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# GBI-network: Land use conflicts for RE production and other threats

## St. Gilgen – Tennengau and Flachgau regions

**Mapping report outlining GBI network elements and areas of land use conflicts for renewable energy production and other major developments that may threaten GBI connectivity function**

This project is co-funded by the European Union through the Interreg Alpine Space programme.

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# GBI-network Land use conflicts

Mapping report outlining GBI network elements and areas of land use conflicts for renewable energy production and other major developments

Activity 2.4 Case Studies 3rd step: Identify unsuitable locations/mitigation measures for impact assessment of renewable energy systems and other major developments that may threaten GBI connectivity function

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# EXECUTIVE SUMMARY

This report, part of the *PlanToConnect* project under the EU Alpine Space Programme, explores land-use conflicts between renewable energy (RE) development and ecological connectivity in the pilot region of St. Gilgen, within the Tennengau and Flachgau regions of Salzburg, Austria.

The study assesses existing and planned infrastructure impacts—especially wind and solar power—on green and blue infrastructure (GBI). Mapping and spatial analysis revealed significant overlaps: 7.5 $km^2$ of wind energy priority zones and 8.6 hectares of designated solar PV areas intersect with ecologically sensitive habitats and corridors.

While Salzburg's Federal Development Programme (Landesentwicklungsprogramm Salzburg 2022) acknowledges ecological connectivity, it prioritizes interregional corridors, often overlooking vital local and regional links. The case of the Zwölferhorn solar installation, partially located in a core habitat, illustrates current planning limitations.

The report proposes mitigation strategies and exclusion criteria for siting infrastructure to better balance RE goals with biodiversity conservation. It concludes with a call for improved integration of ecological data into spatial planning and stronger protection for all levels of habitat connectivity.

# REPORT

# 1 Introduction

The PlanToConnect project is an initiative under the EU Alpine Space Programme that aims to enhance green and blue infrastructure (GBI) connectivity across the Alpine region. Promoting ecological connectivity is a crucial element to enable dynamic adaptation processes in ecosystems, combating biodiversity decline and preserving ecosystem functions, particularly in the face of climate change. While protected areas are well established, their connection through ecological corridors faces significant planning gaps, lack of implementation, and emerging threats such as transport infrastructure, settlement development, and renewable energy expansion. Currently, there is no overarching connectivity planning concept to guide corridor implementation across Alpine regions.

The aim of the PlanToConnect project is to develop and test an Alpine spatial planning strategy for ecological connectivity in cooperation with stakeholders in pilot areas. Proposals for the adaptation of spatial planning systems and territorial policies will be developed.

As part of the PlanToConnect project, a case study is being conducted on the integrated planning of a GBI connectivity network in the pilot site of St. Gilgen within the Tennengau and Flachgau regions. The design of a GBI network for connectivity in this region has been developed and described in report D2.3.1, where priority areas for conservation and restoration were identified. These areas form the basis for integrating ecological connectivity into planning instruments. Ecological connectivity in the pilot region is not considered in the sense of an uninterrupted corridor with directly adjacent habitats but rather as a wide ecological network featuring structural diversity by protecting and restoring both smaller and larger patches (see report D2.3.1).

This report, D2.4.1, focuses on the land-use conflicts arising from renewable energy facilities and other infrastructural developments that may threaten the GBI network for connectivity in the pilot region on different levels: While the development of renewable energies plays a threat on the regional level, the pressures of infrastructure development through urban expansion or streets can be analysed on the municipal level.

The objectives are:

- To assess potential impacts of renewable energy infrastructures or other infrastructures that may threaten the GBI network for connectivity,
- To assess evaluation criteria for unsuitable locations for the various types of infrastructures with a focus on renewable energy,
- To map the land use conflicts for renewable energy production, and
- To suggest possible mitigation measures.

This report covers all spatially relevant infrastructures that have already had a negative impact on connectivity (pressures) as well as those that pose a threat to connectivity in the future (threats).

The findings of this report will serve as a foundation for developing strategies to minimize conflicts between RE expansion and ecological connectivity, contributing to the broader objectives of PlanToConnect.

Chapter 2 shortly describes the pilot region Tennengau and Flachgau with focus on the pilot site St. Gilgen. Chapter 3 deals with the methodological approach used in the pilot region including the working steps and the data used. Chapter 4 shows the major pressures and threats to ecological connectivity in the pilot region. On the municipal level the focus lies on pressures imposed through existing infrastructures. On the regional level the threats provoked through the development of RE such as wind mills and ground-mounted solar panels are described. Chapter 5 covers unsuitable locations for these RE facilities and sets criteria for exclusion zones. In this chapter the land use conflicts for renewable energy production through ground-mounted solar panels and wind power are mapped. Chapter 6 describes the possible mitigation and compensation measures for infrastructures.

## 2 Pilot region St. Gilgen – Tennengau and Flachgau regions

The pilot regions Tennengau and Flachgau are located in Salzburg, Austria, and together cover an area of approximately 1,672 km².

According to the biogeographical regions of the Natura 2000 model, Tennengau and Flachgau both lie within the Alpine region, whereas the northern part of Flachgau extends into the Continental region.

Within this study, the regions work as an overall observation area. The primary focus, however, is on the municipality of St. Gilgen, located in Flachgau at the border to the neighboring federal state of Upper Austria (see Fig. 1). This focus enables the consideration of ecological connections across municipal boundaries, to neighbouring municipalities, and interregional, to Upper Austria, where different spatial planning regulations apply.

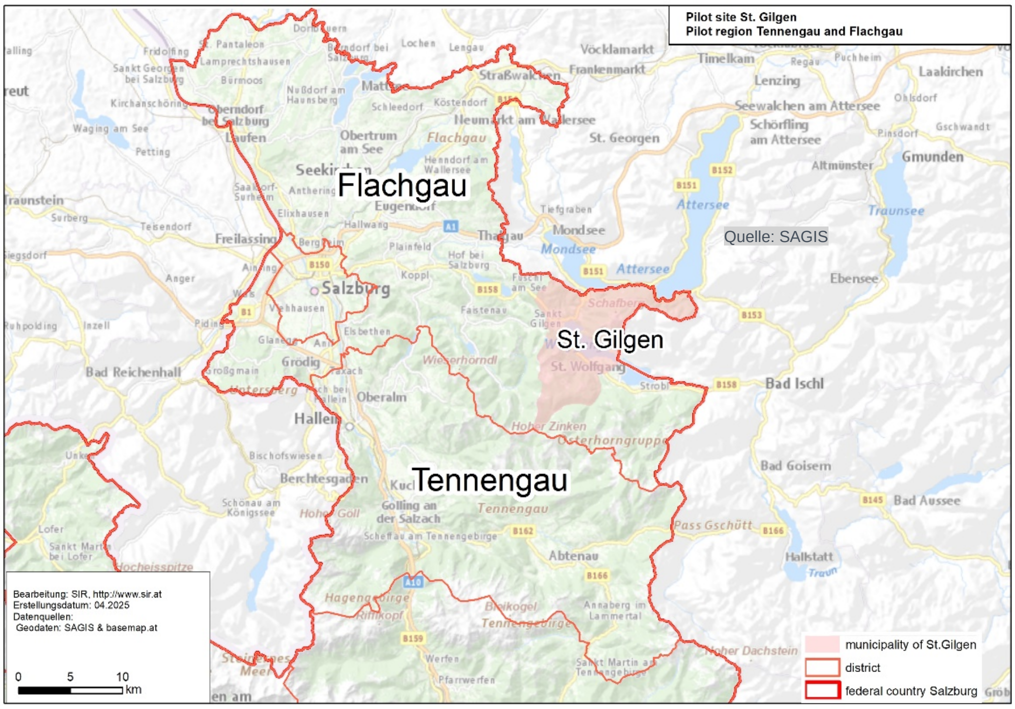


Figure 1: Regions Tennengau and Flachgau with the municipality of St. Gilgen

# 3 Methodological steps

## 3.1 Description of the approach/ working steps

Table 1: Overview of the working steps

| Working Step | Description |
|---|---|
| **1**<br>**General threats of infrastructures and land uses posed to GBI ecological networks** | The first step is to identify which infrastructures or land uses generally have a negative impact on connectivity. The results of report D1.3.1 were used for this purpose. |
| **2**<br>**Definition of relevant infrastructures** | For the second step, the definition for the habitat and green space and migration corridors was set according to the Regional Development Programme of Salzburg. It works as the foundation to analyse pressures and threats of relevant infrastructures. |
| **3**<br>**Existing pressures and expected major threats in the pilot region** | In a third step, all spatially relevant existing and planned infrastructures in the pilot region are compiled on the basis of<br>• references to existing relevant infrastructure in the pilot region St. Gilgen analysed through SAGIS<br>• threats imposed by major infrastructural developments being projected for the coming years at regional level analysed with the Regional Development Programme |
| **4**<br>**Compilation of general criteria for unsuitable locations** | General criteria for unsuitable locations can be found in report D1.3.1. Further definitions of unsuitable locations are set by reffering to the guideline for assessing the wildlife ecological passability of habitat corridors by Grillmayer et al. (2023). |
| **5**<br>**Development of specific criteria for unsuitable locations in the pilot region (exclusion zones)** | Exclusion zones in this context are areas where certain infrastructures are not allowed to be built or operated (unsuitable areas).<br>For this reason, we listed the criteria for the implementation of RE infrastructures as described in the Regional Development Programme of Salzburg. |

| Working Step | Description |
|---|---|
| **6** **Mapping the land use conflicts for renewable energy production** | With regard to ecological connectivity the designated areas for RE production (wind power, solar power) have been mapped and set in relation to the connectivity network (using simple overlay functions). Hydropower, biomass, high voltage transmission lines, roads, railways and urban/industrial development are not being considered in this report. |
| **7** **Possible mitigation and compensation measures** | Possible mitigation or compensation measures for renewable energy facilities or other threats are proposed according to the guideline for assessing the wildlife ecological passability of habitat corridors by Grillmayer et al. (2023). |

## 3.2 Data used

The table below shows the data that were used and were available for analysing the pilot region.

Table 2: Overview of local or regional data used

| Data | Source | Description |
|---|---|---|
| Lebensraumvernetzung Salzburg | LEITNER H., LEISSING D. & J. SIGNER 2014: Lebensraumvernetzung Salzburg. Commissioned by Land Salzburg & Salzburger Jägerschaft. | Report on the green spaces in Salzburg in order to preserve the habitat of large-scale migratory, forest-bound animal species. |
| Leitfaden zur Bewertung der wildökologischen Durchlässigkeit von Lebensraumkorridoren | DI Roland Grillmayer (Umweltbundesamt); Mag. Daniel Leissing, DI Horst Leitner (Büro für Wildökologie und Forstwirtschaft) commissioned by Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (2023) | Guideline for assessing the wildlife ecological passability of habitat corridors. |

| Data | Source | Description |
|---|---|---|
| Salzburger Landesentwicklungsprogramm (LEP) 2022<br>(Regional Development Program 2022 Salzburg) | Land Salzburg | A strategic planning instrument that guides the spatial development of the federal state of Salzburg by setting goals and guidelines for sustainable settlement, economic, and environmental development. |
| SAGIS | Land Salzburg | SAGIS is the geoinformation system of Salzburg. |
| Erläuterung zur Photovoltaik-Kennzeichnungsverordnung | Land Salzburg | Separate paper for further information on the directive for ground-mounted PV systems. |

# 4 Major pressures and threats to ecological connectivity

## 4.1 General threats to GBI ecological networks posed by infrastructure and land uses

The table below lists infrastructures and land uses analysed in report D1.3.1 and assesses their impact on connectivity across the landscape. A distinction is made between structural and functional connectivity (see report D1.3.1).

Table 3: Infrastructures and land uses with their impact on connectivity

| Sector | Type of infrastructure/ Land use | Comments on Connectivity |
|---|---|---|
| Renewable energy | Hydropower - hydroelectric reservoir (dam) | high impact on structural and functional connectivity because of usually large land take and barrier/ fragmentation effects |
| | Hydropower - Run-off-river power plants | low impact on structural connectivity because of minimal land take<br>high impact on functional connectivity because of barrier/ fragmentation effects in the water body |
| | Windpower - windmills | low impact on structural connectivity because of minimal land take<br>partly high impact on functional connectivity because of collisions (birds, bats) |
| | Solar Power - Photovoltaics: Ground-mounted solar panels | mostly low impact on structural and functional connectivity because of usually low soil sealing and marginal barrier effects. Effects depend on the area size and design!<br>large area photovoltaics: high impact due to extensive habitat changes (structural connectivity) and to fragmenting effects if fenced (functional connectivity). Above a length of 500 metres, fragmenting effects on large mammals are to be expected. |
| | Bioenergy - Biomass | Bioenergy plants:<br>Mostly low impact on structural and functional connectivity because of usually low land take and marginal barrier effects. Effects depend on the area size of the facility!<br>Change of land management and land use:<br>no general statements possible because effects depend on the area size, the location and intensity of the biomass production! |

| Sector | Type of infrastructure/ Land use | Comments on Connectivity |
|---|---|---|
| Energy sector as a whole | Transmission of electricity - High voltage transmission line | low impact on structural connectivity because of minimal land take outside of forests;<br>partly high impact on functional connectivity because of collisions (birds) |
| Transport | roads/ highways | high impact on structural and functional connectivity because of usually large land take, barrier effects, wildlife mortality due to traffic and impacts due to noise, dust and pollutants |
| Transport | railway | high impact on structural and functional connectivity because of land take (habitat loss), barrier effects, wildlife mortality due to traffic and impacts due to noise, dust, pollutants and vibrations |
| Urban /industrial development | Urban/ industrial development | high impact on structural and functional connectivity because of land take (habitat loss), barrier effects and impacts due to noise and other pollutants |

## 4.2 Definition of relevant infrastructures

As already described in report D1.3.1 and in table 3 it depends on the size and design of a certain infrastructure whether negative impacts on the environment are to be expected.

For Salzburg, the desired development of the infrastructure in Salzburg is determined by the Federal Development Programme (= LEP 2022). For that reason it is relevant to consider the planning practices defined in the Programme.

First, the Federal Development Program already considers the importance of GBI and connectivity of habitats (Kernlebensräume). It is postulated that the habitats in Salzburg, defined through the project *Lebensraumvernetzung* by Leitner et. al (2014) are “for the most part free of high-level infrastructure (transport routes, pipelines)” (LEP 2022, p.34). Its connecting areas, the green space and migration corridors (Grün- und Wanderkorridore), are protected through the following paragraph:

> „Die tal- und beckenquerenden Wanderkorridore sind die noch verbliebenen Vernetzungsachsen zwischen den Kernlebensräumen. Es soll vermieden werden, dass diese durch zusätzliche harte Barrieren ZB durch Verkehrs- und Infrastrukturachsen oder gewisse Formen der Siedlungstätigkeit ihre Funktion verlieren. […] In Würdigung der Planungshoheit der Gemeinden zielt die Formulierung insbesondere auf

die Erhaltung der überörtlichen Grünraum- und Wanderkorridore ab. Grundlage hierfür ist die Studie zur Lebensraumvernetzung von Horst Leitner (2014). Der Schutz der örtlichen Korridore soll von den Gemeinden im Rahmen ihrer Planungen sichergestellt werden“ (ebd.).

*“The valley and basin-crossing migration corridors are the remaining connectivity axes between the core habitats. It should be avoided that these lose their function through additional hard barriers, e.g. through transport and infrastructure axes or certain forms of settlement activity. [...] In recognition of the planning sovereignty of the municipalities, the formulation is aimed in particular at preserving the interregional green space and migration corridors. The basis for this is the study on habitat connectivity by Horst Leitner (2014). The protection of local corridors should be ensured by the municipalities as part of their planning” (ebd.).*

Therefore, these corridors are not only defined and recognised through the Federal Development Program but already subject to a certain form of protection. However, its protection is effectively the responsibility of municipalities.

Even though it does not seem very likely, infrastructural development within these corridors is still possible under certain circumstances. These circumstances are to be explained in the following chapters.

## 4.3 Existing pressures and expected major threats in the pilot region

This chapter offers an overview of existing pressures and expected major threats infrastructural development (can) have in the pilot region. The pressures and threats are conducted in the pilot site of St. Gilgen whereas only the possible threats are examined on a larger scale in the pilot area of Flachgau and Tennengau regions.

### 4.3.1 Pressures and Threats in St. Gilgen

The following table lists all projects with spatial relevance in the pilot site St. Gilgen (Information through SAGIS). A distinction is made between existing infrastructure (pressures) and planned projects (threats).

Table 1: Overview – Existing pressures and expected major threats in the pilot region St. Gilgen

| Type of infrastructure/ Land use | Existing (pressures) | expected (threats) | Description |
|---|---|---|---|
| Hydropower - Hydroelectric reservoir (dam) | - | - | No planned dam.<br>In the neighbouring municipality Strobl, a small dam regulates the amount of water flowing out of Lake Wolfgangsee and is used for hydropower. |
| Hydropower - Run-off-River power plant | Nußbaumer, KW Zinkenbach (25KW)<br>Wiener, KW am Kienbach (1KW) | - | There are micro hydropower plants located in the municipality of St. Gilgen (0-100KW). They are for private uses only and pose because of its size no major intervention. |
| Windpower - windmills | - | - | No planned windpower within the municipality of St. Gilgen |
| Solar Power - Photovoltaics: Ground-mounted solar panels | Ground-mounted Solar Panel Zwölferhorn 1.057 m²<br>(800KW) | - | The PV system is used to generate electricity for the cable car up the Zwölferhorn. Surplus electricity is made available to the municipality. |
| Bioenergy - Biomass | Nahwärme Farchen (300KW)<br>Nahwärme St. Gilgen (4496KW) | - | |
| Transmission of electricity - High voltage transmission line | - | - | There are only medium voltage transmission lines within the municipality of St. Gilgen |
| Roads/ Highways | B154 Mondsee Straße<br>B158 Wolfgangsee Straße | - | |
| Railway | Schafbergbahn | - | The Schafbergbahn is a private, narrow-gauge cog railway that leads up the Schafberg and is used for tourist purposes. |

| Type of infrastructure/ Land use | Existing (pressures) | expected (threats) | Description |
|---|---|---|---|
| | | | An old railway (Ischlerbahn) was abandoned in 1957. Although a small club is dedicated to restoring it to service, this is not officially planned. |
| Urban/ industrial development | 11.96% of the municipal areas are permanent settlement areas (Dauersiedlungsraum). 8.3% of the municipal areas are settlement areas (Siedlungsraum). | Any rezoning outside the settlement structure has a negative impact. | The permanent settlement area comprises the space available for agriculture, settlement and transport facilities. The settlement area comprises utilisation categories of urban areas, industrial and commercial areas (STATISTIK AUSTRIA 2024). |

### 4.3.2 Threats in Tennengau and Flachgau Regions

On a bigger scale, considering the pilot region Flachgau and Tennengau, we want to focus on the threats posed by planned infrastructural projects for renewable energies.

In this context, wind power and ground-mounted PV systems play an important role. Individual sections of the Regional Development Project are dedicated to them:

#### 4.3.2.1 Solar Power - Photovoltaics: Ground-mounted Solar Panels

In order to achieve the climate goals and specifically the goals of the masterplan "Klima und Energie", the state of Salzburg is focussing on the increased expansion of photovoltaic systems. Although it is planned to install the majority of ground-mounted PV systems on rooftops, it will still be necessary to install 125 GWh of PV systems on suitable open spaces (Erläuterung zur Photovoltaik-Kennzeichnungsverordnung s.a., p.7). To do this, municipalities are to be supported in the selection of suitable sites. For this purpose, criteria have been defined in the Federal Development Programme to determine suitable areas.

If a municipality is planning to reclassify a zone in green areas for PV-projects, potential conflicts are declared and listed. They estimate the extent of the procedural risk between the PV project and the existing use. Here, green space and migration corridors represent a higher conflict potential (LEP 2022, p.41). If rezoning procedures are nevertheless carried out in these areas, the Federal Development Programme recommends agreements under private law (LEP 2022, p.16).

#### 4.3.2.2 Windpower – Windmills

As there is not a single windmill installed in all of Salzburgs area, a need to catch up for the expansion of renewable energies can be determined. Priority zones for the construction of wind turbines have already been designated in the Federal Development Programme. Four out of eleven of these priority zones are located in the Flachgau and Tennengau regions (LEP 2022, p.14f).

For the designation of these priority zones, comprehensive criteria and spatial analyses were carried out to determine potential conflicts and synergies (further described in chapter 5.2.2). Although ecological and environmental criteria were included in the analyses, the green space and migration corridors from the habitat analysis by Leitner et al. did not represent a data basis and were therefore not included.

# 5 Choice of Locations for major developments / renewable energy facilities

## 5.1 General criteria for unsuitable locations

The general criteria for unsuitable sites are compiled in the following table. They are based on the corresponding chapters of the report D1.3.1.

Table 5: General criteria for unsuitable sites (D1.3.1)

| | **Unsuitable locations** |
|---|---|
| **Hydropower** | • protected areas (e.g. Natura 2000 areas, nature reserves, …)<br>• natural or semi-natural rivers |
| **Windpower** | • protected areas (e.g. Natura 2000 areas, nature reserves, core areas of national parks and biosphere reserves)<br>• European bird protection areas with occurrences of wind energy-sensitive bird species<br>• designated bird migration routes<br>• density centers of collision-sensitive bird species<br>• old natural or semi-natural forests<br>• forested ridgelines because of high collision rates of birds and bats<br>• areas with high perceived scenic quality (landscape quality) |
| **Solar power** | • protected areas (e.g. Nature 2000 areas, nature reserves, water protection areas)<br>• areas of high nature conservation value<br>• riparian buffer zones, floodplains<br>• natural watercourses and lakes<br>• soil with very high significance for natural soil functions<br>• agricultural soil with high degree of productivity |
| **Biomass (bioenergy plant)** | • protected areas (e.g. Nature 2000 areas, nature reserves, core areas of biosphere reserves, water protection areas)<br>• areas of high nature conservation value |

| | Unsuitable locations |
|---|---|
| **High voltage transmission line** | • European bird protection areas (Important Bird Areas (IBAs) or Special Protection Areas (SPAs))<br>• wetlands of international importance according to the Ramsar Convention<br>• designated bird migration routes<br>• near large bodies of water and reservoirs<br>• protected areas specifically for landscape (UNESCO World Heritage Sites, Landscape conservation areas, priority areas for tourism)<br>• other protected areas (e.g. Natura 2000 areas, nature reserves, core areas of national parks and biosphere reserves)<br>• old natural or semi-natural forests<br>• water protection areas of zones I and II (no construction of transmission poles in waterways or banks of waterways |
| **Roads/ highways** | • protected areas (e.g. Nature 2000 areas, nature reserves, core zones of national parks and biosphere reserves, water protection areas)<br>• areas of high nature conservation value like old-growth forests or wet- and peatland<br>• soil with very high significance for natural soil functions |
| **Railways** | • protected areas (e.g. Nature 2000 areas, nature reserves, core zones of national parks and biosphere reserves, water protection areas)<br>• areas of high nature conservation value like old-growth forests or wet- and peatland |
| **Urban /industrial development** | • protected areas (e.g. Nature 2000 areas, nature reserves, core zones of national parks and biosphere reserves, water protection areas)<br>• areas of high nature conservation value like old-growth forests or wet- and peatland<br>• existing ecological corridors, especially in bottleneck areas |

As mentioned in D.2.3.1 *Project of local ecological network Salzburg* the project *Lebensraumvernetzung* by Leitner et al. (2014) offers a model which defines important habitats and corresponding corridors in Salzburg and therefore in the pilot area of Tennengau and Flachgau regions.

In chapter 4.2 we already mentioned the status of protection of green space and migration corridors guaranteed through Salzburgs Federal Development Program. Therefore, the green space and migration corridors are defined and act as unsuitable locations for infrastructural development.

In order to carry out an assessment for exceptions, a guideline was created (Leitfaden zur Bewertung der wildökologischen Durchlässigkeit von Lebensraumkorridoren by Grillmayer et al. 2023).

This step-by-step guideline is shown in the following diagram:

Table 6: Guideline for the evaluation of infrastructural development within green space and migration corridors. Illustration according to Grillmayer et al. 2023, p.12.

| No. | Evaluation |
|---|---|
| **1** | Is the new infrastructural project located in a habitat corridor? If yes, then 2; if not, then 1000.<br>Note: This requires a wildlife ecology expertise. Assistance can be found at lebensraumvernetzung.at. |
| **2** | Determine the purpose of the corridor (local, regional, interregional), then continue with 3.<br>Note: The study distinguishes between three categories of corridors depending on their function. |
| **3** | If the project in the habitat corridor is a construction project requiring permission, then continue with 4. If not, then continue with 100. |
| **4** | Does the project fall below the minimum width of the respective corridor category according to its purpose (interregional corridors, regional corridors, local corridors) or restrict the functionality of the corridor? If yes, then 5; if not, then 1000. |
| **5** | Can the functionality of the corridor be maintained through mitigation or compensation measures? If yes, then 6; if not, then 2000. |
| **6** | Setting of mitigation or compensation measures (further description in chapter 6). |
| **100** | Is the project an agricultural activity? If yes, then 101; if not, then 1000. |
| **101** | Does agricultural activity act as a barrier to wildlife? If yes, then 4; if not, then 1000. |
| **1000** | No further examination necessary. |
| **2000** | Realisation of the project not possible. |

Although these guidelines provide good support for decision-making, the Federal (Spatial) Development Programme only refers to interregional corridors (see Fig. 2).

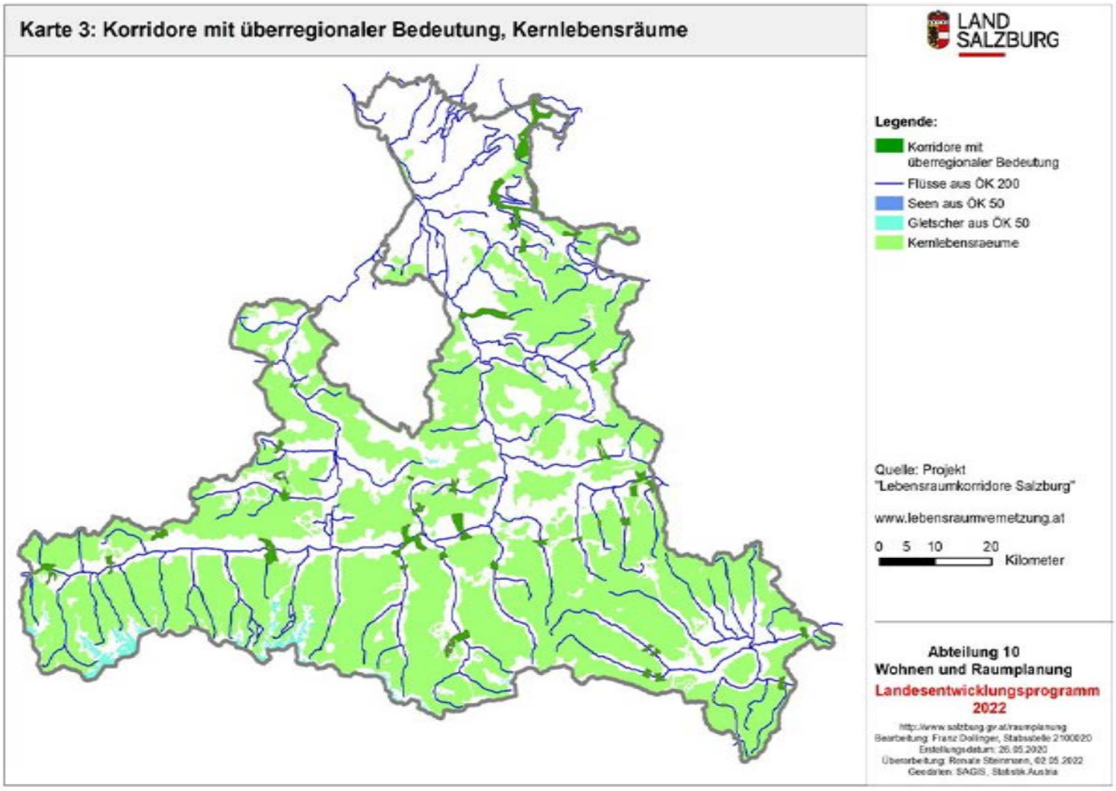


Figure 2: Habitats and corridors of interregional significance according to LEP 2022

However, the habitat analysis study distinguishes between three different categories of corridors depending on their function (local, regional, interregional).

### 5.1.1 Unsuitable Locations – Local Corridors

Local corridors are used for frequent (daily) changes between grazing areas and resting areas. The minimum width is **150 metres**. The guiding function of the corridor is to provide the opportunity to reach the different habitat requirements (grazing, stand) with little effort, to reach special topographical locations and to avoid Lei.

### 5.1.2 Unsuitable Locations – Regional Corridors

Regional corridors: They are primarily used to find seasonally different habitats (e.g. sunny location vs. shady location). In most cases, they are also used to switch between grazing areas and stand areas. The minimum width is **300 metres**. The guiding function of the corridor is to maintain the ability to react to periodically recurring climatic events (ebd.).

### 5.1.3 Unsuitable Locations – Interregional Corridors

Interregional corridors serve the migratory needs and genetic exchange of wild animals. In most cases, they are also used for seasonal migration and for switching between grazing areas and stand areas. The minimum width for interregional habitat corridors is **800 metres**. The guiding function of the interregional corridor is the genetic exchange between populations and sub-populations (ebd.).

## 5.2 Development of specific criteria for unsuitable locations in the pilot region (exclusion zones)

Exclusion zones in this context are areas where certain infrastructures are not allowed to be built or operated. Exclusion zones are the most common planning instrument to mitigate environmental impacts of human land-use, including the deployment of RE.

The criteria for the implementation of wind turbines and ground-mounted solar panels in the Federal Development Program already mentioned in chapter 4.3.2 can be seen as the specific criteria for unsuitable locations in the Flachgau and Tennengau regions, which act as exclusion zones. Therefore, we want to highlight these in the following chapters.

### 5.2.1 Specific Criteria for Unsuitable Locations – Ground-mounted Solar Panels

The criteria defined for the assessment of site suitability regarding ground-mounted PV systems are to be evaluated through to a point ranking system according to their location, configuration and size (Erläuterung zur Photovoltaik-Kennzeichnungsverordnung s.a., p.7ff). Nevertheless, other aspects, such as the municipality's planning intentions and the possibility of a technical integration of the photovoltaic system into the electricity grid, should also play a role.

*Location*

One aim is to use areas that are already contaminated and to preserve high-quality agricultural land for food production. In order to preserve high-quality soils a soil function assessment ("Bodenschutz bei Planungsvorhaben" by Knoll, Sutor, Meier 2010) is taken into consideration.

Apart from that, it is a general aim to use areas which are adjacent to areas where built infrastructure facilities such as streets or buildings are located. Streets are classified according to their relevance for transportation based on the Functional Road Class which is offered through the Graphenintegrationsplattform (GIP) (Erläuterung zur Photovoltaik-Kennzeichnungsverordnung s.a., p.7f).

*Configuration*

This criteria refers to the technical design of the system. A distinction is made between conventional PV systems, agrivoltaic systems and innovative agrivoltaic systems. As agrivoltaic systems should be prioritised in terms of soil protection, they are preferred over conventional systems and therefore receive more points in the evaluation (Erläuterung zur Photovoltaik-Kennzeichnungsverordnung s.a., p.8f).

*Size*

In order to minimise the impact on the landscape, the province of Salzburg is pushing for larger projects instead of many smaller ones. Larger area PV systems are therefore awarded higher points (Erläuterung zur Photovoltaik-Kennzeichnungsverordnung s.a., p.7).

### 5.2.2 Specific Criteria for Unsuitable Locations – Wind Mills

In a coordination process within the state departments, a catalogue of criteria regarding potential areas of conflict was defined on the basis of legal and technical requirements. This catalogue of criteria was discussed again with the participating provincial departments and supplemented with technical content. The criteria catalogue was divided into the following topic clusters

*A - Wind suitability / technology / zone quality*

*B - People / Uses / Infrastructure*

*C - Landscape / recreation*

*D - Natural environment / ecology*

*E - Resources / Water / Hazard zones*

Each of these topic clusters contains up to 20 criteria. As already mentioned in chapter 4.3.2.2 ecological and environmental criteria were included in the analyses, the green space and migration corridors from the habitat analysis by Leitner et al. did not represent a data basis and were therefore not included (LEP 2022, p.43ff) .

## 5.3 Mapping the land use conflicts for renewable energy production

Further down west inserted the maps of the habitat corridors in Tennengau (Fig. 3) and Flachgau (Fig. 4). These were taken from the study on habitat connectivity *Lebensraumvernetzung Salzburg* by Leitner et al. (2014) which served as the basis for the corridor mapping according to the Regional Development Programme.

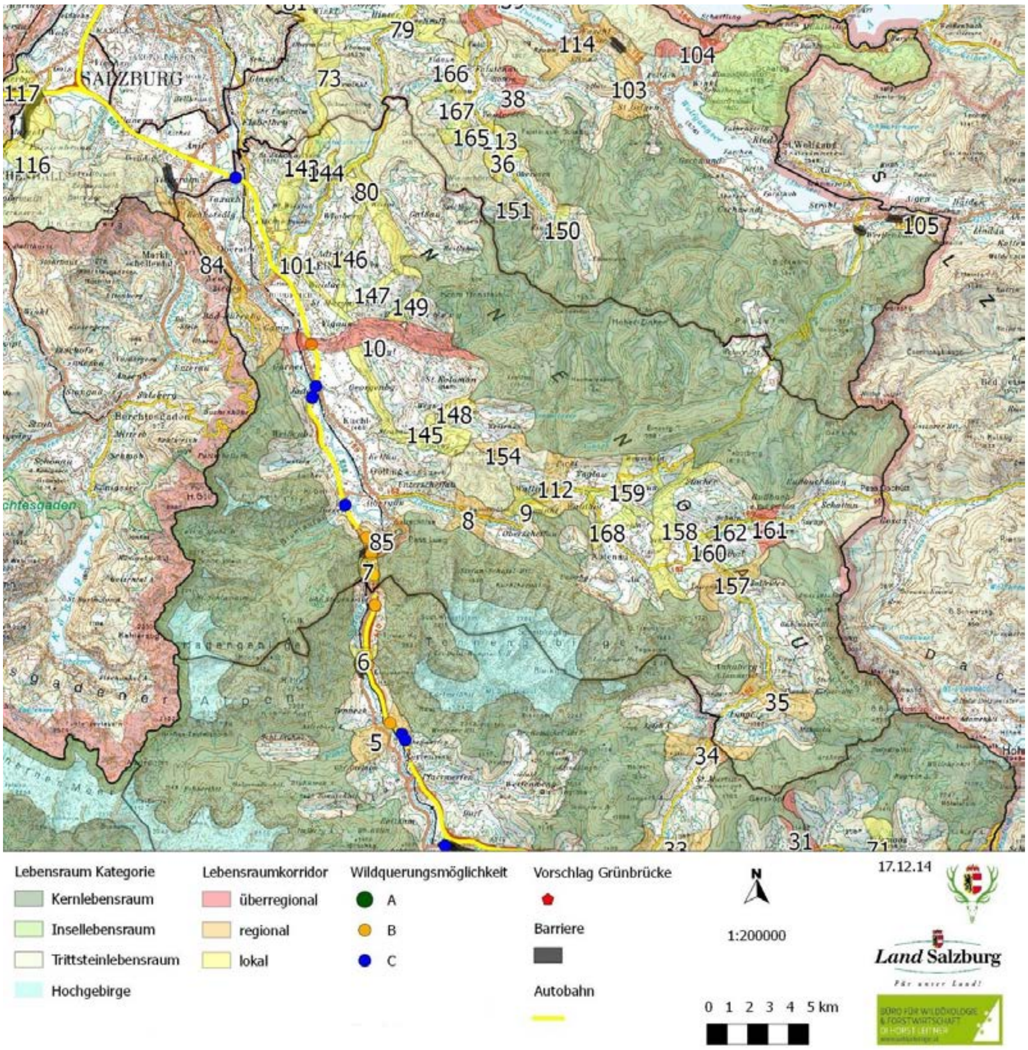


Figure 3: Overview map of the corridors in Tennengau

In the Tennengau region, two important interregional corridors support large-scale habitat networking. A north-south connection across the Lammertal valley (corridor no. 161) enables the exchange between the Tennengebirge and the Salzkammergut mountains, and south of Vigaun near Hallein there is an interregional connection (corridor no. 10) along the Taugl river through the Salzburg-Hallein basin westwards into the Berchtesgaden Alps (Leitner et al. 2014, p.31).

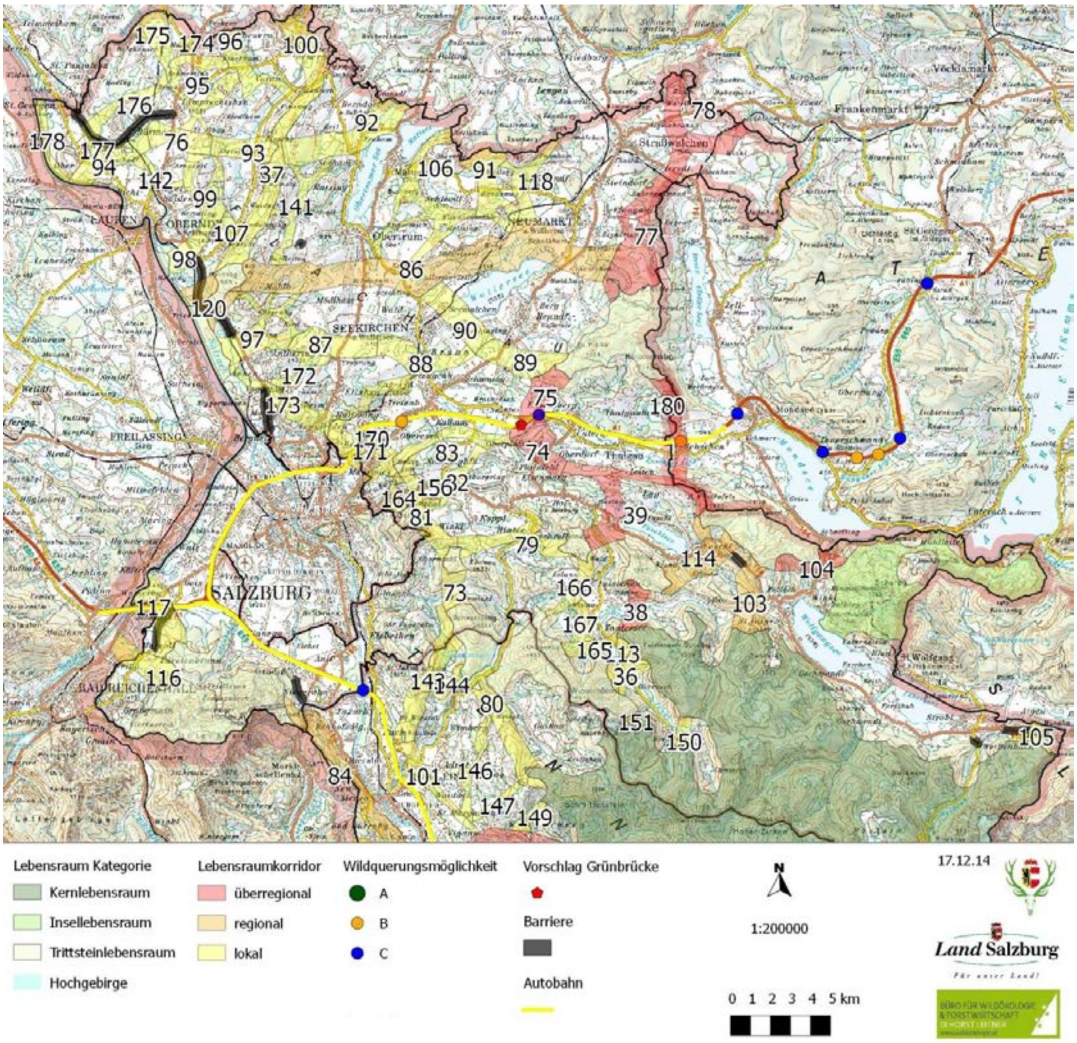


Figure 4: Overview map of the corridors in Flachgau

Flachgau is already heavily fragmented by infrastructure and settlement areas, particularly in the area around the city of Salzburg and in the northern part. In contrast to the rest of the country, there are no longer any core habitats for forest-preferring large mammals in this area. Smaller remnants of contiguous forest areas, which are of great importance for connectivity, form important stepping stones along the corridors here (Leitner et al. 2014, p.32).

Between Fuschlsee and Wolfgangsee - crossing the B158 Wolfgangsee Straße and the B154 Mondsee Straße - a combination of two interregional (No. 38 and 104) and two regional corridors (No. 103 and 114) establishes the connection from Tennengau via Flachgau in the direction of Upper Austria (ebd.).

While the function of corridor no. 104, which is almost entirely wooded, is only limited in places by the steepness of the terrain, the other three corridors also run in the area influenced by settlements. Corridor no. 114 in particular, which runs directly past Fuschl am

See, has narrow sections in the valleys due to settlements, meaning that particular attention must be paid to maintaining the connection in the southern section of the corridor (ebd., p.48ff).

### 5.3.1 Solar power

In order to determine whether ground-mounted solar panels interfere with the connectivity network we layered the data. The data for solar panels is based on the defined areas for ground-mounted solar panels in SAGIS. Please note, that these areas are not a matter of land zoning as in a land-use plan, but rather, that these areas have just been marked as suitable PV areas. The extent to which a PV system has already been realised on these areas must be assessed on a case-by-case basis.

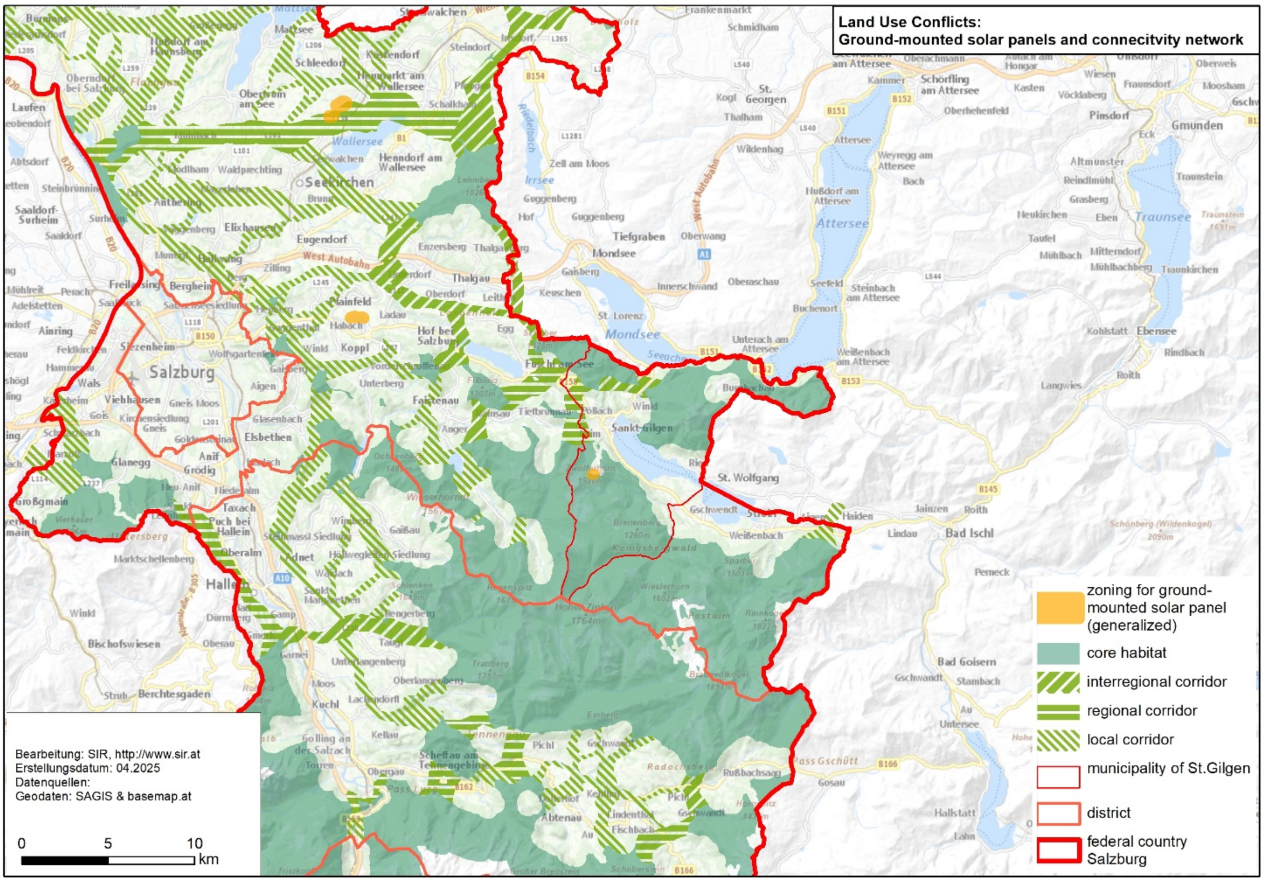


Figure 5: Land use conflicts: Ground-mounted solar panels and connectivity network

The analysis (Fig. 5) shows that of the 26.4 ha of area designated for ground-mounted solar panels, 8.5 ha are located in regional corridors. 0.1 ha area are located in core habitats. In fact, the ground-mounted solar panel, which lies within a core habitat, is located in the municipality of St. Gilgen.

Further research has shown that this represents an already installed PV system on top of the mountain Zwölferhorn (see Fig. 6).

Figure 6: Ground-mounted solar panel on the Zwölferhorn mountain

The PV system, which takes up an area of around 1000m², was installed in 2024 in order to generate renewable energy for the cable car, which goes up that very mountain. With a peak of 800 kW, this generates 930,000 kWh of solar energy per year. The surplus energy is made available to the municipality of St. Gilgen, which amounts to around 300,000 kWh per year (Zwölferhorn Seilbahn 2025).

### 5.3.2 Windpower

#### 5.3.2.1 Mapping of the defined priority zones

Considering the windpower, the following map, taken from the Salzburg Federal Development Programme, shows the designated priority zones for wind energy in the province of Salzburg.

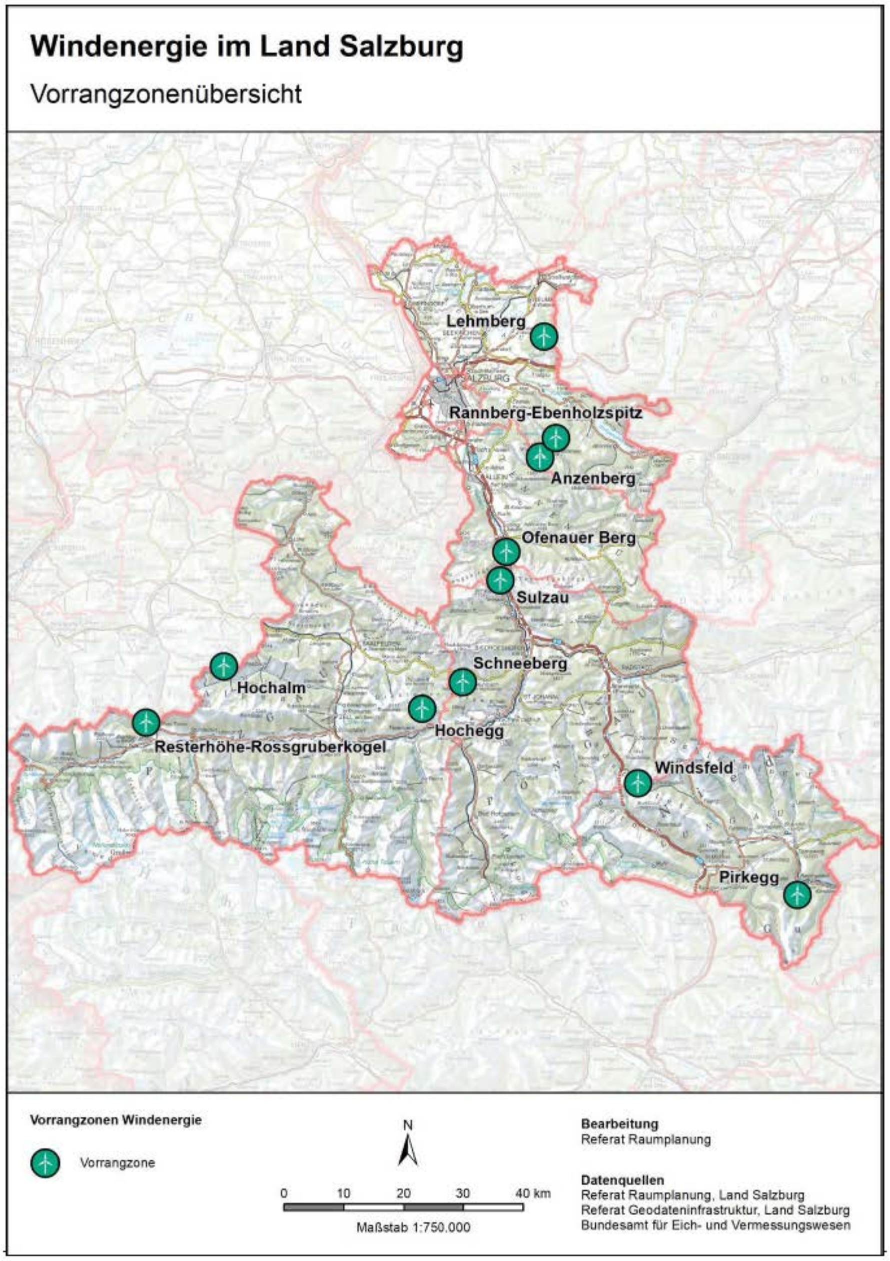


Figure 7: Priority zones for wind power

Out of eleven, four of the priority zones fall into the Tennengau and Flachgau regions. The priority zone Ofenenauer Berg is the only one located in Tennengau (see. Fig. 8).


Figure 8: Priority zone Ofenauer Berg

In Flachgau the priority zones Anzenberg, Lehmberg and Rannberg-Ebenholzspitz are listed (see Fig. 9-11).


Figure 9: Priority zone Anzenberg

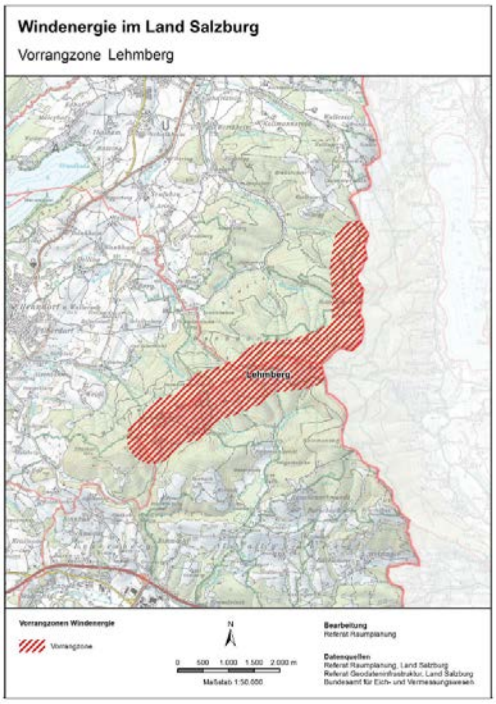


Figure 10: Priority zone Lehmberg

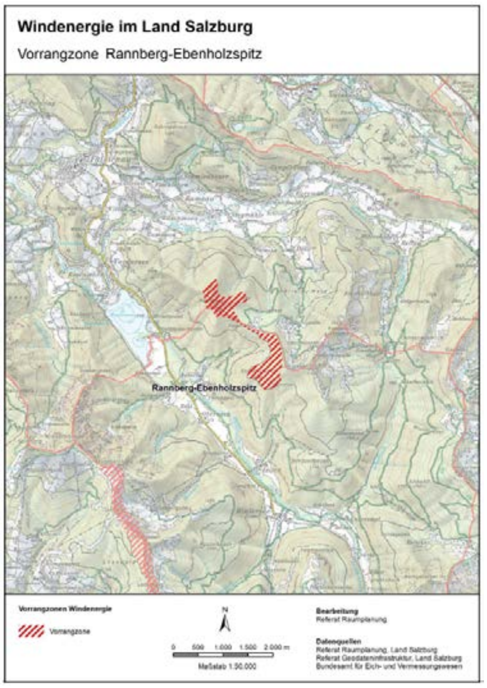


Figure 11: Priority zone Rannberg-Ebenholzspitz

#### 5.3.2.2 Priority zones for wind power overlapping core habitats and corridors

In order to analyse the extent to which the priority zones are located in core habitats or migration corridors, we layered the two data sets. The following map shows the land use conflicts between wind power priority zones and the connectivity network (Fig. 12).

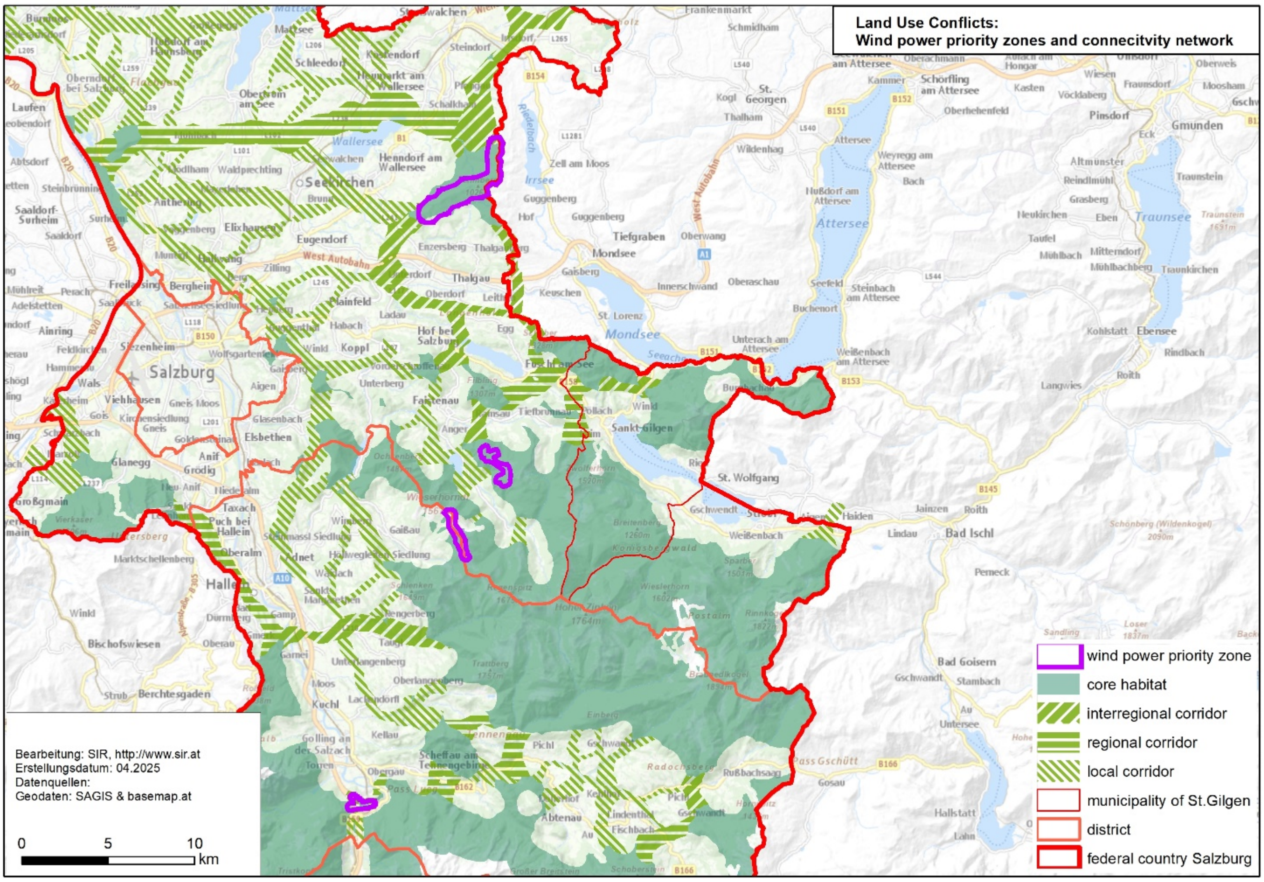


Figure 12: Land use conflicts: Wind power priority zones and connectivity network

This analysis reveals that of the 7.9 km² that make up the area of the priority zones in Tennengau and Flachgau, 7.5 km² are located in core habitats or corridors.

To be more precise, 7.1 km² concern core habitats (5.7 km² stepping stones and 1.4 km² core habitats). The corridors overlap 0.2 km² with regional corridors and 0.1 km² with interregional corridors.

# 6 Possible mitigation and compensation measures

The following chapter describes possible mitigation and compensation measures for infrastructures. They are based on the corresponding chapters of the report D1.3.1.

In general, it can be said that functioning habitat corridors are characterised by certain attributes: Habitat corridors run in the forest or in open land (largely unbuilt area outside the forest). Rows of trees, hedges, wetlands with accompanying vegetation or fallow land are regarded as favourable surface creation outside the forest in order to make the corridor more attractive. Otherwise, agricultural farming is suitable as a corridor component, especially in the period with standing crops. Furthermore, landscape elements such as hedges, wetlands, rows of trees, etc. are helpful for the functionality of habitat corridors (disturbances (Grillmayer et al. 2023, p. 6f).

Habitat corridors should fulfil the minimum requirement in terms of width which was described in chapter 4.4. Furthermore, there should be no human settlements or permanent residences in the corridor area. Exceptions may be individual farmsteads. The number of transport infrastructures to be crossed by wild animals should be low. Fenced roads to prevent wildlife accidents are a reason for excluding a corridor unless the mode of transport is equipped with a crossing option for wildlife (ebd., p.7).

If the minimum width of the habitat corridor is no longer possible or is undercut due to development or unalterable land use, mitigation or compensation measures can be taken in the area of the bottleneck in order to maintain the function of the corridor as a connecting element. The prerequisite for this is that there is no regular disturbance through human activity, at least at night (ebd.).

Such mitigation and compensation measures can be:

- Dense planting on both outer borders of the corridor with a minimum width of ten metres. These help to prevent disturbances from outside.
- The planting should not be easily accessible to people and, if possible, have a wintergreen tree stock.
- Prevention of noise and light pollution from outside the corridor.
- The narrower a corridor is, the more important is the existence of safe stepping stone biotopes or guiding structures for wildlife (e.g. larger islands of bushes, wooded strips, wide shelterbelts, riverbank shrub zones). Such elements can guide wild animals through narrow passages even in sparsely wooded parts of the landscape.
- If wild animals have to cross a more heavily frequented road in the area of a narrow section of the corridor, the presence of a wildlife crossing aid is highly advantageous. In the area of wildlife crossing aids, it is essential that human activity (campsites, leisure facilities, barbecue areas, etc.) is prevented. Purely agricultural use does not necessarily represent non-functionality.

# 7 Conclusions

The analysis of land use conflicts for renewable energy production and other threats in our pilot region Tennengau and Flachgau have shown significant outcomes.

For this the study network Lebensraumvernetzung by Leitner et al. worked as a basis for the connectivity network of core habitats and corridors in Salzburg.

On a regional level we examined the regulations of wind power and solar power as the development of these are prioritised in the Regional Development Programme.

For wind power threats presented through the specification of priority zones for wind mills were described. In addition, unsuitable locations and exclusion zones were outlined using the criteria for priority zones of wind mills as described in the Regional Development Programme.

Four of these are located in Flachgau and Tennengau regions. The mapping of the priority zones for wind power and the connectivity network showed a land use conflict as the majority of the priority zones are located within the network. To be more clear, 7.1km² of the the areas affected are core habitats while 0.1km² affects interregional corridors and 0.2km² regional corridors. While at least the interregional corridors play a fairly high preservation status in the Federal Development Programme, they were not considered as criteria for the priority zones for wind power.

For solar power a development of ground-mounted solar panels also on open spaces is aimed at to meet climate goals. Therefore, a directive for the designation of areas for ground-mounted PV systems was set. Green space and migration corridors were marked in these as representing a higher conflict potential for rezoning procedures. The mapping of the designated areas for ground-mounted solar panels and the connectivity network showed that even though no area was located in an interregional corridor (which carries a higher status of protection), 8.5 ha are located in regional corridors and 0.1 ha are located in core habitats.

On a municipal level we focused on our pilot site St. Gilgen. There existing infrastructures act as pressures for the connectivity network. Herefore, a key example is given by the ground-mounted solar panel which was built on the top of the mountain Zwölferhorn in order to power the cable car. Even though there are criteria defined for the implementation of ground-mounted solar panels which were described in chapter 5.2.1 the PV-system was partially installed in a core habitat. This shows that measures considering the preservation of soils, nature conservation and the conservation of migration corridors which all do play a role in the defined criteria for the implementation of ground-mounted solar panels are not sufficient for the conservation of the connectivity network in general. This shortcoming is also due to the fact that, on the one hand, the importance of corridors is taken into account in the Federal Development Programme in several sections, but on the other hand, the focus is on interregional corridors, while core habitats and local / regional corridors play a subordinate (or no) role.

In the further information for the designation of areas for ground-mounted solar panels it is explicitly stated that the installation of a photovoltaic system can in many cases contribute to the self-sufficiency of adjacent areas or facilities (Erläuterung zur Photovoltaik-Kennzeichnungsverordnung s.a., p.8). For the case of the ground-mounted solar panels on the Zwölferhorn this aspect must have been crucial for the decision of implementation.

Although mitigation and compensation measures are defined a clear need is identified for better integration of ecological data into planning tools and a more robust regulatory framework that considers all levels of ecological connectivity.

Therefore, this study shows that there is still the possibility that land use conflicts may arise between the expansion of renewable energies and the protection of GBI connectivity networks.

# 8 Glossary

| | |
|---|---|
| **Connectivity" (structural and functional)** | "Connectivity comprises two components, structural and functional connectivity. It expresses how landscapes are configurated, allowing species to move. Structural connectivity, equal to habitat continuity, is measured by analysing landscape structure, independent of any attributes of organisms. […]. Functional connectivity is the response of the organism to the landscape elements other than its habitats (i.e. the non-habitat matrix). This definition is often used in the context of landscape ecology. A high degree of connectivity is generally linked to low fragmentation." (EUROPEAN COMMISSION - Technical information on Green Infrastructure (GI), 6.5.2013, Glossary)<br><br>(Definition of connectivity see also Deliverable 1.1.1, chapter 8) |
| **GBI – Green and blue infrastructure** | Green infrastructure (GI) is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings." (EUROPEAN COMMISSION - Green Infrastructure (GI) — Enhancing Europe's Natural Capital, 6.5.2013)<br><br>(Definition of connectivity see also Deliverable 1.1.1, chapter 6) |
| **Hydropower (dams, weirs, run-off-river power plant)** | power derived from the energy of falling water or fast running water to generate electricity<br><br>Hydropower generation including development and use of associated infrastructure (e.g. building dams or weirs, changes of hydrological functioning rivers or chemical and thermal properties of water due to operation of dams and weirs). |
| **Hydroelectric dam** | a barrier that stops or restricts the flow of water; used to create energy in the water flow that can be captured by a turbine to generate electricity |
| **Pressures and Threats** | Definition by the European Environment Agency 2020 (State of nature in the EU - Results from reporting under the nature directives 2013-2018):<br><br>*"Pressures are considered to be factors that have affected habitats and species within the current reporting period, while threats are factors that are anticipated to be likely to have an impact during the subsequent two reporting periods."* |
| **Solar PV panel** | an arrangement of PV materials that absorbs and converts sunlight into electricity |
| **Transmission lines** | power lines used to move electricity from a generating site (e.g., a power plant) to an electrical substation, which often transforms the voltage from high to low before reaching consumers |
| **Wind farm** | a group of wind turbines used to produce electricity |

# 9 References

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# ANNEXES

## Annex 1 Mitigation /compensation (see D1.3.1)

| | Mitigation / Compensation |
|---|---|
| **Hydropower** | • Upstream and downstream fish passage facilities (fish ladders, bypasses) to allow migration<br>• intelligent turbine design or turbine shutdown on a fixed schedule decreasing turbine related mortality<br>• ecologically effective minimum flow of water<br>• bed-load management<br>• morphological enhancement measures:<br>    ➢ improvement of the riverbank structure (unsealing the riverbank)<br>    ➢ introduction of gravel banks<br>    ➢ introduction of disturbance elements (stones, deadwood)<br>• New hydropower technologies with less environmental impacts |
| **Windpower** | • turbine design optimization<br>• switch off systems at times of increased bird/bat activity to prevent/avoid collisions (Automatic anti-collision systems)<br>• unattractive design of the environment at the base of the mast and in surrounding fields for wind energy-sensitive birds (red kites) |
| **Solar power** | • landscape-oriented design of the facility, visual integration into the environment: suitable arrangement of the solar panels (e.g. “Solar biotope network”)<br>• sufficiently large (wide) open spaces between the rows of solar panels (sunlit strips at least 3 m wide between the rows)<br>• elevation of the solar panels (panel distance to the ground at least 0.8 m)<br>• no fencing or at least permeable for small and medium-sized mammals (15 cm distance between the fence and the ground), migration corridors as crossing aids for large-scale facilities<br>• development and maintenance of extensively used, species- and flower-rich grassland in the solar park<br>    ➢ using seeds from local species or locally obtained mown material<br>    ➢ no fertilization, no use of pesticides<br>    ➢ up to 2 mowing intervals (use of insect-friendly mower, cutting height 10 cm) with removal of mowed material or/and site-adapted grazing<br>• no mulching |
| **Biomass (bioenergy plant)** | • - |

| | Mitigation / Compensation |
|---|---|
| **High voltage transmission line** | • bundling of linear infrastructure, appropriate route alignment<br>• appropriate design of the pylons to reduce fragmentation including spanning above the forest canopy<br>• marking transmission lines to reduce bird collision risk<br>• ecological rights-of-way vegetation management creating and connecting new habitats |
| **Roads/ highways** | • appropriate route alignment<br>• traffic management measures: reducing traffic volume or speed<br>• fencing combined with wildlife passages<br>• wildlife passages as overpasses (e.g. green bridge, fauna overpass, multiuse overpass) or as underpasses (e.g. viaduct, fauna underpass, multiuse underpass, small fauna underpass, adapted culverts, fish passage, amphibian passage) reducing the barrier effect and providing a safe crossing<br>• embankments to mitigate noise and provide new habitats for endangered flora species<br>• adapting infrastructure verges<br>• mechanical methods for vegetation control or grazing as alternative methods to the use of chemical substances in the management of green areas<br>• adapting road lighting for mitigating light pollution<br>• noise screens, placing the road between cuttings or earthen mounds, silent pavements for mitigating noise<br>• runoff water management: Retention ponds |
| **Railways** | • appropriate route alignment<br>• fencing combined with wildlife passages<br>• wildlife passages as overpasses (e.g. green bridge, fauna overpass, multiuse overpass) or as underpasses (e.g. viaduct, fauna underpass, multiuse underpass, small fauna underpass, adapted culverts, fish passage, amphibian passage) reducing the barrier effect and providing a safe crossing<br>• embankments/ earthworks to mitigate noise and provide new habitats for endangered species<br>• adapting infrastructure verges<br>• mechanical methods for vegetation control or grazing as alternative methods to the use of chemical substances in the management of green areas<br>• noise screens, placing the road between cuttings or earthen mounds, rail noise absorbers for mitigating noise<br>• runoff water management: Retention ponds |

| | Mitigation / Compensation |
|---|---|
| **Urban /industrial development** | • appropriate location of new urban/industrial development (avoid areas of high nature conservation value including ecological corridors)<br>• preservation of large, undissected open spaces, safeguarding inner-urban trees (particularly large/mature trees)<br>• minimizing the road infrastructure associated with urban/industrial development, keeping vehicle speeds low<br>• reducing use of fertilizers and pesticides in maintenance of public and private green<br>• minimizing artificial lighting<br>• good pet ownership to reduce domestic animal damages to wildlife<br>• runoff water management: minimize water runoff into streams<br>• Integration of connectivity elements in zoning plans / optimising connectivity planning and interfaces between regional concepts and municipal planning |

**PlanToConnect**

Mainstreaming ecological connectivity in spatial planning systems of the Alpine Space

**Project partners:**

Urban Planning Institute of the Republic of Slovenia (SI)
Veneto Region (IT)
ALPARC – the Network of Alpine Protected Areas (FR)
Asters, organisation for the conservation of natural areas in Upper Savoy (FR)
Eurac Research (IT)
ifuplan - Institute for Environmental Planning and Spatial Development (DE)
University of Würzburg (DE)
Salzburg Institute for Regional Planning and Housing (AT)
E.C.O. Institute of Ecology Ltd. (AT)
Fondazione Politecnico di Milano (IT)

**GBI-network: Land use conflicts for RE production and other threats**
**St. Gilgen – Tennengau and Flachgau regions**

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