

POSSIBILITIES OF LOCATING INVESTMENTS IN RENEWABLE ENERGY SOURCES IN THE POST-MINING AREAS OF THE KONIN REGION

MOŻLIWOŚCI LOKALIZACJI INWESTYCJI W ODNAWIALNE ŹRÓDŁA ENERGII NA OBSZARACH POGÓRNICZYCH W REGIONIE KONIŃSKIM

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The article provides an overview of possible locations of renewable energy production sites at the overburden disposal areas situated inside lignite open pits of the Konin region which are researched in frame of the SUMAD project (entitled “Sustainable Use of Mining Waste Dumps”). The three mines currently operating in the Konin region represent different cases in terms of time of operation, pit size and other conditions. Coal excavation in the two of them is about to be ceased so reclamation processes have already taken place in the inactive parts of the pits. The article includes a preliminary site investigation in order to indicate possibilities for future use of the post-mining areas as renewable energy production sites (wind or solar farms).

Keywords: *overburden disposal area, reclamation, renewable energy, photovoltaics, wind power plants*

W artykule przedstawiono przegląd możliwych miejsc produkcji energii odnawialnej na wewnętrznych zwalowiskach górniczych zlokalizowanych w obrębie odkrywek węgla brunatnego regionu konińskiego, które są przedmiotem badań projektu SUMAD (pt. “Zrównoważone wykorzystanie zwalowisk górniczych”). Trzy kopalnie działające obecnie w regionie konińskim reprezentują różne przypadki pod względem czasu trwania eksploatacji, wielkości wyrobisk i innych warunków. Wydobycie węgla w dwóch z nich ma się wkrótce zakończyć, więc w nieczynnych częściach wyrobisk prowadzona jest już rekultywacja. Artykuł obejmuje wstępne rozpoznanie obszaru kopalni w celu wskazania możliwości przyszłego wykorzystania terenów pogórnich jako miejsc produkcji energii odnawialnej (farm wiatrowych lub słonecznych).

Słowa kluczowe: *zwałowisko nadkładu, rekultywacja, energia odnawialna, fotowoltaika, elektrownie wiatrowe*

Introduction

The article aims at identification of scale and characteristics of the former overburden disposal areas in the Konin lignite mining region in order to indicate opportunities and limitations of their development towards renewable energy generation sites. The overview has been prepared in frame of the SUMAD project in order to select possible sites for renewable energy investments. The investigation included the overburden disposal areas that are operated by PAK Konin Lignite Mine S.A. (PAK Kopalnia Węgla Brunatnego Konin S.A.) which is owned by a large energy generation group, ZE PAK Capital Group (ZE PAK S.A.). In 2020, the two coal-fired power plants of ZE PAK Group generated in total 4.9 TWh of net electricity [1]. Nevertheless, the Group has recently adopted a strategy to stop generating energy from coal by 2030 at the latest and transform completely towards renewables.

PAK Konin Lignite Mine currently operates three lignite open cast mines: Józwin IIB, Tomisławice and Drzewce mines along with their overburden disposal areas. Two out of those three plan to stop coal excavation in 2021-2022, therefore their activities in the nearest future will be focused mostly on post-mining land reclamation and adaptation to new functions. The

goal of the SUMAD project and this study, in particular, is to investigate possibilities to use the overburden disposal areas as renewable energy production sites (wind or solar power plants) in the nearest future.

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Overview of the overburden disposal areas

General information on mines in the Konin region

The three operating mines of the PAK Konin Lignite Mine company are located in the Wielkopolska region (voivodship) in west-central Poland, within Konin County (apart from the Drzewce Mine which is located partly in the Konin County and partly in the Koło County). The Konin County covers an area of 1,578 km² and is inhabited by ca. 130 thousand people. The largest population lives in the city of Konin – ca. 74 thousand residents. Along with a neighbouring Turek County and its Adamów Lignite Mine, the area of Konin has been well known for its coal mining and energy industry since the ‘50s of the

XXth century. Almost 637 million Mg of coal was extracted from the beginning of the Konin Mine's operations until the end of 2020 [2]. Vast areas within the Konin County and the city of Konin itself are industrial areas with significant anthropogenic influences. They include former mining excavation pits, now filled with artificial lakes, hills which are external overburden dumping sites, areas reclaimed as forests and agricultural lands and, of course, areas of active mines and energy generation plants with accompanying technical infrastructures.

At the moment the longest running mine in the study area is the Józwin II B mine, which opened in 1999. The Józwin IIB mine excavated 1,585 thousand Mg of coal in 2020. 20,481 thousand m³ of overburden was removed from the excavation pit to the disposal area. In 2019 2,214 thousand Mg of coal came from the mine and 23,890 thousand m³ of overburden ended up at the dumping site. During 2013-2018 period the extracted coal amounts varied between 3,2 and 5,8 Mio. Mg per year. The Józwin IIB constitutes a natural continuation of excavation of coal deposits from Józwin I and Józwin IIA mines. In total 176 million Mg of coal was extracted from all Józwin mines until the end of 2020 [2].

The Drzewce mine opened in 2005 and it consists of three fields: Bilczew Field, Drzewce A and B Fields. Excavation in two out of three fields is already finished. The Field B remains an active mine since 2015. The Drzewce mine extracted 1,414 thousand Mg of coal in 2020 and 4,967 thousand m³ of overburden was removed from the excavation pit to the dumping site. In 2019 1,313 thousand Mg of coal came from the mine and 8,871 thousand m³ of overburden ended up in the dump. From the beginning of its operations until the end of 2020 over 30 million Mg of coal was extracted from the Drzewce mine [2].

The Tomisławice mine is the youngest mine within the PAK Konin Lignite Mine company – opened in 2010. In 2019 for the first time it had the largest share in the annual extraction of coal out of the three operating Konin mines - 2,329 thousand Mg of coal was extracted. 10,134,000 m³ of overburden was removed from the excavation pit to the dump. In 2020 2,107 thousand Mg of coal came from the mine and 8,206 thousand m³ of overburden ended up at the disposal area. From the beginning of its operations until the end of 2020 17 million Mg of coal was extracted from the Tomisławice mine [2].

The operation of Józwin and Drzewce mines is about to finish, the Józwin mine will close in 2021, and Drzewce mine - in 2022. The only remaining mine will be Tomisławice Mine with its ca. 24.9 million Mg of lignite economic resources at the end of 2020 [3].

Characteristics of the overburden disposal areas

There are five internal overburden dumping sites and one external disposal area (heap) within the three active excavation sites of the PAK Konin Lignite Mine company which are subject to analysis in this study. One internal dumping site of non-operating mine is additionally included in the study (Table 1).

The studied sites are characterized by different methods of dumping overburden materials during the starting phases of excavating lignite deposits. The following methods were used to stack overburden from the initial excavation pits:

- dumping on the external heap - used in Tomisławice mine;
- dumping in the foreground of the mining front at the Drzewce mine; after the end of construction of the

initial excavation pit, the foreground heap was reworked and its entire volume was located within the internal disposal area;

- dumping the overburden in a final excavation pit of another mine- used in the operation of Józwin IIB mine from where the overburden was initially dumped into the neighbouring Józwin IIA excavation pit and earlier applied in the operation of Józwin IIA mine from where the overburden was dumped into Józwin I pit.

When using those different methods of dumping, different sizes of final excavation pits are obtained, which in a final phase of mine closure are usually reclaimed as water reservoirs. In case of construction of a temporary dump in the foreground of the mining front, a smaller volume of the final excavation pit (and eventually water reservoir) is obtained. If an external dump is constructed, its volume cannot be used to reduce the size of the final excavation pit [4].

At the moment the overburden materials from all three excavation pits are accumulated within their own internal dumps, constantly reducing the size of the pits. The surfaces and shapes of internal dumps are subject to constant changes as coal excavation progresses and their parts that are already inactive are systematically reclaimed according to the accepted directions of reclamation.

The overburden material from Józwin IIB mine was initially dumped in the excavation pit of Józwin IIA mine which was a continuation of Józwin I mine to the north. In fact, both mines Józwin I and IIA formed one mining area. Production of coal from Józwin IIA mine ended in 2003 and the post-mining area was reclaimed as agricultural and recreational areas. A recreation park with a water reservoir called "Malta", beach and infrastructure for sports was created within the Józwin IIA open pit area, east of the town of Kleczew. In the northern part of the former internal dump PAK KWB Konin still owns some land and they wish to use it economically. Within the internal dump of the „Józwin I” open pit, which is generally reclaimed as agricultural land, there is a municipal waste landfill and waste treatment installation - located in the village of Genowefa, it covers an area of 12 ha. There is also a private fish farm in a place of former technical water reservoirs used by the mine. In 2015, Józwin Wind Park was established (9 wind turbines: 8 x 2.85 MW / 1 x 2.53 MW, a total capacity of 25.3 MW) in the area located south from the municipal waste landfill.

At the moment the excavation of lignite takes place in the south-eastern part of the Józwin IIB mining area and moves to the east. In the western part of the Józwin IIB mining area, where the excavation started, the internal dump is already reclaimed and the land no longer belongs to the PAK Konin Lignite Mine. The area near the village of Złotków was created as a recreational site of about 21 ha. The main element of this area is a hill, built at a request of a local municipality. The top of the hill and one of the slopes were planted with park and forest trees, and the other escarpments were planted with alfalfa. At the bottom of the hill there is a small pond, which is also part of the area intended for recreational purposes. The other parts of the internal dump in this area of the Józwin IIB mine are reclaimed as agricultural lands.

The Drzewce Mine opened in 2005 at Bilczew Field. First, the overburden was stored within a temporary dump in the

foreground of the mining front. Then, it was removed to the disposal area within the excavation pit. Therefore, there is no external overburden dumping site. Almost from the beginning of the open pit's operations, reclamation works were carried out – trees such as pine, birch and black locust were planted. The forest reclamation was chosen due to the occurrence of mainly sandy deposits in the overburden. The western area of the Bilczew Field is reclaimed as forest. At a request of the local municipality of Kramsk, land reclamation was partly changed from forest planting to creation of water reservoir. The water reservoir is located in the eastern part of the Bilczew Field and has an area of 42 ha. Its filling with water took several years. The final reclamation activities at the Bilczew Field are scheduled to be completed in 2021.

The Field A of the Drzewce mine was prepared for mining before closing the Bilczew Field. As a result for a few months in 2010 coal was simultaneously excavated from both fields and afterwards only from the Field A. In 2015 the excavation at the Drzewce mine fluently moved from Drzewce Field A to the Field B. The forest reclamation of the Field A is in progress. In 2019 tree planting works were carried out in a part of the Field A, which is located near Smólniki Racięckie village, in the municipality of Osiek Mały, in the Koło County. Preparation of the area for planting, i.e. technical reclamation (moving earth masses and forming a top and slopes of the dumping site, and then preparing the soil surface) was carried out in 2018. In the preceding years works related to biological reclamation of the Field A were carried out more to the west - in the area of Rysiny village, in the municipality of Kramsk, in the Konin county (The Field A is located at a border of two counties.).

The main tree species that have been planted on the dump are Scots pine, European larch and silver birch. The light soil species were selected because the dumped overburden material was mainly sands and these species are characterized by the largest growth rates in such conditions. The biological reclamation towards forests in the Field A will be completed by 2023-2024.

The south-eastern part of the Field B remains the only area of the Drzewce Mine where some coal is still excavated. The excavation moved there in 2019 from the northern part of the field and it represents a final stage of the Drzewce mine exploitation.

In 2019, reclamation works started at the external dumping site of the Tomisławice open pit. They were associated with the technical reclamation – profiling slopes and the top part of the disposal area. The creation of the dumping site was initiated in 2010 and completed in 2014. The entire Tomisławice external overburden dumping site has an area of about 120 ha and is a hill raised above the surroundings by about 30 m - earthworks in such an area are not easy, because a proper formation of slopes and a top requires huge earth masses to be moved around in order to reconfigure topography and stabilize slopes. Earthworks are also difficult due to the fact that a heap is a mixture of materials of different properties and their behaviour depends much on weather conditions. Forestation has been adopted for the mine as a reclamation method, so eventually the dump will be planted with forest-forming trees. The first tree plantings took place in early spring 2021 - the selected tree species were silver birch, black locust and European oak. In the future, when the hills forming the external heap are covered with forest, they will look picturesque and certainly stand out from the surrounding areas [5]. The completion of reclamation

activities towards forest formation at the Tomisławice external dumping site is planned for 2026 [6].

Selecting possible sites for renewable energy investments

Selection criteria

During selection of possible sites for renewable energy investments several issues were taken into account:

- **ownership of the land** - only the areas within the above mentioned overburden disposal sites which are still in possession of the PAK Konin Lignite Mine were subject to selection; the areas handed over to successive owners already have new functions;
- **current state of post mining operations** (where and what is currently happening within the overburden dumping sites) - only areas where technical reclamation has already taken place or is about to be finalized seem to be suitable with respect to safety and geotechnical stability, therefore, the areas where surface of the dumped overburden materials is stabilized, levelled and it reaches more or less the original level from before the coal excavation began, were taken into account;
- **time** that has passed since the end of the overburden dumping and the start of reclamation - generally, the more time has passed, the better and more stable geotechnical conditions should be attained and the area is more suitable for any type of constructions;
- **major direction of reclamation:**
 - areas where the technical reclamation was most recently completed and agricultural reclamation started were taken into account;
 - generally, the areas with forest planting as the reclamation method should be excluded, because they will be, after all, unavailable for renewable energy investments; possibly, the areas within the dumps where forest reclamation is or will be carried out, but tree planting has not started yet (e.g. Drzewce Field B) can be still recognized as interesting with respect to renewable energy investments - it may be possible to prove that it is worth constructing renewable energy installations instead of planting trees and change the direction of reclamation;
 - areas already reclaimed as recreational sites as well as mine water reservoirs and ponds were obviously excluded from the selection;
 - areas where water reservoirs are planned to be created after ceasing coal excavation in the final pit has to be excluded as well.

Possible sites for renewable energy generation

Two large areas within the Konin lignite mining region have been selected as possible sites for renewable energy generation and are shown in Figure 1. These are:

- an area of ca. 420 ha within the internal overburden disposal area of the Józwin IIB open pit,
 - an area of almost 300 ha within the internal overburden disposal area of the Józwin IIA open pit.
- Both are situated within the municipality of Kleczew in the Konin County.

Tab. 1. Overview of active and inactive overburden dumping sites of currently operating lignite excavation pits of the PAK Konin Lignite Mine company
Tab. 1. Zestawienie aktywnych i nieaktywnych aktualnie eksploatowanych wyrobisk węgla brunatnego w PAK Konin

Name	Józwin I/IIA mines*	Józwin IIB mine	Drzewce mine - Bilczew Field *	Drzewce mine - Field A *	Drzewce mine - Field B	Tomistawice mine
Type of the dumping site	Internal dump	Internal dump	Internal dump	Internal dump	Internal dump	Internal dump
Municipality	Kleczew	Kleczew, Wilczyn	Kramsk	Kramsk, Osiek Mały	Kramsk, Osiek Mały	Wierzbiniek
Remarks	Józwin I and Józwin IIA mines form one mining area. Józwin I mine started operation in 1971. Coal excavation fluently moved to from Józwin I to the Józwin II A mine and lasted until 2003.	Preparation of the pit began in 1999 (overburden was transported to the internal dump of the neighbouring mine Józwin II A). Excavation of lignite started in 2002. The end of coal excavation is planned for 2021.	Removing the overburden to the temporary dump in the foreground of the mining front started in 2005. Coal excavation in 2006-2010.	Field A was prepared for mining before closure of the Bilczew Field. Coal excavation took place in 2010-2015 and then it fluently moved to the Field B.	Coal mining continued from the Field A to B in 2015. The end of excavation is planned for 2022.	Excavation of lignite started in 2011. The end of excavation is planned for 2030
Area of the dumping site [ha]	1697	973	285	305	340	196
Current economic use	Agricultural use, recreation park, landfill and waste processing plant, fish farm, wind power plant	coal mining, in the already reclaimed part: agricultural use, recreation area	none	none	coal mining	coal mining
Current state of reclamation	Reclaimed	Dumping site still during construction; partly reclaimed	To be completely reclaimed in 2021	During reclamation	Dumping site during construction	Dumping site during construction
Type of reclamation/ planned reclamation	Agricultural land, recreation, water reservoir, forest (minor part)	Agricultural land, forest, water reservoir, recreation	forest, water reservoir	forest	forest, water reservoir	Agricultural land, forest, water reservoir, recreation
Water reservoir in the final excavation pit	yes	planned	yes	no	planned	planned
Water reservoir area [ha]	10	840	42	n/a	170	290
					n/a	n/a
					n/a	n/a

* non-operating mine or field

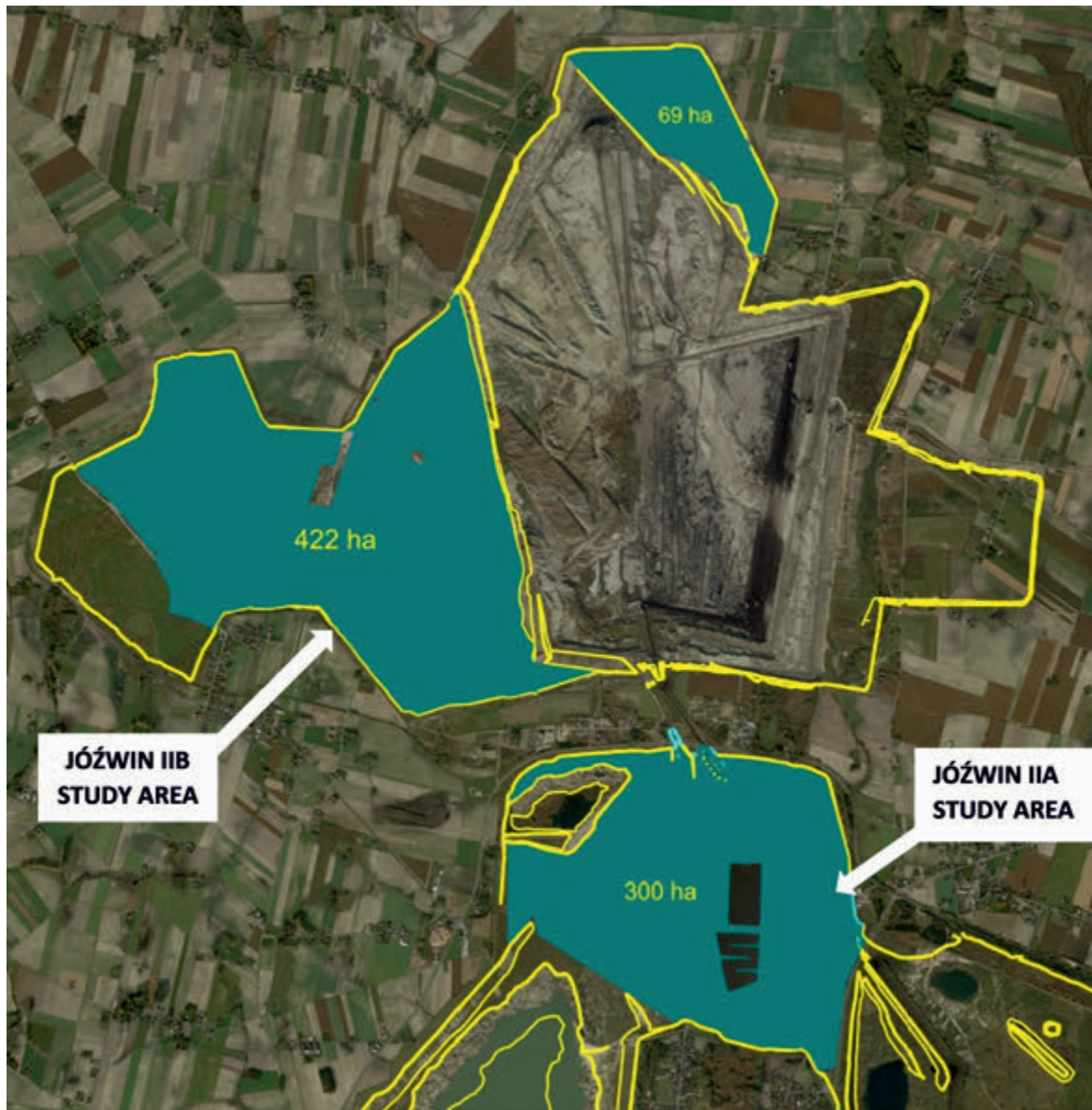


Fig. 1. Location and size of the areas within the former Józwin open pits, where the overburden was disposed, selected as possible sites for renewable energy generation (dark green polygons).

Rys. 1. Położenie i wielkość obszarów w obrębie dawnych odkrywek Józwin, na których składowano nadkład, wytypowanych jako możliwe miejsca wytwarzania energii odnawialnej (ciemnozielone obszary).

The Józwin II A post-mining area has been already reclaimed as agricultural land and recreational sites. Its northern part which is still owned by the PAK Konin Lignite Mine has been selected as a site potentially available for renewable energy development (marked as dark green polygon in Figure 1). The area should be geotechnically stable because coal mining ceased already in 2003 and since then it has gone through the required stages of reclamation.

The area selected within the Józwin IIB Mine internal dumping site is owned by the PAK Konin Lignite Mine in contrast to the westernmost part of the dump which is the oldest part at the same time but has to be excluded from further investigations due to the “ownership criterion” (see the previous subchapter). The area (marked as dark green polygon in Figure 1) has been selected where the level of the dumped material surface reaches the original ground level (“zero” level). The remaining part of the dump and the final excavation pit located east from the selected study area lie at depths below the ground level and will form slopes and bottom of a water reservoir which is planned

to be created after ceasing coal excavation in the pit.

Those parts of the dumps of Drzewce and Tomisławice mines where dumping is no longer carried out (i.e. Drzewce Field A internal dump or Tomisławice mine’s external dump) have been excluded from renewable energy development since their planned reclamation method is forest formation. What is more, the first plantings of forest-forming trees have already taken place. The remaining dumps, i.e. Drzewce Field B and Tomisławice internal dumps remain active dumping sites. Of course, some technical reclamation is being carried out simultaneously with the coal excavation, but actual development of these areas in a direction other than mining operations will be possible only in a few years. It has to be remembered that large areas of Drzewce Field B and Tomisławice mines will be filled with water and create post-mining water reservoirs.

The selection of study areas within the Józwin IIA and IIB internal dumps was discussed with the PAK Konin Lignite Mine company and is in agreement with the Mine’s intentions to use these areas for renewable energy generation if possible.

Preliminary site analysis and discussion

The sites potentially available for renewable energy development have been selected in the presented study based on the different practical criteria. In order to implement any renewable energy project within these sites further site investigations are required. They should determine legal possibilities related to technical, environmental, social, local spatial planning and administrative factors [7-9] in order to identify any constraints. They should also include broad field and laboratory testing in order to examine site's geotechnical conditions and prepare a construction design for a power plant. It is essential to specify risks accompanying both implementation of investment and future operation of renewable energy plant situated within the former overburden disposal area since it is not a typical site for any construction.

Among legal conditions for the construction of renewable energy plants, the most restrictive limitation concerns wind farms. It is specified by the Act of on wind farm investments which came into force in 2016 [10]. The act defines the minimum allowed distance between a wind power plant and a residential building (or a mixed-function building, which includes a residential function) and/or protected area of natural value (such as national park, nature reserve, landscape park and Natura 2000 site) or promotional forest complex (there is 25 such complexes around Poland) as at least ten times greater than the wind power plant height measured from the ground level to the highest point of the plant, therefore including a rotor with blades. In practice, this distance has to be about 1.5 - 2 km from residential buildings/nature protection areas or even more and local authorities are obliged to take this limitation into account when preparing, changing and adopting municipal studies of the conditions and directions of spatial development and local land use plans.

There are several villages that are located in the immediate vicinity of the sites selected in the presented study which exclude a construction of tall wind power plants with the ability to operate at profitable capacities. Consequently, the study of conditions and directions of spatial development in the Municipality and Town of Kleczew [11] indicates locations for wind power plants with capacities exceeding 100 kW which include only the existing and planned wind farms with their protection zones as specified in the administrative decisions and states that no new sites for locating wind farms are planned in the municipality. Therefore, no large wind power plants can be located in both selected areas and photovoltaic power plants are the only option for their development towards large-scale renewable power generation. This conclusion has been confirmed by the draft study of conditions and directions of spatial development in the Municipality and Town of Kleczew which aims at changing the study from 2019 [12]. The draft was presented in May 2021 and indicates both sites proposed in the article as areas potentially available for location of photovoltaic power plants with capacities exceeding 100 kW.

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