Renews Special
Issue 45 / December 2010

Background information
from the German Renewable Energies Agency

Solar parks – Opportunities for Biodiversity

A report on biodiversity in and around ground-mounted photovoltaic plants

www.renewables-in-germany.com

Renewable Energies Agency

The Renewable Energies Agency (AEE) is an official partner of the International Year of Biodiversity 2010.

Author:
Dr Tim Peschel

Editors:
Nils Boenigk
Benjamin Dannemann
December 2010

Published by:
German Renewable
Energies Agency
Reinhardtstrasse 18
10117 Berlin
Tel.: +49 30 200535 3
Fax: +49 30 200535 51
kontakt@unendlich-viel-energie.de

ISSN 2190-3581

Patron:
"Germany has endless energy"
Prof. Klaus Töpfer

Supporting bodies:
German Renewable Energy Federation (BEE)
German Solar Industry Association (BSW-Solar)
German WindEnergy Association (BWE)
German Geothermal Association (GtV-BV)
German Bioenergy Association (BBE)
German Biogas Association
German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
German Federal Ministry of Food, Agriculture and Consumer Protection

Background to the Biodiversity Project:
The project on which this Renews Special is based was initiated by First Solar at the beginning of 2010. Coinciding with the "International Year of Biodiversity", the aim of this project was to analyse current knowledge about the impacts of solar parks on biological diversity and to assess measures designed to conserve or promote biodiversity. The Renewable Energies Agency and its partners collected data over the course of the year, which was compiled in a status report by Dr Tim Peschel. Experts from the fields of planning, project development, renewable energies and nature conservation provided specialist assistance. This English Renews Special is a translation of the original German version.

Content advisors:
- Nadine Bethge, First Solar GmbH
- Dr Dieter Günnewig, Bosch & Partner GmbH
- Jörg Mayer, Renewable Energies Agency
- Tim Meyer, Gehrlicher Solar AG
- Dr Tim Peschel, Büro Peschel Ökologie & Umwelt (author and head of the panel of experts)
- Dr Nicole Schrader, Deutsche Umwelthilfe
- Fabian Zuber, First Solar GmbH

Biodiversity Project partners:
- Beck Energy GmbH / BELECTRIC
- German Solar Industry Association (BSW)
- COLEXON Energy AG
- Conergy AG
- First Solar GmbH
- City of Fürth - Office of Environmental Planning, Waste Management and Urban Forests
- Gehrlicher Solar AG
- juwi Group
- Phoenix Solar AG
- S.G.N. GmbH

www.renewables-in-germany.com

Contents

Foreword

Dear Reader,

Renewable energies are the future and are vital for the implementation of a successful climate protection strategy. However, the rapid expansion of renewables, including solar energy, also entails a change in land use. This has impacts on biodiversity and on the appearance of our countryside. Increasingly, land in rural areas is being used to build solar parks.

The impacts of ecologically significant processes within solar parks have so far not been in the focus of scientists, planners and the renewables industry, and the few existing research findings are largely unknown. It is time, therefore, to assess the extent to which solar parks can contribute to the conservation and protection of species – and to publicise the results.

Biodiversity is an emotive subject. We are more aware now than ever before that we have a special responsibility towards our ecosystems. Ecosystems form the fundamental basis of human life. Therefore, we must all manage our resources carefully and make an effort to protect species diversity and to conserve it over the long term.

The publication of this report, which deals with the topic of solar parks as 'biodiversity multipliers', coincides with the end of the International Year of Biodiversity. The project produced some interesting results. It appears that natural diversity can be re-established following the construction of a solar park. Climate protection and the protection of species can go hand in hand.

I shall, therefore, expressly welcome any continued obligation for long-term monitoring of the impacts of solar parks on open spaces in the future.

I am delighted that the first publication of this kind has been produced in a collaborative, innovative process between science, associations, environmental organizations and industry.

Rainer Baake,
Managing Director Deutsche Umwelthilfe (DUH)

What do solar parks have to do with biodiversity?

The expansion of renewable energies has exceeded all expectations. In the future, solar parks will play an increasingly important role in power generation in Germany and the rest of the world. This expansion is focusing attention on the land requirements of solar plants and the associated ecological aspects. This report documents current knowledge on the subject of solar parks and biodiversity. It clearly shows that, as well as making an important contribution to future energy supplies, solar parks can also provide a refuge for plants and animals.

The first part of this Renews Special summarizes the findings to date. The second part focuses on recommendations based on industry experience. With the right measures in place, solar parks can promote and conserve biodiversity. This report presents positive examples of how existing synergies between solar parks and nature conservation can be exploited or improved based on the different categories of land used for solar parks (e.g. arable land and brownfield sites). These accounts are the result of a project that started in 2010 with the aim of compiling the status of existing research at national and local level and publicising it in a structured format. As well as analysing existing literature, the project examined in detail the conservation measures employed during the planning, construction and operation of solar parks all over Germany. Where possible, an assessment is given of the impacts of the solar plants on biodiversity, following site visits and evaluations of ongoing long-term studies.

This background paper is for information purposes. It is also intended to pre-empt conflicts that might stand in the way of a further expansion of solar parks in Germany and the rest of the world. The conscious selection of suitable sites and the employment of measures to optimize ground-mounted solar installations from a nature conservation perspective can help conserve and even promote biodiversity. Involving local experts increases the chance of conservation aspects being considered in good time and can therefore simplify project completion considerably, creating an opportunity to combine climate protection and nature conservation. This will increase acceptance for the further expansion of solar parks and renewable energies.

What is biodiversity?

Butterflies, like the common blue, which is protected under German law, find refuge on the open and semi-open spaces of solar parks. (Photo: Tim Peschel)

Biodiversity is the variety of plant and animal life. The core element of biodiversity is species diversity. However, biodiversity also includes other levels of nature and the living things that make up the natural world. It includes ecosystems and life communities, and the genetic diversity that is usually invisible to the naked eye. So biodiversity means far more than the number of species.

In order to draw attention to the immense loss of diversity among plants and animals, 2010 was declared by the United Nations to be the International Year of Biodiversity. The background to this was the Convention on Biological Diversity (CBD) adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. It has since been signed and ratified by 193 states. The signatory states have an obligation under international law to transpose the provisions of the convention into national law.

The convention has three objectives:

- to protect biological diversity in all its forms
- to use its components sustainably, and
- to recognise a fair distribution of the benefits arising from the use of its genetic resources.

http://www.cbd.int/convention/

1. Solar parks – Electricity from nature

1.1. Biodiversity: The significance of solar parks for nature conservation

Habitat destruction is without a doubt one of the main causes of the ongoing dramatic loss of biological diversity. However, land use also has an impact on species diversity. In other words, diversity of land use can promote a diversity of species. This is why nature conservation attaches great importance to conserving the traditional European agricultural landscape with its rich diversity of habitats and species. Conservation by no means excludes exploitation. With this in mind, one of the objectives of the Convention on Biological Diversity is therefore to harmonize economic and ecological aspects.

Solar parks can provide habitats for many animal and plant species that are increasingly at risk of decline in today's agricultural landscape. (Photo: BELECTRIC)

Small-scale farming of agricultural areas over the years has gradually created varied habitats for numerous different species. From a nature conservation perspective, it is not just the type of land use that matters, but also its degree of permanence. The survival of many animal and plant species depends on regular maintenance of their habitats. By converting arable or landfill sites into solar parks, it is possible to create areas of grassland, for instance. Cutting the grass regularly creates optimum habitats for many plants and animals. Sheep grazing or mowing are options frequently considered. This gentle, extensive form of site maintenance can create valuable, species-rich habitats of the kind currently in danger of disappearing either through the increasing use of monocropping or because of a lack of maintenance.

Photovoltaic modules in solar parks can be integrated into a wide range of landscapes without dominating them. (Photo: Renewable Energies Agency)

As a land user, the solar industry now has two opportunities to help promote and conserve biological diversity. First, through careful use of environmentally sensitive, species-rich habitats, it can reduce or avoid detrimental effects on biological diversity. Second, by changing the use of e.g. intensively farmed land or brownfield sites, it can in some circumstances improve a site's ecological value considerably. In this way, solar parks can make a valuable contribution to the promotion of biodiversity, as well as producing clean energy. This shows that it is possible to exploit synergies between climate protection and nature conservation.

Solar parks provide ideal conditions for the development of species-rich grasslands. (Photo: Gehrlicher Solar AG)

Solar parks in Germany –
A part of the energy revolution

Numerous solar parks of various sizes have been built across Germany in recent years. The solar plants chosen as examples for this Biodiversity Project have been built on different types of site – some on agricultural sites, some on landfill sites and some on brownfield sites.

53 MWp

162 ha brownfield site

Wealthcap solar park Lieberose
juwi Group, First Solar GmbH, Procon GmbH,
completed 2009

332 kWp

1.6 ha roof

Berlin-Tegel waterworks solar plant
Solargruppe Nord (S.G.N.),
completed 2009

1 MWp

3.8 ha arable site

Salmdorf solar park
Gehrlicher Solar AG,
completed 2007

1.88 MWp

1.8 ha modules on 7 ha arable site

Sulzemoos solar park
Phoenix Solar AG,
completed 2007

1.67 MWp

9 ha farmland

Haunsfeld solar park
Colexon Energy AG,
completed 2008

25.4 MWp

83 ha arable site

Lauingen solar park
Gehrlicher Solar AG,
completed 2010

40 MWp

110 ha brownfield site

Waldpolenz solar park
juwi Group,
completed 2008

1 MWp

0.8 ha former landfill site

Fürth-Atzenhof solar park
City of Fürth,
completed 2004

1.2 MWp

4.8 ha arable site

Schneeberger Hof solar park
juwi Group,
completed 2007

20.5 MWp

65 ha arable and brownfield site

Rothenburg solar park
Gehrlicher Solar AG,
completed 2007

4.2 MWp

15 ha arable site

Hörup solar park
Conergy AG,
completed 2009

www.renewables-in-germany.com

1.2. Solar parks and land consumption in Germany

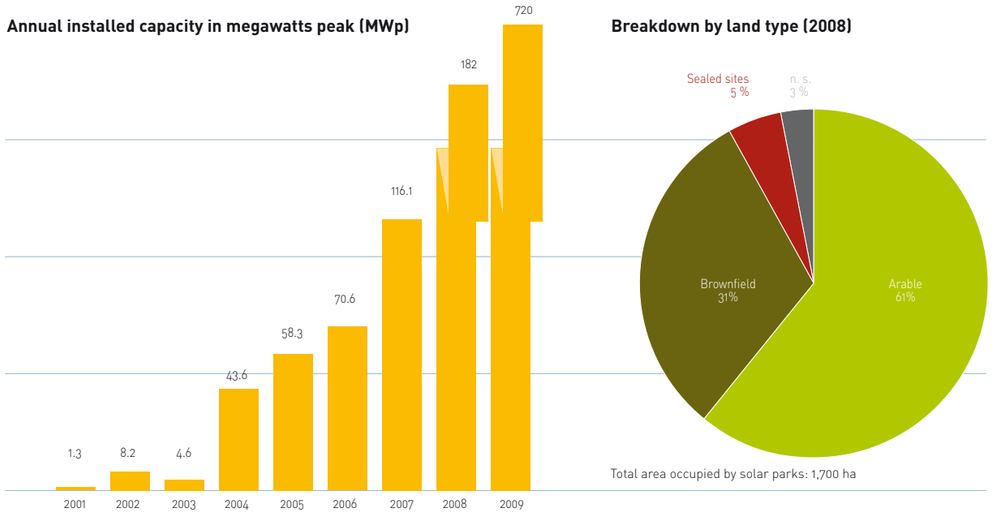
Even with an ambitious expansion programme, by 2020, solar parks will occupy only 0.04 per cent of the total land area of Germany. (Photo: Gehrlicher Solar AG)

The area of land used for agriculture in Germany is around 18.8 million hectares, accounting for approximately 53 per cent of Germany's total land area. In view of the small area (far less than one per cent of the total land area) occupied by solar parks, there is no need to fear competition for land, as claimed in some quarters, even in the future. On the contrary, there are good opportunities for solar parks to improve the ecological value of land. Indeed, the intensification of agricultural land use has generally led to a severe decline in species diversity. Solar parks are relatively benign compared to intensive agricultural land use. The same goes for the conversion of sealed industrial sites into solar parks. The unsealing of these sites and the generally negligible amount of sealing required to support the solar modules, means that there is potential for considerable ecological improvement.

Solar parks and other renewable energy technologies are included in the list of culprits in the debate about the 100 hectares of German land consumed per day for human settlement and transport. A look at the facts shows that, for ground-mounted solar plants at least, the proportion of land area used is comparatively tiny. If solar energy continues to expand to around 4 Gigawatts for ground mounted PV by 2020, a total of around 10,500 - 14,000 hectares would be required for solar parks. This would represent no more than 0.04 per cent of Germany's total land area. By contrast, land consumption for open-cast lignite mines in 2008 was around 48,300 hectares. As well as releasing large quantities of carbon dioxide during electricity generation, open-cast lignite mining irreversibly ruins whole landscapes, with resulting negative ecological and social consequences. Remediation and restoration is very costly. Solar plants do not change the landscape to the same extent and they can be dismantled and recycled.

In summary, the area used by ground-mounted solar plants in Germany is comparatively small, and will remain so in the future, despite ambitious expansion targets.

Construction of ground-mounted photovoltaic plants in Germany



Source: German Ministry of the Environment, BSW-Solar November 2010

1.3. Nature conservation in the legal provisions governing the construction of solar parks

Conservation and environmental issues should be taken into account right at the start of the planning phase for solar parks. There is national, regional and local regulation concerning the conservation aspects of solar park construction. The aim of these rules and regulation is to avoid conflicts with conservation, to adopt suitable measures to compensate for the unavoidable impacts, and to exploit the potential for solar parks to improve the ecological conditions of a site.

Starting with national legislation, Germany's **Renewable Energy Sources Act (EEG)** currently provides the starting point for selecting sites. Section 32 (3) of the EEG (subject to further amendments) provides for feed-in tariffs to be paid (and therefore commercial operation) only where solar plants are located on certain land categories. Sites of ecological value are not to be built on. In addition, the EEG ensures that the local planning authority retains control by linking solar parks to the local development plan, which is significant particularly from a nature conservation perspective. Possible sites are sealed sites, brownfield sites previously used for commercial, transport, residential or military purposes, and sites alongside motorways or railway tracks (at a distance of up to 110 metres). Agricultural sites that do not fit into the above categories were excluded from the tariff provision in the latest amendment of the EEG, following transition periods in 2010.

In addition to the EEG, there are other regulations at regional and local level that play a role in the construction of solar parks.

At a regional level, **regional development plans and planning policies** also have an impact on the construction of solar parks from a conservation law perspective. For instance, the Joint Spatial Planning Department of Berlin and Brandenburg commissioned a comprehensive report on regional criteria for identifying suitable sites for solar parks. Sites have also been identified in Saarland. In 2009, the Bavarian Ministry of the Interior published a guideline for dealing with ground-mounted photovoltaic plants from a construction and regional development law perspective, which sets out recommendations for the local authorities.

www.renewables-in-germany.com

The scope for influence is greatest at local level, through regional planning and land use planning. Since groundmounted solar plants in undeveloped areas are not privileged under the provisions of the German Town and Country Planning Code (BauBG) Section 35 para. 1, a mandatory **local development plan** must be drawn up for their construction. It is usually based on the land use plan. This means that projects must take conservation issues into account at the planning stage. In particular, landscape planning instruments provide an opportunity to consider conservation aspects like the integrated habitat system in a wider context and to take them into account when identifying sites.

The **environmental report** required for a local development plan presents all environmental and nature conservation issues and is submitted for the authorities and the public to comment on. This means that the environmental report has a vitally important role to play, going beyond the identification of environmental impacts to formulate site-specific, individual solutions for the intervention and compensatory measures, where appropriate. Local stakeholders and experts can influence the process by using their knowledge of local conditions to identify measures to protect and conserve biodiversity.

1.4. Existing data and surveys on the significance of solar parks in terms of nature conservation

The available data on the impacts of photovoltaic plants on biological diversity provides a good overview of the key issues and methodological challenges as well as some representative findings.

The photovoltaic industry investigated the topic with the nature conservation associations relatively early on. In 2005, when only a few dozen parks had been built, the German Solar Industry Association (BSW) signed an agreement with the German Society for Nature Conservation (NABU), setting out criteria for incorporating nature conservation interests both when selecting sites and when designing and maintaining them.

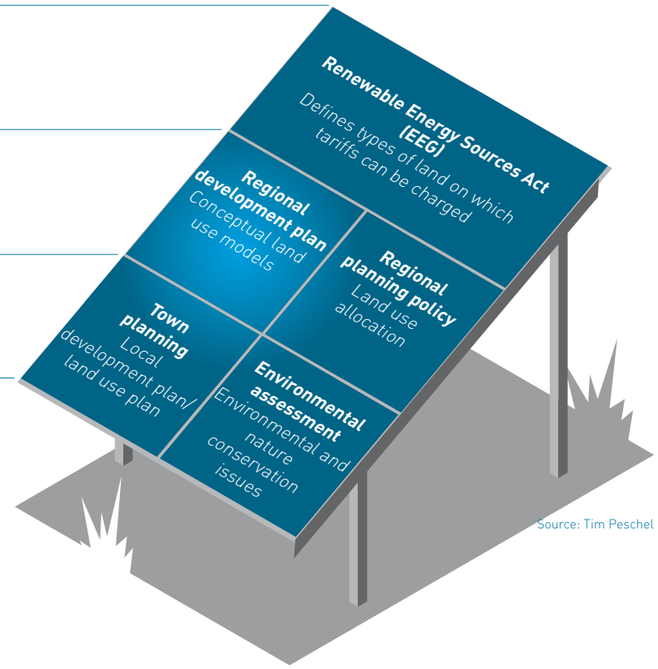
Planning and legal requirements when selecting sites for solar parks

Federal government

Regional government

Local authorities

Nature conservation aspects are regulated at all levels.
The scope for influence is particularly high at local level.



Source: Tim Peschel

These criteria have been widely applied throughout Germany and have helped influence the development of German solar parks.

The NABU criteria

In 2005, the German Society for Nature Conservation (NABU) and the German Solar Industry Association (BSW) drew up criteria for the construction of environmentally sound solar parks.

The key points:

- No intervention in protected areas (preference to be given to sites previously subjected to high stress levels, e.g. intensively farmed or brownfield sites).
- Compatibility assessment based on the European Birds Directive
- Avoiding exposed sites (solar plants should not dominate the landscape)
- Sealed area of site should be small (← 5%)
- Fencing should not present a barrier to small mammals and amphibians
- Sites to be maintained with the help of sheep grazing or mowing, no synthetic fertilizers or pesticides
- Local community to be involved in the project planning to increase acceptance

a. National studies

The following section provides an overview of the research projects on the significance of solar parks from a nature conservation perspective.

Completion of the first ground-mounted solar plants and a lack of scientific research into the associated impacts on the living environment led the **Federal Agency for Nature Conservation (BfN)** to commission a study on the impacts of such projects on nature and the landscape. Between 2005 and 2006, research was carried out at six solar parks to analyse the impacts on vegetation, on the landscape and on selected groups of animals. The study found that the negative impacts of solar parks on nature and landscapes are small. The key device highlighted by the study was to consider minimum requirements when selecting sites. Appropriate action planning in advance can minimize, and maybe even completely avoid, potential harmful impacts during the construction phase and during operation of the plant. The study highlighted the fact that solar parks built on intensively farmed land in particular can improve the environmental value of a site.

The **German Ministry of the Environment (BMU)** also commissioned an extensive study of the ecological impacts of solar parks when it was drawing up a report for the Renewable Energy Sources Act (EEG). Conducted between 2005 and 2007, this research project on monitoring the effect of the amended EEG on the development of electricity generation from solar energy, in particularly ground-mounted photovoltaic sites, came to similar conclusions to the BfN study. Here too, vital importance is attached to appropriate site selection. Appropriate site selection at the pre-planning stage can go a long way towards minimizing or avoiding conflicts during and after the construction phase. Like the BfN study, this study refers to positive effects, where sites that previously contained few plant and animal species are developed into biotopes of a higher value through being converted into solar parks. These results were used to develop guidance designed to provide recommended procedures for environmental impact assessments when planning and operating ground-mounted solar plants.

In 2010, following another project, the German Ministry of the Environment published numerous recommendations for environmentally friendly exploitation of solar energy in an online information database of nature protection standards for renewable energy sources **(www.naturschutzstandards-erneuerbarer-energien.de)**. The dedicated website presents structured background information on the possible conflicts of interest with nature conservation and identifies possible solutions.

b. Local projects

Conservation issues are investigated and studied in greater detail as part of the planning and approval procedures for individual solar park projects. During local planning approval for solar parks, local authorities often commission long-term monitoring programmes. Examples include the monitoring programmes at the Lieberose (Brandenburg), Schneeberger Hof (Rhineland-Palatinate), Tegel (Berlin) and Waldpolenz (Saxony) solar parks. The majority of these are monitoring impacts on birdlife. There is also a monitoring programme on the impact on vegetation and one on grasshoppers.

c. International research on biodiversity and solar parks

Many of the world's largest solar parks are being built in Canada, Italy, Spain, France and the USA, with Germany continuing to play a leading role. German research aimed at achieving a better understanding of the ecological impacts of solar parks has been met with a particularly high level of international interest.

The international debate is still fairly unstructured. Numerous examples of local and national approaches focusing on conservation in solar parks show that the topic is of increasing international importance.

Developments in France provide a good example. In France there is a policy to link photovoltaic development to environmental standards. The French Ministry of Sustainable Development is developing guidelines that will include the environmental impacts of solar parks. The guidelines highlight in detail measures pertaining to site selection, environmental reports, the involvement of local environmental groups and possible conditions and compensatory measures.

The Comité de Liaison Energies Renouvelables (CLER) has also joined forces with other environmental organisations like Greenpeace, the WWF and Birdlife International to draw up a list of criteria similar to the NABU criteria in Germany.

Unlike intensively farmed land, solar parks provide space for species-rich grassland (Photo: Gehrlicher Solar AG)

1.5. Impacts of solar parks on biodiversity

Despite the need for further research, the existing results show that solar parks can have a positive impact on biological diversity. Although construction projects always involve disturbance of existing flora and fauna, with solar parks there is a chance to improve the quality of habitats for various plant and animal species and even to create new habitats.

By integrating the improved sites in a biotope network, positive impacts on biological diversity can be achieved that go beyond the individual solar parks themselves. This applies in particular to previously cleared agricultural land with poor species diversity. These can be improved considerably by being converted into solar parks with extensively maintained grassland. A change of land use can also help reduce greenhouse gas emissions, since grassland acts as a carbon sink. This not only makes a significant contribution to species and biotope protection, but also benefits climate protection, over and above the benefit achieved by the environmentally friendly production of solar power. Avoiding the use of fertilizers and pesticides reduces environmental pollution.

Other sites of low environmental significance (like areas contaminated by pollution, landfill and contaminated brownfield sites) can be significantly improved by being converted into solar parks. But even on high nature value sites, intervention in the habitats of flora and fauna can be minimized and can lead to positive results. In general, observing certain best-practice measures can significantly increase the chances of improving sites from a nature conservation perspective.

The module supports serve as nesting places for birds. (Photo: BELECTRIC)

Lieberose solar park – solar power in a bird sanctuary

The hoopoe has found a new habitat at the Lieberose solar park. (Photo: Steve Klasan)

The former Lieberose military training ground in Brandenburg is a special example of the opportunities for nature conservation that can arise when a solar park is built on a brownfield site. As part of the Spreewald und Lieberoser Endmoräne European bird sanctuary, the site is very important for nature conservation. At the same time, as the result of its Russian military legacy, it had been extensively contaminated with chemicals and munitions until the early 1990s. This had posed a serious risk to the groundwater. Because of the legacy of military contamination, it was not possible to carry out the maintenance needed to conserve the expansion of moorland. The open sand, grass and moorland landscape was increasingly at risk of succession by woodland. These developments also ran counter to the conservation aims of the bird sanctuary.

During construction and operation of the solar park, which occupies around 160 hectares, over 380 hectares were cleaned up and remediated, removing the contamination risks to the soil and groundwater. The cleanup operation completely removed all munitions with no depth limit. Tonnes of munitions and, in particular, several hundred drums of chemical substances, some unidentified, were recovered and disposed of. To compensate for the negative impacts of the construction and operation of the plant, suitable compensatory measures were developed in line with the sanctuary's conservation aims and associated management plan. The compensatory measures aim to conserve and reconstruct open habitats both on the built sites and on the additional compensation and maintained areas. Certain woodland habitats were also improved in line with the management plan. The removal of the munitions and the subsequent measures ensure that the conservation aims for the sanctuary will be met over the long term. This has led to an improvement in the environmental situation. The preliminary results of the 10-year monitoring programme show that the quality of the habitat has been conserved and even improved long-term for the relevant bird species, which include the tawny pipit, the woodlark and the hoopoe.

Solar parks – Best practice recommendations: Nature conservation measures

Solar parks can enrich the biological diversity of sites. Depending on the type of site, an improvement for flora and fauna will be more or less difficult to achieve. The opportunities for improvement can be increased by following a number of nature conservation measures during the planning, building and operating phases.

Planning

Site selection:
Unproblematic sites from a nature conservation perspective are usually contaminated brown-field sites, sites along transport routes, former agricultural land, landfill sites and slagheaps.

Taking local conditions into account in the environmental impact assessment:
Protective measures for flora and fauna can be identified and recorded as conditions in the environmental impact assessment.

Environmental rehabilitation and local planning to draw up compensatory measures:
The construction of solar parks on brownfield sites can go a long way towards undoing existing environmental damage by unsealing sites and removing contamination. Compensatory measures can include identifying refuges and maintained areas for animal and plant life.

Building

Ecological project planning and monitoring:
Environmental construction monitoring can involve nature conservation expertise in the planning, construction and operation early on and throughout the project.

Avoiding barrier effects caused by fencing:
Corridors through large plants and a suitable ground clearance enable solar parks to be integrated in the surrounding area.

Avoiding soil sealing:
By dispensing with foundations, up to 99% of the area can remain unsealed.

Contributing towards conserving the regional genetic diversity of plants:
If plants are sown or planted, the use of native, plants and seeds appropriate to the site in question can promote regional genetic diversity.

Minimizing the canopy effect and reflections:
The impact can be reduced through suitable construction measures. Light reflection and glare do not irritate birds.

Operating

Knowledge gain through monitoring
Continual environmental monitoring helps improve future measures for the protection of flora and fauna.

Site maintenance
Regular mowing or sheep grazing can maintain or create species-rich habitats within the solar park.

2. Best practice recommendations: Nature conservation measures

2.1. Measures during the planning stage

a. The relevance of site selection

Decisions are taken at the planning stage that will have a significant influence on the environmental impacts of the solar park during its construction and operation. These include the choice of site. In general, the following types of site are important for biological diversity and can therefore only be considered for solar power production with certain restrictions:

- Sites protected by international conventions (Natura 2000 Special Protection Areas for birds, and Special Areas of Conservation under the Habitats Directive)
- Sites protected by national and regional regulations (e.g. national parks, nature reserves, nature parks, under Section 30 of the German Nature Conservation Act (BNatSchG) and relevant regional nature conservation laws)
- Sites with specially protected biotopes (Section 30 BNatSchG or relevant regional nature conservation laws)

In particular cases, however, like that of the Lieberose solar park, solar projects can be realized even on these sites. However, it may be necessary to plan for significant extra costs for all phases of the project. Sites that are generally unproblematic in terms of nature conservation are:

- Contaminated brownfield sites previously used for military, commercial or residential purposes, with a large proportion of sealed area.
- Sites along major transport routes (e.g. motorways)
- Former arable land (under the German Renewable Energy Sources Act, arable land is no longer a separate category as of 2010, but is often to be found along major transport routes)
- Landfill sites and slagheaps

b. Taking local conditions into account in the environmental impact assessment, environmental remediation and compensatory measures

As part of the approval process for solar parks, local authorities draw up a local development plan ('B-Plan'), which includes an environmental impact assessment. The environmental assessment collects all the concerns relating to environmental protection locally and describes and evaluates them in an environmental report. The relevant authorities, environmental groups and the public are involved in the process. It is always advisable to involve the expertise of local nature conservation stakeholders. This can play a significant role in ensuring that the plant is designed in an environmentally friendly way and therefore helps increase acceptance. The environmental impact assessment therefore provides an opportunity to include environmental concerns in the planning procedure. By going beyond the identification of construction-related environmental impacts, it is possible to plan for measures that are adapted to the location and make sense in terms of nature conservation.

A change in land use often involves creating measures for environmental rehabilitation and the development of compensatory measures. This usually results in a considerable improvement to the environmental quality of a site. The following selected examples describe which measures relating to the protection of flora and fauna were included in individual environmental reports.

Haar-Salmdorf photovoltaic plant – Planting areas (Not to scale, illustration: Gehrlicher Solar AG)

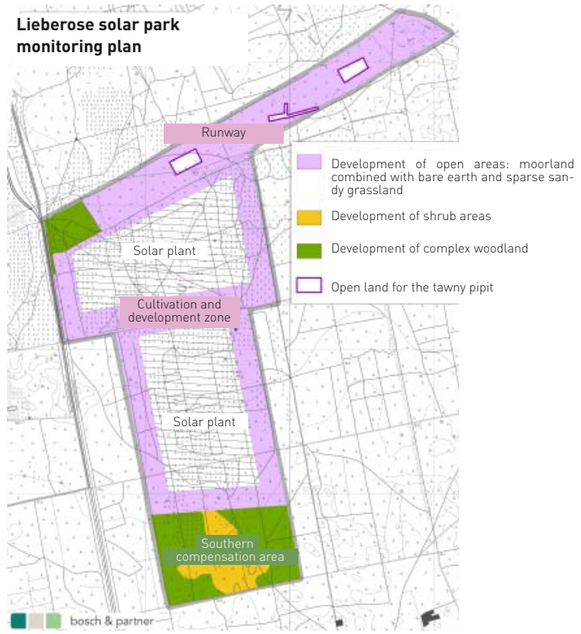
During the planning stage for the **solar plant in Salmdorf** near Munich, various nature conservation measures were defined in the environmental impact assessment as conditions for the plant's construction. These included avoiding the use of foundations to minimize the sealed area, and stipulations for a chain-link fence that would let small wild animals like hares, pheasants and partridges through. The solar plant is on a former field measuring around 6.7 hectares. Most of the surrounding area is dominated by intensive farming. The area covered by the photovoltaic modules is around 1.1 hectares. Most of the area was once used as a gravel pit, which was then filled in with building rubble, material excavated during road construction and refuse. Following restoration with a layer of topsoil, the site had been used for agriculture. During construction of the solar park, a species-rich meadow was developed, which is mown twice a year. This led to a significant improvement in the environmental quality of what used to be a field with few animal or plant species. As well as converting the field to extensive grassland, numerous measures were implemented to enable an additional improvement in environmental quality. The solar plant is surrounded by a 4-8 metre wide belt of grassland with a border of hedges and trees. There is a coppice at the northern end, which also serves as an ecological compensation area. The southern, south-eastern and south-western edges were planted exclusively with bushes. Around 4000 bushes and 30 trees were planted on over 15,000 square metres of land. In addition, two ponds were dug on the site. Construction of the ponds was an important step towards implementing the "green toad scheme" developed with the city of Munich. It includes the creation of spawning grounds and improvements to the habitats of these toads, which are at risk of extinction because of intensive building work to the east of Munich.

A new pond on the site of the solar plant in Salmdorf serves as stepping-stone biotope for the green toad (Bufo viridis, a threatened species, Red List category 1). (Photos: Richard Bartz , Michael von Ferrari)

Another example is the **solar park in Waldpolenz**. The NABU criteria were taken as a basis for the environmental assessment of what used to be the world's largest solar park. The minimization of the sealed area requested in the environmental report was implemented. The canopy effect of the arrays accounts for less than 50 per cent of the total area, in line with the NABU criteria. The environmental report prescribes that the existing grassland structure should be maintained and improved through the use of extensive grazing and mowing. It also stipulates that the fencing around the plant must not present an insurmountable obstacle to small mammals and amphibians.

During the realization of the **Sulzemoos solar park** in Bavaria, a comparative forecast was produced relating to the change in environmental status of an arable site measuring around 7 hectares. It predicted an improvement in the environmental quality of the area as a result of the solar park. Plots covering around 1.3 hectares were earmarked for compensatory measures and implemented within the development area. The sides of a ditch adjacent to the development area were flattened over 1-3 metres at intervals along half the length to improve the natural dynamics and water retention. A strip about eight metres wide along the ditch serves as a transition zone between the site and the nearby forest. The remaining area was turned into extensive grassland. New native hedges were planted that provide hunting grounds and nesting places for the red-backed shrike, an endangered bird species.

Compensation areas are particularly important for building projects in environmentally sensitive areas. In general, the construction of solar parks on brownfield sites can go a long way towards undoing existing environmental damage by unsealing sites and removing contamination where appropriate. The negative impacts on the European bird sanctuary caused by the **solar park in Lieberose Heide** required special, extensive compensatory measures. Because it was contaminated with military materials, the area on which the solar park was built was previously a prohibited zone. As a result, a succession woodland had developed over the years, threatening the habitats of ground-nesting birds and of those that depend on open areas with little vegetation. By preserving and reinstating the open land habitats and some forest habitats over an area of around 100 hectares, the solar project was able to conserve the habitat for certain bird species. This led to an improvement in the environmental status of the site, and means that the habitat can be preserved for specialized bird species like the tawny pipit and hoopoe for years to come.



At the Lieberose solar park, compensation areas were created on a total area of 100 hectares. (Illustration: Bosch & Partner GmbH)

2.2. Measures during construction

a. Environmental construction planning and monitoring

Environmental quality assurance should be taken into account at the planning and approval stage, before construction work starts. The environmental monitoring expert is responsible for taking all relevant concerns into account before and during construction and for supervising the implementation of and adherence to defined conservation and abatement measures. This can avoid environmental damage during the construction phase. The expert can achieve this by taking part in construction meetings, by advising the construction site management and through regular site visits. Environmental construction monitoring raises awareness of environmental concerns within the companies involved. It means that a whole range of factors that could potentially have an adverse effect at the various levels of biological diversity can be included in the planning process and taken into account during construction.

Environmental construction monitoring was employed when a photovoltaic plant was built on the roof of the **water cistern in Berlin-Tegel**, an area covered with grassland habitats. The underground cistern is about 40 years old and is used to store drinking water. This is technically a roof-mounted solar plant, but it looks like a ground-mounted plant. In order to avoid damaging the protected biotopes more than necessary during the construction work, particularly stringent standards were imposed. At the planning stage, the area required for the building work was minimized. Assembly work was carried out by hand without the use of machinery. The access routes were covered with geo fleece to protect them against trampling damage. Protected plants and those on the Berlin red list were transplanted to suitable locations on the Tegel waterworks site before building work started.

Likewise, before cables were laid, sections of turf were removed from the relevant areas and replaced once the cables had been laid and the cable channels had been filled in.

Wheelbarrows were used to remove excavated earth during the building work on the Tegel waterworks site. Because of the high ecological value of the sites, protected plants were transplanted and geo fleece was used to minimize trampling damage (right). (Photo: Tim Peschel)

b. Avoiding soil sealing

The amount of sealed ground in solar parks is usually negligible, leaving enough space for plants and for animals that like open spaces, including the hare. (Photo: BELECTRIC)

Land consumption in Germany is currently around 100 hectares per day (trend: falling). This is the area of a square with sides of 1 kilometre, or around 100 football pitches. The stated aim of the German government is to reduce the rate of at which land is sealed to 30 hectares a day by 2020.

Every construction project involves sealing land. But whereas infrastructure projects like roads require the whole area to be sealed, the sealed area of solar parks is negligible. In most solar parks, 99 per cent of the used area remains unsealed and therefore provides habitats for animal and plant species. The low amount of sealing means that the natural soil functions are largely conserved as a habitat for flora and fauna, along with the soil's filter and buffer characteristics. The sealed area can be further minimized by building on piles, using post support spikes for example, rather than on heavy-base foundations, like circular concrete footings or continuous spread footings.

The relevance of ground sealing is put into perspective on sites that are already sealed, like former airfields. For instance, the area of land sealed during construction of the **Waldpolenz solar park** was less than 0.01 per cent of the site, which measured over 200 hectares.

c. Minimizing the canopy and reflection effects

Erecting solar modules leads to changes in precipitation conditions as well as causing a shadow effect. The canopy effect and uneven draining off of precipitation (rain, snow, dew) causes the site conditions to change, but may also lead to more diverse habitats.

Research into the water permeability of solar plants was conducted at the **Schneeberger Hof** solar park (Rhineland Palatinate) in 2008. One of the things observed was that rainwater mostly runs off the modules down the supports.

Generally, the formation of groundwater on solar park land is not affected because all the rainwater flows off the tilted modules and seeps into the ground. A general assessment of the change in precipitation conditions in terms of their ecological impact is not possible. This can only be carried out on a site-by-site basis because it depends on the quality of the land used. It has, for instance, frequently been observed that some of the ground under solar modules stays free of snow following a snowfall and can therefore be used by birds looking for food, which should be seen as a positive effect.

Lush vegetation grows even underneath the modules. Gaps between the modules allow even rainfall. (Photo: BELECTRIC)

Shadow effects caused by solar panels and the resulting changes to the site are likely to alter the species composition of habitats, especially in warm, dry locations. No conclusive findings are available as yet. Research at the **Waldpolenz solar park** into the impacts on grasshopper populations has not yet found evidence of any relevant changes.

A more frequent debate in relation to photovoltaic plants is the reflection effect. The reflection of sunlight off the modules can attract insects because the module surfaces reflect light in a similar way to reflective water surfaces. This could attract water insects in particular and encourage more of them to lay eggs on the modules. These 'ecological traps' could then have an impact on insect populations. A simple way of reducing this effect is to use white markings, as recent research results have shown.

Research into the negative impacts of light reflection and glare on birds was conducted at the **Lieberose and Schneeberger Hof solar parks**. It was able to refute the widespread concerns that birds might mistake the rows of modules for expanses of water and injure themselves trying to land on them. No negative effects were observed during the monitoring programmes or in the 2006 study by the Federal Agency for Nature Conservation (BfN).

d. Helping conserve the regional genetic diversity of plants

Compensatory measures are often carried out during the erection of solar parks. For example, shrubs are often planted to provide ground cover, while seed mixtures are sown on open areas. The genetic biodiversity can be affected by the choice of plant used for the various purposes.

Solar parks can become flourishing landscapes. Selecting the right seed promotes conservation of the regional genetic diversity of plants. (Photo: Gehrlicher Solar AG)

When creating ground cover for solar parks in the open countryside, one should do more than just make sure that the selected plants are suitable for the site, i.e. that the environmental requirements of the plant match the site characteristics. By using native seeds and plants that are suitable for the site and that have been obtained from within a defined source region, it is possible to make a valuable contribution to the conservation and promotion of regional genetic diversity. Depending on the project objectives, it may be desirable to leave an area unsown. If it is left to form its own ground cover, species will establish themselves over the years. This type of ground cover can be encouraged by sowing hayflowers (Flores graminis) or by spreading suitable grass cuttings containing seeds. For hayflowers one spreads what is left on the ground where hay has been stored, which contains seeds as well as the hay remnants.

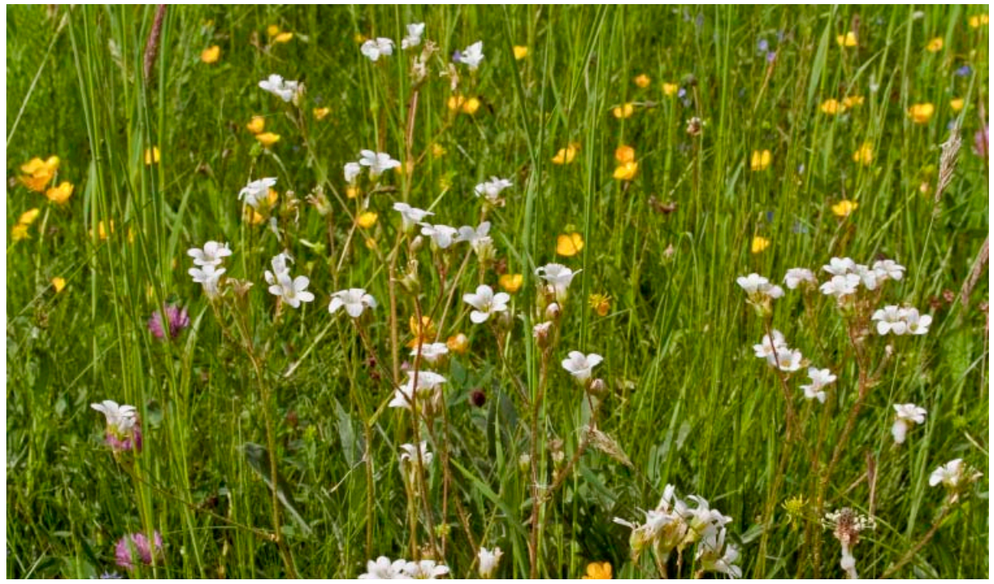
Conserving the regional genetic diversity of plants

Certified, native seeds and plants should be used when developing solar parks. Further information is available from the German Association of Wild Seed and Plant Producers (VWW) at www.natur-im-vww.de and from the Association for the Promotion of Native Shrubs and Trees in Brandenburg (www.gebietsheimische-gehoelze.de).

Grey hair-grass (Corynephorus canescens) prefers sparse, open, sandy areas, like those found at the Lieberose solar park. (Photo: Tim Peschel)

At the **Lieberose solar park** no attempts were made to provide ground cover once the solar park was complete, in order to ensure that the vegetation that developed was typical for the area. No seeds were sown on the open spaces. The aim was for certain open land habitats to develop, e.g. moorland combined with bare earth and sparse sandy grassland.

The **Rothenburg solar park** was built in sections on a plot of arable land measuring around 35 hectares. Following closure of the farm, a valuable vegetation structure had developed which is of particular importance as a feeding and nesting habitat for bird life. For this reason, no new seed was sown at this site either. Instead, the existing fallow land was conserved.



Extensive grassland containing a considerable diversity of flora and fauna often forms between the rows of modules. (Photo: Tim Peschel)

At the **Salmdorf solar park**, seed appropriate to the site was sown to create extensive grassland on a former arable plot. The entire area inside the plant, including the areas underneath the modules, was sown with an appropriate mixture of meadow seed and since then has been managed by mowing once or twice a year. This has transformed a previously species-poor area into a species-rich meadow of a higher environmental standard. A preliminary study in summer 2010 revealed numerous plants typically found in tall oat-grass meadows, which are now rare, including the spreading bellflower (Campanula patula), meadow cranesbill (Geranium pratensis), oxeye daisy (Leucanthemum vulgare), meadow salsify (Tragopogon pratensis) and meadow sage (Salvia pratensis).

Ten hectares of extensive grassland were also created on adjoining plots of former arable land at the **Lauingen solar park** as a compensatory measure. The seed used was appropriate for the site and certified as having coming from within a defined region of origin with no plant-growers involved in its cultivation or propagation. This means that it meets the most stringent nature protection requirements and contributes to the conservation of regional biodiversity.

e. Avoiding barrier effects caused by fencing

Fences are necessary for security reasons, but should allow enough space for small animals to pass through. (Photo: First Solar GmbH)

The premises of solar parks are often fenced off for security reasons. Where possible, the aim should be to avoid fencing off outdoor areas. Alternatively, regular passages and a ground clearance under the fence of at least 10 - 15 cm can conserve the natural functional relationships between the fenced-in solar plant and the surrounding area. Fencing of this kind no longer presents a barrier for large or small animals. Large solar parks in particular should try to achieve this through the use of wildlife-friendly fencing. This enables larger mammals in particular to cross the area occupied by a ground-mounted solar plant. It avoids carving up habitats and the isolation and fragmentation of animal populations that this entails.

Because of the size of the Lieberose solar park and to maintain a route historically used by red deer, the original development area was divided into two separate sections, creating a wildlife corridor. In addition, an appropriate 10 cm clearance under the fence allows smaller mammals and amphibians to pass through and avoids carving up their habitats.

2.3. Measures during plant operation

a. Knowledge gain through long-term monitoring

Monitoring can improve nature conservation measures in solar parks. (Photo: First Solar GmbH)

Scientific research should be conducted over several years to document the impacts of solar parks on the living environment and to demonstrate and monitor the effectiveness of compensatory measures. Monitoring is a necessary and efficient tool that can answer questions relating to nature conservation and make informed statements about the ecological impacts of solar parks. Monitoring is not a direct means of conserving biodiversity, but it makes it possible to check on the measures undertaken and can therefore provide information for developing new measures. Continuous, systematic monitoring over longer time periods makes it possible to draw reliable conclusions about the influence of certain environmental factors on animal and plant life.

The solar plant on the roof of the underground drinking water cistern in Berlin-Tegel with its areas of protected fresh and dry sandy grassland is a unique biotope. (Photo: First Solar GmbH)

One scientific study began in summer 2009 while the photovoltaic plant at the **Tegel waterworks in Berlin** was still under construction. The site contains some protected biotopes and it was suspected that there would be a change in the light and water conditions, especially in the immediate vicinity of the photovoltaic modules. As a result, a monitoring programme was created in 2009 for a period of 5 years (2009-2013). The objective is to conduct a scientific investigation into the impacts of solar parks on legally protected grassland biotopes.

The **Lieberose solar park** is located in a European Special Protection Area for birds. In order to observe the impacts of the construction and operation of the solar park and of the planned compensatory measures on the conservation aims and animal species, a monitoring programme was set up. It began by recording the bird population before the start of construction. The studies are being conducted regularly over a 10-year period. If the monitoring results identify a need for action during this time, further measures are planned to protect the birds. The initial results show that the compensatory measures have been successful in compensating for the construction-related loss of nesting places for the tawny pipit, a species of bird that is highly endangered in Brandenburg (Red List category 2).

The tawny pipit, which likes open spaces, is happy to take up residence in solar parks. (Photo: Steve Klasan)

The official approval for the 40 MW **Waldpolenz solar park** constructed on 110 hectares on the former airfield near Brandis in Saxony in 2007 stipulated a nine-year monitoring programme that began before construction started. The monitoring data is used as a basis for checking and modifying the specified compensatory measures, and for documenting any changes to the monitored bird and grasshopper populations as a result of the solar plant. The research conducted so far shows no relevant changes to the species groups being monitored.

b. Environmental site conservation and maintenance

Because of their location, the land inside solar parks often consists of open habitats with no trees or shrubs. The regular, extensive maintenance required for these open grassland areas can create valuable, species-rich habitats. A number of animal and plant species depend on regular maintenance of their habitats if they are to survive.

To conserve the open spaces, grassland surrounding the solar plants has to be mown at regular intervals. (Photo: BELECTRIC)

At the Fürth-Atzenhof solar park, the grassland is maintained and conserved by a shepherd, who grazes sheep on the site twice a year. Without these measures, shrubs and trees would appear all over the site, and the sun-loving plants would disappear. The 1 hectare solar plant was built in 2003 on the southern slope of the former municipal landfill site. Investigations in 2009 revealed an astonishing diversity of plant species. A total of 254 types of ferns and flowering plants and 30 types of moss were found. Of the plants found on the hill, 23 species are included on red lists at regional, national or international level.

Sheep grazing is an environmentally friendly way of keeping sites free from shrubs and trees, as seen here at the Atzenhof solar park. (Photo: Stadt Fürth)

Whereas mowing once or twice a year is sufficient to conserve the local species diversity at the **Salmdorf solar park**, the **Lieberose solar park** requires more elaborate maintenance. The regular maintenance and conservation measures carried out during the construction and operation of the solar plant ensure the conservation of high nature value moorland and open grassland habitats that had been seriously at risk of being taken over by woodland. The measures are carried out between the solar modules and on undeveloped land within the site and on outlying compensation areas. The measures include extensive maintenance of the areas between and underneath the modules and the regular removal of young trees and shrubs. This conserves the habitat for rare bird species that rely on it, such as the hoopoe.

The open and semi-open character of the site at the **Waldpolenz solar park** and its structural diversity, which was found during investigations to be very valuable particularly for birds like the whinchat, would have been lost without the maintenance measures and extensive grazing. The measures are primarily designed to conserve the vegetation that has developed on the former airfield. As well as conserving the areas that are important for flora and fauna, low-value areas were improved in terms of nature conservation through extensive maintenance measures and selective planting activities. The 121 hectare grassland area surrounding the solar park is maintained to conserve the sparse grassland structures by means of sheep grazing on the compensation areas and by mowing twice a year and removing the cuttings.

3. Appendix

Measures to improve the environmental quality of planning and building operations (in accordance with ARGE* 2007b, revised)

Conservation measure	Effect	Applies to
Using environmentally unproblematic sites (e.g. intensively farmed land, contaminated brownfield sites, landfill sites or slagheaps)	Avoiding using high nature value sites	High nature value sites
Involving experts for environmental construction monitoring	Using expert knowledge to minimize or avoid negative impacts on flora, fauna and the environment	Ecologically sensitive sites
Using vehicles that do not put too much pressure on the soil; halting building activities during long spells of wet weather	Avoiding soil compaction, which changes the site conditions (e.g. stagnant moisture) and can have undesirable effects on habitat conditions.	Cohesive soils (clay, loamy soils)
Restricting the impacts of the building work through sustainable planning of access roads and limiting the size of the construction site	Conserving habitats and minimizing negative impacts on species and living communities	All sites
Using uncontaminated substrates appropriate to the site	Avoiding changes to existing site conditions or the introduction of foreign species	All sites
Reducing extensive lighting as far as possible; limiting the times that lights are switched on	Avoiding endangering valuable insects	All sites
Minimizing fenced-in areas; creating corridors by dividing up the site and/or providing suitable clearance under fences	Avoiding carving up habitats and the isolation and fragmentation of animal populations and habitats that this entails	All sites
Minimizing soil sealing (e.g. by using fixings such as post support spikes or pile-driven posts)	Avoiding the destruction of habitats caused by soil sealing	All sites
Sparing or leaving space around high-value habitats; transplanting or moving affected species and communities	Avoiding site changes or destruction through overbuilding / shading, which lead to a change in the species composition of animal and plant life, particularly on warm, dry sites	Species and habitats of relevant sites (e.g. dry grassland, insects)
Optimizing the reflection characteristics of PV plants; distance from relevant expanses of water	Minimizing reflections, reduces the attraction for water insects in particular	Sites near expanses of water with populations of water-loving insects
Using certified seeds and plants	Conserving and promoting biological diversity, at species level and below	All sites in the open countryside

* ARGE: Working committee for the monitoring of PV plants

Nature conservation aspects in the environmental report (in accordance with ARGE 2007b, revised)

Required content for environmental reports	
Introduction	Short presentation of the content and the main aims of the land use plan including a description of the fixed aspects of the plan with details of the sites, type and size and the land requirements for the project
	Presentation of the environmental protection goals stipulated by relevant laws and plans that apply to the land use plan, and the way in which these goals and the environmental concerns were taken into account when preparing the report
Main section	An evaluation of the current environmental status, including environmental characteristics of the areas that are likely to be substantially affected
	Forecast of changes to the environmental status if the project is carried out and if it is not carried out ('zero option')
	Planned measures to avoid, reduce and compensate for any negative impacts
	Presentation of possible alternative planning options, taking into account the aims and the geographical area of the land use plan (alternatives that conform to the plan).
Additional information	A description of the main features of the technical methods used for the environmental assessment and references to difficulties that occurred when collating the data (e.g. technical gaps or lack of information)
	A description of the planned measures for monitoring the main impacts on the environment of carrying out the land use plan
	A summary of the required information that is intelligible to the general public

Research and further information on the environmental impacts of solar parks:

- Study by the Federal Agency for Nature Conservation (BfN): "Naturschutzfachliche Bewertungsmethoden von Freilandphotovoltaikanlagen", 2006. The final report was presented in 2009 and shows the impact of ground-mounted PV plants on the natural environment and landscape: www.bfn.de/fileadmin/MDB/documents/service/skript247.pdf
- BMU/ARGE monitoring of open spaces: "Monitoring zur Wirkung des novellierten EEG auf die Entwicklung der Stromerzeugung aus Solarenergie, insbesondere der Photovoltaik-Freiflächen", 2007.
- BMU guidance: "Leitfaden zur Berücksichtigung von Umweltbelangen bei der Planung von PV-Freiflächenanlagen": www.naturschutzstandards-erneuerbarer-energien.de/images/literatur/pv_leitfadenl1j.pdf
- BMU information database on nature conservation standards for renewable energy sources 2010: a BMU-funded project setting out environmental standards for the use of land for renewable energies: www.naturschutzstandards-erneuerbarer-energien.de

Sources (some unpublished):

- Altmeier, E., 2006: "Bebauungsplanverfahren Energiepark Waldpolenz. 1. Änderung des Flächennutzungsplanes der Gemeinde Bennewitz". Environmental report as per Section 2 (4) BauGB, 15/06/2010
- Working committee for the monitoring of PV plants (ARGE), 2007: "Leitfaden zur Berücksichtigung von Umweltbelangen bei der Planung von PV-Freiflächenanlagen". Published by the BMU
- Local development plan No. 15 for Solarpark Haunsfeld II, 2008. Environmental report. Extract
- Local development plan No. 182 for the Haar-Salmdorf PV plant, 2007. Terms of reference and justification
- Local development plan for Solarpark Helmeringen III, 2010. Environmental report, extract
- BMU 2009: "Monitoring zur Wirkung des novellierten EEG auf die Entwicklung der Stromerzeugung aus Solarenergie, insbesondere der Photovoltaik-Freiflachen", 2009: http://www.bmu.de/erneuerbare_energien/downloads/doc/35964.php
- Bosch & Partner, Gotze RAe & Solar Engineering Decker & Mack, 2009: "Erarbeitung von Grundlagen zur regionalplanerischen Steuerung von Photovoltaik-Freiflächenanlagen am Beispiel der RegionLausitz-Spreewald"
- Bosch & Partner, 2007: "Vorhabenbezogener Bebauungsplan Fotovoltaik-Solarpark Turnow-Preilack". Environmental report.
- Bosch & Partner in collaboration with RANA, 2009: "Solarpark Turnow-Preilack". Environmental construction monitoring report and monitoring results for 2009
- Büro Knoblich, 2009: "Energiepark Waldpolenz, Brandis". Summary of monitoring results for 2009. Unpublished report, 8 pages
- Büro für Landschaftsökologie und Geoinformation, 2009: "Monitoring von Brut- und Zugvogeln an einer PV-Anlage am Schneeberger Hof, Donnersbergkreis". Interim report for 2009. Unpublished report
- Büro für Landschaftsökologie und Geoinformation, 2007: "Monitoring von Brut- und Zugvogeln an einer PV-Anlage am Schneeberger Hof, Donnersbergkreis". Interim report for 2007. Unpublished report, 12 pages
- Comité de Liaison Energies Renouvelables (CLER) in collaboration with other environmental organisations, http://www.cler.org/info/spip.php7article8429

- "Erarbeitung von Grundlagen zur regionalplanerischen Steuerung von Photovoltaik-Freiflächenanlagen am Beispiel der Region Lausitz-Spreewald", 2009: http://gl.berlin-brandenburg.de/imperia/md/content/bb-gl/energie/gutachten_endbericht.pdf
- Municipality of Sulzemoos, 2007: "Vorhabensbezogener Bebauungsplan Sulzemoos, 'Freiflächenphotovoltaikanlage'". Construction drawings, terms of reference, justification
- Municipality of Sulzemoos, 2007: Annex to the "Vorhabensbezogener Bebauungsplan Sondergebiet Freiflächenphotovoltaikanlage". Environmental report
- Gutschker, J., 2008: "Erläuterungsbericht zur Erfassung von Niederschlagsdurchlässigkeit von Solaranlagen am Beispiel der Freiflachen-Photovoltaik-Anlage Gerbach, Donnersbergkreis", unpublished report
- Hellwig, H., 2009: "PVA Worrstadt. Umsetzung und Zustandsbericht der Kompensationsmaßnahmen". Unpublished report
- Herden, C., Rassmus, J. & B. Gharadjedaghi, 2009: "Naturschutzfachliche Bewertungsmethoden von Freilandphotovoltaikanlagen" (final report, 2006). BfN Skripten 247
- Horvath, G., Blaho, M., Egri, A., Kriska, G., Seres, I. & Robertson, 2010: "Reducing the maladaptive attractiveness of solar panels to polarotactic insects"
- Jessel, B., 2009: "Kulturlandschaften im Klimawandel - Herausforderungen für den Naturschutz". Garten + Landschaft 3
- Guidance from the Bavarian Ministry of the Interior on ground-mounted PV plants, 2009: http://www.regierung.oberpfalz.bayern.de/leistungen/landesplanung/photovoltaik/ims_pv091119.pdf
- "Leitfaden zur Zulassung von Photovoltaik-Freiflachen-Anlagen: Anregungen für Gemeinden" http://www.solarinitiativen.de/LeitfadenFreiflaechenanlagen.pdf
- "Naturschutzstandards Erneuerbare Energien", 2010: http://www.naturschutzstandards-erneuerbarer-energien.de/
- Natur und Landschaft 2010: "Das 2010-Ziel zur Erhaltung der Biodiversität". 85 (7)
- Solar Power Turnow GmbH & Co. KG. 2010: "Maßnahmenkonzept", unpublished report
- Solarwirtschaft (UVS) and Naturschutzbund (NABU): http://www.nabu.de/imperia/md/content/nabude/energie/solarenergie/1.pdf
- Stapff, M. & Th. Kronert 2008: "Faunistisches Sondergutachten. Vorgezogenes Monitoring der Avifauna auf Teilflachen des Energieparks Waldpolenz". Unpublished report commissioned by juwi solar GmbH
- UVS/NABU, 2005: "Kriterien für naturverträgliche Photovoltaik-Freiflächenanlagen". Agreement between UVS and NABU
- Wartner, H., 2009: "Solarparks - vom Umgang mit technischen Anlagen in der Landschaft". Garten + Landschaft 3

German Renewable Energies Agency
Reinhardtstrasse 18
10117 Berlin
Tel.: +49 30 200535 3
Fax: +49 30 200535 51
kontakt@unendlich-viel-energie.de

ISSN 2190-3581

www.renewables-in-germany.com

Renewable Energies Agency