# goldbecksolar

# Zwartowo Solar power plant

Opening Ceremony September, 2022

#### ANARADONO ANARAN

# **PROJECT!**

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The project originally named Zwartowo because of its location near the village with the same name, is currently the largest solar power project built in Central and Eastern Europe. It has an installed capacity of 204 MWp (145 MWAC) realized in its first phase of construction, making it today the biggest project in this area. In 2023 a second phase is planned, brin ging Zwartowo to a total capacity of 290 MWp and in a later stage to more than 350 MWp.

The solar power plant is built on the extensive area of 300 hectares, in a terrain where at least three uses can harmoniously coexist. The first is the space for archaeological remains, some of which were extracted before construction began. The second is the rich biodiversity in the intact nature reserve that is also located on the site and that will be reinforced with an additional biodiversity project. Finally, the suitable terrain for the construction of the large solar plant.

Zwartowo is much more than a solar project, it is a symbol of energy independence at a decisive moment for Europe. A photovoltaic, Ecovoltaic and Archaeovoltaic project, which demanded and received one of the most flexible planning and construction process, we have ever had in the history of GOLDBECK SOLAR so far.

The investors were determined to act and make a major contribution to the environ-

ment and to the energy independence in Europe with a mega-project, regardless of the challenges they faced. The team developed enormous flexibility skills to plan and adapt to the unexpected variable conditions and to cope with all the constant challenges. At the time they were also in the process of setting up a new subsidiary in Poland-GOLDBECK SOLAR Poska Sp. Z o.o.

The impressive size, the conditions of the area, the time of construction that coincides with the pandemic, disruption of supply chains, rising energy prices, inflation, and an unexpected war in Ukraine, marked the construction process with many particularities that we describe in the following pages.

For the GOLDBECK SOLAR team. Zwartowo is a great source of satisfaction in multiple ways. The largest project the company has ever undertaken. Scaling up the construction of solar power plants in Europe and worldwide is a priority for the company and Zwartowo is the proof of its determination.

# GENERAL INFORMATION



#### Zwartowo

**Region:** Pomerania **District:** Gmina Choczewo **Area:** 300 ha

The Project Zwartowo is located near the village of the same name in the administrative district of Gmina Choczewo, in Wejherowo County, Pomeranian Voivodeship, in northern Poland.

#### **Technical Information**

#### Solar Panels

Manufacturer	Suntech
Model	Ultra V STP550S C72 Pmh+
Module Power	535 Watt and 540 Watt
Technical Feature	glass/glass solar panels
No. of panels	378.027 pcs.

#### Substructure

Manufacturer	Mounting systems Meiser Axial
Technical Feature	one. double and triple pole structure

#### String Combiner Boxes

Manufacturer	Gantner / Amount: 529 units
No. of Strings	14.001

#### Cable

Solar Cable (1,500V)	1,150,000 m
Main DC Cable (1,500V)	250.110 m
Medium Voltage Cable (30kV)	7.290 m
HV cables (110kV)	34.000 m
Data Cable	50.530 m
Optical Fibre	11.000 m

#### Inverters

Manufacturer	SMA
Model	of MVPS SMA Sunny Central 4600/4400 UP 30 kV
No. of Inverters	32 units

#### **High Voltage Substation**

Manufacturer	ZREW Transformatory S.A.
Power	2 x 83 MVA voltage ratio 110/30 kV

#### **Installed Capacity**

Total DC Capacity	290 MWp (205 MWAC)
First phase	204 MWp (145 MWAC)
Second phase	86 MWp (60 MWAC)

#### Production of clean energy

The specific yield is approx. 1,015 kWh/kW thus rendering an annual production of more than 290,000 MWh from Phase 1 and Phase 2. Yield and production data are based on a yield report by independent technical advisor.

The Project has been granted a 15-year CfD under the state auction system and additionally secured a private PPA with a tenor of 5 years.

#### **Environmental impact**

Positive impact on the environment will be tremendous by providing green energy for over 153,000 households and reducing CO2 emissions by about 5 million tonnes over the project lifetime considering the 290 MWp alone.

#### **Financial Information**

#### Ownership

The Project is held in a Polish governed special purpose vehicle named. Stigma Sp. z o.o.("SPV") being the owner of the Project.

The SPV itself is owned by Green Energy Service Sp. z. o. o., a joint venture of Joachim Goldbeck Holding based in Hirschberg, Germany with a majority shareholding of 80% and Respect Energy based in Warsaw, Poland with a 20% shareholding.

#### **Project finance**

Due to the capital required for the construction of this large utility scale project it was necessary to establish a consortium of three strong banks. Thus, the financing of PLN 635 million (EUR 136 million) was achieved by closing the financing with the support of the EBRD (European Bank for Recons

truction and Development) as multilateral lender and the two largest Polish banks, PKO BP and Bank Pekao.

The project was built by GOLDBECK SOLAR. which acts as EPC (engineering procurement and construction) company and who will also be responsible for the operation and maintenance during the operational life of the power plant. During construction, the best components available on the market were used. which have been operationally tested by the solar specialist to guarantee maximum production of clean energy.

# PROJECT PARTICULARITIES

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#### 1. The land

The size and variety of the land offer unique characteristics to this project. Archaeological remains have been found on the site, as well as a rich biodiversity of species, which find safe refuge in the area. The land also contains a natural pond of approximately 15m2 and a small forest. In some areas, the terrain also contains different layers of stone of various sizes – souvenirs from the last glacial period at different depths, which presented a challenge to achieve the tamping of the structure.

#### 2. Archaeological findings

There is a large archaeological area in the south of the site, covering almost half of the area. Finds from this site include a tomb, an ancient mill a distillery and several small artifacts were also found. The archaeological excavation process represented a great challenge for the construction team who supported the archaeologists during the process. They helped to remove soil continuously in 37 cm layers within and area of 17 hectares. Local subcontractors actively collaborated in the excavation process with the aim of preserving the cultural heritage found.



#### 3. Waste deposit

Part of the Zwartowo project area was previously used as an illegal dump. The construction team carried out major clean-up work to be able to start the construction.

#### 4. Fence and roads

The site has a 13 km long protective fence, which was necessary to ensure the safety of the plant and visitors. In addition, the construction of internal roads with a length of 11 km allowed the construction process to run smoothly and safely.

#### 5. Transformer station/ High voltage line

The size and complexity of the substation is also a special aspect to pay attention to in this case. The power plant is connected to the high-voltage grid. But it is not only the size of the substation, but also the modern technology used.

It was necessary to construct a 32 km long (110 kV) underground high voltage line from the MV/ HV substation on the site to the national grid substation in Zarnowiec operated by PSE (Polskie Sieci Elektroenergetyczne). The connection required a pipeline route, with cables of dimension D 100. The cable design has been custom fit to include precise temperature control over the full length, enabling a precise localization of a fault in case of damage. The project used about 96 km (32x3) of three-phase cable for its construction. The cables were delivered to site on cable drums of 1 km, each weighing 27 t.

In addition, the splicing process was very interesting due to the dimensions of the cables used to transmit this amount of power to the grid. The cable was laid at a depth of 1.5 meters and, in some regions, up to 1.8 meters to avoid any impact on the surface for the farmers in the area.

In two sections, small tunnels for each cable had to be dug in either case running for 1 km using flush bore technology. In one case, a forest was not to be harmed, thus the cable now runs well below the unharmed roots. Every kilometer, a cable has to be connected to the next section. Due to the high transmitted power, the so-called splicing had to be performed precisely and carefully.







#### 6. The weather

Especially the rainy season represented a major challenge in the construction process. People and materials waiting to be installed were sinking into the ground due to the intensity of the rain.

#### 7. Delivery difficulties

As a result of the pandemic and the outbreak of war in Ukraine, the disruption of delivery chains created major challenges for planning and execution. Delivery schedules could no longer be planned reliably. Both management and all subcontractors were forced to develop enormous flexibility to keep the process flowing.

#### 8. Modules

A special configuration of glass modules was ordered specifically for this project. which created some logistical and manufacturing challenges: as the module factories had to dedicate special resources to make the batches of modules to be supplied for this project. The delivery process was also at times very impressive, with some receiving up to 30 large trucks delivering modules simultaneously.

#### 9. Building a team

It is worth mentioning that parallel to the large construction project in Zwartowo, a dynamic process of selection and recruitment of the team that makes up the new GOLDBECK SOLAR Polska was also carried out. The team currently consists of 24 people motivated employees.





#### **10. Financial particularities**

→ Largest single asset solar PV project financing deal in Poland split into 2 phases (204 and 86 MWp).

→ High market responsiveness of 91 % based on lenders approached. There was a strong lender interest (20 non-binding offers received which translated into 10 binding offers). Finally 3 full underwriters out of 20 non-binding offers. given a large ticket size (EUR 136 Mio) and mandated lead arrangers 4 out of 20 non-binding offers.

- Transaction successfully realised despite increased complexity due to challenging macroeconomic conditions (i.e., war in Ukraine and interest rate spikes) and due to COVID restrictions the negotiation and execution was transfer to an online format.
- Project financed by a consortium of 3 banks (EBRD as multilateral. PKO BP and Bank Pekao as two of the largest commercial banks in Poland) due to debt quantum and maximum hold limitation per bank. Bank roles:
  - → EBRD as consortium leader
  - EBRD, PKO BP and Bank Pekao as term loan, DSRF and hedging providers.
  - → PKO BP and Bank Pekao as VAT providers
  - Bank Pekao as agent, security agent and account bank.
- First renewable project in Poland securing the lowest interest rate margin below/at 200 bps
- Loan tenor of +18 years enforced
- → CfD optimisation taken into consideration and resulted in increased debt quantum.



Foto of documentation delivered to the 3 banks. A great achievement.



ARCHAEOLOGICAL

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Photo 8: Fragment of a modern steering wheel for preparing the ceramic mass. Photo: **by K. Piątkowska** 





Archaeological investigations were carried out in connection with the presence of archaeological sites in the area of the planned project, which are included in the conservation zone. They took place from June to mid-November 2021 on behalf of GOLDBECK SOLAR and were carried out by Compass Witold Ochocinski. In total, an impressive area of over 17 hectares was excavated on 11 sites, and 933 archaeological artefacts of various types were recorded, with a huge collection of movable artefacts, mainly ceramics, but also metal objects.

Photo 6: Modern Brickworks. Photo: by K. Piątkowska

#### Lusatian and Pomerian cultures, lavic settlement, rubish dump

Thanks to the possibility of surveying such a large area, it was possible to record entire settlement complexes. associated with prehistoric cultures, including the Lusatian and Pomeranian cultures and the Wielbark culture. In addition, the edge of an early medieval settlement site was discovered, which can probably be linked to the earliest Slavic settlement in Zwartowo, dated at least to the 11th-12th century. The high density of objects, mainly hearths but also cookers of stone and clay construction, containing large quantities of medieval pottery suggests that this was the edge of a habitation zone, used for economic purposes, but also as a rubbish dump of an early medieval Slavic village functioning not far to the east.

#### Slavic remains

The Slavs at that time were on the verge of building their own statehood: There was already a Bohemian state, a Piast state and Kievan Rus. In Vorpommern and Polabia, the Slavic element clashed with German expansion, and Eastern Pomerania was in the orbit of the Piast influence from Gniezno. It was also a period of early feudalism and the development of Christianity. slowly supplanting the resisting Slavic traditions. Unfortunately. most of this settlement is outside the scope of the project, so it was not possible to identify the entire Slavic settlement.

Particularly interesting results were obtained in the north-eastern part of the southern part of the future farm. where a huge field of hearths and bonfires was found, as well as furnaces and a dugout, indicating very intensive use of the area in prehistory. It is worth noting that the 'hearth field' has a clear spatial organisation. The pelanches and hearths are arranged in concentric clusters, often also in arrangements of straight lines. These clusters surround relatively empty squares. devoid of other immovable objects. This may indicate that the hearths were surrounded by objects or structures that were not sunken into the ground and therefore did not leave traces in the ground – such as timber-framed houses. However, there may have been some kind of ritual or tribal rally here. where concentric clusters of bonfires separated an empty square where members of the local communities could

congregate, from the outside space. Although the hearths themselves do not appear to be unusual, they become interesting when viewed as a whole, especially considering that they are located on a prominent hill.

In addition to the hearths in this zone, the presence of cookers and other objects was also observed at the boundary between the green area and the unexplored area. This may indicate that the unexplored part of the site hides the remains of houses and farm equipment under the arable soil layer.

In the north-western zone of the research area, in the southern field of the farm, another interesting find was located - a complex consisting of a field brickworks full of burnt and abandoned bricks, an adjacent cellar where fuel was most probably stored and successive batches of bricks were dried for firing, and a nearby wheel, on which ceramic mass for the production of raw bricks was probably prepared. There was also a pillar structure nearby, traced by 10 post holes – this may have been a shed associated with the brickworks. Although there was no movable material recorded throughout this complex to date the finds, it is possible to date the complex to the mid-19th century on the basis of other sources. It was then, in 1853, that the then owner of the landed estate in Zwartow, Baron von Hammerstein carried out work to extend the palace complex. This assumption can be further confirmed by the fact that, despite the German meticulousness in mapping, an establishment such as the brickworks is not visible on the map of 1806, nor is it on the maps of the early 20th century. when probably no trace of it remained on the surface.

#### Metallurgy and smithy

In the south of the area of the future farm, where surveys were also carried out, other interesting finds were encountered. Although few finds have come from this area, they are among the more interesting ones. Among other things, they include the remains of the so-called "pit furnaces", primitive smelting furnaces used to smelt iron from turf ores. These small ground-level cavities were filled with incineration, lumps of slag and pig iron, proving that the local population, most likely from the Wielbark and Pomeranian periods, practised primitive metallurgy and smithy on site.

In addition, two small box graves – also associated with the Pomeranian culture – were found in this area. Unfortunately, due to the fact that the humus in this area was very shallow, many years of agricultural work had destroyed both graves, so that only the bottom part was preserved, and the burnt human remains inside the urns, as well as the urns themselves, were broken up and mangled. Despite this, a bronze pin, a product used to fasten robes, cloaks and fetters used by the people of the time, survived in one of the graves.

Excavations at the photovoltaic farm in Zwartowo have revealed traces of human settlement from the Late Bronze Age, through the Early Iron Age, the period of Roman influence (i.e. the Late Iron Age) to the early Middle Ages. and the 19th century. The earliest archaeological culture recorded is the Lusatian culture. It existed and developed in the lands of present-day Poland and neighbouring countries (Germany, the Czech Republic, Slovakia, western Ukraine and Belarus) from 1700 to about 400 BC. During



Photo 7: Modern Brickworks, plan. Photo: K. Frątczak



Photo 1: Fragment of an early Slavic vessel. Photo: **K. Frątczak** 



Photo 2: Early medieval iron knife, before and after conservation. Photo: M. Nowak



Photo 3: Profile of a Lusatian culture furnace. Photo: K. Frątczak



Photo 9: Profile of a kettle furnace. Photo: **K. Frątczak** 



Photo 4: Plan of a Lusatian culture furnace. Photo: K. Frątczak



Photo 5: Profile of a Lusatian culture furnace. Photo: **K. Frątczak** 



Photo 10: Plan of a destroyed box grave. Photo: K. Frątczak



Photo 11: A pin found in a box grave, before and after conservation. Photo: M. Nowak



Photo 12: Profile of a hearth from the Roman influence period. Photo: M. Nowak

this time, archaeology attests to intensive civilisational development, the growth of a settled economy and a dense settlement pattern. Bronze is the predominant raw material for making tools, and iron tools appear towards the end of this culture's decoction period. The people led a sedentary lifestyle and lived in small rural settlements, cultivating the land and raising animals.

At the end of the Lusatian culture, the Kimmer and Scythians invaded central Europe from the Black Sea steppes. These invasions brought about significant changes in the life of the Lusatian people, best demonstrated by the formation of fortified settlements and the concentration of settlements in their vicinity. The most famous example is Biskupin, however, larger and smaller fortified settlements were located on islands, hilltops and marshes throughout the functioning area of the Lusatian culture – proof of how far the nomads penetrated into Europe from the staples. Unfortunately for the Lusatian people, these invasions and climatic changes ultimately led to a civilisational decline and destabilisation of the settlement of the Lusatian people. Settlement networks thinned out and depopulation occurred – whether this was due to emigration or the extinction of part of the community is still uncertain today.

However, on its "ruins" new cultural formations arose, including the Pomeranian culture. It developed from the 7th to the 3rd century BC and covered almost the entire territory of present-day Poland. It originated from the local Pomeranian group of the Lusatian culture and in the following centuries of its existence covered almost the whole area of modern Poland. Typical of the people of this culture were the box graves found in the excavation area, also known as stone-encased graves. Other typical creations were also urns with a human face motif, the so-called face urns. This was already an early Iron Age culture and bronze as the basic raw material for making tools was beginning to lose its importance. Like its predecessors, the population lived in small village-like communities, cultivating and farming. In the 3rd century BC, the culture began to undergo changes related to the influx of Celtic cultures from Western Europe, the so-called Latenisation. Eventually, it was transformed into the Przeworsk culture (identified with the Vandal people) and the Oxywska and then Wielbark culture (identified with the Goths).

The Wielbark culture, on the other hand, is a Mature Iron Age culture. Its development can be linked to the earlier Oxvillian culture, the result of the blending of local patterns with Celtic influences. Characteristic features of this culture are the burial cemeteries, where the dead were buried in urns or directly in the ground. Large quantities of arms and weapons and other iron tools are found in the cemeteries. The way of life of this population did not differ greatly from that of the Pomeranians, but it seems that they were a warlike people for whom weapons were extremely important. At some point, however, there was a significant transition from the Oxvillian to the Wielbark culture. This transformation was probably connected with the arrival of the Scandinavian Goths and Gepids to Gdansk Pomerania and coincided with the expansion of the Roman Empire. whose borders reached in the 1st century BC. In the 1st century AD the borders of the Roman Empire reached the Rhine and the Danube, eliminating the cultural dominance of the Celts in this part of Europe.

Developing in Pomerania from the 1st to the 3rd century AD, the Wielbark culture had a Germanic character. Characteristic features of this culture were the unique burial rites, based on birritualism – some people were burnt at the stake as before, while others were buried directly in the ground. It is also noteworthy that the custom of placing weapons and iron objects in the grave had disappeared, and almost all grave gifts and parts of the ditto made of metal were bronze. In the course of the 1st-2nd century AD we observe that a power elite develops among the Goths – rich, so-called "princely" burials appear, containing significant amounts of metal objects, jewellery, also objects imported from the Roman Empire, often placed in/under barrows. The Goths were probably a warlike people. but they also made their civilising fortune by controlling the amber trade with Rome.

Certain groups of Goths were already making expeditions to the Danube lands to take part in Rome's wars against the barbarians of the time, and returning with booty and tales of the great land to the south. During this time, the culture spread from Pomerania to northern Greater Poland. Moreover, cemeteries with stone cemeteries are established all over Pomerania, the best known of which are Odry, **Węsiory** in Kashubia, Grzybnica near Koszalin, and the recently discovered **Pławno** near Czarplink in the West Pomeranian Voivodeship.

These sites were most likely sacred, being cemeteries and places of worship, perhaps meetings and tribal rallies. In the following centuries, the Goths left Wielkopolska and Western Pomerania and began to colonise areas to the south-east. Mazovia, the Lublin region, and further settled western Ukraine and the Crimea, eventually moving in the 4th-6th centuries to the Balkans, Italy and Spain, where they built their own states on the ruins of the collapsed Roman Empire. They were later conquered by, among others, the Arabs in Spain and the Byzantines and Longobards in Italy. They survived longest as a separate and independent people in the Crimea, where their independence was only ended by the Mongol invasions.

In a nutshell, although the results of the research at Zwartowo may not seem particularly impressive, they are very valuable for the development of the state of research in Polish archaeology. First and foremost, it was possible to uncover entire settlement complexes dating from different periods and to obtain a wide cross-section of historic material, especially pottery, which is the primary source for analysis. The large research area made it possible to survey a very extensive complex of sites of broad chronology. Thanks to the large amount of research material, especially from sites 1, 30, 31 and 34, it will be possible to carry out detailed chronological-cultural analyses. The very extensive study area, which included 4 large sites, a number of smaller sites and the spaces between them, will also allow a detailed spatial analysis of these. Multi-hectare developments such as the construction of a photovoltaic farm in Zwartowo enable research to be conducted on areas which are virtually unparalleled in the country, and potentially allow entire settlements or settlement clusters to be analysed. This, in turn, makes it possible to carry out comprehensive analyses of entire assemblages from a single, broad context.

This leads to the conclusion that this type of multi-hectare archaeological excavations on this type of investments should become a standard procedure and the method of not pre-limiting the range of excavations, but expanding the area in accordance with the directions of expansion of the sites, gives optimal results. It allows for the excavations to cover the real existing sites without artificially generating costs of filling in the "empty acres" in the pre-limited areas for research.



Photo 13: Profile of a well from the Roman influence period. Photo: K. Frątczak



Photo 14: Fragment of an early medieval pot. Photo: M. Nowak



This fantastically pristine area contains a great variety of animals and wildlife, which find here their natural and safe habitat, especially several species of open land. Among them we can mention mammals (e.g. deer, hares, wild boars), as well as a great variety of birds that were directed to the northern protected area, where they can enjoy almost untouched conditions. Reptiles and amphibians will be expected in the near future: for both groups habitats are planned.

The biodiversity will be supported and promoted by a joint project which is already underway with a neighbouring company of biologists with whom GOLDBECK SOLAR is planning a new concept for the biological revaluation of solar power plants. They are responsible for developing the necessary measures to protect the species found in the area and to create ideal conditions for their reproduction. In this way, photovoltaic technology can coexist in a balanced way and support the balance of the ecosystems.

To mention just a few examples of these activities. During the first official visit of the biologists. 24 different bird species were observed, of which 12 of them are on the German endangered species list (red list). Of course, the raven, marsh harrier and red kite are also worth mentioning and would be an absolute highlight in Germany. if they could be seen on a PV open space plant.

As far as reptiles are concerned, there are also good conditions for promoting this group of species. During the inspection it was noted that although there are small natural lake conditions, there are no amphibians. Through analysis it was determined that there is a lack of adequate water for spawning, especially for open space species such as garlic toad, green toad, natterjack toad or fire-bellied toad. Therefore, activities to encourage the development of these species will be included by offering seasonal breeding ponds.

Very interesting was also the presence of wild bees and other hymenopterans such as the European beewolf. which provide enormous stability to the ecosystems. Also for the species group a lot could be done on the site.

The following is a list of birds species (partly endangered farmland birds) that could be observed during the first analyses of the region.



### Linnet

Carduelis cannabina II Frequency BVerd Status in the area NG Open land Habitat preference

## 3 Yellowhamme

Emberiza citrinella II Frequency BV Status in the area Open land Habitat preference

# 5 Red-backed Shrike

Lanius collurio I Frequency BVerd Status in the area NG Open land Habitat preference

# 7 Yellow Wagtail

Motacilla flava III Frequency BV Status in the area Open land Habitat preference

# 9 Quail

Coturnix coturnix II Frequency BV Status in the area Open land Habitat preference

## 2 Skylark

Alauda arvensis III Frequency BV Status in the area Open land Habitat preference

# 4 Corn Bunting

Miliaria calandra III Frequency BV Status in the area Open land Habitat preference

## 6 Grey Partridge

Perdix perdix I Frequency BV Status in the area Open land Habitat preference

# 8 Northern Wheatear

Oenanthe oenanthe I Frequency DZ Status in the area Open land Habitat preference

## 10 Meadow Pipit

Anthus pratensis I Frequency DZ Status in the area Open land Habitat preference

#### Frequency

I = single individual/ pair II = 2 - 10 individuals/ 2 - 5 pairs III = > 10 individuals/ > 5 pairs

**Status in the area** BV = breeding bird BVerd = suspected breeding DZ = migrant























# THE TEAM





We would like to thank the entire team that participated in the succesful construction of this wonderful project.

**Ramon Ares Stefan Assmus Daulet Baitumenov** Lars Beige **Michał Cielecki** Piotr Dziobkowski **Steffen Emmerich** Marta Fojcik Kamil Gajda **Marek Gielarowiec Jarosław Gorzela** Mateusz Misiura **Rainer Neumann** Michał Nowacki **Konstantin Peter Andriy Romanov Hussein Saab Ralf Steinheiser Maciej Struck Bartosz Wroński** 











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