Biodiversity and Solar – Tackling the Twin Crises

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Introduction – Two Sides of a Coin: Biodiversity and Climate Crisis

The urgent need to reduce our dependence on greenhouse gas (GHG) emission intensive sources of energy is widely recognised. Usually, this is related to climate change mitigation, yet the climate emergency is closely tied to the equally looming biodiversity crisis. The Intergovernmental Panel on Climate Change (IPCC) together with the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) published a joint report highlighting that biodiversity loss, together with climate change, is one of the biggest threats of the Anthropocene[1]. The **twin crises of climate change and biodiversity loss** are inextricably linked in a two-way process: **Climate change is one of the main drivers of the biodiversity crisis, but the loss of ecosystems weakens our planet's capacity to regulate GHG emissions** and defend against extreme weather. As a consequence, climate change is further exacerbated. Nature increasingly lacks the capacity to absorb more negative impacts from our future developments.

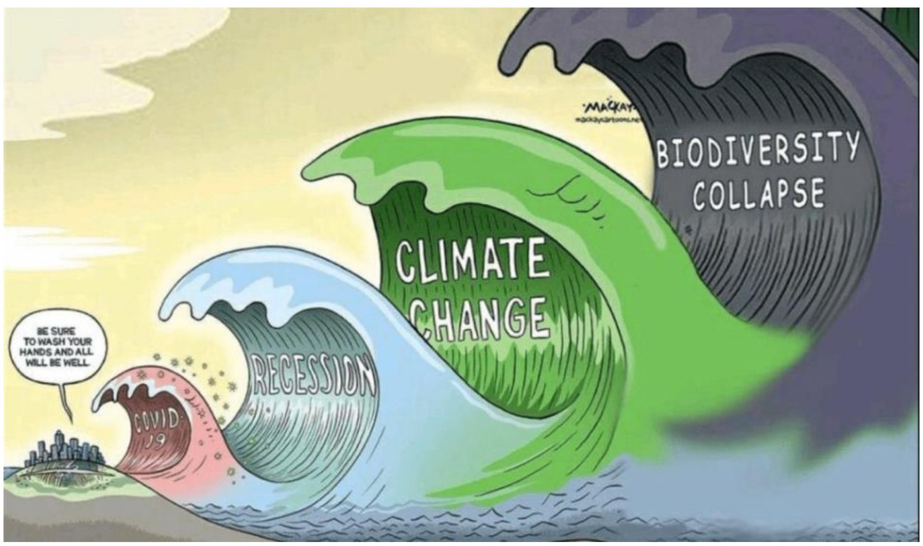

Figure 1: Graeme MacKay's Editorial Cartoon Archive (2020)

Indeed, the World Economic Forum's annual global risk report identified biodiversity loss, besides climate change, as one of the most pressing issues[2]. Maxwell et al. (2016) list overexploitation of species, habitat modification, invasive alien species and disease, and lastly pollution as the main drivers of biodiversity loss next to climate change. This is mirrored by the

[1] https://ipbes.net/sites/default/files/2021-06/20210609_workshop_report_embargo_3pm_CEST_10_june_0.pdf
[2] https://www.weforum.org/reports/the-global-risks-report-2021

five direct drivers of ecosystem change and biodiversity loss reported in the Millennium Ecosystem Assessment[3].

How does the biodiversity crisis manifest? The World Wide Fund for Nature's (WWF) latest Living Planet Report[4] highlights that, on average, the populations of around 4,400 mammals, birds, reptiles, amphibians and fish had **declined by 68% since 1970**. As Figure 2 highlights, this is **not evenly distributed** around the globe, with Latin America and the Caribbean seeing a decline of over 90%. In Ireland, 85% of protected habitats are "in inadequate or poor condition"[5] as well as over 40% of rivers[6].

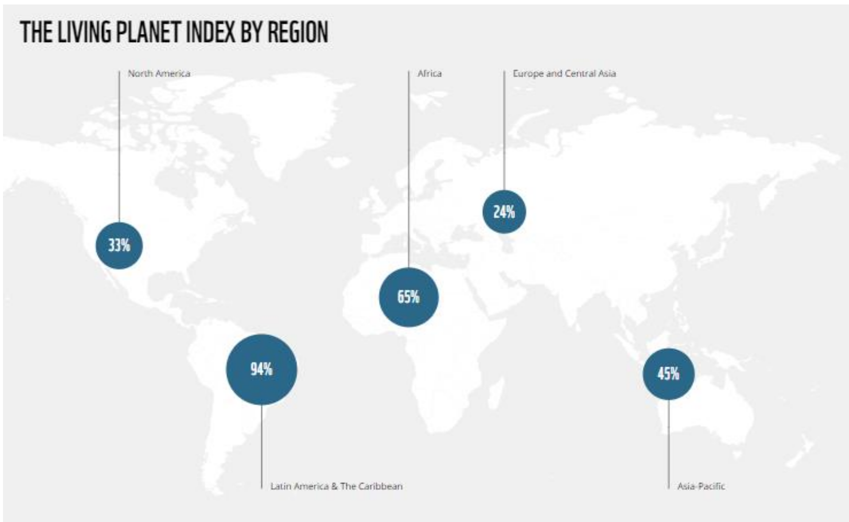

Figure 2: The Living Planet Index by Region (WWF, 2020)

One of the dangerous consequences of biodiversity loss has been most forcefully felt recently: Pandemics. Pandemics are occurring more frequently and will only more so unless preventative strategies are deployed. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) finds that pandemics have the same underlying causes as global environmental changes related to biodiversity loss and climate change - their emergence "is entirely driven by human activities" [7]. Human development is directly linked to the increase in the risk of diseases which then can turn into pandemics. Cutting down forests and moving the frontier of human expansion towards the rural edge is naturally causing the decimation of wildlife and fosters the contact of pathogens, increasing the pool of potential transfers to humans. The disruption of ecosystems and loss of biodiversity directly contributes to the risk of future pandemics and hence the report suggests a shift from pandemic strategies that are designed to control a disease after they break out to preventing its emergence.

[3] https://www.millenniumassessment.org/en/index.html
[4] https://livingplanet.panda.org/en-us/
[5] https://www.npws.ie/publications/article-17-reports
[6] https://www.epa.ie/publications/monitoring--assessment/freshwater--marine/water-quality-in-2020.php
[7] https://ipbes.net/sites/default/files/2020-11/201104_IPBES_Workshop_on_Diversity_and_Pandemics_Executive_Summary_Digital_Version.pdf

Solar energy's role

Through the link to climate change, reducing the combustion of fossil fuels and the related emissions has a positive impact on biodiversity, which is why solar energy can contribute by providing green electricity.

In their report, IPCC and IPBES specifically name options to combine nature-based and technology-based measures for climate change mitigation and adaptation, while contributing to biodiversity. One example listed is grazing underneath solar panels which allows for improving soil carbon stocks. Moreover, cropping associated with solar farms could provide food, and flora and fauna underneath panels can serve as pollinator habitat, thereby further benefiting agricultural land in the vicinity.

Benefits and Potential

Green electricity

First, an assessment of the potential of solar to showcase the tremendous resource it represents: The sun as a renewable resource has the capacity to supply over 2,500 terawatts (TW) of technically accessible energy over large areas of Earth's surface (Nelson, 2003). In fact, Hernandez et al. (2014, p. 767) find that 'solar power technology dwarfs the potential of other renewable energy technologies such as wind- and biomass-derived energy by several orders of magnitude'. Similarly, the World Bank reports that for most countries the potential for green electricity generated from solar photovoltaic (PV) overweighs the current electricity demand[8]. The International Energy Agency (IEA) notes a global solar PV production of nearly 1,000 TWh for 2021 and forecasts a capacity growth of 17%[9].

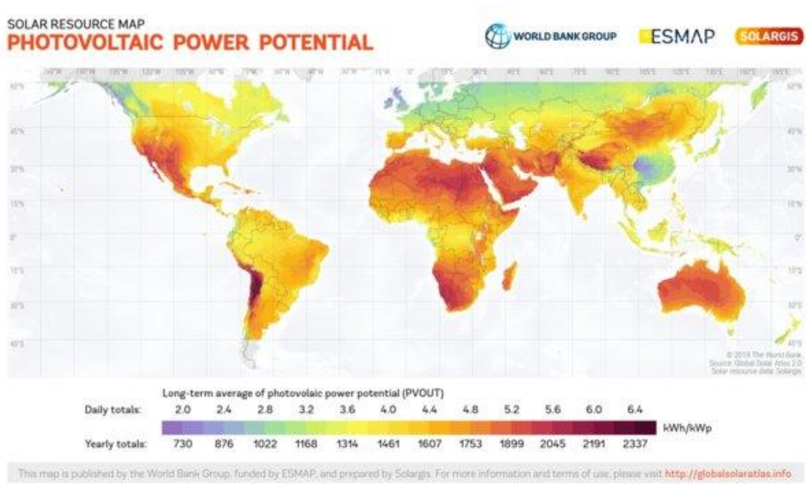

Figure 3: PV Power Potential Map (The World Bank, 2020)

[8] https://www.worldbank.org/en/topic/energy/publication/solar-photovoltaic-power-potential-by-country
[9] https://www.iea.org/fuels-and-technologies/solar

The Sustainable Energy Authority of Ireland (SEAI)[10] offers some illustrating examples for the emerald Island:

- On a sunny day, 1 square meter (sqm) of silicon solar panels will generate around 150 Watt (W) of power, enough to power a laptop computer.
- A home solar PV system sized at 20sqm, equivalent to 3 kW, generates around 2,600kWh of electricity a year, equivalent to over 40% of the average annual electricity demand of an Irish home.

Moreover, solar energy as a technology is no longer cost prohibitive: The IEA goes as far as to say that solar PV is becoming the lowest-cost option for electricity generation in most of the world[11]. The International Renewable Energy Agency (IRENA) reports that costs for electricity from utility-scale solar PV fell 85% between 2010 to 2020. They furthermore state that new solar farms are outcompeting the cheapest (and least sustainable) existing coal plants, estimating that replacing these facilities would save the system 32 billion UDS per year, in addition to reducing emissions by around 3 Gigatonnes of CO_2e annually[12].

Overall, there is more untapped solar energy at low cost waiting to be harnessed than currently being used. Solar PV could therefore be a key driver in our clean energy transition and by this means help to tackle both the climate and the biodiversity crisis.

Other benefits

Besides being a source of clean electricity, solar PV can offer a range of other benefits for biodiversity and ecosystems.

Co-location with agriculture

Co-location generally is a concept of sustainable use of land. So-called ‘agrivoltaic’ systems describe sites that simultaneously host solar PV as well as agriculture. Existing sites combine corn grown for biogas, but also lettuce and tomatoes that flourish under solar panels. Emerging technologies such as semi-transparent PV allow for an even broader range of crops to grow in ‘organic greenhouses’ (Emmott, et al., 2015).

This setting, besides more efficient land use, has benefits both for the solar and agricultural output but also for biodiversity. Depending on the vegetation chosen, it may lower soil temperatures and thereby contribute to increased solar performance. By sheltering the below ground the panels offer protection and climate resilience and by this means provide for what is planted and living below. One common form of co-location is grazing grass, for example

[10] https://www.seai.ie/technologies/solar-energy/electricity-from-solar/
[11] https://www.iea.org/fuels-and-technologies/solar
[12] https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020

accommodating sheep. This has the additional benefit of reducing the frequency of mowing maintenance.

Figure 4: Solar and Animal Grazing (Source: Elgin Energy)

One impressive proven example of agrivoltaics is the 1 GW solar park currently being built by China's Baofeng Group. Based on the already 640 MW which are already grid connected, Huawei, responsible for providing inverters to the site, attest to an improved ecosystem measured in for example the increased count of wild animals such sparrows, hares, and pheasants[13].

Indeed, Hernandez et al. (2014) report anecdotal evidence of birds nesting on the backside of PV module infrastructure as shown in the picture below.

Figure 5: Bird Nests on the Backside of PV Module Infrastructure (Hernandez, et al., 2014)

[13] https://www.pv-magazine.com/magazine-archive/a-unique-position/

Location

In general, any installation integrated into the existing built environment such as rooftop PVs will likely have negligible direct effects that adversely impact biodiversity - solar development can utilize lands that humans have already disturbed. Examples include brownfields, rooftops, abandoned agricultural fields, dry lakes, and even airports. Naturally, project repowering falls into the same category. In all such places, wildlife generally does not flourish. As governments limit the use of agricultural land, alternative locations will increasingly play a role.

One growing application of this is so-called "floatovoltaics": Solar panels floating on water such as canals and human-made reservoirs. Besides using already disturbed land, this further adds the benefit of slowing water loss by evaporation (McKuin, et al., 2021). To again highlight the potential of just this one subsection of solar PV, the US federal government's National Renewable Energy Laboratory (NREL) estimates that floating solar installed on just a fourth of the nation's manmade reservoirs would be able to generate about 10% of U.S. energy needs[14].

Another example is landfill solar sites: Due to their small reuse potential, closed landfill sites come at a very low land cost. This is especially attractive in areas with high deployment or low availability of feasible land. Sites in the vicinity of large cities are perfect candidate: Besides by shortage of land, they also are characterised by high demand for electricity. In the US alone, at the start of 2020 500 MW were already installed[15]. Additionally, there is potential for 63 GW more on existing sites and sites to be closed by 2030 – that's equivalent to the power required to supply 7.8 million homes[16]. Given that landfills tend to be located near lower-income communities, the creation of jobs through site development further adds to social justice goals.

In fact, studies show that when rooftop solar PV is combined with green roofs, they may provide for both plants and insects and hence create habitat and the related ecoservices in urban areas (Gasparatos, et al., 2017).

Ecoservices

Overall, by strategically selecting sites, solar PV has the power to stabilize degraded land. Panels offer protection from rainfall and heat through shading. If the right measures are taken, solar sites may act as prime protected habitats for native plants, bringing back key local species and restoring a native environment. This may entail incorporating pollinator habitat for example by installing pollinator-friendly foliage. Field experiments prove that pollinator-friendly plants even helped lift energy yields by enabling a cooler microclimate which leads to panel efficiency gains. As an additional benefit, it also reduces maintenance costs by decreasing the need for mowing (Moore-O'Leary, et al., 2017). Other ecoservices from pollinator-friendly solar

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[14]https://www.nrel.gov/news/press/2018/nrel-details-great-potential-for-floating-pv-systems.html

[15] https://www.reutersevents.com/renewables/solar-pv/landfill-solar-set-grow-big-projects-sprout-texas?utm_campaign=NEP%20PV%2019JAN22%20Newsletter%20Database&utm_medium=email&utm_source=Eloqua

[16] https://rmi.org/press-release/rmi-projects-a-bright-future-for-landfill-solar/

are more groundwater recharge and a greater cut in soil erosion than either conventional solar or farming (Siegner, et al., 2018). Generally, solar PV sites can provide ecosystem services like stormwater control and carbon storage and sequestration.

Additionally, when designed for this specific purpose, solar PV sites can be used for conservation of short-grass prairie land and serve as wildlife corridors. This refers to the possibility for wild animals to move across lands in order to complete their life cycles – these routes can span distances of some kilometres or entire continents. As the human development frontier expands, these pathways become more critical as refuges for wildlife are key to animal life. However, for a solar site to be part of such a corridor typically requires substantial adjustments to fencing and other built infrastructure.

As with most things, the devil is in the details. Promoting the growth and expansion of certain plant species underneath the solar installation can lead to other species being outcompeted - especially if additionally introduced species are invasive and oust the rarer native species which could tolerate the harsher conditions.

These kinds of nuances call for systemic and structured measurement of actual impact on ecosystems. The following section provides an overview of potentially adverse impacts as well as a framework on how to address them.

Potentially Adverse Impacts

Naturally, any large-scale deployment requires the consideration of land use and how it impacts the ground that is covered. Given that the earth's surface is limited, energy, food, and conservation goals intersect. Hence **resource opportunities, constraints, and trade-offs must be integrated into siting decisions** (Hernandez, et al., 2015).

This also means that planning for installations must factor in proximity to protected areas. A case study in California – one of the solar hot spot states – finds that PV plants are located an average of 7km away from protected areas (Hernandez, et al., 2015). Relatedly, the International Union for Conservation of Nature (IUCN) find that around 17% of large-scale renewable energy is operating within boundaries of important conservation areas[17].

Since the beginning of solar as a clean source of energy, reviews on environmental impact of its deployment were subject to scrutiny, see for example Harte & Jassby (1978). **Looking at all the life-cycle stages**, both upstream and downstream, associated with the development is of utmost importance here. The previous thought piece of this series looked at downstream recycling considerations. On the upstream part of the value chain, mining supply chain issues are one material factor to mention. The IPCC and IPBES report stresses that especially renewable energies in the transport and energy sector are important options for mitigating climate change but currently rely on mining for minerals on land and in the ocean. Prominent

[17] https://www.iucn.org/renewables-and-biodiversity

examples are rare-earth metals used in wind turbines, electric car motors and batteries (Sonter, et al., 2020).

Hernandez et al. (2014) provide an extensive overview of possible adverse impacts from solar energy, visualized in Figure 6.

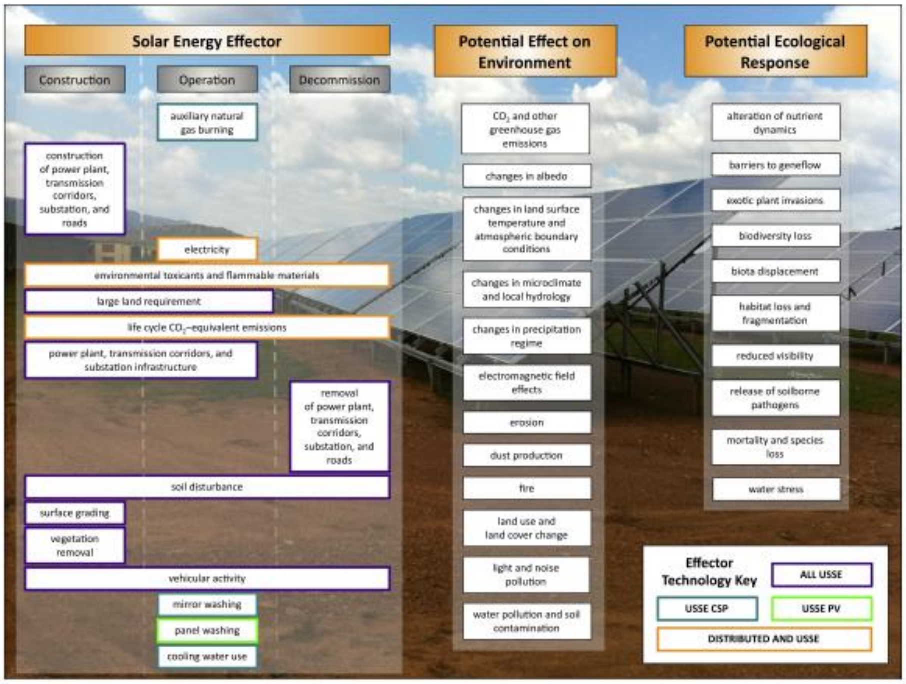

Figure 6: Solar Energy Effectors for Utility-Scale Solar Energy Technologies (Hernandez, et al., 2014)

A full life cycle assessment must scrutinize direct, indirect, and regional effects on biodiversity. As visualized in the above figure this starts from construction, including supply chain, through operation to decommissioning of the site. On the potential impact side, effects on the environment and ecological response can be differentiated.

The actual impact is highly project specific – from worst case eroding a biodiverse untouched forest to using already disturbed, otherwise unusable landfill. It also differs between different renewable energy technologies: The International Union for Conservation of Nature (IUCN) states that compared to wind energy developments, there is currently limited scientific evidence of the impacts from solar developments on biodiversity and ecosystem service[18].

In fact, studies quantifying the direct impact of solar PV on biodiversity in otherwise undisturbed habitats are few as this for obvious reasons is the least preferred option (Chock, et al., 2021). Generally, research coverage is far better for North America and Europe, yet many tropical regions - prime biodiversity areas - have ambitious renewable energy expansion plans[18]. This gap in research needs to be addressed so that biodiversity impacts risk does not outweigh the biodiversity benefits of climate mitigation from renewable energy.

[18] https://portals.iucn.org/library/sites/library/files/documents/2021-004-En.pdf

Moore-O'Leary et al. (2017) discuss five critical ecological concepts which apply to utility-scale solar energy (USSE) in order to be truly sustainable:

Concept 1: **USSE exists within the land-energy-ecology nexus**

This is to say that the development of USSE needs to balance trade-offs between the physical landscape where the site is located, the energy production and development facilities, and habitats and their organisms in the given environment.

Concept 2: **There are "Winner" and "Loser" species in USSE ecosystems**

Naturally, each species responds differently to habitat modification induced by USSE development. Some animals may benefit from prey attracted by the disturbance; others may find shelter in fenced sites.

Concept 3: **Cumulative and large-scale environmental impacts require careful consideration and planning**

The aggregation of especially larger projects within an area creates an additional layer of complexity and makes it more challenging to mitigate any potential adverse impacts. Clustering of development occurs naturally in predestined regions with for example high irradiation. Considering a site's position within existing and future development hence is a key part of early screening processes and should be factored in during location decision making.

Concept 4: **USSE ecological commonalities and idiosyncrasies**

While all USSE projects share some benefits and potential impacts – generation of clean electricity and need to control for invasive species to name some – each site has its individual features that require case by case solutions. As different types of ecosystems are affected customized design and management strategies are vital.

Concept 5: **The long-term ecological consequences of USSE sites are unknown**

It cannot be stressed enough that all life stages matter, including the long-term ecological consequences. A life-cycle assessment includes decommissioning, dismantling, recycling and repurposing or restoring. Given the relatively recent boom of larger scale sites and the advancement of technology in combination with longer project lifetimes, there is very little data and peer-reviewed research on the end-of-life stage of USSE installations.

Advancing solar in the way we need for it to be a key driver of the transition of our energy systems in a way that is sustainable and compatible with conservation goals necessitates coordination by research, industry, developers and also policymakers. The next section is looking into regulations related to biodiversity and solar.

Regulation

Published in May 2020, the EU Biodiversity Strategy for 2030[19] follows the credo "Bringing nature back into our lives". Reflecting on the current pandemic, it emphasizes the **links between our own health and the health of ecosystems**. It recognises the role climate change plays and specifically addresses the energy system as a key component of climate neutrality. Solar panels are specifically prioritised in this context, as a "*Win-Win solution for energy generation*" because they can provide biodiversity-friendly soil cover.

Solar power is a source of renewable energy and can provide green electricity. We will need more sustainably sourced renewable energy in our fight against climate change and related biodiversity loss. It is in the interest of scientists, solar energy developers, land managers, and policymakers to understand the environmental impacts – both beneficial and adverse – of any energy source to decide how and where to deploy it. Every economic activity will potentially generate adverse environmental or social side effects or unintended consequences.

That's why the **EU Taxonomy for sustainable activities looks at six environmental objectives all equally weighted**, when setting Do No Significant Harm (DNSH) criteria, as visualized in Figure 7. These need to be passed by any activity that wants to be labelled sustainable by substantially contributing (SC) to one of these objectives. Biodiversity is one of the 6 objectives, which means that a substantial contribution to biodiversity qualifies to be Taxonomy-aligned. It also means that any activity wanting to qualify through another objective, such as climate change mitigation, must pass the minimum thresholds set by DNSH criteria on biodiversity.

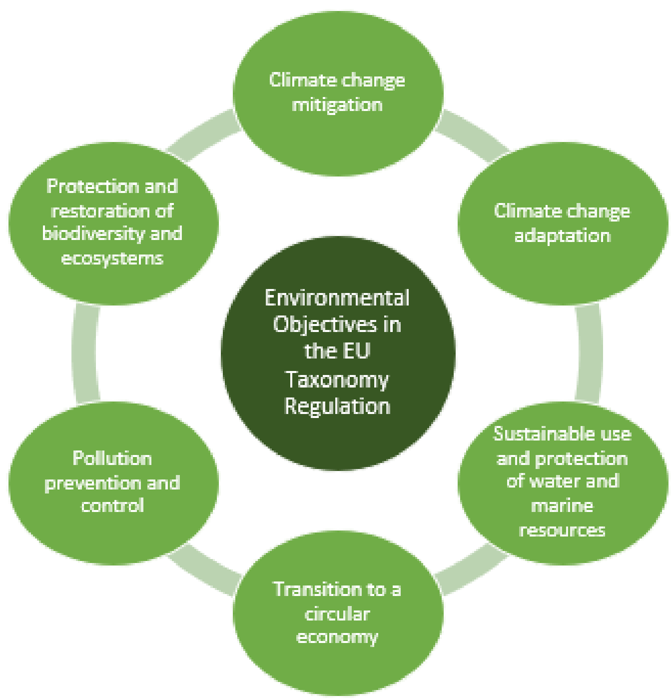

Figure 7: Six Environmental Objectives of the EU Taxonomy

[19] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590574123338&uri=CELEX:52020DC0380

Specifically, the general DNSH criteria on biodiversity as set in the Climate Delegated Act[20] require an Environmental Impact Assessment (EIA) as outlined below:

"An Environmental Impact Assessment (EIA) or screening has been completed in accordance with Directive 2011/92/EU. Where an EIA has been carried out, the required mitigation and compensation measures for protecting the environment are implemented. For sites/operations located in or near biodiversity-sensitive areas (including the Natura 2000 network of protected areas, UNESCO World Heritage sites and Key Biodiversity Areas, as well as other protected areas), an appropriate assessment, where applicable, has been conducted and based on its conclusions the necessary mitigation measures are implemented."

L 442/143, Appendix D, Generic Criteria for DNSH to protection and restoration of biodiversity and ecosystems.

Other initiatives

Pollinator-friendly solar is the practice of planting native grasses and wildflowers as part of a solar development and constitutes one approach to cultivating additional land use benefits from solar projects. In the US, 15 states now have pollinator-friendly solar scorecard. The annex includes the North Carolina Solar Site Pollinator Habitat Planning and Assessment Form. Other states use the scorecards as published by their neighbours. Only in the Southwest extreme heat and limited water resources leave it difficult to cover the ground with pollinator-friendly vegetation. Figure 8 visualizes the geographical distribution of pollinator scorecards.

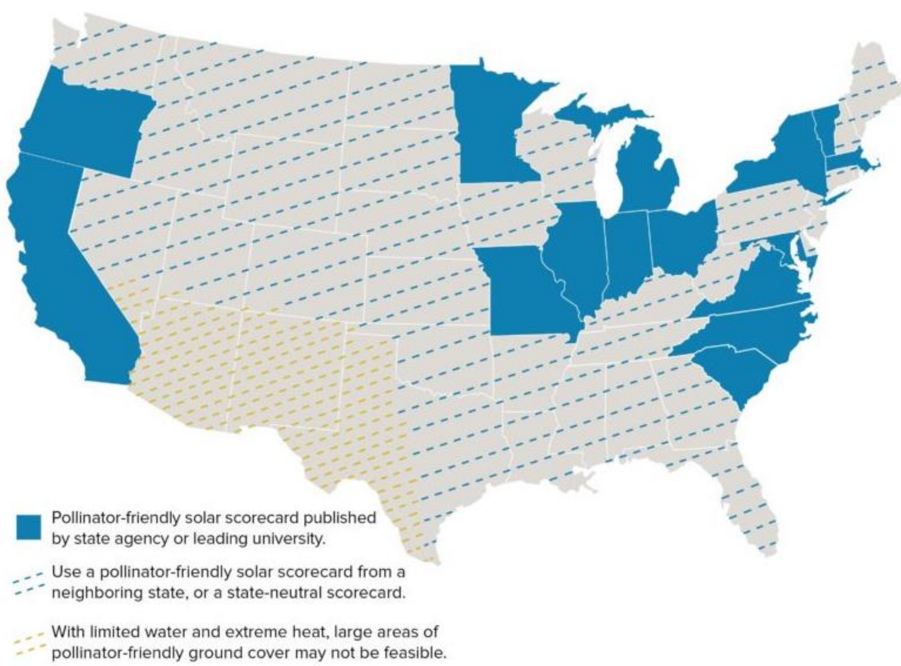

Figure 8: Map of Pollinator Scorecards in the US [Fresh Energy, 2022]

[20] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R2139&from=EN

Mitigation Hierarchy

In the energy sector a framework commonly applied when tackling negative impacts on biodiversity is the mitigation hierarchy (Arlidge, et al., 2018). Like net zero pledges in climate change mitigation, targets typically refer to net neutral goals in biodiversity. So rather than completely abating all impacts, last remaining negative effects are compensated so that in sum ("net") the undertaking is neutral. The hierarchy itself is set as follows:

1. Avoid
2. Minimize
3. Remediate
4. Offset

Within the first level, screening for risks pre project development and considering alternative locations are key. Once a site is selected, in the subsequent development phase, impacts are minimized. This may entail applying the most sustainable construction methods and materials but also 'post-siting' compliance measures to minimize biodiversity impacts like land acquisition and road fencing. Additionally, in the third level, any loss that occurred is remediated. Possible techniques revolve around reseeding and breeding programmes. Lastly, for anything not addressed by through the first three levels, an offset can be achieved by introducing biodiversity enhancement programmes elsewhere. This could entail restoration programmes but there's also innovative solutions to circumvent possible drawbacks. Examples are repatriation and translocation programs. This describes the process of individuals of native species being collected from the impacted habitat, moved, and released into reserve areas. However, research notes low success rates of repatriation and translocation programs (Hernandez, et al., 2014). Moreover, they are expensive and usually target a single species, yet species such as birds cannot be moved. This further reinforces that this last level should only be explored when all other mitigation options are unavailable.

Table 1 from Arlidge et al. (2018) further elaborates on conceivable tools of the different mitigation hierarchy steps. The authors list a range of challenges related to the application of the mitigation hierarchy such as additionality, compliance and monitoring, biodiversity indicators, equivalency, least cost, longevity, multipliers, substantiality, reversibility, thresholds, and time lag.

Just as with climate change mitigation, **special scrutiny should be applied whenever considering offsets**. In the UN's Decade of Action[21], **the focus really should be on avoidance** (abatement).

[21] https://www.un.org/sustainabledevelopment/decade-of-action/

Mitigation-hierarchy step	Examples of existing conservation tools and approaches
Avoid	Protected areas[†]; Alliance for Zero Extinction sites; Key Biodiversity Areas; no development in Vulnerable Marine Ecosystems (FAO vulnerable ecosystems) or critical habitat (International Finance Corporation PS6+); no damage to any listed threatened species or ecosystems (IUCN Red List of threatened species and ecosystems; national conservation list species); no damage to intact habitat, UNESCO World Heritage Sites, or Wilderness Areas.
Minimize	Sustainable use; agrienvironment schemes; shift from passive nonselective gear to actively targeted gear in fisheries; multiuse protected areas; payment for ecosystem services; demand reduction; certification and ecolabeling; economic incentives (market prices, taxes, subsidies, and other signals); green infrastructure; corporate environmental strategies and operations; maintenance of ecosystem resilience.
Remediate	Rewilding[†]; restoration[†]; natural flooding of wetlands[†]; artificial habitat creation[†]; deextinction.
Offset	Degraded ecosystem restoration away from impact site[†]; averted risk; reseeding or respawning[†]; captive breeding; invasive removal; species creation.

Table 1: Tools within the Mitigation Hierarchy (Arlidge, et al., 2018)

† Conservation tool or action that can shift between steps of the mitigation hierarchy depending on (a) whether the biodiversity baseline is set at a present-day or historic point in time and (b) what national and regional legislation is in place to enforce the action taken.

How the mitigation hierarchy can be applied in practice by project developers in the solar and wind sector in is addressed in the International **Union for Conservation of Nature's (IUCN) 2021 guidelines**[22]. These list strategic-level planning and early identification of risks through screening as key tools and stress the importance of avoiding high sensitivity areas for biodiversity to meet regulatory obligations and align with investor standards and stakeholder expectations. The guidelines cover all phases of a project, from inception to end-of-life and

[22] https://portals.iucn.org/library/node/49283

gives detailed measures for each of the level of the mitigation hierarchy. The summary table of their recommendations can be found below.

Project phase	Mitigation hierarchy	Approach
Project design phase	Avoidance and minimisation	Micro-siting: changing the layout of project infrastructure to avoid sensitive areas Re-routing, marking or burying powerlines to avoid collision risks and barrier effects
Construction phase	Avoidance	Scheduling: changing the timing of construction activities to avoid disturbing biodiversity during sensitive periods
	Minimisation	Abatement controls to reduce emissions and pollutants (noise, erosion, waste) created during construction Operational controls to manage and regulate contractor activity, such as exclusion of fencing around sensitive areas, designated machinery and lay-down areas, minimising vegetation loss and disturbance to soil
	Restoration and rehabilitation	Repair of degradation or damage to biodiversity features and ecosystem services from project-related impacts that cannot be completely avoided and/or minimised by revegetating of temporary-use and lay down areas as soon as reasonably practicable after construction activities are complete
Operational phase	Minimisation	Physical controls involving modification to infrastructure, or its operation, to reduce impacts (e.g. modifications to solar technology and their associated foundations, implementing dry or hybrid cooling systems rather than wet cooling systems, and modifying security perimeter fencing and overhead transmission lines) Abatement controls including wastewater management and water conservation measures at CSP facilities) Operational controls to manage and regulate contractor activity such as managing the timing of vegetation control activities at suitable intervals)
End-of-life	Avoidance	Scheduling: changing the timing of decommissioning activities to avoid disturbing biodiversity during sensitive periods (e.g. during breeding seasons)
	Minimisation	Abatement controls to reduce emissions and pollutants (noise, erosion, waste) during decommissioning and repowering Operational controls to manage and regulate contractor activity through, for example, exclusion fencing around sensitive areas, designated machinery and lay-down areas)
	Restoration and rehabilitation	Repair of degradation or damage to biodiversity features and ecosystem services from project-related impacts that cannot be completely avoided and/or minimised by revegetating temporary-use and lay down areas as soon as reasonably practicable after construction activities are complete Reinstatement of original vegetation, as far as feasible, following decommissioning

Table 2: Summary of mitigation approaches for solar power projects (IUCN, 2021)

Conclusion

Among the most pressing issues of the Anthropocene are the twin crises of climate change and biodiversity loss, intrinsically linked. In order for solar energy to not only constitute a renewable source of energy but to provide truly sustainable electricity, biodiversity considerations must be paid close attention to. There is consensus that the consideration of impacts on ecosystems from early phases and throughout all stages of a project’s lifecycle are key. Mitigation must be favoured over offsetting; a wide range of tools is available to avoid and address potential adverse impacts.

When developed responsibly, solar can provide a valuable contribution to biodiversity protection. Not only can adverse impacts be avoided or mitigated but positive benefits can be accrued, and solar energy can help preserve and restore ecosystems.

We need to move from addressing our planetary crises one at a time to a comprehensive solution, which considers nature and climate as two sides of the same coin. Narrowly focused actions towards climate change mitigation may ultimately harm biodiversity and vice versa, yet when thoroughly considered synergies can be realized which enables us to maximize benefits and meet global development goals. By investing in nature, we allow for healthier people.

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Appendix

North Carolina Solar Site Pollinator Habitat Planning and Assessment Form

1. Planned Native Flowering Plant Diversity in Buffer Areas (species with more than 1% cover)
- ☐ 5-10 flowering species +5 pts
- ☐ 10-15 flowering species +8 pts
- ☐ 16-20 flowering species +10 pts
- ☐ >20 flowering species +15 pts

2. Planned Native Grass Diversity in Buffer Areas
- ☐ 2 species +2 pts
- ☐ 3 or more species +5 pts

3. Planned Native (or Naturalized) Plant Diversity in Rows and Under Solar Array*
- ☐ 1-3 species +5 pts
- ☐ 4-6 species +8 pts
- ☐ More than 7 species +10 pts

4. Planned Percent of Site Dominated by Native Plant Species**
- ☐ 0-10% 0 pts
- ☐ 11- 40 % +5 pts
- ☐ 41-70 % +10 pt
- ☐ More than 70% +15 pts

5. Seasons with at Least Three Blooming Species Present (check all that apply)
- ☐ Spring (March-May) +5 pts
- ☐ Summer (June-August) +5 pts
- ☐ Fall (September-November) +5 pts

6. Site Preparation Prior to Implementation
- ☐ Measures taken to control weeds prior to seeding +5 pts
- ☐ None -10 pts

7. Observed Habitat Components Within 0.25 Miles (check all that apply)
- ☐ Native bunch grass for bee nesting +1 pt
- ☐ Native trees/shrubs for bee nesting +1 pt
- ☐ Clean, perennial water sources +1 pt
- ☐ Created nesting habitat features +2 pts

(please see NC Technical Guidance for Native Plantings on Solar Sites)

8. Site Planning and Management (check all that apply)
- ☐ Detailed establishment and management plan +10 pts
- ☐ Mowing occurs only after August 15, and before spring each year +5 pts
- ☐ Signage legible at forty or more feet stating pollinator-friendly solar habitat +3 pts

9. Insecticide Risk
- ☐ Planned on-site use of insecticide or pre-planting seed/plant treatment (excluding buildings/electrical boxes, etc) -40 pts
- ☐ Communication/registration with local chemical applicators or on www.fieldwatch.com to prevent drift +5 pts

10. Planned Native Hedgerow/Screening Area (check all that apply)
- ☐ At least 50% of hedgerow/screen will be planted with flowering plant species +5 pts
- ☐ At least 50% of hedgerow/screen will be planted with native plant species +5 pts
- ☐ Hedgerow/screen will be a minimum of 30 feet wide +10 pts

11. EXTRA CREDIT (check all that apply)
- ☐ Forested stream and wetland buffers of 100 and 50 feet, respectively, are observed +10 pts
- ☐ Install permeable fencing that allows wildlife passage +10 pts
- ☐ Install bird boxes (one box/half acre) +5 pts

(please see NC Technical Guidance for Native Plantings on Solar Sites)

TOTAL POINTS: ____________

Provides Exceptional Habitat	**85 and higher**
Meets Pollinator Standards	**70 – 84**

- ☐ NEW
- ☐ RETROFIT

Owner:______________________________
Vegetation Consultant: ________________
Project Location: ____________________
Seed Supplier:_______________________
Project Size (acres): __________________
Target Seeding Date: _________________

** For the array seeding, these can be a short-stature wildflower mix or clovers and other non-native, naturalized species beneficial to pollinators. If clovers are used, these should be seeded in locations separate from the native wildflowers in the perimeter/buffer locations.*

***Measurements of percent cover should be based on the percent of the ground surface covered by foliage as viewed from above. To measure cover diversity, it is recommended to use plots, and/or transects for accurate measurements.*