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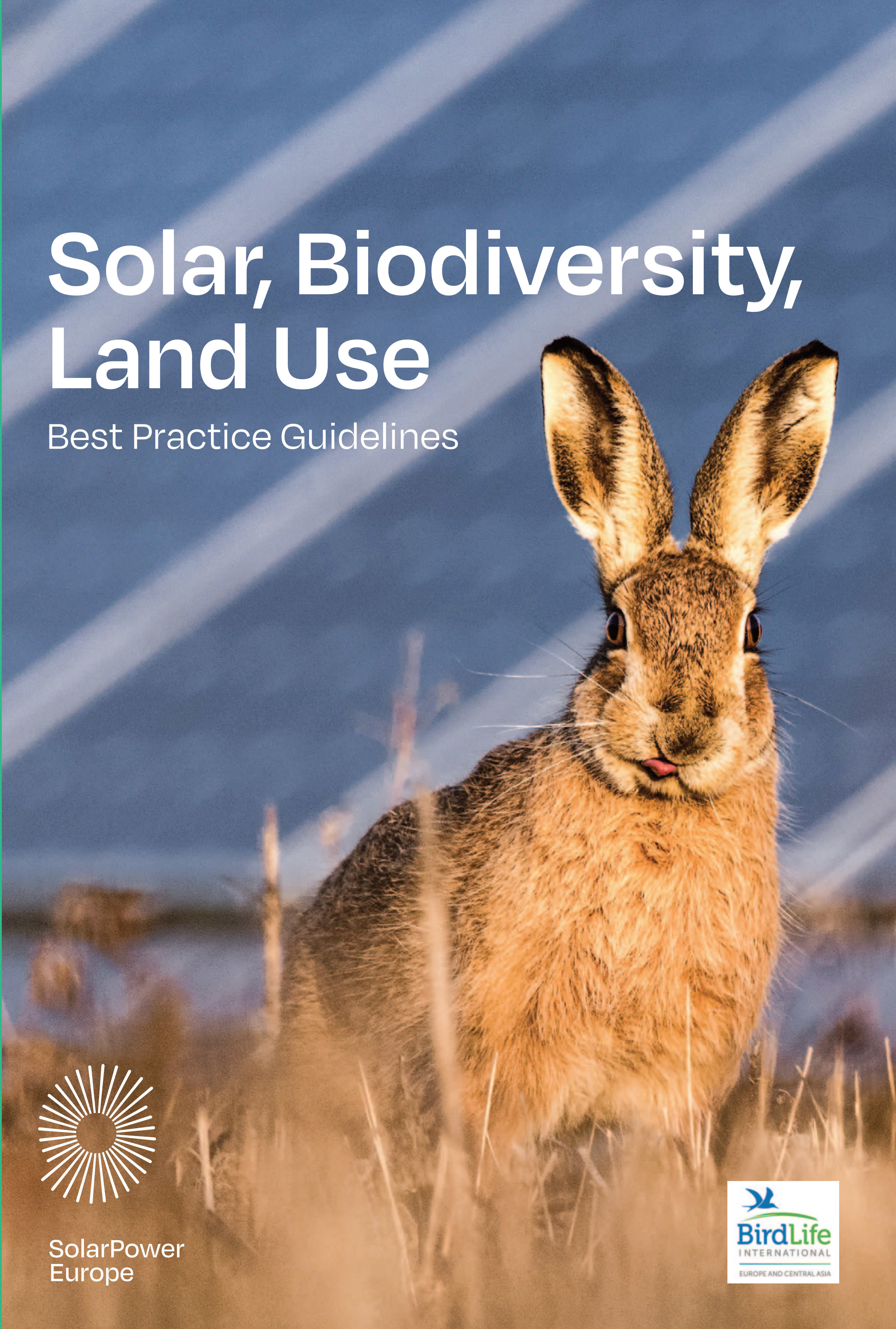

Solar, Biodiversity, Land Use

Best Practice Guidelines

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SolarPower
Europe

Foreword

Europe is currently experiencing an unprecedented energy crisis. At the same time, we are facing a climate crisis, and the massive degradation of soils, biodiversity, carbon sinks and water resources. Wildlife populations have declined by an average of 69% in the past 50 years. Russia's invasion of Ukraine has sent waves of uncertainty and fear across Europe with rising gas prices creating record highs in household energy bills. Renewable energy offers real and long-lasting solutions to energy security concerns; the resources at our fingertips and must be utilised.

The European Union's response to the energy crisis, including the REPowerEU package and EU Solar Strategy, recognises the urgent need to accelerate renewable deployment with an increased solar target of 750 GWdc by 2030. As we strive to reach these new ambitions, we must ensure a focus on biodiversity and land use efficiency. There is no energy transition without sustainability.

How do we reconcile our energy and biodiversity needs? How do we overcome a duality in land use?

With SolarPower Europe's Agrisolar Best Practices Guidelines, we demonstrated that because of integrated solar PV and dual-land usage, the solar and agricultural sectors can work effectively together to advance the clean energy transition and protect our planet.

With these best practice guidelines to enhance biodiversity and land use efficiency through solar PV projects, we are now addressing a new type of synergy between biodiversity and solar PV. We examine how these two major sectors can boost renewable energy infrastructure deployment, while ensuring the protection and restoration of our ecosystems.

By addressing decarbonation and regeneration challenges together, we demonstrate that an integrated approach can offer solutions and examples to inspire all industrialists, politicians, organisations and citizens.

Through these best practices, we outline recommendations which aim to inform readers and accelerate the deployment of business models which integrate biodiversity and solar PV concerns.

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Executive summary

The world is currently facing a climate and biodiversity crisis, driven by human activities which pose a threat to our nature, society, and economy. Combatting climate change and reducing greenhouse gas emissions are essential actions to safeguard the world's most valuable ecosystems and biodiversity.

In 2021, the European Commission adopted its Climate Law, which commits Europe to reach climate neutrality by 2050, and reduce its net greenhouse gas emissions to 55% by 2030. In parallel, the Commission has introduced its REPowerEU package, which outlines the EU's pledge to end its dependence on Russian fossil fuels and increase renewable energy deployment. The package features an unprecedented EU Solar strategy that sets an EU solar target of 750 GW_{DC} by 2030, with an intermediary target of 400 GW_{DC} of solar installed by 2025.

In parallel, the EU has also unveiled another landmark initiative – the EU Nature Restoration Law – to protect Europe's most valuable biodiversity and restore damaged ecosystems. The regulatory proposal sets an ambitious target to restore at least 20% of the EU's land and sea areas by 2030 as well as to recover all degraded ecosystems by 2050.

Reaching the EU's climate, nature protection, and nature restoration objectives will require the mobilisation of land for renewable energy projects. It will be necessary to use appropriate regulatory frameworks to ensure that land is mobilised for solar deployment. Guidance and best practices on nature conservation and degraded ecosystem restoration are also required to reach both climate and nature protection objectives.

This report provides support to solar industry stakeholders, detailing relevant EU environmental legislation for solar projects. It also provides case studies from several EU Member States, highlighting how different EU nature rules are applied at the national level. These guidelines tackle the potential impacts of land usage and outline key actions for appropriate land identification for solar PV projects. These guidelines also provide best practice examples on nature-positive solar sites across the EU, and recommendations on how to incorporate environmental considerations across different solar PV project phases.

The results of this report reveal that different EU laws are transposed and applied independently at a Member State level, and thus can vary from country to country. Environmental assessments are a core part of renewable energy projects, specifically for solar, across various EU Member States. Nature conservation and landscape integration for solar PV projects are considered a top priority in some regions, such as the Netherlands. Additional guidelines and best practice examples need to be developed to support the transition to renewable energy deployment, while ensuring that all nature objectives are met. In particular, spatial planning must be facilitated at a local level, with the involvement of local communities in the planning process. Moreover, Member States should publish guidelines on Strategic Environmental Assessments (SEAs) and Environmental Impact Assessment (EIAs) for solar projects, in line with EU and national nature laws. It is essential to provide access to standardised environmental data to guarantee better spatial planning and identification of favourable areas. Likewise, aggregated data on the environmental impacts of solar PV should be made available by the European Commission.

The demand for renewable energy sources is growing exponentially. At the same time, land scarcity is posing a real challenge, driven by complex multisector activities, including but not limited to urbanisation and agricultural production. Ensuring sustainable land use and its management is key to delivering the energy transition, whilst preserving healthy ecosystems. Evidently, land areas and water bodies will prove essential to situate solar PV projects. Therefore, good site assessment and well-implemented spatial planning will be crucial to facilitate solar PV deployment, while preserving ecological diversity. Moreover, well-designed solar PV can provide environmental benefits, not only by protecting and enhancing local flora and fauna, but also by restoring vulnerable ecosystems.

Different innovative technologies such as agriPV and floating PV can support dual land use. AgriPV technologies, if well-designed and incorporated into an early planning phase, can offer multiple opportunities for carbon storage and soil regeneration, whereas floating PV can provide benefits to the water ecosystems, such as improving water quality and increasing biodiversity in the artificial water bodies.

To ensure sustainable and environmentally friendly solar PV projects, it is fundamental to implement best practices throughout the lifespan of a solar project, from design to decommissioning. Various aspects such as site assessments, input from a local environmental expert, and assessing environmental factors such as the soil, water, air and noise pollution during the different phases of a solar project, need to be considered. Similarly, industry best practices are pivotal to showcase the potential benefits which the solar sector can bring to the environment.

1 Introduction

The world faces two unprecedented challenges: global warming caused by the large concentration of greenhouse gases and biodiversity loss, both driven by human activities which threaten our nature, society, and economy. Today, more than 85% of global wetland areas have been lost and one million animal species are endangered. In Europe, more than 80% of the continent's habitats are under critical conditions. In addition to decarbonising all sectors, the regeneration of ecosystems is essential. Therefore, addressing both biodiversity and climate change challenges simultaneously is absolutely necessary. As stated by the European Commission, "we cannot address biodiversity loss without tackling climate change, but it is equally impossible to tackle climate change without addressing biodiversity loss."[1] **The fight against climate change — including by limiting the emissions of the energy sector and by deploying more renewables — is critical to slow down biodiversity loss.** Following the Paris Agreement in 2021, the Commission adopted the European Climate Law, under which the EU outlined its commitment to reach climate-neutrality by 2050. To help Europe achieve this goal, the Commission also published its 'Fit for 55' Package which proposes to increase the EU's greenhouse gas emissions reduction target and renewable energy deployment targets to 55% and 40% respectively by 2030. TThese targets will strengthen the Commission's work under the 2030 Agenda for Sustainable Development. In May 2020, the EU adopted the EU Biodiversity Strategy for 2030 with the aim to protect biodiversity and restore degraded ecosystems in the EU. The Commission also extended the EU Green Taxonomy with environmental objectives, including, but not limited to biodiversity recommendations. Today, more than 75% of global land areas are degraded, caused by man-made activities. To tackle these effects, a specific focus on soil regeneration is needed. As stated by the FAO, "33% of the Earth's soils are already degraded and over 90% could become degraded by 2050."[2] In this context, the EU adopted the Soil Strategy for 2030. Considerations of soil ecosystems and restoration measures must be taken into account in land use and the deployment of any kind of infrastructure in natural areas.

Protection and restoration of ecosystems will support climate mitigation and will help us adapt to climate change. Scientific evidence suggests that preserving and protecting at least 30% of the Earth's land, freshwater and ocean areas is key to ensure the resilience of ecosystem services and derive biodiversity benefits. This preservation and protection can also reduce risks of disasters and ensure climate change adaption and mitigation.[3] To secure a prosperous and sustainable future, there is a need to safeguard biodiversity and ecosystems, while tackling climate change. It is essential to take rapid action and engage stakeholders across different domains.

This year, the EU has proposed a landmark initiative – the EU Nature Restoration Law – that aims to halt biodiversity loss and restore disrupted ecosystems across Europe. This comes at a crucial time, amid the UN's Decade on Ecosystem Restoration – an

1 Source: https://ec.europa.eu/environment/nature/climatechange/index_en.htm

2 Source: https://www.fao.org/about/meetings/soil-erosion-symposium/key-messages/en/

3 Source: https://www.iucn.org/news/commissions/202203/joint-statement-iucn-commissions

international movement that seeks to increase the restoration projects and ensure sustainable future for all. **In parallel, renewable energy deployment needs to be dramatically accelerated, both to tackle Europe's climate emergency, and support its energy security.** The energy crisis exposes Europeans to both high power prices and the risk of gas disruptions, in particular during the winter of 2023. Under the REPowerEU package, the Commission presented a plan to save and diversify energy supply, produce clean energy, and reduce Europe's dependency on fossil fuel imports. The package included a first-of-its-kind EU Solar Strategy which sets out new objectives of almost 320 GW_{ac} (400 GW_{dc}) by 2025 and almost 600 GW_{ac} target for EU solar by 2030 – equivalent to 750 GW_{dc}. Among the flagship measures proposed under this strategy was a European Solar Rooftop Initiative. The EU will aim at maximising the deployment of solar PV on rooftops through a proposed a mandate for solar on all new and renovated buildings. Despite the potential of rooftop solar, at least half of this capacity will need to be deployed on land. Large-scale, ground-mounted PV offers, thanks to economies of scale and optimised design, a very competitive price of electricity for businesses and energy-intensive consumers.

Reaching those objectives will therefore require mobilising land in the coming years and at an accelerated pace, while not compromising on the nature protection and restoration objectives stated above. The amount of land needed to deploy solar is marginal when compared to activities causing artificialisation of land: 1% of EU's arable land would be needed to produce 900 GW of solar capacity, substantially contributing to the fight against climate change, while, in contrast, golf courses currently take up a little less than 2% of land area.

In this light, the European Commission has proposed that Members States designate "priority areas,"[4] i.e. land available for an accelerated development of renewable energy projects. As proposed by SolarPower Europe, this category will likely consist of built-up areas, and include the necessary grid connection for the integration of renewables. Similarly, favourable areas including larger land or sea areas which are necessary for the installation of renewable energy plants, should be identified swiftly after priority areas. These favourable areas should take the renewable energy potential, grid connections and financial costs into consideration, to ensure that the deployment of renewables within these zones is technically, environmentally and economically feasible.

Against this background, it is essential to develop the right regulatory frameworks to mobilise the suitable land for an accelerated solar PV deployment, while promoting guidance and a view of best practices that can ensure the protection of nature and restoration of degraded ecosystems.

The main objective of the guidelines is to support solar industry stakeholders with information about environmental legislation at the EU and national levels. It also intends to address the potential impacts on land use and outline key actions for suitable land identification for solar PV projects. These guidelines will provide best practice examples on nature-positive solar sites across the EU, and include guidelines on how to incorporate environmental considerations across different solar PV project phases.

Three specific chapters are outlined, focusing on:

1. Mapping the existing European regulatory measures related to environmental protection, including an overview of Member States' regulation, and a list of key recommendations;
2. Identification of suitable land for solar PV deployment and;
3. Provision of best practice examples to mitigate negative impacts and improve the environmental profile of solar sites.

4 Proposed definition by SolarPower Europe in comparison to the European Commission's initial definition of 'go-to areas' as set out in RePowerEU package.

2 Environmental regulation

Regulatory frameworks for renewable project development and nature protection have been established at international, EU and the national level. However, country, or region-specific regulations are often applied when developing a solar PV project. This creates a fragmented understanding of EU and national environmental law, and their role in solar project development. The objective of this chapter is to outline the key environmental policy files at the EU and national levels. This will help to better understand the existing regulatory landscape related to nature protection and its impact on solar PV deployment.

2.1. European Green Deal

The European Green Deal was adopted by the Commission in 2019; it sets out an ambitious commitment to combat climate change and address environment-related challenges. The European Green Deal's key measures aim to protect biodiversity and preserve ecosystems, whilst reducing greenhouse gas emissions across Europe. It consists of the Biodiversity Strategy for 2030, EU Nature Restoration Law, 2030 Climate Target Plan and much more. These initiatives set Europe on a path towards a sustainable, resilient, and healthy future for all (see Table 1 on the following page).

2.2. EU Nature Directives

Birds and Habitats Directives and Natura 2000 sites

Cornerstones of the EU's biodiversity policy, the Habitats (92/43/EEC 11) and Birds (2009/147/EC12) Directives aim to safeguard Europe's rarest and most threatened species, and valuable habitats. The Habitats Directive promotes the protection of biodiversity while considering economic, social, cultural and regional requirements. Equally, the Birds Directive outlines rules for Member States to ensure the protection of wild bird species across the EU. Under the two Nature Directives, Europe has succeeded in implementing the Natura 2000 network – an EU-wide ecological network of protected areas encompassing around 18% of land and 8% of the sea.

Natura 2000 stems from the Habitats Directive and is the largest coordinated network of protected areas globally. The Natura 2000 sites are established at a national level in line with EU Nature Directive requirements.

Even though EU level environmental policies provide a solid legal framework to protect its most valuable and threatened flora and fauna, at least one third of the EU's bird species are under a bad conservation status,[5] while 80% of habitats are in a poor condition.[6] Integrated policies along with strong monitoring and data availability, is essential to ensure effectiveness of these EU measures. Consolidated systems will accelerate the deployment of renewable energy sources, and simultaneously protect Europe's natural heritage.

5 Species that are threatened (according to IUCN Red List criteria).

6 Unfavourable, inadequate conservation status of habitats and species.

TABLE 1 ENVIRONMENTAL LAWS AND INITIATIVES ON THE EU LEVEL

	Overview of the key EU environmental laws and initiatives		
	Year	Objective	Link with other nature initiatives
BIRDS DIRECTIVE	Adopted in 1979	To protect all of the 500 wild bird species naturally occurring in the EU.	Birds and Habitats Directives are the cornerstones of EU's nature protection policy. Under the two Directives, Natura 2000 sites were implemented.
HABITATS DIRECTIVE	Adopted in 1992	To preserve wild animal and plant species of European importance and protect natural habitats.	
EU NATURE RESTORATION LAW	Published in 2022	To restore degraded ecosystems across the EU territory with an interim target of 2030 to restore 20% of EU's land, and surrounding sea and restore all degraded ecosystems by 2050.	The EU Nature Restoration Law is a complementary initiative to support the two EU Nature Directives and raise the ambition of nature protection and restoration across the EU.
EIA DIRECTIVE	Adopted in 1985	To assess environmental implications of public and private projects; can be divided into mandatory EIAs and EIAs that fall under the discretion of Member States (i.e., screening).	The two cornerstone directives that aim to assess environmental implications. SEA is complementary to the EIA; however, these two assessments are not interchangeable.
SEA DIRECTIVE	Adopted in 2001	To assess public plans and programmes (e.g., land use, energy, transport, etc.) and their likely significant effect on the environment.	
EU BIODIVERSITY STRATEGY FOR 2030	Launched in 2020	An ambitious long-term plan set out to protect and reverse degradation of Europe's biodiversity and ecosystems.	The EU Biodiversity Strategy sets out long-term commitments in line with the UN Sustainable Development Goals, and with the climate change objectives of the Paris Agreement. One of the key actions of the Strategy is to establish the EU Nature Restoration Law.
EU SOIL STRATEGY FOR 2030	Launched in 2021	The EU Soil Strategy for 2030 sets out a framework and concrete measures to protect and restore soils, and ensures a sustainable use of soil ecosystems. The framework includes a vision and objectives to achieve healthy soils by 2050, with concrete actions by 2030. It also announces a new Soil Health Law by 2023 to ensure a level playing field and a high level of environmental and health protection.	EU Soil Strategy for 2030 is a key deliverable of the EU Biodiversity Strategy for 2030. The strategy is also a part of the European Green Deal objectives.

2.3. EU Nature Initiatives

Biodiversity Strategy 2030

The Biodiversity Strategy for 2030 was published in 2020 and is an integral component of the European Green Deal. The strategy is an ambitious long-term plan set out to protect and reverse degradation of Europe's biodiversity and ecosystems. The strategy's goals call on Member States to commit to protect and preserve Europe's environment while setting a path towards global ecosystem restoration by 2050. The key actions of the Strategy are fourfold:

1. Expansion of existing Natura 2000 areas.
2. Restoration of ecosystems by introducing the EU Nature Restoration Law.
3. Introduction of specific measures to ensure transformative change.
4. Setting an ambitious global biodiversity agenda.

Today, only 11% of seas and only 26% of land in the EU are protected.[7] Moreover, poor management and monitoring practices are employed. The Biodiversity Strategy for 2030 is a key tool for facilitating the protection of EU marine and land areas, calling for a legal protection of at least 30% of land and 30% of sea areas. The Biodiversity Strategy also pushes Member States to create ecological corridors between protected areas by building a Trans-European Nature Network.

EU Nature Restoration Law

The second key pillar of the Biodiversity Strategy for 2030 aims to restore degraded ecosystems across the EU territory by introducing a new Nature Restoration Plan for Europe. The law includes two main elements which will strengthen the EU legal framework for nature protection. Firstly, it will introduce legally binding targets to restore degraded ecosystems, with a focus on areas that have the potential to capture and store carbon. Secondly, it calls on Member States to prioritise the conservation and protection of species and habitats under the EU Nature Directives. Specifically, the restoration law requires EU countries to implement national plans with the objective of restoring at least 20% of EU land and sea by 2030. Member States will also have to restore all degraded ecosystems by 2050.

Notably, the legislation outlines the opportunities for renewable sources, including solar deployment and the need for accelerated permitting while promoting suitable areas for deploying solar PV.

Environmental Assessment: SEA and EIA Directives

EIA and SEA directives are intended to guarantee that the environmental implications of decisions are taken into account. The EIA was adopted in 1985, and its objective is to assess environmental implications of individual projects such as airports, highways and bridges. The SEA, which was adopted in 2001, assesses public plans and programmes, and is complementary to the EIA. The two regulatory frameworks ensure that plans, programmes, and projects undergo an assessment for any significant environmental impacts that may occur, and are applied prior to the approval or authorisation of the particular plan, programme or project. In parallel, the directives should facilitate both the integration of environmental considerations into the planning stages, and public participation into the decision-making process. Currently, a shift in spatial planning is taking place to better facilitate the conservation actions required to maintain species' populations, habitats, and ecological functions.

Depending on the size of the installation, solar PV plants and projects can be subject to environmental assessment. This allows for the evaluation of environmental implications, and ensures that suitable compensation and mitigation measures are integrated into the planning process. However, better guidance for solar PV developers and relevant authorities is needed.

These directives ensure that EU Member States are obliged to safeguard Europe's most valuable natural assets. Nonetheless, each Member State is responsible for its effective implementation and transposition into national law. Currently, these directives are not being sufficiently applied at a national level; an inadequate level of guidance documents are available on how to conduct an EIA and SEA for renewable energy projects. EIA and SEA thresholds, and environmental screening requirements, also vary widely across EU countries.

2.4. Member State Case Studies

To ensure the effectiveness of EU policies concerning renewable project development and nature protection, Member States need to adopt appropriate measures and management plans to report on their biodiversity status. The harmonisation and communication of such data creates a holistic picture of EU biodiversity.

This section will look at Germany, the Netherlands, Portugal, France and Italy, examining how different EU nature rules are applied on a national level. In addition, it will provide insights into solar PV deployment and its harmonisation with nature regulations. Several key policy recommendations are summarised to highlight what must be improved at a national, regional, and local level.

7 11% of the EU seas are protected, with 8% in Natura 2000 sites and 3% under additional national protection, whereas 26% of land is under protection with 18% as part of Natura 2000 sites and 8% under national schemes. Source: https://ec.europa.eu/info/sites/default/files/communication-annex-eu-biodiversity-strategy-2030_en.pdf

TABLE 2 MEMBER STATE CASE STUDIES

Country	
GERMANY	• **Authorities in charge:** National and regional authorities oversee the implementation of EU policies and ensure their application. • **Permits:** Building permit, which falls under the building planning regulation, is required to develop solar PV projects. Building permits are provided at a local level, and regulations can vary across municipalities. • **Implementation of EIA Directive:** EIA is carried out at a project level and includes solar PV projects. Municipalities are responsible to ensure implementation of EIA measures and its application to solar projects. • **Implementation of SEA Directive:** SEA is carried out at a regional level and thus excludes solar PV deployment. • **Citizen engagement:** Public participation along with an environmental report must be carried out during the approval procedures. Voluntary public participation is sometimes seen during the planning stage. • **Application of environmental laws:** Different national regulations such as nature and species protection laws must be applied for any project development.
THE NETHERLANDS	• **Authorities in charge:** Municipalities and respective authorities oversee the implementation of EU policies and ensure compliance. The WNB is the legal framework which includes regulations about nature protection in the Netherlands. • **Implementation of EIA Directive:** There is no common tool used for solar PV projects. Environmental assessment is applied during the permitting process. • **Implementation of SEA Directive:** There is no common tool used for solar PV projects. • **Integrated Impact Assessment:** This type of an assessment is used prior to receiving a permit for project development. Mitigation measures are prioritised, e.g. replanting trees on solar sites, and installing projects during off-season when there is no impact on birds and their migration. • **Application of environmental laws:** Natura 2000 sites are excluded from any project development. • **Environmental integration:** There is a high environmental priority on nature protection and landscape-integration for solar PV projects in the Netherlands. The government also concentrates on dual-land use (e.g., introducing sheep grazing on solar sites, introducing agrivoltaics, using solar PV on degraded land, etc).
PORTUGAL	• **Authorities in charge:** For the projects below the thresholds for EIA and depending on land features, a declaration must be requested from authorities in charge, including Hydrographic Region Administrations, Forest Commissions, etc. For projects located in sensitive areas, and below 20 MW, they need to comply with an Environmental Analysis of Incidences, a simplified EIA. There is an environmental evaluation assessment for all solar projects above 50MW, and all projects above 20 MW in sensitive areas. These thresholds are expected to be reviewed shortly. The new thresholds will be based on occupied land (i.e. area of the solar panels). • **Implementation of EIA Directive:** An EIA is a common practice applied for solar PV projects. Other projects may also be subject to an EIA if they are considered to develop cumulative impacts with other projects in the surrounding areas. The Portuguese Environmental Agency is responsible for ensuring the implementation of EIA measures, and its application to solar projects. An Evaluation Committee (composed by different national authorities) is created for each EIA and is responsible for the assessment of the Environmental Impact Study. • **Implementation of SEA Directive:** Not a common tool used for solar PV projects. • **Application of environmental laws:** Authorities have started to define go-to-areas for solar PV.

TABLE 2 MEMBER STATE CASE STUDIES - *CONTINUED*

Country	
FRANCE	• **Authorities in charge:** National authorities oversee the implementation of EU policies and ensure their application. National, regional, sub-regional (*département*), and even local authorities implement measures. • **Implementation of EIA Directive:** EIA is a common practice applied for ground-mounted solar PV projects equal to or above 1MWp. Solar PV installations equal to or greater than 300 kWp are assessed on a case-by-case basis. National level authorities are responsible for the implementation of EIA measures and their application to solar projects. • **Implementation of SEA Directive:** National and regional authorities implement SEA measures. • **Application of environmental laws:** Different national regulations, including nature and species protection laws are applied. Construction permits for PV plants are decided at a sub-regional level with the involvement of technical departments, local authorities and the public (*enquête publique*). DDTM or DREAL submit the EIA to the environmental authority, MRAE. For further details, read 'Guide - L'instruction des demandes d'autorisations d'urbanisme pour les centrales solaires au sol.' • **Environmental integration:** Environmental integration of the PV plant is required. Criteria can differ from location to location.
ITALY	• **Authorities in charge:** National and regional authorities oversee the implementation of EU policies and ensure their application. • **Permits:** Both building permits and environmental assessments are required to develop solar PV projects. Solar plants which are: a) below 20 MW (industrial areas); b) below 10MW (priority areas and floating PVs[8]); and c) advanced agrivoltaics (as reported in the Italian AgriPV guidelines), can be authorised following a simplified procedure. Solar plants with different characteristics as mentioned before, can be authorised following a more complex procedure and involve local, regional and national level authorities. • **Implementation of EIA Directive:** EIA can be carried out at regional or national level, depending on the size of the project. • **Implementation of SEA Directive:** SEA can be carried out at national, regional, or local level. • **Integrated Impact Assessment:** This assessment is required prior to receiving a permit for a project development. A concentration is placed on mitigation measures, for instance, buffer zones around the plant to mitigate the impact on the landscape, replanting trees, and protecting aboriginal species on solar sites. • **Citizen Engagement:** Citizens can participate in a specific public consultation phase that usually lasts 60 days. • **Application of environmental laws:** Natura 2000 sites are excluded from any project development. • **Environmental integration:** Nature protection and landscape-integration for solar PV projects is prioritised (creation of buffer areas of trees around the plant to mitigate the presence of the solar plant).

8 Priority areas are defined as follows: a) industrial areas; b) agricultural areas that are located within a perimeter of no more than 300m away from industrial areas, commercial use areas, quarries, mines); c) areas close to highways (within 150m).

KEY RECOMMENDATIONS

- More integrated spatial planning is required at a local level. Local authorities must conduct a regular integrated spatial planning to identify suitable land for renewable energy project development, while ensuring high levels of environmental impact considerations. In doing so, local authorities must also consider economic factors and grid availability for solar PV.
- Local communities must be involved in the strategic planning process, or the process of defining suitable areas for renewables. This is a prerequisite to create effective biodiversity conservation strategies. The EU should also facilitate the sharing of best practices on community involvement and information exchange between Member States.
- Member States must publish guidelines on how to conduct the SEA and EIA in relation to solar projects, and with respect to EU and national environmental law (including, the Birds Directive and Habitats Directives). They must ensure that guidelines are available and disseminated to the public. This would create a more efficient validation of the environmental impact assessment, and the overall permit-granting procedure at the national level.
- The Commission should ensure the circulation of SEA and EIA best practices in relation to solar PV, and provide recommendations to Member States. This could be integrated as part of its regular recommendations to Member States in the European Semester. The European Semester is a cycle of economic, fiscal, labour and social policy coordination within the EU.
- A set of standardised methods and data on ecological features of areas across Member States is needed. This would facilitate spatial planning and identification of suitable areas by Member States.
- The Commission should make the aggregated data on the environmental impact of solar PV available, building on previous reports.[9] The aggregated data must be based on a scientific literature review, as well as past solar project EIA results. This data should be shared by national authorities. The EIA results should also be accessible to assess biodiversity impacts and compliance with DNSH thresholds[10] in the context of the EU Green Taxonomy.
- Soil health measures and indicators should be included in EIAs and SEAs.

9 Source: https://ec.europa.eu/environment/nature/natura2000/management/docs/POTENTIAL%20IMPACTS%20OF%20SOLAR_%20GEOTHERMAL%20AND%20OCEAN%20ENERGY%20ON%20HABITATS%20AND%20SPECIES%20PROTECTED%20UNDER%20THE%20BIRDS%20AND%20HABITATS%20DIRECTIVES%20-%20Final%20report.pdf

10 'Do No Significant Harm' principle as proposed by the European Commission.

BEST PRACTICE EXAMPLE 1 FRANCE

During the early 2010s, the French Ministry of Ecology, Sustainable Development and Energy published detailed guidelines on how to conduct environmental impact assessments at a project level for renewable energy projects. These guidelines have been issued for onshore wind, offshore wind and utility-scale solar PV. They are designed to help project promoters to integrate renewables better into their environment, and local authorities to assess the entirety and relevance of the EIA. They focus *inter alia* on:

- The analysis of the existing environment, including sensitivities of physical, biological status, as well as landscape and socio-economic aspects
- The evaluation of potential effects of the project, and their translation into impacts via hierarchisation matrixes
- The analysis of cumulative impacts
- The design of avoidance, mitigation, and compensation measures
- The environmental monitoring strategy
- The process of public participation
- A dedicated Natura 2000 conservation study

Those guidelines are following the principles of the "avoid, reduce and compensate" methodology (ERC). The sequence's objective is to avoid damage to the environment, to reduce damage that could not be sufficiently avoided and, if possible, to compensate for significant effects which could neither be avoided nor sufficiently reduced.

3

Identifying suitable land for solar PV projects

Solar energy generation can play an important positive role in combating climate change, one of the biggest threats for biodiversity. Studies have shown[11] that solar parks can provide significant biodiversity gains where appropriately sited, designed and managed. Conversely, poorly sited, designed and managed solar parks have the potential to negatively impact biodiversity. It is important to limit any negative impacts on the development of local environments and ecosystems, and instead, promote and enhance biodiversity where possible.

While the amount of land used for mining and extracting fossil fuels is expected to decrease, the need for additional renewable energy sources will substantially grow. This is happening in the context where land scarcity is driven by complex multisector activities, including urbanisation and agricultural production. Ensuring sustainable land use and management is crucial to facilitate the energy transition, whilst preserving healthy ecosystems. **Statistics show that if the United Kingdom was powered by RES only, solar infrastructure would take up as little as 2.1% of its total land.** Agricultural land covers around 71.7% of UK territory.[12] **While solar parks cover a small land area relative to the world's land surface, project developments still need to be strategically implemented to safeguard ecological processes and principles.** This chapter looks at different land use types, and the potential risks and benefits for biodiversity of solar development in these areas.

Land areas and water bodies are optimal for placing renewable energy infrastructure, including solar, to meet energy demand needs. However, poorly located and/or designed parks can negatively impact biodiversity. Therefore, it is important to consider site-specific aspects such as ecological features, geographical location, and land use practices to ensure the protection and enhancement of local biodiversity. **Good site assessments** along with well-implemented **spatial planning**, will create solar parks that avoid disrupting vulnerable ecosystems and provide biodiversity benefits. Solar energy can play an important role in bridging the gap between the restoration of ecosystems and tackling the climate crisis. For instance, **employing solar parks on degraded land**[13] helps to finance site restoration, whilst also facilitating vegetation growth underneath solar panels (in dry areas), improving soil carbon stocks, and enhancing the nitrogen cycle by promoting animal grazing on the site. Throughout this process, local communities are receiving supplies of green energy sources.

Similarly, **solar PV projects installed on agricultural areas can considerably improve local flora and fauna.** In the UK, solar sites have created a greater diversity of vegetation, invertebrates and birds in comparison to surrounding agricultural areas.[14] Similarly, in Germany, research conducted by BNE has indicated

11 Source: https://www.bne-online.de/fileadmin/bne/Dokumente/Englisch/Publications/201911_bne_study_biodiversity_profits_from_pv.pdf

12 Source: https://uk.edenrenewables.com/news/2021/9/10/land-use-and-solar

13 Land degradation: negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity, or value to humans. Source: https://www.ipcc.ch/srccl/chapter/chapter-4/

14 Bennun, L., van Bochove, J., Ng, C., Fletcher, C., Wilson, D., Phair, N., Carbone, G. (2021). Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers. Gland, Switzerland: IUCN and Cambridge, UK: The Biodiversity Consultancy. https://portals.iucn.org/library/node/49283

that large-scale PV pants when designed to be compatible with nature, can deliver positive impacts on biodiversity in comparison to conventional or monocultural agricultural uses.[15] Dual-land usage is important in tackling the climate crisis. As outlined under the EU's REPowerEU package, the "multiple use of space can contribute to mitigating land constraints linked to competition for space, including for environmental protection, agriculture and food security." Inevitably, solar PV can play a leading role in the decarbonisation of the energy sector, and provide innovative technologies for dual-land use to reach climate targets and secure social sustainability. Social sustainability involves recognising and managing both positive and negative business impacts, on people. (See Agrisolar Best Practice Guidelines).

The EU has proposed a number of mandatory and voluntary frameworks to protect the most valuable habitats and preserve ecosystems across its territory. These regulatory instruments will enable Member States to safeguard Europe's most prized natural assets. In particular, Natura 2000 – the largest coordinated network of protected areas in the world – plays an important role in protecting the most valuable and threatened species and habitats across Europe. Therefore, any solar PV project developments need to comply with national, regional and local nature protection regulations; situating green field PV plants on natural, semi-natural or agricultural land in Natura 2000 sites should be avoided.

3.1. Toolbox: sustainable land use for solar PV projects

This section will explore the different types of land cover and assess what potential impacts can be associated with solar PV deployment in these areas. This will help with the identification of suitable land for solar PV installations and highlight areas where mitigation practices are necessary. This chapter will also outline key recommendations for solar PV developers, installers, and other relevant stakeholders, including public authorities.

This toolbox can be used by solar PV developers, installers, and other interested parties related to the solar sector to inspect different land types and their suitability for project developments. This toolbox is also intended to assist local, regional, and national authorities on how to identify suitable land for solar PV. It provides key recommendations which should accelerate solar PV deployment.

This toolbox is based on the CLC classification.[16] It is used to outline the various types of land cover classes, and assess the potential impacts of solar PV deployment on these areas.

3.1.1. Artificial surfaces

Artificial land, as defined by CLC guidelines, refers to "all surfaces where [the] landscape has been changed by, or is under [the] influence of human construction activities by replacing natural surfaces with artificial constructions or artificial materials." The classification of artificial surfaces includes, but is not limited to, industrial, commercial and transport units, mines, dumps, construction sites, and artificial and non-agricultural vegetated areas.

Artificial land can be divided into different types of land, including waste and industrial sites, rail roads, and more. Some of these types of land are suitable for solar PV installations as they often provide little to no biodiversity. Siting solar on degraded lands that are areas of low biodiversity can support biodiversity enhancement.[17] Nonetheless, certain areas that are classified as artificial land can also provide a hot spot for biodiversity. These can be abandoned places like airports or old quarries; such sites should be assessed prior to solar PV deployment.

Important to consider:

Artificial land can be suitable for solar PV deployment. If installed on degraded land, it can even bring positive ecological features to the site. However, aspects such as the design and planning of the site, and technical and economical characteristics need to be considered.

- **Port areas, carparks and areas nearby road and rail networks**, etc. are sealed sites that **can be used** for **solar PV** installations. Regardless, nearby ecological features including forests must be taken into account.

15 Source: 201911_bne_study_biodiversity_profits_from_pv.pdf (bne-online.de).

16 Source: https://land.copernicus.eu/user-corner/technical-library/corine-land-cover-nomenclature-guidelines/html

17 Bennun, L., van Bochove, J., Ng, C., Fletcher, C., Wilson, D., Phair, N., Carbone, G. (2021). Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers. Gland, Switzerland: IUCN and Cambridge, UK: The Biodiversity Consultancy. https://portals.iucn.org/library/node/49283

- **Degraded land such as waste** and **construction sites, can potentially be used** for solar PV development. However, technical aspects such as grid availability and the characteristics of the site must be considered.
- Artificial sites like abandoned airports, old quarries, etc. can be appropriate for wildlife inhabitation. Hence, a comprehensive site **assessment** and **well-designed plan is required** to ensure the preservation of local habitats while ensuring the regeneration of lost ones. (See more about solar PV project planning and design in Solar Power Europe's EPC Best Practice Guidelines version 2.0).
- **Artificial sites can be used for solar PV deployment.** However, **technical aspects** (grid availability, etc.) and **financial costs need to be considered.**
- **Development on contaminated land can risk releasing / exposing contaminants** through ground disturbance. Thorough assessments are required, and decontamination may be a requirement to allow for PV development in such areas.

KEY RECOMMENDATIONS

- Certain types of artificial land are low in biological diversity. Areas such as those with nearby road and rail networks, parking areas, in addition to other sealed land areas, can be utilised for solar PV projects with little or no adverse impacts on biodiversity.
- Screening or site-specific assessments should be encouraged for particularly sensitive artificial land areas such as abandoned sites, that can provide the right environment for a thriving wildlife.
- Spatial planning and zoning plans should be used to map out industrial areas that can be used for deployment of solar PV. These plans should be accessible to all relevant stakeholders.

TABLE 3 EXAMPLES OF NATIONAL INITIATIVES THAT SUPPORT SOLAR DEPLOYMENT ON ARTIFICIAL TYPES OF LAND

Country	Initiative
ITALY	The Italian government intends to publish a decree outlining the guidelines for the definition of suitable areas for the development of renewable energy projects. Suitable areas will then be defined by regional laws. In the meantime, the government has identified different types of "go-to areas" along with simplified permitting procedures, for instance: ▪ Land in the radius of 500 m from industrial or commercial areas ▪ Areas secluded in the radius of max. 500 m by industrial plants ▪ Buffer zones in the radius of max. 300 m from highways ▪ Areas in the availability of the railway operator ▪ Ceased mines and quarries ▪ Sites subjected to remediation
FRANCE	In France, the French Ministry for Energy Transition has asked local state representatives ("préfet") to consider the list of 843 wastelands identified by ADEME. Local authorities are obliged to consider this list in the planning process.

3.1.2. Agricultural land

Agricultural land can be defined as a land area that "is either arable, under permanent crops, or under permanent pasture."[18] It can be further divided into land types that include arable land, permanent crops, pastures and heterogenous agricultural areas, etc.

Agricultural land is a vital ecosystem which provides food production, the regulation of hydrology and more. In Europe, rural areas account for nearly 70% of the total land area; 50% is covered by agriculture. Nevertheless, the exponential growth of agricultural practices can adversely affect the environment. Agricultural activities alone pose a risk to biodiversity, threatening around 86% of global species that are at risk of extinction.[19] Furthermore, the agricultural sector accounts for 24% of global greenhouse gas emissions and is one of the main drivers of global warming.[20] That sector will have to adapt to climate change through the decarbonisation of its sector, and the preservation and restoration of soils and ecosystems. Innovative technologies like agrivoltaic systems can support adaptation measures by securing and adding complementary revenue to farmers. It can also offer better conditions for agricultural production by reducing the use of chemical products, and contributing to increased carbon capture and soil regeneration.[21]

Solar PV projects installed on agricultural lands offer a wide range of opportunities not only to generate clean energy, but also to enhance local biodiversity alongside agricultural production. Moreover, agricultural lands such as improved semi-natural grasslands and pastures are often low in biological diversity. Placing well-designed solar PV projects on these type of lands will avoid significant biodiversity impacts while also improving the site's ecological status. This should be complemented by early project planning, and the integration of biodiversity considerations into the design of solar parks.

Important to consider:

- **Solar PV projects on agricultural land can offer significant opportunities to improve biodiversity.**

For instance, solar sites can increase biodiversity and improve soil health in areas that have been altered by man-made agricultural activities like monoculture farming. Converting these types of land into solar parks can in fact diversify the land in terms of economic activities and biological diversity. The protection and strengthening of biodiversity can be achieved by proactive planning and site design, including mitigation measures that avoid negative biodiversity impacts, and in turn create and restore local habitats.

- **Solar PV on improved grasslands, semi-natural grasslands, and pastures can enhance biological diversity by implementing various land management activities.**

Biodiversity can be improved within solar arrays, for instance, by planting diverse species and grass mixes, including pollinator seeds to increase pollinators, and by creating foraging areas. A more targeted habitat creation is possible around project boundaries, e.g. green corridors for wildlife migration and nesting areas.

- **Introducing** simple **management practices** like **switching from agriculture with pesticide** and **herbicide use to animal grazing** can exponentially increase local biodiversity.

As previously mentioned, introducing monocultures such as energy crops often damages local flora and fauna. These areas usually have a low biological diversity. Hence, the development of solar PV on such sites can bring added environmental value and enhance biodiversity, particularly where developers actively plan for biodiversity and habitat restoration and enhancement.

It is essential to understand the differences between the various types of agricultural land and its importance for biodiversity. Some agricultural lands can host valuable species and be biologically diverse, whereas other agricultural areas like intensive agriculture sites, can negatively affect local ecosystems. Each site has its own specific ecological features and hence should be assessed on a case-by-case basis.

18 Defined by OECD. Source: https://data.oecd.org/agrland/agricultural-land.htm

19 Source: https://www.unep.org/news-and-stories/press-release/our-global-food-system-primary-driver-biodiversity-loss

20 Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

21 Matthew W. Jordon, Pete Smith, Peter R. Long, Paul-Christian Bürkner, Gillian Petrokofsky, Kathy J. Willis, Can Regenerative Agriculture increase national soil carbon stocks? Simulated country-scale adoption of reduced tillage, cover cropping, and ley-arable integration using RothC, Science of The Total Environment, Volume 825,2022,153955. https://doi.org/10.1016/j.scitotenv.2022.153955

KEY RECOMMENDATIONS

- The ecological value of agricultural lands can vary; some may be biologically valuable areas, hosting important local species, whereas others (for example, monocultural crops and grassland pastures), can have low biodiversity. Therefore, site-specific screening needs to be applied to identify potential positive and negative impacts.
- Where agricultural lands have low biological diversity, studies have shown[22] that there is significant potential for solar park developments to enhance flora and fauna. This occurs through the seeding of diverse grasslands and pollinator habitats, planting of native boundary vegetation, and installing habitats such as nesting boxes and hibernacula.[23]
- It is important to engage with landowners and farmers to assess the opportunities for dual-land use practices. Retaining an agricultural use will further minimise potential social-economic land-use conflicts, and may also assist in supporting biodiversity while controlling invasive plant species.
- Alongside biodiversity enhancement and agricultural co-use, there are also opportunities for solar parks to play a role in alleviating water scarcity, and improving soil regeneration and carbon storage.[24, 25]

© TCO Solar.

22 Source: https://helapco.gr/wp-content/uploads/Solar_Farms_Biodiversity_Study.pdf

23 A shelter occupied during the winter by a dormant animal (such as an insect, snake, bat, or marmot). Source: https://www.merriam-webster.com/dictionary/hibernaculum

24 Earth and Space Science Open Archive (ESSOAr) Pickerel, K. (2022, January 25). Solar Power World. https://scholarshare.temple.edu/handle/20.500.12613/7254

25 Hassanpour Adeh E, Selker JS, Higgins CW (2018) Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency. PLoS ONE 13(11): e0203256 https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0203256&type=printable

TABLE 4 EXAMPLES OF INITIATIVES THAT SUPPORT SOLAR DEPLOYMENT ON AGRICULTURAL TYPES OF LAND

Country	Initiative
GERMANY	The newly amended German Renewable Act (EEG 2023) will recognise dual-land use solar projects, including agriPV and floating PV. It will also support the construction of solar sites to restore degraded moorlands used for agricultural purposes. However, the development of floating PV is being curtailed with new restrictions (at least 40 m distance from the shore, maximum 15% usage of a lake's surface).
AUSTRIA	Austria recently passed a federal law called the Renewable Expansion Law (EAG). The legislation contains numerous regulations outlining the provision of state aid for renewable energy projects, including solar-PV projects. Innovative PV systems including agriPV and floating PV systems fall under the scope; they are eligible for a 30% additional investment subsidy. PVs installed on farm and grasslands will receive a 25% deduction of the investment subsidy.
ITALY	The most relevant regulatory advancements for the deployment of solar PV on agricultural land concern agrivoltaics. AgriPV plants have access to funding from the PNRR; €1.1 billion has been allocated. In June 2022, the Italian government published a public consultation outlining eligibility requirements for PNRR funds. For agriPV plants, the following conditions must be fulfilled: ▪ Cultivated land should amount to no less than 70% of the total surface of the project. ▪ The land area occupation ratio by PV panels should not exceed 40%. ▪ The continuity of agricultural and electrical production must be ensured. ▪ Modules should be installed at a minimum height of 2.10 m (1.30 m for livestock farms). ▪ Monitoring systems should be installed to measure the plant's environmental performance and its effect on crops. A law outlining rules to access public incentives and PNRFF funds is due to be published.
FRANCE	Two types of combinations between agriculture and PV energy production are supported by ADEME: ▪ Projects where the PV installation delivers a service for the agricultural activity (*projets agrivoltaïques*). For example, the shading of PV modules protects plants against excessive insulation, reduces their stress during periods of drought, and provides a mechanical protection against hail or strong winds. ▪ Projects where PV provides an added value to the agricultural activity by making specific installations accessible to the farmer (for example, PV panels placed on a greenhouse).

3.1.3. Wetlands

Wetlands are areas that are either covered by water or saturated with water for at least part of the year. Wetlands can be categorised as inland wetlands, which consist of marshes and peat bogs; or coastal wetlands which contain salt marshes, saline, and intertidal flats.

Important to consider:

Naturally occurring wetlands are **the most valuable ecosystems** on the Earth. Wetlands play multiple crucial roles. They can act as a reservoir and absorb excess water, protect coastal areas, and improve air and water quality. In Europe, wetlands cover around 2% of the total land area, and are a significant component of Europe's biodiversity.

These ecosystems are important natural assets as they can absorb atmospheric carbon and store it for a long period of time, providing a natural solution to climate change mitigation. As these **ecosystems are essential nature components**, any project development including **solar PV deployment on natural wetlands should be avoided.**

However, **man-made or artificial wetlands** that are made of concrete and plastic do exist. These types of wetlands **do not host diverse species.** Therefore, these **areas may be suitable for solar PV implementation.** If properly designed, they could in fact increase biodiversity by integrating elements such as nesting and foraging areas, boundary features and other wildlife-inclusive practices.

KEY RECOMMENDATIONS

- Natural wetlands are biodiversity rich areas. PV development in these areas should be avoided, and development of adjacent land should be thoroughly assessed beforehand.
- Man-made, plastic and concrete-based wetlands do not host important wildlife and accordingly, could be used for solar PV deployment.

3.1.4. Forests and semi-natural areas

Forests can be defined as "a large area of land covered with trees and plants, usually larger than a wood, or the trees and plants themselves."[26] Forests and semi-natural areas can be categorised as natural grasslands, moors and heathlands, beaches, dunes, sand plains and more.

Important to consider:

Naturally occurring forests are one of the **most important ecosystems.** In Europe, around 39% of the land is covered with forests; they provide carbon storage, and improve air and water quality. Likewise, semi-natural areas such as **moors, and heathland** are also **an important biodiversity hotspot.** These areas provide homes to a large amount of Europe's flora and fauna. These areas are crucial contributors to carbon storage, flood protection and more.

Given the importance of these areas, **solar PV deployment on such sites must be avoided.** Certain exceptions apply to semi-natural areas that are intensively managed with grazing or mowing and have good management practices in place. It is crucial to recognise the importance of re-establishing healthy and robust biodiversity on sites which have been impacted by human activities.

KEY RECOMMENDATIONS

- Naturally occurring forests are an essential part of the Earth's ecosystem. PV deployment on such lands can be detrimental and therefore should be avoided.
- EIAs and site-specific assessments must be conducted to evaluate the potential of certain intensively managed semi-natural areas that can be used for solar PV projects. Opportunities for biodiversity enhancement should be considered into any such projects.

26 Definition by Cambridge Dictionary. Source: https://dictionary.cambridge.org/dictionary/english/forest

3.1.5. Water bodies

A water body "is a certain clearly distinguishable part of surface water, such as a lake, a stream, river or a part a stream or river."[27] It can be further classified as inland waters, including rivers and lakes; and marine waters, including coastal lagoons, estuaries, and seas and oceans.

Important to consider:

Water plays a key role in sustaining life on the planet, supporting the climate regulation cycle, and is an important resource to the world's economy. Protecting and managing Europe's freshwater and saltwater ecosystems is crucial for the health of our environment, our livelihood and the prosperity of our society and economy. That said, **European marine territories** have **potential for deploying FPV**, and which can contribute to tackling climate change while providing benefits to marine environments. There is **potential for FPV in the artificial lakes** and **reservoirs** that remain unused, or where economic and productive activities can be combined with floating PV. This minimises land competition concerns. However, some water areas can host important species and vegetation. These sites need to be assessed prior to any project deployment. In addition, **strategically placed FPV projects can benefit** from the **existing grid connections** of already installed assets, such as hydroelectric dams or industrial reservoirs. This may prevent additional cabling, and reduce disturbances for the surrounding biodiversity.

One of the environmental benefits that FPV provides is the reduced proliferation of algae and evaporation. **FPV is an adaptive technology** that can be applied in accordance with the site-specific parameters and weather constraints. Floating PV can also be **deployed on poorly managed water sites.**

Nevertheless, each water site has its own ecological characteristics; some sites might host a species-rich environment, whereas other sites might be less biologically diverse. Therefore, site-specific assessments must be conducted. In addition, considerations such as grid-availability and financial costs should be considered.

KEY RECOMMENDATIONS

- Floating PV can improve water quality when properly designed and sited. The use of this solar technology needs to be accelerated. In addition, monitoring and data collection of environmental impacts on these sites, in addition to site-specific pre-construction assessments must be increased and expanded to more types of structures and applications, to have a better understanding of the relevant phenomena.
- Artificial areas such as artificial lakes and reservoirs can potentially be suitable for FPV deployment as little to no impact has been measured on the aquatic environment, based on existing studies.[28] Sites like old quarries have shown an increase in species and fauna counts after the installation of floating PV projects. A proper assessment of the site needs to be applied, especially for more biologically rich water bodies.

27 Source: https://www.eea.europa.eu/archived/archived-content-water-topic/wise-help-centre/faqs/water-body

28 de Lima RLP, Paxinou K, C. Boogaard F, Akkerman O, Lin F-Y. In-Situ Water Quality Observations under a Large-Scale Floating Solar Farm Using Sensors and Underwater Drones. Sustainability. 2021; 13(11):6421. https://doi.org/10.3390/su13116421

KEY RECOMMENDATIONS TO SUPPORT SUITABLE LAND SELECTION FOR SOLAR PV

In identifying areas of potential solar PV deployment – either by individual developers, or government agencies – ecological sensitivity should be included as one of the key considerations for site selection, alongside other factors including grid availability, technical suitability (yield, accessibility etc.). Environmental constraints such as flood risk, natural hazards, and cultural and landscape sensitivity should also be reviewed.

These are then the key recommendations that in the long-term, can facilitate the swift and sustainable deployment of solar PV:

- SEA tool should be applied to assess the available zones for solar PV at a national and regional level. This will help to identify (a) land areas that can be categorised as favourable areas for solar PV deployment; (b) areas that need further assessment; and (c) areas that are strictly protected by national and regional regulations.
- National authorities should strengthen governmental administrations to increase the deployment of RES, in particular solar, and enable effective strategic planning at a national and regional level.
- Appropriate training schemes must be provided for regional and local authorities to facilitate EIA and SEA implementation, and ensure a sufficient understanding of land use and its impacts.
- EIA or site-specific assessment needs to be carried out to identify key impacts, and outline possible mitigation measures for case-specific projects. This will help the identification of appropriate land for solar PV deployment.
- Responsible authorities conducting EIA/SEAs should create stakeholder engagement and facilitate discussions amongst the relevant experts, NGOs and local communities. This is crucial to strengthen the quality, transparency, and integration of decision-making processes.

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4 Best practices

RES accelerated deployment is crucial for reaching climate neutrality. Solar PV will play an important role in decarbonisation and when appropriately sited and designed, can provide significant benefits to local ecosystems. As discussed earlier, solar PV sites should work in synergy with renewable energy deployment and nature conservation practices. Involving relevant stakeholders in the decision-making process from an early-stage and throughout all stages of planning, is crucial. This will facilitate the integration of sustainable solutions to protect and enhance local biodiversity on solar sites.

Well-designed and managed solar PV projects can restore and improve degraded ecosystems. This chapter will focus on providing guidelines that incorporate environmental considerations at different solar PV project steps. This chapter will also outline best practice examples that work towards the restoration of ecosystems, and protecting local flora and fauna.

4.1. Guidelines for environmental integration at different project stages

To ensure sustainable and environmentally friendly PV projects, it is important to implement best practices throughout the lifespan of a solar project, from the plant's design to the decommissioning phase. However, it is crucial to recognise that each site is unique in terms of environment, location, native flora and fauna, and land use practices. Therefore, no 'one size fits all' approach can be applied, and each site needs to be individually assessed to ensure that best ecological considerations are implemented. Environmental factors like soil, noise, water, and air pollution must also be considered. Therefore, consulting a local environmental expert will help to facilitate appropriate management practices in line with environmental considerations. The following guidelines will provide an overview of different solar project phases, and outline key environmental considerations which should be incorporated to protect and preserve local biodiversity.

Project design

- Conduct appropriate base line assessments which evaluate the ecological features of the site.
- Follow a mitigation hierarchy by avoiding adverse impacts through site selection and design, mitigating negative impacts, and restoring and offsetting.
- Prepare a site-specific biodiversity management plan to outline key habitats and mitigation measures, and define restoration and the creation of site habitats.
- Specific environmental considerations:
  - Ensure a permeable fence around the solar PV plant to allow biodiversity movement, especially for smaller animals.
  - Based on the characteristics of local flora and fauna, create suitable habitats on site.
    - For instance, create bird nesting and breeding places, for example, installing bird boxes, creating water habitats for amphibians, etc.

  - Creating habitat areas in the surroundings of solar sites, along the fence and within the parks. This can provide suitable living conditions for the repopulation of a species.
- Plant native wildflower meadows and trees, and create hedgerows, field margins and other nature elements. This can support water transpiration, avoid nutrient run off, and make solar sites more integrated into the local landscape.
  - Creating flower meadows can also increase the pollinator biodiversity onsite and in the adjacent areas. Locally sourced seed mixes should be used.
  - Field margins or buffer stripes can provide favourable conditions for biodiversity enhancements, benefiting plants and different animal species such as invertebrates and ground nesting birds, reptiles, and small mammals. Field margins could be created between 7m to 10m in width.
- Ensure that appropriate space between the module rows is taken into consideration. This can positively influence the number of species and improve population density.
- Ensure that appropriate lighting practices are taken into consideration, for instance, avoid lighting in sensitive wildlife areas, turn off the lights during the night, etc.
- Consider opportunities for dual land use with agriculture (where agricultural land is used), and incorporate into the planning and design of the project.

Project construction[29]

- Maintain a limited speed and number of vehicle movements on site. This can boost the upper soil layer and strengthened vegetation, as well as helping to reduce noise and air pollution (should also be considered during the repowering phase).
- Limit soil sealing. This could be achieved by limiting soil sealing to less than 2%.
- Limit vegetation clearance and land stripping/levelling. A habitat's transformation can affect soil, i.e. compaction of soil, reduced infiltration, increased erosion and nutrient run off, decreased soil activity and loss of organic matter, etc.
- Create water-bound roads only in the PV plant.
- Limit the number of buried cables and earth movement by using the support structures as cable duct when possible.
- Avoid the use of concrete for the support structure.
- Avoid tree and bush clearing when possible and ensure re-planting after construction. It is also a good practice to plant bushes on the northern border of the site. This structures the landscape, provides habitats for many species and acts as a natural screen against strong winds. It is important to only plant local species.
- Avoid spread of invasive alien species on the site. This could be caused by the movement of equipment or human activities on site.
- Ensure the safe disposal of solid and liquid waste during construction works (should also be considered during the repowering phase).
- Install a drainage system to avoid any water-related damages on site, and reduce habitat fragmentation.

Project operation & maintenance

- Avoid the use of herbicides where practicable.
- Introduce grazing management. Under certain conditions grazing may promote biodiversity. It is necessary to pay careful attention to the animal welfare and consider the number of livestock in proportion to the grazing area. Likewise, it is necessary to assess the need for animal shelters and watering places. Local experts should be brought in to find the best approach.
- Consider sustainable water usage during the maintenance of solar modules. It is important to consider alternatives in dry regions. For instance, rainwater collection tanks can be used.

29 For additional information, please see EPC Best Practice Guidelines version 2.0: https://www.solarpowereurope.org/insights/thematic-reports/epc-best-practice-guidelines-version-2-0

- Ensure the maintenance of plants and vegetation, including the vegetation height to avoid shading PV modules.
- Ensure the safe use of solvents and heat-transfer fluids. Similarly, use environmentally friendly cleaning agents in a safe manner to avoid leakage and run-off.

Project decommissioning:

- Limit soil disturbance (i.e., vehicle movement and speed) during the decommissioning process. (*See project installation section*)
- Limit vegetation clearance and land stripping (*See project installation section*)
- Ensure the safe dismantling of panels and electric wires, the safe handling and disposal of hazardous materials, and compliance with legal requirements. Make sure that these components are recycled.
- Ensure the safe disposal of solid and liquid waste during the dismantling of PV installations.

BEST PRACTICE EXAMPLE 2 BayWa r.e.: PV PARK SPITALHÖFE IN GERMANY

Spitalhöfe solar PV park, located in Villingen-Schwenningen, Germany, is one of the first hybrid energy plants in Germany that combines a 7.5 MWp ground-mounted solar plant and a 4 MWh battery storage. This plant was commissioned in May 2022.

Various long-term measures to preserve and promote biodiversity have been integrated. Flowering islands were planted on the site to improve biodiversity, and to increase the number of pollinating insects, e.g., wild bees. The islands have a positive effect on neighbouring agricultural land. They promote insect abundance and secure the food source for many breeding bird species. The project has also incorporated nature-positive elements such as nest boxes, biodiversity corridors that provide paths for wild animals (e.g., deer and wild boars), and habitats for reptiles, small mammals, hedges, and trees. Sheep grazing has also been introduced on site to improve soil health while fertiliser and herbicide use has been restricted.

The project has brought in local nature conservation organisations into the planning and project design process.

BEST PRACTICE EXAMPLE 3 AMARENCO'S PLEDGE FOR REGENERATIVE PROGRAMMES: TO IMPLEMENT NATURE-BASED SOLUTIONS ATTACHED TO SOLAR INFRASTRUCTURES

Amarenco is deploying nature-based solar infrastructures to produce regenerative electrons. In 2021, Amarenco made the pledge to invest in the restoration of natural ecosystems under its stewardship, by improving soil health, biodiversity, and water management and quality. This pledge, called ECHO, consists of a capital allocation and commitment by all of its shareholders of €2 million per GW of projects reaching full completion, followed by €500,000 per GW in operation, invested every year during the lifetime of the plants.

Amarenco is deeply committed to its regenerative vision, and is working with funding partners who share the same vision.

Capital is allocated to two different regenerative initiatives. The first one is called the 'ECHO Portfolio' which is funding solutions dedicated to Amarenco ground-mounted sites, storage sites, and AgriPV plants. These are all based on site-specific programs focusing on micro forestry and soil regeneration. The second one is called 'ECHO Territories' and is funding autonomous regeneration projects which are focusing on regenerative agriculture and agroforestry.

With the objective of providing regenerative electrons through all its plants globally, Amarenco is developing a framework to transform projects' selection, development, construction, and operation.

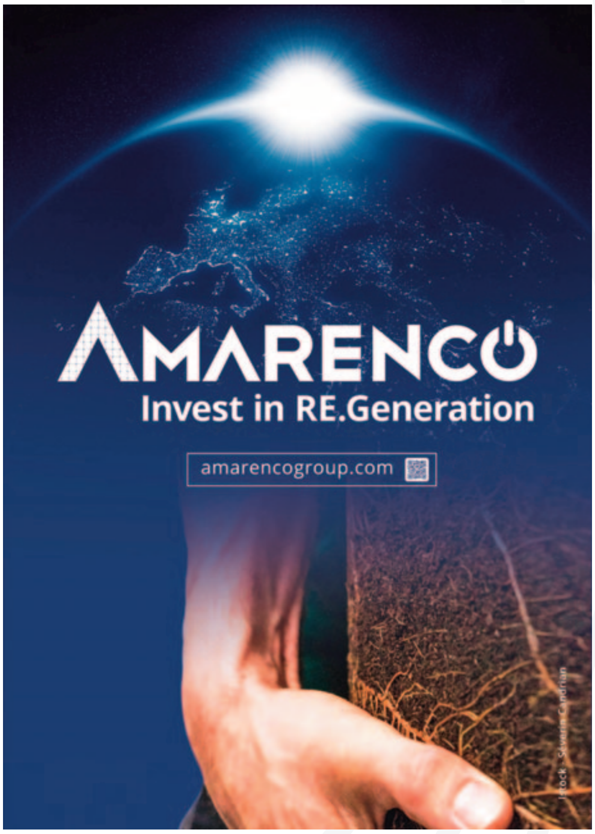
For the 'ECHO Portfolio,' two approaches have been undertaken. The first approach concerns historical sites where a recovery phase will be required post-construction depending on the initial site condition, before a regeneration program creates a more ecological wealth compared to the initial state. The second approach deals with the selection criteria of new sites. This is conducted on the basis of an in-house assessment tool which is systematically applied to the initial site analysis during the origination phase. These conclusions are supported by a matrix comparing the initial ground cover and ecological status with the expected one, once in operation. Only sites complying with the corporate regeneration screening criteria are then selected and developed to deploy solar infrastructures.

Beyond compulsory ecological protection and compensation measures, a technical framework is being developed to identify site-specific actions prioritising soil regeneration. Collaborative relationships with local stakeholders including plant operators, farmers, communities and associations, are considered essential to ensure the deployment of Amarenco's ecological regeneration programmes.

To ensure the success and adaptability of the ecological regeneration programmes, a set of regeneration indicators is being finalised, ensuring progress on:

- Soil Organic Carbon content
- Above ground biodiversity
- Below ground biodiversity
- Soil contamination
- Water infiltration
- Vegetative cover on the site

Amarenco has gathered a community of experts, researchers and associations to build this ambitious programme.



BEST PRACTICE EXAMPLE 4 ENEL GREEN POWER, SUSTAINABLE SOLAR PARK: AN INNOVATIVE AND HOLISTIC CONCEPT

Enel Green Power is developing 'Sustainable Solar Parks,' a global initiative which tests tailor-made agrozootechnical solutions and sustainable practices on different photovoltaic (PV) sites. The company implements biodiversity measures in selected PV sites, including in marginal unused areas. Several demonstrations have occurred in different PV plants, across 5 countries and 3 continents. Enel's programme has been developed for standard PV plants (height of 2.2-2.5 m), to improve their environmental/ecological sustainability and social acceptability. It's intended to create a shift from the concept of Industrial Solar Plants to 'Sustainable Solar Parks.' This innovative vision is focused on multipurpose land use through the harmonisation of photovoltaic energy production, biodiversity preservation, the improvement of ecosystem services, and the integration of agrozootechnical activities. The initiative outlines two main targets:

- *Solar inclusivity*, which focuses on crops, regenerative agriculture and pasture, while ensuring a collaborative multi-stakeholder approach.
- *Solar diversity*, which focuses on safeguarding biodiversity and habitats everywhere while improving overall ecosystem services.

The 'Sustainable Solar Park' concept incorporates agrozootechnical activity integration in PV plants (agrivoltaic concept), in addition to specific measures for safeguarding biodiversity and ecosystems. Consequently, these solar PV plants are both renewable energy generators and biodiversity promoters, as seen with plants in Spain, Greece and Italy.

For example, in Spain, the protection of steppe birds is prioritised, as well as improving soil oxygenation on the site, through the creation of ecological corridors.

In Greece, the creation of biodiversity hot spots within the plant, and around installed PV modules. Wild pollinators, in particular endangered butterflies, are safeguarded on sites.

In Italy, an oasis for bees and other wild pollinators (bumble bees, etc.) with different flower mixes has been designed. In this case, the pollinators are used as biosensors for evaluating the evolution of the ecosystem and soil regeneration over a set period. Another fundamental aspect is the local community's integration, with dedicated training sections for students, young people and families. Moreover, the adoption of high-technology sensors and innovative tools promote more efficient and environmental-friendly practises (i.e. water use reduction) which decrease the stress on the surrounding ecosystems.

BEST PRACTICE EXAMPLE 5 HOLLAND SOLAR: ECOCERTIFIED SOLAR PARKS

Holland Solar, in partnership with Wageningen University & Research and several other parties, are actively involved in an ecological study for solar PV installations. EcoCertified Solar Parks is a project that was initiated in 2021, with a primary objective to develop and implement guidelines for the layout and management of solar parks that guarantee healthy soil and increased biodiversity. The EcoCertified Label will be established in the course of the project and will be up and running by 2025.

The EcoCertified Solar Label will be developed based on extensive research of 20 different solar parks across the Netherlands. The experiments will analyse park management and maintenance practices, and its impact on local biodiversity, including birds and mammals. These tests will also assess overall soil quality, and explore different innovative techniques to assess biodiversity while undergoing a cost-benefit analysis

As part of the project activities, a labelling system will be developed. This scoring system will allow developers, stakeholders and governmental bodies to evaluate solar parks on their overall ecological and environmental merit.

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BEST PRACTICE EXAMPLE 6 BayWa r.e. / GROENLEVEN: BOMHOFSPLAS FLOATING PV PLANT

Bomhofsplas Floating PV plant, located on a sandpit near Zwolle, Netherlands, was commissioned by Groenleven, a Dutch subsidiary branch of BayWa r.e., in March 2020, with a size equivalent to more than 25 football fields and an installed capacity of 27.4 MWp. This amount covers 25% of the water surface and its energy yield is equivalent to the average energy consumption of around 7,800 Dutch households.

Since its construction, the plant has been used to conduct studies of the impact of Floating PV installations on the water quality and ecology of the reservoir. A research team including experts from Dutch research institutes (Hanze University of Applied Sciences Groningen, Deltares, INDYMO) conducted an independent water quality study using several in-water sensors and underwater drones at different depths. The results revealed no major differences in the key water quality parameters below the floating plant.[30] The findings were similar in another study, conducted by Buro Bakker and commissioned by Groenleven in the same location, which showed limited to no variations in the measured water parameters, including the chlorophyll-A content.[31]

To further understand the impact on the water ecosystem, 20 biohuts have been installed at the edges of the floating plant. They function as nurseries protecting small fish from predators and as habitats and spawning grounds for fishes, micro-organisms and invertebrates. The biohuts, provided by the company Ecocean, are monitored for a minimum of 3 years. Already, preliminary results show an increase in the number and diversity of species in the area below the floating PV plant. Different species of fish, vertebrals, mussels and sponges were discovered, with a good balance between predator and prey species.

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30 Lima et al., In-Situ Water Quality Observations, Sustainability, 2021. https://doi.org/10.3390/su13116421

31 Source: Solar Magazine, https://solarmagazine.nl/nieuws-zonne-energie/i24329/onderzoek-drijvende-zonnepanelen-groenleven-waterkwaliteit-blijft-gelijk-voldoende-zuurstof-in-water

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