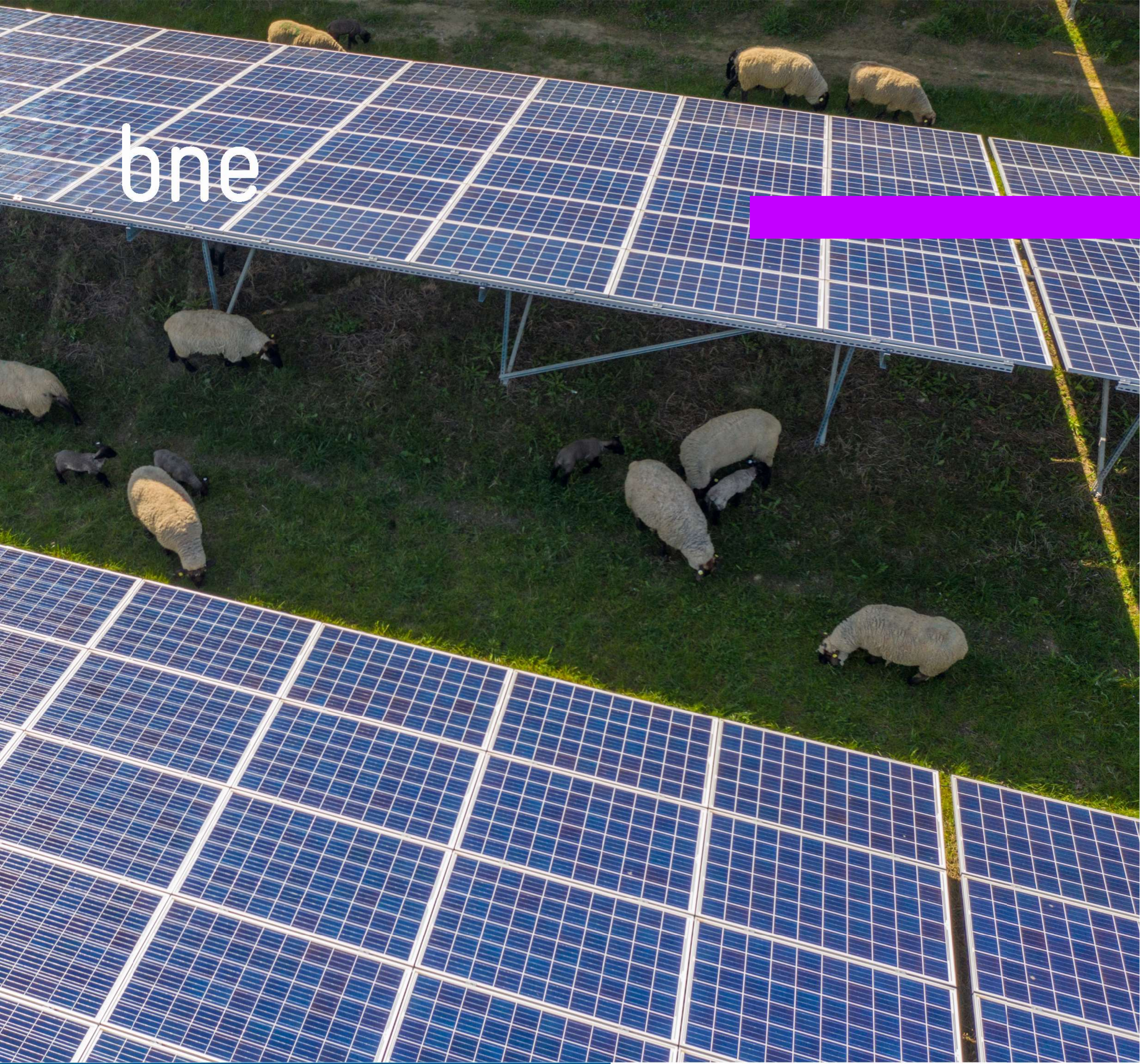

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The bne combines competition, renewables and innovation in the energy market. Its member companies are dismantling old boundaries and unleashing the forces of the energy transition.

Contents

0 Summary

The aim of this study is to show whether and to what extent solar parks can contribute to floristic and faunistic biodiversity.

For this purpose, documents on the vegetation and fauna of 75 solar parks in Germany were evaluated. However, the studies and investigations available for the parks, spread over 9 federal states, were mostly compiled during the approval phases for the parks and are very heterogeneous. Nevertheless, it was possible to use documents from just under 40% of the solar parks considered for evaluation. For some parks, intensive studies are also available, partly as a comparison of their states before and after, so that meaningful conclusions can be drawn. From this it can be deduced that solar parks have a fundamentally positive effect on biodiversity and what structures can help increase biodiversity, especially with regard to the distance between the rows of modules and maintenance of the spaces between the rows.

In addition to an evaluation of the appropriate documentation with regard to the characteristics of the vegetation and the colonisation of the parks with different animal groups, this study describes some parks in more detail by way of example. Finally, information is provided on the content, structure and scope of future monitoring studies. One goal of such monitoring could be to develop uniform minimum standards for the construction of solar parks in the medium term.

The main results of the evaluation of the available documents are:

- The use of land for solar parks should be seen in a fundamentally positive light, as it can lead to an increase in the value of the land in terms of the preservation of biological diversity, in addition to its contribution to climate protection through the production of renewable energy.
- Using land for solar installations can have a clearly positive effect on biodiversity if they are designed to be compatible with nature.
- One of the main reasons for populating solar parks with diverse species comprising sufficient individuals from different animal groups is the permanent extensive utilisation or maintenance of grassland in the spaces between the rows. This clearly distinguishes these sites from sites used intensively for agriculture or sites for energy production from biomass.

- Solar parks can promote biodiversity compared to the surrounding landscape. This is substantiated in the available documents for butterflies, grasshoppers and breeding birds.
- There is sometimes a clear difference between solar parks with wide and narrow spacing of rows. Wider sunny strips between module rows increase the density of species and individuals. This is documented in the colonisation by insects, reptiles and breeding birds. This has been demonstrated particularly clearly for the sand lizard.
- The evaluation of the documents also reveals a possible trend in the difference in importance of small facilities compared to large facilities: While smaller facilities act as stepping stone biotopes and can thus maintain or restore habitat corridors, large facilities – if properly maintained – can create sufficiently large habitats that enable the preservation or establishment of populations of, for example, sand lizards or breeding birds.
- Solar parks on conversion sites can help stop the succession of vegetation that leads to the loss of open, sunny habitats.
- Further investigation is required. In particular, there is often no monitoring of the colonisation of the solar parks after construction of the facilities. However, it can clarify the importance of solar parks for the densities of species and individuals of different animal groups.

1 Occasion

The problems of species and biotope protection in Central Europe have not diminished in recent years. This is evidenced not least by the increasing number of creatures on the Red Lists. Despite increased efforts on the part of official and voluntary nature conservation authorities, it has apparently been impossible to stop this trend to any great extent. Regardless of numerous statements and efforts at European and national levels, the decline of biodiversity continues on a broad scale. Bad news reaches us on a regular basis, such as the Krefeld study[1] on the dramatic decline in biomass for flying insects in protected areas in Germany. Recent studies show that the biodiversity crisis is even affecting a large part of all insect groups at the landscape level[2].

Developments in other species groups are also worrying.

Almost three quarters of the native breeding bird species in open country are on the current Red List of Germany’s breeding birds[3]. The situation is also critical for plants. Almost 30% of the plant species studied in Germany are endangered, and nearly 2% of them are extinct or have disappeared[4].

What are the causes and how can this development be stopped?

2010 saw the publication of the study “Solarparks - Chancen für die Biodiversität” [Solar Parks - Opportunities for Biodiversity][5]. Here, for the first time, the knowledge available was collated on the effects of photovoltaic (PV) facilities on biological diversity and recommendations given for nature conservation measures for their construction and operation.

Following on from this, it was decided almost 10 years later to produce a study on the current state of affairs.

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[1] HALLMANN et al. (2017)

[2] SEIBOLD et al. (2019)

[3] GRÜNEBERG et al. (2016)

[4] METZING et al. (2017)

[5] PESCHEL (2010)

1. Nature conservation and biological diversity

In 1992, the Convention on Biological Diversity was adopted in Rio at the United Nations Conference on Environment and Development (UNCED). To date, 196 states (including the EU Commission) have joined the agreement.

The three equal objectives of the Convention are

- the conservation of biological diversity
- the sustainable use of its components
- the fair and equitable sharing of the benefits deriving from the use of genetic resources

The basic idea is that biological diversity can only be preserved in the long term if the opportunities and gains from the sustainable use of nature benefit all groups involved equally.

However, biodiversity is not just understood as the diversity of species. The term encompasses the entire diversity of life, and thus the genetic diversity of species as well as that of ecosystems.

By signing the Convention on Biological Diversity, Germany committed itself to its implementation under international law. In 2007, the German government adopted a National Strategy on Biological Diversity,[6] which defines numerous goals and measures for the preservation of biological diversity.

2. Causes of the biodiversity crisis

The causes of threats to individual species groups are often complex and multifaceted, not least because they act and interact over long periods of time. Nevertheless, on the basis of the Red Lists and relevant studies,[7][8] some important causes for the widespread decline of many plant and animal species in Germany can be determined:

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[6] BMUB (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) (2007)

[7] BFN (Federal Agency for Nature Conservation) (2015)

[8] BFN (Federal Agency for Nature Conservation) (2017)

- over-fertilisation with nutrients, especially nitrogen
- the destruction of biotopes or the structural impoverishment of the landscape
- the increasing tendency for agricultural land to be intensified through the use of pesticides, but also a decrease in the practice of leaving land uncultivated, fallow land.

With an share of about 50% of land, agriculture is the largest land user nationwide, see Figure **1**-1. Since numerous species depend on agriculturally influenced habitats in Germany, it has a correspondingly large influence on species diversity.

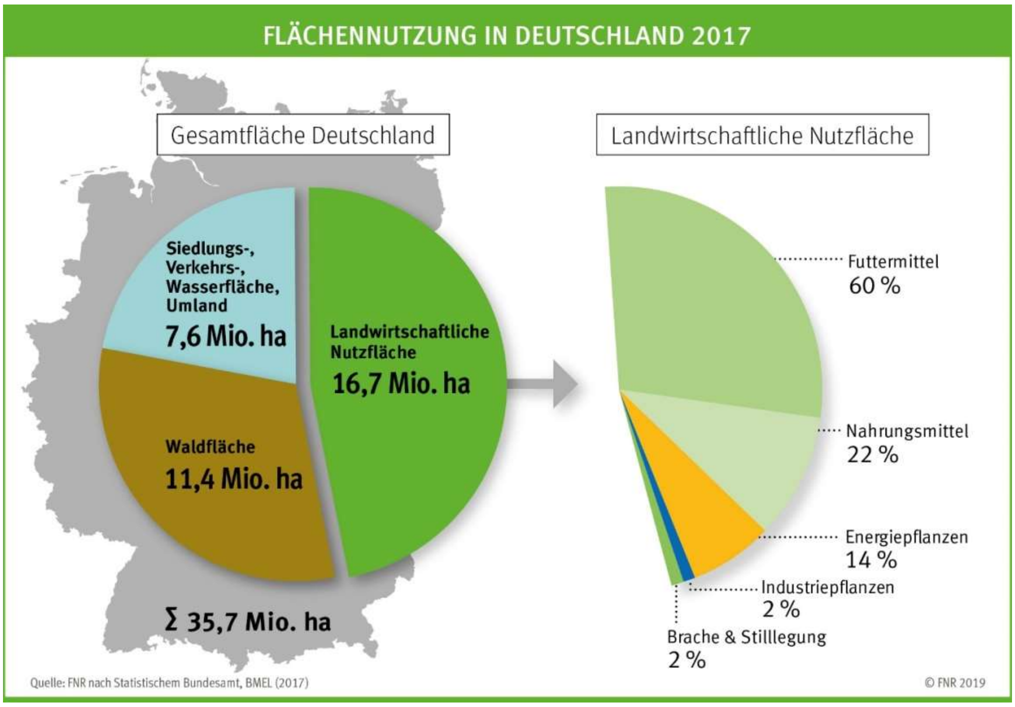

Figure 1-1: Land use in Germany[9]

[9] FNR (2019)

A large portion of agricultural land is intensively used, with the deployment of plant protection products and fertilisers.

Added to this is the sharp increase in acreage under cultivation for energy crops and the concentration on just a few crop species, resulting in increasing pressure of usage. Most of the plants are used for biogas and biofuel production. In 2017, this amounted to 2.2 million hectares, which is equivalent to about 14 percent of arable land. This leads to a narrowing of the chronological sequence of the crop species cultivated and, as a consequence, to a reduction in the diversity of cultivation. The current report by the Federal Agency for Nature Conservation on research projects for an expansion of renewable energy compatible with nature,[10] concluded therefore: “For bioenergy from cultivated biomass, in particular biogas, there are therefore no expandable options for action compatible with nature.”

Not surprisingly, an overview of the causes of threats to animal groups in Germany relevant for planning also revealed that these are greatest in the agricultural sector[11].

Two recent studies underline this fact: the diversity and number of butterflies in the vicinity of intensively cultivated and regularly sprayed fields is significantly lower than in meadows close to little or unused areas[12]. In another study, it was found that the greatest insect losses occur in grassland areas that are surrounded to a large extent by arable land[2].

At the same time, the decline in insects has a negative effect on other species groups. An adequate food supply is, for example, of central importance for the reproduction of bird populations, because they can only survive if animal proteins are available for raising their offspring[13]. Since 80% of our breeding bird species feed mainly on animal food during the breeding season, the connection between the adverse situation of populations of formerly more frequent bird species and the decline of insects is therefore not insignificant.

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[10] BFN (Federal Agency for Nature Conservation) (2019)

[11] GÜNTHER et al. (2005)

[12] HABEL et al. (2019)

[13] WAHL et al. (2015)

The quantity and quality of habitats plays a decisive role in terms of biodiversity.

More than one third of Germany's agricultural area is used as grassland[8]. This is important, because more than one third of all native ferns and flowering plants are found here. From the point of view of the preservation of biological diversity, grasslands play a prominent role, since about 40% of the endangered ferns and flowering plant species in Germany have their main occurrence here[8]. Calcareous grasslands is actually one of the most species-rich biotope types in Central Europe[14]. Since species-rich grassland is also of great importance to the animal world for food and habitat, it plays a significant role in the preservation of biodiversity.

For a long time there was a decrease in grassland area due to ploughing[15]. Since 2011, this has been largely slowed down or halted by the Federal Government due to EU legal obligations[8].

From a qualitative point of view, however, a deterioration can still be observed. The main reason for this is, firstly, the intensification of grassland due to increased cutting frequency and fertilisation. Secondly, grassland types dependent on maintenance are threatened by abandonment, i.e. the abandonment of management.

As a result of this development, the majority of types of grassland biotope are on the current Red List of endangered biotope types in Germany[16], with 83% classified as endangered and 31% actually falling into the category "under acute threat of complete destruction". However, only 16% (=12 types) out of a total of 75 grassland biotope types are classified as safe, see Figure **1**-2.

[14] DIERSCHKE & BRIEMLE (2002)

[15] BFN (Federal Agency for Nature Conservation) (2014)

[16] FINCK et al. (2017)

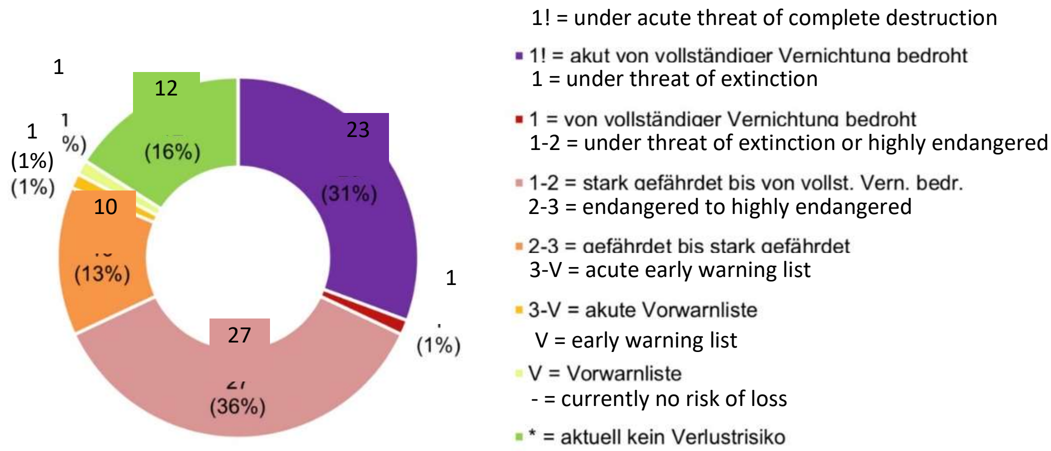


Figure 1-2: Distribution of the Red List categories (RLD) of grassland biotope types (groups 34 and 35) according to the current Red List of endangered biotope types in Germany. n = 75 (from FINCK et al. 2017)

3. What role do open space photovoltaic power plants play for biodiversity?

As early as 2007 the Federal Government adopted the National Strategy on Biological Diversity (NBS)[6]. This is intended to achieve the implementation of the UN Convention on Biological Diversity at the national level. To this end, around 330 goals and 430 measures were formulated for all biodiversity-related topics.

The degree to which the strategy has achieved its objectives is determined with the help of various indicators and monitoring programmes. As things currently stand, however, it is clear that most of the objectives defined for the agricultural landscape and farmland "(...) have not only been missed so far, but that the developments to which they refer, particularly in species and habitats, regularly show a negative trend"[8].

Against this backdrop, the objective called for in the National Strategy on Biological Diversity to support the use of synergies between the preservation of biological diversity and the production of renewable energy[6] is to be intensively pursued. The current Renewable Energies Report[10] also makes the demand that "(...) the production and use of renewable energies must not be at the expense of biodiversity. Further expansion must therefore be planned and controlled in a targeted manner so that it is compatible with nature and is not carried out at the expense of nature and the landscape."

Fears are sometimes expressed that the expansion of photovoltaics will lead to competition with other land uses, such as arable land or nature conservation areas (“plate or tank debate”). These fears are unfounded from the perspective of nature conservation and environmental protection, especially for areas where energy crops such as maize are currently being cultivated. On the contrary, a considerable increase in value can be achieved here through conversion.

The negative effects of energy crop cultivation on the environment are well known. As early as 2013, Leopoldina, the German National Academy of Sciences, stated on the subject of bioenergy: “The direct use of biomass as a raw material for industrial, energetic use is forbidden because of its low efficiency and manifold side effects”[17].

In a current article, BUND (Friends of the Earth Germany) summarises the many negative effects that the cultivation of maize can have on the environment[18].

They mainly include heavy use of plant protection products, especially insecticides, high nitrogen fertilisation and a reduction in crop rotation. Soil erosion is also a significant problem in maize cultivation. Maize does not reach a soil cover of more than 30 percent, which is considered the minimum for effective soil protection, until a very late stage after sowing[19]. As a consequence, this leads to seepage output of nutrients and pollutants bound to the soil particles, which results in the pollution of adjacent habitats. In the long term, creeping soil loss can even endanger food security, as the rate of soil regeneration is slower than the rate of soil loss[19].

Since the technical use of solar radiation provides area-specific yields that are one to two orders of magnitude higher than those of biomass[20] for energy generation, the use of these areas for solar installations also makes sense from the point of view of efficiency. In view of the use of 0.9 million hectares (see

[17] NAW (2013)

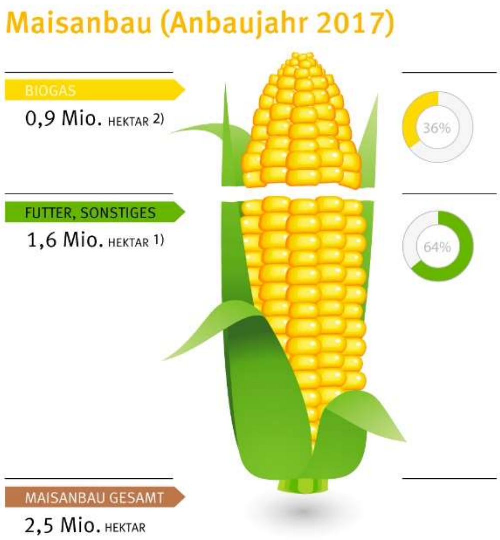
[18] BUND (2019)

[19] FEA (2019)

[20] DLR (2012)

Figure **1**-3) for the cultivation of maize for biogas production[9], the relevant area sizes for such a conversion are available.

Figure 1-3: Maize cultivation in Germany (FNR 2019)



In response to the demand for an expansion of renewable energies compatible with nature and the environment, solar installations offer opportunities according to various aspects to make a positive contribution to the preservation and promotion of biological diversity. Using land for solar installations can have a clearly positive effect on biodiversity if they are designed to be compatible with nature. In this way, there is the possibility of practically realising the use of synergistic effects between the conservation of biodiversity and the production of renewable energies, as called for in the National Biodiversity Strategy. From this point of view, land use for solar installations is to be seen as positive, as it leads not only to the production of renewable energy but also to an increase in the value of the land in terms of the preservation of biological diversity.

The factors known today to be the main causes of threats to many types of agricultural landscapes play scarcely any role at all in the management of solar installations. Since grassland is not subject to any significant pressure from economic exploitation, neither large quantities of fertiliser nor pesticides have to be used, nor is there any attempt to achieve maximum hay yields through early and frequent mowing.

Due to the extensive, continuous type of farming with low mowing frequencies and – if any – comparatively low fertilisation, grassland here is often richer in species.

In order to keep the PV modules free of shade, sheep are also successfully used in maintenance [21], see

Figure 1-4

Figure 1-4:
Sheep grazing in a solar installation, Source: Wattner AG, Cologne

[21] SCHALOW (2013)

From the point of view of nature conservation, this type of agricultural use can certainly be advantageous.

Due to a dense litter layer and sometimes resulting changes in micro-climatic conditions, the germination of plant seeds can be made more difficult or even completely prevented. Sheep create open ground with their hooves, on which some plant species depend for their survival since they need open areas for germination. Competitively inhibited species in particular benefit from this, especially if they are short-lived (therophytes[22], hapaxanthic[23] hemicryptophytes[24]) and reproduce through seeds. Many animal species are also dependent on disturbances and certain small structures, which are created or maintained by grazing as opposed to mowing[25].

Sheep also contribute to the spread of seeds and animals that are transported in their fur[25]. Provided that they are grazed on different areas, they can therefore contribute to a biological exchange of species and thus to the networking of habitats. Diaspores[26] from some plants can also be spread via faeces and claws[27].

As a conclusion of the studies, Schalow writes[21] that "(...) the implementation of sheep grazing is highly recommended if the respective solar park is suitable and is associated with many advantages for operators, sheep farmers and the environment." From a nature conservation point of

[22] Therophytes are herbaceous plant species with a short life span that survive an unfavourable season (winter or dry season) as seeds in the soil. Therophytes are annual or biennial plants. The seeds are very resistant to cold due to their very low water content (from Wikipedia, accessed 13.11.2019).

[23] Hapaxanthic plants flower and bear fruit only once in their life and completely die off afterwards (from Wikipedia, accessed 13.11.2019).

[24] Hemicryptophytes are plants whose perennial buds are located on the surface of the earth. Usually these are covered by snow, leaves or earth as weather protection (from Wikipedia, accessed 13.11.2019).

[25] ZAHN & TAUTENHAHN (2016)

[26] Plant propagation units

[27] FISCHER et al. (1995)

view, it is crucial that a target for the areas is defined so that the grazing regime can be adapted if necessary.

The conversion of arable soils is relevant not least from the point of view of carbon storage, since humus in soils is the largest terrestrial store of organic carbon. Land-use changes therefore also affect the CO_2 concentration in the atmosphere and thus are relevant to climate change. Soils under permanent grassland have on average higher humus reserves than comparable soils under arable farming. According to the Federal Ministry of Food and Agriculture (BMEL)[28], an additional contribution to climate protection can be made by converting arable land into permanent grassland by increasing humus.

Open space photovoltaic power plants differ in their construction in many ways, but the main features from a biological aspect are:

- the distances between the module rows

resulting in the areas between the rows of modules receiving sunlight. This is shown in

- Figure **1**-5 to Figure 1-8.

[28] BMEL (2018)

Figure 1-5: Row spacing of approx. 5.5 meters in the Finow II solar farm (Brandenburg). Area exposed to sunlight approx. 4 - 4.5 m wide

Figure 1-6: Row spacing of approx. 6 metres in a solar farm north of Werneuchen airfield (Brandenburg). Area exposed to sunlight approx. 4 - 4.5 m wide

Figure 1-7: Row spacing of about 2.5 metres in a solar farm north of Neuhardenberg (Brandenburg) airfield. Area exposed to sunlight approx. 0.8 m wide

Figure 1-8: Row distance of about 2 metres in a solar farm south of a former airfield east of Fürstenwalde (Brandenburg). Area exposed to sunlight approx. 0.8 m wide

The differences in the designs can be illustrated by comparing two solar farms on the former Fürstenwalde airfield, see

Figure **1-9**. In the park to the north, the distance between the rows is about 5.5 m, in the park to the south about 2 m. Furthermore, the heights of the solar panels are different. This in turn leads to correspondingly more extensive shading with higher panels.

Figure 1-9: Comparison of different design methods using the example of 2 solar parks on the former Fürstenwalde airfield (Brandenburg). Aerial photo source: Google Earth ©2019 GeoBasis-DE/BKG ©2009, date taken 06.06.2018, modified, orientation north

In addition to row spacing, other factors are characteristic of solar farms:

- A typical feature of all solar farms is that they must be fenced in due to security requirements and are not accessible to the general public. This means that anthropogenic disturbances are largely eliminated in such cases, except for servicing of installations or occasional maintenance work.
- Furthermore, most solar farms have fences that are permeable enough to allow animals up to the size of medium-sized mammals to pass through without any problems.
- The maintenance of solar farms must be oriented so as to prevent shade falling on the modules, ensuring fire protection and, at the same time, being as economical as possible. As a rule, this leads to extensive use of the area, which is beneficial to nature conservation.
- Solar farms are not normally fertilised, nor are pesticides used. Thus, the typical effects from agriculture mentioned in Chapter 0 do not apply.
- Parameters such as integrated compensation areas also play a role. Sometimes such areas are created within solar farms and not externally.

These can increase the structural diversity in such installations. These can be, for example, water bodies or groups of bushes.

2 Procedure

In order to obtain the largest possible number of expert opinions for the current study, opinions on the subject were provided by all the actors involved in the Bundesverband Neue Energiewirtschaft e. V. (Association of Energy Market Innovators) in the form of development plans (B plans) with the associated preliminary and follow-up investigations, such as environmental reports and monitoring after the respective plants have been built, see also Chapter 5.2. In addition, the authors' own documents were used as well as contributions from specialist literature or scientific studies on the subject, see Chapter 5.1. In particular, these are documents relating to the solar farms listed in Chapter 5.3 and maps provided in Chapter 0, Figure **5**-1 to Figure **5**-4.

The goal was to obtain a nationwide, comprehensive overview of information on biodiversity in solar farms. The documents were not only structured according to political units, i.e. federal states, but also according to natural landscape areas. This should ensure better comparability of the studies from an environmental point of view.

The documents were successively screened for their suitability for the study according to the following criteria:

- Documents not complete
- Unsuitable due to lack of relevance
- Unsuitable methods
- Documents basically suitable
- Documents suitable for certain species groups (e.g. birds)

3 Results

3.1 General information on the development of available data

As a result, the documents for 75 installations were examined. These were qualified with regard to their suitability. Table 3-1 shows the result, Figure **3**-1 shows the results in graph form.

Table 3-1: Result of assessing the suitability of the reviewed documents

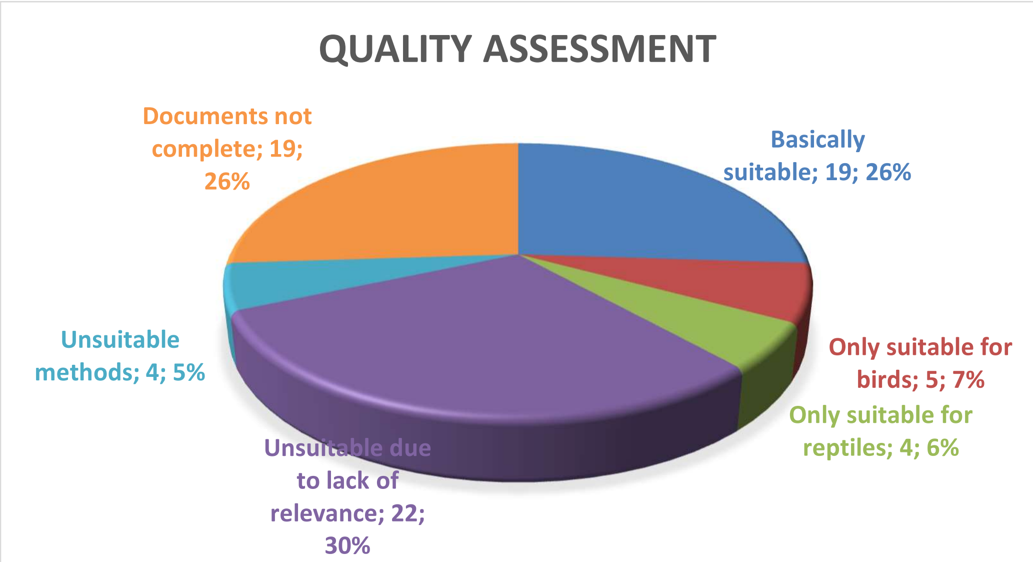


Figure 3-1: Quality assessment

Differences in biodiversity before and after the erection of solar parks cannot be evaluated, mostly due to heterogeneous data.

Appropriately qualified investigations made the situation before and after comparable and thus evaluable. These in turn were further qualified according to their suitability for biologically relevant subject areas, such as birds, reptiles or even several groups of organisms. Relatively little is available here, which is due to the fact that little research has been done on the situation after regarding solar farms due to the lack of appropriate requirements.

Furthermore, a check was made as to the data available for which federal states. This is shown in Figure **3**-2. Due to the lack of data from 7 federal states and very little from another 4 federal states, a nationwide consideration is not possible in this study.

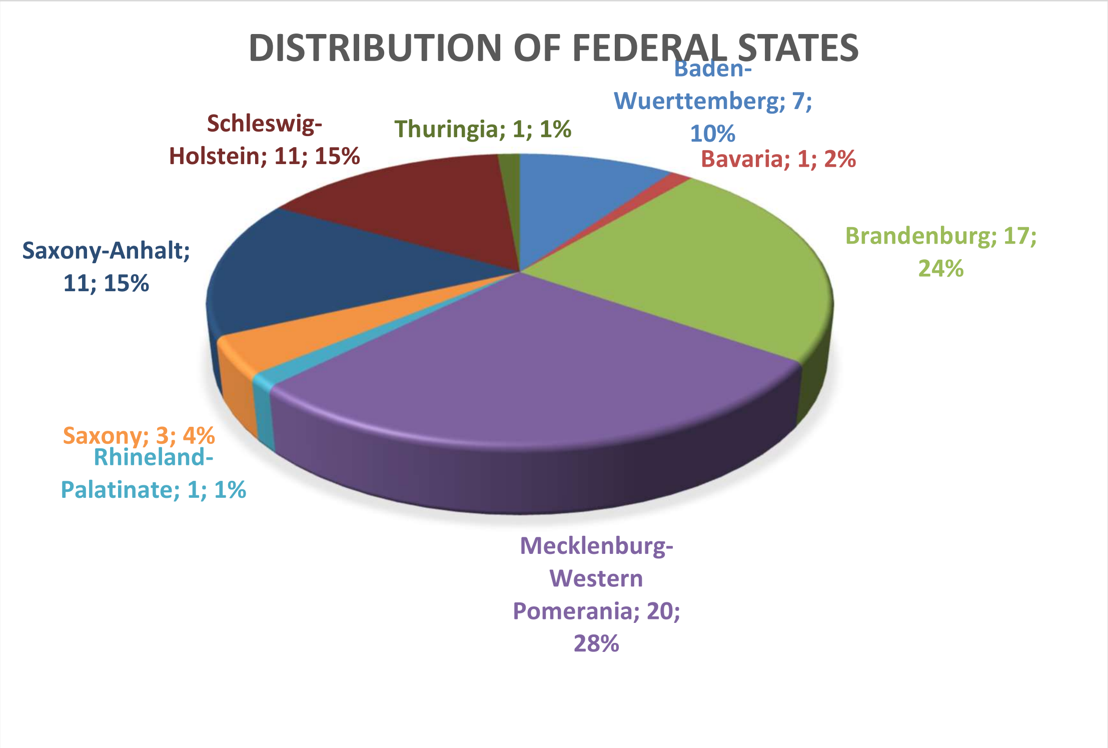


Figure 3-2: Data origin by federal states

Hence an evaluation covering the entire area or relating to essential natural landscape areas is also not possible, as shown in Figure **3**-3. Data from a total of 12 regions are now available from the 21 secondary natural regions of Germany, of which 17 are in principle suitable for solar farms.

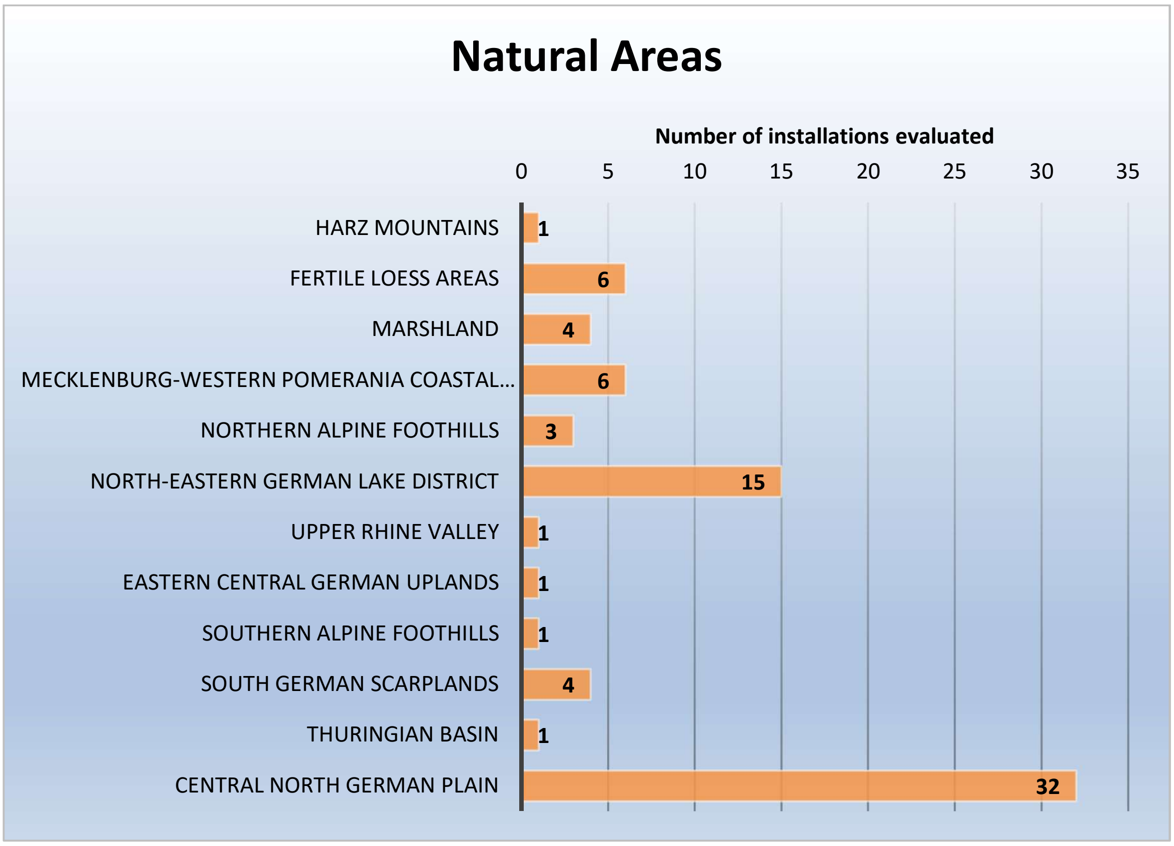


Figure 3-3: Data from individual natural landscape areas

This database therefore does not allow for a detailed assessment of biodiversity within solar farms, but does allow trends to be identified. These trends are described below.

3.2 Findings for individual groups of organisms

3.2.1 Insects

In England, a comparison was made between solar farms and agricultural land immediately adjacent. The main study[29], which was presented in 2016, is based on a preliminary[30] study from 2013. In

[29] MONTAG et al. (2016)

[30] PARKER & MCQUEEN (2013)

addition to the vegetation, various groups of insects, including butterflies and bumblebees, were studied. A total of 11 locations in the southern part of England were processed. What they had in common was that they had all previously been agricultural land, either arable or grazing. As a result, it could be shown that the diversity in solar farms, independent of the respective maintenance, was slightly increased for the most part and the number of individuals in both species groups was significantly higher in comparison to neighbouring agricultural areas. The study also clearly showed that the diversity of the solar farms themselves is directly related to the maintenance regime implemented and also to the preparation of the land, for example through seed mixes. With regard to the bumblebees studied, it was also shown that the diversity within the solar farm was rarely the same compared to the environment, but was mostly higher. The numbers of individuals were considerably higher at 9 out of 11 investigated sites, in some cases many times higher.

In various studies carried out in Brandenburg, insects were also examined within solar farms. A relatively large amount of data is available on butterflies and grasshoppers. In various monitoring studies in the solar farms Finow II and III[55] and in the comparison of 2 installations on the former airfield in Fürstenwalde[31], a total of 31 cricket species were detected. Another 4 species were found outside specific projects during private study trips in these facilities: oak bush cricket, house cricket, ant cricket and short-winged sword cricket. So a total of 35 cricket species were detected in only 3 solar farms in Brandenburg. Table **3**-2 shows this in summary.

Table 3-2: Cricket species detected in 3 solar farms in Brandenburg with indications of their respective endangerment in the Red Lists of the Federal Republic of Germany and information from Brandenburg on risk classification: + = not endangered, V = early warning list, but not endangered, 3 = endangered, 2 = highly endangered, 1 = threatened with extinction, N = Not classified

Species name (common name)	Species name (lat)	RL BRD	RL BB
Ant cricket	Myrmecophila acervorum	3	D
Blue-winged bush cricket	Oedipoda caerulescens	V	+
Blue-winged sand cricket	Sphingonotus caerulans	2	3
Brown grasshopper	Chorthippus brunneus	+	+
Common green grasshopper	Omocestus viridulus	+	V
Common field grasshopper	Chorthippus apricarius	+	+
Field cricket	Gryllus campestris	+	V

[31] LEGUAN GMBH (2016a)

Species name (common name)	Species name (lat)	RL BRD	RL BB
Mottled grasshopper	Myrmeleotettix maculatus	+	+
Common groundhopper	Tetrix undulata	+	+
Common oak-bush cricket	Meconema thalassinum	+	+
Sickle-bearing bush cricket	Phaneroptera falcata	+	+
Meadow grasshopper	Chorthippus parallelus	+	+
Dark bush cricket	Pholidoptera griseoaptera	+	+
Large gold grasshopper	Chrysochraon dispar	+	+
Great green bush-cricket	Tettigonia viridissima	+	+
Stripe-winged grasshopper	Stenobothrus lineatus	+	3
House cricket	Acheta domesticus	+	G
Italian locust	Calliptamus italicus	2	1
Small gold grasshopper	Euthystira brachyptera	+	2
Short-winged conehead	Conocephalus dorsalis	+	+
Long-winged conehead	Conocephalus fuscus	+	+
Bow-winged grasshopper	Chorthippus biguttulus	+	+
Speckled bush cricket	Leptophyes punctatissima	+	+
Roesel's bush cricket	Metrioptera roeselii	+	+
Orange-tipped grasshopper	Omocestus haemorrhoidalis	3	+
Water-meadow grasshopper	Chorthippus montanus	V	3
Marge marsh grasshopper	Stetophyma grossum	+	V
Lesser grasshopper	Chorthippus mollis	+	+
Wart-biter	Decticus verrucivorus	3	V
Italian tree cricket	Oecanthus pellucens	+	N
Lesser marsh grasshopper	Chorthippus albomarginatus	+	+
Grey bush cricket	Platycleis albopunctata	+	+
Steppe grasshopper	Chorthippus dorsatus	+	+
Two-coloured bush-cricket	Metrioptera bicolor	+	3
Upland green bush cricket	Tettigonia cantans	+	3

With approx. 58 grasshopper species currently occurring naturally in Brandenburg, this corresponds to a proportion of approx. 60%. The presence of highly endangered species, such as the Italian locust or the blue-winged sand cricket, is proof that such installations can also be a habitat for highly specialised species. This shows the potential that such solar farms can have.

If one considers butterflies in this context, which are mostly dependent on meadow flowers and on food plants to lay their eggs on for the larvae, the evaluations of the 3 solar farms already considered also show good suitability. A total of 44 species were recorded here between 2012 and 2016. In Brandenburg there are currently about 110 species, so 40% have already been detected in the solar farms investigated. Since many specialised species from forests, bogs and wet grasslands are known to occur in this group of organisms, they do not occur in solar farms since such habitats are not present there.

Table 3-3: Butterfly species detected in 3 solar farms in Brandenburg and their respective endangerment in the Red Lists of the Federal Republic of Germany and information from Brandenburg on endangered species classification: + = not endangered, V = early warning list, but not endangered, 3 = endangered, 2 = highly endangered, 1 = threatened with extinction, D = insufficient data

Species name (common name)	Species name	RL BRD	RL BB
Red admiral	Vanessa atalanta	+	+
Six-spot burnet	Zygaena filipendulae	+	+
Sooty copper	Lycaena tityrus	3	+
Small skipper	Thymelicus sylvestris	+	+
Comma	Polygonia c-album	+	+
Painted lady	Vanessa cardui	+	+
Scarce copper	Lycaena virgaureae	V	3
Holly blue	Celastrina argiolus	+	+
High brown fritillary	Argynnis adippe	3	3
Common blue	Polyommatus icarus	+	+
Green forester	Adscita statices	V	V
Small heath	Coenonympha pamphilus	+	+
Large white	Pieris brassicae	+	+
Meadow brown	Maniola jurtina	+	+
Silver-washed fritillary	Argynnis paphia	+	3
Small copper	Lycaena phlaeas	+	+
Small tortoiseshell	Aglais urticae	+	+
Small white	Pieris rapae	+	+
Queen of Spain fritillary	Issoria lathonia	+	+
Silver-spotted skipper	Hesperia comma	3	2
Short-tailed blue	Cupido argiades	V	1
Map	Araschnia levana	+	+
Dingy skipper	Erynnis tages	+	3
Weaver’s fritillary	Boloria dia	+	3
Green-veined white	Pieris napi	+	+
Eastern Bath white	Pontia edusa	+	+

Species name (common name)	Species name	RL BRD	RL BB
Chestnut heath	Coenonympha glycerion	V	+
Large skipper	Ochlodes sylvanus	+	+
Marbled white	Melanargia galathea	+	+
Ringlet	Aphantopus hyperantus	+	+
Old world swallowtail	Papilio machaon	+	+
Essex skipper	Thymelicus lineola	+	+
Wood white	Leptidea sinapis	D	V
Chalkhill blue	Polyommatus coridon	+	3
Brown argus	Aricia agestis	+	+
New Forest burnet	Zygaena viciae	+	V
European peacock	Inachis io	+	+
Mourning cloak	Nymphalis antiopa	V	+
Purple-shot copper	Lycaena alciphron	2	2
Mazarine blue	Polyommatus semiargus	+	3
Heath fritillary	Melitaea athalia	3	V
Glanville fritillary	Melitaea cinxia	3	2
Pale clouded yellow	Colias hyale	+	+
Common brimstone	Gonepteryx rhamni	+	+

It is noticeable that many rare or specialised species occur, even more so than with grasshoppers.

A somewhat more detailed analysis is possible for the group of grasshoppers with regard to the different designs of solar farm under consideration. During a monitoring project in Fürsten-walde,[32] two adjacent solar farms were compared. These differ in terms of their design, but the ground is identical. Areas of about the same size were studied to ensure a direct comparison, see Fig-ure **3**-4. The work by leguan gmbh[32] was carried out in the course of monitoring the facility located to the south.

It is easy to see in Figure 3-4 how the distances between the module rows differ. A detailed view is shown in

[32] LEGUAN GMBH (2016b)

Figure **1-9**.

Figure 3-4: Investigation area of a study by leguan gmbh comparing 2 solar farms of different types on the former Fürstenwalde airfield, aerial photo source google earth ©2019 GeoBasis-DE/BKG ©2009, date of recording 06.06.2018, modified, orientation north

The total number of species detected shows Table **3**-4.

Table 3-4: grasshopper species detected in 2 neighbouring solar farms in Brandenburg with their respective endangerment in the Red Lists of the Federal Republic of Germany (RL BRD) and Brandenburg (RL BB) and the abundance: 1 = 1 - 2 individuals, 2 = 2 - 10 individuals, 3 = 11 - 100, 4 = >100

Species name (common name)	Species name (lat)	RL BRD	RL BB	Photovoltaic facility North	Photovoltaic facility South
Blue-winged	Oedipoda caerulescens	V	+	3	2

Species name (common name)	Species name (lat)	RL BRD	RL BB	Photovoltaic facility North	Photovoltaic facility South
bush cricket					
Blue-winged sand cricket	Sphingonotus caerulans	2	3	2	
Brown grasshopper	Chorthippus brunneus	+	+	4	2
Common field grasshopper	Chorthippus apricarius	+	+	4	3
Field cricket	Gryllus campestris	+	V	2	1
Mottled grasshopper	Myrmeleotettix maculatus	+	+	3	
Sickle-bearing bush cricket	Phaneroptera falcata	+	-	3	2
Meadow grasshopper	Chorthippus parallelus	+	+	2	2
Large gold grasshopper	Chrysochraon dispar	+	+	3	3
Great green bush-cricket	Tettigonia viridissima	+	+	2	2

Species name (common name)	Species name (lat)	RL BRD	RL BB	Photovoltaic facility North	Photovoltaic facility South
Stripe-winged grasshopper	Stenobothrus lineatus	+	3	3	1
Italian locust	Calliptamus italicus	2	1	1	
Long-winged cone-head	Conocephalus fuscus	+	+	4	
Bow-winged grasshopper	Chorthippus biguttulus	+	+	4	3
Roesel's bush cricket	Metrioptera roeselii	+	+	3	2
Orange-tipped grasshopper	Omocestus haemorrhoidalis	3	+	2	
Lesser grasshopper	Chorthippus mollis	+	+	4	3
Grey bush cricket	Platycleis albopunctata	+	+	3	2
Steppe grasshopper	Chorthippus dorsatus	+	+	2	2
Two-coloured bush-cricket	Metrioptera bicolor	+	3	1	1

Species name (common name)	Species name (lat)	RL BRD	RL BB	Photovoltaic facility North	Photovoltaic facility South
Upland green bush cricket	Tettigonia cantans	+	3	2	
Number of species				**21**	**15**

It can be seen that in the northern facility with wide row spacing 21 species occur, which is 40% more than in the southern facility. Furthermore, highly specialised species that are particularly dependent on dry grasslands or areas with little or no vegetation, such as the blue-winged sand cricket, the Italian locust and the orange-tipped grasshopper, were only found in the facility with wide row spacing. In addition, the long-winged conehead, which is relatively widespread in Brandenburg, is found. It is completely absent in the southern facility. And for the species detected in both facilities, it is apparent that the population sizes in the north facility are usually larger. However, there is no species with larger populations in the southern facility.

These types of differences can also be observed for other groups of organisms when comparing such different designs.

With regard to insects, the following should be noted:

- Solar farms promote the diversity of this group of organisms compared with the surrounding landscape.
- Within the solar farms very high densities of individuals can be achieved, which results in animals migrating and colonising other habitats. This means that solar farms can be so-called source habitats.
- Solar farms are stable habitats due to the care and maintenance of the status quo, also for insects with longer development cycles or those with strong natural fluctuations in population.

- The distances between the module rows influence the number of species and the population densities achieved. Sunny strips of 3 m or more increase diversity considerably.

3.2.2 Amphibians

15% of available studies provided results on amphibian occurrences within the areas of the solar parks.

The basic tenor of most of the results is that the investigated areas do not represent a suitable aquatic habitat for amphibians due to the lack of water bodies, and therefore reproduction is not possible here. However, they are suitable as a terrestrial habitat or as migration routes between adjacent waters. It should be noted that most native amphibians spend most of their lives outside the water and are therefore predominantly found in terrestrial habitats.

In a few solar parks (PV Zabakuck (ST)[33] and the Finow II - III solar farm[55]), water bodies are located within the parks or were created as compensation areas on the edge of the parks (e.g. Jüterbog solar park (BB)[34], Lausitzring Ost photovoltaic power plant - municipality of Schipkau (BB)[35], Tutow solar park (MV)[36], Düssin solar park (MV)[37]). In these solar farms the areas around the modules are classified as terrestrial habitats, while the waters often located on the external borders of the parks are classified as spawning grounds for various species, depending on their structure.

In the case of a solar farm which was built at the end of 2016 in Eberswalde on the site of the Eisenspalterei (iron works), the concerns regarding moor frogs present there were taken into account

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[33] BÜRO RENALA (2017)

[34] IDAS PLANUNGSGESELLSCHAFT MBH (2015-2018)

[35] LANDSCHAFTSPLANUNG DR. REICHHOFF (2018)

[36] MUNICIPALITY OF TUTOW (2010)

[37] BÜRO FÜR FREILANDKARTIERUNG UND LANDSCHAFTSPLANUNG (2019)

during planning so that parts of the facility itself were used as compensation areas[38]. Hence in an area that could not be used for static reasons, a further water body was created in addition to an existing one to support the moor frog population present here. Since solar farms are basically suitable as terrestrial habitats, the facility could be included as a terrestrial habitat to compensate for its impact. Furthermore, wintering possibilities were created in the facility by installing suitable dens, or hibernacula. Ongoing monitoring[39] [40]shows that habitat suitability is continuously given. The extensive maintenance regime also ensures that a rich supply of food is available. Here, within a solar farm, a complete habitat for a population of moor frogs was sustainably protected.

The results show that amphibians are relevant to nature conservation in the sector of solar farms if water bodies were already present before the plant was built and the habitats are protected or developed as part of avoidance or compensation measures.

In addition, given the current forecast of an increasing choice of location for future plants in the agricultural sector, it can be assumed that amphibians will be even more present. Agricultural areas with a number of water bodies, especially in the north-eastern German lowlands (Mecklenburg-Western Pomerania, Brandenburg), which were shaped by the ice age, represent important habitats in this context.[41] Species of amphibians regularly travel long distances (sometimes several kilometres) between their spawning grounds and their summer and winter habitats. In the future, solar installations can play an important role as winter or temporary accommodation, which can be met by means of suitable measures (structural upgrading, management of construction periods and maintenance).

[38] LEGUAN GMBH (2016c)

[39] LEGUAN GMBH (2018b)

[40] LEGUAN GMBH (2019)

[41] BERGER et al. (2011)

It can be said that for amphibians:

- solar farms may be suitable habitats for amphibians. If there are no water bodies within the installations themselves, they provide very favourable conditions due to the coverage by the module rows and due to the abundance of food in the form of insects.
- The distances between the rows of modules have no influence on the occurrence of amphibians, as they prefer shade, especially during the warm season.

3.2.3 Bats

From the available documents, it is clear that solar installations are generally only of importance as a food habitat for bats. This may be relevant from the point of view of nature conservation if the facilities are located in intensively used agricultural landscapes and if species-rich grassland with a high insect density can develop between the module panels. For example, studies from the Tutow solar park (Mecklenburg-Western Pomerania)[42] have confirmed the use of the park as a food habitat. The installations do not provide bat boxes, or there is no information available to date about the bat boxes installed within solar farms.

In the British study, which compares the results from 11 solar parks with neighbouring agricultural land[29], it was found that bat activity was higher in the control areas than within the solar parks. It is suspected that bats are irritated by the smooth artificial surface of the panels. However, the species composition did not differ.

Overall, however, after reviewing the existing material there are too few reliable statements available.

For bats, the following can be observed:

- Solar farms may be suitable hunting grounds for bats due to the abundance of insect food.

[42] BÜRO PRO CHIROPTERA (2017)

- The current state of research is not sufficient to make more detailed statements.

3.2.4 Reptiles

Almost one third of the available studies provide results on reptile occurrences within the areas of the solar parks.

As a rule, compensation measures are proposed on the basis of existing evidence of sand lizards, by far the most common species relevant to the project, before the plants are constructed. This includes the creation of sunning, hiding, egg laying and wintering areas both in peripheral areas of the parks along the fence and along paths within the parks. There are also specially designated compensation areas.

The results from performance reviews of these measures are currently only available for a few plants (e.g. Eggersdorf solar park[43] and Fürstenwalde solar park[32 63], both in Brandenburg). However, there are studies on Finow II and III solar parks[55] (also in Brandenburg), for which detailed multi-year monitoring studies are available. These prove a continuous increase in the population of sand lizards with reproduction and use of the areas on the solar farm as a year-round habitat. Regarding the Fürstenwalde solar project it can be convincingly demonstrated in an exemplary manner that given suitable living conditions and requirements (reproducing populations existing peripherally) the sand lizard can hardly be prevented from repopulating the solar farm. Within a period of 4 years, the total number of individuals detected within the plant quadrupled, compared to the number before the start of construction. However, this, as well as the findings of further studies, show that certain conditions are necessary for successful colonisation. For example, in Neuhardenberg (Brandenburg)[44] where different designs (row spacing, module heights) coexist, clear preferences for areas with wide, sunlit areas can be demonstrated. This was also observed in other studies

[43] CS PLANUNGS- UND INGENIEURGESELLSCHAFT MBH (2017)

[44] LEGUAN GMBH (2014a)

(Mösthinsdorf[45], Hohenerxleben - Saxony-Anhalt[46]). Although juvenile sand lizards also used areas with narrow row spacing apparently in order to avoid competition with adult animals, certain minimum distances between the module rows, depending on the module heights (shading) seem to be essential for permanent colonisation of the installations.

In an investigation from 2020[47], a sand lizard was detected in a solar farm in Werneuchen with relatively narrow row spacing in early April. Proof so early in the year means the animal had spent the winter here, so it must have also lived there the previous year. This finding corresponds with proof of two further occurrences of skylark and corn bunting, which is explained in more detail in Chapter 3.2.5, page 39. The conclusions regarding row spacing or sunny areas between the module rows are also drawn there.

From all these results it is clear that within solar farms, with adapted planning and implementation of the built-over areas on the one hand (e.g. variable row spacing depending on the location, technical design of the module installations – construction methods) and design of the open spaces and peripheral zones on the other hand (e.g. development of barren vegetation, structural enrichment, adapted maintenance regime), habitats with high importance for reptile fauna, especially for sand lizards in this case, can be created.

With regard to reptiles it can be said that:

- Very high individual densities can be achieved within the solar farm (if soil conditions permit) due to the good supply of food, suitable hiding places and egg-laying habitats. Here, too, what was said about insects applies. Given large populations, animals migrate and colonise other habitats. This means that solar farms can be source habitats and help to support populations.

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[45] HAUKE (2019a)

[46] HAUKE (2019b)

[47] Secondary observations in the context of planning a new solar farm at Werneuchen (PESCHEL 2019)

- Based on the maintenance regime, which has also been identified as essential for insects, suitable conditions can be provided on a permanent basis.
- The distances between the rows of modules have a considerable influence on the number of individuals and the population densities achieved. Sunny strips of 3 m or more lead to a massive increase in the population, while narrower row spacing results in smaller population sizes.

3.2.5 Breeding birds

The evaluation of the available studies on this group of species, with a relatively large area of activity that is usually affected by planning (and for this reason is almost always taken into account), reflects the importance of large solar farms in particular. About one third of all available studies provided evaluable documents. In view of the results it is clear that, with regard to breeding birds, solar farms in particular are of great importance in the agricultural landscape. Depending on the structural conditions within the installations, an increase in diversity can be observed of about 70% of the sites and a constant or increased abundance (breeding bird density) of 85%. This trend is particularly notable in some large installations in Brandenburg (Finow II and III[55], Welzow[48]), Mecklenburg-Vorpommern (Tutow[49]), Thuringia (Ronneburg South I[50]).

In addition to the presence of species that breed widely in solar farms, such as skylarks and stonechats, the increase or even immigration of rare species, such as wheatear, hoopoe, woodlark and crested lark, could be observed. Other species, such as the corn bunting, sometimes find such favourable conditions in the low-disturbance habitats in the facilities that their density of territory can be significantly higher than in the initial situation or in the surrounding area (Solar parks at Barth Airport[51], Finow II and III solar park[55], Welzow[48])

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[48] BEAK CONSULTANTS (2018)

[49] UMWELTPLAN (2018)

[50] LIEDER & LUMPE (2012)

[51] LUTZ (2014)

In light of their relatively large marginal effects on breeding bird fauna, especially within structurally weak habitats, smaller solar installations can also function as biotope islands and thus be important. For example, many species require or use vertical structures (in this case modules, installation fences) as hideouts and therefore shift their territories to the boundaries of installations that they would not otherwise colonise (red-backed shrike, yellowhammer, warbler, stonechat, whinchat).

A decline in other species (open, cavity and niche breeders) due to the change in the characteristics of the area, which sometimes goes hand in hand with change, can be countered by increasing the structure (planting of trees and shrubs, installation of artificial nesting aids and habitat elements) in conjunction with appropriate maintenance management. Furthermore, many studies emphasize the importance of the facilities as a feeding habitat for migrant and visitor birds. Because of the heterogeneous structures (different vegetation heights and characteristics) and areas that remain free of snow for a long time in winter, solar farms offer a diverse food supply. There is still a need to investigate their use by nocturnal species (owls, nightjars) in particular.

There is a study from the United Kingdom[29] in which 11 solar parks underwent avifaunistic investigation. Species numbers and individual densities of breeding birds in the parks were determined in comparison to neighbouring “control areas” outside the parks. The results show that, mainly due to the conversion of the site from agricultural land to grassland rich in structure, species diversity in the solar parks is on average higher compared to the control areas. At two locations, the number of individuals is also higher. In the study, this is explained by better food availability in the solar parks in comparison with the neighbouring control areas. The availability of cover and perches also appears to be relevant. This study also shows that endangered species occur in significantly higher numbers in the solar parks than in the adjacent agricultural areas. In the case of the skylark, however, it was found that the species did not breed between the module rows in the parks studied. Contrary to some findings in domestic installations, no higher breeding density of skylarks could be detected within the solar parks, based on the control areas.

Structural differences between the parks, such as row spacing, module heights or similar, are not addressed in the study. However, the importance of the type and intensity of maintenance of the grassland areas around the module tables is emphasised.

A significant influence of the design on breeding bird densities cannot be determined on the basis of the available data, especially since it only affects ground-nesting species. However, breeding records for this nesting cohort (within the module areas) have only been observed in parks with module row spacings of 3 m and more. In this context, observations on skylarks from different parks in Barth[51] and near Werneuchen[52] [53] suggest that row spacing that allows a sunny strip of at least 2.5 m width from about 9:00 a.m. to about 5:00 p.m. in the period between mid-April and mid-September creates the conditions for these and possibly other ground-nesting species to establish themselves. Since peripheral control areas with the same equipment were also mapped on both sites, it was possible to determine the proportion of skylarks distributed on areas inside and outside the solar farms. In Werneuchen, 22 skylark breeding pairs were found on 20 hectares of grassland north of the runway[53]. This is approximately the maximum density of breeding pairs that can be observed in skylarks[54]. On the "Wildfarm Werneuchen" solar farm[47,] located in the west and which is 2 ha in size, one breeding pair was detected in the centre in the same year. This corresponds to twice the space required per hunting ground. In Barth[51], eight breeding pairs of skylarks were detected on the undeveloped northern apron of the airfield on an area of 52 ha; within the two solar parks on an area of another 64 ha three breeding pairs were detected. The conditions are therefore very similar at both sites in very different natural landscape areas.

With regard to birds, it should be noted:

- that, due to the maintenance regime that provides suitable conditions on a permanent basis, endangered species of grasslands or dry grasslands (if the soil allows it) can find suitable habitats here on a permanent basis.
- On conversion areas, the permanent maintenance of solar farms regularly leads to an increase in the diversity of breeding bird communities as the surrounding areas gradually become overgrown through succession.
- The distances between the rows of modules have a considerable influence on the number of individuals and the population densities achieved. Sunny strips of 3 m and more lead to a massive increase in

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[52] Secondary observations in the context of planning a new solar farm at Werneuchen (PESCHEL 2019)

[53] PROJEKTBÜRO DÖRNER + PARTNER GMBH (2019)

[54] Z. B. BAUER et al. (2005)

the population, while narrower row spacing leads to lower numbers of species and smaller population sizes.

3.3 Examples from solar parks

3.3.1 Finow II and III

The Finow II and III solar farms (Brandenburg) were built in 2011 and commissioned at the beginning of 2012. Extensive monitoring studies began as early as 2013, some of which are still ongoing.[55] [56] In addition to external compensation areas, the solar farm itself was also examined.

From earlier investigations in connection with a plan to expand the airfield, which did not come about, biotope types and occurrences of various animal groups had been examined.[57] In 2005, 28 species of grasshoppers and 44 species of butterflies were recorded. It should be noted that both species groups were recorded in a larger study area than the area of the solar farm. For example, forest edges and their typical species were also recorded; these cannot exist in a solar park due to the lack of suitable habitats.

Furthermore, in 2006, eight breeding pairs of woodpeckers, five breeding pairs of whinchats, two breeding pairs of wheatears, four breeding pairs of quail and a breeding pair of corn bunting were recorded on the site of the current solar park. Furthermore, 53 breeding pairs of skylarks were found, whereby the exact allocation is not possible on the basis of the available documents. However, given the layout of installations on the site at the time, it can be assumed that these were distributed more or less equally within suitable areas. Furthermore, a breeding pair of crested larks was detected north of the present park.

Amphibian occurrences are also known, although the park can only function as a summer habitat due to the lack of water.

As far as reptiles are concerned, sand lizards have been recorded several times in the area of this park.

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[55] LEGUAN GMBH (2014a, 2015, 2016b)

[56] MÖLLER et al. (2012)

[57] TRAUTMANN GOETZ (2007)

The monitoring mentioned previously was carried out by the Eberswalde University for Sustainable Development (HNEE)[56] as well as leguan gmbh[55].

The following findings have been identified to date.

With regard to grasshoppers, 25 species have been recorded in the park so far. This is 3 less than in the first survey in 2005 and therefore about 50% of the 52 species occurring in the federal state of Brandenburg. It should be noted that typical forest species do not occur here because such habitats do not exist in solar farms.

The butterfly surveys[58] have so far identified 38 species, six fewer than in the 2005 surveys. It must be taken into account that both forest and wetland species find no or few suitable habitats. Of the total of 110 species currently present in Brandenburg, this is a percentage of about 35%.

Investigations are continuing with regard to breeding birds. An interim result from the year 2016, recorded by leguan gmbh in 2014[59] and HNEE in 2015[60], showed breeding birds within the solar farm: white wagtail (1 breeding pair), skylark (between 54 and 60 breeding pairs), yellowhammer (between 5 and 6 breeding pairs), corn bunting (between 10 and 20 breeding pairs), crested lark (between 1 and 2 breeding pairs), woodlark (between 17 and 21 breeding pairs), stonechat (1 breeding pair), starling (between 6 and 9 breeding pairs), wheatear (between 1 and 4 breeding pairs), hoopoe (1 breeding pair).

With regard to reptiles, it could be proved by area-wide inspections over several years that the population of sand lizards is continuously growing. At least 600 animals could be assumed for 2015, and this number had risen steadily since the plant was commissioned. It can be assumed that it has continued to grow in the following years.

It must be taken into account that the solar farm has been extensively maintained since commissioning and the mowed grass is removed. This is intended to achieve soil degradation in the long term and so further reduce the intensity of mowing.

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[58] These include diurnal butterflies and burnet moths.

[59] LEGUAN GMBH (2014a)

[60] MÖLLER & REICHLING (2015)

Side effects are the maintenance and creation of dry grasslands in the solar farm, few disturbances, and hence also increasing breeding bird density. The fact that the operator has also installed artificial nesting aids means that further immigration of rare birds such as wheatears or hoopoes can be assumed. Figure **3**-5 and Figure **3**-6 show some nesting aids.

Figure 3-5: Artificial nest to encourage colonisation by the hoopoe (Photo: H. Gruß)

Figure 3-6: Artificial nest to encourage colonisation by the wheatear (Photo: H. Gruß)

Overall, a number of animal species, which are endangered and particularly worthy of protection, have been identified in solar farms Finow II + III, and have found a stable habitat there.

3.3.2 Turnow-Preilack

The Turnow-Preilack solar park, which was the largest solar park at the time, was put into operation in 2009 on a total area of around 160 hectares on the former military training area Lieberose in the district of Spree-Neiße (Brandenburg). In the area, which is largely characterised by structurally poor pine forest and open land threatened by increasing succession (including maintenance, development and compensation areas totalling approx. 380 ha), extensive preliminary surveys and monitoring studies were carried out and commented on between 2010 and 2015 (estimated until 2027).[61]

The species and nature conservation value of the area is mainly related to the enormous size of the area; the main objective was and remains the preservation of the "European dry heaths" (FFH habitat type) with their protected biotope types of grey hair-grass meadows, nutrient-poor grasslands, pioneer forests and dwarf shrub heaths as well as the populations of the breeding bird species that live in them and give them value.

With regard to the biotope types to be developed, the focus was primarily on maintenance and development zones and less on the installation areas discussed in this document. Due to extensive interventions while clearing the site of unexploded ordnance, the first stages of succession developed slowly in the majority of areas. After only 6 years of monitoring (last documentation), it has been shown that a high level of maintenance is necessary for the long-term preservation and development of diverse, structurally rich semi-open land sites with the establishment of competitively inhibited plant communities (monitoring until 2027).

Within avifauna, the focus from the outset has been on species that enjoy a special protection status and are regarded as keystone species (breeding bird communities) for the relevant biotope types. The importance of the peripheral areas of the solar fields is particularly evident here. While only five species were recorded with the centre of their territory within the installations, numerous other and, above all, endangered semi-open land species, such as hoopoe, woodlark, tawny

[61] BOSCH & PARTNER & RANA (2012, 2015)

pipit, nightjar, wheatear and great grey shrike, preferred to colonise the actual border areas of the installations. So in 2009 a frequency four to eight times higher was observed in the periphery than in the inner areas, but also in the pine forests surrounding the study area[62]. The increased availability of food and the presence of vertical structures (as singing and perching places) in these areas apparently play a prominent role.

Contrary to the situation in other projects and also to reference areas in the vicinity, the skylark, for example, only brooded very occasionally within the installations despite the rather wide spaces between module tows; here it was outrivalled by the woodlark even. Alongside natural fluctuations in population densities, in 2014/15, in contrast to previous monitoring years, no breeding pair was detected within the entire study area. One reason for this was certainly the ground vegetation which was still weakly developed. Further monitoring must be awaited before the trend can be assessed. Niche breeders, such as wagtail and black redstart, benefit from the module racks, as does the wheatear, which was found in equal proportions inside and outside the installations.

All in all, it can be stated with regard to the avifauna of the Turnow-Preilack solar park that, on the basis of the data available to date, the total number of species is increasing rather than decreasing, despite the delicate initial situation (small species spectrum compared to other habitats but the pre-existence of endangered species) and is similar to the findings of other solar projects. With the help of an increased offering of artificial nesting aids for cavity and niche breeders, as well as adapted maintenance management, much can be done to increase the density of breeding birds within the installations.

3.3.3 Fürstenwalde

Two adjacent photovoltaic facilities were compared in terms of grasshoppers, reptiles and birds[32]. An essential factor is that the soil conditions in both plants are the same. In this respect, they differ only in their design, mainly with respect to the distances between module rows: For example, the row spacing in the northern facility is wider than in the southern facility. These different distances lead to different colonisations by the species under consideration.

With regard to grasshoppers, in 2015 it was found that the northern facility contained a total of 21 species, whereas the southern facility contained 15 species, see Figure **3**-7. Far more

[62] NEULING (2009)

remarkable, however, is the comparison between the species that are endangered. Six endangered species were found here compared to two.

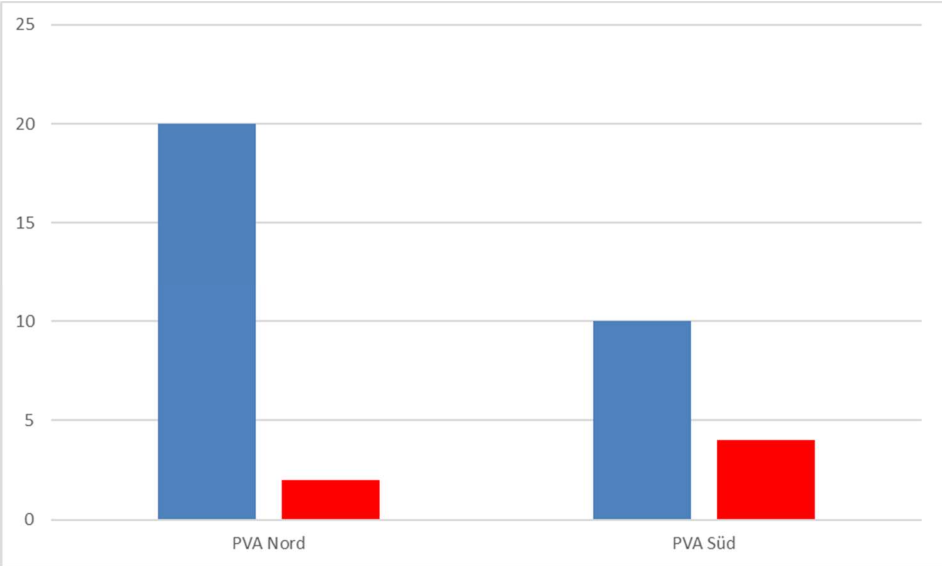


Figure 3-7: Comparison of species numbers (blue) and number of species on the Red Lists (red) of the Federal Republic of Germany and the State of Brandenburg for grasshoppers between the two photovoltaic facilities at the former Fürstenwalde airfield in 2015

At a repeat investigation two years later[63], a similar picture emerged, although the suitability of the southern facility for grasshoppers had improved, see Figure **3**-8. The number of Red List species in 2017 is the same in both facilities, but the total number of species is slightly higher in the facility with the wide row spacing.

On closer inspection, it becomes apparent that the numbers of individuals detected in the northern facility are usually either equal to or greater than in the southern facility. This has to do with the fact that the heat-loving grasshoppers in the northern facility have more habitat available in total than in the southern facility, precisely because of the wider spacing of rows. Populations are more stable the more space is available to them.

[63] LEGUAN GMBH (2018a)

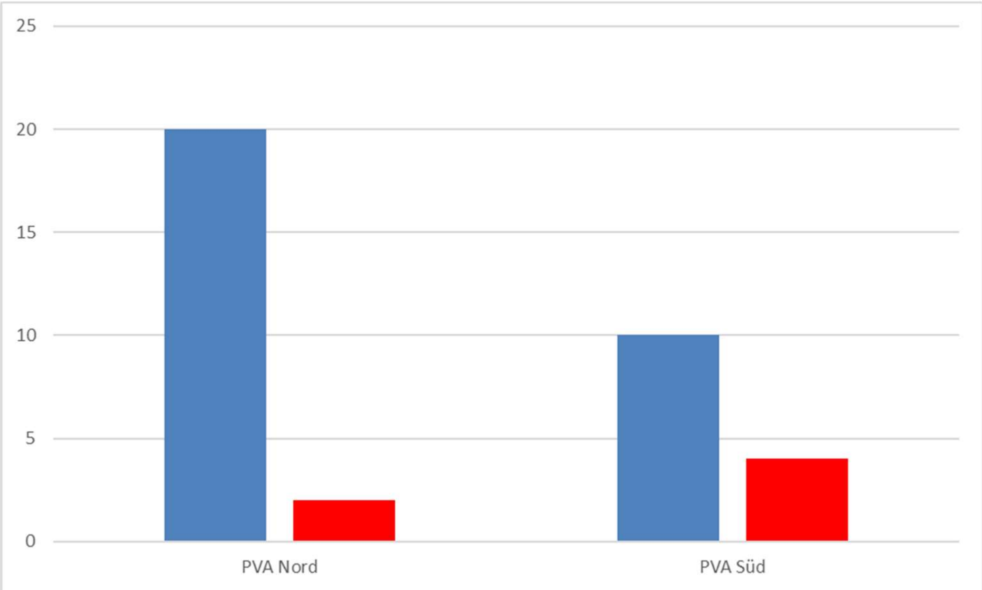


Figure 3-8: Comparison of species numbers (blue) and number of species on the Red Lists (red) of the Federal Republic of Germany and the State of Brandenburg for grasshoppers between the two photovoltaic facilities at the former Fürstenwalde airfield in 2017

With regard to birds, both years were also examined[32 63]. Since the results differ greatly because another photovoltaic facility has been built to the south in the meantime, only the results from 2017 after its construction will be used here. In order to compare the photovoltaic facilities directly with each other, areas further away were not considered, so that the focus is exclusively on the module rows and the immediate vicinity of the photovoltaic facilities.

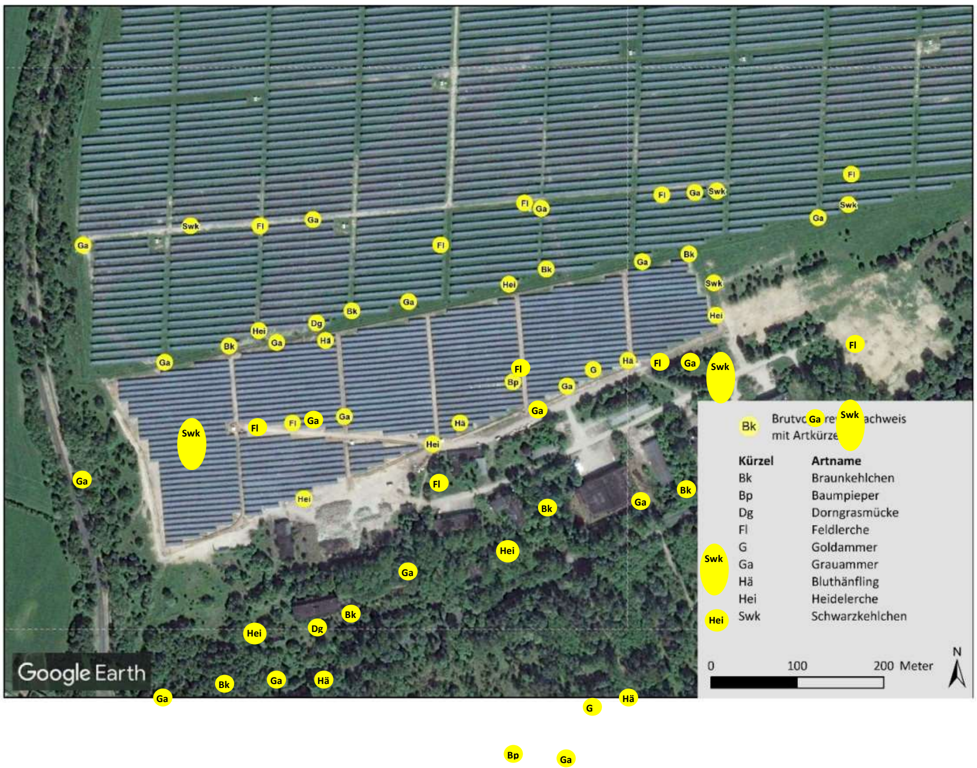


Figure 3-9: Map of the territory centres and/or breeding sites for the identified breeding bird species in the study area in the 2017 study period (Source: 2017, © 2009 GeoBasis-DE/BKG, © 2018 Google)

Altogether the two solar parks are populated by the following species and the following breeding pair numbers, see Table **3**-5. In the photovoltaic facility North there are one third more breeding pairs than in the photovoltaic facility South, but the number of species is comparable.

Table 3-5: Breeding bird species recorded in the two photovoltaic facilities, FüWaPVANord and FüWaPVASüd, including the number of breeding pairs and information on endangered species classification: + = not endangered, V = early warning list, but not endangered, 3 = endangered, 2 = highly endangered, 1 = threatened with extinction[64] [65]

Species name (common name)	Species name (lat)	BRD	BB	FüWaPVANord	FüWaPVASüd
Whitethroat	Sylvia communis	+	+	1	
woodlark	Lullula arborea	V	+	2	2
Whinchat	Saxicola rubetra	2	2	3	1
stonechat	Saxicola rubicola	+	+	3	
skylark	Alauda arvensis	3	3	5	1
corn bunting	Miliaria calandra	V	+	6	4

[64] GRÜNEBERG et al. (2015)

[65] RYSLAVY et al. (2008)

Species name (common name)	Species name (lat)	BRD	BB	FüWaPVANord	FüWaPVASüd
Tree pipit	Anthus trivialis	3	V		1
Linnet	Carduelis cannabina	3	3		3
yellowhammer	Emberiza citrinella	V	+		1
Total breeding pairs				**20**	**13**

In the photovoltaic facility North two species from the Brandenburg Red Lists were found and four in the photovoltaic facility South, see Figure **3**-10. However, a total of eight breeding pairs from two endangered species were again found in the photovoltaic facility North and six from a total of four species in the photovoltaic facility South.

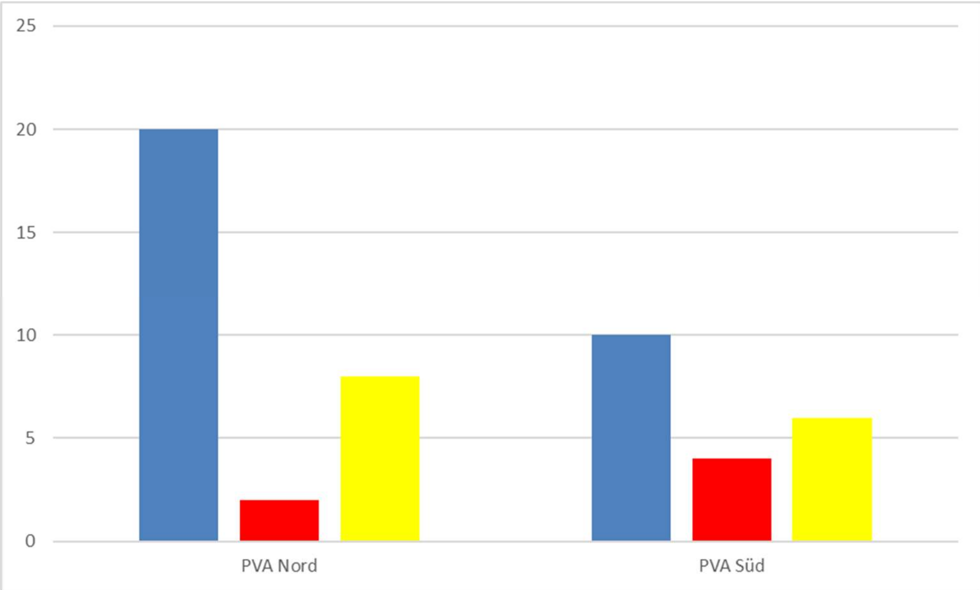


Figure 3-10: Comparison of the number of species (blue), the number of species on the Red Lists (red) and the number of breeding pairs of endangered species in the Federal Republic of Germany and the State of Brandenburg for breeding birds between the two photovoltaic facilities at the former Fürstenwalde airfield in 2017

Three breeding pairs of common linnets nested in the photovoltaic facility South. Apparently, there are conditions under the module tables that are particularly suitable for this type. The yellowhammer, on the other hand, which was also found in the photovoltaic facility South, has its breeding ground on the southern edge. The fact that it uses the edges of solar farms is known from various studies[31] [66]. The situation is different with the pairs of stonechats identified: All three breeding pairs were detected in the photovoltaic facility North. In contrast, the tree pipit only occurred in the photovoltaic facility South. The species inhabits ecotones, i.e. transitional areas between habitats with different characteristics, e.g. between forest and open land areas. Occurrences within photovoltaic power plants are known[66] [67], although no breeding evidence has yet been found. However, no trend

[66] TRÖLTZSCH & NEULING (2013)

[67] HERDEN et al. (2006)

can be deduced from this finding. Whinchats are present with three pairs in the photovoltaic facility North and one pair in the photovoltaic facility South. They use the marginal areas between the two facilities.

The examples given show:

- It should be noted that solar farms can increase biodiversity.
- Solar farms with wider spacing are more suitable for open land bird species than those with narrow spacing.
- Bird species that build nests under the modules can find favourable breeding opportunities in solar farms with narrow row spacing.
- In terms of insect fauna, solar farms with wide row spacing tend to be more species-rich and the number of individuals is higher than in those with narrow row spacing.

3.3.4 Neuhardenberg

This solar park was built in 2012 and was the largest in Europe at the time. There are a total of 4 individual photovoltaic facilities here, as shown in Figure **3**-11. The decisive factor for further consideration is that the entire site has similar soil conditions over a large area, but the individual areas were partly covered with plantations or individual buildings before the solar park was built. Therefore, the effect of the solar park on the situation was projected before construction to illustrate conditions, see Figure **3**-12. Furthermore, it must be taken into account that the large photovoltaic facility, which is located north, east and south-east of the runway, was built with very narrow distances between the module rows, see also

Figure **1**-7. The other 3 photovoltaic facilities have wider row spacing.

Figure 3-11: Neuhardenberg solar park 2019 with the 4 different photovoltaic facilities built in 2012. The coloured lines highlight the respective boundaries between the individual photovoltaic facilities (Aerial photo source: © 2009 GeoBasis-DE/BKG, © 2019 CNES Airbus, © 2018 Google).

Figure 3-12: Neuhardenberg airfield and surrounding area in 2010 with the projection of the 4 different photovoltaic facilities built in 2012. The coloured lines highlight the respective boundaries between the individual photovoltaic facilities, (Aerial photo source: © 2019 GeoBasis-DE/BKG, © 2019 Google)

In connection with the construction of the solar park, extensive protective measures were taken in relation to birds, bats and sand lizards. Among other things, the sand lizards from the construction site were driven into the peripheral areas, where temporary structures were built to allow them to hibernate in 2012/2013. This meant that the construction site was free of sand lizards in 2012. Monitoring[44] took place in 2014 to investigate whether and in what density the solar park had been repopulated by sand lizards. The module rows were walked by a total of eight biologists on 3-4 September 2014 and each detection of a sand lizard was located by GPS. These findings were then projected onto an aerial photograph from 2016, which only shows the park built in 2012. A total of 309 individual sand lizards were detected two years after the solar park was built, as shown in Figure **3**-13.

Figure 3-13: Individual recordings of sand lizards[68] in the Neuhardenberg solar park in 2014. The 4 different photovoltaic facilities built in 2012 are marked by different coloured lines, (Aerial photo source: © 2019 MAXAR Technologies, © 2019 Google)

This illustration already shows that the facility with the relatively narrow row spacing has comparatively few animals. A total of 71 were detected here, while in the approximately equal area of the other 3 photovoltaic facilities there were 238, i.e. about 3 times as many.

This finding can be further differentiated. Figure **3**-14 shows an analysis of only juvenile animals, i.e. the 2014 hatchlings. In the photovoltaic facility with narrow row spacing, 65 young animals were detected, whereas in the three photovoltaic facilities with wide spacing 169, about 2.5 times as many, were detected.

[68] The western area had not yet been repopulated at the time of the mapping. The area is also sealed in the western section by concrete that was not removed during construction. Even in the central area south of the runway, parts of the facility had not yet been colonised by sand lizards.

Figure 3-14: Individual recordings of exclusively juvenile sand lizards in the Neuhardenberg solar park in 2014. The 4 different photovoltaic facilities built in 2012 are marked by different coloured lines, (Aerial photo source: © 2019 MAXAR Technologies, © 2019 Google)

Finally, the findings were also differentiated according to all other animals, i.e. sub-adults and adults. This finding is shown in Figure **3**-15. Hence six adults or sub-adults were found in the photovoltaic facility with narrow row spacing and 69 animals in the photovoltaic facility with wide spacing, or about 11 times as many.

Figure 3-15: Individual records of adult and sub-adult sand lizards at the Neuhardenberg solar park in 2014. The 4 different photovoltaic facilities built in 2012 are marked by different coloured lines, (Aerial photo source: © 2019 MAXAR Technologies, © 2019 Google)

Based on this study, there is clear evidence that facilities with wide row spacing for heat-loving animals, such as sand lizards, are generally more suitable for stable populations. Photovoltaic facilities with narrow row spacing offer hardly any habitat for adult animals. Therefore a population increase is not to be expected here, since animals too old to reproduce are very rare.

- The example shows that photovoltaic facilities with wider spacing are more suitable for sand lizards than those with narrow spacing.
- Populations of sand lizards in photovoltaic facilities with wide row spacing can become very large, providing source habitats for other adjacent habitats.

3.4 Trend

For this study, results from biological investigations of 75 photovoltaic power plants were evaluated; these had been constructed on different sites (arable land, grassland, former military training areas, former mining areas, etc.), have different designs (especially different module row spacing), are maintained differently to an extent (mowing intensity) and are located in different landscape environments.

For the biotope types and flora as well as the species groups of birds, grasshoppers and amphibians/reptiles, the results of investigations show – in some cases clearly – trends in the importance of photovoltaic facilities for the promotion of biodiversity. It has also already been shown that the extent to which the installations contribute to biodiversity depends on the design of the module rows. For example, negative impacts on nature conservation concerns can be reduced through the appropriate design of open space photovoltaic facilities and extensive land management[69].

The following statements can already be made on the basis of the results:

- Photovoltaic facilities are suitable for promoting biodiversity.
- Sites on which photovoltaic facilities are built usually achieve higher diversity than before. Reservations to this statement cannot be clearly demonstrated from the available documents, but are conceivable at sites where high diversity was already marked in the initial stage. However, it can be assumed that this can be avoided from the outset – at least where endangered species are present – through appropriate site selection.
- An essential prerequisite for an increase in biodiversity is the design of the installations (wide spaces between module rows are intensively populated, e.g. by sand lizards, narrow module rows remain partially unpopulated) and the maintenance of the spaces between rows (extensive use of grassland with removal of the mown material)[70].
- Photovoltaic facilities which are erected on conversion sites, for example, can help to permanently maintain open habitat structures (e.g. sandy open ground areas). This can counteract the trend that the succession of vegetation on fallow land leads to closed ruderal

[69] BFN (Federal Agency for Nature Conservation) (2019)

[70] LEGUAN GMBH (2014)

vegetation cover or to reforestation. One example of this is the settling of hoopoes in the vicinity of the module rows in the Turnow-Preilack solar park in Brandenburg[71].

- Photovoltaic facilities in the agricultural landscape produce wildflower meadows when properly cared for, and are thus often a source of food for nectar-seeking insects that cannot find food in an agricultural environment. This makes them withdrawal areas for species in the agricultural landscape.
- Photovoltaic facilities can have an effect on the environment beyond the solar farm itself. This is the case, for example, when the installations are used by breeding bird species in the adjacent areas to forage for food.
- Photovoltaic facilities in the agricultural sector are largely free of fertilisers and pesticides. This means that – in light of current studies[72] on the subject of insect mortality and the Federal Action Programme for Insect Protection[73] adopted in September 2019 – large-scale installations in intensively farmed environments can significantly counteract this.
- Photovoltaic facilities in the agricultural sector are refuges for animals of the agricultural landscape, such as birds, mammals, various groups of insects.
- Photovoltaic facilities are basically suitable for extensive agricultural use: beekeeping, grazing, cultivation of crops by nurseries. Such uses can also promote biodiversity. In arid regions of Arizona, for example,

[71] BOSCH & PARTNER & RANA (2015)

[72] SEIBOLD et al. (2019)

[73] BMU (2019)

the total yield of certain vegetables grown under solar modules (chili, tomatoes) was up to three times higher than in open cultivation due to lower temperature fluctuations and higher humidity[74].

- The evaluation of the documents also reveals a possible trend in the difference in importance of small facilities compared to large facilities: While smaller facilities act as stepping stone biotopes and can thus maintain or restore habitat corridors, large facilities – if properly maintained – can create sufficiently large habitats that enable the preservation or establishment of populations of, for example, sand lizards or breeding birds.

[74] BARRON-GAFFORD (2019)

4 Further recommendations

The evaluation of documents on 75 solar parks shows that photovoltaic plants can contribute to the promotion of biodiversity, especially in structurally poor agricultural landscapes. In addition to the choice of location, the key to this is obviously adapted land use management as well.

In order to be able to prove this scientifically, a nationwide standardisation of the content of investigations, investigation methods as well as investigation intensity (in particular the duration of investigations) should be aimed for in order to achieve meaningful monitoring. Accordingly, the Federal Agency for Nature Conservation in its current "Renewable Energies Report"[10] calls for the development of monitoring concepts for standardised data collection: "Testing and accompanying research on RE plants must be intensified. Scientific monitoring, e.g. at test plants or during regular plant operation, can be used to assess compatibility with nature (...) Positive examples of RE projects with added value for nature conservation and landscape planning should be analysed, evaluated and compiled into a collection of examples of best practice."[75]

To this end it is recommended to set up and maintain in-house company databases with biodiversity-relevant project files (fast research access). These can be designed similar to the compensation area cadastres of the federal states and contain all essential information on the condition, maintenance, investigations carried out, etc.

The results of the evaluation of the studies available to date, which come from the different planning levels of solar farms, show that standardised monitoring should include the following aspects:

1. Recording of the initial situation

- Standardisation of the investigation methods/procedures as well as qualification of experts and planners for the evaluation of investigation results with the aim of improving the quality of impact assessments and thus increasing the legal certainty of planning, see also recommendations of the BFN10.

[75] BFN (Federal Agency for Nature Conservation) (2019): Page 35f

- Standards should already be defined before recording the biotope/habitat/use types (balance). Pre-existing sets of rules and regulations can be used here76.
- Species surveys in the required and recommended time periods and patterns (no estimations of potential), including area-based assessment of qualities.
- Consideration of adjacent areas with regard to their potential (migration, impairment and assessment of the qualities present).
- The different qualities determined in an area to be developed can lead to adaptation of construction design, secondary uses and maintenance regimes.

2. Monitoring after construction of installations

- Wherever possible, attention should be paid to a standardised methodology or one adapted to the previous surveys.
- Do not implement exclusively on compensation areas (include installations).
- Multi-annual, with a focus on specific species groups, including special attention to insects (in view of the alarming decline in species, particularly in the agricultural sector).
- Medium-term follow-up investigation.
- If required, short-term adjustments via flexible options for exerting influence (maintenance management, secondary use, habitat upgrading).

3. Design

- Use of uncontaminated substrates appropriate to the location (neophytes, neozoa, nutrient load)
- Use of locally produced certified seed and planting stock

[76] ALBRECHT et al (2014)

4. Site selection

- Use of areas that are unproblematic from the aspect of nature conservation, such as intensive fields with opportunities for enhancing biodiversity
- If areas of high nature conservation value are used, then the advantages (e.g. management concepts for conversion areas) and disadvantages should be weighed

5. Using expertise, making knowledge available

- Involvement of experts to avoid negative impacts on nature conservation or to develop/promote measures that are sensible from a point of view of nature conservation ("upgrading") from the perspective of areas of unspoiled nature
- Formulation of nature conservation objectives in advance
- Trials and accompanying research on photovoltaic facilities: scientific monitoring can be used to assess compatibility with nature (avoidance and compensation measures)
- Long-term establishment of a central cadastre with successfully implemented methods and measures

5 Annex

5.1 Bibliography

ALBRECHT, K., T. HÖR, T., HENNING, F. W. TÖPFER-HOFMANN, G. & GRÜNFELDER, C., 2014: Leistungsbeschreibungen für faunistische Untersuchungen im Zusammenhang mit landschaftsplanerischen Fachbeiträgen und Artenschutzbeitrag. Forschungs- und Entwicklungsvorhaben FE 02.0332/2011/LRB im Auftrag des Bundesministeriums für Verkehr, Bau und Stadtentwicklung. Schlussbericht 2014 [Specifications for faunistic investigations in connection with landscape planning and species protection contributions. research and development project FE 02.0332/2011/LRB on behalf of the Federal Ministry of Transport, Building and Urban Affairs. Final report 2014].

BARRON-GAFFORD, G. A., PAVAO-ZUCKERMAN, M. A., MINOR, R. L., SUTTER, L. F., BARNETT-MORENO, I., BLACKETT, D. T., THOMPSON, M., DIMOND, K., GERLAK, A. K., NABHAN, G. P., MACKNICK, J. E., 2019: Agrivoltaics provide mutual benefits across the food - energy - water nexus in drylands. Nature Sustainability volume 2, pages 848 - 855.

BAUER, H.-G., BEZZEL, E. & FIEDLER, W. (ed.), 2005: Das Kompendium der Vögel Mitteleuropas [The Compendium of the Birds of Central Europe], 3 volumes AULA-Verlag, Wiebelsheim.

BERGER, G., PFEFFER, H., KALETTKA, T. (ed.), 2011: Amphibienschutz in kleingewässerreichen Ackerbaugebieten [Amphibian protection in small water-rich arable farming areas]. Natur & Text, Rangsdorf: 384 S.BFN, 2014: Grünland-Report. Alles im Grünen Bereich? [Grassland report. Everything OK?] (https://www.bfn.de/fileadmin/MDB/documents/presse/2014/PK_Gruenland-papier_30.06.2014_final_layout_barrierefrei.pdf, accessed 02.11.2019).

BFN, 2015: Artenschutz-Report 2015. Tiere und Pflanzen in Deutschland. [Species Protection Report 2015: Animals and Plants in Germany] (https://www.bfn.de/fileadmin/BfN/presse/2015/Dokumente/Artenschutzre-port_Download.pdf, accessed 02.11.2019).

BFN, 2017: Agrar-Report 2017. Biologische Vielfalt in der Agrarlandschaft. [Agriculture Report 2017. Biological diversity in the agricultural landscape.]

(https://www.bfn.de/fileadmin/BfN/landwirtschaft/Dokumente/BfN-Agrar-Report_2017.pdf, accessed 29.10.2019).

BFN, 2019: Erneuerbare Energien Report. Die Energiewende naturverträglich gestalten [Renewable Energies Report: Shaping the energy transition in a way that is compatible with nature] (https://www.bfn.de/fileadmin/BfN/erneuerbareenergien/Dokumente/BfNErneuerbareEnergienReport2019_barrierefrei.pdf, accessed 29.10.2019).

BMEL - Federal Ministry of Food and Agriculture, 2018: Humus in landwirtschaftlich genutzten Böden Deutschlands. Ausgewählte Ergebnisse der Bodenzustandserhebung. [Humus in German agricultural soils: Selected results of the soil condition survey] (https://www.bmel.de/SharedDocs/Downloads/Broschueren/Bodenzustandserhebung.pdf?__blob=publicationFile, accessed 29.10.2019).

BMU - Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (ed.), 2019: Action Programme for Insect Protection (https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/aktionsprogramm_insektenschutz_kabinettversion_bf.pdf, accessed 05.11.2019).

BMUB (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) - Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (ed.), 2007: German National Biodiversity Strategy. (https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/nationale_strategie_biologische_vielfalt_2015_bf.pdf, accessed 29.10.2019).

BUND, 2019: Mais & Umwelt: Vermaisung, Grundwasser, Pestizide, Fruchtfolge, Bienensterben, Neonicotinoide & Greenwash. [Corn & Environment: Maize Monoculture, Groundwater, Pesticides, Crop Rotation, Bee Death, Neonicotinoids & Greenwashing] (http://www.bund-rvso.de/mais-umwelt.html, accessed 10.11.2019).

DIERSCHKE, H. & BRIEMLE, G., 2002: Kulturgrasland [Cultivated grassland], 1st edition, published by Eugen Ulmer, 239 p.

DLR, Fraunhofer IWES, IFNE 2012: Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei der Berücksichtigung der Entwicklung in Europa und global. Schlussbericht BMU-FKZ 03MAP146 [Long-term scenarios and strategies for the expansion of renewable energies in

Germany taking into account developments in Europe and globally. Final report BMU-FKZ 03MAP146] (https://www.bfn.de/fileadmin/BfN/erneuerbareenergien/Dokumente/BfNErneuerbareEnergienReport2019_barrierefrei.pdf, accessed 10.11.2019).

PROJEKTBÜRO DÖRNER + PARTNER GMBH, 2019: Vorhabenbezogener B-Plan „Solarpark Flugplatz Werneuchen West IV“ zugleich Vorhaben- und Erschließungsplan Bestand Beschlussvorlage Anlage 3 [Project-related B Plan “Werneuchen Airfield West IVsolar park”, also Project and development plan Inventory Draft resolution Annex 3]

FINCK, P., HEINZE, S., RATHS, U., RIECKEN, U. & SSYMANK, A., 2017: Rote Liste der gefährdeten Biotoptypen Deutschlands - dritte fortgeschriebene Fassung 2017. [Red List of endangered biotope types in Germany – third updated version 2017], Naturschutz und Biologische Vielfalt 156, 637 p.

FISCHER, S, POSCHLOD, P. & BEINLICH, B., 1995: Die Bedeutung der Wanderschäferei für den Artenaustausch zwischen isolierten Schaftriften [The importance of migratory sheep farming for the exchange of species between isolated sheep pastures – Supplement] - Beiheft Veröffentlichungen für Naturschutz und Landschaftspflege Baden-Württemberg: 229 - 256.

FNR - Agency for Renewable Resources 2019: Land use in Germany. (https://mediathek.fnr.de/flachennutzung-in-deutschland.html, accessed 29.10.2019).

GRÜNEBERG, C., BAUER, H.-G., HAUPT, H., HÜPPOP, O., RYSLAVY, T. & SÜDBECK, P, 2015: Rote Liste der Brutvögel Deutschlands [Red list of German breeding birds] 5th version, 30 November 2015. Ber. Vogelschutz 52: 19 - 67.

GÜNTHER, A., NIGMANN, U., ACHTZIGER, R. & GRUTTKE, H. (Eds.), 2005: Analyse der Gefährdungsursachen planungsrelevanter Tiergruppen in Deutschland [Analysis of the causes of the endangerment of animal groups relevant for planning in Germany] Naturschutz und Biologische Vielfalt 21: 605 p.

HABEL, J. C., ULRICH, W., BIBURGER, N., SEIBOLD, S. & SCHMITT, T., 2019: Agricultural intensification drives butterfly decline. Insect Conserv Divers, Feb. 7, 2019 DOI: 10.1111/icad.12343.

HALLMANN, C. A., SORG, M., JONGEJANS, E., SIEPEL, H., HOFLAND, N., SCHWAN, H., STENMANS, W., MÜLLER, A., SUMSER, H., HÖRREN, T., GOULSON, D. & DE KROON, H., 2017: More than 75 percent decline over 27 years in total flying insect biomass in protected areas.- PLoS ONE 12(10): e0185809. https://doi.org/10.1371/journal.pone.0185809.

HERDEN, C., RASSMUS, J., GÖDDERZ, S., GEIGER, S., GHARADJEDAGHI, B. & JANSEN, S., 2006: Naturschutzfachliche Bewertungsmethoden von Freilandphotovoltaikanlagen - Endbericht - Stand Januar 2006 [Nature conservation assessment methods for open field photovoltaic plants. Final Report, January 2006] - on behalf of the Federal Agency for Nature Conservation.

METZING, D, HOFBAUER, N., LUDWIG, G. & MATZKE-HAJEK, G., (Eds.) 2018: Rote Liste gefährdeter Tiere, Pflanzen und Pilze Deutschlands. Band 7: Pflanzen [Red list of endangered animals, plants and fungi in Germany Volume 7: Plants] Naturschutz und Biologische Vielfalt 70 (7), 784 p.

MÖLLER, J., REICHLING, A., BRAUNER, O. & HOFMANN, C., 2012: Monitoring Solaranlage „Finow II“ Zwischenbericht 2012. - im Auftrag der S Quadrat Finow Tower Grundstücks GmbH & Co. KG [Monitoring of “Finow II” solar park Interim Report 2012 - on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG]

MÖLLER, J. & REICHLING, A., 2015: Monitoring Solaranlage „Finow II“ Zwischenbericht 2015. - im Auftrag der S Quadrat Finow Tower Grundstücks GmbH & Co. KG [Monitoring of “Finow II” solar park Interim Report 2015 - on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG]

MONTAG H., PARKER, G. & CLARKSON, T., 2016: The effects of solar farms on local biodiversity: a comparative study.- Clarkson and Woods and Wychwood Biodiversity.

NAW - National Academy of Sciences Leopoldina 2013: Bioenergy - Chances and Limits. (https://www.leopoldina.org/uploads/tx_leopublication/201207_Stellungnahme_Bioenergie_LAY_en_final_01.pdf, accessed 10.11.2019).

NEULING, E., 2009: Auswirkungen des Solarparks „Turnow-Preilack“ auf die Avizönose des Planungsraums im SPA „Spreewald und Lieberoser Endmoräne“. Abschlussarbeit im Studiengang Landschaftsnutzung und Naturschutz (B.Sc.)

[Effects of the "Turnow-Preilack" solar park on avicenosis in the planning area in the SPA "Spreewald and Lieberoser Endmoräne". Final thesis in the course of studies landscape use and nature conservation (B.Sc.)]

ÖKO-INSTITUT E.V. & PROGNOS, 2018: Germany's electricfuture II – Regionalization of renewable power generation. Eds. WWF Germany. 160 p. (https://mobil.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF-Germanys-Electric-Future-2-RES-Regionalization.PDF), accessed 08.11.2019.

PARKER, G. & MCQUEEN, C., 2013: Can Solar Farms Deliver Significant Benefits for Biodiversity? Preliminary Study July-August 2013.- Wychwood Biodiversity.

PESCHEL, R., 2019: PVA Werneuchen - Artenschutzkonzept.- im Auftrag von Stadt- und Landschaftsplanung Bandow, Wölsickendorf Höhenland [Werneuchen solar farm - Species protection concept on behalf of Stadt- und Landschaftsplanung Bandow, Wölsickendorf Höhenland]

PESCHEL, T., 2010: Solarparks - Chancen für die Biodiversität, Erfahrungsbericht zur biologischen Vielfalt in und um Photovoltaik-Freiflächenanlagen [Solar parks – Opportunities for Biodiversity, A report on biological diversity in and around ground-mounted photovoltaic plants], published by the Agentur für Erneuerbare Energien e. V., Berlin.

RYSLAVY, T., MÄDLOW, W., & JURKE, M., 2008: Rote Liste und Liste der Brutvögel in Brandenburg [Red list and list of breeding birds in Brandenburg] – Naturschutz und Landschaftspflege in Brandenburg 17 (4).

SCHALOW, L. E. 2013: Schafbeweidung in Solarparks in Deutschland [Sheep grazing in solar parks in Germany] Unpublished master's thesis, Univ. Potsdam, 140 p.

SEIBOLD, S., GOSSNER, M. M., SIMONS, N. K., BLÜTHGEN, N., MÜLLER, J., AMBARLI, D., AMMER, C., BAUHUS, J., FISCHER, M., HABEL, J.C., LINSENMAIR, K.E., NAUSS, T., PENONE, C., PRATI, D., SCHALL, P., SCHULZE, E.-D., VOGT, J., WÖLLAUER, S. & WEISSER, W. W., 2019: Arthropod decline in grasslands and forests is associated with drivers at landscape level. Nature, 30.10.2019 - DOI: 10.1038/s41586-019-1684-3.

TRAUTMANN GOETZ, 2007: Document B: Umweltverträglichkeitsstudie zum Raumordnungsverfahren für den Regionalflughafen Eberwalde-Finow

[Environmental impact study for the regional planning procedure for the Eberwalde-Finow regional airport] - on behalf of Tower Finow GmbH. 238 pp.

TRÖLTZSCH, P. & NEULING., E, 2013: Die Brutvögel großflächiger Photovoltaikanlagen in Brandenburg [Breeding birds in large-area photovoltaic plants in Brandenburg] - Vogelwelt 134: 155 - 179

FEA - Federal Environmental Agency 2019: Bodenerosion durch Wasser - eine unterschätzte Gefahr [Soil erosion by water - an underestimated danger] (https://www.umweltbundesamt.de/themen/boden-landwirtschaft/boden-belastungen/erosion#textpart-1, accessed 10.11.2019).

WAHL, J., R. DRÖSCHMEISTER, B. GERLACH, C. GRÜNEBERG, T. LANGGEMACH, S. TRAUTMANN & SUDFELDT, C., 2015: Vögel in Deutschland [Birds in Germany] – 2014 DDA, BfN, LAG VSW, Münster. (https://www.bfn.de/fileadmin/BfN/monitoring/Dokumente/ViD2014_Internet_barrierefr.pdf, accessed 02.11.2019).

WIRTH, H., 2019: Recent facts about photovoltaics in Germany: Fraunhofer ISE. https://www.ise.fraunhofer.de/en/publications/studies/recent-facts-about-pv-in-germany.html; Version dd. 14.10.20196.

ZAHN, A. & TAUTENHAHN, K., 2016: Beweidung mit Schafen [Grazing with sheep] In: Burkart-Aicher, B. et al., online manual „Beweidung im Naturschutz“ [Grazing with sheep In: Burkart-Aicher, B. et al., online manual “Grazing in Nature conservation”], Akademie für Naturschutz und Landschaftspflege (ANL), Laufen, (https://www.anl.bayern.de/fachinformationen/beweidung/7_5_schaf-beweidung.htm, accessed 11.11.19)

5.2 Results from studies on photovoltaic facilities

Brandenburg

BEAK CONSULTANTS, 2018: Monitoring Brutvögel und Biotope 2018 im **Sondergebiet Photovoltaik des Verkehrslandeplatzes Welzow.** Bericht [Monitoring of breeding birds and biotopes in 2018 in the **special photovoltaic area at the Welzow airfield.** Report] – on behalf of juwi Operations & Maintenance GmbH. 25 p. + annex

BOSCH & PARTNER, 2007: Vorhabenbezogener Bebauungsplan Fotovoltaik -**Solarpark „Turnow-Preilack“.** Teil C Umweltbericht [Project-related development plan photovoltaics **“Turnow-Preilack” solar park.** Part C environmental report] 100 p. – on behalf of Solar Projekt GmbH.

BOSCH & PARTNER & RANA, 2012: **Solarpark Turnow-Preilack**. Bericht zum naturschutzfachlichen Monitoring für die Jahre 2011 und 2012 - einschließlich Maßnahmenkonzept 2013 [**Turnow-Preilack solar park**. Report on nature conservation monitoring for the years 2011 and 2012 – including concept for 2013 measures] - on behalf of juwi solar GmbH. 60 pp. + Appendix

BOSCH & PARTNER & RANA, 2015: **Solarpark Turnow-Preilack** 1. Bericht zum naturschutzfachlichen Monitoring für den Zeitraum 2014-2015 [**Turnow-Preilack solar park** 1st report on nature conservation monitoring for the period 2014-2015] – on behalf of Solar Power & Co GmbH. 80 pp. + Appendix.

CS PLANUNGS- UND INGENIEURGESELLSCHAFT MBH, 2012: Naturschutzfachliches Eingriffsgutachten zum B-Plan **Solarpark Eggersdorf** in der Gemarkung Eggersdorf, Landkreis Märkisch-Oderland und der Gemarkung Schönfelde, Landkreis Oder - Spree [Nature conservation expert’s report on the B-Plan **Eggersdorf solar park** in the Eggersdorf district of Märkisch-Oderland and the Schönfelde district of Oder-Spree] - on behalf of FIRU, Forschungs- und Informations-Gesellschaft für Fach- und Rechtsfragen der Raum- und Umweltplanung mbH. 84 p. + maps.

CS PLANUNGS- UND INGENIEURGESELLSCHAFT MBH, 2017: **Solarpark Eggersdorf** - Gemarkung Schönfelde, Landkreis Oder - Spree, Gemarkung Eggersdorf, Landkreis Märkisch-Oderland. Monitoring Avifauna, Reptilien, Vegetation. Bericht 2017 **[Eggersdorf solar park** – Schönfelde sub-district, Oder-Spree district, Eggersdorf sub-district, Märkisch-Oderland district. Monitoring avifauna, reptiles, vegetation. Report 2017] – on behalf of juwi Operations & Maintenance GmbH.

DIPL. ING. MARTIN HOFFMANN, 2013: Stadt Neustadt (Dosse) im Amt Neustadt (Dosse). Vorhabenbezogener Bebauungsplan Nr. 16 „**Bahnenergiepark**“. Begründung zum vorhabenbezogenen Bebauungsplan [Town of Neustadt (Dosse) in the Amt of Neustadt (Dosse). Project-related development plan No. 16

“**railway energy park”**. Justification for the project-related development plan]. On behalf of greenfuture invest GmbH. 12 pp. Including drawings.

FIRU, Forschungs- und Informations-Gesellschaft für Fach- und Rechtsfragen der Raum- und Umweltplanung mbH, 2012: Bebauungsplan Nr. 01/01/2011 „**Solarpark Eggersdorf**“ Stadt Müncheberg, Ortsteil Eggersdorf. Teil A Planzeichnung, Teil B Textliche Festsetzungen [Development plan No. 01/01/2011 “**Eggersdorf**” **solar park** Town of Müncheberg, urban district of Eggersdorf, Part A: Drawing, Part B: Textual assessments].

GRUPPE PLANWERK & BOSCH & PARTNER GMBH, 2007: Amt Peitz, Gemeinde Turnow-Preilack. vorhabenbezogener Bebauungsplan **Fotovoltaik-Solarpark „Turnow-Preilack“**. Vorhaben- und Erschließungsplan [Amt Peitz, municipality of Turnow-Preilack. Project-related development plan **“Turnow-Preilack” photovoltaic solar park**. Project and development plan] – on behalf of Solar Projekt GmbH.

IDAS PLANUNGSGESELLSCHAFT MBH, 2015 - 2018: Umwelt-Monitoring für den **Solarpark Jüterborg II**. Monitoring 2015 bis Monitoring 2018 [Environmental monitoring for the **Jüterborg II solar park**. Monitoring 2015 to monitoring 2018].

INGBA INGENIEURGESELLSCHAFT, 2011. 2. Änderung und Erweiterung des Bebauungsplans „**Verkehrslandeplatz Welzow**“ Teilgeltungsbereich 1 - Nord. Vorentwurf / Konzept [2nd modification and extension of the development plan “**Welzow airfield”**, part of area 1 – north, preliminary design/concept] – on behalf of juwi solar GmbH.

KRUSE, K. (Eds.), 2011: Stadt Jüterbog. Umweltbericht zum Bebauungsplan 031 „**Freiflächen-Solarpark Jüterbog II**“ Stadt Jüterbog, Landkreis Teltow-Fläming. [City of Jüterbog. Environmental report on development plan 031 “**Jüterbog II Open Space Solar Park”** City of Jüterbog, rural district of Teltow-Fläming]. On behalf of BEC-Energie Consult GmbH. 64 p.

LANDSCHAFTSPLANUNG DR. REICHHOFF, 2018: Vorhabenbezogener B-Plan Nr. 2/2015 der Gemeinde Schipkau „**Sondergebiet Photovoltaikanlage Lausitzring Ost**“ - Faunistisches Monitoring 2018 [Project-related B-Plan No. 2/2015 of the municipality of Schipkau “**Lausitzring East special area photovoltaic facility**” -

Faunistic monitoring 2018] - on behalf of the Wattner Projektentwicklungsgesellschaft mbH.

LEGUAN GMBH, 2012: Bericht zur ökologischen Bauüberwachung zum **Solarpark Finow II und III** 2011-2012 [Report on the ecological supervision of construction of the **Finow II and III solar park** 2011-2012] – on behalf of Trautmann Goetz Landschaftsarchitekten, Berlin. 62 p.

LEGUAN GMBH, 2014a: Monitoring auf der **PV-Anlage Finow II und III**. Zwischenbericht 2014 [Monitoring at the **Finow II and III PV facility** Interim Report 2014] – on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG. 33 p.

LEGUAN GMBH, 2014b: Monitoring der Zauneidechsenpopulation auf den Photovoltaikanlagen des **Solarparks Neuhardenberg**. Bericht 2014 [Monitoring of the population of sand lizards at the photovoltaic facilities in the **Neuhardenberg solar park**. 2014 report] - on behalf of Trautmann Goetz Landschaftsarchitekten. 13 p.

LEGUAN GMBH, 2015: Monitoring auf der **PV-Anlage Finow II und III**. Zwischenbericht 2015 [Monitoring at the **Finow II and III PV facility** Interim Report 2015] – on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG. 90 p.

LEGUAN GMBH, 2016a: Biologisches Monitoring zu **Solarpark II Fürstenwalde**. Bericht 2015 [Biological monitoring of **Fürstenwalde Solarpark II**. Report 2015] - on behalf of Trautmann Goetz Landschaftsarchitekten, Berlin. 11 pp. + Photo Appendix.

LEGUAN GMBH, 2016b: Monitoring der **PV-Anlage Finow II und III**. Abschlussbericht [Monitoring of the **Finow II and III PV facility** Final report] – on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG. 90 p.

LEGUAN GMBH, 2016c: **Solarpark Eisenspalterei**, Konzept zum Schutz von Amphibien und Reptilien während der Erstellung der Anlage **[Eisenspalterei solar park**, concept for the protection of amphibians and reptiles during construction of the plant] – on behalf of Dörner & Partner, Bahnhofstrasse 7, 16227 Eberswalde

LEGUAN GMBH, 2018a: Biologisches Monitoring zu **Solarpark II Fürstenwalde**. Bericht 2017 [Biological monitoring of **Fürstenwalde solar park II**. 2017 report] - on behalf of Trautmann Goetz Landschaftsarchitekten. 67 p. + Appendix.

LEGUAN GMBH, 2018b: Monitoring auf der **Photovoltaik-Anlage Eisenspalterei** in Eberswalde, Bericht 2018 [Monitoring at the **Eisenspalterei PV facility** in Eberswalde, report 2018] - on behalf of envalue GmbH, Hofkirchen.

LEGUAN GMBH, 2019: Monitoring auf der **Photovoltaik-Anlage Eisenspalterei** in Eberswalde, Bericht 2019 [Monitoring at the **Eisenspalterei PV facility** in Eberswalde, report 2019] - on behalf of envalue GmbH, Hofkirchen.

MEP PLAN GMBH, 2017a: Bebauungsplan „**Photovoltaik an der Bahn“ Milkersdorf** (Landkreis Spree-Neiße). Umweltbericht mit integriertem Grünordnungsplan [Development plan “**Photovoltaics on the railway**” **Milkersdorf** (Spree-Neisse rural district). Environmental report with integrated green structures plan]. On behalf of Konzepte für Immobilien. 32 p. and Appendix (Kolkwitz boundary field hedge).

MEP PLAN GMBH, 2017b: Bebauungsplan „**Photovoltaik an der Bahn“ Milkersdorf** (Landkreis Spree-Neiße). Artenschutzbeitrag [Development plan “**Photovoltaics on the railway” Milkersdorf** (Spree-Neisse rural district). Species protection contribution] - on behalf of Konzepte für Immobilien. 29 p. and 1 map.

MÖLLER, J. & REICHLING, A., 2015: Monitoring **Solaranlage „Finow II“** Zwischenbericht 2015 [Monitoring “**Finow II” solar power plant.** Interim report 2015] - on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG.

MÖLLER, J., A. REICHLING, O. BRAUNER & C. HOFFMANN, 2011: Monitoring Solaranlage „Finow I“. Zwischenbericht 2011 [Monitoring “Finow I” solar power plant. Interim report 2011]. 41 p. + Annex.

MÖLLER, J., REICHLING, A., BRAUNER, O. & HOFMANN, C., 2012: Monitoring **Solaranlage „Finow II“** Zwischenbericht 2012 [Monitoring “**Finow II” solar power plant.** Interim report 2012] - on behalf of S Quadrat Finow Tower Grundstücks GmbH & Co KG.

MUNICIPALITY OF KOLKWITZ, 2017: Landkreis Spree-Neiße. Satzung über den vorhabenbezogenen Bebauungsplan **Photovoltaik „An der Bahn“** Milkersdorf; Begründung gemäß § 9 Abs. 8 BauGB. Teil A - Satzungsfassung. Teil B -

Umweltbericht mit integriertem Grünordnungsplan [District of Spree-Neisse. Statutes on the project-related development plan **photovoltaics "An der Bahn"** Milkersdorf; Justification in accordance with Art 9 para. 8 of the Building Code (BauGB). Part A – Statutes. Part B – Environmental report with integrated green structures plan].

NATUR + TEXT GMBH, 2016: **Solarpark Fürstenwalde**. Monitoring. - Abschlussbericht 2015. Untersuchte Artengruppen: Brutvögel, Reptilien [**Fürstenwalde solar park**. Monitoring. Final report 2015. Investigated species groups: breeding birds, reptiles] - on behalf of juwi Operations & Maintenance GmbH.

NESSING, G., 2010: Bebauungsplan Nr. 031 der Stadt Jüterbog „**Freiflächen-Solarpark Jüterbog II**". Artenschutzrechtlicher Fachbeitrag zum Umweltbericht [Development plan No. 031, town of Jüterbog "**Jüterbog II open space solar park"**. Technical paper on the environmental report on species protection law] - on behalf of BEC-Energie Consult GmbH. 31 p.

PÄPKE, A. (Eds.), 2011: Bebauungsplan Nr. 031 der Stadt Jüterbog „**Freiflächen-Solarpark Jüterbog II**". Begründung (gemäß § 9 Abs. 8 BauGB) [Development plan No. 031 of the town of Jüterbog "**Jüterbog II Open Space Solar Park**". Justification (in accordance with Art 9 para. 8 of the Building Code (BauGB))] - on behalf of BEC-Energie Consult GmbH. 27 p.

PLAN UND RECHT GMBH, 2011: Stadt Fürstenwalde / Spree. Bebauungsplan Nr. 72 „**Solarpark James-Watt-Straße**". Teil A - Planzeichnung; Teil B - Textliche Festsetzungen [Town of Fürstenwalde/Spree. Development plan No. 72 "**James-Watt-Strasse**" **solar park**. Part A: Drawing; Part B: Textual assessments]

PLANUNGSBÜRO U. SCHNEIDER; 2006: Stadt Senftenberg. Bebauungsplan Nr. 32 „**Solarpark Senftenberg**". Rechtsplan, Satzungsbeschluss Teil A - Planzeichnung, Teil B - Text. [Town of Senftenberg. development plan No. 32 "**Senftenberg solar park**". Legal plan, resolution of the statutes. Part A: Drawing, Part B: Text]

PLANUNGSVERBAND „VERKEHRSLANDEPLATZ WELZOW", 2011. 2. Änderung und Erweiterung des Bebauungsplans „**Verkehrslandeplatz Welzow**" Umweltbericht [2nd modification and extension of the development plan "**Welzow airfield**". Environmental Report] – on behalf of juwi solar GmbH. 46 p.

RAUTH, T., 2018: Vorhabenbezogener B-Plan Nr. 2/2015 der Gemeinde Schipkau „**Sondergebiet Photovoltaikanlage Lausitzring Ost**" - Faunistisches Monitoring 2018 [Project-related B-Plan No. 2/2015 of the municipality of Schipkau "**Lausitzring East special area photovoltaic facility**" - Faunistic monitoring 2018] - on behalf of the Wattner Projektentwicklungsgesellschaft mbH.

SPIELHAUS, J., 2016a: Bebauungsplan Nr. 2/2015 der Gemeinde Schipkau „**Sondergebiet Photovoltaikanlage Lausitzring Ost**". Umweltbericht. [Development plan No. 2/2015 of the municipality of Schipkau "**Lausitzring East special area photovoltaic facility"**. Environmental report] - on behalf of HDS Schilling GmbH. 40 p.

SPIELHAUS, J., 2016b: Bebauungsplan Nr. 2/2015 der Gemeinde Schipkau „**Sondergebiet Photovoltaikanlage Lausitzring Ost**". Artenschutzrechtlicher Fachbeitrag [Development plan No. 2/2015 of the municipality of Schipkau "**Lausitzring East special area photovoltaic facility"**. Expert contribution on species protection law] - on behalf of HDS Schilling GmbH. 42 p.

STADT- UND LANDSCHAFTSPLANUNG DIPL.-ING. RAINER DUBIEL, 2012: Stadt Schwarzheide. Vorhabenbezogener Bebauungsplan - Vorhaben- und Erschließungsplan Nr. 5. „**Photovoltaikanlage – Hochkippe Schwarzheide**". Begründung mit Umweltbericht zur Satzung [Town of Schwarzheide. project-related development plan - project and development plan No. 5. "**Schwarzheide elevated landfill photovoltaic facility**". Justification with environmental report in accordance with statutes] - on behalf of unlimited energy GmbH. 36 p.

STADT- UND LANDSCHAFTSPLANUNG R. DÜBEL, 2010: Bebauungsplan „**Solarpark Senftenberg II**". Planzeichnung (Teil A), Textliche Festsetzungen (Teil B) [Development plan "**Senftenberg II solar park"**. Drawing (part A), textual assessments (part B) - on behalf of the "Lausitzer Seenland Brandenburg" special purpose association].

TOWN OF WITTENBERGE, 2010: Bebauungsplan Nr. 23 „**Solaranlage Nord**". Begründung - Fassung zum Satzungsbeschluss [Development plan No. 23 "**Solar Facility North**". Justification. Version of the resolution on the articles of association].

TRAUTMANN GOETZ, 2013: Stadt Neustadt (Dosse). Vorhabenbezogener Bebauungsplan Nr. 16 „**Bahnenergiepark**“. Umweltbericht einschl. „Nachtrag zum Umweltbericht“ [Town of Neustadt (Dosse). Project-related development plan No. 16 “**Railway energy park**”. Environmental report including "supplement to the environmental report”]. 28 p.

Mecklenburg-Western Pomerania

ARCHITEKTEN FÜR STADTPLANUNG SCHÜTZE & WAGNER, 2010: Bebauungsplan Nr. 3/2001 „**Gewerbegebiet Wiesenstrasse**“ der Stadt Eggesin. Begründung mit Umweltbericht [Development plan No. 3/2001 “**Wiesenstrasse industrial estate”** of the municipality of Eggesin, justification with environmental report] - on behalf of the municipality of Eggesin. 61 pp.

BÜRO FÜR FREILANDKARTIERUNG UND LANDSCHAFTSPLANUNG, 2019a: Bebauungsplan Nr. 3 „**Solarpark Düssin im Bereich südlich von Düssin, südlich der Bahnstrecke**“ Gemeinde Brahlstorf; Bebauungsplan Nr. 3 „Photovoltaik-Freiflächenanlage Melkof“ Gemeinde Vellahn, Erfassung Brutvögel in der Freiflächen-Solaranlage - Brutperiode 2018 - Landkreis Ludwigslust - Parchim, Mecklenburg-Vorpommern [Development plan No. 3 “**Düssin solar park in the area south of Düssin, south of the railway line**” Community of Brahlstorf; Development plan No. 3 “Melkof open space photovoltaic facility" municipality of Vellahn, Recording breeding birds in the open space photovoltaic facility, breeding period 2018. Rural district of Ludwigslust-Parchim, Mecklenburg-Western Pomerania] - on behalf of solar konzept GmbH. 17 p.

BÜRO FÜR FREILANDKARTIERUNG UND LANDSCHAFTSPLANUNG, 2019b: Bebauungsplan Nr. 3 „**Solarpark Düssin im Bereich südlich von Düssin, südlich der Bahnstrecke**“ Gemeinde Brahlstorf. Bebauungsplan Nr. 3 „**Photovoltaik-Freiflächenanlage Melkof**“ Gemeinde Vellahn. Kontrolle von Ausgleichsmaßnahmen gem. § 4c BauGB - 2. Monitoringjahr 2018. Landkreis Ludwigslust - Parchim, Mecklenburg-Vorpommern [Development plan No. 3 “**Düssin solar park in the area south of Düssin, south of the railway line**” municipality of Brahlstorf. Development plan No. 3 “**Melkof open space photovoltaic facility**”. Municipality of Vellahn. Supervision of compensation measures in accordance with Art 4c of the Building Code (BauGB) - 2nd monitoring year 2018.

Rural district of Ludwigslust-Parchim, Mecklenburg-Western Pomerania] - on behalf of solar konzept GmbH. 23 p.

BÜRO KNOBLICH, 2010: Bebauungsplan Nr. 7 „**Solarpark Tutow II, Auf dem Flugplatz**“. Satzungsexemplar. Planteil A - Planzeichnung 1, Planzeichnung 2; Planteil B - textliche Festsetzungen [Development plan No. 7 “**Tutow II solar park, Auf dem Flugplatz”**. Copy of the statutes. Plan part A - drawing 1, drawing 2; plan part B - Textual assessments] - on behalf of the municipality of Tutow, Amt Jarmen-Tutow.

BÜRO PRO CHIROPTERA, 2017: Errichtung von PV-Freiflächenanlagen auf dem **Flugplatz Tutow**. Fledermausmonitoring der Bestandsanlagen. Ergebnisbericht Monitoring [Creation of open space photovoltaic facilities at **Tutow airfield**. Bat monitoring in existing facilities. Monitoring results report] - on behalf of juwi Solar GmbH / juwi Operations & Maintenance GmbH. 15 p. + Annexes I - V.

CITY OF WISMAR, 2012: Satzung der Hansestadt Wismar über den Bebauungsplan Nr. 77 / 10 „**Sondergebiet Photovoltaik Wismar Ost**“. Teil A - Planzeichnung, Teil B - Textl. Festsetzungen [Statutes of the Hanseatic City of Wismar on development plan No. 77/10 “**Wismar East special area photovoltaics**”, Part A -Drawing, Part B - Textual assessments].

CITY OF WISMAR, 2012: Satzung der Hansestadt Wismar über den Bebauungsplan Nr. 77 / 10 „**Sondergebiet Photovoltaik Wismar Ost**“. Begründung. einschl. Anlage 1: Hansestadt Wismar: Errichtung einer Photovoltaikanlage. Umweltbericht nach § 2 Abs. 4 und § 2a Satz 2 Nr. 2 BauGB zur vorläufigen Einschätzung der anlagenbedingten Beeinträchtigunge [Statutes of the Hanseatic City of Wismar on development plan No. 77 / 10 “**Wismar Eastspecial area photovoltaics**”. Justification including Annex 1: Hanseatic City of Wismar: Construction of a photovoltaic power plant. Environmental report in accordance with Art 2 para. 4 and Art 2a para. 2 No. 2 of the Building Code (BauGB) for a preliminary assessment of the impairments caused by the installation].

FRASE, T., 2018: Monitoring der Brutvögel innerhalb des B-Plans Nr. 9 der Gemeinde Tutow „**PV-Anlage südlich des Casinosees**“ [Monitoring of breeding birds within B-Plan No. 9 for the municipality of Tutow, “**PV facility south of the Casinosee**”] - on behalf of Sonnenenergie Osterhof 11 GmbH & Co KG. 8 p.

LUTZ, K., 2014: Feldlerchenerfassung an den **Solarparks am Flughafen Barth** [Skylark detection at the **solar parks at Barth airport**] - on behalf of SunEnergy Europe GmbH, Hamburg. 4 p.

MUNICIPALITY of BAUMGARTEN, 2017: Begründung zum Bebauungsplan Nr. 2 für das Sondergebiet „**Energiepark Baumgarten**“. Satzung [Justification of development plan No. 2 for the special area “**Baumgarten Energy Park**”. Statutes].

MUNICIPALITY OF HORNSTORF, 2012: Satzung der Gemeinde Hornstorf über den Bebauungsplan Nr. 8 “**Gewerbestandort - ehemalige Obstplantage Kritzow**“ in der Fassung der 1. Änderung. Teil A: Planzeichnung mit textlichen Hinweisen, M 1:1000 [Statutes for the municipality of Hornstorf on development plan No. 8 “**Industrial site - Kritzow former fruit plantation”** version of the 1st amendment. Part A: Drawing with textual references, M 1:1000].

MUNICIPALITY OF HORNSTORF, 2013: Satzung der Gemeinde Hornstorf über den Bebauungsplan Nr. 13 „**Photovoltaikanlage an der Bahnstrecke Wismar-Hornstorf**“ einschließlich der 1. Änderung. Teil A: Planzeichnung mit textlichen Hinweisen, M 1:1000 [Statutes of the municipality of Hornstorf on development plan No. 13 “**Photovoltaic facility on the Wismar-Hornstorf railway line”** including the 1st amendment. Part A: drawing with textual references, M 1:1000].

MUNICIPALITY OF TUTOW, 2010: Satzung des Bebauungsplanes Nr. 6 „**Solarpark Tutow, Auf dem Flugplatz**“, 1. Änderung der Gemeinde Tutow, Landkreis Demmin. Begründung. Teil II - Umweltbericht mit integriertem Grünordnungsplan [Statutes for development plan No. 6 “**Tutow solar park, Auf dem Flugfeld**”. 1st amendment for the municipality of Tutow, rural district of Demmin. Justification. Part II - Environmental report with integrated green structures plan].

RAITH, HERTELT FUSS PARTNERSCHAFT FÜR STADT-, LANDSCHAFTS- UND REGIONALPLANUNG, 2017: Gemeinde Tutow Bebauungsplan Nr. 9 „**PV Anlage südlich des Casinosees**“. Satzungsfassung. Planzeichnung (Teil A), Textliche Festsetzungen (Teil B) [Municipality of Tutow development plan No. 9 “**PV facility south of the Cassinosee**”. Version of the statutes.Drawing (Part A), Textual assessments (part B)].

RAITH, HERTELT FUSS PARTNERSCHAFT FÜR STADT-, LANDSCHAFTS- UND REGIONALPLANUNG, 2017: Gemeinde Tutow Bebauungsplan Nr. 9 „**PV Anlage südlich**

des Casinosees“. Begründung [Municipality of Tutow development plan No. 9 “**PV facility south of the Casinosee**”. Justification]. 61 p.

SÄWERT STADTPLANUNG, 2013: Änderung des Bebauungsplanes der Stadt Laage „**Am Flugplatz Laage**“ / ehem. Bebauungsplan für das Gewerbe- und Industriegebiet „Am Flugplatz Laage“ des Planungsverbandes Laage für das Gebiet der Gemarkung Weitendorf, Flur 2, Flurstück 7/7 (teilweise). Teil A Planzeichnung; Teil B: Text [Amendment of the development plan for the town of Laage “**Am Flugplatz Laage**” / former development plan for the commercial and industrial area "Am Flugplatz Laage" by the Planungsverband Laage for the Weitendorf subdistrict, cadastral section 2, parcel 7/7 (in part). Part A: Drawing; Part B: Text].

STADT LAND FLUSS, 2012: Gemeinde Kummerow: Bebauungsplan Nr. 1 “**Sondergebiet Photovoltaik - Kummerow**“. Umweltbericht / Fachbeitrag Artenschutz [Municipality of Kummerow: Development plan No. 1 “**Kummerow special areaphotovoltaics”**, Environmental report / Technical paper on species protection]. 26 p.

STADT LAND FLUSS, 2016a: Vorhabenbezogener Bebauungsplan Nr. 3 **Solarpark Hohenmin, Gemeinde Neddemin**. Anlage 1. Umweltbericht. 27 S. - einschl. grünordnungsplan zur Umsetzung der Kompensationsmaßnahmen zum Bebauungsplan [Project-related land-use plan No. 3 **Hohenmin solar park, Municipality of Neddemin**. Appendix 1. Environmental report. 27 p., including green structures plan for the implementation of compensation measures related to the land-use plan].

STADT LAND FLUSS, 2016b: Gemeinde Blankensee - Bebauungsplan Nr. 01/2016 „**Photovoltaikanlage an der Bahn Blankensee**“ Landkreis Mecklenburgische Seenplatte [Municipality of Blankensee – Development plan No. 01/2016 “**Photovoltaic facility on the Blankensee railway**”. Mecklenburg Lake Plateau]. 24 p.

STADT LAND FLUSS, 2016c: Stadt Burg Stargard. Bebauungsplan Nr. 18 „**Sondergebiet Photovoltaik Cammin**“ Landkreis Mecklenburgische Seenplatte. Umweltbericht. [Town of Burg Stargard. Development plan No. 18 “**Camminspecial area photovoltaics**". Mecklenburg Lake Plateau. Environmental report]. 31 p.

STADT LAND FLUSS, 2016d: Stadt Woldegk Bebauungsplan Nr. 10 „**Photovoltaikanlage Bahn Helpt**“ Landkreis Mecklenburgische Seenplatte. Umweltbericht [Town of Woldegk development plan No. 10 “**Photovoltaic facility Bahn Helpt**" Mecklenburg Lake Plateau. Environmental report]. 31 p.

STADT LAND FLUSS, 2017: Gemeinde Lüttow-Valluhn. Bebauungsplan Nr. 5 „**Photovoltaik-Freiflächenanlage im Bereich des Kiessandtagebaus**“. Landkreis Ludwigslust-Parchim. Anlage 2. Fachbeitrag Artenschutz [Municipality of Lüttow-Valluhn. Development plan No. 5 “**Open space photovoltaic facility in the gravel & sand open pit**”. Rural district of Ludwigslust-Parchim. Annex 2. Technical paper species protection]. 17 p.

STADT LAND FLUSS, 2018: Gemeinde Lüttow-Valluhn. Bebauungsplan Nr. 5 „**Photovoltaik-Freiflächenanlage im Bereich des Kiessandtagebaus**“. Landkreis Ludwigslust-Parchim. Anlage 1. Umweltbericht [Municipality of Lüttow-Valluhn. Development plan No. 5 “**Open space photovoltaic facility in the gravel & sand open pit**”. Drural district of Ludwigslust-Parchim. Annex 1. Environmental report. 29 p.

STADT UND REGIONALPLANUNG, 2018: Satzung der Gemeinde Neuburg über den Bebauungsplan Nr. 15 „**Freiflächenphotovoltaikanlagen an der Bahnstrecke Wismar - Rostock, Bereich Steinhausen - Hagebök**“. Begründung. Satzungsbeschluss über die südöstliche Teilfläche. Teil 1: Begründung, Teil 2: Umweltbericht. 59 S. - einschl. Planzeichnung [Statutes of the municipality of Neuburg on development plan No. 15 “**Open space photovoltaic facilities on the Wismar - Rostock railway line, Steinhausen - Hagebök area**”. Justification. Resolution on the south-eastern part of the area in the statutes. Part 1: Justification, Part 2: Environmental Report. 59 p. including drawing].

TOWN OF JARMEN, 2012: Begründung zum Bebauungsplan Nr. 16 „Sondergebiet **Photovoltaikanlage Stadt Jarmen**”, OT Müssentin. Satzung [Justification for development plan No. 16 “**Town of Jarmen special area photovoltaic facility**”, urban district of Müssentin. Statutes]. 19 p.

UMWELTPLAN GMBH, 2018: Photovoltaikanlage Tutow 5. Monitoring Brutvögel auf **Tutow 5** und Ausgleichsflächen des B-Plan Nr. 7 und abschließenden Bewertung [Tutow 5 photovoltaic facility. Monitoring of breeding birds on **Tutow 5** and compensation areas of B-Plan No. 7 and final assessment] - on behalf of juwi Operations & Maintenance GmbH. 45 p.

UNIGEA SOLAR PROJECTS GMBH, 2016: Begründung zum Bebauungsplan Nr. 72/16 der Stadt Neustrelitz „**PV-Anlage westlich der Bahnlinie Neustrelitz-Berlin**“, Umweltbericht; einschl. Anhang 1: (§§ 2 Abs. 4 und 2a Satz 2 Nr. 2 BauGB) zum vorhabenbezogenen Bebauungsplan Nr. 72/16 der Stadt Neustrelitz sowie Anlage 2: FFH-Vorprüfung. Stand: 27.09.2016. 18 S. - einschl. Planzeichnung [Justification for development plan No. 72/16, town of Neustrelitz "**PV facility west of the Neustrelitz-Berlin railway line**", Environmental report including Appendix 1: (Art 2 para. 4 and 2a sentence 2 No. 2 of the Building Code (BauGB)) on project-related development plan No. 72/16, town of Neustrelitz and Appendix 2: FFH preliminary examination. 27.09.2016. 18 p. including drawing].

WAGNER PLANUNGSGESELLSCHAFT, 2012: Satzung über den Bebauungsplan Nr. 1 „**Sondergebiet Photovoltaik - Kummerow**“, Gemeinde Kummerow - Satzungsfassung. Begründung gemäß § 9 Abs. 8 BauGB [Statutes on development plan No. 1 "**Kummerow special area photovoltaics**", municipality of Kummerow. Version of the statutes. Justification in accordance with Art 9 para. 8 of the Building Code (BauGB)] - on behalf of the municipality of Kummerow via S.I.G. Dr.-Ing. Steffen GmbH. 13 p.

WAGNER PLANUNGSGESELLSCHAFT, n.d.: Begründung zum Bebauungsplan Nr. 78.11 „**Sondergebiet Photovoltaik - Gosewinkel**“ der Landeshauptstadt Schwerin [Justification for development plan No. 78.11 "**Gosewinkel special area photovoltaics"** Schwerin state capital]. 10 p.

Saxony-Anhalt

BÜRO RENALA, 2017: Abschlussbericht einer faunistischen Erfassung von Brutvögeln, Reptilien, Laufkäfern und Heuschrecken anlässlich der geplanten Installation einer **Photovoltaik-Anlage** auf dem Gelände des ehemaligen Betonwerks in Zabakuck, Jerichower Land [Final report on a faunistic survey of breeding birds, reptiles, ground beetles and grasshoppers on the occasion of the planned installation of a **photovoltaic power plant** on the site of the former concrete factory in Zabakuck, Jerichower Land] - on behalf of S.I.G. Dr.-Ing. STEFFEN GmbH.

CS PLANUNGS- UND INGENIEURGESELLSCHAFT MBH, 2012: Naturschutzfachliches Eingriffsgutachten zum B-Plan **Solarpark OT Ferchland** in der Gemarkung Ferchland, Flur 6 [Nature conservation intervention report on the B-Plan **solar park in the urban district of Ferchland** in the subdistrict of Ferchland, cadastral section 6]. 71 p.

HAUKE, J., 2019a: **Freiflächenphotovoltaikanlage Mösthinsdorf**, LK Saalekreis, LSA. Artenschutz Zauneidechse (Lacerta agilis). Monitoring 2015-2017. Schlussbericht [**Mösthinsdorf open space photovoltaic plant**, rural district Saalekreis, LSA. Sand lizard (Lacerta agilis) species protection. monitoring 2015-2017. Final report] - on behalf of ENERPARC. 19 p.

HAUKE, J., 2019b: Monitoringbericht Reptilien (in Vorb.), **Solarpark Hohenerxleben**, Stadt Staßfurt, Salzlandkreis. Monitoring 2015-2017.

IIP GmbH Westeregeln Ingenieurbüro Invest-Projekt, 2018: Stadt Jerichow OT Zabakuck Landkreis Jerichower Land Satzung über den vorzeitigen vorhabenbezogenen Bebauungsplan „**Sondergebiet Photovoltaik ehemaliges Betonwerk Zabakuck**“ Begründung gemäß § 9 Abs. 8 BauGB. Satzung - Teil A [Monitoring report Reptiles (in prep.), **Hohenerxleben solar park**, town of Staßfurt, Salzland district. Monitoring 2015-2017. IIP GmbH Westeregeln Ingenieurbüro Invest-Projekt, 2018: City of Jerichow Zabakuck Urban District. Jerichower Land Statutes on the early project-related development plan “**Special area photovoltaics, Zabakuck former concrete plant**” Justification in accordance with Art 9 para. 8 of the Building Code (BauGB). Statutes, Part A]. 24 p.

IIP GMBH WESTEREGELN INGENIEURBÜRO INVEST-PROJEKT, 2018: Umweltbericht zum vorhabenbezogenen Bebauungsplan „**Sondergebiet Freiflächen-Photovoltaikanlage Demsin**“ der Einheitsgemeinde Stadt Jerichow [Environmental report on the project-related development plan “**Demsin special area open space photovoltaic power plant**” for the municipality of Jerichow]. 39 pages and measures plan.

INGENIEURBÜRO H.-W. RICHTER, 2018: Umweltbericht mit integriertem Artenschutzbeitrag zum vorzeitigen vorhabenbezogenen Bebauungsplan „**Sondergebiet Photovoltaik ehemaliges Betonwerk Zabakuck**“. 56 S. + Anhang. Anhang I: Bestands- und Konfliktplan. Anhang II Maßnahmenpläne. Anhang III: Prüfung der artenschutzrechtlichen Verbotstatbestände des § 44 Abs. 1 Nr. 1 - 3

BNatSchG. Anhang IV: Fotodokumentation [Environmental report with integrated species protection paper on the early project-related development plan "**special photovoltaic area for the Zabakuck former concrete factory**". 56 p. + appendices. Appendix I: Inventory and conflict plan, Appendix II: Action plans, Appendix III: Examination of species protection-related prohibitions under Art 44 para. 1 No. 1-3 Federal Nature Conservation Act (BNatSchG) and Appendix IV: Photo documentation].

LAUTERBACH, A., 2015: Begründung und Umweltbericht zum Bebauungsplan Nr. 3 "**Ehemaliger militärischer Bereich, Sondergebiet Photovoltaik**". Gemeinde Angern, OT Mahlwinkel. - im Auftrag des Landkreises Bördekreis [Justification and environmental report for development plan No. 3 "**Former military area, special area photovoltaics**". Municipality of Angern, urban district of Mahlwinkel. On behalf of the Bördekreis district].

MILAN - Mitteldeutsche Bürogemeinschaft für Landschafts- & Naturschutzplanung Halle (Saale), 2017: Stadt Mansfeld. Bebauungsplan **Sondergebiet Photovoltaik „Siebigeröder Straße"**. Fachbeitrag Artenschutz - im Auftrag der Grüne Energien Solar GmbH [Town of Mansfeld. Development plan "**Siebigeröder Straße**" **special area photovoltaics**. Technical paper on species protection - on behalf of Grüne Energien Solar GmbH]. 48 p.

MILAN - Mitteldeutsche Bürogemeinschaft für Landschafts- & Naturschutzplanung Halle (Saale), 2018: Vorhaben **Solarpark „Siebigeröder Straße"** in Mansfeld. Dokumentation zur Umsiedlung von Schlingnattern (*Coronella austriaca laurenti* 1768) von der Fläche des Solarparks. - im Auftrag der Enerparc AG [Project "**Siebigeröder Straße**" **solar park** in Mansfeld. documentation of the resettlement of smooth snakes *(Coronella austriaca laurenti* 1768) from the area of the solar park - on behalf of Enerparc AG]. 30 p.

MUNICIPALITY OF SÜDHARZ, 2010: Begründung zum Bebauungsplan Nr. 4 Gewerbegebiet „**Wickeröder Straße**" der Gemeinde Südharz (Ortsteil Bennungen) [Justification for development plan No. 4 "**Wickeröder Strasse**" industrial estate in the municipality of Südharz (district of Bennungen)].

SPARFELD, GLORIA, 2012: Bebauungsplan "**Solarpark Sennewitz"**. Umweltbericht zur Satzung. - einschließlich Anlage 1 zum Umweltbericht: Bewertung und Bilanzierung des grünordnerischen Eingriffs zum Bebauungsplan „Solarpark

Sennewitz“ in der Ortschaft Sennewitz. Im Auftrag der Gemeinde Petersberg - Gemarkung Sennewitz [Development plan “**Sennewitz solar park**”. Statutory environmental report, including Annex 1 to the environmental report: Evaluation and balancing of green structures intervention with the development plan “Sennewitz solar park" in the village of Sennewitz. On behalf of the municipality of Petersberg, Sennewitz subdistrict]. 33 p.

SUBATZUS & BRINGMANN GbR, 2016: B-Plan **Solarpark Völpke**. Begründung zum B-Pan Entwurf. Umweltbericht. - im Auftrag der HDS Schilling GmbH [B-Plan **Völpke solar park**. Justification of the B-Plan design. Environmental report on behalf of HDS Schilling GmbH]. 40 p.

Baden-Württemberg

BÜRO FÜR STADTPLANUNG ZINT & HÄUSER GMBH and BÜRO FÜR LANDSCHAFTSPLANUNG PROF. A. SCHMID & M. RAUH, 2017a: Vorhabenbezogener Bebauungsplan “**PV-Freiflächenanlage Zwiefaltendorf**” Begründung zum Bebauungsplan A. Städtebaulicher Teil, B. Umweltbericht. - im Auftrag der Stadt Riedlingen [Project-related development plan “**Zwiefaltendorf open space photovoltaic facility**” Justification for development plan A. Urban development part, B. Environmental report on behalf of the town of Riedlingen]. 22 p. + 3 annexes.

BÜRO FÜR STADTPLANUNG ZINT & HÄUSER GMBH, 2017b: Stadt Riedlingen, Ortsteil Zwiefaltendorf. Vorhabenbezogener Bebauungsplan „**PV-Freiflächenanlage Zwiefaltendorf**“. Karte und Text Planungsrechtliche Festsetzungen [Town of Riedlingen, Zwiefaltendorf urban district. Project-related development plan “**Zwiefaltendorf open space photovoltaic facility**”. Map and text Planning law assessments]. 6 p.

BÜRO SIEBER, 2013: Stadt Leutkirch i. Allgäu. Vorhabenbezogener Bebauungsplan „**Freiflächen-Photovoltaikanlage Leutkirch Haid 2**“ und die örtlichen Bauvorschriften hierzu [City of Leutkirch im Allgäu. Project-related development plan “**Leutkirch Haid 2 open space photovoltaic facility**” and the local building regulations for this project]. 60 p. and map.

IFK INGENIEURE, 2011: Stadt Krautheim - Bebauungsplan **Solarpark Hühnerfeld** - Begründung. Teil 1: Planbericht; Teil 2. Umweltbericht; einschl. Karte [Town of Krautheim - **Hühnerfeld solar park** development plan. Justification. Part 1: Plan report; Part 2: Environmental report incl. map] - on behalf of EnBW-Erneuerbare Energien GmbH.

PLANQUADRAT GAISER & PARTNER, 2009: Bebauungsplan „**Sondergebiet Photovoltaik Pfaffensteig**“ Kreis Sigmaringen, Gemeinde Leibertingen [Development plan “**Pfaffensteig special area photovoltaics**” Sigmaringen district, municipality of Leibertingen] - on behalf of EnBW Erneuerbare Energien GmbH. 12 p.

PLANQUADRAT GAISER & PARTNER, 2009: Bebauungsplan „**Sondergebiet Photovoltaik Pfaffensteig**“ in Leibertingen - Kreenheinstetten. Umweltbericht nach § 2 Abs. 4 und § 2a Satz 2 Nr. 2 BauGB. Stand 05.10.2009. Kreis Sigmaringen, Gemeinde Leibertingen [Development plan “**Pfaffensteig special photovoltaic area**” in Leibertingen-Kreenheinstetten. Environmental report in accordance with Art 2 para. 4 and Art 2a Line 2 No. 2 of the Building Code (BauGB). Version 05.10.2009. Sigmaringen district, municipality of Leibertingen] - on behalf of EnBW Erneuerbare Energien GmbH. 25 p.

PLANSTATT SENNER, 2018: LANDKREIS Konstanz Gemeinde Steißlingen: Umweltbericht mit integriertem Grünordnungsplan und Eingriffs- / Ausgleichsbilanz zum vorhabenbezogenen Bebauungsplan Sondergebiet “**Solarpark Steißlingen**” [Konstanz rural district, municipality ofSteisslingen: Environmental report with integrated green structures plan and impact/compensation balance for project-related special area development plan “**Steisslingen solar park**”] - on behalf of Wattner SunAsset Solarkraftwerk 082 GmbH & Co. KG. 63 p.

SCHMID, S., & M. RAUH, 2016a: **PV Freiflächenanlage Hessenhöfeweg**, Gemeinde Berghülen OT Bühlenhausen. Umweltbericht [**Hessenhöfeweg open space photovoltaic facility**, municipality of Berghülen, urban district of Bühlenhausen. Environmental report]. 25 p.

SCHMID, S., & M. RAUH, 2016b: Vorhabenbezogener Bebauungsplan “**PV Freiflächenanlage Hessenhöfeweg**“, Gemeinde Berghülen. Anlage 1 zum Umweltbericht [Project-related development plan “**Hessenhöfeweg open space photovoltaic facility**”, municipality of Berghülen, Annex 1 to the Environmental Report].

STADTBAUAMT (CITY PLANNING OFFICE) /FB STADTPLANUNG, NATUR UND UMWELT LEUTKIRCH IM ALLGÄU, 2011: Bebauungsplan großflächige **Photovoltaikanlage**

Leutkirch - Haid. Umweltbericht [Development plan large area **Leutkirch-Haid photovoltaic facility**. Environmental report]. 17 p. and map.

Schleswig-Holstein

DIPL.-ING. THOMAS BÜNZ, 2012a: Gemeinde Oeversee, Ortsteil Barderup. Vorhabenbezogener Bebauungsplan Nr. 18 „**Solarfelder Barderup**“ - Begründung mit Umweltbericht [Municipality of Oeversee, urban district of Barderup. project-related development plan No. 18 “**Barderup solar fields**”. Justification with environmental report] - on behalf of Solar-Kontor-Flensburg GmbH. 29 p.

DIPL.-ING. THOMAS BÜNZ, 2012b: Satzung über den vorhabenbezogenen Bebauungsplan Nr. 18 „**Solarfelder Barderup**“. Teil A: Planzeichnungen, Teil B: textliche Festsetzungen [Statutes on project-related development plan No. 18 “**Barderup solar fields**”. Part A: Drawings, Part B: Textual assessments] - on behalf of the municipality of Oeversee.

EFF-PLAN, 2012: Satzung der Gemeinde **Risum Lindholm** über den Bebauungsplan Nr. 24. Planzeichnung (Teil A) und Text (Teil B) [Statutes of the municipality of **Risum Lindholm** on development plan No. 24. drawing (part A) and text (part B)].

INGENIEURBÜRO HANS-WERNER HANSEN, 2010: Satzung der **Stadt Niebüll** über den Bebauungsplan Nr. 51. Planzeichnungen (Teil A) und Text (Teil B) [Statutes for the **town of Niebüll** concerning development plan No. 51. Drawings (Part A) and text (Part B)] - on behalf of the town of Niebüll, district of North Frisia.

INGENIEURBÜRO HANS-WERNER HANSEN, 2011: Satzung der **Gemeinde Süderlügum** über den Bebauungsplan Nr. 21. Planzeichnung (Teil A), Text (Teil B) [Statutes for the **municipality of Süderlügum** on development plan No. 21. Drawing (part A), text (part B)] - on behalf of the municipality of Süderlügum.

INGENIEURGESELLSCHAFT NORD - IGN, 2010a: Begründung nach § 9 Abs. 8 des Baugesetzbuches (BauGB) zur Satzung der Gemeinde Tarp über den Bebauungsplan Nr. 22 „**Photovoltaik-Freiflächenanlage am Wiesenweg**“. Begründung - Teil A, Begründung - Teil B Umweltbericht, Begründung - Teil C Naturschutzrechtlicher Ausgleich zum Eingriff in Natur und Landschaft [Justification in accordance with Art 9 para. 8 of the Building Code (BauGB) for the statutes of the municipality of Tarp concerning development plan No. 22 “**Open space photovoltaic facility on the Wiesenweg**” Justification: Part A, Justification; Part B, Environmental report; Part C, Nature conservation compensation for intervention in nature and landscape].

INGENIEURGESELLSCHAFT NORD - IGN, 2010b: Satzung der Gemeinde Tarp über den Bebauungsplan Nr. 22 „**Photovoltaik-Freiflächenanlage am Wiesenweg**“. Planzeichnung (Teil A + B), Text (Teil C) [Statutes of the municipality of Tarp on development plan No. 22 “**Open space photovoltaic facility at Wiesenweg”**. Drawing (Parts A + B), text (Part C)].

INGENIEURGESELLSCHAFT NORD - IGN, 2012a: Gemeinde Oeversee. Bebauungsplan Nr. 17 „**Photovoltaikanlage Wanderuper Weg**“. Begründung - Teil A [Municipality of Oeversee. Development plan No. 17 “**Wanderuper Weg photovoltaic facility**”. Justification, Part A]. 7 p. and 1 annex.

INGENIEURGESELLSCHAFT NORD - IGN, 2012b: Satzung der Gemeinde Oeversee über den Bebauungsplan Nr. 17 „**Photovoltaikanlage Wanderuper Weg**“. Planzeichnung (Teil A) und Text (Teil B) [Statutes of the municipality of Oeversee concerning development plan No. 17 “**Wanderuper Weg photovoltaic facility**”.Drawing (part A) and text (part B)] - on behalf of the municipality of Oeversee.

KLEIN RHEIDE MUNICIPALITY, 2012: Satzung über den vorhabenbezogenen Bebauungsplan Nr. 1 „**Solarpark Klein-Rheide Süd**“. Teil A: Planzeichnung, Teil B: Textliche Festsetzungen [Statutes on project-related development plan No. 1 “**Klein-Rheide Süd solar park**” Part A: Drawing, Part B: Textual assessments].

MUNICIPALITY OF BOSBÜLL, 2012: Satzung der Gemeinde Bosbüll über die 6. Änderung und Erweiterung des Bebauungsplanes Nr. 1 für das Gebiet „**südlich und östlich der Westerstraße** (K 114), westlich der Bahnstrecke Niebüll-Süderlügum bis zum Teilgebiet 1 sowie östlich der Bahnstrecke bis zum Bosbüller Sielzug im Süden“. Planzeichnung und Text [Statutes for the municipality of Bosbüll on the 6th amendment and extension of development plan No. 1 for the area “**south and east of the Westerstrasse** (K 114), west of the railway line Niebüll-Süderlügum up to sub-area 1 and east of the railway line up to Bosbüller Sielzug in the south".Drawing and text].

MUNICIPALITY OF HUMPTRUP, 2012: Bebauungsplan Nr. 4 für das Gebiet „**an der Bahnlinie Niebüll-Tondern und nördlich der Gemeindegrenze zu Uphusum**“. Teil A -Planzeichnung und Teil B - Text [Development plan No. 4 for the area “**Along the railway line Niebüll-Tondern and north of the municipal boundary with Uphusum**” Part A: Drawing and Part B: Text].

PRO REGIONE GMBH, 2016a: Satzung der Gemeinde Schafflund über den Bebauungsplan Nr. 29 - **Sonstiges Sondergebiet Photovoltaikanlage**. Planzeichnung Teil A, Text Teil B [Statutes of the municipality of Schafflund concerning development plan No. 29- **Special area photovoltaic facility**. Drawing part A, text part B] - on behalf of the municipality of Schafflund.

PRO REGIONE GMBH, 2016b: Umweltbericht zum Bebauungsplan Nr. 29 der **Gemeinde Schafflund „Sondergebiet Photovoltaik**“. Begründung Teil B [Environmental report on development plan No. 29 of the **municipality of Schafflund “Special area photovoltaic facility**”. Justification part B] - on behalf of the municipality of Schafflund. 18 p.

PRO REGIONE GMBH, 2017: Vorhabenbezogener Bebauungsplan Nr. 2 der **Gemeinde Sörup. Sonstiges Sondergebiet „Photovoltaik**“. Satzung [Project-related development plan No. 2 of the **municipality of Sörup. Other special “photovoltaic**” **area**. Statutes] - on behalf of Enerparc Solar Invest 109 GmbH. 29 p.

Saxony

ALTMEIER, E., 2006: Bebauungsplanverfahren **Energiepark Waldpolenz**. 1. Änderung des Flächennutzungsplanes der Gemeinde Bennewitz. Umweltbericht gem. § 2 (4) BauGB [Development plan procedure for the **Waldpolenz energy park**. 1st amendment of the land use plan for the municipality of Bennewitz. Environmental report in accordance with Art 2 (4) of the Building Code (BauGB)] - on behalf of juwi solar GmbH. 79 pp.

ARCHITEKTEN WÄSSERLING + LÜDKE, 2017: Vorhabenbezogener Bebauungsplan „**Photovoltaikanlage Deponie Dittmannsdorf, Stadt Penig**“ - Entwurf - Umweltbericht [Project-related development plan “**Dittmannsdorf landfill photovoltaic facility, town of Penig**”. Draft environmental report] - on behalf of HDS Schilling GmbH. 51 p.

TOWN OF HOYERSWERDA, 2012a: Bebauungsplan **Hoyerswerda-Nardt** - Erweiterung Nordwest; Satzung zur 1. Änderung; Anhang 2 zur Begründung: Umweltbericht [Development plan **Hoyerswerda-Nardt**. North-west expansion; Statutes for the 1st amendment; Annex 2 to the explanatory memorandum: Environmental report]. 31 p.

TOWN OF HOYERSWERDA, 2012b: Bebauungsplan **Hoyerswerda-Nardt** - Erweiterung Nordwest; Satzung zur 1. Änderung; Anhang 3 zur Begründung: Artenschutzrechtliche Vorprüfung [Development plan **Hoyerswerda-Nardt** - North-west expansion; Statutes for the 1st amendment; Annex 3 to the explanatory memorandum: Preliminary examination under species protection law]. 22 p.

Bavaria

INGENIEURBÜRO CHRISTOFORI UND PARTNER & EDGAR TAUTORAT, 2010: Bebauungs- und Grünordnungsplan „**Freiflächenphotovoltaikanlage Wörnitzhofen**“. Begründung mit integriertem Umweltbericht gemäß § 9 (8) Baugesetzbuch. - einschl. Planzeichnung. Im Auftrag von Markt Weiltingen, Landkreis Ansbach [Development and green structures plan “**Wörnitzhofen open space photovoltaic facility**”. Justification with integrated environmental report in accordance with Art 9 (8) Building Code (BauGB). Incl. drawing] - on behalf of Markt Weiltingen, Ansbach district. 35 p.

Thuringia

LIEDER, K. & J. LUMPE, 2012: Vögel im Solarpark - eine Chance für den Artenschutz? Auswertung einer Untersuchung im Solarpark Ronneburg „Süd I“. [Birds in a solar park – a chance for species conservation? Evaluation of a study in the **Ronneburg “Süd I” solar park**]. http://www.windenergietage.de/20F3261415.pdf (access 04.11.2019).

Rhineland-Palatinate

GUTSCHKER - DONGUS LANDSCHAFTSARCHITEKTEN, 2012: Umweltbericht nach § 2 BauGB zum Bebauungsplan **„Sondergebiet Photovoltaik“ der Ortsgemeinde Ilbesheim**, Verbandsgemeinde Kichheimbolanden, Donnersbergkreis [Environmental report in accordance with Art 2 of the Building Code (BauGB) on the

development plan “**Special area photovoltaics**” **of the municipality of Ilbesheim**, Kichheimbolanden, Donnersbergkreis local authorities association] - on behalf of the municipality of Ilbesheim.

5.3 Solar farms investigated

Name of solarpark	**Seq. no. in maps**
Schleswig-Holstein	
Süderlügum special photovoltaics area	1
Development plan No. 4, municipality of Humptrup	2
Development plan south and east Westerstrasse, Bosbüll	3
B-Plan no. 51 south railway line TG 1	4
B-Plan no. 51 south railway line TG 2	4a
Schafflund special photovoltaics area	5
B-Plan no. 24, sub-area 1, south of the Niebüll-Westerland railway line	6
Sörup municipality special photovoltaics area	7
Solar power area Barderup	8
Photovoltaic installation Wanderuper Weg, Oeversee	9
Tarp municipality ground-mounted photovoltaic installation	10
Solar park Klein Rheide South	11
Mecklenburg-Western Pomerania	
Solar parks at Barth airport	12
Solar park Divitz	13
Development plan no. 1 “Special photovoltaic area”, Kummerow	14
Tutow solar park “Auf dem Flugfeld”	15
Photovoltaic plant south of Casinosee	16
Town of Jarmen special area photovoltaic power plant	17

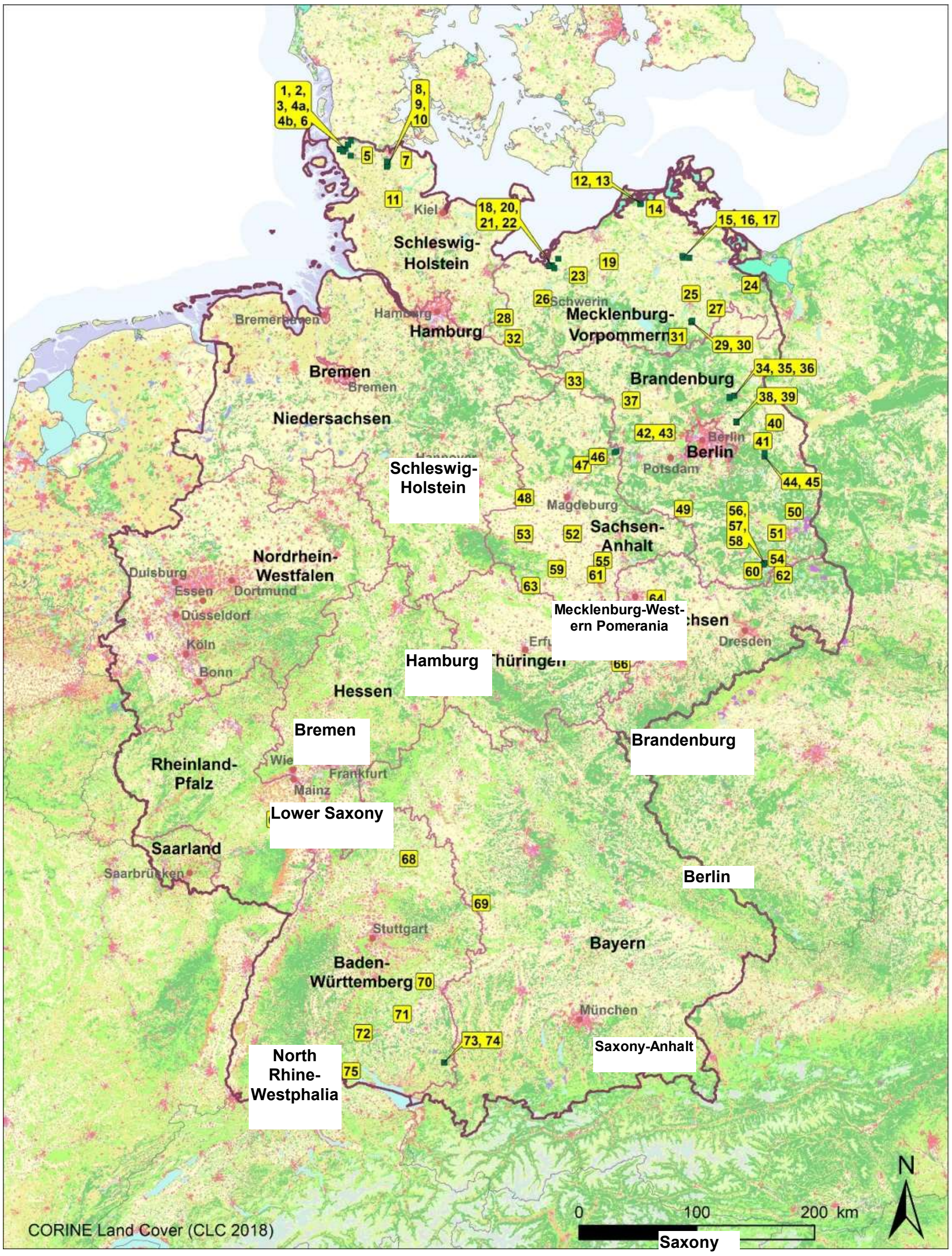
Name of solarpark	Seq. no. in maps
Ground-mounted photovoltaic power plants railway line Wismar-Rostock, Steinhausen-Hagebök area	18
B-Plan “Am Flugplatz Laage”	19
Photovoltaic power plant on the Wismar-Hornstorf railway	20
Wismar East special area photovoltaic power plants	21
Industrial site Kritzow former fruit plantation	22
Baumgarten Energy Park	23
B-plan industrial park Wiesenstraße	24
Hohenmin solar park	25
Gosewinkel special area for photovoltaics	26
Photovoltaic power plant Helpt railway	27
Ground-mounted photovoltaic power plant in the area of the Lüttow-Valluhn gravel-sand open-cast mine	28
Cammin special area for photovoltaics	29
Photovoltaic power plant on the Blankensee railway	30
Photovoltaic power plant west of the Neustrelitz-Berlin railway line	31
Düssin solar park, Melkof ground-mounted photovoltaic power plant	32
Brandenburg	
Solar plant North, Wittenberge	33
Eisenspalterei solar park	34
Photovoltaic power plants Finow II and III	35
Photovoltaic power plant Finow I	36

Name of solarpark	Seq. no. in maps
Zoning plan No. 16, railway energy park	37
Werneuchen photovoltaic power plant	38
Werneuchen photovoltaic power plant Wldfarm	39
Neuhardenberg photovoltaic solar park	40
Eggersdorf solar park, town of Müncheberg	41
Fürstenwalde photovoltaic power plants I and II	44
Solar park “James-Watt-Straße”	45
Jüterbog solar park	49
Turnow-Preilack/Lieberose photovoltaic solar park	50
Milkersdorf photovoltaic plant “An der Bahn”	51
Hohenerxleben solar park	52
Klus special photovoltaic area	53
Welzow commercial airfield special photovoltaics area	54
Mösthinsdorf solar park	55
Senftenberg II solar park	56
Senftenberg solar park	57
Lausitzring East special area photovoltaic power plant	58
Schwarzheide elevated dump photovoltaic power plant	60
Saxony-Anhalt	
Demsin special area ground-mounted photovoltaic power plant	42
Zabakuck former concrete plant photovoltaic power plant	43
Ferchland solar park	46

Name of solarpark	Seq. no. in maps
Angern special photovoltaics area	47
Völpke solar park	48
Sennewitz solar park	61
Wickeröder Straße development plan	63
Saxony	
“Siebigeröder Straße” Special photovoltaics area	59
Hoyerswerda-Nardt expansion north-west	62
Waldpolenz Energy Park	64
Dittmannsdorf landfill photovoltaic power plant, town of Penig	65
Thuringia	
Ronneburg South I solar park	66
Rhineland-Palatinate	
Ilbesheim special photovoltaics area	67
Bavaria	
Wörnitzhofen ground-mounted photovoltaic power plant	69
Baden-Württemberg	
Hühnerfeld solar park	68
Hessenhöfeweg ground-mounted photovoltaic power plant	70
Zwiefaltendorf ground-mounted photovoltaic power plant	71
Pfaffensteig Kreenheinstetten photovoltaic power plant	72
Leutkirch Haid 2 ground-mounted photovoltaic power plant	73
Leutkirch-Haid photovoltaic power plant	74

Name of solarpark	Seq. no. in maps
Special construction area Steißlingen solar park	75

5.4 Maps



Thuringia

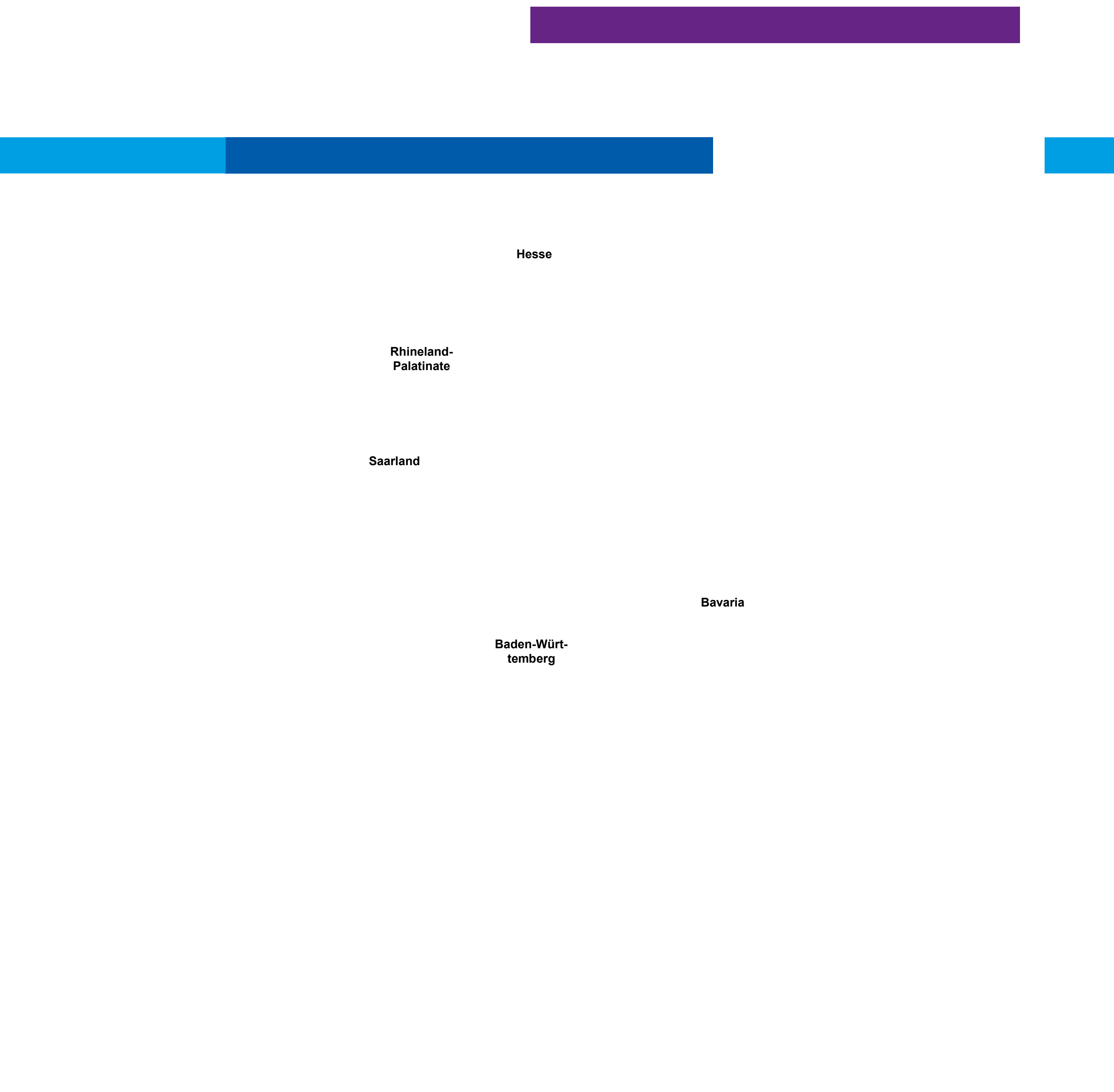
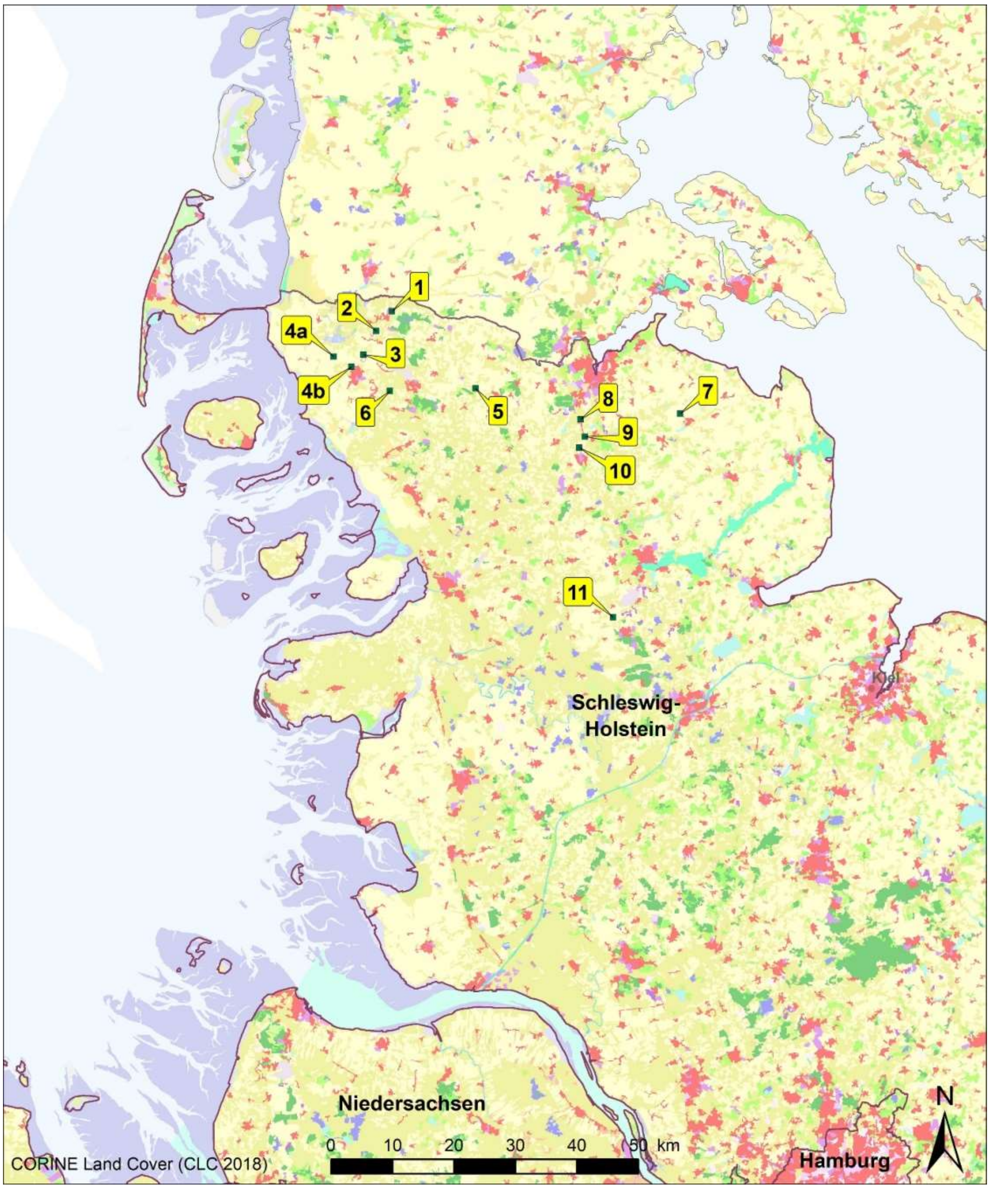


Figure 5-1: General map of the solar parks covered in this study



Schleswig-
Holstein

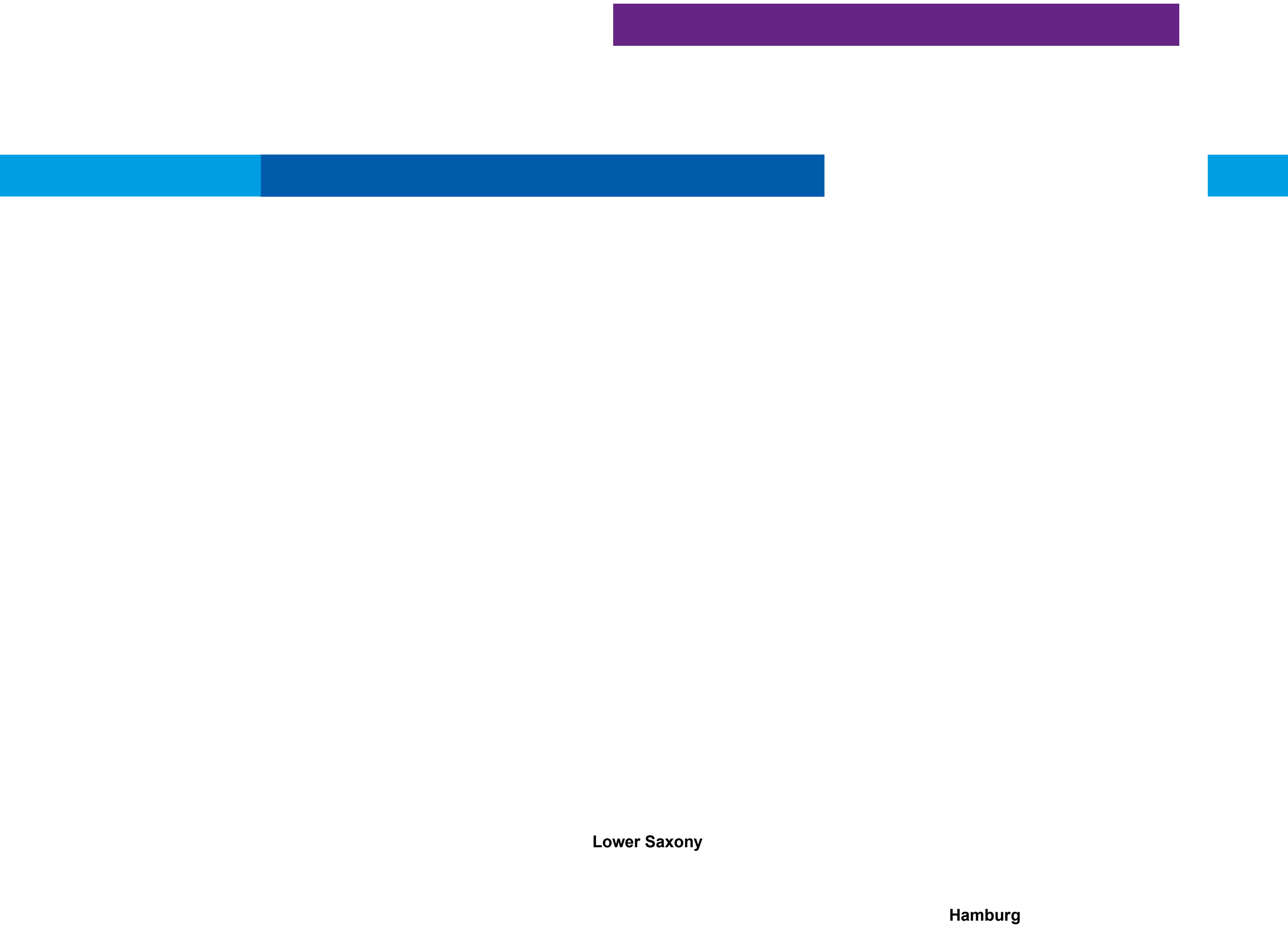
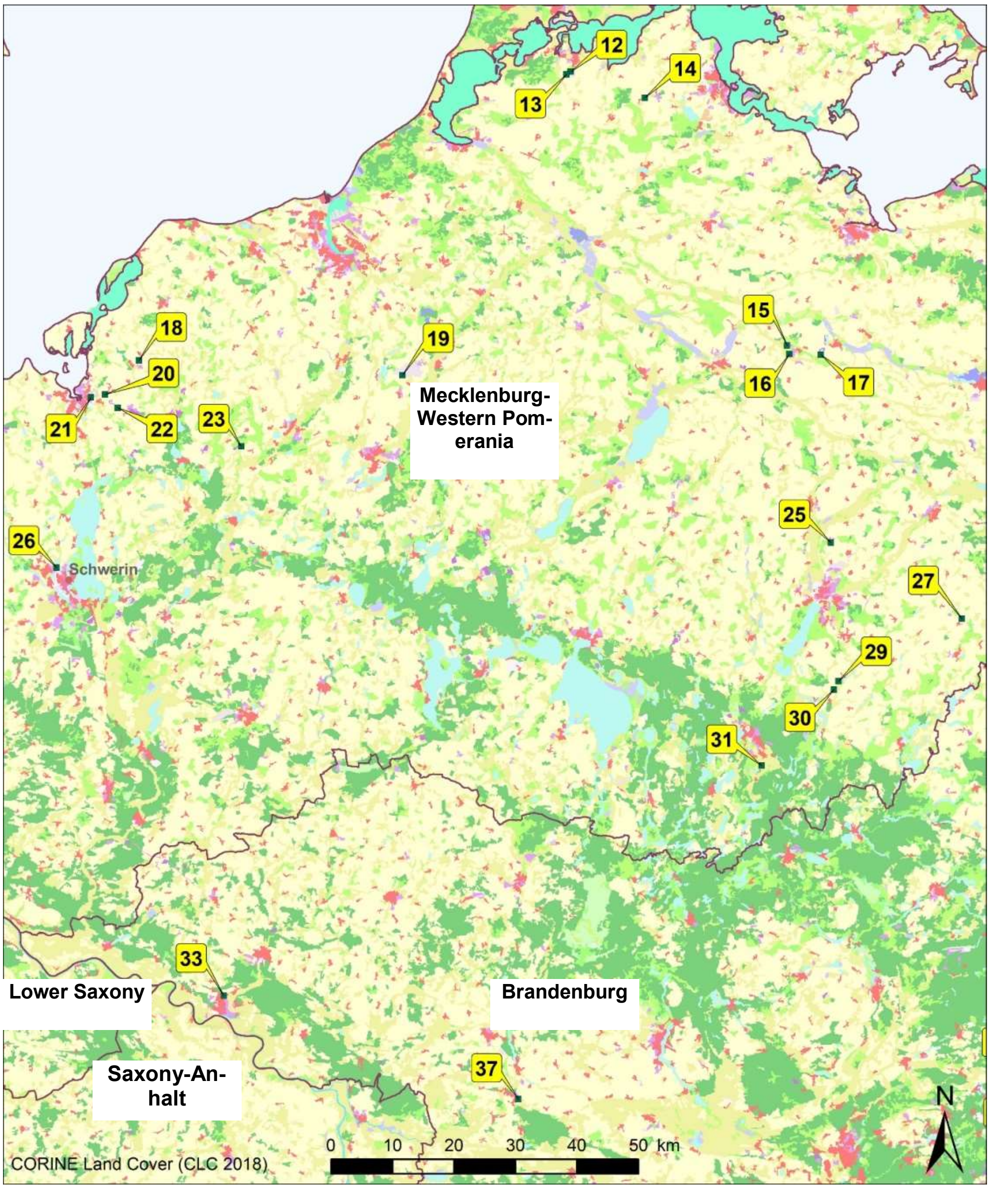


Figure 5-2: Detailed map north

Figure 5-3: Detailed map north-east



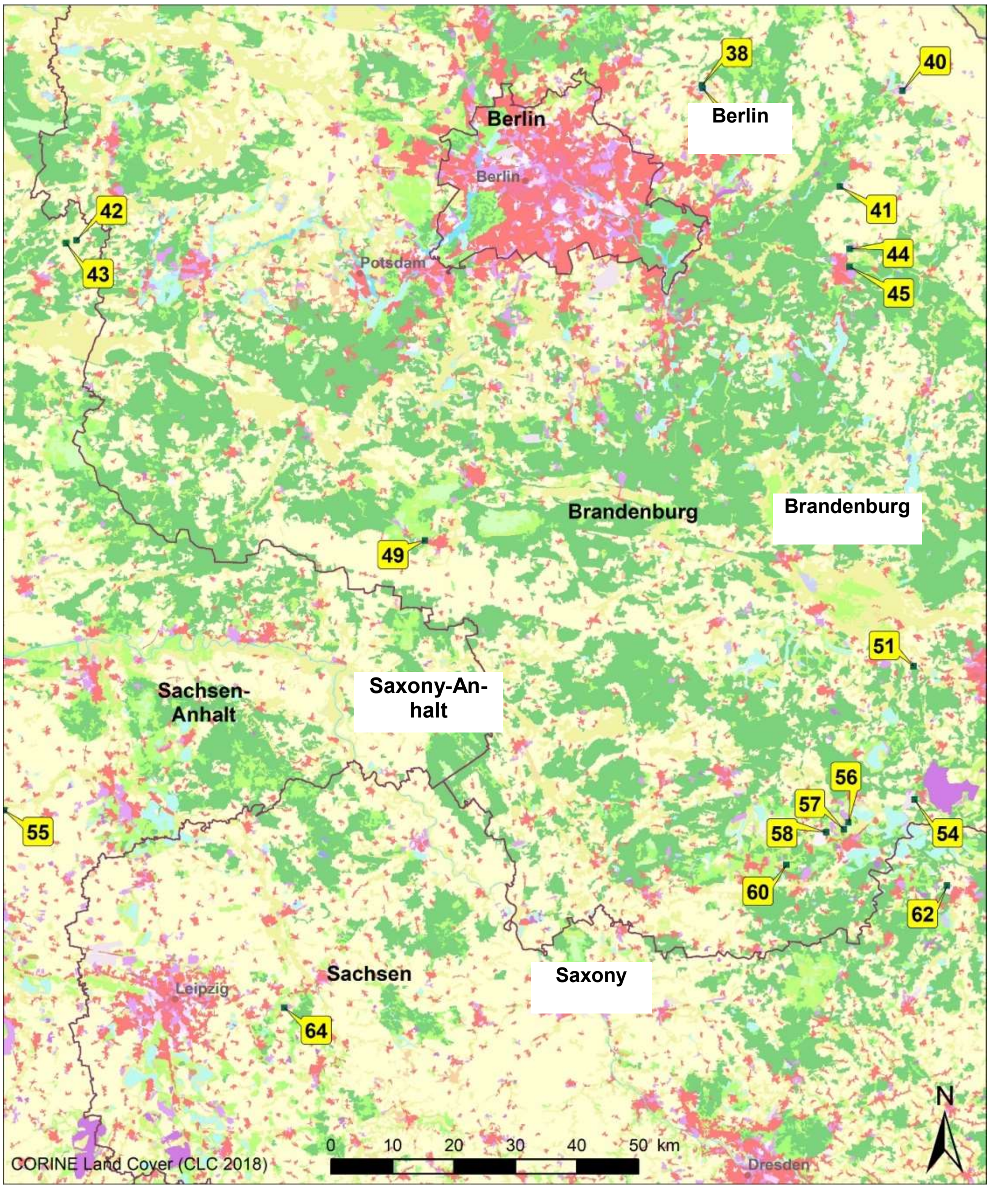


Figure 5-4: Detailed map east