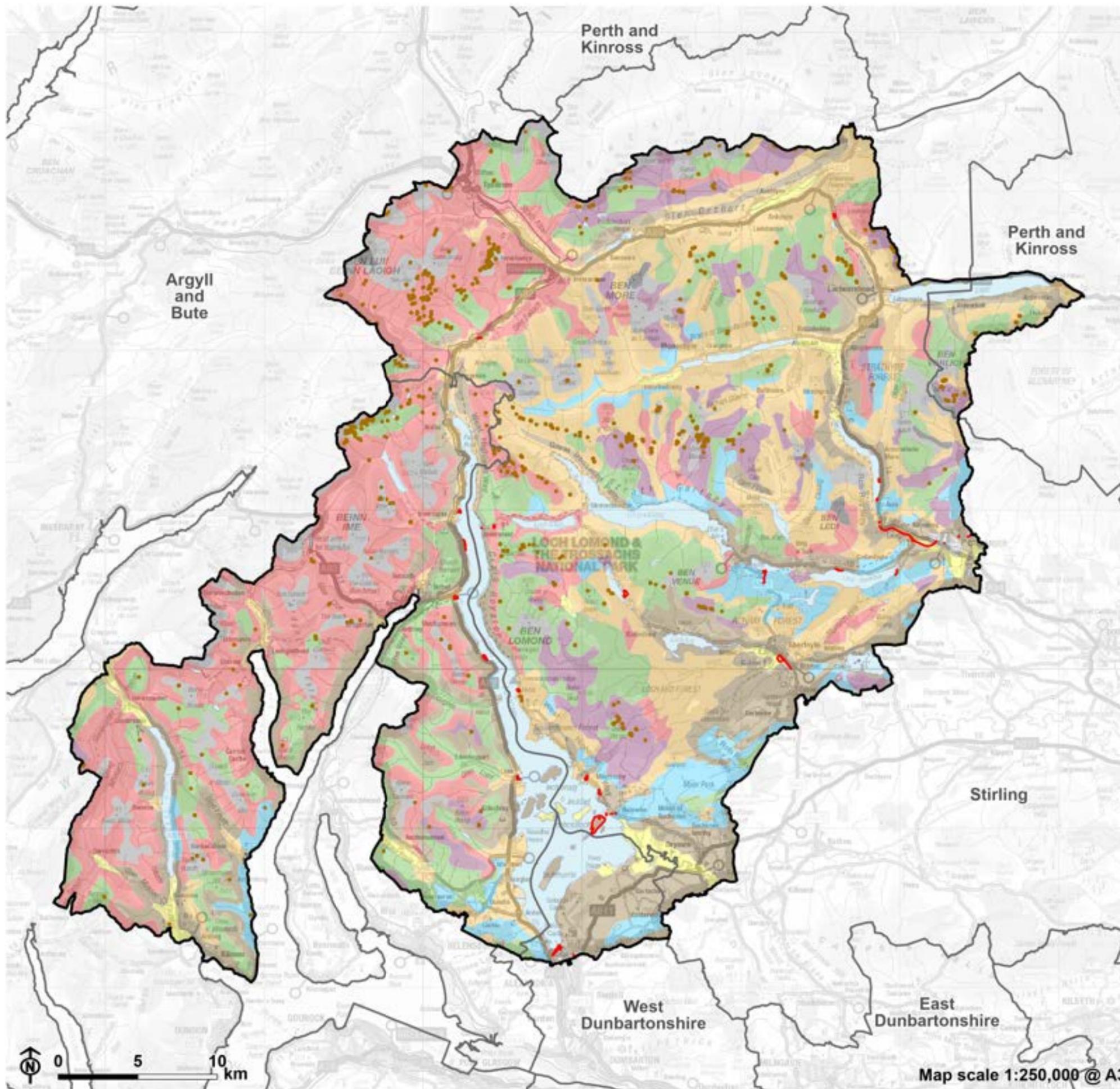


- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- National Nature Reserve
- Ramsar site
- Special Protection Area
- Special Area of Conservation
- Site of Special Scientific Interest

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.



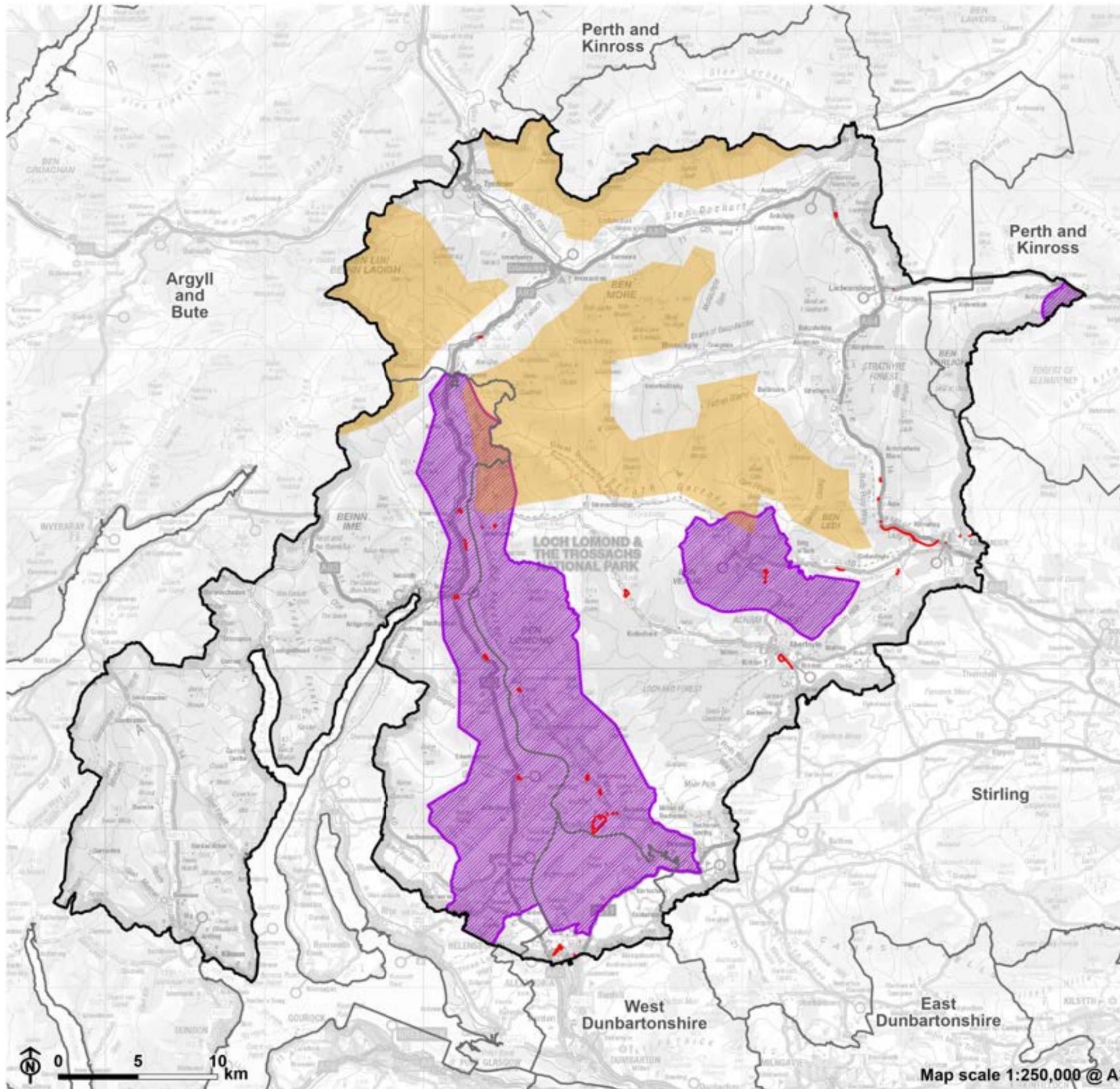
- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Bare peat area
- National soil map of Scotland**
- Alluvial soils
- Brown soils
- Immature soils
- Lochs
- Mineral gleys
- Mineral podzols
- Montane soils
- Peat
- Peaty gleys
- Peaty podzols

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Figure 10.5: Wind constraints - Landscape constraints



- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- National Scenic Area
- Wildland Area

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

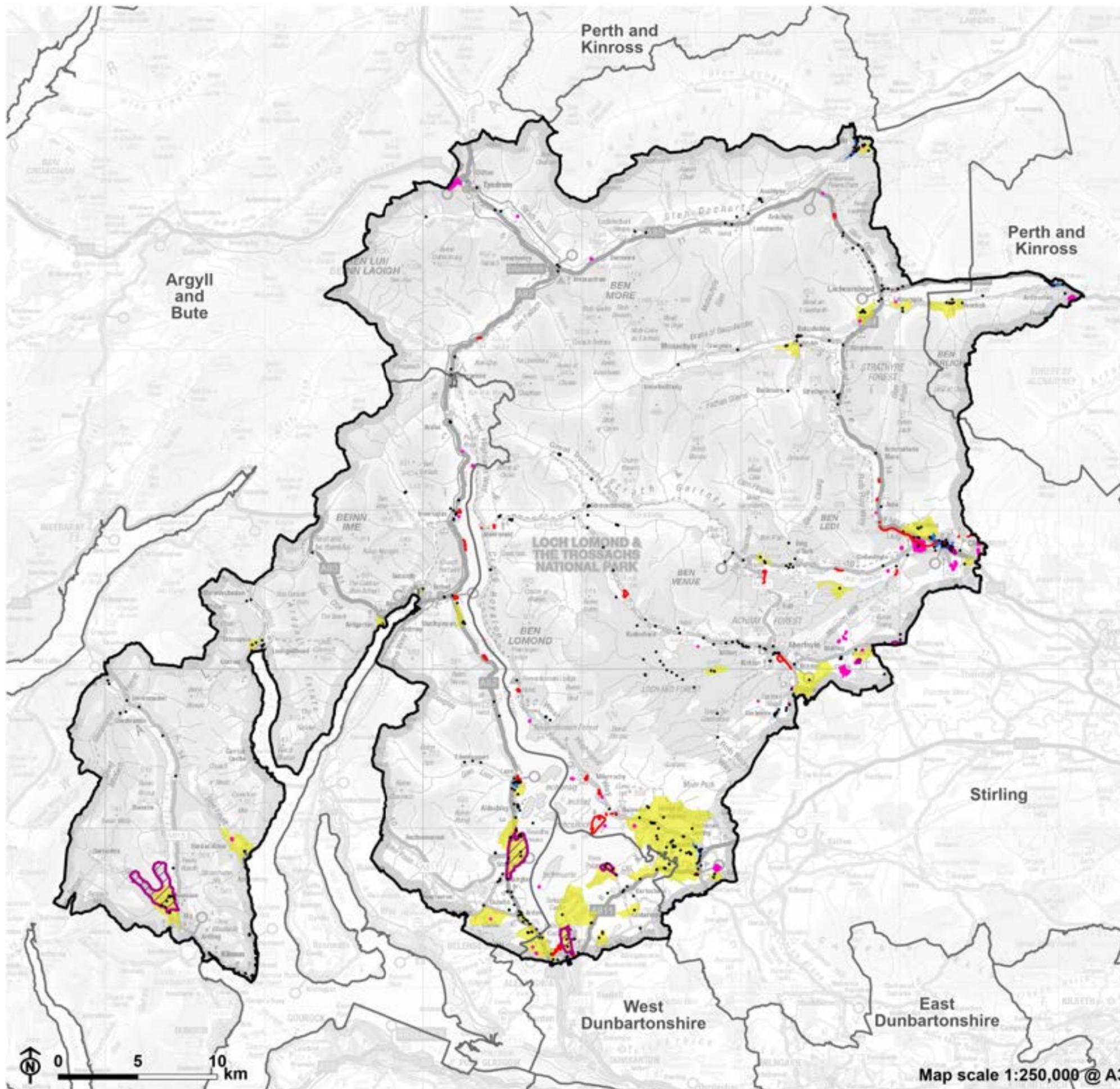


Figure 10.6: Wind constraints - Cultural heritage constraints

- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Listed building
- Gardens and Designed Landscapes
- Scheduled monument
- Conservation area
- Historic Designed Landscape

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Chapter 11

Biomass opportunities and constraints

Overview of the technology

Biomass energy produces heat from the burning of organic materials from plants and animals. Wood is the most commonly used biomass fuel, but it can also involve dried vegetation, crop residue and other organic materials. Biomass boilers are differentiated based on the type of fuel they use: chips, logs or pellets.

- Wood pellet boilers are the most popular systems used in the UK for average sized households. They are compact but require additional storage space compared to regular boilers.
- Wood log boilers provide a solution for people who have waste wood on their property. However, logs must be stored and seasoned for a long time before they can be used as fuel.
- Wood chip boilers are not recommended for domestic use unless a system needs to be of a larger scale. Fuel delivery costs and storage requirements would not be convenient for most households.



Biomass wood pellets (Freepik)

Size/scale	<p>Biomass boilers for individual properties are typically the size of a domestic boiler. Fuel storage requires additional space, depending on the boiler size and household energy demand. This should be located close by to facilitate easy loading.</p> <p>Larger scale commercial and industrial biomass boilers come in a range of sizes depending on the needs of the business. In the UK, larger scale biomass boilers are popular renewable heat sources on farms as some agricultural practices can have high heat demand.</p>
Power output / storage	<p>For domestic use, biomass boilers typically have power outputs of 10kW to 30kW. Larger commercial/industrial boilers can vary in output depending on the needs of the business.</p>
Colour	<p>Units are usually available in neutral tones (white, grey, or black) and may be customised to match interiors or utility rooms.</p>
Positioning	<p>Domestic biomass boilers are usually located indoors. However, for some installations, the system itself and fuel storage requirements mean that systems require additional space and an outbuilding/shed is required to house the infrastructure.</p> <p>For larger biomass boilers, fuel storage is typically housed in large silos or bunkers.</p>

Construction / operation impacts	For domestic installations, construction impacts are likely to be short-term and limited to the property. Many domestic biomass boilers are located indoors or in an outbuilding/shed. Larger scale biomass proposals may require development of a dedicated boiler room or separate building. There may be substantial groundwork required for storage silos or bunkers, boilers and flue systems.
Infrastructure / access	Given that some biomass boilers can be much larger than conventional fossil fuel boilers, it may be necessary to either construct a separate boiler house or extend the existing building. Larger scale biomass will require fuel storage and chimney/flue systems for managing combustion gases. Larger systems may require automatic ash extraction and storage for disposal. Additionally, development of commercial biomass drying floors and storage buildings is also associated with large scale biomass development. These may be located separately, even distant, from biomass plant but growth in biomass is likely to result in growth in this associated commercial development.
Scope of existing guidance	Technology specific guidance for biomass is provided in the existing guidance.

Technical potential and locational guidance

11.1 The technical potential for biomass has been undertaken for biomass generation from woodland and forestry with results presented in chapter 12. It is assumed that most properties could incorporate a domestic scale biomass boiler. Larger scale biomass proposals may require the development of a dedicated boiler room or separate building but there are no technology specific locational requirements to assess.

Key planning considerations

11.2 PDRs allow the installation, alteration or replacement of a flue, forming part of a biomass heating system, on a dwellinghouse or building containing a flat, or a flue for combined heat and power systems within key parameters. Exceptions apply to flues on the principal elevation of dwellinghouses or flats within a conservation area or World Heritage Site. Non domestic PDR do not apply to biomass and associated infrastructure.

Environmental considerations

Natural heritage considerations

11.3 The generic natural heritage considerations outlined in the existing guidance in relation to the habitat and species designations will apply (paragraphs 4.9 - 4.12). Paragraph 6.10 outlines key ecological considerations relating to the installation of biomass plants, which remains relevant. Development of flues for domestic biomass heating systems are unlikely to directly influence habitats and species due to their small size and their position⁷⁹.

11.4 However, potential ecological effects from an installation may vary depending on the scale of biomass installations (i.e. of a scale requiring construction of buildings) and proximity to sensitive receptors. Ecological surveys may be required and should be proportionate to the nature and scale of proposals.

⁷⁹ <https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/micro-renewables>

Landscape and visual considerations

Small-scale Biomass

11.5 Small-scale biomass boilers are typically the size of a large domestic boiler. Small-scale biomass is therefore unlikely to have a significant effect on landscape and visual receptors, or on the SLQs of the National Park. Landscape and visual considerations have therefore been ‘scoped out’ of this report.

Medium / large-scale Biomass

11.6 Medium / large-scale biomass developments come in a range of sizes. The key components are the boiler, turbine houses, generators and transformers. Larger scale biomass will require fuel storage and chimney/flue systems for managing combustion gases. Medium / large-scale biomass developments therefore have the potential to result in significant landscape and visual effects, including effects on SLQs and the key attributes and qualities of WLAs.

11.7 As noted in the existing renewables guidance, location and design will influence the extent of likely landscape and visual effects. Generic landscape siting and design considerations to reduce effects relating to all technology types are set out in chapter 5. In addition to the generic guidance listed in chapter 5, siting and design guidance specific to biomass developments may include:

- Minimising landscape and visual impacts through design of buildings required (e.g. boiler, turbine houses, generators, transformers); and
- Minimising landscape and visual impacts associated with woodland management, where applicable.

11.8 As noted, there are no locational requirements for biomass.

11.9 Some LCTs are likely to be less susceptible to biomass related development. These LCTs are more likely to be able to accommodate biomass developments without significant landscape effects, subject to appropriate siting, design and mitigation.

11.10 Landscapes that are flat or gently sloping, with a simple and regular pattern, and limited intervisibility with surrounding landscapes, are likely to be less susceptible to change. Landscapes with a higher proportion of field boundary vegetation, woodland and / or forestry may also be able to accommodate development as existing vegetation will help to integrate the

development with its landscape setting as well as helping to filter/screen views. LCTs which exhibit these key characteristics, include LCT 260 – River Valley Farmland and Estates, LCT 253 - Straths and Glens and LCT 254 - Straths and Glens with Lochs.

11.11 Landscapes that have strong topographical variety or distinctive landform features, are complex or rugged, are remote from signs of human activity or have highly visible skylines are more likely to be susceptible to change. Landscapes that are open, with limited tree cover, are also likely to be more widely visible and therefore more susceptible to change. LCTs which exhibit these key characteristics include LCT 215 – Open Ridgeland – Glasgow & Clyde Valley, LCT 251 Highland Summits and LCT 255 – Parallel Ridges – Loch Lomond & the Trossachs.

11.12 All proposals should be assessed on a case-by-case basis. For biomass developments requiring planning consent, a landscape and visual assessment is likely to be required in accordance with GLVIA3.

Cultural heritage considerations

Small-scale biomass

11.13 Generally, domestic-scale biomass boilers should have little impact on the historic environment where they are like-for-like replacements for gas, oil or electrical heating systems. Where they are entirely new installations in historic buildings, there will need to be careful consideration of installation approach, external flue design and the efficacy of radiator/under-floor heating. Traditional buildings are highly sensitive to changes in moisture balance and heating profiles, therefore ensuring that the new system is designed to work with the traditional building, rather than against its inherent characteristics, is imperative.

Medium/large-scale biomass

11.14 At a minimum, it is likely that community- or grid-scale biomass installations will require screening for EIA. The historic environment should therefore be systematically considered as part of that process. Applicants should take the necessary advice from appropriately qualified and experienced professionals, as well as the authority conservation officer, archaeological adviser and – where necessary – HES.

Cumulative impacts

11.15 There is potential for cumulative landscape and visual and heritage impacts to occur in the case of multiple medium scale developments within a small area.

Other issues affecting deployment

11.16 Biomass boilers can be more expensive to install than traditional fossil fuel boilers, and the cost of the fuel storage container or regular fuel deliveries must also be considered. Therefore, one of the largest disadvantages of biomass boilers is that the initial investment, including purchasing the boiler and installing it, is higher compared to traditional gas or oil boilers.

11.17 High electricity and heat consumption appears as one of the arguments against biomass-fired power plants. The production process itself is time-consuming and requires the use of expensive technology and equipment, which creates significant costs and a burden on the environment.

11.18 Biomass boilers require space for fuel storage, which may be difficult to accommodate in smaller homes or businesses. Biomass boilers need more space than gas or oil boilers because the system is larger. Some space is needed to store the fuel itself, such as a hopper or wood store. Pellets, chips and straw (biomass sources) require proper storage. If not properly conditioned, they quickly absorb moisture and their efficiency degrades.

11.19 Biomass boilers also produce smoke and can emit a number of pollutants including nitrogen dioxide (NO₂), particles (PM) and sulphur dioxide (SO₂)⁸⁰. Large biomass boilers are regulated under the Integrated Pollution Prevention and Control (IPCC) and medium and small biomass boilers fall under the Clean Air Act 1993. Air quality is a material consideration in the planning system.

11.20 The Scottish Government's position is that bioenergy should only be used in those applications where its carbon reduction impact is maximised, where alternative options are not

available, and where it comes from sustainable sources. In addition, both the Heat in Buildings strategy and proposals included in the consultation on a Heat in Building Bill put forward the Scottish Government's intention to prohibit the use of polluting heating systems after 2045⁸¹.

11.21 However, going forward biomass or biofuels may be the only solution for some existing properties that are not currently suitable for clean heating systems. This may act as a driver for woodfuel within the National Park.

11.22 Biomass boilers require regular maintenance to ensure that they are running efficiently and to prevent breakdowns. Biomass boilers need to be cleaned regularly, around once a week. However, modern models make the process very simple or even incorporate the feature automatically.

Summary of biomass opportunities and constraints

Demand for biomass technologies has reduced over time as other technologies become more popular and lower cost. National policy direction indicates that the role of biomass in a domestic setting going forward is likely to be limited to existing properties that are not currently suitable for clean heating systems. Where scaling-up bioenergy is supported, the focus in the long-term should be on Bioenergy with carbon capture and storage (BECCS).

With regard to the technical potential for biomass within the National Park, it is assumed that most properties could incorporate a domestic-scale biomass boiler. Larger scale proposals may require a dedicated boiler room or separate fuel store. Biomass development is covered by the existing Renewable Energy Planning Guidance and key environmental considerations include, but are not limited to, landscape and visual and air quality impacts.

⁸⁰Institute of Air Quality Management. (undated) Biomass and Air Quality Information for Developers https://www.iaqm.co.uk/text/guidance/epuk/biomass_developers_leaflet.pdf

⁸¹ Scottish Government (2024) Part IV of the Environment Act 1995 Local Air Quality Management Policy Guidance PG (S) (24). Available at:

<https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2024/05/local-air-quality-management-policy-guidance-2/documents/local-air-quality-management-policy-guidance/local-air-quality-management-policy-guidance/govscot%3Adocument/local-air-quality-management-policy-guidance.pdf>

Overall, future role of biomass within the National Park is likely to align with the Scottish Government's position that bioenergy should only be used in those applications where its carbon reduction is maximised and where alternative options are not available.

Chapter 12

Biomass resource assessment

12.1 This chapter represents an assessment of the technical potential for biomass fuel within the National Park. However, planted biomass resource (i.e. the potential for biomass generation from forestry and woodland in the National Park) must be understood within the wider land use context of the National Park.

12.2 As acknowledged in the Scottish Government's Draft Bioenergy Policy Statement⁸², there is limited land suitable for growing bioenergy crops. Consideration is required for other land use priorities including food production, housing, woodland creation, peatland restoration, nature restoration and protection of ecosystems. The National Park Partnership Plan 2024-29 sets out ambitions for tackling both the climate and nature crisis, going beyond Net Zero targets and reversing nature loss within the National Park. LLTNPA's Future Nature Route Map⁸³, amongst other aims, sets out a vision for *'native broad-leave woodland and scrub continues to expand in extent both in the lowlands and uplands of the National Park'*. Strategic aims for carbon sequestration and nature restoration requires land. As such, land use requirements for the implementation and expansion of renewable and low-carbon energy within the National Park must be balanced with other objectives.

12.3 Biomass is defined generally as material of recent biological origin that is derived from plant or animal matter. 'Dry' biomass is commonly combusted to produce electricity or generate heat. 'Wet' biomass is commonly used to produce biogas via anaerobic digestion. This can be used as 'green' gas on the grid or used to produce 'biofuel' for transport. Wet agricultural biomass includes manure and slurry, and also wet residues from waste and sewage. Wet agricultural biomass has not been considered further in relation to the National Park, due to the extensive nature of agriculture in the area.

⁸² Scottish Government (2024) Draft Bioenergy Policy Statement – consultation (see: <https://www.gov.scot/publications/draft-bioenergy-policy-statement/>)

⁸³ LLTNPA – Future Nature Route Map (see: <https://www.lochlomond-trossachs.org/wp-content/uploads/2023/05/Future-Nature-route-map-final.pdf>)

12.4 In many countries, dry biomass materials such as wood are commonly used as a fuel for modern heating systems. These modern technologies can be used to heat a variety of building sizes and can be utilised within individual boilers or district heating systems.

12.5 In addition, organic wastes can be considered a source of low-carbon energy production if their use in generation prevents them from otherwise decomposing and potentially releasing methane, a more potent greenhouse gas than carbon dioxide.

12.6 Biomass can also be used to generate electricity, fuelling electricity plants or combined heat and power (CHP) plants. This is becoming increasingly common due to the low carbon emissions of its use. However, to ensure the technology is low-carbon, consideration must be given to ensuring the biomass feedstocks are sustainably sourced with minimal carbon emissions associated with any required processing and transportation. Except for landfill gas, energy supply from most bioenergy sources has grown since 2010 with the largest upturn from plant biomass (imported and domestic).

12.7 The most common types of biomass feedstocks for energy production include:

- Virgin woodfuel: Including forestry and woodland residues, and energy crops (crops planted specifically to be used in the production of heat and electricity, as further described below).
- Waste residues: Including municipal and commercial solid waste (such as coffee waste), recycled wood waste, agricultural residues and sewage. This report has scoped out these biomass sources.

12.8 This section focuses on the potential from virgin wood fuels. The virgin wood fuel considered within this study includes:

- Untreated wood residues (from forestry, woodlands, arboriculture, tree surgery, etc); and
- The energy crops Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF).

12.9 It is noted that there is some overlap in which virgin wood enters certain waste streams, however this is difficult to extract from contaminated non-virgin wood. As such, virgin woodfuel within waste streams is not considered within this part of the assessment.

12.10 It is necessary to separately consider virgin and non-virgin woodfuel resources as different legislation will apply to its usage for energy generation regarding emission permits.

Virgin woodfuel is considered to be clean and safer than non-virgin woodfuel, which may be contaminated for example by paint or preservatives. As such the use of non-virgin woodfuel for energy generation would fall under stricter emission and pollution controls.

12.11 Provided virgin woodfuel is sustainably sourced, such as via sustainable woodland management through re-growth and low emissions from processing and transportation, it can be considered a sustainable fuel. The carbon emissions released from the combustion of the wood are theoretically balanced by the regrowth of replacement woodland and energy crops, provided the carbon emissions released in growing and transporting the woodfuel are mitigated. For example, logs and woodchip are considered to be less sustainable due to their 'bulky' nature, and as such should be sourced locally to limit greater transport emissions.

12.12 Woodfuel biomass is commonly produced as logs, woodchips, pellets and briquettes, and there are several processes that are required to prepare the woodfuel to reach these usable states. Processing influences the moisture content, size and form of the biomass fuels and the quality control of these factors is necessary to ensure the biomass is usable within specific boilers and thermal conversion processes.

12.13 Virgin woodfuel biomass can be utilised for both heat-only generation as well as CHP, and a variety of energy conversion technologies can be used, such as direct combustion, gasification and pyrolysis.

12.14 Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF) are the two main virgin woodfuel energy crops used within biomass and considered within this study. Such crops are commonly planted specifically to be used in the production of heat and electricity, whilst other 'biofuel' crops, including sugar cane, maize and oilseed rape, are more commonly planted to be used as transport fuels.

Biomass – wood fuel

Technical potential

12.15 To determine the potential for biomass generation from forestry and woodland in the National Park, it was assumed that all woodland within the study area has a sustainable yield of two odt/yr (oven-dried tonnes/ha/year) and assumptions (see **Table A.6**) were applied. Both the potential for heating and for combined heat and power were calculated.

12.16 To identify existing suitable woodland within the study area, the Forestry Commission’s National Forest Inventory (NFI) was used. The NFI records the location and extent of all forests and woodland above 0.5ha across the UK and it is noted that although a sample of forests and woodland are ground surveyed every 5 years, the inventory is updated annually using aerial photography, interpretation of satellite imagery and administrative records of newly planted areas covered by government grant schemes. As such, there can be occasional errors due to misidentification of sites not ground-surveyed.

12.17 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a national capacity factor was applied, as based on national data for plant-sourced biomass.

12.18 The woodland and forestry biomass resource was calculated using the assumptions outlined in Appendix A, with technical potential results shown in Table 12.1 for heating-only use and in Table 12.2 for combined heat and power (CHP) generation. The assessment considers only woodfuel sourced from woodland within Loch Lomond and the Trossachs National Park.

Figure 12.1 Estimated total capacity (MWth) and potential CO₂ savings (tCO₂/yr) (including SPF) for biomass - woodfuel.

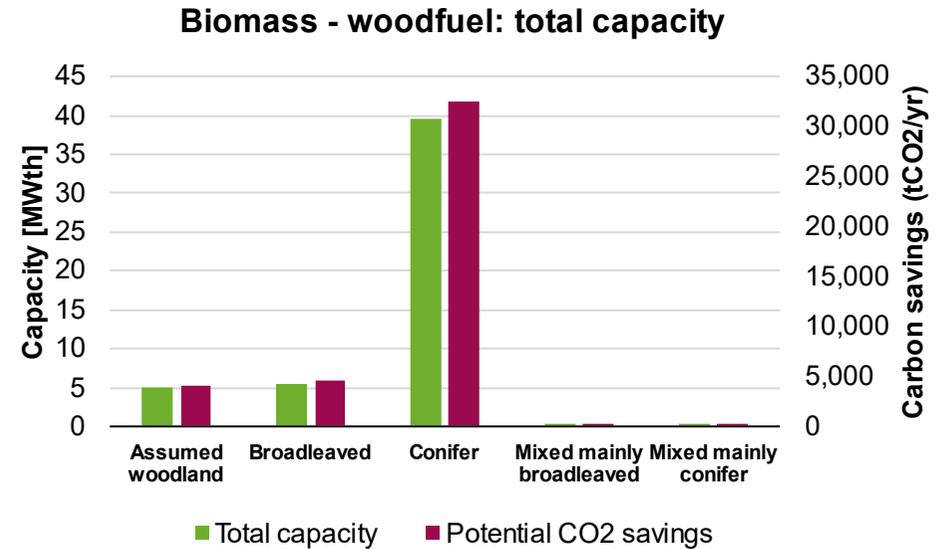


Figure 12.2 Annual generation capacity (MWth) and potential CO₂ savings (tCO₂/yr) (including SPF) for biomass – woodfuel boiler heating.

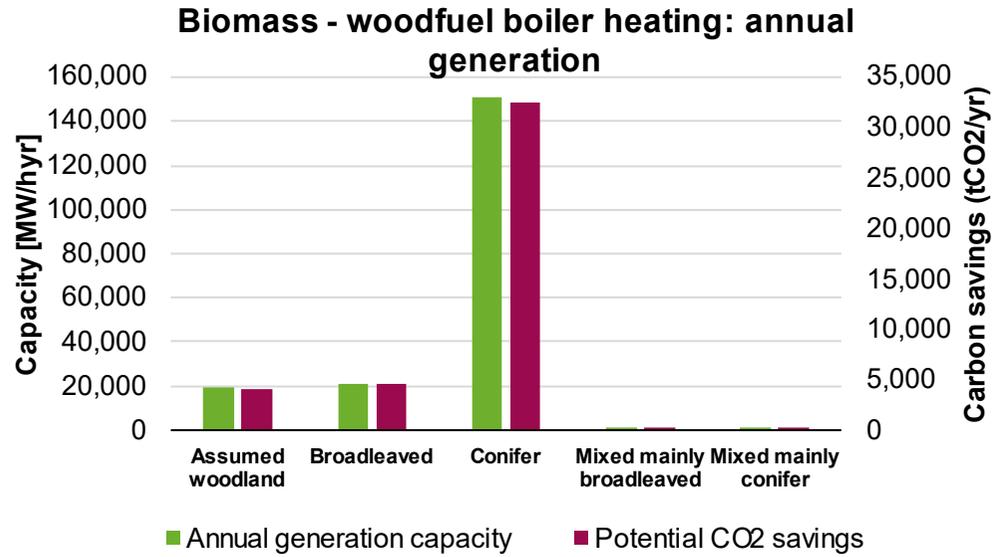


Table 12.1 Woodfuel: Assessment of forestry and woodland resource - use for heating

Woodland Type	Estimated Capacity (MW)	Delivered Heat (MWh/year)	Potential CO ₂ Savings (tonnes/year)
Assumed woodland	0.1	480	102
Broadleaved	1.9	7,177	1,522
Conifer	0.2	888	188
Coppice	0.0	0.0	0.0
Mixed mainly broadleaved	0.2	643	136
Mixed mainly conifer	0.2	651	138
Total	2.6	9,838	2,087

Figure 12.3 Annual generation of heat (MW/yr) and potential CO₂ savings (tCO₂/yr) for biomass – woodfuel CHP.

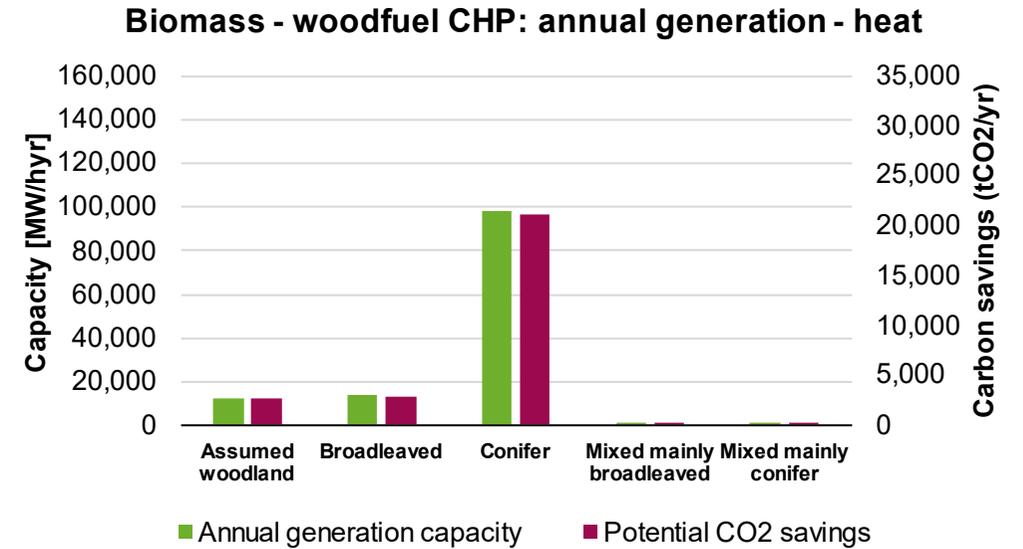


Figure 12.4 Annual generation of electricity (MW/hr) and potential CO₂ savings (tCO₂/yr) for biomass – woodfuel CHP.

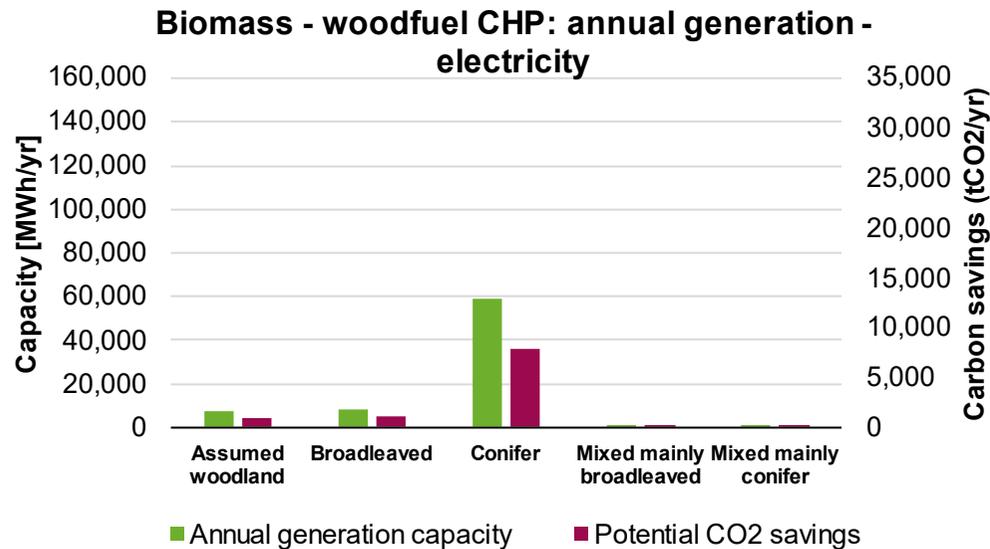


Table 12.2 Woodfuel: Assessment of forestry and woodland resource - use for CHP

Woodland Type	Estimated Capacity (MW)	Delivered Electricity (MWh/year)	Delivered Heat (MWh/year)	Potential CO ₂ Savings (tonnes/year)
Assumed woodland	0.1	187	312	91
Broadleaved	1.9	2,793	4,660	1,360

⁸⁴ Forestry Research (2024) Potential yields of biofuels per ha p.a. Available at: [https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-](https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/)

Woodland Type	Estimated Capacity (MW)	Delivered Electricity (MWh/year)	Delivered Heat (MWh/year)	Potential CO ₂ Savings (tonnes/year)
Conifer	0.2	346	577	168
Coppice	0.0	0.0	0.0	0.0
Mixed mainly broadleaved	0.2	251	418	122
Mixed mainly conifer	0.2	254	423	123
Total	2.6	3,833	6,389	1,865

12.19 In addition to the calculated potential woodland and forestry biomass resource within the National Park, surplus woodfuel could potentially also be sourced from neighbouring authorities, provided the cost and transportation sustainability were viable. Furthermore, the cutting of hedgerows could additionally provide a source of woodfuel, however due to the lack of data regarding hedgerow yields, it has not been possible to factor this into the assessment. Woodfuel could be used from neighbouring areas but as stated above, this assessment only focuses the technical potential for wood fuel grown within the National Park.

Biomass – energy crops

Technical potential

12.20 To determine the potential for biomass generation from forestry and woodland, it was assumed that all woodland within the study area has a sustainable yield of two odt/yr (oven-dried tonnes/ha/year)⁸⁴ and assumptions (see **Appendix A**) were applied. Both the potential for heating and for combined heat and power were calculated.

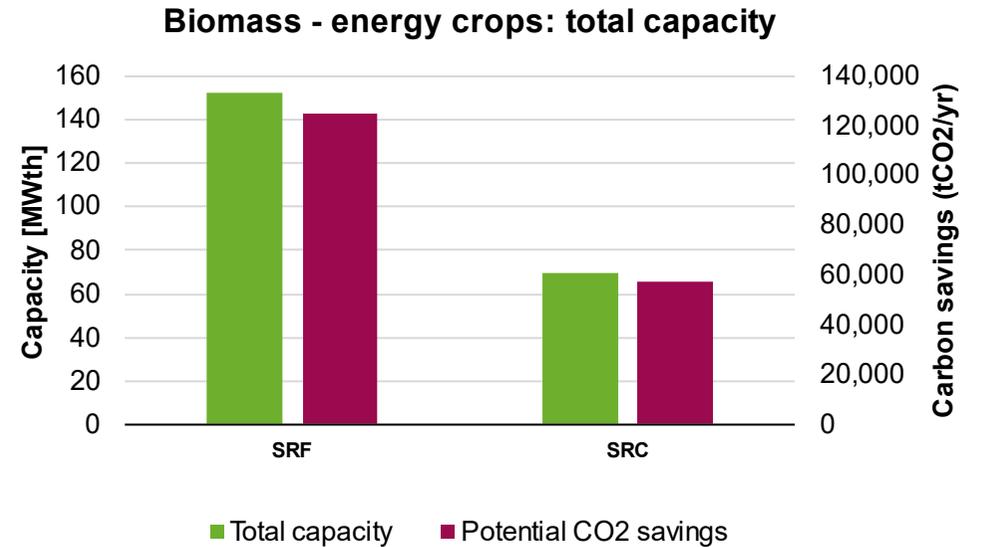
[biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/](#). Data for Wood (forestry residues, SRW, thinnings, etc.).

12.21 To identify existing suitable woodland within the study area, the Forestry Commission’s National Forest Inventory (NFI) was used, as described for biomass woodfuel.

12.22 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a national capacity factor was applied, as based on national data for plant-sourced biomass⁸⁵.

12.23 Table 12.3 presents the findings of the technical assessment, assuming that the energy crops would be used for heating only, and Table 12.4 presents the findings assuming that the energy crops were used to produce electricity and heat via CHP. A total area of 34,500 hectares was identified to have technical potential for energy crop growth.

Figure 12.5 Total capacity of heat (MW/th) and potential CO₂ savings (tCO₂/yr) for biomass – energy crops.



⁸⁵ BEIS (2023) Load factors for renewable electricity generation (DUKES 6.3). Available at: <https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes>

Figure 12.6 Annual generation capacity (MWh/yr) and potential CO₂ savings (tCO₂/yr) for biomass – energy crops boiler heating.

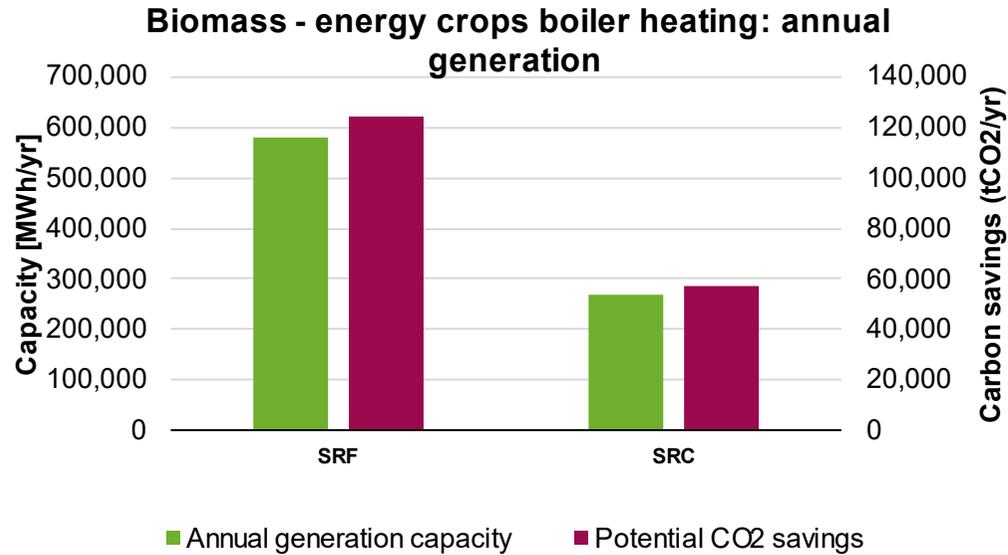


Figure 12.7 Annual generation capacity of heat (MWh/yr) and potential CO₂ savings (tCO₂/yr) for biomass – energy crops.

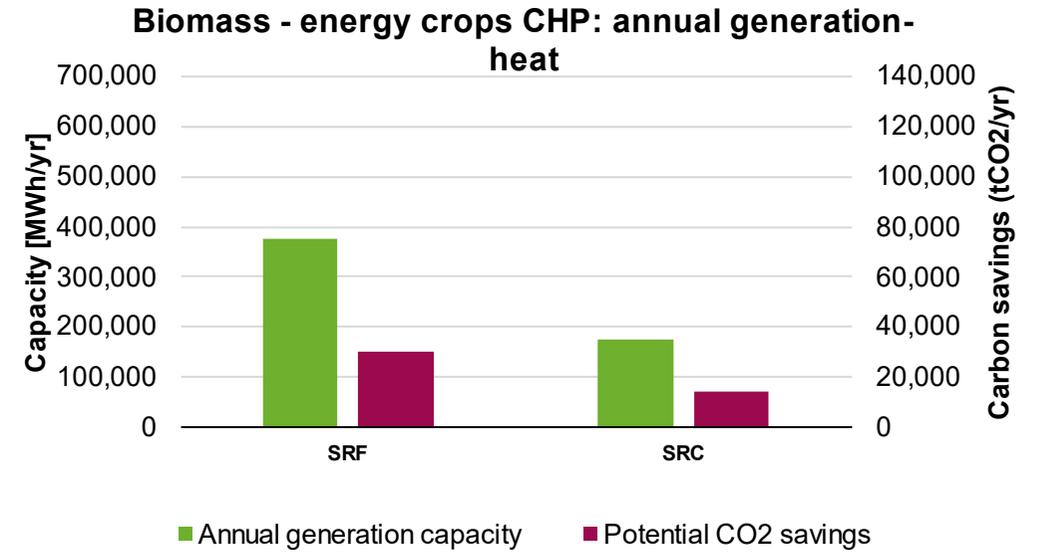


Table 12.3 Assessment of biomass energy crops – heating only

Energy Crop Type	Estimated Capacity (MW)	Delivered Heat (MWh/year)	Potential CO ₂ Savings (tonnes/year)
SRF	152.18	582,014.07	124,810.52
SRC	69.81	266,973.76	57,251.42
Total	221.98	848,987.83	182,061.94

Table 12.4 Assessment of biomass energy crops – CHP

Energy Crop Type	Estimated Capacity (MW)	Delivered Heat (MWh/year)	Potential CO ₂ Savings (tonnes/year)
SRF	152.18	377,931.22	81,045.79
SRC	69.81	173,359.58	37,176.25
Total	221.98	551,290.80	118,222.04

Locational guidance and constraints

12.24 A series of figures have been produced which show areas of opportunity for woodland which could be used as biomass and the natural heritage, cultural heritage and physical constraints.

12.25 Figure 12.8 shows where land is capable for forestry and agriculture for the production of biomass in the National Park. This is based on the national land capability for forestry and agriculture mapping. It shows that most of the national park has land capability for both the forestry classes and agriculture classes relevant for biomass production for virgin woodfuel and energy crops respectively. There are relatively more areas with land capability for the relevant agriculture classes than the forestry classes. Areas which do not have land capability are more common in the south-east of the National Park, as well as in larger settlements and along travel routes.

12.26 Figure 12.9 shows the areas of opportunity for woodland which could be used for biomass (i.e. that which is assumed to be mature and able to provide a sustainable yield of woodfuel) as well as constraints in the National Park, including Listed Buildings, National Nature Reserves, Ramsar sites, SPAs, SACs, SSSIs, ancient woodland, Inventory listed Gardens and Designed Landscapes, conservation areas and scheduled monuments. The figure shows that areas of woodland which are most viable to be used for biomass in the national park are medium to small patches scattered throughout the National Park, particularly in the west and south east of the Park, away from larger settlements such as those which are along the southern and eastern boundaries of the National Park and from designated landscapes such as the Great Trossachs Forest NNR, SACs and SSSIs.

12.27 Figure 12.10 shows where the physical constraints to the development of biomass fuel are located in the National Park. Physical constraints include infrastructure such as roads and railways, buildings, open space and watercourses / bodies. It shows that larger settlements in the National Park, such as those to the south of Loch Lomond, near Callendar, Aberfoyle and Lochearnhead in the east of the National Park, Killin in the north and near Tyndrum, Arrochar and Lochgoilhead in the west, tend to have the highest concentration of physical constraints, especially buildings and open spaces. Watercourses/ bodies and roads run throughout the National Park and a railway line runs through the north-west of the National Park. Areas with the least physical constraints are located in the northern part of the National Park.

12.28 Figure 12.9 shows where the natural heritage constraints to the development of biomass fuel (virgin woodfuel and energy crops) are located in the National Park. It shows that one of the largest constraints is the Great Trossachs Forest NNR in the centre of the National Park, another large area of constraint is the Glen Etive and Glen Fyne SPA in the north-west of the National Park. Other key constraints in the National Park are the numerous SSSIs and SACs. The largest land areas without constraints to the development of biomass fuel are located in the north-east, south-west and south-east of the National Park.

12.29 Figure 12.11 shows where the cultural heritage constraints to the development of biomass fuel (virgin woodfuel and energy crops) are located in the National Park. It shows that larger settlements in the National Park tend to have the highest concentration of cultural heritage constraints, especially Inventory listed Gardens and Designed Landscapes and conservation areas. Both scheduled Monuments and listed Buildings tend to be more concentrated in more populous areas and along transport routes, though are relatively more dispersed throughout the National Park. Western, north-western and central areas of the National Park tend to have the least amount of cultural heritage constraints to the development of biomass.

Other issues affecting deployment

12.30 The deployment of energy crops in Scotland, and to a lesser degree the management of woodland for woodfuel, faces several key limitations, primarily related to land use, economic viability, and environmental concerns. Influences include:

- Economic viability;
- End-use/market;
- Land ownership;
- Land use competition;
- Yield variability;
- Initial costs;
- Existing farming activities;
- Potential biodiversity impacts;

- Access, affected by remoteness and landscape topography;
- Protected landscapes; and
- The presence of water-stressed areas.

12.31 Key for the National Park is the issue of access and steepness of slope to facilitate harvesting. Notably, the conflict between land use for food production or for energy crops will require consideration with regards to the potential scale of energy crop potential within Loch Lomond.

12.32 Energy crop production depends on incentives for landowners and farmers, with longer-term supply contracts often needed in advance. The establishment of supply chains and fuel processing logistics may initially slow the widespread use of energy crops. Additional to this is the distance to processing facilities and markets. In the National Park, additional challenges include the need for Environmental Impact Assessments (EIA) for energy crop projects, planning and permitting for energy generation plants and the availability of alternative markets for crops like Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF) beyond energy use. In addition, the growing deployment of heat pumps in the UK, as the electricity grid decarbonises, may reduce the competitiveness of biomass, which also faces challenges such as fuel storage space, solid fuel flue regulations and maintenance requirements.

12.33 Research was conducted in 2020 to assess the land use impacts of perennial energy crops in Scotland⁸⁶. Key issues relevant to the potential for energy crops in the National Park include:

- The production of energy crops in Scotland is currently very low, only Short Rotation Coppice (SRC) is grown on a small commercial scale of approximately 250 ha;
- The theoretically suitable total land area identified across all three crops considered and land types, is more than 900,000 ha, however the majority of the theoretically available land is located in the east of Scotland and the lowlands.

- In practice, the availability of land will be limited by a range of other factors, which were not modelled in the study e.g. non-spatial constraints and the need for land for other uses, such as food and fodder production, forestry (non-energy), biodiversity etc.

12.34 A report outlining the potential contribution of bioenergy to Scotland's energy system⁸⁷, outlines that the development of future additional energy crop resource will depend on overcoming barriers and persuading farmers to plant crops. To achieve increased production propagation of planting material is vital. In addition, energy crops require specialist planting and harvesting machinery, which is also in short supply at present. Together these factors limit the rate at which planted areas can be expanded. The report also outlines that the lack of production of energy crops by farmers to date reflects a number of barriers. These include; the lack of a perceived stable market for energy crops, lack of experience with crops, perception of risk and uncertainty, and requirements for up-front investment and cash flow issues in early years. Farmers can also be reluctant to commit land to long term production of one crop. Energy crops also need to be an attractive financial investment compared to alternative land uses.

12.35 There is ambition at national level for biomass to play an important role in decarbonising the UK's energy generation, as outlined in the Clean Growth Strategy (2017)⁸⁸ and the Committee on Climate Change's Net Zero report (2019)⁸⁹. Biomass has significant potential, especially when combined with carbon capture and storage technology, which allows for both carbon sequestration through plant growth and the capture of emissions from bioenergy conversion. However, the Committee on Climate Change emphasises that sustainable, low-carbon bioenergy is only feasible if:

- Rules for sourcing sustainable biomass are improved, and
- Biomass use is managed carefully to maximise carbon removal and minimise emissions.

12.36 The Scottish Government is in the process of creating a bioenergy action plan. They published a draft Bioenergy policy statement in 2024⁹⁰ and a bioenergy update paper in March

⁸⁶ <https://www.climateexchange.org.uk/research/projects/perennial-energy-crops-and-their-potential-in-scotland-evidence-review/>

⁸⁷ <https://www.climateexchange.org.uk/wp-content/uploads/2023/09/the-potential-contribution-of-bioenergy-to-scotland-s-energy-system.pdf>

⁸⁸ <https://www.gov.uk/government/publications/clean-growth-strategy>

⁸⁹ <https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf>

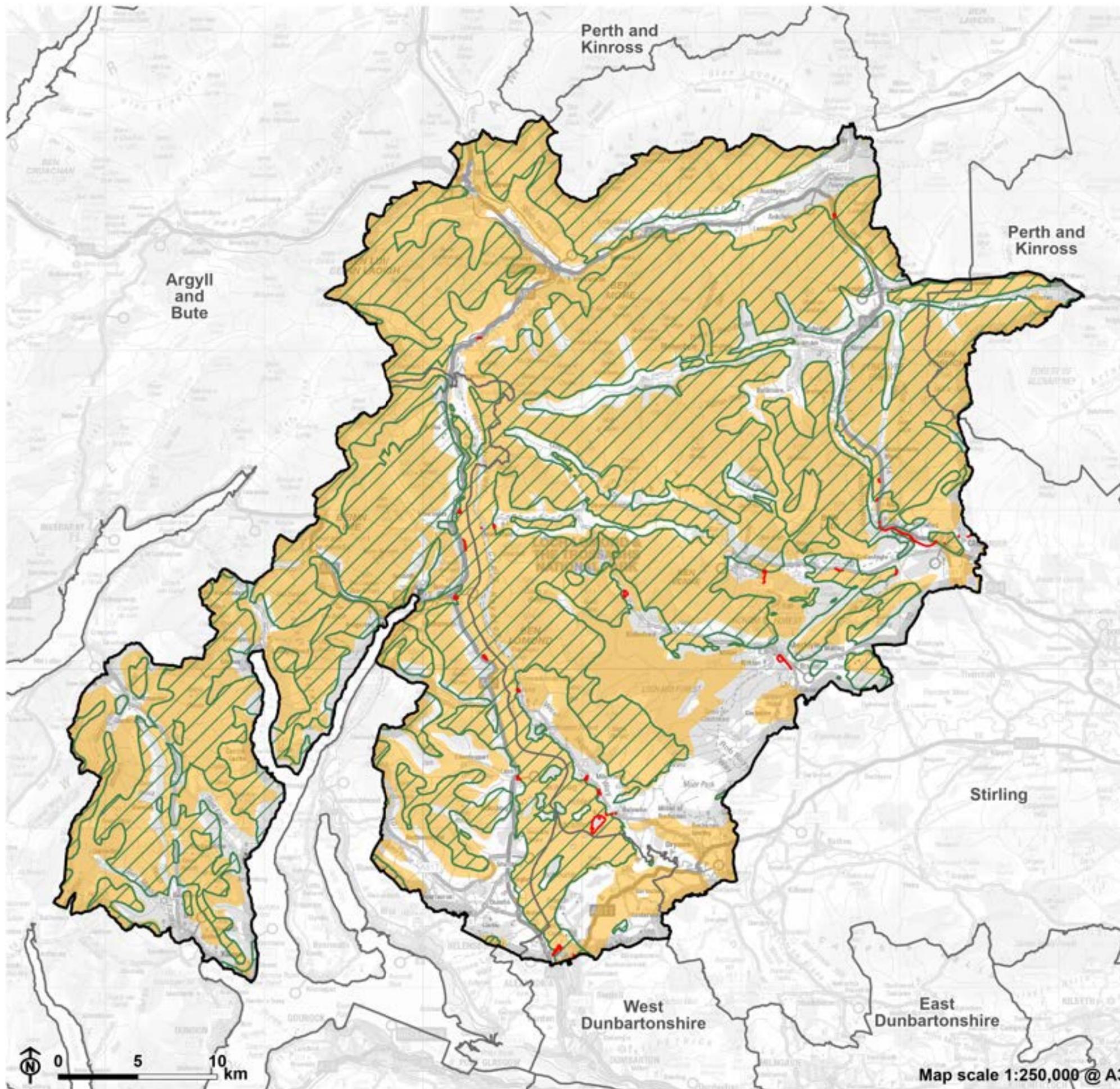
⁹⁰ Scottish Government (2024) Draft Bioenergy Policy Statement – consultation (see: <https://www.gov.scot/publications/draft-bioenergy-policy-statement/>)

2021⁹¹ which set out their programme of work to appraise the potential to scale up the bioenergy sector.

Summary of biomass resource assessment

This study includes an assessment of the total technical potential for biomass resource within the National Park i.e. the production of both wood fuel and energy crops. However, while considerable amounts of land within the National Park are considered technically suitable for biomass fuel, this assessment must be understood within the broader land use context of the National Park (including food production, forestry, nature restoration,). As such, while the production of biomass fuel within the National Park could provide local sources of biofuel, this must be balanced with other land use objectives for nature restoration and carbon sequestration.

⁹¹ <https://www.gov.scot/publications/bioenergy-update-march-2021/>



Loch Lomond and The Trossachs NPA:
Decarbonising Energy Generation within
the National Park



Loch Lomond and The Trossachs NPA

Figure 12.8: Constraints - Biomass - Virgin Woodfuel - Energy Crops - Land Capability

- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Land capability for forestry classes: 6, 7, 9 and built up
- Land capability for agriculture classes: 1-3.2, 6.2-7, built up and other

Notes:

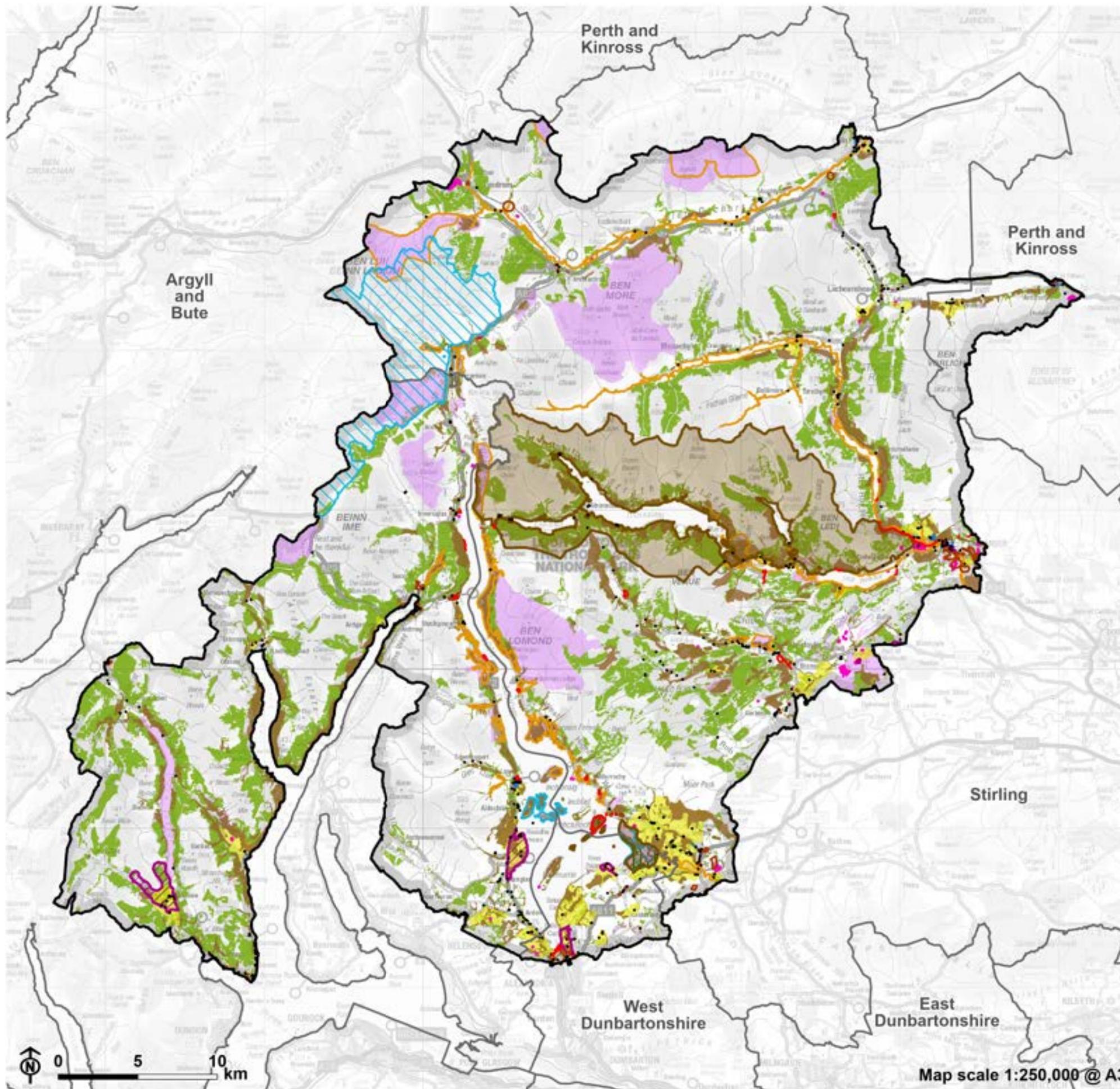
Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

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**Figure 12.9: Opportunities and constraints -
Biomass - Virgin Woodfuel - Forestry and
Woodland**

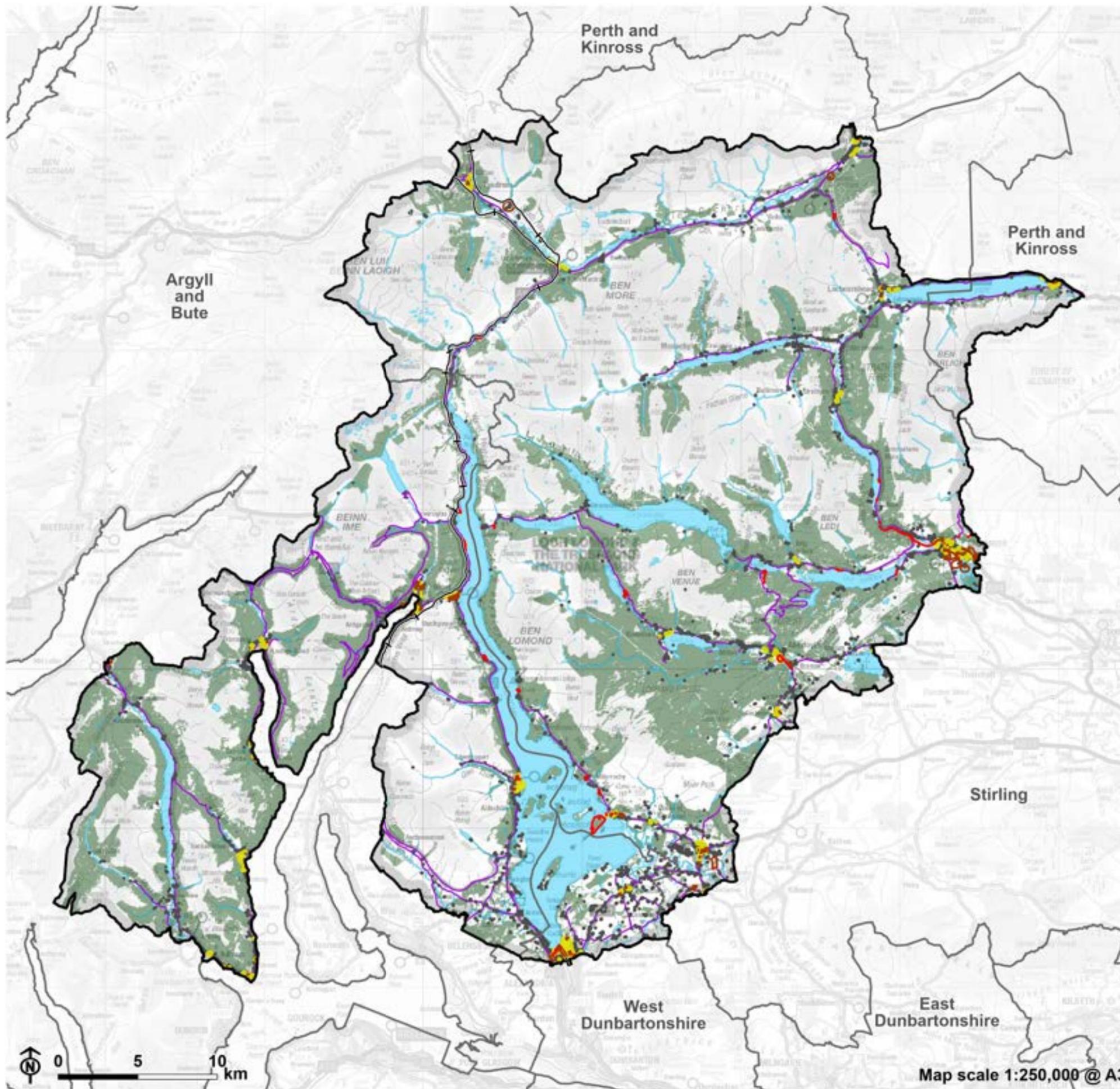


- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Opportunities**
- Woodland opportunity
- Constraints**
- Listed building
- National Nature Reserve
- Ramsar site
- Special Protection Area
- Special Area of Conservation
- Site of Special Scientific Interest
- Ancient woodland
- Gardens and Designed Landscapes
- Historic Designed Landscape
- Conservation area
- Scheduled monument
- Site allocation

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.



- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Road
- Railway
- Site allocation
- Building
- Open space
- Watercourses and water bodies
- Woodland

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

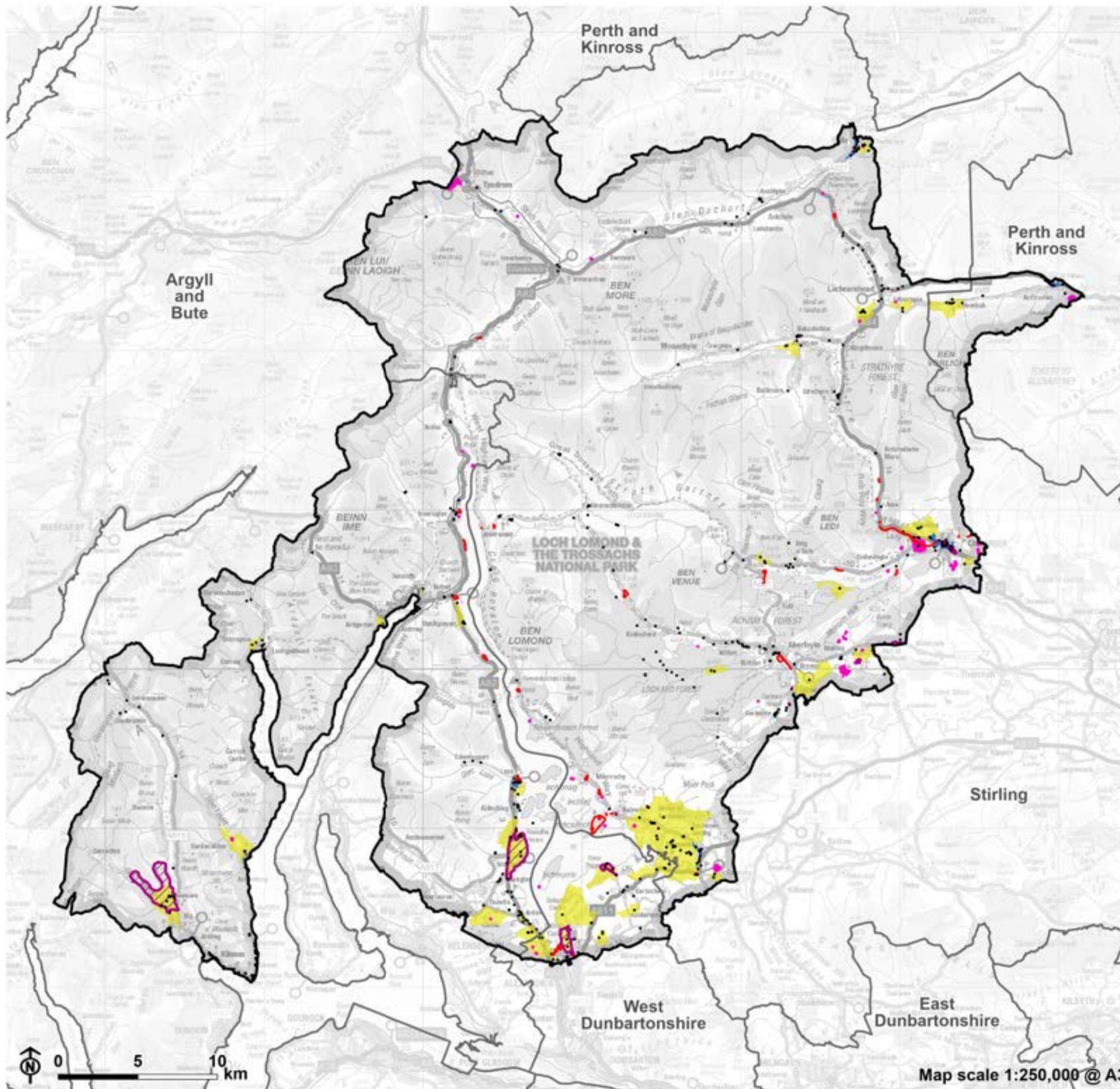


Figure 12.11: Constraints - Biomass - Virgin Woodfuel - Energy Crops - Cultural Heritage

- Loch Lomond and the Trossachs National Park
- Local Authority
- Loch Lomond and the Trossachs National Park Authority estate
- Listed building
- Gardens and Designed Landscapes
- Scheduled monument
- Conservation area
- Historic Designed Landscape

Notes:

Please refer to this map in conjunction with the assessment assumptions detailed in Appendix A.

The representation of features or boundaries in which LLNTPA or others have an interest does not necessarily imply their true positions. For further information please contact the appropriate authority.

Chapter 13

Recommendations for planning guidance

13.1 This chapter provides recommendations on how the findings of this assessment should be used to inform updates to the National Park Authorities Renewable Energy Planning Guidance.

13.2 The recommendations are presented as a table following the existing structure of the planning guidance. For each section of the guidance a recommendation is made to either keep, change or remove elements of the existing guidance. At the end of the chapter additional overarching recommendations are provided as well as recommendations for additional guidance on the two additional technologies; solar and battery energy storage systems.

Table 13.1 Current guidance document content - recommended updates

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Cross cutting recommendations		
	n/a	<ul style="list-style-type: none"> References to Scottish Natural Heritage (SNH) should be updated to NatureScot throughout.
	n/a	<ul style="list-style-type: none"> References to Historic Scotland should be updated to Historic Environment Scotland (HES) throughout.
	n/a	<ul style="list-style-type: none"> References to 'scheduled ancient monuments' – should be 'scheduled monuments'
	n/a	<ul style="list-style-type: none"> Ensure all references and hyperlinks are up to date and reflective of the most recent guidance.
	n/a	<ul style="list-style-type: none"> Ensure all references to paragraph numbers within the document are updated throughout.
1. Introduction		
Introduction	Paragraphs 1.1 – 1.3	<ul style="list-style-type: none"> Update introductory text to reflect the adoption of NPF4 and its status as part of the statutory development plan. Noting that while the development plan should be read as a whole, particular reference should be made to NPF4 Policy 1: Tackling the climate and nature crises, Policy 2: Climate mitigation and adaptation, and Policy 11: Energy, setting out the high level planning policy support and key policies related to renewable energy development in Scotland. Reference to NPF4 Policy 4: Natural places, and the implementation of Policy 4(c) with regard to renewable energy development in the National Park, should also be included.
	Diagram on page 5	<ul style="list-style-type: none"> Update to include solar and battery storage.
	Table 1	<ul style="list-style-type: none"> Update to include solar and battery storage (see Table 14.3 of this document).
	Paragraph 1.7 and Appendix 6	<ul style="list-style-type: none"> Update to provide most up to date guidance and contacts for providing support and advice to communities within the National Park. Guidance should include reference to Local Place Plans which should identify any local level aspirations and constraints relating to renewable energy development.

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
	Paragraph 1.8	<ul style="list-style-type: none"> Update '2020 Road Map for Renewable Energy' to reflect most up to date Scottish Government renewable energy generation targets, set out in the Scottish Energy Strategy (2017) and reflecting Draft Scottish Energy Strategy and Just Transition Plan (2023).
	Paragraph 1.9	<ul style="list-style-type: none"> Update reference to National Park Partnership Plan to reflect the approved NPPP 2024-29.
	Paragraph 1.11	<ul style="list-style-type: none"> Update to reflect up to date demand trends with the inclusion of solar, battery storage and heat pump technologies Update to reflect progress/timescales for the delivery of the next Local Development Plan and status of the updated planning guidance.
2. Summary - Renewable Energy Development in Loch Lomond & The Trossachs National Park		
Special qualities		No change.
Planning considerations – hydro, wind and biomass	Title - Planning considerations – hydro, wind and biomass	<ul style="list-style-type: none"> Update to 'Planning considerations – hydro, wind, biomass, solar and battery storage'.
	Paragraph 2.4	<ul style="list-style-type: none"> Add reference to Wild Land Area descriptions (2017) and updated guidance: Assessing impacts on Wild Land Areas - technical guidance (NatureScot, published in 2020 and revised in 2023). Add reference to NPF4 Policy 4 and wild land. Remove reference to the superseded National Park Partnership Plan.
	Paragraphs 2.5-2.6	<ul style="list-style-type: none"> Include reference to approved NPPP 2024-29 to signpost nature-based solutions, land management and nature-based opportunities identified within the National Park. Include statement to set out that proposals should not compromise and should contribute to the delivery of restoring nature within the National Park. Include reference to the NPF4 Policy 3 and 4 including the requirement for certain developments to deliver biodiversity enhancement. Signpost Scottish Government draft planning guidance on improving biodiversity and NatureScot guidance for supporting the delivery of Policy 3(c) – Developing with Nature guidance.
Cultural and Historic Environment	Title – Cultural and historic environment	<ul style="list-style-type: none"> Update title to historic environment.

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
	Paragraph 2.7	<ul style="list-style-type: none"> ■ Streamline by separating into the various components of the historic environment, and covering protection separately to ensure clarity. ■ Audit terminology and update to match NPF4 (or ensure consistent terminology)
	Paragraph 2.8	<ul style="list-style-type: none"> ■ Update text on direct/indirect effects: <ul style="list-style-type: none"> – Direct – construction works in an area of archaeological sensitivity can cause irreversible damage to valuable irreplaceable assets; – Indirect – the development of renewable energy infrastructure can have a significant impact on the setting of important historic features within the landscape. This includes views from and towards the feature of interest.”
	Paragraph 2.9	<ul style="list-style-type: none"> ■ LLTNPA does not have its own SMR – managed by WoSAS. ■ National Monuments Record has been re-branded as the ‘National Record of the Historic Environment’. ■ Process for impact assessment needs updating and aligned with current guidance.
	Map 4	<ul style="list-style-type: none"> ■ Title should be ‘designated historic assets’ ■ IGDLs not sufficiently clear ■ Map should be updated
	Map 5	<ul style="list-style-type: none"> ■ Provide additional guidance on the difference between IGDLs and regional designed landscapes (i.e. one is a national designation, and the others are non-designated assets)
Recreation and Access	Paragraphs 2.13 – 2.16	No change.
Summary of renewable energy potential	Paragraph 2.19	<ul style="list-style-type: none"> ■ Paragraph 2.19 should be amended to incorporate solar and battery storage. Include a statement to reflect that ground mounted solar PV is likely to have the greatest opportunity but the appropriate scale of development is not defined. Proposals must consider impacts and cumulative impacts which will determine its acceptability.
6. Planning Application Process		

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Pre-application discussions, Environmental Impact Assessment (EIA) screening and scoping	Paragraph 3.2	<ul style="list-style-type: none"> Update to: 'The Environmental Impact Assessment (Scotland) Regulations 2017 specify when EIA is required. The National Park is identified in Regulation 2(1) as a 'sensitive area' which means the thresholds/criteria in the second column of Schedule 2 do not apply...'
	Paragraph 3.3	<ul style="list-style-type: none"> Update 'Environmental Statement (ES)' to 'EIA Report' throughout planning guidance, to reflect updated terminology used in the 2017 EIA Regulations. Update to reference Planning Circular 1/2017: Environmental Impact Assessment regulations
Planning application and the decision-making process	Table 2	<ul style="list-style-type: none"> Under 'Applicant / National Park Authority: pre-application discussions' include additional bullet points for solar (including specifications such as location (roof- or ground-mounted), number of panels, height and dimensions, specifications, appearance, ancillary infrastructure and details of site area) and battery storage (including specifications such as number of battery units, dimensions, appearance, specifications, noise levels, ancillary infrastructure and site area).
	Table 3	<ul style="list-style-type: none"> Under 'Applicant: submission of planning applications': under (3), note requirement for certain types of development to also deliver significant biodiversity enhancements. New Scottish Government BNG guidance should be referenced here if and when this is published.
Other consenting regimes:	Paragraph 3.8 – 3.15	<ul style="list-style-type: none"> Audit to ensure all consenting regime referenced are up to date.
	Map 5	<ul style="list-style-type: none"> Update Map 5 Electricity Grid Network. For example, to reflect changes such as the undergrounding of sections of the 132kV overhead line as part of the VISTA project.
7. Hydro		
Technical feasibility and scope	Map 6	<ul style="list-style-type: none"> Update to illustrate up to date approved/completed hydro schemes.
Locational guidance	Map 7 and Map 8	<ul style="list-style-type: none"> Update dependent on further technical assessment, if conducted.

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Planning considerations – Introduction		No change.
Natural heritage considerations	Paragraph 4.13	<ul style="list-style-type: none"> ■ Add consideration regarding impacts between hydro schemes and changes in future water availability due to climate change, and refer to Scotland’s National Water Scarcity Plan.
	Paragraph 4.14	<ul style="list-style-type: none"> ■ Signpost to sources of good practice guides
	Paragraph 4.16	<ul style="list-style-type: none"> ■ Signpost River Tay SAC guidance for developers⁹² was produced in 2020, providing advice on planning applications within the catchment of the SAC, or which could affect the water quality of the SAC. This guidance was produced by PKC and Angus Council with NatureScot and SPEA. However it sets out the key sensitivities of the SAC which spans into LLTNP. ■ Any similar site-specific guidance for other designated sites, and their tributaries, within the National Park (such as the River Teith SAC) should also be signposted here.
Landscape and visual considerations	Paragraph 4.20	<ul style="list-style-type: none"> ■ Add reference to Wild Land Area descriptions (2017) and updated guidance: Assessing impacts on Wild Land Areas - technical guidance (NatureScot, published in 2020 and revised in 2023).
Assessing cumulative impacts	Paragraph 4.22	<ul style="list-style-type: none"> ■ Greater emphasis on the significant potential cumulative impacts of abstraction activity across a catchment. ■ Include consideration of cumulative impacts of hydropower - with any other water abstraction activities along the waterway – on the protected rights of river users, such as recreational access rights
Hydro topic advice	After paragraph 4.28	<ul style="list-style-type: none"> ■ Include statement to make clear that permissions on use of waterways for hydropower are commonly issued with a time limit period on the permitted abstraction period. Unless such time periods are sufficiently long, the long-term viability of hydropower developments may be at risk if these permissions are not renewed in the future.
8. Wind		
Technical feasibility and scope	Paragraphs 5.1 – 5.5	<ul style="list-style-type: none"> ■ Reflect findings of this report to set out technical feasibility for wind energy development within the National Park. ■ Add reference to policy wording of NPF4 Policy 11(b)

⁹² NatureScot, PKC, SEPA and Angus Council (2020) River Tay Special Area of Conservation (SAC) (see: https://www.pkc.gov.uk/media/46816/River-Tay-SAC-Guidance-Adopted-2020/pdf/River_Tay_SAC_2020_Adopted.pdf?m=1607092292013)

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Locational guidance	Paragraphs 5.6 – 5.8	<ul style="list-style-type: none"> ■ Update reference to “Landscape Character Assessment” to include reference to NatureScot’s National Landscape Character Assessment (2019) and the complementary Loch Lomond and the Trossachs Landscape Evolution and Influences (NatureScot, 2019). ■ The locational guidance refers to LCTs from a study which has now been superseded by the above, and should be updated to reflect their equivalent new LCTs.
Wind energy development outside the National Park	Paragraphs 5.9 – 5.10	<ul style="list-style-type: none"> ■ Update text in accordance with policy wording of NPF4, providing direct reference to NPF4 Policy 4(c).
Wind planning considerations – Introduction	Paragraph 5.11	No change.
Landscape & visual impact considerations:		
<ul style="list-style-type: none"> ■ Landscape and visual impact assessment 	Paragraph 5.12 – 5. 13	No change.
<ul style="list-style-type: none"> ■ Landscape character assessment 	Paragraph 5.14	<ul style="list-style-type: none"> ■ Update reference to “Landscape Character Assessment” to include reference to NatureScot’s National Landscape Character Assessment (2019) and the complementary Loch Lomond and the Trossachs Landscape Evolution and Influences (NatureScot, 2019). ■ Update reference to The Special Landscape Qualities of Loch Lomond & The Trossachs National Park (link broken).
<ul style="list-style-type: none"> ■ Siting considerations, sensitivities and examples 	Paragraph 5.15	No change.

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Landscape scenario – Development potential illustrations	Paragraphs 5.17 – 5.29	<ul style="list-style-type: none"> ■ The scenarios refer to LCTs from a study which has now been superseded by NatureScot’s National Landscape Character Assessment (2019), although the landscape characteristics and design principles described remain relevant. ■ Include reference to NatureScot’s Siting and Designing Wind Farms in the Landscape Guidance, Version 3A (August 2017).
Assessing the cumulative impacts	Paragraphs 5.30 – 5.35	<ul style="list-style-type: none"> ■ Update reference to NatureScot cumulative guidance which was updated in 2021. ■ Insert paragraph which discusses the co-location of wind turbines with other renewable energy technologies. NPF4 provides high-level support for the co-location of renewable technologies. Wind turbine development is commonly seen in combination with other technologies, such as solar PV or battery storage, and consideration of in combination effects / benefits of this approach should be considered. ■ Update paragraph 5.34 to refer to current sources of renewable energy projects such as https://spice-spotlight.scot/2024/06/17/renewable-energy-map-of-scotland/ or https://www.data.gov.uk/dataset/3219c645-9664-4e86-b73b-e36190626ef8/wind-farm-proposals-scotland - noting the limitations of these.
Natural heritage considerations	Paragraphs 5.36 – 5.45	<ul style="list-style-type: none"> ■ Include statement outlining the requirement for some developments to deliver biodiversity enhancements, in line with NPF4 Policy 3 and signpost further guidance.
	Paragraph 5.39	<ul style="list-style-type: none"> ■ Include reference to NatureScot Bats and onshore wind turbines - survey, assessment and mitigation (updated 2021). Update link to guidance for the installation of micro-renewables
	Paragraph 5.40	<ul style="list-style-type: none"> ■ Update link to NatureScot information on windfarm impacts on birds
	Paragraph 5.42	<ul style="list-style-type: none"> ■ Update link to NatureScot guidance on dispersal and foraging distances https://www.nature.scot/sites/default/files/2022-12/Assessing%20connectivity%20with%20special%20protection%20areas.pdf
	Paragraph 5.43	<ul style="list-style-type: none"> ■ Update link to CAR licencing.
	Paragraph 5.44 – 5.45	<ul style="list-style-type: none"> ■ Include reference to ensure wording reflects NPF4 Policy 5.
Wind topic advice	Paragraphs 5.46 – 5.58	<ul style="list-style-type: none"> ■ Include reference to NatureScot’s Siting and Designing Wind Farms in the Landscape Guidance, Version 3A (August 2017).
9. Biomass		

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Technical feasibility and scope	Paragraphs 6.1 – 6.5	<ul style="list-style-type: none"> ■ Reflect findings of this report to set out technical feasibility for biomass development within the National Park. ■ Reflect key messages of the draft bioenergy policy statement in setting the context for bioenergy.
Locational guidance	Paragraphs 6.6 – 6.8	No change.
Biomass planning considerations - Introduction	Paragraph 6.9	No change.
Natural heritage considerations:	Paragraph 6.10	<ul style="list-style-type: none"> ■ Insert statement outlining the requirement for some developments to deliver biodiversity enhancements, in line with NPF4 Policy 3 and signpost further guidance.
	Paragraph 6.11 – 6.13	<ul style="list-style-type: none"> ■ No change.
	Paragraphs 6.14 – 6.18	No change.
Landscape and visual considerations	Paragraph 6.19	No change.
Assessing cumulative impacts	Paragraphs 6.20 – 6.22	No change.
Biomass topic advice	Paragraph 6.23	<ul style="list-style-type: none"> ■ Update to SEPA Thermal Treatment of Waste Guidelines (2014).
Appendices		
Appendix 4		<ul style="list-style-type: none"> ■ Insert at Section 4.2 'Reference – Hydro' Marine Scotland's 'Salmon and Sea Trout – Scottish Salmon Rivers' distribution mapping data (https://marine.gov.scot/maps/843) ■ Check all links and update as per rest of document
Appendix 6		
Appendix 7		
Appendix 8		

Current guidance document content	Page/paragraph/table/figure reference	Recommended update
Appendix 8	Section 2.1, page 82	<ul style="list-style-type: none"> ■ Add reference to solar and battery

Table 13.2 Recommended additional guidance document content

Proposed new guidance document content	Recommendation
7. Solar	
Technical feasibility and scope	<ul style="list-style-type: none"> ■ Outline summary of the main types of solar development including roof-mounted solar PV, solar thermal and ground-mounted solar PV. ■ Include statement that while this guidance is likely to be most relevant to small-scale solar applications and micro-renewables, there is not a defined scale for acceptable ground-mounted solar PV proposals. Therefore, this guidance relates to developments of all scales and applications should be assessed on a case-by-case basis. ■ Reflect findings of this report to set out technical feasibility for solar development within the National Park.
Locational guidance	<ul style="list-style-type: none"> ■ The most suitable sites for ground-mounted solar PV development are likely to be in proximity to a grid connection (i.e. a substation with suitable capacity), have suitable road access for transportation of materials, be located away from 'prime' agricultural land, be generally flat or on a gentle south-facing slope and be unshaded. The size of scheme will determine the scale of ancillary infrastructure required and impacts of access tracks, security fencing, substations and grid connections. ■ Updated planning guidance should include drawings similar to the sketched figures throughout the existing planning guidance, illustrating the siting and design of solar panels. This should include illustrations for both siting of rooftop solar applications on different types of buildings and ground-mounted solar positioning within the landscape.
Planning considerations – Introduction	<ul style="list-style-type: none"> ■ Planning guidance should signpost Permitted Development Rights for both domestic and non-domestic solar installations. A summary of types of solar applications not covered by PDR should be included to provide clear indication on the types of solar development which will require planning permission within the National Park. ■ Siting and design guidance for rooftop solar applications may include consideration of colour, framing, symmetry, size, mounting systems and visibility from the surrounding area.

Proposed new guidance document content	Recommendation
Cultural heritage considerations	<ul style="list-style-type: none"> ■ The generic historic environment considerations provided in Chapter 2 of the planning guidance will be relevant to all solar development applications. ■ As most applications for rooftop solar PV or solar thermal will relate to solar panels on listed buildings or within a conservation area, it may be beneficial to include more detailed guidance for appropriate assessment of effects, siting and design of rooftop solar applications on the historic environment (see 'Chapter 6 – Cultural heritage considerations' of this report). ■ Additional key considerations for ground-mounted solar is the potential to result in direct physical effects to archaeological remains due piling for solar panel foundations. Therefore, understanding the archaeological potential of the proposed site will be a key consideration for solar applications.
Natural heritage considerations	<ul style="list-style-type: none"> ■ Key natural heritage considerations for rooftop solar include consideration to the presence of bat roosts and nesting birds. Installation activity could cause temporary disturbance and the relevant statutory consents should be applied. ■ For ground-mounted solar and larger-scale developments, in addition to generic natural heritage considerations, key considerations should include: <ul style="list-style-type: none"> – impacts on trees, hedgerows and areas of higher ecological sensitivity and habitat connectivity; – consideration of how construction works (e.g. piling for mounting poles/frames), lighting installations and fencing may impact local ecology; – changes to land management practices; – impacts on protected and notable species through habitat loss, displacement and disturbance; – impacts on carbon-rich soils, peat and prime agricultural land should be minimised, with reference to NPF4 Policy 5; – incorporation of opportunities to enhance the natural capital value of solar development and contribute to biodiversity enhancement (e.g. improved habitat connectivity of hedgerows and field margins, tree planting and sowing of species-rich grassland communities), in line with NPF4 Policy 3. Further guidance should be signposted.
Landscape and visual considerations	<ul style="list-style-type: none"> ■ For rooftop solar, landscape and built heritage impacts should be minimised through consideration of: <ul style="list-style-type: none"> ■ Colour – the colour and finish of solar panels should be chosen to best blend with the roof it is mounted on and any surrounding buildings ■ Framing – the use of panels without frames or black framed panels should be used, where framed panels would detract from the building ■ Symmetry – panels should be laid in a symmetrical pattern, where possible. Consider moving aerials or flues. ■ Coverage – panels should cover the entire roof of a building. If the roof is not symmetrical, seek to achieve a clean edge.

Proposed new guidance document content	Recommendation
	<ul style="list-style-type: none"> ■ In roof or on roof – where possible in-roof panels should be installed. Where on-roof panels are installed, the distance between the panel mounting system and the roof should be minimised. ■ Visibility – roof mounted panels can impact on the roofscape of settlements, however panel location needs to support adequate energy generation. Where there is flexibility in panel location, this can seek to avoid the main elevation of a building. ■ In addition to generic landscape siting and design considerations, guidance specific to solar farms may include: <ul style="list-style-type: none"> – Use of non-reflective surfacing to reduce glare where possible; – Continuation of current land management practices (e.g. grazing) beneath the solar panels where possible; and – Minimising landscape and visual impacts through design of any buildings required (e.g. electrical switchgear, inverters) and use of construction materials that reflect the local landscape context. ■ For ground-mounted solar farms requiring planning consent, a landscape and visual assessment is likely required in accordance with GLVIA3. ■ Some LCTs are likely to be less susceptible to the development of the nature development proposed.
Assessing cumulative impacts	<ul style="list-style-type: none"> ■ Cumulative impacts may be considered in relation to incremental changes to the character of conservation areas, where multiple rooftop solar applications are coming forward. ■ Include cross-reference to discussion of co-location of renewables technologies and in-combination effects / benefits. Solar technologies of all scales are often sited in proximity of renewable energy sources, such as wind turbines or battery storage technologies.
Solar topic advice	<ul style="list-style-type: none"> ■ Cross reference to existing guidance documents such as NatureScot general pre-application advice and scoping advice for solar farms.
8. Battery storage	
Technical feasibility and scope	<ul style="list-style-type: none"> ■ Reflect findings of this report to set out technical feasibility for solar development within the National Park. ■ It is expected that majority of applications for battery storage within the National Park will typically be of a smaller scale, reflecting the scale of energy generation infrastructure. However, the guidance provided in this chapter should relate to battery storage developments of all scales and applications assessed on a case-by-case basis. ■ Battery storage technology is rapidly evolving in response to market demand and technological evolution. Guidance on battery technologies should be flexible to accommodate future change (e.g. expected size/capacity of BESS units).

Proposed new guidance document content	Recommendation
Locational guidance	<ul style="list-style-type: none"> ■ Battery storage is typically located close to an energy generating source and the scale of the battery storage will be proportional to the output of the energy generating resource. Otherwise, battery storage systems are likely to be located near an existing substation to support the functioning of the grid. ■ Commercial-scale battery storage technologies are likely to be accommodated within a business' operational land or buildings. Larger-scale technologies (i.e. shipping container sized units) might be accommodated within the National Park and may require ancillary infrastructure such as access, security fencing and grid connection.
Planning considerations – Introduction	<ul style="list-style-type: none"> ■ Set out the types of battery storage development which will require planning permission within the National Park (i.e. non-domestic battery storage) ■ Identify LCTs which are more likely to be able to accommodate ground mounted solar without significant landscape effects, subject to appropriate siting, design and mitigation (LCT 260 – River Valley Farmland and Estates, LCT 253 - Straths and Glens and LCT 254 - Straths and Glens with Lochs).. ■ The generic historic environment considerations provided in Chapter 2 of the planning guidance will be relevant to all solar development applications.
Natural heritage considerations	<ul style="list-style-type: none"> ■ Guidance for battery storage should signpost generic natural heritage considerations for all renewable development. ■ Other key considerations are likely to include impacts of lighting, noise and security fencing on local ecology. ■ Include statement outlining the requirement for some developments to deliver biodiversity enhancements, in line with NPF4 Policy 3, and signpost further guidance.
Landscape and visual considerations	<ul style="list-style-type: none"> ■ Some LCTs are likely to be less susceptible to development of the nature proposed, such as LCT 260 – River Valley Farmland and Estates, LCT 253 - Straths and Glens and LCT 254 - Straths and Glens with Lochs. These LCTs are more likely to be able to accommodate large-scale battery storage without significant landscape effects, subject to appropriate siting, design and mitigation. All proposals should be assessed on a case-by-case basis. For large-scale battery storage requiring planning consent, a landscape and visual assessment is likely to be required in accordance with GLVIA3.
Assessing cumulative impacts	<ul style="list-style-type: none"> ■ Likely requirement for assessment of cumulative landscape and visual effects to occur for large scale battery storage, including when the location of battery storage is in proximity to other renewable energy generation infrastructure. ■ Include cross-reference to discussion of co-location of renewables technologies and key considerations. Battery storage technologies of all scales are often sited close to renewable energy sources, such as solar or wind development, or grid infrastructure.

Proposed new guidance document content	Recommendation
Battery storage topic advice	<ul style="list-style-type: none"><li>■ Battery storage fire risk and safety management. It would be helpful to set out the level of information expected in relation to battery safety, for example encouraging engagement with the local Fire and Rescue Service or provision of a Battery Safety Management Plan for larger applications.

Table 13.3 Main permissions and licenses required for renewable energy developments – solar and battery

Technology	Planning authority	Scottish Government	SEPA CAR and PPC	NatureScot	Forestry Commission
	Determination				
Solar	<50MW generating capacity	>50MW generating capacity	Any associated river engineering works (CAR)	Licenses for protected species	Felling licenses and associated environmental impact assessments
Battery storage	<50MW generating capacity	>50MW generating capacity	Any associated river engineering works (CAR)	Licenses for protected species	Felling licenses and associated environmental impact assessments

Appendix A

Key Assumptions to be Applied in the Assessment of Renewable and Low Carbon Energy Resource

Introduction

A.1 This note sets out the key assumptions used for the assessments of technical potential for the different types of renewable energy technology including:

- Rooftop solar;
- Heat pumps; and
- Biomass (including forestry and woodland residues, energy crops, and agricultural residues).

A.2 It also sets out the potential constraints to wind and ground-mounted solar development that were mapped.

Existing Property Statistics for Loch Lomond

A.3 The existing stock of domestic dwellings and non-domestic properties within the National Park was derived from OS AddressBase data.

A.4 The overall proportion of 'off-gas' properties (those not connected to the gas network) was derived from the 2024 Department for Energy Security & Net Zero (DESNZ) LSOA estimates⁹³.

⁹³ DESNZ (2024) LSOA estimates of properties not connected to the gas network 2015 to 2022. Available at: <https://www.gov.uk/government/statistics/lsa-estimates-of-households-not-connected-to-the-gas-network> This data is available LSOA level. As such, the average percentage of off-gas properties within LSOAs located wholly or mainly within the National Park was used. This included LSOA codes: S01007355;

S01007356; S01007358; S01007404; S01013001; S01013009; S01013010; S01013110; S01013111; S01013112; S01013113; S01013114; S01013115; S01013116; S01013117; S01013118; S01013119; S01013120; S01013121; S01013233; S01013234; S01013235; S01013236; S01013241; S01013242.

Table A.1 Properties in Loch Lomond and the Trossachs National Park

Property type	Number of properties
Detached dwelling	3,564
Semi-detached dwelling	1,935
Terraced dwelling	1,005
Flat ⁹⁴	1,286
Other dwelling ⁹⁵	23
Total dwellings considered in the rooftop solar and air source heat pump assessments	6,504
Properties other than dwellings ⁹⁶	1,644
Total properties considered in the rooftop solar and air source heat pump assessments	8,148

Source: OS AddressBase data

Emission Factors

A.5 To determine the potential CO₂ savings from the identified potential renewable resources, the identified potential electricity/heating output was multiplied by the emissions factors at present of the fuels the renewable energy generation would replace:

- Grid electricity: 0.133 kgCO₂e/kWh⁹⁷
- Mains gas: 0.210 kgCO₂e/kWh⁹⁸
- Heating oil: 0.298 kgCO₂e/kWh⁹⁹
- Wood fuel: 0.011 kgCO₂e/kWh¹⁰⁰

UK Capacity Factors

A.6 Regional capacity factors, where available, were used when calculating technical potential within the National Park. Where unavailable, national DESNZ and RHI data on annual load factors were used when calculating technical potential.

Table A.2 UK renewable capacity factors

Technology	UK-level Capacity Factor
Anaerobic Digestion ¹⁰¹	64.9%
Solar PV ¹⁰²	9.0% (Regional Scotland value)

⁹⁴ Flats could not be considered in in the rooftop solar and air source heat pump assessments as data was not available to determine if all flats were suitable.

⁹⁵ Excluding ancillary buildings, car parking, garages, house boats, caravans and chalets. Other dwellings could not be considered in the rooftop solar and air source heat pump assessments as data was not available to determine if all properties were suitable.

⁹⁶ Commercial properties excluding land, ancillary buildings, military buildings, objects of interest, parent shells, waste sites, minerals sites, ancillary buildings, parking, and other inappropriate locations including fisheries, telephone boxes, lighthouses, beach huts; ATMs, cemeteries; and utilities.

⁹⁷ National Grid (2024) Future Energy Scenarios: FES 2024 Data workbook – Key Stats; Annual average carbon intensity of electricity (five year forecast from 2023). Available at:

<https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes>.

⁹⁸ BRE (2023) Standard Assessment Procedure: RdSAP10 Specification. Available at:

<https://bregroup.com/sap/sap10>

⁹⁹ BRE (2023) Standard Assessment Procedure: RdSAP10 Specification. Available at:

<https://bregroup.com/sap/sap10>

¹⁰⁰ BEIS and DESNZ (2022) Greenhouse gas reporting: conversion factors 2022. Available at: <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022>. Wood logs/chips/pellets.

¹⁰¹ BEIS and DESNZ (2023) Quarterly and annual load factors. Available at:

<https://www.gov.uk/government/publications/quarterly-and-annual-load-factors>. The average of all the available load factors was used.

¹⁰² BEIS and DESNZ (2023) Quarterly and annual load factors. Available at:

<https://www.gov.uk/government/publications/quarterly-and-annual-load-factors>. The average of all the available load factors for Scotland was used for the technical potential assessment for solar.

Technology	UK-level Capacity Factor
Solar Water Heating ¹⁰³	4.5%
Air Source Heat Pumps ¹⁰⁴	18.4%
Biomass (plant-based) ¹⁰⁵	56.7%

Rooftop Solar Resource Assessment

A.7 The total potential capacity of roof mounted solar was estimated based on typical system sizes and the estimated percentage of suitable roof space within the study area. Roofs that have potential to deliver solar PV also have the potential to deliver solar water heating generation. However, this was treated as being mutually exclusive with solar PV potential, i.e. the same roof space can only be utilised for one of the technologies. Generation potential was therefore calculated for each technology for separate comparison.

Table A.3 Solar PV resource assessment assumptions

Parameter	Assumption	Data Source	Justification and Notes
System Size	<p>Average size of system based on property type:</p> <ul style="list-style-type: none"> ■ Detached¹⁰⁶: 5.2kW ■ Semi-detached¹⁰⁶: 3.4kW ■ Terrace/end-terrace²⁹: 1.7kW ■ Non-domestic: 12.75kW¹⁰⁷ 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) 	<p>Typical system sizes for dwellings were estimated based on Energy Saving Trust and Jinko solar Data¹⁰⁸. Due to lack of appropriate data on typical system sizes and suitability of roofs, dwellings classed as 'flats' and those classed as 'other dwellings' were not included within the assessment. Average sized solar PV systems in the National Park for non-domestic installations recorded on the FiT Register up to March 2019 was 28.61kW.</p>

¹⁰³ BEIS and DESNZ (2023) Non-domestic RHI mechanism for budget management: estimated commitments – RHI budget caps. Available at: <https://www.gov.uk/government/publications/rhi-mechanism-for-budget-management-estimated-commitments>

¹⁰⁴ BEIS and DESNZ (2023) Non-domestic RHI mechanism for budget management: estimated commitments – RHI budget caps. Available at: <https://www.gov.uk/government/publications/rhi-mechanism-for-budget-management-estimated-commitments>

¹⁰⁵ BEIS and DESNZ (2023) Load factors for renewable electricity generation (DUKES 6.3). Available at: <https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes>

¹⁰⁶ Energy Saving Trust (2024) Solar panel calculator. Available at: <https://energysavingtrust.org.uk/tool/solar-energy-calculator/>. Assumption of a sloping roof. The calculator advises on average you can have up to 12 panels on a detached house, 8 panels on a semi-detached

house, and 4 panels on a terraced house. Jinko Solar (2024) Tiger Neo. Available at: <https://www.jinkosolar.com/en/site/tigerneo>. Assumption of 430w solar panel modules being used.

¹⁰⁷ BEIS and DESNZ (2020) Sub-regional Feed-in Tariffs statistics: March 2019. Available at: <https://www.gov.uk/government/statistical-data-sets/sub-regional-feed-in-tariffs-confirmed-on-the-cfr-statistics>. This data is available at Local Authority level. As the majority of the National Park is covered by the Local Authorities Argyll and Bute and Stirling. As such, the average of systems within these authorities was used.

¹⁰⁸ Energy Saving Trust (2024) Solar panel calculator. Available at: <https://energysavingtrust.org.uk/tool/solar-energy-calculator/>. Assumption of a sloping roof. The calculator advises on average you can have up to 12 panels on a detached house, 8 panels on a semi-detached house, and 4 panels on a terraced house. Jinko Solar (2024) Tiger Neo. Available at: <https://www.jinkosolar.com/en/site/tigerneo>. Assumption of 430w solar panel modules being used.

Parameter	Assumption	Data Source	Justification and Notes
Suitable Roofs	<p>Proportion of properties with suitable roofs (estimate):</p> <ul style="list-style-type: none"> ■ 40% of dwellings¹⁰⁹; and ■ 75% of non-domestic properties¹¹⁰. 	<ul style="list-style-type: none"> ■ OS Addressbase ■ OS OpenMap 	<p>Proportions estimated from prior research undertaken by CSE, which considered suitable type and orientation of roof, and space availability¹¹¹.</p> <p>Conservation areas, listed buildings, National Scenic Areas and Historic Gardens or Designed Landscapes were not treated as constraints to rooftop solar generation. Permitted development rights in Scotland allow domestic rooftop solar to be installed within conservation areas provided the solar panels and equipment are mounted on a rear elevation or a side elevation if that side elevation does not front a road¹¹². In addition, rooftop solar generation has the potential to be installed in this circumstance and on any listed buildings, within National Scenic areas or within Historic Gardens or Designed Landscapes through the granting of planning permission.</p> <p>Properties were included in the assessment based on Loch Lomond and the Trossachs National Park OS AddressBase data (see Table A.1). Allocated sites were not considered, it is assumed that opportunities for renewables within such sites will potentially be considered as part of their design.</p> <p>Note: Where OS OpenMap buildings did not overlay address points data, these buildings were assumed to be of commercial use, most often forming outbuildings to properties such as agricultural buildings.</p>

¹⁰⁹ Detached, semi-detached and terrace/end terrace.

¹¹⁰ Excluding land, car parking, utilities, marina and moorings, and objects of interest.

¹¹¹ LUC and CSE (2020) Test Valley Renewable and Low Carbon Energy Study. Available at: <https://www.testvalley.gov.uk/planning-and-building/planningpolicy/evidence-base/evidence-base-environment>

¹¹² Scottish Government (2024) Circular 1/2024: Householder Permitted Development Rights. Available at: <https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2024/05/circular-1-2024-householder-permitted-development-rights/documents/circular-1-2024-householder-permitted-development-rights/circular-1-2024-householder-permitted-development-rights/govscot%3Adocument/circular-1-2024-householder-permitted-development-rights.pdf>.

Table A.4 Solar water heating resource assessment assumptions

Parameter	Assumption	Data Source	Justification and Notes
System Size	Average size of system based on property type: <ul style="list-style-type: none"> ■ Domestic: 2.8kW ■ Non-domestic: 18.83kW 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) 	Average sizes for solar water heating systems in the UK were obtained from RHI deployment data ¹¹³ . Due to lack of appropriate data on typical system sizes and suitability of roofs, dwellings classed as 'flats' and those classed as 'other dwellings' were not included within the assessment.
Suitable Roofs	See above – the same as for roof-mounted solar PV.	<ul style="list-style-type: none"> ■ See above – the same as for roof-mounted solar PV. 	See above – the same as for roof-mounted solar PV.
Heating Fuel Offset	Heating fuel assumed to be offset: <ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹¹⁴ ■ Oil: 55% of off-gas properties¹¹⁵ ■ Gas: All on-gas properties 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) 	

¹¹³ DESNZ (2023) RHI monthly deployment data: March 2023 (Quarterly edition). Available at: <https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-march-2023-quarterly-edition>

¹¹⁴ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹¹⁵ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

Heat Pumps

Air Source Heat Pumps

A.8 Almost any building theoretically has the potential for an air source heat pump to be installed. Therefore, the assessment considered the potential for air source heat pumps to be delivered in all buildings.

Table A.5 Air source heat pump resource assessment assumptions

Parameter	Assumption	Data Source	Justification and Notes
System Size	Average size of system based on property type: <ul style="list-style-type: none"> ■ Domestic: 10.20kW ■ Non-domestic: 46.52kW 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) ■ OS Addressbase ■ OS OpenMap 	Average sizes for air source heat pump systems in the UK obtained from RHI deployment data ¹¹⁶ . Due to lack of appropriate data on typical system sizes and suitability of individual properties, dwellings classed as 'flats' and those classed as 'other dwellings' were not included within the assessment.

¹¹⁶ DESNZ (2024) RHI monthly deployment data: March 2024 (Annual edition). Available at: <https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-march-2024-annual-edition>

Parameter	Assumption	Data Source	Justification and Notes
Heating Fuel Offset	SPF: 3.6 (efficiency of 72%). Heating fuel assumed to be offset: <ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹¹⁷ ■ Oil: 55% of off-gas properties¹¹⁸ ■ Gas: All on-gas properties 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) 	SPF derived from BEIS Renewable Heat Incentive data: 3.6 ¹¹⁹ . For every 3.6kW of heat generated, offsetting CO ₂ from the existing heating fuel (gas/oil/electricity), 1kW of energy is consumed, contributing to CO ₂ generated by consuming electricity.

Ground Source Heat Pumps

A.9 Ground source heat pumps require more space than air source, requiring pipes to be buried vertically in a deeper system or horizontally in a shallow wider system. Due to these significant space constraints, this study did not estimate the potential capacity of ground source heat pumps across the study area, as it was not possible to estimate how many properties have access to the required space.

A.10 It is noted however that the average system size of domestic pumps is 15kW in the UK¹²⁰.

Biomass Resource Assessment

Virgin Woodfuel Thermal Conversion: Forestry and Woodland

A.11 To determine the potential for biomass generation from forestry and woodland, it was assumed that all woodland within the study area has a sustainable yield of two odt/yr (oven-dried tonnes/ha/year)¹²¹ and assumptions (see **Table A.6**) were applied. Both the potential for heating and for combined heat and power were calculated.

A.12 To identify existing suitable woodland within the study area, the Forestry Commission's National Forest Inventory (NFI) was used. The NFI records the location and extent of all forests and woodland above 0.5ha across the UK and it is noted that although a sample of forests and woodland are ground surveyed every 5 years, the inventory is updated annually using aerial

¹¹⁷ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹¹⁸ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹¹⁹ DESNZ (2024) RHI monthly deployment data: March 2024 (Annual edition). Available at: <https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-march-2024-annual-edition>

¹²⁰ DESNZ (2024) RHI monthly deployment data: March 2024 (Annual edition). Available at: <https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-march-2024-annual-edition>

¹²¹ Forestry Research (2024) Potential yields of biofuels per ha p.a. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/>. Data for Wood (forestry residues, SRW, thinnings, etc.).

photography, interpretation of satellite imagery and administrative records of newly planted areas covered by government grant schemes¹²². Therefore, there can be occasional errors due to misidentification of sites not ground-surveyed.

A.13 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a national capacity factor was applied, as based on national data for plant-sourced biomass¹²³.

Table A.6 Proposed assumptions to be used for assessment of technical potential for virgin woodfuel thermal conversion: forestry and woodland

Parameter	Assumption	Data Source	Justification and Notes
Woodland Resource	<p>The following National Forestry Inventory (NFI) woodland categories within the study area were included:</p> <ul style="list-style-type: none"> ■ Broadleaved; ■ Conifer; ■ Coppice; ■ Coppice with standards; ■ Assumed woodland; ■ Mixed mainly conifer; and ■ Mixed mainly broadleaved. <p>Energy generation per hectare per year: 10.3 MWh/ha/year</p>	<ul style="list-style-type: none"> ■ Forestry Commission 	<p>These woodland categories were included as they were assumed to be mature and able to provide a sustainable yield of woodfuel.</p> <p>The following woodland categories were not included as they were assumed to currently be unable to provide a sustainable yield of woodfuel:</p> <ul style="list-style-type: none"> ■ Cloud\shadow; ■ Failed; ■ Felled; ■ Ground prep; ■ Low density; ■ Shrub; ■ Uncertain; ■ Windblow; and ■ Young trees. <p>The non-woodland categories within the NFI were also not assessed as they do not provide woodfuel.</p> <p>The assumed energy generation per hectare per year is derived from Forestry Commission data¹²⁴.</p>

¹²² Forestry Commission (2019) About the NFI. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/national-forest-inventory/about-the-nfi/>

¹²³ BEIS (2023) Load factors for renewable electricity generation (DUKES 6.3). Available at: <https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes>

¹²⁴ Forestry Research (2024) Potential yields of biofuels per ha p.a. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/>. Data for Wood (forestry residues, SRW, thinnings, etc.).

Parameter	Assumption	Data Source	Justification and Notes
Constraints	<p>The following constrained areas of woodland were excluded from the assessment:</p> <ul style="list-style-type: none"> ■ Ancient woodland Inventory; ■ Special Protection Areas (SPA); ■ Special Areas of Conservation (SAC); ■ Ramsar sites; ■ Sites of Special Scientific Interest (SSSI); ■ National Nature Reserves (NNR); ■ Historic Designed Landscapes ■ Conservation areas; ■ Listed buildings; ■ Inventory listed Gardens and Designed Landscapes; ■ Scheduled monuments; and ■ Local Plan Allocations. 	<ul style="list-style-type: none"> ■ Nature Scot ■ Historic Environment Scotland ■ Scottish Government ■ Loch Lomond and the Trossachs National Park ■ OpenStreetMap 	<p>As protected by:</p> <ul style="list-style-type: none"> ■ Wildlife and Countryside Act 1981 ■ The Conservation (Natural Habitats, &c.) Regulations 1994 ■ NPF4 ■ Natural Environment and Rural Communities Act 2006 <p>The following designations would also be considered constraints however none are present within the study area:</p> <ul style="list-style-type: none"> ■ Potential SAC; ■ Potential SPA; ■ Proposed Ramsar sites; ■ Local Nature Reserves; ■ World Heritage Sites; and ■ Battlefields Inventory Boundaries. <p>It is noted that further site-specific study would be required to make consideration of non-designated biodiversity and cultural heritage features.</p> <p>MOD land may also be considered unsuitable for use for biomass harvesting, as this land is already in use for MOD activities. Further consultation with the MOD would be required to determine if there is any potential for wind turbine development to be delivered on this land.</p>

Parameter	Assumption	Data Source	Justification and Notes
Heating Fuel Offset: Heating Only	Boiler efficiency assumed to be 77% ¹²⁵ . Heating fuel assumed to be offset: <ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹²⁶ ■ Oil: 55% of off-gas properties¹²⁷ ■ Gas: All on-gas properties 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) 	Biomass boiler efficiency derived from research by BEIS (DESNZ) ¹²⁸ .

¹²⁵ BEIS and DESNZ (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: <https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance>. As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the boiler efficiency was considered to calculate the overall energy generation potential, not the load factor for biomass boilers, which considered the percentage of time a boiler is operating at peak output annually.

¹²⁶ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹²⁷ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹²⁸ BEIS and DESNZ (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: <https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance>. As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the boiler efficiency was considered to calculate the overall energy generation potential, not the load factor for biomass boilers, which considered the percentage of time a boiler is operating at peak output annually.

Parameter	Assumption	Data Source	Justification and Notes
Fuel Offset: Combined Heat and Power (CHP)	CHP efficiency: <ul style="list-style-type: none"> ■ Electricity: 30% ■ Heating: 50% Heating fuel assumed to be offset: <ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹²⁹ ■ Oil: 55% of off-gas properties¹³⁰ ■ Gas: All on-gas properties 	<ul style="list-style-type: none"> ■ CSE 	Average CHP efficiencies estimated from prior research undertaken by CSE ¹³¹ .

Virgin Woodfuel Thermal Conversion: Energy Crops

A.14 To determine the potential for biomass generation via thermal conversion (burning within a boiler) from two woodfuel energy crops Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF), the below assumptions (**Table A.7**) were applied. Both the potential for heating and for combined heat and power were calculated.

A.15 Miscanthus is an additional energy crop commonly planted in England. However, winterhardiness of miscanthus is a major constraint for this crop in much of Scotland¹³², and

only grows on favourable sites in south west Scotland and potentially in the Scottish Borders¹³³. As such, this crop type was not included in this assessment, as SRC and SRF are more suited to the location.

A.16 To calculate the total capacity of the resource in MW from the annual generation potential in MWh, a national capacity factor was applied, as based on national data for plant-sourced biomass¹³⁴.

¹²⁹ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹³⁰ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹³¹ LUC and CSE (2020) Test Valley Renewable and Low Carbon Energy Study. Available at: <https://www.testvalley.gov.uk/planning-and-building/planningpolicy/evidence-base/evidence-base-environment>

¹³² ClimateXChange (2020) Evidence Review: Perennial Energy Crops and their Potential in Scotland. Available at: <https://www.climateexchange.org.uk/wp-content/uploads/2023/09/land-use-impacts-of-perennial-energy-crops-in-scotland-december-2020.pdf>.

¹³³ SRUC (2020) Alternative crop factsheet: Fibre and energy crops. Available at: https://www.sruc.ac.uk/media/jiwlzyqg/sac_fibre-and-energy-crops-factsheet-v1-0.pdf.

¹³⁴ DESNZ (2023) Load factors for renewable electricity generation (DUKES 6.3). Available at: <https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes>

Table A.7 Proposed assumptions to be used for assessment of technical potential for virgin woodfuel thermal conversion: energy crops

Parameter	Assumption	Data Source	Justification and Notes
Energy Crop Resource	<p>Yields:</p> <ul style="list-style-type: none"> ■ SRC: 9 odt/ha/year¹³⁵ ■ SRF: 5.3 odt/ha/year¹³⁶ <p>Ratio of crops per hectare:</p> <ul style="list-style-type: none"> ■ SRC: 19% ■ SRF: 81% <p>Energy generation per hectare per year:</p> <ul style="list-style-type: none"> ■ SRC: 46 MWh/ha/year¹³⁷ ■ SRF: 28 MWh/ha/year¹³⁸ 	<ul style="list-style-type: none"> ■ Forestry Commission 	<p>SRC and SRF yields and assumed energy generation per hectare per year was derived from Forestry Commission data.</p> <p>Where opportunities for SRC and SRF were both identified to have technical potential on the same area of land, the ratio of planting on that land was estimated to prevent double counting. The ratio was estimated by the ratio of the area of land identified as suitable for each crop as identified by research commissioned by ClimateXChange¹³⁹. It is noted that these areas calculated by the ClimateXChange research for each crop can overlap and are therefore not mutually exclusive, however it provides an indication of potential deployment ratios in Scotland. The analysis assumed that of the land identified as suitable for both energy crops, 4.2ha of SRF would be delivered for every 1ha of SRC.</p>
Constraints	<p>Land capability – agriculture constraints for SRC:</p> <ul style="list-style-type: none"> ■ Class 1 – 3.2 ■ Class 6.2 – 7 ■ Built up and other (888, 999, 9500) 	<ul style="list-style-type: none"> ■ James Hutton Institute ■ Aerial imagery ■ BEIS (now DESNZ) ■ Forestry Commission 	<p>In line with ClimateXChange’s review of perennial energy crops in Scotland¹⁴⁰, land capability for agriculture and forestry were considered. This ensured that with regards to SRC that the highest quality agricultural land is protected for food crops, and that with regards to SRF that only suitable land for such forestry was identified. It is noted that ClimateXChange’s study considers additional constraints such as elevation and rainfall, however this is beyond the scope of this project to consider.</p>

¹³⁵ Forestry Research (2024) Potential yields of biofuels per ha p.a. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/>. Data for Wood (SRC Willow) @ 30% MC.

¹³⁶ Forestry Research (2024) Short Rotation Forestry. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/fuel/energy-crops-3/short-rotation-forestry/>. Table: “What are the estimated yields for SRF species?” The midpoint of all estimated species productivity ranges were used and averaged to provide an overall SRF value.

¹³⁷ Forestry Research (2024) Potential yields of biofuels per ha p.a. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/potential-yields-of-biofuels-per-ha-pa/>. Data for Wood (SRC Willow) @ 30% MC.

¹³⁸ SRF Yield (see footnote 136) multiplied by the calorific value of wood (solid – oven dry): 5.3 kWh/kg. Forestry Commission (2024) Typical calorific values of fuels. Available at: <https://www.forestryresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/typical-calorific-values-of-fuels/>.

¹³⁹ ClimateXChange (2020) Evidence review: Perennial energy crops and their potential in Scotland. Available at: <https://www.climatechange.org.uk/projects/perennial-energy-crops-and-their-potential-in-scotland-evidence-review/>.

¹⁴⁰ ClimateXChange (2020) Evidence review: Perennial energy crops and their potential in Scotland. Available at: <https://www.climatechange.org.uk/projects/perennial-energy-crops-and-their-potential-in-scotland-evidence-review/>.

Parameter	Assumption	Data Source	Justification and Notes
	<p>Land capability – forestry constraints for SRF:</p> <ul style="list-style-type: none"> ■ Class 6, 7 and 9 ■ Built-up (class 8) <p>Physical constraints:</p> <ul style="list-style-type: none"> ■ Roads ■ Railways ■ Country parks ■ Open space ■ Buildings ■ Local Plan Allocations ■ Waterbodies ■ Woodland and ancient woodland <p>Natural heritage constraints:</p> <ul style="list-style-type: none"> ■ Special Protection Areas (SPA) ■ Special Areas of Conservation (SAC) ■ Ramsar sites ■ Sites of Special Scientific Interest (SSSI) ■ National Nature Reserves (NNR) <p>Cultural heritage constraints:</p> <ul style="list-style-type: none"> ■ Historic Designed Landscapes ■ Conservation areas ■ Listed buildings ■ Inventory listed Gardens and Designed Landscapes 	<ul style="list-style-type: none"> ■ Nature Scot ■ Historic Environment Scotland ■ Scottish Government ■ Ordnance Survey OpenMap ■ Ordnance Survey OpenRoads ■ Loch Lomond and the Trossachs National Park 	<p>It was assumed that existing woodland would be retained as woodland, and not developed for energy crops such as SRF.</p> <p>Physical features preventing the planting of energy crops were excluded. With regards to existing renewable energy developments, only existing ground-mounted solar farms would be considered as their land take prevents crop planting. Wind turbines have a far smaller land-take and crops could in theory be planted beneath and surrounding turbines within a wind farm. However, there are no known operational ground-mounted solar developments within the National Park.</p> <p>In addition, designated sites were also excluded, as protected by:</p> <ul style="list-style-type: none"> ■ The Conservation (Natural Habitats, &c.) Regulations 1994 ■ Wildlife and Countryside Act 1981 ■ NPF4 ■ The Convention Concerning the Protection of the World Cultural and Natural Heritage ■ Historic Environment Scotland Act 2014 ■ National Heritage Act 1983 ■ Ancient Monuments and Archaeological Areas Act of 1979 ■ Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997 <p>The following designations would also be considered constraints however none are present within the study area:</p> <ul style="list-style-type: none"> ■ Existing ground-mounted solar developments; ■ Airports and airfields; ■ Potential SAC; ■ Potential SPA; ■ Proposed Ramsar sites; ■ Local Nature Reserves; ■ World Heritage Sites; and

Parameter	Assumption	Data Source	Justification and Notes
	<ul style="list-style-type: none"> ■ Scheduled monuments 		<ul style="list-style-type: none"> ■ Battlefields Inventory Boundaries. <p>It is noted that further site-specific study would be required to consider non-designated biodiversity and cultural heritage features.</p> <p>MOD land may also be considered unsuitable for use for biomass harvesting, as this land is already in use for MOD activities. Further consultation with the MOD would be required to determine if there is any potential for wind turbine development to be delivered on this land.</p> <p>Note: Only line data for roads was available and in order to create a footprint from the road centre, it was assumed that single carriageways are 10m in width, dual carriageways 20m and motorways 30m. In order to create a footprint from the railway centrelines data, it was assumed that railways were 15m in width. Listed building point data was buffered 5m to estimate building footprints.</p>
Heating Fuel Offset: Heating Only	<p>Boiler efficiency assumed to be 77%¹⁴¹.</p> <p>Heating fuel assumed to be offset:</p> <ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹⁴² ■ Oil: 55% of off-gas properties¹⁴³ ■ Gas: All on-gas properties 	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) 	<p>Biomass boiler efficiency derived from research by BEIS¹⁴⁴.</p>

¹⁴¹ BEIS and DESNZ (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: <https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance>. As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the boiler efficiency was considered to calculate the overall energy generation potential, not the load factor for biomass boilers, which considered the percentage of time a boiler is operating at peak output annually.

¹⁴² Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹⁴³ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹⁴⁴ BEIS and DESNZ (2018) Measurement of the in-situ performance of solid biomass boilers. Available at: <https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance>. As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the boiler efficiency was considered to calculate the overall energy generation potential, not the load factor for biomass boilers, which considered the percentage of time a boiler is operating at peak output annually.

Parameter	Assumption	Data Source	Justification and Notes
Fuel Offset: Combined Heat and Power (CHP)	CHP efficiency: <ul style="list-style-type: none"> ■ Electricity: 30% ■ Heating: 50% Heating fuel assumed to be offset: <ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹⁴⁵ ■ Oil: 55% of off-gas properties¹⁴⁶ ■ Gas: All on-gas properties 	<ul style="list-style-type: none"> ■ CSE 	Average CHP efficiencies estimated from prior research undertaken by CSE ¹⁴⁷ .

Biogas from Agricultural Residues

A.17 As the National Park is predominantly rural, agricultural waste is a potential renewable energy resource, particularly from using livestock slurry as a feedstock for the anaerobic digestion process. However, Scottish Government statistics on animal numbers¹⁴⁸ are not available for the National Park. Therefore, the technical potential for biogas from agricultural residues was not calculated.

A.18 If statistics on livestock populations within the National Park were collated in the future, the technical potential for biogas from agricultural residues could be calculated using the assumptions set out in the table below. To calculate the total capacity of the resource in MWh from the annual generation potential in MWh, a capacity factor would be applied, as based on national data for animal-sourced biomass¹⁴⁹.

¹⁴⁵ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹⁴⁶ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹⁴⁷ LUC and CSE (2020) Test Valley Renewable and Low Carbon Energy Study. Available at: <https://www.testvalley.gov.uk/planning-and-building/planningpolicy/evidence-base/evidence-base-environment>

¹⁴⁸ Scottish Government (2023) June Agricultural Census: 2023. Available at: <https://www.gov.scot/publications/results-scottish-agricultural-census-june-2023/documents/>.

¹⁴⁹ DESNZ (2023) Load factors for renewable electricity generation (DUKES 6.3). Available at: <https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukes>

Table A.8 Slurry resource assessment assumptions

Parameter	Assumption	Data Source	Justification and Notes
Slurry Resource	<p>Number of animals required to produce 1 tonne of slurry per day:</p> <ul style="list-style-type: none"> ■ Cattle: 30 ■ Pigs: 275 ■ Poultry: 10,500 <p>Biogas yield:</p> <ul style="list-style-type: none"> ■ Cattle: 20m³/tonne ■ Pigs: 20m³/tonne ■ Poultry: 65m³/tonne <p>Energy content of biogas:</p> <ul style="list-style-type: none"> ■ 6.7kWh per m³ 	<ul style="list-style-type: none"> ■ Shared Practice ■ The Andersons Centre 	<p>The number of animals required to produce 1 tonne of slurry per day was derived from the average of the figure brackets provided in the Shared Practice Anaerobic Digestion Good Practice Guidelines¹⁵⁰:</p> <ul style="list-style-type: none"> ■ Cattle: 20-40 ■ Pigs: 250-300 ■ Poultry: <ul style="list-style-type: none"> – Laying hen litter: 8,000-9,000 – Broiler manure: 10,000-15,000 <p>Biogas yields derived from the average of the figure brackets provided in The Andersons Centre data¹⁵¹:</p> <ul style="list-style-type: none"> ■ Cattle: 15-25 m³/tonne ■ Pigs: 15-25 m³/tonne ■ Poultry: 30-100 m³/tonne <p>Energy content of biogas also derived from The Andersons Centre data.</p>
Heating and Electricity Fuel Offset	<p>CHP plant efficiency¹⁵²:</p> <ul style="list-style-type: none"> ■ Electricity: 30% ■ Heating: 50% <p>Heating fuel assumed to be offset:</p>	<ul style="list-style-type: none"> ■ The Andersons Centre 	<p>CHP plant efficiency derived from The Andersons Centre data¹⁵⁵.</p>

¹⁵⁰ Shared Practice (1997) Good Practice Guidelines: Anaerobic Digestion of farm and food processing residues. Available at: <http://www.sharedpractice.org.uk/Library/library.html>

¹⁵¹ The Andersons Centre (2010) A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems. Available at: <https://theandersonscentre.co.uk/service/economic-analysis/>

¹⁵² As this study is calculating the potential energy generation from a known amount of fuel, as opposed to an infinite energy supply such as wind, only the CHP efficiency was considered to calculate the overall energy generation potential, not the load factor for biogas CHP units, which considered the percentage of time a boiler is operating at peak output annually.

¹⁵⁵ The Andersons Centre (2010) A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems. Available at: <https://theandersonscentre.co.uk/service/economic-analysis/>

Parameter	Assumption	Data Source	Justification and Notes
	<ul style="list-style-type: none"> ■ Electricity: 45% of off-gas properties¹⁵³ ■ Oil: 55% of off-gas properties¹⁵⁴ ■ Gas: All on-gas properties 		

Wind Resource Constraints

A.19 The potential constraints to wind developments were mapped within the National Park and are listed within **Table A.9**. These constraints are based on the main constraints to all scales of wind development.

A.20 It is beyond the scope of this project to map all potential constraints, such as buffer distances between homes and turbines of varying height. Moreover, as the National Park is

primarily focusing on micro-scale technologies, these have the ability to be carefully micro-sited to consider nearby constraints. As such it is not appropriate for this strategic-scale study to merge all constraints to identify an area of "unconstrained" land with potential for wind development, as it has for biomass virgin wood fuel technologies.

A.21 The constraints maps provide an indication of the constraints to wind development across the National Park, and further study would be required to identify potential sites for wind development.

Table A.9 Wind Resource Constraints

Constraint	Data Source	Justification and Notes
Wind Speed	<ul style="list-style-type: none"> ■ Global Wind Atlas/Vortex ■ Industry practice 	<p>Wind speed requirements change with turbine scale and model. Some turbine manufacturers produce models which may operate at lower wind speeds and the configuration of certain turbine models can be altered to improve yield in lower wind speed environments.</p> <p>Future changes in government policy, such as the reintroduction of greater financial support for wind projects, and turbine technology could allow developments to be deliverable at lower wind speeds than are currently viable.</p>

¹⁵³ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

¹⁵⁴ Scottish Government (2024) Scottish House Condition Survey 2022 Key Findings. Table KA9a: Percentage of dwellings by primary heating fuel and urban rural location, 2022. Rural values used. This excludes consideration of other heating sources used by off-gas properties, as they provide heating for only a small percentage of properties. Available at: <https://www.gov.scot/publications/scottish-house-condition-survey-2022-key-findings/documents/>.

Constraint	Data Source	Justification and Notes
Roads (excl. restricted access tracks)	<ul style="list-style-type: none"> Ordnance Survey OpenRoads 	<p>Roads with a buffer of the height of the turbine (to blade tip height) +10% are a safety consideration. The proposed buffer distance is based on standard safety distances used by wind turbine developers and the DECC Renewable and Low-carbon Energy Capacity Methodology¹⁵⁶.</p> <p>Restricted access tracks were excluded from consideration as these predominantly comprise of forestry and other tracks which could be more easily diverted than standards roads.</p>
Railways	<ul style="list-style-type: none"> Ordnance Survey OpenMap Local 	<p>Railways with a buffer of the height of the turbine (to blade tip height) +10% are a safety consideration, based on the same principles as used for roads.</p>
Major electricity transmission lines	<ul style="list-style-type: none"> Ordnance Survey OpenMap Local 	<p>Major transmission lines (132kV minimum) with a buffer of the height of the turbine (to blade tip height) +10% are a safety consideration. It is derived from guidance by the Energy Networks Association (Engineering Recommendation L44) and National Grid (Technical Advice Note 287).</p> <p>It is noted that this guidance also states that a buffer of 3x the rotor diameter should be applied to account for turbine wake downwind of a turbine impacting the weathering of electricity lines. However, this also states that this impact is variable depending on factors including turbine positioning. This would require site-level study and consultation with the relevant DNO. As such, this buffer distance was not applied as a constraint.</p> <p>Further study would be required to make consideration of transmission lines operated by the local DNO SSSEN.</p>
Buildings & noise receptors	<ul style="list-style-type: none"> OS OpenMap 	<p>Buildings with a buffer of the height of the turbine (to blade tip height) +10% are a safety consideration. National Planning Practice Guidance notes that the topple distance + 10% is a safe separation distance between turbines and buildings.</p> <p>In addition, buffer zones would need to be considered around sensitive¹⁵⁷ and non-sensitive receptors¹⁵⁸. Wind turbines generate sound during their operation, and their noise impacts upon nearby properties must be limited to appropriate levels, defined in particular by the 'ETSU' Guidance – The Assessment and Rating of Noise from Wind Farms (1995) (as supplemented by the Institute of Acoustics). The relationship between turbine size and the separation distance from properties at which acceptable noise levels will be achieved is in practice quite complex and variable. Specialist acoustic advice and further study would be required.</p>

¹⁵⁶ DECC (2010) Renewable and Low-carbon Energy Capacity Methodology. Available at: <https://www.gov.uk/government/news/decc-publishes-methodology-for-renewable-and-low-carbon-capacity-assessment>

¹⁵⁷ Sensitive receptors include residential properties, schools, hospitals and care homes. These were identified via the LLPG data.

¹⁵⁸ Non-relevant addresses that have no applicable noise receptors were excluded, identified via the LLPG data, including: ancillary buildings, car parking, garages, non-buildings.

Constraint	Data Source	Justification and Notes
Local Plan Allocations	<ul style="list-style-type: none"> Loch Lomond and the Trossachs National Park 	Generally unsuitable for wind turbine development, unless allocations contain relatively large undeveloped portions. Identification of suitable land for wind within specific allocation boundaries would require a separate site-specific study. It is assumed that opportunities for renewables within such sites will potentially be considered as part of their design.
Terrain greater than 15% slope	<ul style="list-style-type: none"> OS Terrain 50 	This is a development/operational constraint. Developers have indicated that this is the maximum slope they would generally consider feasible for development. Although it is theoretically possible to develop on areas exceeding 15% slopes, turbine manufacturers are considered unlikely to allow turbine component delivery to sites where this is exceeded.
Watercourses and waterbodies with a 50m buffer	<ul style="list-style-type: none"> Ordnance Survey OpenMap Local 	A 50m buffer is commonly applied around all rivers and waterbodies to take account of good practice such as that relating to pollution control during construction.
<p>Woodland: Ancient Woodland Inventory with a 50m buffer, and woodland as shown on the National Forest Inventory with a 50m buffer including:</p> <ul style="list-style-type: none"> Assumed woodland; Broadleaved; Conifer; Coppice; Coppice with standards; Low density; Mixed mainly broadleaved; Mixed mainly conifer; and Young trees. 	<ul style="list-style-type: none"> Forestry Commission Nature Scot Loch Lomond and the Trossachs National Park 	<p>All areas of woodland are considered a constraint with a +50m buffer to reduce risk of impact on bats.</p> <p>A 50m clearance distance of turbine blades from tree canopies and other habitat features is standard practice and endorsed by Nature Scot guidance set out in 'Bats and onshore wind turbines - survey, assessment and mitigation'. A 50m horizontal buffer from turbine masts is a reasonable proxy clearance for the purposes of a strategic study bearing in mind unknowns concerning tree height and turbine dimensions. In addition, a 50m buffer cannot be applied to all linear habitat features and individual trees due to a lack of data for a study of this scale. Further site specific study would therefore be required to accurately define buffer distances between turbines and adjacent woodland.</p> <p>The following National Forestry Inventory categories of woodland were considered non-permanent or non-woodland and therefore not considered as constraints as wind turbine development may be suitable in these locations:</p> <ul style="list-style-type: none"> Cloud/shadow; Failed; Felled; Group prep; Shrub; Uncertain; and Windblown.

Constraint	Data Source	Justification and Notes
Biodiversity (International Designations): <ul style="list-style-type: none"> ■ Special Protection Areas (SPA); ■ Special Areas of Conservation (SAC); ■ Ramsar sites. 	<ul style="list-style-type: none"> ■ Nature Scot 	As protected by: <ul style="list-style-type: none"> ■ Wildlife and Countryside Act 1981 ■ The Conservation (Natural Habitats, &c.) Regulations 1994
Biodiversity (National Designations): <ul style="list-style-type: none"> ■ Sites of Special Scientific Interest (SSSI); and ■ National Nature Reserves (NNR). 	<ul style="list-style-type: none"> ■ Nature Scot 	As protected by: <ul style="list-style-type: none"> ■ Wildlife and Countryside Act 1981 ■ The Conservation (Natural Habitats, &c.) Regulations 1994
Cultural Heritage designations: <ul style="list-style-type: none"> ■ Historic Designed Landscapes ■ Conservation areas; ■ Listed buildings; ■ Inventory listed Gardens and Designed Landscapes; and ■ Scheduled monuments. 	<ul style="list-style-type: none"> ■ Historic Environment Scotland ■ Scottish Government ■ Loch Lomond and the Trossachs National Park 	As protected by: <ul style="list-style-type: none"> ■ NPF4 ■ National Heritage Act 1983 ■ Ancient Monuments and Archaeological Areas Act of 1979 Planning (Listed Buildings and Conservation Areas)(Scotland) Act 1997It is noted that further site specific study would be required to determine if any unexpected archaeological remains or non-designated but nationally or locally significant features are present that would require consideration, as well as the setting of historic features.
Landscape designations: <ul style="list-style-type: none"> ■ Wildland Areas; ■ National Scenic Areas; and ■ Special Landscape Qualities. 	<ul style="list-style-type: none"> ■ Nature Scot ■ Scottish Government 	Developers would need to make consideration of landscape designations and the potential impact of wind developments upon these when considering development siting. NPF4 sets out the policy for National Scenic Areas and wild land in Policy 4, Natural Places.

Constraint	Data Source	Justification and Notes
<p>Peatlands:</p> <ul style="list-style-type: none">■ National Soil Map of Scotland;■ Bare Peat Areas from Remote Sensing; and■ Carbon And Peatland map.	<ul style="list-style-type: none">■ James Hutton Institute■ Nature Scot	<p>Developers would need to make consideration of peatlands and the potential impact of wind developments upon these when considering development siting.</p> <p>NPF4 sets out the policy for protecting peatland and carbon rich soils in Policy 5, Soils.</p>

A.22 The parameters below have not been included as constraints to wind development for the purposes of this study. This does not mean that these constraints are not present or do not require consideration on a specific site.

Table A.10 Wind Resources Constraints considered but not used

Constraint	Data Source	Justification and Notes
Biodiversity (International Designations)	<ul style="list-style-type: none"> ■ Nature Scot 	<p>The following designations would also be considered constraints however none are present within the study area:</p> <ul style="list-style-type: none"> ■ Potential SAC ■ Potential SPA ■ Proposed Ramsar sites
Biodiversity (Regional and Local Designations)	<ul style="list-style-type: none"> ■ Nature Scot 	<p>The following designations would also be considered constraints however none are present within the study area:</p> <ul style="list-style-type: none"> ■ Local Nature Reserves
Cultural Heritage designations	<ul style="list-style-type: none"> ■ Historic Environment Scotland 	<p>The following designations would also be considered constraints however none are present within the study area:</p> <ul style="list-style-type: none"> ■ World Heritage Sites ■ Battlefields Inventory Boundaries
Airports and Airfields	<ul style="list-style-type: none"> ■ Ordnance Survey OpenMap Local Functional Site layer with the theme 'Air Transport' 	<p>It is noted that land within consultation zones surrounding airports and airfields may also be unsuitable for wind turbine development, and further consultation between potential developers and airport and airfields is required to determine if there is any impact from a proposed development.</p> <p>However, there are no airports or airfields present within the National Park.</p>
Gas pipelines	<ul style="list-style-type: none"> ■ National Gas 	<p>Gas pipelines with a 1.5x hub height buffer are a safety consideration. It is derived from guidance by the United Kingdom Onshore Pipeline Operators' Association (UKOPA/GP/013 Edition 1).</p> <p>It is noted that only National Grid open data was available for use within this study, and no such pipelines are present within The National Park. Further site-specific study would be required to consider any other buried pipelines not contained within this dataset.</p>

Constraint	Data Source	Justification and Notes
MOD Land	<ul style="list-style-type: none"> OpenStreetMap 	MOD land may be considered unsuitable for wind turbine development, as this land is already in use for MOD activities. Further consultation with the MOD would be required to determine if there is any potential for wind turbine development to be delivered on this land.
Electricity Grid	<ul style="list-style-type: none"> SSEN 	<p>As grid capacity is so variable with little certainty in advance of where there could be capacity for additional electricity generation to be connected, no land was treated as a constraint on this basis. Further consultation would be required with SSEN to determine the feasibility to connect specific sites to the electricity grid.</p> <p>Moreover, for larger wind turbine schemes, developers commonly deliver substations and additional grid infrastructure as required to support the additional generation capacity requirements of the development, limiting concerns regarding connecting to constrained parts of the existing grid.</p>
NATS Safeguarding Areas	<ul style="list-style-type: none"> NATS 	<p>Further consultation between potential developers and NATS is required to determine if there is any impact from a proposed development.</p> <p>NATS safeguarding areas were therefore not treated as constraints.</p>
Shadow Flicker	<ul style="list-style-type: none"> N/A 	Wind turbines may in some circumstances cause 'shadow flicker' within nearby properties. However, shadow flicker effects can be readily mitigated and so shadow flicker was not considered as a constraint for the purposes of this study.
Residential Amenity	<ul style="list-style-type: none"> N/A 	<p>It is noted that it may be inappropriate to develop wind turbines in proximity to residential properties, due to impacts upon residential amenity. However, due to the potential for mitigation, it would require further site specific study to determine whether wind turbines would be suitable in proximity to residential properties.</p> <p>Therefore, this factor would require consideration within a site specific residential and visual amenity assessment (RVAA).</p>
Public Rights of Way, Core Paths and Cycle Paths	<ul style="list-style-type: none"> Loch Lomond and the Trossachs National Park Sustrans 	<p>Public Rights of Way, core paths and cycle paths can be diverted if necessary to ensure they are safely distanced from wind turbines.</p> <p>Public Rights of Way and cycle paths were therefore not treated as constraints.</p>
Blade oversail of biodiversity and cultural heritage designations	<ul style="list-style-type: none"> N/A 	<p>Depending on individual designated site characteristics, it may not be suitable for the blades of adjacent wind turbines to oversail the site. However, this is site dependent and would require further studies.</p> <p>As such, a blade oversail buffer was not treated as a constraint.</p>

Constraint	Data Source	Justification and Notes
Existing Renewable Energy Developments	<ul style="list-style-type: none"> ■ BEIS (now DESNZ) ■ Loch Lomond and the Trossachs National Park 	<p>The quarterly BEIS (DESNZ) Renewable Energy Planning Database and hydroelectric data provided by Loch Lomond and The Trossachs National Park Authority were used to determine the locations of operational and consented renewable energy installations.</p> <p>Wind farms and ground-mounted solar developments would occupy land that would prevent wind turbine development, however, no operational wind farms or ground-mounted solar developments were identified.</p> <p>Further work would be required to determine the land-take of other renewable developments and their suitability for co-location with wind turbines.</p>

Ground-Mounted Solar Resource Constraints

A.23 The potential constraints to ground-mounted solar developments were mapped within the National Park and are listed within **Table A.11** below. These constraints are based on the main constraints to all scales of wind development.

A.24 It is beyond the scope of this project to map all potential constraints, such as buffer distances between solar developments and different width of road. Moreover, as the National

Park is primarily focusing on micro-scale technologies, these have the ability to be carefully micro-sited to consider nearby constraints. As such it is not appropriate for this strategic-scale study to merge all constraints to identify an area of "unconstrained" land with potential for solar development, as it has for biomass virgin wood fuel technologies.

A.25 The constraints maps provide an indication of the constraints to ground-mounted solar development across the National Park, and further study would be required to identify potential sites for solar development.

Table A.11 Ground-Mounted Solar Resource Constraints

Parameter	Data Source	Justification and Notes
Solar irradiance	<ul style="list-style-type: none"> ■ Global Solar Atlas 	Locations of higher annual solar irradiates levels will have the potential to generate larger yields of solar power and therefore be more attractive to developers.
Roads (excl. restricted access tracks)	<ul style="list-style-type: none"> ■ Ordnance Survey OpenRoads 	Physical features preventing the development of ground-mounted solar PV include roads. There is no requirement for safety buffers in relation to these with respect to ground-mounted solar PV. Restricted access tracks were excluded from consideration as these predominantly comprise of forestry and other tracks which could be more easily diverted than standards roads.
Railways	<ul style="list-style-type: none"> ■ Ordnance Survey OpenMap Local 	Physical features preventing the development of ground-mounted solar PV include railways. There is no requirement for safety buffers in relation to these with respect to ground-mounted solar PV.
Planning/Land Use Other: <ul style="list-style-type: none"> ■ Country Parks; and ■ Local open spaces. 	<ul style="list-style-type: none"> ■ Nature Scot ■ Loch Lomond and the Trossachs National Park 	Due to land take requirements, these land uses/types were considered generally to constrain ground-mounted solar development, particularly at larger scales, although in some circumstances they may offer opportunities for smaller scale development co-located with their other facilities. They were treated as constraints but may be subject to bespoke policies with the Local Plan allowing development to take place in principle subject to defined criteria being satisfied.
Buildings with a 10m buffer	<ul style="list-style-type: none"> ■ OS OpenMap Local data 	Buildings were buffered by 10m to account for shading and impacts on solar output. It is noted that further site specific study considering building heights and orientation in relation to the site would be required to determine the exact buffers required to account for shading.
Local Plan Allocations	<ul style="list-style-type: none"> ■ Loch Lomond and the Trossachs National Park 	Generally, these will be unsuitable for ground-mounted solar, although there may be some potential for installations on undeveloped land/open space within these areas. Identification of this potential would require a

Parameter	Data Source	Justification and Notes
		separate, site-specific study. In addition, it is assumed that opportunities for renewables within such sites may potentially be considered as part of the master planning activities for the allocations.
Terrain with north-east to north-west aspect and inclinations greater than 7 degrees; and all areas with inclinations greater than 15 degrees	<ul style="list-style-type: none"> OS Terrain 50 	Although it is possible to develop Ground-mounted solar PV installations on slopes facing north-east to north-west, it would generally not be economically viable to do so. However, slopes that are north-east to north-west facing and below 7°, as well as all other land with inclinations less than 15°, are considered potentially suitable ¹⁵⁹ , as generation output will not be significantly affected.
Productive land use: <ul style="list-style-type: none"> Land Capability for Agriculture classes 1-3.2 	<ul style="list-style-type: none"> James Hutton Institute Scottish Government 	NPF4 sets out the policy for prime quality agricultural land in Policy 5, Soils. Prime agricultural land is that identified as being Class 1, 2 or 3 in the land capability classification for agriculture developed by Macaulay Land Use Research Institute (now the James Hutton Institute). Ground-mounted Solar PV projects, over 50kWp, should ideally utilise previously developed land, brownfield land, contaminated land, industrial land or agricultural land preferably of classification 4 – 7, but avoiding areas of high carbon soils. Within the National Park, the majority of land is Classes 6.2 and 6.3 agricultural land. As such, Class 1 to Class 3 (land capable of supporting arable agriculture) were treated as a constraint to solar development, and further site-specific study would be required to determine if sites on lower class land would be suitable.
Watercourses and waterbodies with a 50m buffer	<ul style="list-style-type: none"> Ordnance Survey OpenMap Local 	A 50m buffer was applied around all rivers and waterbodies to take account of good practice such as that relating to pollution control during construction.
Woodland: Ancient Woodland Inventory with a 20m buffer, and woodland as shown on the National Forest Inventory with a 20m buffer including: <ul style="list-style-type: none"> Assumed woodland; Broadleaved; 	<ul style="list-style-type: none"> Forestry Commission Nature Scot 	Forested areas were buffered by 20m to account for shading and impacts on solar output. It is noted that further site specific study considering woodland heights and orientation in relation to the site would be required to determine the exact buffers required to account for shading. The following National Forestry Inventory categories of woodland were considered non-permanent or non-woodland and therefore not treated as constraints and ground mounted solar development may be suitable in these locations: <ul style="list-style-type: none"> Cloud/shadow;

¹⁵⁹ Based on current standard developer practice.

Parameter	Data Source	Justification and Notes
<ul style="list-style-type: none"> ■ Conifer; ■ Coppice; ■ Coppice with standards; ■ Failed; ■ Felled; ■ Group prep; ■ Low density; ■ Mixed mainly broadleaved; ■ Mixed mainly conifer; ■ Shrub; and ■ Young trees. 		<ul style="list-style-type: none"> ■ Uncertain; and ■ Windblown.
<p>Biodiversity (International Designations):</p> <ul style="list-style-type: none"> ■ Special Protection Areas (SPA); ■ Special Areas of Conservation (SAC); and ■ Ramsar sites. 	<ul style="list-style-type: none"> ■ Nature Scot 	<p>As protected by:</p> <ul style="list-style-type: none"> ■ The Conservation (Natural Habitats, &c.) Regulations 1994
<p>Biodiversity (National Designations):</p> <ul style="list-style-type: none"> ■ Sites of Special Scientific Interest (SSSI); and ■ National Nature Reserves (NNR). 	<ul style="list-style-type: none"> ■ Nature Scot 	<p>As protected by:</p> <ul style="list-style-type: none"> ■ Wildlife and Countryside Act 1981 ■ The Conservation (Natural Habitats, &c.) Regulations 1994
<p>Cultural Heritage designations:</p>	<ul style="list-style-type: none"> ■ Historic Environment Scotland 	<p>As protected by:</p>

Parameter	Data Source	Justification and Notes
<ul style="list-style-type: none"> ■ Historic Designed Landscapes ■ Conservation areas; ■ Listed buildings; ■ Inventory listed Gardens and Designed Landscapes; and ■ Scheduled monuments. 	<ul style="list-style-type: none"> ■ Scottish Government ■ Loch Lomond and the Trossachs National Park 	<ul style="list-style-type: none"> ■ NPF4 ■ National Heritage Act 1983 ■ Ancient Monuments and Archaeological Areas Act of 1979 ■ Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997 <p>It is noted that further site specific study would be required to determine if any unexpected archaeological remains or non-designated but nationally or locally significant features are present that would require consideration, as well as the setting of historic features.</p>
<p>Landscape designations:</p> <ul style="list-style-type: none"> ■ Wildland Areas; and ■ National Scenic Areas. 	<ul style="list-style-type: none"> ■ Nature Scot ■ Scottish Government 	<p>Developers would need to make consideration of landscape designations and the potential impact of wind developments upon these when considering development siting.</p> <p>NPF4 sets out the policy for National Scenic Areas and wild land in Policy 4, Natural Places, sections c and g.</p>
<p>Peatlands:</p> <ul style="list-style-type: none"> ■ National Soil Map of Scotland; ■ Bare Peat Areas from Remote Sensing; and ■ Carbon And Peatland map. 	<ul style="list-style-type: none"> ■ James Hutton Institute ■ Nature Scot 	<p>Developers would need to make consideration of peatlands and the potential impact of wind developments upon these when considering development siting.</p> <p>NPF4 sets out the policy for peatland and high carbon soils in Policy 5, Soils, sections c and d.</p>

A.26 The parameters below have not been included as constraints for the purposes of this study. This does not mean that these constraints are not present or do not require consideration on a specific site.

Table A.12 Ground-Mounted Solar Resource Constraints considered but not used

Parameter	Data Source	Justification and Notes
Biodiversity (International Designations)	<ul style="list-style-type: none"> ■ Nature Scot 	<p>The following designations would also be considered constraints however none are present within the study area:</p> <ul style="list-style-type: none"> ■ Potential SAC ■ Potential SPA

Parameter	Data Source	Justification and Notes
		<ul style="list-style-type: none"> Proposed Ramsar sites
Biodiversity (Regional and Local Designations)	<ul style="list-style-type: none"> Nature Scot 	The following designations would also be considered constraints however none are present within the study area: Local Nature Reserves
Cultural Heritage designations	<ul style="list-style-type: none"> Historic Environment Scotland 	The following designations would also be considered constraints however none are present within the study area: <ul style="list-style-type: none"> World Heritage Sites Battlefields Inventory Boundaries
MOD Land	<ul style="list-style-type: none"> OpenStreetMap 	MOD may be considered unsuitable for solar development, as this land is already in use for MOD activities. Further consultation with the MOD would be required to determine if there is any potential for solar development to be delivered on this land.
Operational and allocated minerals and waste sites	<ul style="list-style-type: none"> Perth and Kinross; Stirling; Argyll and Bute; and West Dunbartonshire Councils 	<p>The IAQM 2016 Guidance on the Assessment of Mineral Dust Impacts for Planning indicates that adverse dust impacts from sand and gravel sites are uncommon beyond 250m and beyond 400m from hard rock quarries measured from the nearest dust generating activities.</p> <p>Waste sites will frequently be quite highly constrained with respect to ground-mounted solar development (e.g. areas of active landfill) but landfill sites equally may present opportunities in some circumstances, particularly when they are to be decommissioned/restored during a plan period. Waste sites could therefore be treated as a constraints to ground-mounted solar resource but potentially subject to bespoke policy wording in the local plan.</p> <p>As such, all operational and allocated minerals sites with a 250m buffer, and all operation and allocated waste sites would be considered constraints. However, data for these sites was not available for this project. Further site specific study would be required to consider these sites.</p>
Electricity Grid	<ul style="list-style-type: none"> SSEN 	<p>As grid capacity is so variable with little certainty in advance of where there could be capacity for additional electricity generation to be connected, no land was treated as a constraint on this basis. Further consultation would be required with SSEN to determine the feasibility to connect specific sites to the electricity grid.</p> <p>Moreover, for larger wind turbine schemes, developers commonly deliver substations and additional grid infrastructure as required to support the additional generation capacity requirements of the development, limiting concerns regarding connecting to constrained parts of the existing grid.</p>

Parameter	Data Source	Justification and Notes
Gas pipelines	<ul style="list-style-type: none"> National Grid 	Although the presence of buried pipelines could impact the suitability of overlaying above-ground solar panels, mitigation and panel layout design can be applied to limit impacts.
Electricity lines	<ul style="list-style-type: none"> Ordnance Survey OpenMap Local 	Although overhead lines have the potential to cause some limited shading of solar panels, and thereby impact on potential PV generation potential, panel layout design can limit impacts. Further site-specific study would be required to consider this parameter.
Residential Amenity	<ul style="list-style-type: none"> N/A 	It is noted that it may be inappropriate to develop solar farms in proximity to residential properties, due to impacts upon residential amenity. However, due to the potential for micro siting, property aspect and potential for mitigation, it would require further site specific study to determine whether solar developments would be suitable in proximity to residential properties.
Public Rights of Way, Core Paths and Cycle Paths	<ul style="list-style-type: none"> Loch Lomond and the Trossachs National Park DEFRA Sustrans 	Public Rights of Way, core paths and cycle paths can be diverted if necessary around or safely through ground mounted solar developments, and these impacts are considered as part of the assumed development density. Public Rights of Way and cycle paths were therefore not treated as constraints.
Airports and Airfields	<ul style="list-style-type: none"> Ordnance Survey OpenMap Local Functional Site layer with the theme 'Air Transport' Aerial imagery 	<p>Glint and glare caused by solar panels is a consideration for aviation safety. However, this is site dependent and scheme design can enable solar developments to be situated within airports and airfields themselves. As such, only the airport and airfield buildings and hardstanding should be treated as constraints to solar development.</p> <p>There are however no airports or airfields present within the National Park.</p>
Existing Renewable Energy Developments	<ul style="list-style-type: none"> BEIS (now DESNZ) Loch Lomond and the Trossachs National Park 	<p>The quarterly BEIS (DESNZ) Renewable Energy Planning Database and hydroelectric data provided by Loch Lomond and The Trossachs National Park Authority were used to determine the locations of operational and consented renewable energy installations.</p> <p>Wind farms and ground-mounted solar developments would occupy land that would prevent wind turbine development, however, no operational wind farms or ground-mounted solar developments were identified.</p> <p>Further work would be required to determine the land-take of other renewable developments and their suitability for co-location with wind turbines.</p>

Hydropower

A.27 Assessment of the potential for additional hydropower installations within the National Park is beyond the scope of this assessment. This would require a bespoke study by hydropower specialists to identify locations along waterways where suitable yearly flow characteristics are present and could feasibly support hydropower sites. Further assessment would then be required to determine the suitability of such sites for development, making consideration of constraints such as ecological factors and landscape and cultural heritage impacts. A high-level strategic assessment, such as this study, cannot make consideration of this.