Solar Energy UK

Natural Capital Best Practice Guidance

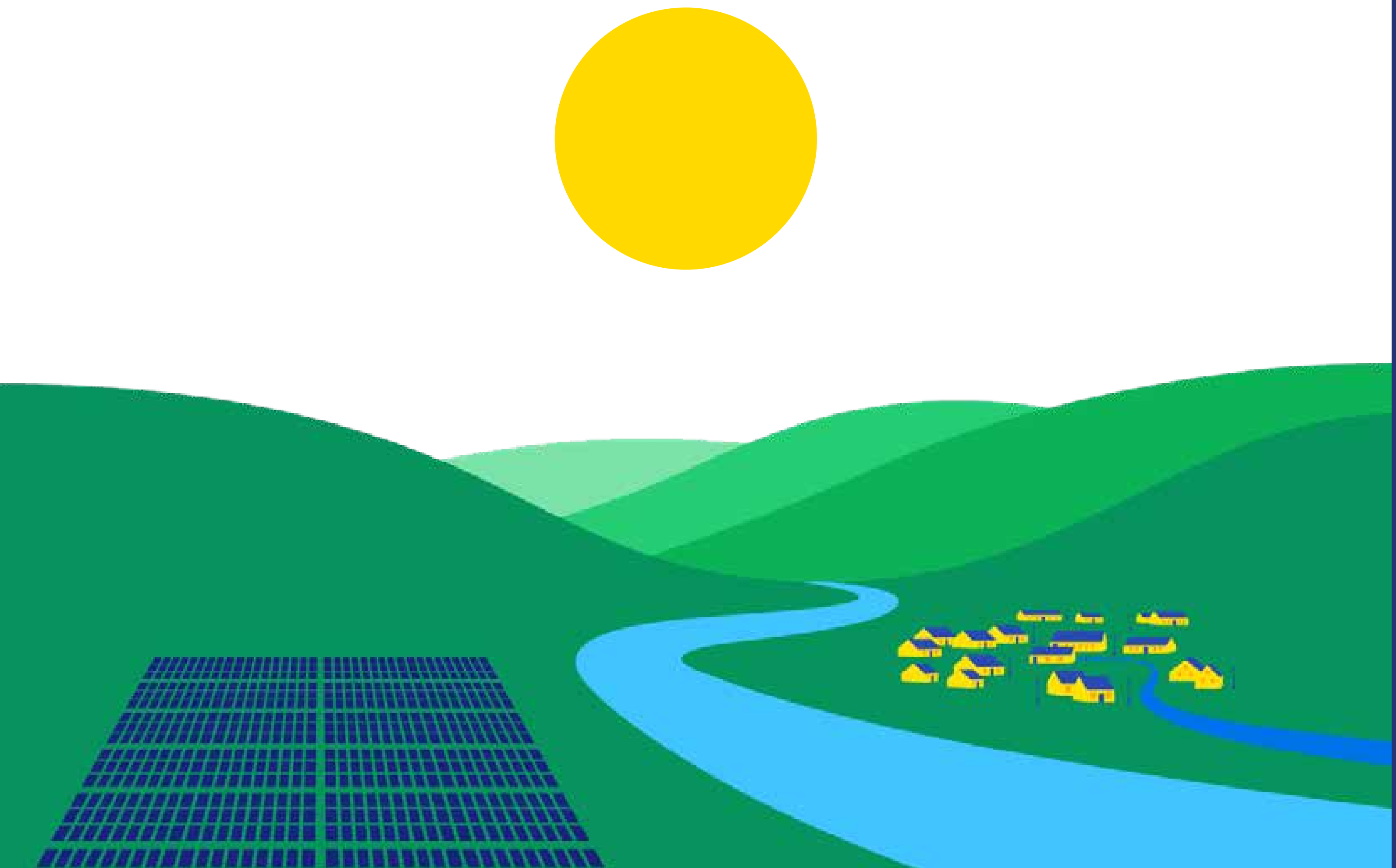
Increasing biodiversity at all stages of a solar farm's lifecycle

About us

As an established trade association working for and representing the entire solar and energy storage value chain, Solar Energy UK represents a thriving member-led community of over 260 businesses and associates, including installers, manufacturers, distributors, large-scale developers, investors, and law firms.

Our underlying ethos has remained the same since our foundation in 1978 - to be a powerful voice for our members by catalysing their collective strengths to build a clean energy system for everyone's benefit.

Our mission is to empower the UK's solar transformation. Together with our members, we are paving the way for solar to deliver 40GW by 2030 by enabling a bigger and better solar industry.



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Please note that the report and its contents do not necessarily represent the views of any of these organisations.

Designed by Lawtz Design Group

Glossary

Agricultural Land Classification (ALC) UK system for classifying agricultural land for versatility and suitability for growing crops

Albedo effect Measure of how a surface reflects light

Beaufort scale Measure of wind intensity

Bifacial panels: Solar panels that generate power by exposing both sides of the cell to sunlight, maximising total energy generation

Biodiversity Net Gain An approach to development that aims to deliver measurable improvements for biodiversity by creating or enhancing habitats

Carbon sequestration Process by which carbon dioxide is captured from the atmosphere and stored

Conservation covenant Legally binding obligation for environmental benefits on land

Construction Environmental Management Plan (CEMP) A detailed plan submitted to the local authority which sets out how environmental matters will be managed during construction of the solar farm

Department for Environment, Food and Rural Affairs (DEFRA) UK Government department for environmental protection, food production and standards, fisheries and rural communities

Development of National Significance (DNS) In Wales, a planning application for a large infrastructure project

District Network Operator (DNO) A company licensed by Ofgem to distribute electricity in the UK. There are six such operators in the UK

Easement strip Land 6 -12m wide for cables or pipelines left free from development to allow access

Ecological Clerk of Works (ECoW) Person advising on ecological and environmental concerns prior or during construction of a project

Ecosystems A biological area where living organisms and their environment interact with one another

Ecosystem services Economic, social, environmental, cultural or spiritual benefits arising from healthy ecosystems

Environmental Impact Assessment (EIA) Detailed report to identify and assess likely significant environmental impacts arising from the solar farm development

Environment Act 2021 UK legislation setting out out legally binding targets on air quality, biodiversity, water, resourse efficiency and waste reduction

EPC Engineering, procurement and construction

ESG Environmental, social and governance

Habitat banking Trade in habitat or biodiversity credits

Herpetofauna Amphibians and reptiles

Hibernaculum Shelter for dormant animals such as reptiles over winter

Injurious weeds Plants that can damage crops, habitats or ecosystems

Landscape and Ecological Management Plan (LEMP) Detailed plan describing how the landscaping and biodiversity measured will be implemented and maintained

Local Planning Authority (LPA) Council with responsibility for approving planning applications at a local level

MAGIC UK government mapping tool which provides authoritative geographic information about the natural environment

Megawatt (MW) Measure of energy generation capacity used in reference to solar farms. One megawatt equals 1,000 kilowatts

Natural capital The aspects of nature that directly or indirectly produce value for people, such as the stocks of forests, rivers, land, minerals and oceans

Natural Environment Research Council (NERC) The UK's largest independent funder of environmental science, training and innovation projects delivered through universities and research centres

Nationally Significant Infrastructure Projects (NSIP) Major infrastructure projects in England and Wales where planning consent is decided at a national government level rather than locally. For energy projects such as solar farms these are 50 megawatts (MW) and above

Okta scale Measurement of cloud cover

O&M Operations and maintenance

Ofgem The energy regulator for Great Britain

Open mosaic habitats Patchwork of previously developed land providing different habitats

Quadrat A square frame used to define a study area in ecology

REGO Renewable energy guarantee of origin

Repower To replace old energy generating equipment with updated technology

Riverine Relating to or near a river

Scrape Shallow depression with gently sloping edges designed to hold water

Section 106 agreement A planning obligation to mitigate the impact of a new development

Single-axis tracker System for moving solar panels in one direction, typically east to west

Site of Special Scientific Interest (SSSI) A formal conservation to protect land typically because it provides habitats for rare species

Toolbox talk A short presentation given on a single aspect of health and safety

UKHab UK habitat classification system

Contents

Foreword

Tony Juniper, CBE, Chair, Natural England

If we are to reach net zero by 2050 and halt the decline in biodiversity by 2030, a major change will be required in the way we manage our land, coast, and seas. The climate crisis and the ecological emergency are inextricably linked, each amplifying the other. They must be tackled not in isolation but very much together - and solar provides a wonderful opportunity to do so.

Well-designed and well-managed solar farms deliver clean, affordable energy. They can also offer additional benefits to the local environment, meaning that the UK's solar farms can make a significant contribution to both local and national biodiversity targets. For example, significant ecological gain can be achieved through establishing wildflower meadows and grasslands, hedgerows, woodland scrub, wetland habitats and land quality restoration. This has the potential to support the creation of a Nature Recovery Network across the country whilst benefiting rural communities through job creation and the provision of recreational and educational opportunities.

This new natural capital best practice guidance answers the question on how solar farms can deliver for biodiversity at every stage of a solar farm's operational lifespan from site appraisal and design through to decommissioning. The guidance seeks to highlight solar's ability to empower multi-functional land use, promoting space for agricultural practices and biodiversity enhancements together with green energy generation.

Purpose & intended audience

This best practice guidance has been produced to raise awareness and promote the design, construction and operation of high-quality solar farm projects which support ecology and deliver additional benefits arising from multiple land use. It provides detailed guidance on how to deliver a solar farm from site design through to decommissioning with an emphasis on promoting environments which provide natural capital, biodiversity, and in some cases agriculture, alongside green energy supply.

Most Local Planning Authorities (LPAs) will by now have some experience with the consenting process for renewable energy technologies, however many may be unaware of the specific opportunities for solar farms to improve biodiversity and increase ecosystem services. Solar farms can be a critical tool for LPAs to achieve both their climate and ecological objectives.

Solar farm developers should also find this guide useful in the development, construction, and operation of sites. It has been designed to clearly set out the benefits of implementing biodiversity enhancement strategies alongside maximising the output of solar installations. This has progressed considerably in the past few years, presenting exciting new financial opportunities as well.

Introduction

There is now universal consensus among global climate scientists and governments that the climate is changing due to rising greenhouse gas emissions. The impacts of climate change are already being felt around the world; here in the UK extreme weather events such as storms, droughts and flooding are becoming much more frequent and severe. Generating energy from fossil fuels is the largest contributor of global carbon emissions, and the world is working together to limit the increase in temperatures to 1.5°C.

The path to Net Zero and energy security

In 2019 the UK government became the first in the world to set a legally binding target of Net Zero carbon emissions by 2050. In October 2021 it set an interim goal to completely decarbonise our energy supplies by 2035. The proportion of renewable energy we generate has now grown to over 40% of our total mix.

The Climate Change Committee estimates that 75 to 90% of the UK's electricity will need to come from solar and wind by 2050. This means the UK must install a minimum of 40GW of solar by 2030 to keep Net Zero on track – a tripling of current capacity over the next decade, with an average annual installation rate of 2.6GW. [1]

Over the past decade, the solar industry has gone from strength to strength with over 14GW of solar generation capacity installed as of the end of 2021.

The importance of energy security in the UK has been underlined by the current geopolitical situation, with the UK's dependence on gas causing huge spikes in energy bills. Large-scale solar, alongside onshore wind, is the cheapest new energy-generating technology and can help reduce bills for everyone as well as providing a secure source of homegrown energy. The government's Energy Security Strategy (April 2022) sees solar increasing five-fold to 70MW.

> *"Onshore wind and solar will be key building blocks of the future generation mix, along with offshore wind. We will need sustained growth in the capacity of these sectors in the next decade to ensure that we are on a pathway that allows us to meet net zero emissions in all demand scenarios."*
>
> **UK Government Energy White Paper, 2020**

> *"This is no longer about tackling climate change or reaching net-zero targets. Ensuring the UK's clean energy independence is a matter of national security. Putin can set the price of gas, but he can't directly control the price of renewables and nuclear we generate in the UK."*
>
> **Kwasi Kwarteng, Secretary of State for Business, Energy and Industrial Strategy, March 2022**

Tackling the ecological crisis through natural capital

Not only are we facing a climate crisis, but we are facing an ecological emergency too, and the two are intrinsically linked. According to the ground-breaking 2019 'State of Nature Report', 60% of British wildlife species monitored have declined and 15% are facing extinction for a variety of reasons including use of pesticides and habitat loss.

The Government's 25-year Environment Plan 'A Green Future' highlights the importance of natural capital as a tool in decision-making.

Natural capital refers to the aspects of nature that directly or indirectly produce value for people, such as the stocks of forests, rivers, land, minerals and oceans. From these stocks of natural capital flow ecosystem services or benefits which may be economic, social, environmental, cultural or spiritual with qualitative or quantitative values. For example, access to open spaces and providing a healthy environment.

Ecosystem services arising from well-managed solar farms

- Biodiversity and wildlife habitat provision
- Carbon storage and climate regulation
- Flood attenuation and water cycle support
- Water quality regulation
- Pollination
- Air quality regulation
- Soil erosion mitigation and soil quality regulation
- Education, leisure and community engagement
- Food provision and support for sustainable agriculture

Multifunctional land use

Utility or large-scale ground mounted solar projects are the lowest-cost and most efficient form of solar PV generation, due to economies of scale and because they can be designed to make the most of the available light resource. They cover large areas of land and have long operational lifespans (typically 25-40 years) during which time they are largely undisturbed by people; there is therefore an obvious synergy between using solar farms to generate clean energy, promote natural capital and continue some agricultural uses.

For solar farms on previous arable land, giving the land a break from intensive cultivation for extended periods – with minimal or no inputs of pesticides, herbicides and fertilisers – can reap big rewards in terms of boosting biodiversity, soil health and regeneration. With a positive ecological enhancement strategy built into the project design as well, the gains can be increased multiple times.

With less than 2% of land disturbed by infrastructure, the remainder of the site can be set aside for grassland and wildflower meadows to provide habitats for pollinators, birds, and other wildlife and/or for sheep grazing, ensuring the land continues to contribute to food production. These enhancements can be delivered easily and at a low cost to project developers.

In the 10 years since the UK large-scale solar industry began, some solar companies have looked to optimise biodiversity across their solar projects from the outset. However their plans were sometimes met with scepticism from planners and members of the public, around both their implementation and effectiveness. Over time, the results of their activities have been monitored resulting in a growing body of evidence to show that, when managed properly, solar farms can lead to a dramatic increase in biodiversity and so help to boost natural capital.

Solarview, a annual report produced by Clarkson & Woods amalgamates the results of ecological monitoring undertaken on solar farms across the UK and pulls together insights and trends to help inform developers, local authorities, ecologists and farmers across the solar industry. [2]

Regular monitoring and surveys typically show increases in botanical diversity with corresponding growth in numbers or varieties of bumblebees, butterflies and birds as well as mammals such as brown hare, barn owls and a range of invertebrates. Solar Energy UK's The Value of Natural Capital report showcases examples of existing solar sites delivering biodiversity benefits through a range of ecological enhancements. [3]

Studies from experienced ecologists have been complemented by academic institutions such as Lancaster University demonstrating the potential beneficial impacts of managing solar farms for biodiversity.

Solar parks boost bumblebees; win-win for nature

Research from Lancaster University published in December 2021 showed that land on a solar farm managed for wildflowers rather than grass can boost bumblebee numbers by up to four times. The benefits extend up to 1 km beyond the solar park, benefiting farmers who need bees to pollinate their crops. [4]

Using a model that simulated bumble bee foraging in UK solar parks, the researchers investigated different management scenarios that offered varying degrees of resources for bumblebees. Their findings indicated that managing the land around the arrays as meadows - offering the most resources - would support four times as many bumblebees as land managed as turf grass.

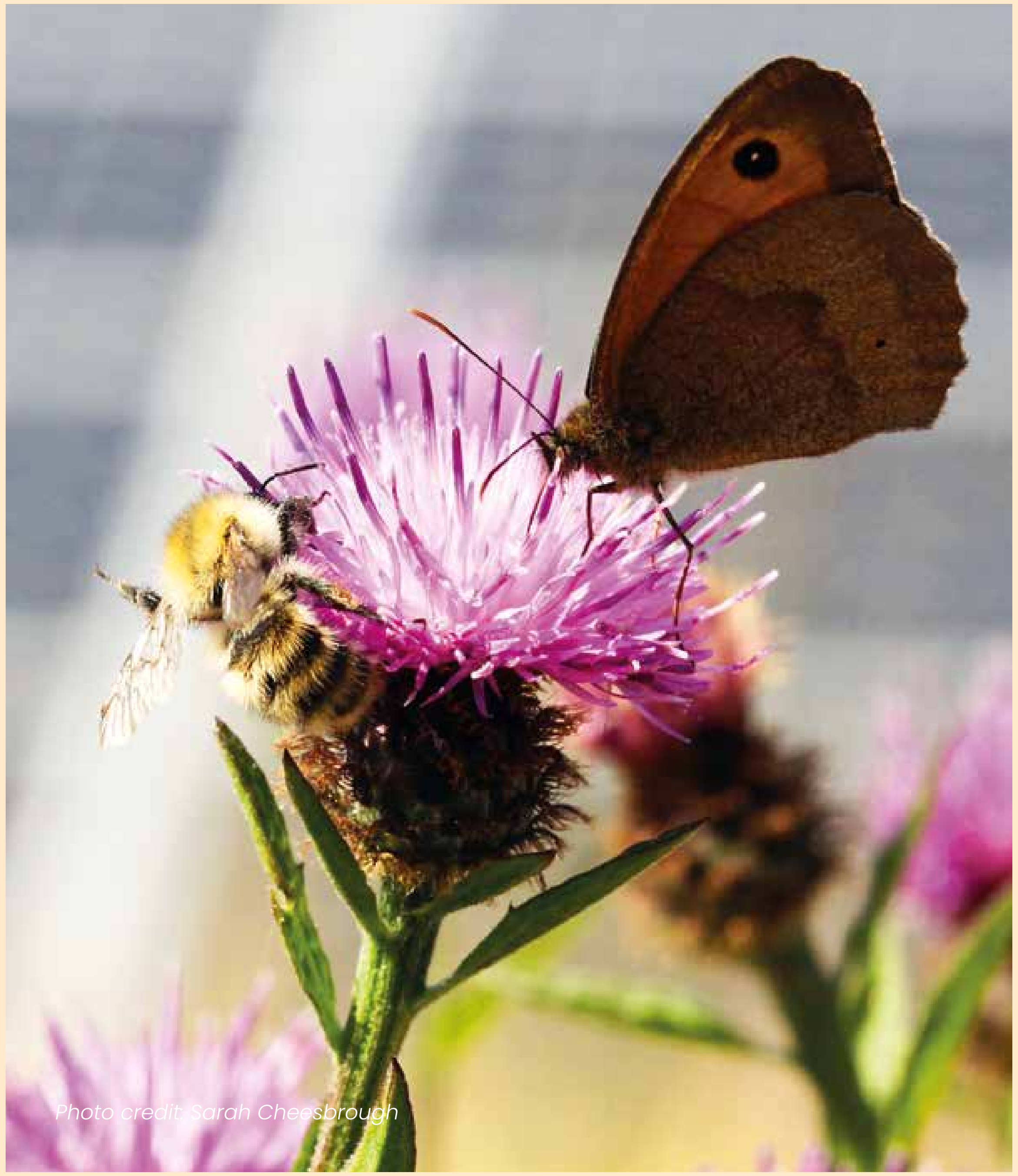


Photo credit: Sarah Cheesbrough

Benefits for society arising from well-managed solar farms

Benefit to...	By...
Biodiversity and environment	• Creating and enhancing ecological habitats • Providing increased habitat connectivity through hedgerow planting or infilling • Reducing or eliminating use of pesticides, herbicides and fertilisers • Stopping intensive farming practices leading to lower pollution and better soil and water quality • Improving soil regeneration and carbon sequestration
Local communities	• Building new bridleways and footpaths • Providing educational and recreational opportunities for schools and local community groups • Supporting local conservation priorities e.g. tree planting/orchards, and flood prevention
Farmers	• Diversifying revenue opportunities • Opportunities for sheep grazing • Providing pollination services leading to increased yields on and off site

Delivering for farmers and communities

For farmers, solar farms offer an important opportunity to diversify revenue streams, reduce energy bills and maximise the value of underutilised land. Promoting natural capital also builds on farmers' environmental stewardship role helping to integrate them more closely within their local communities.

Natural capital enhancements can also be a useful tool during public consultation in the planning process. A focus on biodiversity, pollinators, soil health and new hedgerow and tree-planting may help to offset community concerns about the visual impact of solar panels.

Solar farms can also be used to host educational visits from local schools and community groups to provide practical, hands-on learning opportunities, creating empowered and engaged community members for the future. [5]

Some community-owned solar farms have been particular champions for the broader benefits of solar, from natural capital to hosting innovative beehives to organising community tree-planting events. Commercial developers can learn from their example.

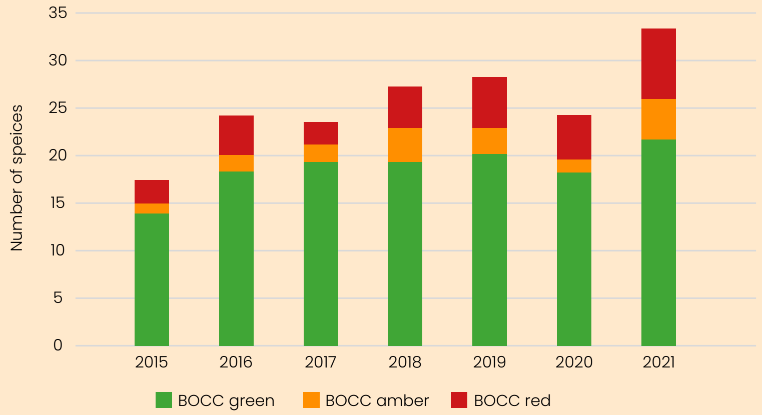
Sawmills solar farm

Sawmills solar farm is a 6.6MW project on a 29ha site in Devon which was commissioned in 2015. It was developed by Eden Renewables, is operated by Belltown Power and is owned by Foresight Solar Fund. Previously arable land used mainly for growing oats, the site was designed to promote biodiversity, with the LEMP focused particularly on providing habitats for declining species including the rare cirl bunting. Enhancements include sowing winter bird seed mix, native meadow seed, creating rough grassland, planting new hedgerows, installing bird and bat boxes and hosting beehives.

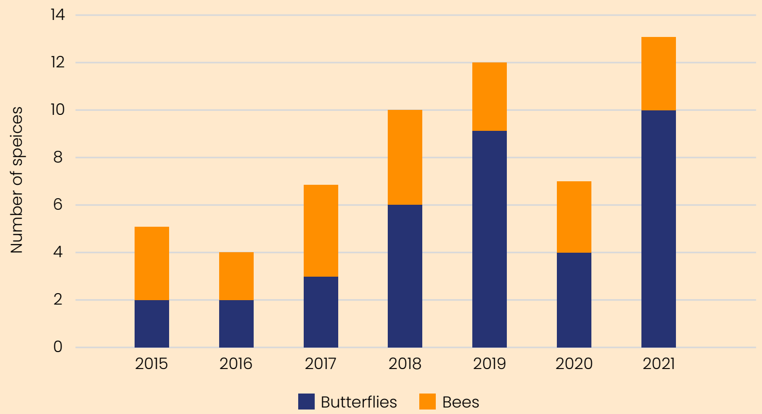
Wychwood Biodiversity has advised on ecological enhancements and has carried out annual monitoring from 2015 to 2021, focusing on three indicator groups: botany, selected invertebrate pollinators, and breeding birds. The seven years of monitoring have seen overall gains in all three groups across the site. The most recent surveys in April to July 2021, showed the highest botanical diversity recorded to date, which in turn is likely to have influenced the highest invertebrate diversity and abundance. Seven bird species of conservation concern were observed, including the nationally rare cirl bunting which has been seen several times on site during breeding bird surveys.

The graphs below demonstrate the key findings over seven years of biodiversity monitoring.

Bird species



Invertebrate species



Changing legal landscape

The aspiration to boost natural capital on solar farms has now been legally underpinned with the 2021 Environment Act. This ground-breaking new legislation sets a mandatory requirement for every new Town and Country Planning Act (TCPA) development in England – from housing estates to motorways – to deliver a measurable Biodiversity Net Gain (BNG) of 10%, from November 2023 (with NSIP development likely to follow from late 2025). Solar farm developers should look to this as a minimum requirement; gains of 20% to over 100% are achievable on some sites.

This marks a critical change in public and political attitudes, providing an objective and authoritative acknowledgement of the value society places on measures to enhance ecology. It can also be a benchmark for stakeholders, LPAs and statutory consultees such as Natural England to evaluate good solar developments.

In Wales, under the Environment (Wales) Act 2016, Natural Resource Wales and other public bodies are required to at the very least maintain and enhance biodiversity and promote resilient ecosystems. While under the Act, the Welsh Government's 2021 ecosystem resilience guidance sets out key principles. In Scotland, the Environmental Strategy for Scotland outlines the Government's vision.

Return on investment

Historically solar developers who incorporated measures to boost natural capital into their solar farm designs did so on the basis that it was the 'right thing to do', at an additional cost to their budgets with no expectation of a financial return. However, BNG creates the possibility of selling biodiversity units generated on solar farms (by enhancing or creating new habitats) to developers in need of offsite units to meet their BNG requirements. This should enable the solar industry to push ecological enhancements further and ensure better maintenance and monitoring programmes with better data collection so ecological benefits can be properly evaluated and remunerated.

The wider potential benefits for the solar industry and society are huge, with the future prospect of tens of thousands of hectares of multi-functional land generating clean energy and creating a massive investment in the UK's natural capital and associated ecosystem services.

Photo credit: Sarah Cheesbrough

Key learnings

Solar farms come in all shapes and sizes and are built on land with a wide range of characteristics. Whilst there is not a 'one size fits all' approach to the development and operation of solar farms, there are key learnings which all developments can follow to maximise natural capital and biodiversity benefits.

1. Mitigation hierarchy

Choosing a suitable site for a utility scale solar farm is a careful balancing act between constraints, such as landscape designations, and commercial considerations, such as the availability of an economic grid connection. Impacts on biodiversity and agriculture also need to be considered alongside other factors such as visual impact.

Land of high value for biodiversity, such as protected areas and sites of importance for protected species should be avoided where possible. If development impacts are unavoidable, an appropriate strategy for mitigation and enhancement is needed which takes local ecology into account.

Each site should be considered on a case-by-case basis. The 'mitigation hierarchy' provides a useful framework for assessing the natural capital potential of a site and should be applied to all impacts of the proposals at the earliest possible stage. Additional enhancements, sometimes referred to as Additional Conservation Actions (ACAs), can enhance the biodiversity value of the site over and above requirements for avoidance, mitigation, or compensation.

First, avoiding potential negative impacts altogether. For example, retaining hedgerows with appropriate buffers.

If impacts cannot be completely avoided, then they should be minimised. For example removing as little hedgerow habitat as possible.

Steps should be taken to rectify or restore any impacts that cannot be avoided. For example, replanting hedgerows as soon as feasible.

If all avoidance, minimisation and restoration measures have been taken and impacts still remain, the final option is to offset or compensate the losses elsewhere. For example, planting additional hedgerows off-site.

2. Consistent lead consultants throughout project life

Developing a solar farm requires contributions from a large number of different specialists, many of whom will be consultants rather than part of an in-house team. Having the same people involved in the project throughout, from initial design, through planning, implementation, and operation of the solar farm can make a huge difference to its success.

For example, lead ecology consultants should be involved in the site appraisal and design process. All specialist surveyors, such as heritage, arboriculture, landscape and visual impact, ecology, hydrology, and flood risk surveyors should feed in their results before the detailed technical design begins. Land maintenance contractors should be consulted to ensure designs are practical. Regular meetings between all parties should be established in order to share learnings.

These service providers who will be involved throughout the project should also be signed up to key terms before financial close to ensure plans are carried through after construction and during the maintenance phase.

3. Consistency of key documents throughout the project

Key documents should be kept updated by the lead ecologists, developer and asset owner and shared with all other parties through design, construction and operation of the project to ensure the programme is fully costed and understood by all relevant parties: future asset owner, EPC, land maintenance provider, sheep grazer, etc.

- The constraints and opportunities map will be the basis for the high level landscape and biodiversity plan, which in turn is the basis for the Landscape and Ecological Management Plan (LEMP), including the establishment and management maps and the planting plan
- Construction and CEMP maps
- A landscaping and biodiversity costing schedule that tracks the above implementations and management practices from high level / rough costs to detailed plans and detailed costs

This is especially important if there is a change of asset owner, lead ecologist, EPC, O&M, or land maintenance provider.

4. Costing of proposed works and full disclosure

All consultants and the developer should fully understand the cost implications of their recommended natural capital prescriptions, including implementation, maintenance and monitoring costs, before they are fixed in the LEMP, as it is legally binding. A landscaping and biodiversity costing schedule should be completed at the earliest stages, kept updated throughout the project life, incorporated into the project's financial model, and if the project is sold, disclosed before financial close. It can also serve as a useful guide to the EPC and land maintenance provider. A sample landscaping and biodiversity costing schedule can be downloaded from the supplementary documents.

5. Effective monitoring and communication

An effective monitoring plan is essential to track the development of habitats within a site, adhere to management plans and identify any potential issues. The collection and sharing of monitoring data (through submission to the Local Biological Record Centre and perhaps by participating in national data collection projects) helps to increase understanding of how solar farms affect natural capital assets and solutions to deal with management issues. Managing landowners' expectations effectively will also ensure the management is successful, as often land managed for wildlife can look "untidy".

Biodiversity Net Gain

Biodiversity Net Gain (BNG) applies to all new developments - including solar farms - and is designed so that a project 'leaves biodiversity in a better state than before'. Under Part 6 of the Environment Act (2021) new developments are required to show a minimum net gain in biodiversity of 10%.

BNG is calculated by a qualified ecologist by comparing the baseline biodiversity units - measured in its pre-development state - with the results that would be expected after construction is complete and all the ecological enhancements have been implemented. The metric most widely used at the time of writing is the Biodiversity Metric 3.0 (developed by Natural England and DEFRA) which gives values for hedgerow units and habitat units.

Applying BNG to a solar farm is quite straightforward, as very little habitat is destroyed through the construction process. Typically, access tracks, buildings and piles take up less than 2% of the total land area. However, the impacts from the panels upon the ground beneath must be taken into account.

The current difficulty in applying the Biodiversity Metric to solar developments is categorising the land between and directly beneath the panels, which can have great influence on the BNG score. Current research (awaiting publication) shows that in most cases, habitats within solar farms can be classified as Other Neutral Grassland of Moderate condition within the metric (where the site is formerly arable or pasture).

The habitat directly under the panels is more variable, but in most cases, a similar habitat can be achieved. Natural England has advised SEUK that in the absence of empirical evidence, ecologists should categorise it as one area or sub-categorise it into multiple areas based on their experience of the habitats under panel areas.

BNG calculations will clearly vary depending on whether the solar farms are being built on brownfield, non-agricultural land, heathland/peatland, pasture or arable land.

The following reports are useful in relation to BNG:

- *CIEEM guideline Biodiversity Net Gain Report & Audit Templates (July 2021).* The guideline provides a template for a 'BNG Audit Report' which provides an audit checklist confirming the delivery of BNG at project completion

- *CIEEM 'BNG Feasibility Report'* (feasibility of delivering net gain at early stages of a project) and *BNG Design Stage Report* (to inform a planning application submission, aimed at decision-makers such as LPA)

- *BS 8683: Process for designing and implementing biodiversity net gain – Specification (August 2021)*

- *CIEEM/CIRIA/IEMA Biodiversity Net Gain: Good Practice Principles for Development, A Practical Guide (2019)*

Any solar scheme that is selling biodiversity units to developers to enable them to meet the future mandatory BNG requirement will need to register their site on the National Register for net gain delivery sites. Sites selling biodiversity units will need to manage and maintain the biodiversity for a minimum of 30 years and will need a legal agreement in place (s106 or a conservation covenant) to underpin the contractual arrangement (see finance chapter).

To satisfy trading rules for Biodiversity Net Gain credits, "trading down" of valuable habitats for those of lower biodiversity is not allowed. The BNG metric is not designed to adequately address losses of Very High Distinctiveness habitat or irreplaceable habitat, which should be given wider consideration outside the scope of the metric.

While BNG will become mandatory for new planning applications from winter 2023, it is already a local plan requirement within a number of LPAs and is being widely used by many solar developers on projects now going through planning to showcase the natural capital benefits their projects will bring. It can also be used by some local authorities to benchmark the biodiversity value of sites built some time ago. Sites need to be monitored during their lifetime to ensure the proposed habitats, and the planned biodiversity gains, have been achieved.

Photo credit: Sarah Cheesebrough

Site appraisal & design

The site selection and design of the solar farm should address all opportunities and constraints relating to biodiversity. These should be continued through planning and construction, ensuring that everyone involved with the project is on the same page.

The key document defining the site design is the biodiversity constraints map, which will provide the building blocks for the Landscape and Ecological Management Plan (LEMP).

Site selection

The government's Planning Practice Guidance (PPG) on renewable and low carbon energy (updated 2015) states that large scale solar farms should focus on::

"previously developed and non agricultural land, provided that it is not of high environmental value; where a proposal involves greenfield land, whether (i) the proposed use of any agricultural land has been shown to be necessary and poorer quality land has been used in preference to higher quality land; and (ii) the proposal allows for continued agricultural use where applicable and/or encourages biodiversity improvements around arrays."

In practice, it is rare to find a previously developed (brownfield) site which meets all the other requirements for a large-scale solar farm, such as grid connection and minimal visual impact, and most solar farms are developed on agricultural land. They provide vital income to farmers boosting the sustainability of the agricultural sector, and with multiple land use can continue to contribute to food production and the stock of natural capital.

Agricultural land classification (ALC)

To inform planning decisions for agricultural land in Britain, assessments are made of the long-term limitations on agricultural land use. Two separate methodologies are used, Land Capability for Agriculture (LCA) in Scotland, and Agricultural Land Classification (ALC) for England and Wales. Both grade land into classes (seven for LCA and six for ALC) according to quality and versatility imposed by factors such as climate, topography and soil characteristics.

For England and Wales, the Best and Most Versatile (BMV) land is that in ALC Grades 1, 2 and 3a. LCA grades 1, 2 and 3.1 are considered Scotland's prime quality agricultural land. National planning guidance seeks to avoid the unnecessary loss of this superior land resource to development. However protection is weighed against other sustainability considerations. In Scotland, 1:50k scale maps identify the distribution of prime quality agricultural land, focusing on lowland and eastern Scotland, corresponding to areas of greater population and development pressure.

For England and Wales, a detailed site assessment of ALC grade is often required to accompany planning applications. Natural England provides guidance for developers and planning authorities in *Agricultural Land Classification: protecting the best and most versatile agricultural land (TIN049)*. Although specific to England the recommendations on conducting an ALC assessment are appropriate to England and Wales. Welsh Government provides an excellent predicative ALC map but a definitive ALC grading still requires detailed site assessment.

Both the LCA and ALC predate solar farm planning applications. Solar farms can remain in agricultural production throughout their operational life and are granted temporary consent. Therefore the agricultural land resource is not lost, nor does it become brownfield land.

Desktop study

The mitigation hierarchy needs to be applied at all stages of the site selection and design. Areas of higher biodiversity value, including statutorily protected sites and internationally designated areas (e.g. Ramsar wetland sites, Special Protection Areas (SPAs) and Special Areas of Conservation (SACs)); nationally designated sites such as Sites of Special Scientific Interest (SSSIs); and Local Nature Reserves (LNRs) should be avoided.

Identifying protected sites and locations important for notable species and habitats should be done initially through screening using a mapping system such as MAGIC or SiteLink.[6] Local Wildlife Sites (terminology may differ depending on region/county) are administered by Local Planning Authorities or Local Wildlife Trusts or their designated management partner, and often do not appear on data searches. The Local Environmental Records Centre can provide their locations and reasons for designation.

For peatland habitats, online mapping resources such as Scotland's Soils, the Unified Peat Map of Wales and the UK Soil Observatory can be used to identify the presence of sensitive habitat.

Once constraints have been mapped and the site location has been finalised a more detailed desktop study should be carried out. This should include:

- A data search of all notable species and habitats from the Local Environmental Records Centre
- A pond search using Ordnance Survey mapping at 1:25,000 scale
- A full search of species and habitats using an online mapping system such as MAGIC
- A check of nearby planning applications to ascertain if recent surveys have been conducted
- Where particular species are of concern, direct contact with local recording groups or the County Recorder is advised. Where birds are of particular concern, the British Trust for Ornithology's Data Request System may be utilised
- Data searches should be undertaken at a minimum of a 2km radius from the site's boundary (the search buffer will vary depending on the habitats or species that may be impacted and availability of records within the local area)

Site walkover

Following the desktop surveys, an ecologist should do a site walkover to assess the ecological features on site. This can initially be a rapid assessment, followed by a full survey later. A short report known as a Preliminary Ecological Appraisal (PEA) should be produced initially which will include an ecological constraints map and identify enhancement opportunities. Recommendations for further surveys are usually produced. This report is issued for internal use rather than to support a planning application and the aim is to guide the site design so that ecologically important areas can be retained and appropriate mitigation and buffers can be incorporated.

Following the desktop study and site walkover, the developer and their consultants should meet to discuss the results. Considering the constraints from different disciplines helps the developer make an objective decision about whether the site is suitable for development, or whether part of it should be excluded. If it is suitable, an initial basic layout taking account of the ecological constraints can be prepared.

Detailed seasonal surveys

Where required, ecologists will then carry out detailed protected species and habitat surveys at appropriate times of year (for example breeding bird surveys, wintering birds, great crested newts, reptiles, bats, badgers, dormice, crayfish, water voles, otters, invertebrates and botany, see 'Planning' chapter for details). These surveys will identify further constraints and opportunities to influence the site design.

On upland sites, peat depth surveys provide an indication on the spatial distribution of peat across the site and can help inform design (common practise in Wales and Scotland). The collection of peat cores may also be required to verify recorded depths.

The process of refining the site's design will continue right up to the point at which the planning application is submitted.

Refining the site design

As the site design is refined further, the mitigation hierarchy should continue to be applied.

Avoidance

Identify areas of higher biodiversity value within the site and on neighbouring land, so impacts can be avoided. For example:

- Buffers to protect ancient semi-natural woodland (15m minimum)
- Root protection areas around trees, see BS5837 for current recommendations on infrastructure design relating to trees [7]
- Buffers around riverine and wetland areas to avoid impacts from sediment and pollution and on notable species
- Species-specific buffers, for example, buffers around ponds to protect great crested newts or around trees to protect bat roosts
- Avoid key or sensitive habitats such as areas of deep peat or priority habitats

Baseline data should be collected to inform the mitigation and enhancements. In some cases, avoidance means surveys will not be needed. For example, if watercourses are protected by the right buffer, with no anticipated impacts, then water vole surveys are unnecessary. Conversely, for other species baseline data can prevent unexpected discoveries. For example, even with sufficient buffers around ponds, it is best practice to carry out great crested newt surveys where this species may be present, as individuals can travel large distances and unforeseen encounters during construction could cause significant delays and costs.

Buffers may also be required for operational reasons, such as shading or leaf fall from trees (especially where new planting is proposed) to ensure that tree reduction is not necessary once the trees have matured.

Minimisation

Thoughtful design and operational measures to minimise impacts on wildlife. For example:

- Gaps in security fencing to allow small and medium mammals in and out of the site; typically a rural deer fence with wooden posts, square mesh wire and at least 100mm gaps between the bottom wire and the ground
- Minimising the number of permanent buildings and the total area each occupies
- Optimising road layouts to reduce the overall footprint and use existing gaps in hedgerows where possible
- Limiting lighting only to those areas where it is essential – permanent lighting is not usually needed on a solar farm
- In high-value habitat areas, consider laying cables above-ground either in trays or using a post-and-wire system to avoid disturbing the land by burying them. Their use should be balanced against operational and construction considerations

An ecological Construction and Environmental Construction Plan (CEMP) should set out key measures for minimising impacts during construction. (See Construction chapter and supplementary documents).

Restoration

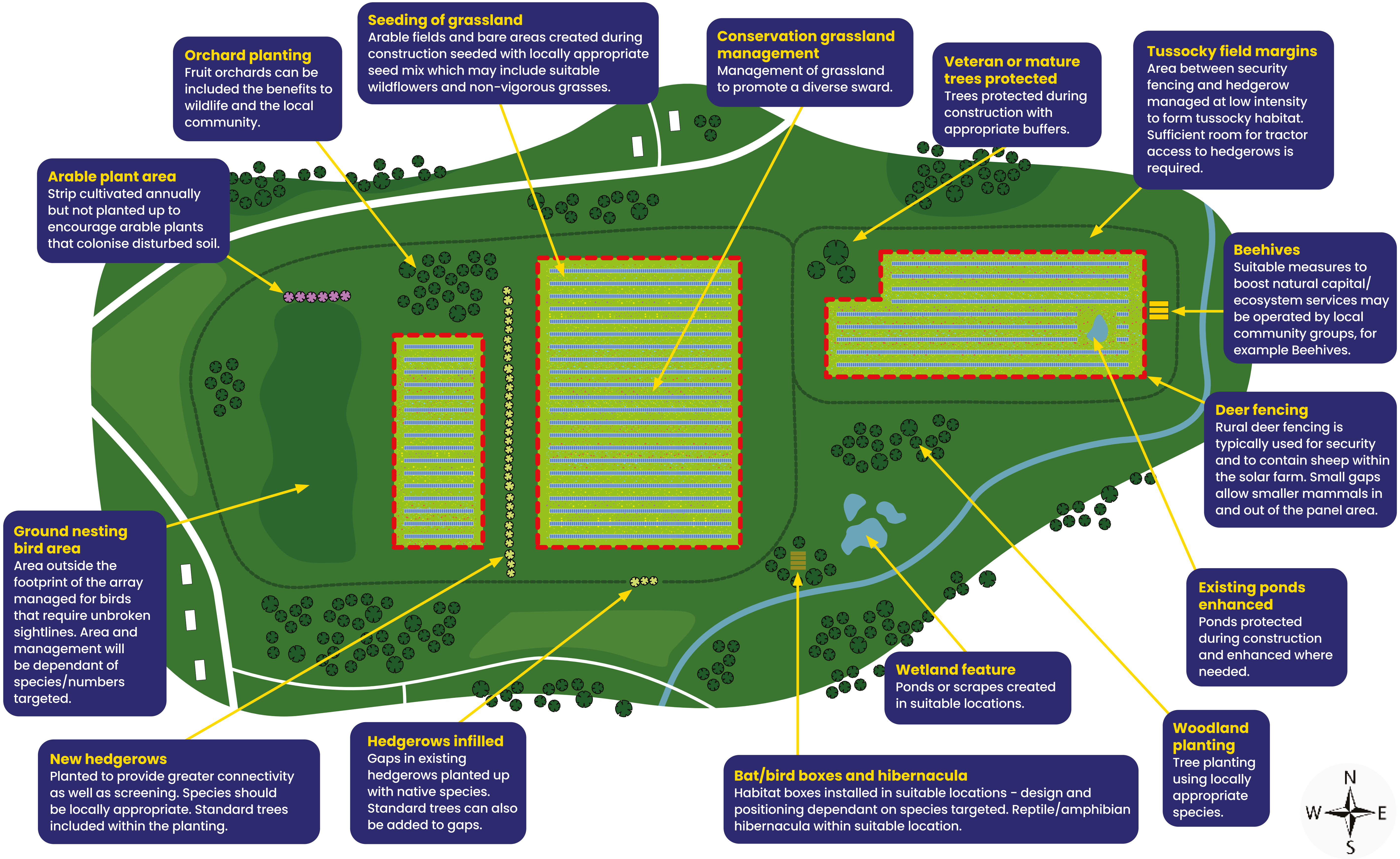
Provision should be made to restore any areas damaged or removed during the construction process, including trenching, temporary tracks, and landscaping of permanent hardstanding for the delivery of building materials. These areas will be identified during site design but will be dealt with during the construction phase (see Construction chapter).

Compensation

In some cases, where the impacts are greater than usual or there are features of higher biodiversity value present on site, then a compensation strategy may be required. This may be in the form of a biodiversity offset, whereby features or enhancements are developed offsite to compensate for any losses (such as an area managed for ground nesting birds). The details are usually determined through the planning process (see Planning chapter).

Photo credit: SFW Communications

Suitable ecological enhancements for a solar farm



Suitable ecological enhancements

The potential for biodiversity improvements will vary from site to site due to soil types, topography and climate. There are some easy wins which are cost effective and deliver significant ecological gain that can be applied to most solar farms. For example:

- Seeding a diverse wildflower and grass mix over part or all of the site. This is often done in areas where solar panels are avoided, for example for easement strips or areas where archaeological impacts should be avoided. It can also be done under the whole panel area, especially where the site was previously arable or there are areas of bare ground. The seed mix should be selected to reflect soil type and fertility to ensure success
- Hedgerow planting and management around the boundary of the site. This includes filling in gaps of existing hedgerows or planting new hedgerows to join up existing hedgerows, for wildlife corridors or networks. Existing hedgerows may also be cut less frequently. These measures not only provide biodiversity value but are also likely to be part of the landscape strategy for screening the development
- A bund with a hedge planted on top can also be effective for both screening and to increase habitat, and can be done at a low cost
- Planting native scrub or woodland in locations where panel shading is not a concern, which also provides screening
- Creating tussocky grassland around the margins between the security fence and the site's boundary, usually at least 4m wide, left for maintaining the exterior hedgerows. Tussocky grassland is beneficial to a variety of different species and is generally easy to manage
- Creating ponds, scrapes and other wetland features in low-lying wet corners of the site. Features implemented to manage site drainage, such as swales can also be managed for wildlife
- Providing habitat for specific species, such as hibernacula for reptiles and amphibians, bird and bat boxes. These provide a relatively easy long-term benefit at a low cost when installed during the construction phase. N.B. such features, though beneficial, cannot be counted towards or sold as biodiversity net gain

These measures can all be delivered at a low cost - see appendix 1 for more details.

More specialised habitats can also be created where conditions are appropriate, such as:

- Riverine habitats (may require a licence from Environment Agency)
- Specific grassland habitats, e.g. chalk grassland seed mix where soil conditions are suitable
- Wild bird habitats using a suitable seed mix
- Orchard planting can also benefit wildlife and local communities
- Subject to site conditions, restoration of peatland (which could also be considered a compensation measure for particular sites)
- Integration with other natural capital initiatives such as natural flood management

Carbon sequestration

Soil carbon sequestration – the process by which carbon dioxide is captured and stored in soils – is another benefit likely to arise from the increased vegetation and low level of management of a solar farm managed for biodiversity. The regeneration of the soil following a period of intensive cultivation is likely to increase the amount of organic matter, which in turn holds more carbon. Studies are currently underway to measure and assess this effect on solar farms over time.

Agricultural considerations

Agricultural use will continue on many solar farms with sheep grazing on the site. More detail is provided on managing sheep in the Operation chapter. However, this also needs to be considered at the design stage as the panels must be sufficiently high off the ground to allow the sheep access to the grass underneath and for shelter (minimum 70cm), and with enough space between the arrays so they can move freely. There should be no loose cables and electrical infrastructure should be protected.

With their abundance of wildflowers and lack of disturbance, solar farms make good sites for apiaries, which can also boost pollination on adjacent agricultural land. The site design should identify areas suitable for beehives – they need to be accessible for the beekeeper but away from other public areas of the site (such as footpaths or areas for school visits). The design should also consider whether hives are better inside the security fence or in a quiet area outside. While bees make a great addition to agricultural activities, there can be competition between honeybees and native pollinators so the suitability of beehives needs to be carefully assessed.

Hydrology services and water management

Water management and land drainage need to be considered at the site design stage. As well as ensuring surface water is controlled and won't cause issues on site this can also provide an opportunity to establish wetland habitats.

A flood risk assessment is usually required as part of the planning process. These usually require simple measures to be incorporated into the site design, such as open drainage systems (e.g. ditches and swales).

There can often be concerns from local communities about the impacts of solar farms on flooding. However, these are usually misplaced and there is no evidence of any significant long-lasting flood issues on solar farms. As the land often transitions

Photo credit: Above Surveying

from intensive agricultural land, with low organic matter content and poor soil structure, to low input grassland with a healthy grass sward developing, organic processes return, water infiltration and retention improves, there is less surface-water runoff (reducing loss of nutrients and pollution), and risk of flooding decreases. Some solar farms are now being monitored to assess this effect and provide further evidence of these benefits.

Operational considerations

Design features that will help with land management include:

- 4m clearance between the ends of the panel rows and the security fence, to enable machinery to turn between the rows
- 4m clearance between hedge and security fence to allow tractor access for hedgerow maintenance
- Single leg frames to support the panel rows are much simpler to mow around than double legs, which create a 'no go' zone for mowers between the legs
- A high front edge to panels (over 70cm), to allow mowing equipment and/or sheep to access the grass beneath the leading edge of the solar panels, and prevent shading from taller flowers or grasses

Technology selection

Solar technology is advancing rapidly and there is a growing trend towards using single-axis tracker systems rather than fixed-tilt, usually with bifacial panels. While this has implications for electricity generation it can also influence biodiversity on the site.

The traditional mounting systems used in the UK until recently are 'fixed tilt' systems with arrays oriented east-west, facing south at an angle of around 20-25 degrees. Arrays can be up to four panels deep, set in landscape. Whilst the ground between the arrays and at the front and back gets enough sunlight for a healthy sward to develop, the area in the middle of the array may have areas of heavy or permanent shading causing bare soil and injurious weeds and woody plants to grow. This can be exacerbated as arrays set on frames with two rows of legs need to be managed with hand-operated tools rather than machinery. While weeds can contribute to biodiversity through the creation of an additional habitat, their height must be kept short and maintained as it can cause shading and hotspots where they are in contact with the panels, reducing performance.

More recently, developers are using single axis tracker (SAT) systems and bifacial panels, either together or separately, which can increase electricity generation by around 10%. SATs are oriented north-south, set one panel deep per row, and move to track the sun from east to west during the day. They get more consistent and even light during the day, so a more consistent sward can develop.

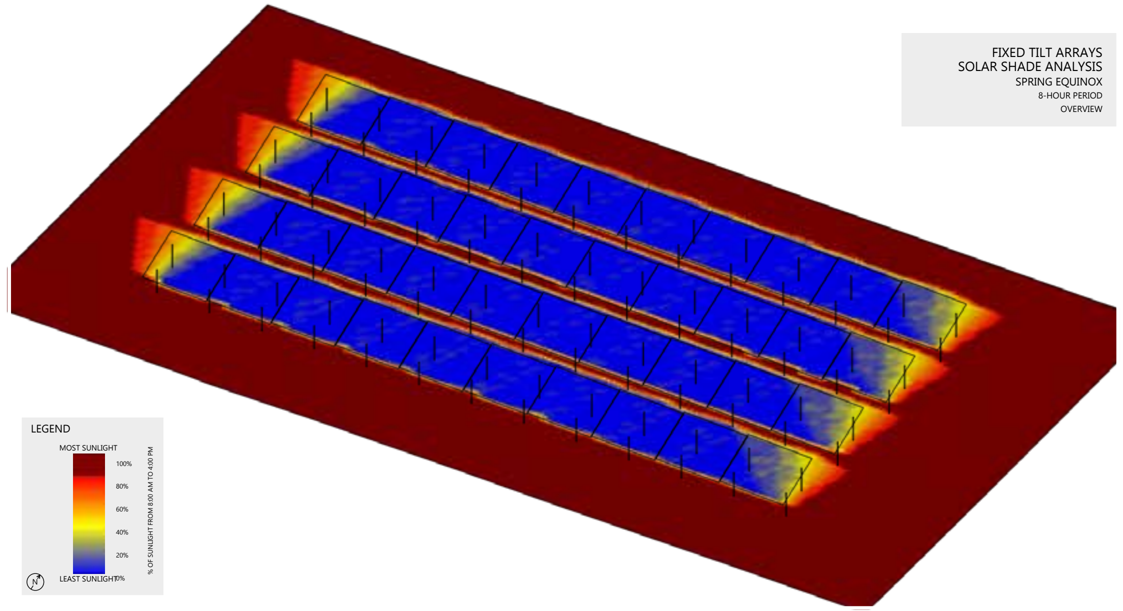
Bifacial panels have no backing sheet and therefore pick up light reflected from the ground, and tend to be set higher than fixed tilt panels to increase the diffuse light which also helps with vegetation growth.

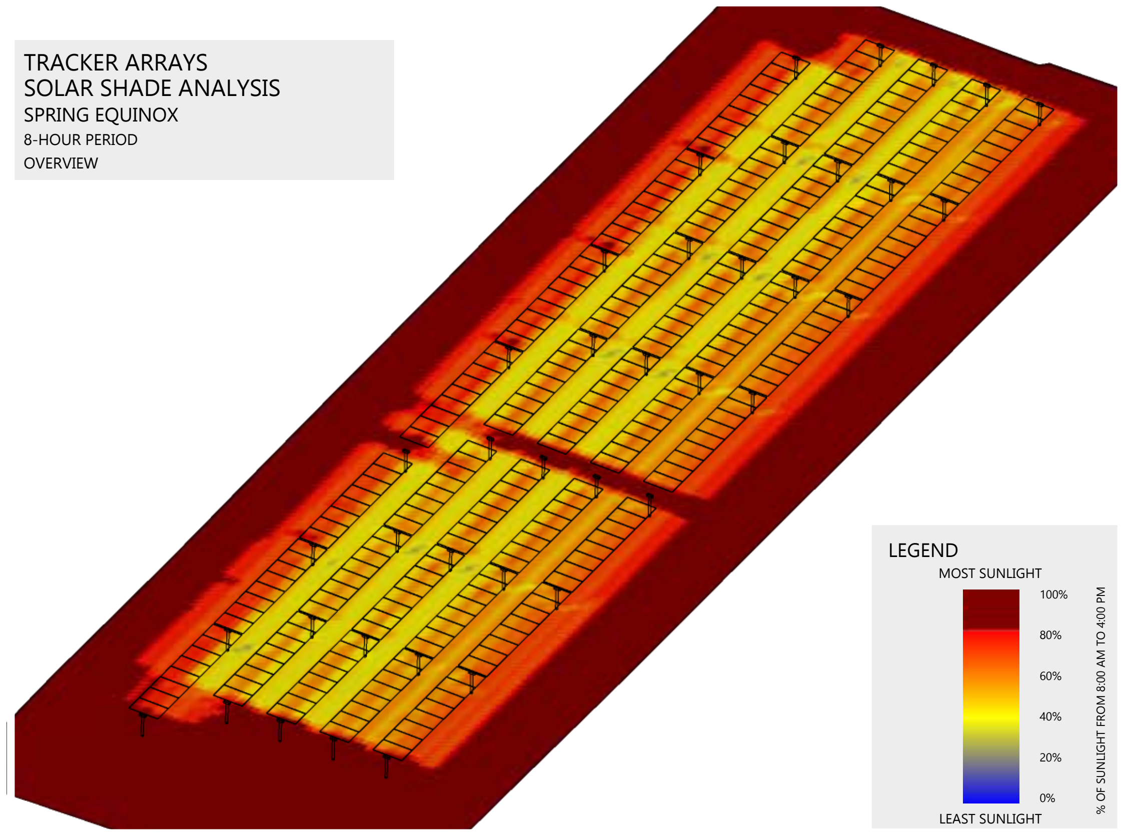
Lancaster University is investigating the potential for planting a dense wildflower sward with light-coloured blooms under the panels, which would increase this albedo affect and therefore increase electricity production. [10 11]

Comparison of shading on fixed tilt vs tracker panels

The images show the amount of sunlight that reaches the ground beneath and around solar panels during the course of the spring equinox.

Single axis trackers allow much more light to reach the ground (shown by the red/orange/yellow colours) than fixed tilt panels, where some areas remain in permanent shade (shown by the blue).





Planning

Although planning applications for large sites (such as Nationally Significant Infrastructure Projects) and smaller solar farms (under 50MW) will go through different planning processes, the approach to natural capital set out below will be appropriate in most situations. Natural capital impacts are becoming an increasingly important consideration in the planning process.

The National Planning Policy Framework states that all communities have a responsibility to help increase the use and supply of green energy, but this does not override environmental protections and the planning concerns of local communities. [13] It is important that these are addressed and where necessary the mitigation hierarchy applied.

Pre-application

The first contact with the LPA will typically be a request for pre-application advice, which can sometimes steer the scope for ecological surveys, or an Environmental Impact Assessment (EIA) screening, to determine if the planning application is likely to have significant environmental impacts and so falls under the remit of the Town and Country Planning Regulations 2017.

Where impacts on protected species or habitats are considered likely, full EIA and Habitat Regulations Assessments may be required to support a solar application, either due to size (NSIP for over 50MW), location in relation to designated sites or through potential direct impacts on protected species or habitats. A solar farm which affects peatland habitat may require additional Impact Assessments which will be determined from a screening opinion, with a scoping exercise to identify key features which must be assessed.

Consultation

Stakeholder engagement is best carried out at an early stage, particularly as it may take a while to receive a response. This may be through a formal paid-for discretionary planning advice service offered by statutory consultees such as Natural England, Natural Resources Wales, or Nature Scot. This may be required if there could be impacts on sites with statutory designations (either directly or if the site lies within a Natural England Impact Risk Zone) or impacts on European Protected Species. [c]

Non-statutory consultees are also a key part of the pre-application process. Examples of organisations which may have useful local knowledge are bodies such as the Local Wildlife Trust and local recording groups such as bird, bat, reptile/amphibian and mammal groups.

Early involvement and input from community groups can be helpful for understanding local priorities and provides an opportunity to support local conservation aims, from tree planting to flooding alleviation or planting locally scarce species.

Community consultation is also vital and should be conducted at an early stage to ensure that there is an opportunity for voices to be heard. Tapping into local knowledge allows potential concerns and constraints to be identified at an early stage and addressed, such as through additional screening planting to avoid negatively impacting visual amenity. The consultation process is also an opportunity to showcase and obtain feedback on the natural capital enhancements proposed for the site. It also allows developers to dispel common misconceptions about solar farms, such as felling trees, removing grassland and flood risk.

Other community considerations may include a community benefit fund, educational initiatives and new footpaths and bridleways. A positive community engagement strategy can also help to

Boxted Airfield solar farm

Boxted Airfield solar farm was built in 2015 on 20ha of former RAF land in Essex. The 18.8 MW project is owned by NextEnergy who are working with Wychwood Biodiversity to achieve a significant gain in biodiversity by creating native wildlife habitats.

After surveying to establish the baseline for wildlife, a Biodiversity Management Plan was agreed with NextEnergy and the landowner. Five areas were seeded with clay tolerant wildflowers such as corn cockle, cornflower, marigold, red clover, bird's foot trefoil and yellow rattle. Two large bug hotels were built from old pallets, building rubble and natural materials.

A light touch management approach has been adopted. Wildflowers are left and encouraged to set seed before an annual cut. A local flock of sheep grazes the land during autumn and winter, keeping the weeds down whilst maintaining agricultural production.

Wychwood Biodiversity carries out two survey visits a year to monitor the site and ensure that biodiverse habitats continue to flourish. The results show a rapid increase in the diversity of botany, bumblebees and butterflies, as well as breeding birds. Many positive comments have been received from the local community, especially users of the neighbouring footpath.

The graph shows bumblebee and butterfly abundance on the site increasing over time.

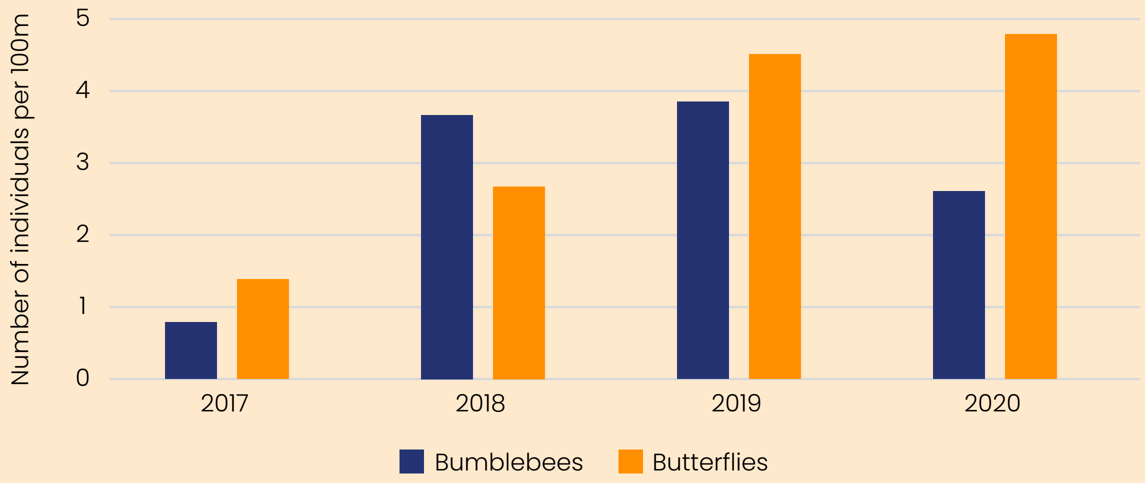


Photo credit: Wychwood Biodiversity

deliver greater local support for the project and/or minimise objections. While it is good practice on all solar farm projects, NSIP developments are required to demonstrate community involvement throughout the process.

Further surveys and reports

While a range of surveys will have been carried out during the site selection and design phase, more may be required during the consultation phase, depending on the results of the various consultations and preliminary surveys. Sufficient time should be allowed as surveys can be seasonally dependent.

It is important to distinguish between surveys required for the planning application and baseline surveys which will inform future site monitoring. The latter can be overlooked, particularly where the developer is expecting to sell the project on after planning consent. Extending planning surveys to include baseline survey visits can save significant costs and travel related emissions.

Other reports should be shared among consultants to ensure they are aligned and their natural capital impacts are understood. For example:

Arboricultural Survey: Setting out tree buffers and other tree protection measures typically included in an Arboricultural Method Statement.

Flood Risk Assessment: Mitigation may be proposed such as swales/SUDS which could be enhanced to create wetland habitat or integrated into wider natural capital initiatives such as Natural Flood Management.

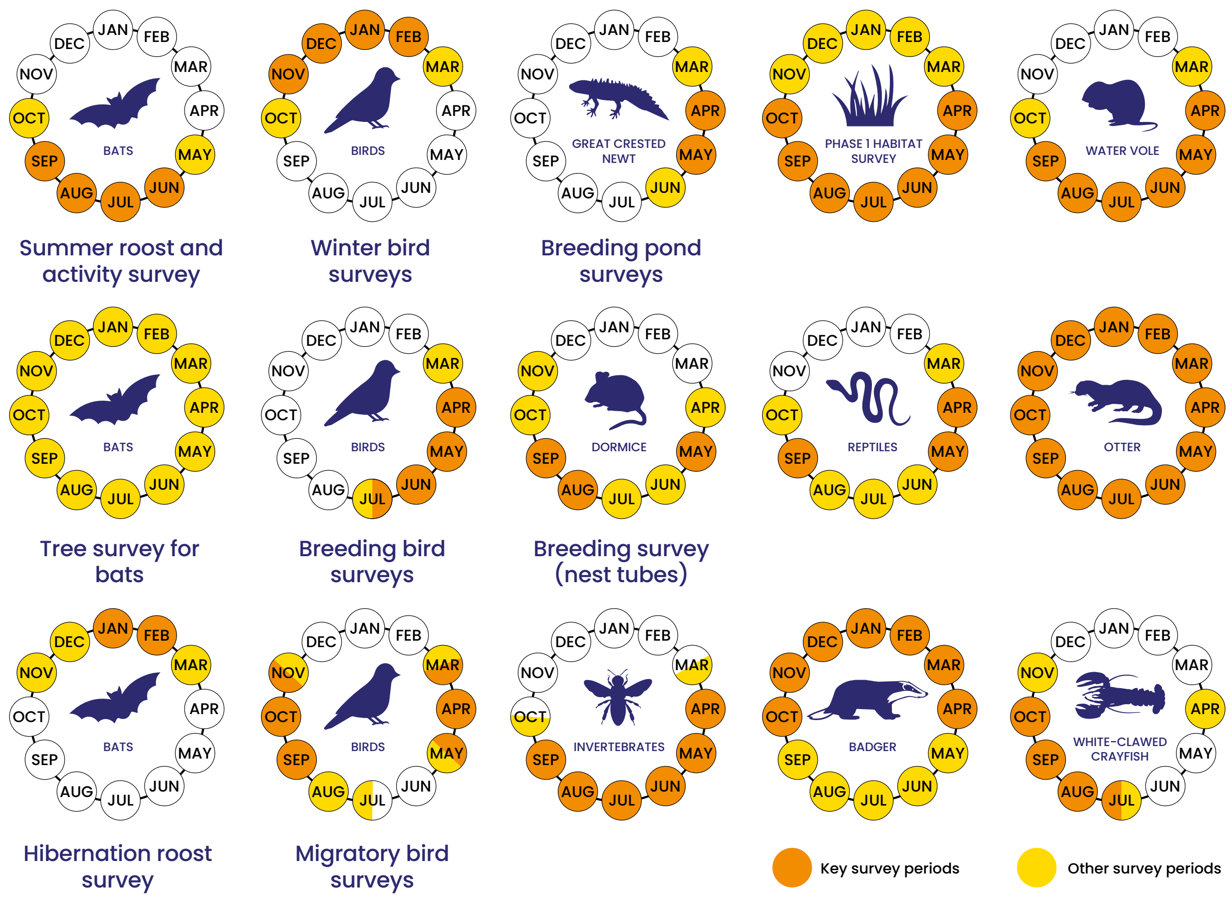
Soil Survey: Field Survey data from the Agricultural Land Classification (ALC) assessment provides data on the physical characteristics of the soil needed to inform soil management planning. These characteristics include soil depth, texture and stone content.

Peat Survey: Information on peat depth and condition needed for some sites. Should infrastructure be located on areas of peat, a Peat Management Plan and Peat Landslide Hazard Risk Assessment would be included.

Archaeological Survey: Trial trenching to check for archaeological remains can have an impact on botany or protected species as well as affecting the soil structure or drainage.

Landscape and Visual Impact: Screening will often include planting new hedgerows/ woodland or management of existing habitat.

Ecology Survey Calender



This calendar provides guidance on survey periods for species commonly encountered on development projects. Since survey requirements can vary, professional advice is recommended. Survey work should be carried out by suitably experienced, qualified and, where necessary, licensed individuals.

Landscape and Ecological Management Plans (LEMPs)

Key considerations

Local and national conservation priorities: These will be set out in the Local Biodiversity Action Plan or other local strategies such as local pollinator plans. National strategies which may be relevant include Buglife's B-Lines, RSPB targeted areas for specific bird species and conservation priority species set out in the National Environment Research Council, Environment Act (2021), Environment (Wales) Act, Scottish Biodiversity List.

Local species and habitats: Enhancements should target local native species. For example, new hedgerows should reflect species typically found in the local area or identified during baseline surveys and be locally sourced.

Clear management prescriptions: Management prescriptions should be set out clearly with a timetable. Enhancements should deliver biodiversity value, be practical and costed. They should be discussed with all parties, including the landowner, to ensure that everyone is committed. Establishment and management maps and a planting plan should also be included as they provide an easy to follow visual guide, which should be displayed in the site office alongside the construction layout

Roles and responsibilities: The plan should clearly set out who is responsible for implementing different aspects of the LEMP and when. Contracts can be secured early on to ensure the actions under the LEMP are passed on with any subsequent change of ownership.

Costs and commitments: Implementation, management and monitoring costs should be calculated at an early stage so they can be built into the financial model (see Finance chapter). All parties involved (i.e. the landowner, contractors, ecologists and asset owners) should agree to roles, responsibilities and objectives; an early meeting of the full team can be very beneficial. This should happen before financial close for any projects that are sold to provide continuity.

Management prescriptions

The prescriptions within the LEMP will be site specific, but may include some of the following:

- Species rich grassland or wildflower meadow creation (location, ground preparation measures, seed mix used and subsequent management). A UK provenance native seed mix should also be used. Seeding should take into account soil type and nutrient levels to ensure success and maybe best done over a period of years. The seed mix should also be designed so that the height of the grasses and wildflowers does not cause shading. If this is kept below 70 cm – the lower leading edge height of the panels - it should not cause shading

- Grassland enhancement (oversowing of bare areas created during construction, location, and management)

- Arable plant or weed area (annual ploughing regime, location, remediation measures if required)

- Tree/hedgerow/orchard planting (species, size, provenance, location, numbers, planting methodology and aftercare). Specimens from the local Region of Provenance (ROP) should be used where possible

- Habitat boxes such as bat, bird, hedgehog or dormouse boxes (model, number, placement such as height and orientation)

- Hibernacula and log piles (size, shape, placement and materials)

- Pond creation (number, location, size, shape, spoil use and future management)

- How to address injurious weeds including use of herbicides/ mechanical treatment

- Monitoring methodology setting out which surveys will be completed and in which years

Management prescriptions should be based on clear targets, and it may be more helpful to be less prescriptive and instead more target-driven. For example, if a target grass height is prescribed, stocking density of sheep grazing may be adjusted until that height is achieved. This can be more useful than specifying numbers of livestock as different grasslands or sheep can interact in different ways.

Although management prescriptions should be precise, there can be scope for flexibility. Tweaks may be needed in response to issues such as spread of injurious weeds, plant failures, discovery of notable species etc. The LEMP may also incorporate a complete review at various points. For some sites (such as extremely large sites or those situated in sensitive areas), a steering group may be set up with the LPA and other stakeholders where regular reviews of the LEMP are undertaken and any required changes discussed.

Photo credit: Sarah Cheesbrough

Submission

The key reports demonstrating natural capital benefits are:

Biodiversity Net Gain Calculation: The 2021 Environment Act requires all new developments to have a minimum of 10% BNG and some Local Authorities already require it. At present this is not mandatory in Wales or Scotland. See more information on page 17.

Landscape and Ecological Management Plan (LEMP): Sets out how enhancements will be achieved and managed over the lifetime of the solar farm. The LEMP should include plans for monitoring, with reports submitted to the LPA. It is a legally binding document for the lifetime of the project and should be submitted at the planning stage so the LPA can secure the proposed enhancements to ensure BNG will be achieved. All parties involved in the project should be made aware of the obligations within the LEMP and sign to show understanding.

A Compensation Habitat Plan: If compensation land is required this will include details of habitat establishment, management and monitoring for the life of the project.

Additional supporting information could include:

Construction Environmental Management Plan (CEMP): Shows how impacts will be mitigated during construction, particularly at more sensitive sites. It may include the provision of buffers, protective fencing, a toolbox talk, pre-construction surveys for protected species such as badgers, measures to protect soil and watercourses, and remedial measures post construction such as seeding damaged areas.

A Construction Traffic Management Plan with SMART (Specific Measurable Attainable Relevant Timed) features to reduce traffic movements and subsequent air pollution or soil impacts.

Evaluation of Ecosystem Resilience: In Wales the Environment (Wales) Act 2016 requires the strengthening of habitats so that they can withstand an increase in the amount of disturbance.

Wild Power's Biodiversity Scorecard: A free to use scorecard specific to solar farms offering a broader way to assess natural capital gains (including hibernacula/habitat boxes, planting geared to linking fragmented habitats, targeting of key species and active management of ecosystem services). The scorecard can track progress on a site and allow comparisons across projects. Wild Power is creating a new certification scheme based on the scorecard. [9]

Solar Parks Impacts on Ecosystem Services (SPIES) Tool: An evidence-based decision-tool which draws on over 700 pieces of evidence from over 450 peer reviewed scientific papers to assess the effects of different management strategies on ecosystem services. [10]

Planning conditions relevant to natural capital are likely to refer to the CEMP, LEMP, Traffic Management Plans and lighting schemes. Planning conditions may also require documents such as lighting schemes, decommissioning plans and soil management plans.

Skylark mitigation

Skylarks are a ground-nesting bird species often found on farmland which is considered suitable for solar farms. As skylarks evolved within steppe grasslands, in the UK they are usually found in relatively open landscapes, free of tall structures such as trees or tall hedgerows. They need long, unbroken sight lines in order to avoid predators during nesting.

Skylarks will usually choose to nest in vegetation 10-60cm tall and at least 50-100m from the nearest woodland or hedgerows. The presence of solar arrays therefore is not conducive for skylark nests and so their presence on a solar farm site and potential impacts on their habitats need to be considered early in the planning process.

Mitigation can be provided by creating alternative nesting habitats nearby, which can even be more suitable for the birds.

This may be on traditionally farmed arable land, with spring-sown cereal crops which include small patches of undrilled land, or on organic setaside or fallow land.

For more information, visit: Skylark plots (rspb.org.uk)

While skylarks have not been observed nesting in solar farms, they are often seen foraging within the arrays, and a well-managed grassland habitat on-site can support successful nesting territories on adjacent farmland.

On-site mitigation is likely only to be effective where there is enough space, perhaps in areas which are excluded for other reasons such as heritage/archaeology, visual impact or flood risk. Alternatively, off-setting or financial contributions to conservation schemes may be available either via the LPA or a third party.

Photo credit: RSPB

Great crested newts

Great crested newts (GCN) are a European Protected Species therefore legally protected and should be considered early in the design stage of a solar farm.

Surveys need to be carried out to establish the presence of GCN, or likely absence as a minimum, within the proposed site and including a 250m buffer, so that avoidance or mitigation can be considered. The quickest and most cost-effective survey technique is eDNA sampling of the water, which must be done seasonally.

Where GCN are present, a range of avoidance and mitigation options are available. Appropriate buffers from ponds and suitable terrestrial habitat features can be incorporated into the site design, with advice from an experienced ecologist.

Other avoidance techniques could include restricting construction to the hibernation season as long as no suitable hibernation features are present within the construction area; however, this is unlikely to be appropriate given the preference for building in summer when other impacts can be avoided.

If avoidance is not possible, a mitigation licence may be required. The type of licence depends on strict criteria such as proximity to breeding ponds and timing. Low impact licences are quicker and easier to obtain than full mitigation licences as they can be issued by a Registered Consultant ecologist. In England a District Level licence is available in most areas from NatureSpace or Natural England. This involves payment into a scheme to build ponds (and habitats) within the local area, proportionate to the number of ponds within or near the site.

In many cases, both Natural England and NatureSpace may provide a discount for solar farm developments due to the temporary nature of the impacts on great crested newts.

A full European Protected Species mitigation licence can be obtained from Natural Resources Wales, NatureScot or Natural England; however this is both time consuming and expensive as it involves trapping and relocating GCN.

Construction

The main documents to consider at this stage of development are the LEMP and CEMP, both of which are completed during the planning phase, and which may be subject to planning conditions (see supplementary documents).

Timing

The timing of construction is key to minimising impact. Building a solar farm during the winter months (November – April) is usually wetter with much more challenging ground conditions. Heavy construction traffic and mud are not a good combination and can cause damage to soil that is costly to remedy, with an increased risk of loss of vegetation and sediment being washed into water courses.

A summer build is usually preferable. Not only is it better for the land, but it is usually quicker (therefore cheaper to construct) and has better working conditions for the workforce.

Photo credit Eden Renewables

Pre-construction

A register of commitments is normally drawn up to include all planning conditions. It is advisable to extend this to include any corporate commitments and good practice voluntary commitments, describing the activity, time frame and people responsible.

Before construction, planning conditions will need to be discharged within specified timeframes. Those relating to natural capital may include:

- Pre-construction surveys for protected species and habitats, e.g. badgers and their setts, reptiles or nesting birds, by a suitably qualified ecologist. The results must be incorporated into the construction plan. It may be that areas containing protected features, e.g. nesting birds, must be avoided until breeding activity has been completed. In other cases, a licence may be needed.
- Controlling invasive species and common pernicious weeds. In the case of Japanese knotweed or Himalayan balsam, a specialist contractor is likely to be involved. Measures may also be specified to limit the introduction of invasive species on site, through ensuring plant equipment and light vehicles are clean and soil and seed-free and all tools and boots arrive on site in an 'as new' state. Injurious weeds may provide some biodiversity benefits however under The Weeds Act 1959 they must be contained to the solar farm and prevented from spreading to neighbouring fields.

- Installation of fencing or signage to clearly delineate root protection areas and no-go areas for construction. Site security fencing can act as protective fencing and if installed before construction can negate the need for temporary fencing.

- The land surface should be covered in vegetation to bind the soil together and provide a stable surface for construction, resulting in less loose mud and damage to the soil structure. In some sites, existing vegetation can be used, e.g. crop stubble or pasture. Alternatively, suitable grasses can be sown across the site in the year before construction to ensure a good vegetative layer has established. Timing is a key consideration as the pre-seed needs to fit around planning, harvest and construction cycles and prepare the site for building in summer, which is preferred.

- Fine grass seed takes 12 months to set properly. Therefore, seeding in September, straight after harvest, won't allow for construction to start until September the following year

- Wildflower seed with non-vigorous grasses requires a full growing season until they will be established enough to drive on with construction machinery

- A low diversity non-native ryegrass mix may establish in a couple of months but will have fewer ecological benefits

- An open field is easier and therefore cheaper to sow. However if the site is wet during construction a large proportion of the seed may be lost and it is more likely to need remedial work

During construction

The CEMP will be the key document. Measures to minimise construction impacts may include:

- Appointment of an ecological clerk of works (ECoW) to provide training and toolbox talks, oversee any activities that could potentially impact biodiversity and check on fencing and buffer areas

- Reasonable Avoidance Measures (RAMs) such as covering excavations overnight and ensuring all hazardous materials are correctly stored according to Control of Substances Hazardous to health (COSSH) legislation

- Use of low-pressure construction vehicles with turf tyres or rubber tracks to minimise soil compaction and rutting

- Construction of good quality access roads of minimum width and with suitable drainage and sediment controls. This may include non-permeable membrane to prevent weed damage or laying tracks and roadways that work with the land such as timber mats or road mats which allow vegetation to grow through and minimise the initial impact of laying a solid roadway

- General checks by the site manager to assess fencing, litter and proper storage of materials

- Environmental monitoring surveys on water and soil to ensure they are being managed appropriately during the construction period. Water monitoring usually focuses upon sediment control, while soil monitoring will check soil consistency following rainfall, to ensure it has not dried below the plastic limit. In severe instances activity may need to be suspended on certain areas of the site. Water pooling may take place on areas where soil is compacted. However, this tends to be localised to small areas and should be resolved through the CEMP through de-compaction after construction, with cultivation and reseeding, if required

- Water quality monitoring of adjacent waterways may also be required. Localised flooding can occur if field drains are damaged during piling or trenching, which sometimes requires more significant intervention and correction

- Soil excavations should be covered to prevent animal entrapment and filled in as soon as possible. Where trenching for cables, soil and subsoil should be split and replaced in original order. Any topsoil removed should be conserved for eventual use in site decommissioning

- Smart traffic controls are being implemented at some sites to optimise movements of vehicles and increase efficiency. This will limit the impact on surface vegetation and soils; additional benefits include reducing carbon emissions and operating costs

Post-construction

Areas impacted by construction can be restored in the next suitable season following the completion of the build. While restoration may be covered by planning conditions, the following best practice approach should be applied:

- Areas of bare or disturbed soil (except for those specified for ecological reasons) should be planted or sown with suitable vegetation as soon as possible, in accordance with the LEMP, to minimise the risk of injurious weed infestations, such as dock and thistle

- Where soil compaction has occurred, this should be decompacted by subsoiling. This involves the use of a tractor-pulled tillage tool with angled wings used to lift and shatter the hardpan that builds up. The design provides deep tillage, loosening soil deeper (up to 60cm) than a tiller or plough is capable of reaching

- Where areas of hedgerow require removal for cable routes or visibility splays, these should be replanted with whips the following winter

- Other new planting as set out in the LEMP will be carried out including new hedgerows and trees, sowing grasslands and wildflowers

- Other ecological measures such as excavating ponds, installing bird boxes and creating hibernacula should be implemented.

Photo credit: Eden Renewables

Operations

Just as an operational solar farm requires regular maintenance to ensure that it is generating electricity with maximum efficiency, so must the natural capital elements of the project be properly managed to ensure they are delivering the maximum biodiversity benefits.

The LEMP must be adhered to or the LPA can take enforcement action against the site owner which could include fines.

Good preventative and proactive maintenance in the early years of operation reap significantly larger benefits than a substandard approach. A site where management has been carefully considered in the first few years and follows a well written management plan with regular monitoring has the potential to deliver far greater natural capital benefits.

Although the LEMP will set out specifics in terms of management, some considerations during the operational stage of a solar array are set out below.

Grassland management

Grassland habitat covers the largest area on a solar farm and is where the majority of management – and costs - will be concentrated. Where sites have been seeded, regular cutting during the first year of growth will remove unwanted annual speices and help reduce the spread of injurious weeds.

However, in order to maximise diversity, the site should not be cut between approximately April and July allowing plants to flower and set seed, and providing longer foraging times for pollinators. On older sites where panel height and species mix weren't taken into consideration, this may cause operational issues with tall vegetation shading the panels. To tackle this, "shading cuts" can be implemented using walk behind mowers or compact tractors to cut "production strips". As the economics for biodiversity improve, O&M companies need to ensure their engineers are adequately trained to work on sites with longer grassland in summer.

A fire protection plan may be required particularly during drier years which may include cutting fire strips or taking an early hay cut in very dry conditions.

Where possible the arisings (usually grass clippings) can be collected and removed from site. This reduces nutrients leaching back into the soil (promoting floral diversity) and prevents thatch building up which can suppress growth. However, collection of arisings is time consuming and expensive and historically, sites have not been designed to allow easy access for machinery capable of doing this. There is also often no use for the arisings once collected as a cut late in the year does not produce good quality silage or hay. In future, it may be possible to link up solar farms with local composting sites such as open-air windrow, or anaerobic digesters.

Sheep grazing

As with grass cutting, sheep grazing should not take place during the late spring/ summer to allow plants to set seed. There are a couple of different approaches to consider:

- Conservation grazing is a regime where livestock are removed between April and July or where the grassland is grazed at a low intensity to leave a varied and tall sward with flowering plants present
- Mob grazing involves a high stocking density in a restricted area on a very small proportion of the site over a very short time to graze the grass right down, with the sheep moved to a new area on a rotation between 0.5 to 2 days. Again, with this approach, sheep are removed from April to July. This requires much more intensive management with additional temporary fencing
- In an ideal situation, where sheep are removed from April to July, a haycut should be taken before sheep are reintroduced. This will be particularly important for specific sites where the vegetation may be too coarse for the sheep to tackle by July

Local sheep farmers are often happy to take out a grazing licence with a solar farm operator; however insurance costs can be prohibitive for some farmers. There are also new businesses starting to emerge specialising in matching solar farms with flocks of sheep and taking on the administration too.

Hedgerow management

New hedges should be carefully managed in the first 3-5 years of their development. Weeds must be controlled through a permeable membrane or a thick layer (10cm) of mulch, and any diseased or damaged whips replaced. Weed management is usually less important once the hedge has established, as the hedge shades out any competitive vegetation.

New hedges should not be cut in the same way as mature hedges. Side branches should be cut by half in the spring after the first growing season and then cut lightly in year 3.

Stakes and guards should be removed once the whips have become established (generally after 3-5 years, earlier if growth is becoming spindly, dependent on the risk of browsing damage), if the guards are not biodegradable.

Once hedgerows are mature, they should be cut every 2-3 years using a tractor-mounted flail. The hedge should be cut on one side only in any one year, leaving the other side uncut to ensure flowers and fruits are preserved.

Hedgerows must not be cut in the bird breeding season, i.e. between 1st March and 30th August. Ideally, hedges should be cut late in the Winter, i.e. January, after fruits have been eaten by wintering birds and mammals and before the bird nesting season.

Care must be taken to avoid cutting hedgerow trees and allow them to grow into full size trees. Usually this means clearly marking such trees and pointing them out to the flail operator.

Control of injurious weeds

If injurious weeds are a problem, they may be controlled by changes in management such as additional cuts at certain times of the year to dampen growth, depending on the species. Chemical controls should be minimised, with no reason to use pesticides and only spot-spraying individual targets with herbicides in the early years.

When an expensive seed mix has been sown, spot spraying in a specific window can prevent killing desirable broadleaved plants and grasses, and should aim for complete eradication. Sensitive habitats (such as rivers or wetland) and species which may be present must be considered. Amphibians in particular are particularly susceptible to herbicides.

There are alternatives to glyphosate, such as manual pulling, heat retentive biodegradable foam and organic herbicides, although some may be costly or not effective over large areas.

Panel cleaning

Most panels require annual cleaning. No chemicals are needed, with de-ionized water used to prevent accumulations of lichens which would make them less productive.

Monitoring

Monitoring biodiversity is essential to assess progress towards targets, and identify any problems early on so they can be rectified. It also provides valuable quantitative evidence to guide emerging policies and support ongoing research.

The following key principles should be applied:

- Use standardised methods (see below) appropriate for site conditions and planning obligations
- Ensure surveys are being conducted at the optimal time of year, at the same time each year and in suitable weather conditions
- Use the same recorder and equipment wherever possible
- Pass on monitoring results to the LPA and Local Record Centre or national database

Habitat establishment

Responsibility for monitoring habitat establishment for the first two to three years of operation lies with the EPC and O&M company, with compliance checks by the asset owner's technical adviser. For best practice the asset owner should ensure that the lead ecologist who did the baseline surveys also implements their recommended monitoring programme.

The first few years are when problems are more likely to occur. For example, new hedge plants are vulnerable to browsing by deer or livestock, drought or swamping by weeds, and newly sown grassland habitats are at risk from weed infestations.

Regular monitoring ensures these problems can be rapidly diagnosed and remedied. Typically, new habitats are assessed through a walkover survey whereby a competent ecologist walks the entire site and checks that the habitat is healthy and establishing as intended.

Compliance surveys

Wider monitoring may be specified in the LEMP forming part of planning consent, for example hedgerows managed in a certain way to fulfil screening or biodiversity goals. Monitoring may be required to check the height or cutting frequency of existing hedgerows, or that any tree works have been undertaken correctly.

When new BNG rules come in as set out previously, there will be a legal imperative to monitor and record establishing habitats to ensure compliance.

Operational monitoring

After year 3, establishment compliance checks may become less frequent, checking environmental progress over the lifetime of the solar farm and highlighting any necessary changes in management to meet the desired outcomes of the management plan. For example, ensuring habitats are maturing and tracking biodiversity gain.

Best practice sites should include annual monitoring for the first five years, moving to every two years until year 10 and every five years thereafter. Data collected can show the habitat is performing optimally, helping with positive communications, informing wider understanding of how solar farms affect natural capital and contributing to research. This level of monitoring may also be required to demonstrate BNG or for an accreditation system such as Wild Power.

Methodology will vary depending on a site's baseline data, location, planning obligations and the asset owner's ESG requirements. A standardised approach to monitoring should be agreed at the outset. Standardised approaches for monitoring aspects of solar farms have been developed, and the table below sets out a new standardised approach which covers key components as well as additional aspects which may be included depending on planning obligations/budget/ESG goals.

Contribution to management, science, and research

As best practice, monitoring data should be passed on to the Local Record Centre to help build up a picture of the local area. Other data holding organisations may include iNaturalist or specialist groups such as the local bat/mammal/amphibian group or the British Trust for Ornithology Bird Track Application.

Biodiversity data from solar farms helps us understand how these developments impact natural capital, assess ecological impacts and guide appropriate management. Research already underway in the UK includes the impacts of solar PV on pollinators, birds and bats; carbon sequestration and soil health on solar farms; impacts on drainage and flooding; standardised methodology to measure the ecology on a solar farm; technical research into methodologies to measure ecosystem services; and developing a virtual lab for collation and analysis of this data.

Solar farms offer ideal opportunities to bridge the gap between academia and industry either informally, or through a more formal Knowledge Transfer Partnership. There are also opportunities for local schools and other community members to get directly involved.

Photo credit: Earth Energy Education

Measuring natural capital on solar farms

Component	Description	Time on Site/*Frequency*	Further considerations
Site information	The asset owner or O&M company should record current and past management; seeding or planting completed; planned future changes in management. Technical information including location, size, date of grid connection, PV technology, height of panels and distance between panels	Time required: high ***Every visit***	Creating and enhancing ecological habitats
Standard survey data	• Name of surveyor • Date • Weather (temp, wind - Beaufort scale, rain, cloud – Okta scale) • Time at start/end of survey (i.e. time spent on site)	Minimal time required ***Every visit***	Some of this information can be recorded as part of a desk study
Site management	The following site management categories can provide a standard summary comparable between sites: 1 - Optimal management for wildlife with conservation cutting/grazing applied and no herbicide use. Arisings removed from the site. Diversity of habitats (e.g. meadows, tussocky grassland, woodland planting, hedgerow planting) 2 - Conservation cutting/grazing applied. Arisings may be left on the site with signs of a thatch of vegetation in places. Diversity of habitats (e.g. meadows, tussocky grassland, woodland planting, hedgerow planting). Herbicides may be used, but spot treatment only 3 - Site cut or grazed throughout the season leading to short sward in summer. However, some other habitats present such as tussocky margins or planted hedgerows/woodland. Use of herbicides apparent (i.e. blanket spraying beneath panels) 4 - Site cut or grazed throughout the season leading to short sward in summer. No other habitats (tussocky margins, new hedgerows/woodland). Use of herbicides apparent (i.e. blanket spraying of fields or beneath panels)	Minimal time required ***Every visit***	More detailed information on management may be available. However, at several sites, management may need to be ascertained from the survey (i.e. evidence of grazing, height of vegetation, evidence of spraying, etc.)
Standard botanical quadrats	2x2m quadrats placed at fixed locations: • 5 quadrats recorded directly beneath panels • 5 quadrats recorded in the open, between the strings of panels • 5 quadrats recorded in "enhanced" area – selected as the most diverse habitat within the redline/lease boundary. Habitat category recorded: field margin (within security fencing); field margin (outside security fencing); easement area; ground nesting bird area; other (please specify). • 5 quadrats recorded within a control site – a field within the same landowner's holding, which is managed in the same way the land within the array was prior to construction • Record percentage cover of all species within the quadrat, height of sward in cm and percentage cover of bare ground, dead thatch and standing water (where applicable)	Time required: approx. 3-5 hrs ***Every visit*** ***April to August***	Where a site is very large, or distinct habitats are present, more quadrats may be required. There may not be enhanced areas on each site and it may not be possible to access control areas given land ownership. Moreover, 20 quadrats may not be possible in one day and thus undertaking both "enhanced" and "control" may not be feasible
UKHab survey	Mapping of all habitats within the redline boundary using the UKHab categories. These can then be used to calculate Biodiversity Net Gain if required [11]	Time required: dependent on size of site ***Every 5 years*** ***April to October***	Where habitat is distinct beneath panels, a calculation may be made from the number of panels on the site (see the Site Layout Plan)
Nectar production potential	Use the botanical quadrats to infer nectar production potential using established data [4]	Minimal time required ***Should be repeated with every botanical survey***	
Basic soil survey	Basic soil properties (pH, soil type, soil organic matter, bulk density, soil moisture, infiltration capacity, texture). Soil can be collected on site and sent to a laboratory at minimal cost, following their recommended methodology, or equipment purchased to enable in house analyses. We recommend taking samples from one field within the array within a 4ha area, with samples from a field outside the array managed in the same way as prior to construction, as a control	Time required: 1hr to collect samples ***Should be repeated every 5 years*** ***Any time of year***	A basic measure of soil carbon can also be obtained from the organic matter measurement (approximately 50% of organic matter will be carbon). Soil analyses can also help to inform seeding of a site and indicate why seeding may have failed
Fixed point photographs	A simple way to visually assess change. 5- 10 photos, depending on variability of habitats, taken from the quadrat location and recording the orientation	Minimal time required ***Every visit***	

Pollinator survey - butterfly and bumblebee transects	Butterfly and bumblebee transect surveys involve a surveyor walking a pre-determined 100m transect route through the site and noting all butterflies and bumblebees within an imaginary 5m X 5m quadrat in front of them. 10 transects spread across the site	Time required: approx. 2-3 hrs ***Every 2-5 years*** ***April to September, we recommend standardising to June/July***	The survey does not require specialist ID skills and species can just be counted (i.e. "butterfly species 1"). The survey is weather dependent and needs to be carried out during warm, dry, still weather. 2-3 visits in a single year would give best results. However, can be done in a single visit if conditions are suitable.
Ad-hoc sightings	Observations of species recorded during the time spent on site; this may include sightings of hares and other mammals, birds by song or sight, patches of wildflowers, badger latrines, owl pellets, invertebrates, a tally of butterflies and bumblebees	Minimal time required ***Every visit*** ***April to August***	Although not directly comparable, ad hoc sightings can give a qualitative picture of a site

Additional components site/budget dependent

Component	Description	Time requirements	Further considerations
Wild Power Biodiversity Scorecard	A useful way to categorise sites according to their focus on biodiversity and track overall change on a site or identify areas where positive changes can be made to management or habitat provision	Time required: approx. 3-4 hrs ***Every 3-5 years (or when management changes are made)*** ***Any time of year***	
SPIES Tool Assessment	Assessment of how management practices currently impact ecosystem services using an evidence-based tool. This can also be used to assess any proposed changes to management	Time required: approx. 0.5hr ***Every 3-5 years (or when management changes are made)*** ***Any time of year***	
Biodiversity Net Gain (BNG)	The Natural England Biodiversity Net Gain Metric (currently v3) can be used to compare data for the site pre-construction with the data collected during monitoring to assess changes in habitats and net gain achieved	Time required: approx. 2-4hrs ***Every 3-5 years (or when management changes are made)***	Calculation of BNG during operation may be required for trading credits
Detailed soil analyses	This may include soil carbon, nitrogen, phosphorous, potassium and magnesium. Soil can be collected on site and sent to a laboratory at minimal cost	Time required: 1hr to collect samples ***Every 5 years*** ***Any time of year***	
On and offsite water survey	Monitoring of basic water parameters in water features on site and any features off site that could be impacted by the solar farm. Use a handheld water quality meter to measure parameters including temperature, dissolved oxygen, turbidity and conductivity	Time required: approx. 15 mins per water feature ***Every time on site given variability in measures***	Ensure the meter is calibrated. There is also potential to take samples and send for analyses for other parameters, such as nitrogen and phosphorous
Breeding bird survey	Between 2-6 visits to the site conducted April to June and following the new bird survey guidelines[7]. The number of surveys will depend on the level of detail required	Time required: 2hr per 15-20 ha per survey (although site dependent) ***Every 2-5 years*** ***March to early July, recommended April/May***	From half an hour before sunrise to 11am. Avoid heavy rain or strong wind. Specialist bird ID skills are required to identify birds by sight and sound
Wintering bird survey	Between 2-3 visits to the site conducted November to February to assess how birds utilise the solar farm and its boundaries over winter	Time required: approx. 1hr per 15-20 ha per survey (although site dependant) ***Every 2-5 years*** ***November to February***	Avoid heavy rain or strong wind. Specialist bird ID skills are required to identify birds by sight and sound
Other species-specific surveys	Other surveys may be included within the monitoring where there are known records, habitat is managed with a focus on that species or due to local conservation priorities/ planning obligations. This may include: • Nocturnal/dusk birds • Reptiles • Bats (activity surveys or checks of roosts) • Amphibians (including great crested newt) • Dormice • Harvest mice • Hedgehogs • Badgers • Otter/water voles • Invertebrates • Earthworms • Surveys to assess grazing productivity such as above ground biomass or forage quality (above ground biomass calculation)		

This standardised methodology has been developed by Solar Energy UK, Clarkson & Woods, Wychwood Biodiversity and Lancaster University.

Decommissioning

Unlike many other forms of energy infrastructure, solar farms are temporary and completely reversible developments designed to have a limited life. During decommissioning all equipment above and below ground will be removed and the site fully restored to its former condition. In practice the land will often be restored to a better condition than before having benefited from resting from intensive agriculture and the wide range of ecological enhancements.

The decommissioning process is straightforward and quick, taking six to twelve months, depending on the size of the project. Works should be scheduled so that ground work can be done in the summer and early autumn when conditions are driest.

Decommissioning sequence

1. Solar farm de-energised and panel strings disconnected
2. Panels, inverters and transformers dismantled and removed from site
3. Mounting framework dismantled and removed from site
4. Vertical steel piles (above and below ground) pulled out, causing little or no damage beneath ground
5. Electrical cabling pulled out by tractor where viable; if more than 1m deep usually left in ground
6. Access tracks removed by scraping up, with material removed off site
7. Land graded and / or restored where required e.g. access tracks, where concrete plinths lay, or areas of compaction during decommissioning. The majority of the site should have little need for restoration
8. Land returned to former agricultural use and / or habitat areas being retained made good

Decommissioning process

Decommissioning should adopt a similar process to construction, with the following considerations to mitigate impacts on natural capital:

- Decommissioning plan drawn up well in advance with input from lead ecologist, taking into account the mitigation hierarchy
- Project owners should engage with the LPA to inform them of the decommissioning and seek guidance well in advance
- Seek guidance from an Ecological Clerk of Works (ECoW) on how to manage any ecological or environment issues
- A full ecological survey of the site before removing any infrastructure, with sufficient time allowed as surveys may be seasonally constrained
- A Wildlife Mitigation Strategy which may include measures such as translocation of animals, manipulation of vegetation to disperse animals present or careful timing of works
- Use of low-pressure construction vehicles
- Waste materials should be disposed of sustainably. EPCs should identify and secure waste, recycling, or reuse options before decommissioning

Planning

Many projects in the UK are still in the early stages of their operational life. However, over the next decade, the first generation of solar farms – which were typically granted planning consent for 25 years- will either need to be decommissioned or repowered. To date, LPAs have not been overly prescriptive on a decommissioning strategy, however there is often a planning condition that the land is fully restored to its former use. This also provides important reassurance to communities who often worry that solar farms will go from being agricultural land to brownfield, paving the way for other permanent forms of development, which is not the case. They may also be worried about recycling components and other environmental impacts, which should be addressed.

Whilst the UK has no mandatory requirement to deliver a decommissioning plan for solar farms, decommissioning should be considered early. A reinstatement fund, equal to the cost of decommissiong and reinstatement, in the form of a bond, letter of credit or escrow account, is the market norm in solar farm leases, usually from year 10 to 20. The cost, and therefore funds put aside, is required to be recalculated annually or every 5 years. This provides assurance for LPAs and communities.

An example of a UK decommissioning plan can be found in the supplementary documents.

Repowering

In the early years of the industry UK solar farms were designed to have an operational lifespan of at least 25 years, limited by the subsidy period granted. Since subsidies were removed, 35 to 40 years is typical. This is set by planning condition with an obligation to restore the land at the end of the project's life.

A solar farm built today uses a third less land than the first projects built a decade ago due to advances in panel and inverter efficiency, with these technology improvements likely to continue. So, as a solar farm approaches the end of its useful life, the landowner and asset owner may wish to apply for planning permission to extend it. Repowering it with new equipment would enable the solar farm to generate the same amount of power using much less space. The land which is no longer needed could be returned to agricultural use or left for further natural capital improvements.

If the grid connection can be upgraded (currently limited at most sites) the project could be repowered to generate double or even more energy from the original footprint.

Repowering could also take place at an earlier stage in the project lifecycle, although we are not aware of any projects where this has been done yet.

The same principles for protecting and managing natural capital in construction and decommissioning should be applied to repowering, and planning consent is likely to be required.

Aside from commercial and regulatory considerations, the repowering plan should be reviewed by an ECoW to determine if any ecological alterations will need to be made to accommodate the changes to the site.

Recycling and reusing materials

As the solar industry continues to grow, an ethical and environmentally focused approach to the disposal and recycling of PV panels at the end of their useful life is critical.

In most cases, 99% of a solar panel is recyclable, with a good salvage value, and there are well established industrial processes to do this.

A solar panel is made of a frame (typically aluminium), glass, crystalline silicon solar cells, and copper wiring, all of which can be extracted, separated, and recycled or reused. The remaining one percent is an encapsulant material which bonds the layers of a panel together.

There are organisations around the UK and Europe specialising in solar recycling, such as PV Cycle and the European Recycling Platform. They are working with solar developers to minimise electrical waste and recycle old panels in line with the Waste from Electrical and Electronic Equipment (WEEE) regulations.

Panels under 20 years old have a good second-life value, and where appropriate, working panels and inverters should be reused. Companies like SECONDSOL offer a marketplace service for the purchase and selling of second-hand PV panels, inverters, storage and mounting systems. (https://www.secondsol.com/en/index.htm)

Panels that have developed faults (for example cracked glass or delamination issues) can also be refurbished and repowered. (http://www.resolar.co.uk/)

To promote responsible and environmentally conscious disposable of PV panel and inverters, best practice is set out in Solar Power Europe's Lifecycle Quality Best Practice Guidance V.1 (https://www.solarpowereurope.org/lifecycle-quality-best-practice-guidelines-version-1-0/)

Other components of the solar farm infrastructure also have good recyclability and salvage value:

- Inverters and transformers are largely recyclable
- Steel mounting frames are recyclable with high scrap value
- Copper cables are recyclable with high scrap value, aluminium is also recyclable but lower value
- Material used to make access tracks, typically stone, has a reuse value

Finance and legal

Key financial and legal contracting principles should be followed for a well-designed site to be successful throughout the project life. All of the developer's and ecologists' good work through the design and planning stages may come to nothing if the right documents are not completed to ensure future asset owners, EPCs and O&M providers are bound to implement, maintain and monitor the natural capital measures. They can also be of real help to them and reduce the risk of projects failing from not implementing the works correctly or at all. The new BNG requirements make accountability even more critical.

Consistency throughout the development, construction and operation of the solar farm is important to its success. This is equally true for operational, financial and legal documentation and for consultants and contractors.

Exciting new opportunities are also emerging to realise income from the value of natural capital enhancements. Where previously biodiversity-rich projects could cost developers six-figure sums, new markets are being developed that will allow them to receive value for such works.

In the early years of the solar industry, well-designed projects did not fully implement the planned biodiversity works partly due to the stop-start nature of the industry caused by the subsidy regime. A key learning from this is that developers should aim for consistency of consultants and practitioners for as long as possible during the project life, with the lead ecologist involved from the earliest stage of development right through to monitoring.

Project developers should:

- Agree terms and bind parties in early on ensuring consistency through construction and operation, and reducing the workload of the asset owner and EPC before and during construction
- Fully cost the work needed to implement and maintain the natural capital benefits and have the right legal agreements in place; these solar farm projects are more likely to be successful over the long term

Legal documents should:

- Identify and calculate the obligations and real costs of the proposed works in the LEMP to ensure they are viable within the project economics
- Ensure that all future parties are aware of those obligations and costs, and
- Make sure works are legally binding

Where a project sale is proposed, the seller should disclose the documents, while the buyer, asset owner, asset manager & O&M provider should also ensure they have been disclosed. Ensuring these documents are legally bound into the project not only reduces the risk of non-performance in future but can also be helpful for future parties in carrying out the works as most contractors are identified and the works costed.

Contractors

Developers should include good consultants and contractors in the project as early as possible. They should aim to sign Heads of Terms or a full agreement before financial close. They should ensure all parties are reputable and fully costed in the budget so there is no negative impact on a subsequent project sale and economics.

Key documents

Sample documents can be downloaded from SEUK Best Practice guide section of the website.

Key document	Purpose
Landscaping and biodiversity costing schedule Covers implementation, annual maintenance, and ongoing monitoring. • Should be completed by the principal ecologist with input from the landscape adviser at the design proposal stage and kept updated through design iterations to ensure recommendations remain within the project budget and the funder is aware of project liabilities • Should form a permanent project document to be referred to alongside the LEMP and planting plan, through construction and operation • Important to disclose document during due diligence on financial close with a new buyer or debt funder	• Ensures designs are costed and affordable • Assists future asset owner, EPC, O&M provider & land maintenance contractor in knowing what needs to be done • Ideal tool for disclosure in sale of financial liabilities associated with biodiversity commitments
Share purchase agreement • Requires purchaser and future successors to carry out works according to LEMP and biodiversity costing schedule (& other community benefits)	• Increases likelihood of designs being fully implemented by ensuring future owner is aware and has a legal obligation
EPC and O&M agreement • Scope should include all landscaping and biodiversity actions • Where sheep grazing is planned, ensure construction is specified for sheep, otherwise it is much more expensive to fit later	• Increases likelihood of designs being fully implemented by ensuring future owner is aware and has a legal obligation
Optional: Option and lease agreement • Tenant should comply with LEMP & community benefit commitments • Specify annual monitoring programme • Publicise monitoring results (e.g. Biodiversity Scorecard or ecologists' monitoring report) to website and industry register	• Increases likelihood of designs being fully implemented by ensuring future owner is aware and has a legal obligation

Potential revenue

There is now a real opportunity for landscaping and biodiversity works and their related monitoring costs to move from being an expensive cost centre to a potential revenue earner. The objective measurement of BNG units, as well as the financial value that may be applicable to those units (credits), is a huge win for the industry in making clear to policymakers, LPAs and members of the public how valuable well-designed solar farms are to the wider environment and society. The main potential revenue stream from the creation and protection of natural capital on solar farms will be BNG credits. However other sources of income include Wildpower Guarantees of Origin and Nutrient Neutrality.

Biodiversity net gain units

With BNG now enshrined in the Environment Act 2021, a marketplace will be created to allow developers who are unable to achieve their 10% net gain obligation to buy excess units generated by other sites. These 'habitat banks' will need to be registered on the government register in order to sell their units.

Qualified ecologists calculate the biodiversity baseline units and net gain units using the Natural England/DEFRA Biodiversity Net Gain calculator The Biodiversity Metric (version 3 was released in early 2022). The metric assumes a certain failure rate per activity.

The new law will also allow the creation and registration of 'conservation covenants' which will legally bind BNG works and the management plan to the land and will be registered on the local land register. They may be fixed term or permanent. However, before putting one in place legal advice should be sought to ensure the covenant doesn't conflict with the other property legal documentation and is acceptable to funders.

Secondary legislation is expected to be put in place by November 2023 to provide a legal framework for market mechanisms and conservation covenants. Until then it will be up to local authorities to interpret the legislation, which means there is currently a wide range of different treatment between authorities.

Whilst it is not certain from the primary legislation, it appears likely that new solar farms designed for biodiversity enhancements should be able to qualify for and be able to sell their excess biodiversity units. The key concept of 'additionality' needs to apply – i.e. the works would not have happened anyway.

Before they can be created, habitat banks must qualify – including obtaining planning consent - and be added to the national register. Then excess credits can be sold. Units are expected to be traded within the local authority area. However, it will be possible to sell units outside of that at a discount of 25% for neighbouring authorities and 50% for non-neighbouring authorities. Proximity to the development site will be favoured for offsite BNG. LPAs will have the right to increase the national 10% gain rate in their are.

Instead of, say, a housing developer waiting for units to come on the market in their local authority area, they can choose to discharge their liability under the Section106 agreement by making a payment to the authority in lieu of buying biodiversity units. The authority can then buy the same number of units from a future habitat bank in their area (or even outside it) and if this costs them less, they can benefit from the differential.

The buyer pays for a monitoring fee on top of the cost of the units. Sites must be monitored by a 'responsible body' such as the local authority, the RSPB, National Trust and others. Local authorities can choose to carry out the monitoring themselves and retain the monitoring fees, providing them with funds to monitor projects. This provides a further benefit as previously they rarely had the resources to monitor compliance with LEMPs.

If the BNG fails to occur due to the habitat bank owner not carrying out the works in line with the management plan, they can be prosecuted and fined and/or be required to buy replacement units in the market. Some parties are concerned that the value of BNG could drive the purchase and conversion of large areas of farmland leading to higher land prices and therefore food prices. Solar should be a particularly good solution for this concern as it is delivering units from land that is being used for another purpose at the same time ('land sharing not sparing, or multi-functional land use'). This is an important message for the industry to communicate.

Wild Power revenue model

Wild Power (WP) is working on an independent certification standard for biodiversity and natural capital enhancements at renewable energy sites. Wild Power rewards investment in biodiversity at solar farms, providing monetisation opportunities for projects which comply with Wild Power standards.

Initially, energy retailers may create premium Wild Power certified energy packages selling biodiversity-rich power to people wanting to support wildlife with their power purchases. This premium will feed back to WP-certified generators.

Later Wild Guarantees of Origin (WIGO) will be tradable tokens which anyone wanting to support or invest in supporting biodiversity can acquire, similar to a Renewable Energy Guarantee of Origin (REGO). They will be issued to WP-certified generators who will be able to sell them on, with the power purchaser paying a small premium for the biodiversity works.

Potential BNG unit values

The market has not yet begun formally, however some local authorities have implemented voluntary programmes where they are being traded.

An illustrative example of the value is set out below:

A new proposed solar project has a baseline BNG metric of 200 units so is therefore obligated to provide a biodiversity net gain of at least 20 units. The biodiversity metric shows that the project will deliver a net gain of 100 units, therefore a surplus of 80 units.

At a price of £10,000 per unit, this would give a sale value of surplus units of £800,000.

This one-off payment must cover the long-term liability of delivering the net gain units (typically 35-40 years for subsidy free solar farms) including implementation, maintenance, monitoring and reporting, and replacement cost of units if works aren't carried out according to the LEMP.

The cost of delivering the biodiversity enhancements detailed in the metric may be £500k in NPV terms over and above the costs of operating a 'normal' / non-biodiversity enhanced project. Therefore, the project can make a profit on the biodiversity works of £300k instead of what would have been a sunk cost of £500k in the past for the same works.

Through Wild Power certification, solar farm developers can provide evidence of their commitment to biodiversity in their land use, creating value in stakeholder management, fund raising, and compliance.

Nutrient neutrality

Nutrient Neutrality is the principle that developers must remove as much existing nitrogen from the water course as their proposed development will produce. High nitrogen levels can cause algal blooms which use up all the oxygen in the water and create dead zones.

A 2018 European Court of Justice judgement led to Natural England advising local authorities not to grant planning permission for a development unless it could prove that it had a nutrient neutral impact on all Natural sites including UK's Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and RAMSAR sites.

It is thought that the construction of over 30,000 new houses is on hold due to lack of phosphate and nitrate mitigation.

Nutrient mitigation can come from improving wastewater treatment works or through land use change, for example from cereal crops to woodland. However agreements are for a minimum term of 100 years and generally assume an 'in-perpetuity' land use change. It therefore seems unlikely that solar projects could be rolled out in tandem with nutrient neutrality agreements. Nutrient mitigation projects also need to be close to the location of the offending development, which also reduces the likelihood of solar benefiting.

Carbon credits

As the UK makes progress towards Net Zero, carbon is fast becoming a tradeable commodity in particular through the Woodland Carbon Code (WCC) and Peatland Code. The WCC allows landowners or third parties to afforest areas, calculate the carbon that will be sequestered from the project and sell those carbon credits to companies that would like to offset their emissions.

Recent grants have been awarded for the development of new carbon codes. The Natural Environment Investment Readiness Fund (NEIRF) awarded funding for the development of both the Hedgerow Carbon Code (HCC) and the Soil Carbon Code (SCC).

Under the assumption that carbon levels within the soils increase with solar developments, it is theoretically possible for someone to claim the increase in carbon stores and in time generate revenue from the carbon credits. There are issues with the permanence of soil carbon as carbon stored in soil can be swiftly released.

Appendices

Planning

Appendix 1
Ecological enhancements that can be delivered within a solar farm

The table below shows typical post construction habitat provisions on solar farms based on the SPIES tool, including biodiversity net gain value calculated using BNG Metric 3.0, rounded to the nearest whole number, and based on current research of what can be achieved. Please note that "scaling up" does not apply due to the complexities of the calculation, and not all habitat types are suitable for each site. Please also note that the figures within the table have been rounded to the nearest whole number when over 10.

Habitat	Type	Description	Lessons learned	BNG Units achieved	Assumptions and considerations	Natural Capital Benefits based on SPIES	Useful links
Grassland	Wildflower and wild grass seeding	Sow local wildflower seed. Conservation grazing or cutting applied.	Whether limited to where the panels won't be or within the entire field, whether by oversowing existing grassland or sowing an ex arable site; the future management and height of the panels need to be considered when choosing a mix. Other key considerations include drainage, soil type and nutrients. The best time to sow a wildflower meadow is autumn.	334 units gained by creating 50ha of "moderate" other neutral grassland from 50ha of cereal crop	Achieving "moderate" other neutral grassland can be difficult on arable sites, particularly under panels, due to the persistence of weeds. Soil conditions will affect the sward, high nutrient clay sites may take longer to establish into more diverse grassland.		Plantlife-The-Good-meadow-guide-English_WEB.pdf How can I restore or create a meadow? | Magnificent Meadows Convert arable land to permanent grassland - GOV.UK (www.gov.uk)
	Wild bird seed mixes	Sowing mixes such as Farm Seeds Wild Bird Seed	Mixes targeted for local needs should be chosen. Where regular maintenance is necessary (such as annual resowing) this should be budgeted in early and access to enable it ensured.	9 units gained from converting 5 ha of arable crops into arable field margins - game mix or into pollen & nectar	If location is ecologically desirable, for instance due to the species which will forage within the area then an additional 2 units are gained. The seed mix should be chosen to benefit local foraging species.		Wild Bird Cover (Or Wild Bird Seed Mixtures) | Farming Advice - RSPB Wild Bird Seed Mix - Farm Wildlife
	Grazing pasture seeding	Sow diverse grazing mix with year-round grazing applied	Can be difficult to find a grazier if there isn't one already. A good relationship with the farmer is key to ensuring stocking densities can be adjusted as required, the goals and plans should be agreed with the grazier to ensure they are deliverable.	334 units gained by creating 50ha of "moderate" other neutral grassland from 50ha of cereal crop	Where sites are intended for sheep grazing, a more productive seed mix may be selected. However, some mixes are more diverse than a monoculture ryegrass mix (such as traditional grazing mixes).		Wildflower-rich meadows - Farm Wildlife Farming for Wildlife - Grazed pasture (rspb.org.uk) Maintain species-rich grassland - GOV.UK (www.gov.uk)
	Grassland en-hancement	Seed mixes can struggle to compete against establish grassland and scarifying may be required.	Prescribing targets is often more helpful than specifying livestock units, tweaks to the management are often required. Grazing or cutting should be avoided during late spring/ summer to allow plants to set seed.	313 units gained from enhancing "moderate" modified grassland to "moderate" other neutral grassland	Increasing the condition of existing grazing pasture by reducing the management, preventing poaching and allowing plants to flower during the summer is anticipated to take 10 years, however with good management and seeding of any bare areas following construction this can be achieved much faster.		
	Rough grassland	Tussock grassland such as Habitat Aid's Tussock seed mix	Often easy to incorporate between the fence-line and the hedgerows (provided access for management can be maintained and this area isn't generally used for access).	9 units gained from converting 5 ha of arable crops into arable field margins - game mix or into pollen & nectar	If location is ecologically desirable, for instance due to the species which will forage within the area then an additional 2 units are gained. The seed mix should be chosen to benefit local foraging species.		Rough grassland - Farm Wildlife How to manage land for Barn Owls - The Barn Owl Trust

Habitat	Type	Description	Lessons learned	BNG Units achieved	Assumptions and considerations	Natural Capital Benefits based on SPIES	Useful links
Grassland	Heathland / heather		Only possible on certain soil types and in certain locations, will require a lot of specialist involvement.	Minus 3 units from converting 5 ha of "poor" modified grassland into "poor" lowland heathland.	Turning grassland into heathland is a difficult task, that comes with different management concerns. Due to the difficulty in establishing this habitat type and time taken (estimated 10 years to reach "poor" condition) the BNG units are negative. Enhancing 5 ha of existing lowland heather from poor condition to moderate achieves a gain of 14 units, again this can be very difficult to achieve.		Lowland_heathland_timescales_to_recovery_advisory_note_FINAL-Design.pdf (magnificent-meadows.org.uk) Heathland Conservation | Heathland Extent and Potential Maps - RSPB
Woody plants, scrub & screening plants	Trees	5 species, branched, 10-12cm girth	Specimens from the local Region of Provenance (ROP) should be used where possible. Appropriate guards should be used, particularly in an area with a high risk of browsing. Best planted in autumn to minimise the need for watering over summer.	2 hedgerow units achieved by creating a 1 km "moderate" condition line of trees	Assumes native species only, which are appropriately managed and healthy. Requires watering, maintenance and protection from any wild deer. This can be expensive. Without existing veteran or ancient trees (every 30 m) the line of trees cannot be considered "ecologically valuable". To achieve "good" condition would take 30+ years resulting in a "non standard agreement may be required" flag within the metric.		Tree Planting Advice - Plant Trees - Woodland Trust
	Orchards	Mixed species such as apples, plums, cherries and pears.	Can be a great way to get communities involved and provide a real benefit to wildlife.	2 hedgerow units achieved by creating a 1 km "moderate" condition line of trees	The metric allows 5 years to reach target "poor" condition. To get a higher condition will take longer (20 years to achieve "moderate" condition) and doing so only gains a total 4 units. However, this may be achievable in some areas.		Planning and designing an orchard - The Orchard Project Orchards - British Habitats - Woodland Trust
	Hedgerow	Double row of willow, hazel and alder.	Care must be taken to avoid cutting hedgerow trees and allow them to grow into full size trees. Usually this means clearly marking such trees and pointing them out to the flail operator.	Planting 1 km of native species rich hedgerow of "moderate" condition results in 6.69 hedgerow units!	If the hedgerow is in an ecological desirable location (i.e., connecting valuable habitats it becomes 7.36 hedgerow units). Young plants need protection from sheep, deer and rabbits. Watering may also be required.		Best Hedges for Wildlife | Planting Hedges - The RSPB Top tips for managing hedgerows - People's Trust for Endangered Species (ptes.org)
	Scrub	Mixed native scrub such as field maple, hazel, hawthorn, spindle, goat willow and crack willow.	Scrub can be very competitive and if not controlled can spread, the placement and management of such features needs to be carefully considered. They can be hugely beneficial for wildlife such as turtledoves.	Turning 1 ha of "poor" modified grassland into "moderate" condition hazel scrub achieves 1.75 habitat units gain, the same extent of bramble scrub gains 1.86 habitat units	Other scrubs are available and different species have different benefits depending on the habitats and species present or targeted. The accessibility of management needs to be considered when creating this habitat.		KWT Land Mgt Advice_Sheet 7 - Scrub -value for wildlife&mgt.pdf (kentwildlifetrust.org.uk) Scrub | Shrubs and Trees | Advice For Farmers - The RSPB
	Ponds	100m2, varying depths (0.25-1.2m), lined with puddling clay. Plant wetland herbs.	Much easier to create during construction (while diggers are on site). Need to ensure they are in sensible places for management of the ponds and arrays while also somewhere that will stay wet and away from PRoW.	0.5 habitat units gained by turning 0.1 ha of cereal crop into a pond (non-priority habitat) of "moderate" condition	In the absence of priority or protected species it is difficult for a new pond to achieve priority habitat status, with careful management of invasive species and livestock, a "moderate" condition pond is estimated to take 3 years. For sites with great crested newts, priority status is possible and 0.59 (total) habitat units could be achieved.		Pond Creation Toolkit - Freshwater Habitats TrustFreshwater Habitats Trust

Habitat	Type	Description	Lessons learned	BNG Units achieved	Assumptions and considerations	Natural Capital Benefits based on SPIES	Useful links
Woody plants, scrub & screening plants	Scrapes	Excavation of scrape 50m2, 0.25-0.75m deep	Much easier to create during construction (while diggers are on site). Need to ensure they are in sensible places for management of the ponds and arrays while also somewhere that will stay wet and away from PRoW. Specimens from the local Region of Provenance (ROP) should be used where possible. Appropriate guards should be used, particularly in an area with a high risk of browsing. Best planted in autumn to minimise the need for watering over summer.	0.03 habitat units achieved from turning 0.005 ha of cropland into a "moderate" condition temporary pond.	Scrapes are particularly easy to create while construction works are underway on site, as with all water features as they require digging.		Temporary ponds and scrapes - Farm Wildlife
	Swale	5 species, branched, 10-12cm girth		Turning 0.1 ha of arable land into SUDs gains 0.04 habitat units or a bioswale gains 0.06 habitat units	This assumes "moderate" target habitat condition for both habitats. This habitat type falls within the "urban" category, if a solar farm is near a major roadway SUDS would likely collect pollutants.		Rural sustainable drainage systems - GOV.UK (www.gov.uk)
Animal and insect habitat creation	e.g. hibernacula, wood piles, bird boxes, bat boxes, solitary bee hotels, hedgehog houses & tunnels and beetle banks		These are often easier to install during/at the end of construction – provided there is sufficient advice to those doing the installation in terms of location, aspect, height etc. The locations also need to be agreed with the landowners so that no trees containing boxes are unknowingly managed. They should also be installed away from PRoW where they are prone to disturbance.	Wild Power points are scored for targeted species provision, but they do not contribute to BNG The metric allows 5 years to reach target "poor" condition. To get a higher condition will take longer (20 years to achieve "moderate" condition) and doing so only gains a total 4 units. However, this may be achievable in some areas. The metric allows 5 years to reach target "poor" condition. To get a higher condition will take longer (20 years to achieve "moderate" condition) and doing so only gains a total 4 units. However, this may be achievable in some areas.			Install wildlife boxes for species at risk - GOV.UK (www.gov.uk)

Appendix 2
Direct and indirect habitat impacts of solar farms

Impact	Description	Possible Avoidance/ Mitigation/Compensation Approach
Habitat creation	New habitats can be created as part of solar farm developments whether for screening, as part of the reduced management or as part of the enhancements; including new hedgerows, woodland creation, seeding of new wildflower rich meadows and creation of swales.	Locally relevant species and habitats should be provided with landscape scale benefits sought.
Habitat loss	This may be direct loss such as hedgerow removal (usually small sections for access purposes only), construction of ancillary buildings and tracks (generally small areas required), removal or reduction of trees (diseased trees or height reduction to avoid shading though this should be avoided where possible). The physical changes to the habitats on site relating to the introduction of solar panels can also lead to displacement of certain species. Birds requiring unbroken sightlines such as nesting skylarks, lapwing, yellow wagtail, stone curlew are likely to be displaced by introduction of solar panels. Additionally, foraging birds such as woodcock, various waders and wildfowl may also be displaced from feeding grounds, which may be especially important close to designated sites.	• Minimise hedgerow loss and ensure new hedgerow planting within or adjacent to the site • Consider trees early in the proposals and allow for retention and sufficient buffers to avoid shading or damage to panels from dead material • Ensure sufficient baseline information on breeding birds is obtained and avoid breeding areas where possible. If not possible, offsite mitigation should be secured
Habitat Degradation	Habitat degradation during construction may include soil compaction, soil damage (through mixing of subsoil/topsoil), erosion, runoff or pollution (affecting watercourses), dust deposition, lighting etc.	• Production of a concise CEMP • Monitoring during construction • Timing of construction on certain sites to avoid winter months
Habitat enhancements	The solar farm creation with reduced management of grasslands and field margins can enhance and increase existing habitats including tussock rich margins, infill hedgerow planting or allowing the hedgerows to grow up or semi-improved grasslands to diversify over time.	This is best achieved through seeding/planting with locally appropriate species and appropriate management in line with the LEMP.
Habitat fragmentation	Installation of impermeable security fencing may affect movement of larger animals such as badger, hare and otter.	• Use of fencing which permits movement of mammals (though where sites are grazed by sheep care should be taken to ensure lambs cannot escape) • Badger gates are generally ineffective as they become blocked and are seldom used
Disturbance	Mainly relevant during short construction phase (typically less than 6 months) as a result of piling and the additional movements on site. But may also occur during management of the site such as grass cutting or hedgerow management.	• Ensure adequate surveys are carried out to identify species which may be disturbed • Time works to take place during the least disturbing period, depending on the species identified (for instance spring/summer vegetation management poses threats to nesting birds while piling in the winter could disturb nearby waders) • Creation of adequate buffers to mitigate for disturbing activities
Reduced use of Agri-Chemicals	Solar farms typically have no need of fertiliser or pesti-cide , the panels are typically cleaned with de-ionised water and limited applications of herbicide to control any establishment of woody perennials.	• Successful establishment and creation of grassland under the panels reduces the need for herbicides throughout the operation of the array. This should be targeted within the first two years of operation
Mortality/Collision	Although unlikely, there is a risk of injury or mortality to animals during the construction phase. This may be via vehicular collision or getting trapped in trenches or machinery. There may also be a risk of collision with the solar panel structures during operation, although this is a heavily debated subject. There is no definitive evidence from the UK that bats or birds collide with solar panels, however, work in other countries with very different habitats present suggest that there may be risk in terms of collision. All structures pose a collision risk to some extent and further research is required to fully assess the scale of these impacts in the UK. There is some evidence to suggest aquatic invertebrates are attracted to horizontally polarised light and use this as a stimulus to induce egg-laying. This may cause mortality and reproductive failure. This is further elaborated on within BSG Ecology, 2019.[16]	• Ensure CEMP covers aspects such as covering of trenches overnight, minimisation of vehicle movements and speed limit and the provision of a toolbox talk by an ecologist • Avoidance of highly sensitive/ important aquatic habitats. White gridding and anti-reflective coatings were found to reduce attraction to aquatic invertebrates

Footnotes/References

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