Polish
Photovoltaics
Association

AgriPV in Poland.

Modern solar-powered agriculture.

www.stowarzyszeniepv.pl

The Polish Photovoltaic Association (PSF), established in 2019, is the largest industry organisation in Poland supporting the development of large-scale solar power. The association currently represents nearly 100 stakeholders. The main objectives of the association include raising political and public awareness of the PV sector and supporting the creation of an appropriate regulatory environment. PSF integrates the PV market in Poland by providing a platform to exchange knowledge and establish new contacts by organising seminars and conferences. It is the organiser of the Solar Power Congress (kongresPV.pl), Poland's largest event in the PV industry.

www.stowarzyszeniepv.pl

This publication was made possible thanks to our Content Partners who shared their knowledge and experience.

Main Partner

BayWa r.e.

Legal Partner

CLIFFORD CHANCE

Report Partners

ALSEVA · EC GROUP · Energy5 · Kelfield. Polskie Centrum Agrofotowoltaiki · kwietna FUNDACJA · tpa · UNITE

Date of publication:
May 2023

Graphic design:
Sylwia Nowakowska

Cover photo:
BayWa r.e. AG, Don Rodrigo, Spain, 175 MWp, sheep grazing between rows of PV panels

Contents

1. Introduction

Dear Readers,

We are pleased to present Poland's first publication on agrivoltaics (AgriPV). Agrivoltaics is the simultaneous use of land for agricultural production and electricity generation. It is much more than a new pathway for the solar sector; it is an innovative form of investment that is gaining popularity in Europe and around the world. In Poland, AgriPV projects are not yet known and little knowledge is available. The Polish PV Association has decided to promote the concept, and this publication aims to start a broad discussion; we hope its fruits will soon be seen in the Polish countryside.

Poland ranks third in Europe in terms of the share of agricultural land in the total area of the country. At the same time, this vast area is a potential for a number of tasks related to clean energy, energy transition, sustainable agriculture, food security, biodiversity or rural development; these areas are also the pillars of the European Green Deal.

We hope that this report contributes to a broad discussion resulting in a new regulatory environment providing a secure framework for new AgriPV projects.

We wish you an interesting read.

Ewa Magiera, President of the Board,
Polish Photovoltaics Association

Roman Karbowy, Chairman,
AgriPV working group at PSF

2. AgriPV – description, characteristics, various types of coexistence between PV and agriculture

Agrivoltaics or AgriPV is the combination of two activities in the same area of land: production of clean, green electricity through PV installations, and agricultural production on the same land. Installing PV modules above or next to crops or livestock production allows for more efficient, dual use of the same land. For the agricultural sector, it is an opportunity to increase its resilience to climate change and have better control of crop conditions, while generating electricity at the same time.

History

The idea of using land simultaneously for farming and energy production dates back to the 1980s. It was then that two German scientists: Adolf Goetzberger and Armin Zastrow became interested in the concept of dual use of land for plant cultivation. They both developed it at the Fraunhofer Institute (Fraunhofer Institute for Solar Energy Systems – Fraunhofer ISE), which they founded. The first implementations of AgriPV were developed at the Institute, based on Goetzberger's 1976 invention, the fluorescence collector.

However, the real boom of AgriPV did not occur until after 2004, with the development of PV technology. One of the contributions was the research of Japanese engineer Akira Nagashima, showing that it was possible to combine the energy production of PV panels with the cultivation of even such a shade-intolerant crop as maize. Nagashima's results were recognized in Japan, a country where every piece of land is extremely valuable. The use of agrivoltaic technologies received government support and gained some popularity among Japanese farmers. The interest in technologies allowing for dual use of land emerged rapidly in Europe, with prototype installations developed in Austria (2004), Italy (2009) and, since 2015, deployments have accelerated, with the APV-RESOLA project led by Fraunhofer ISE. Today (2022), more than 14 GWp of AgriPV systems have already been installed worldwide.

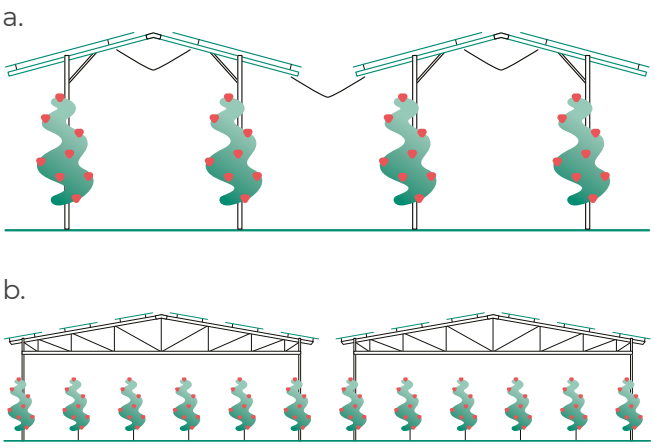
Source: RWA/Imre Antal, Pöchlarn, Austria, Agri-pV between crop rows, free passage of agricultural machinery between panel rows.

Ways for PV and agriculture to coexist

At present, there are **three types of AgriPV installation**, in use, allowing simultaneous farming and electricity generation. However, the popularity of the first two significantly exceeds the prevalence of the third.

- **AgriPV above crops.** PV modules are mounted on special structures above the cultivated plants. This helps protect them from adverse weather conditions such as excessive sunlight, heavy rain or wind. It is most often used in the cultivation of soft fruits such as raspberries, strawberries and blueberries, as well as in orchards (apple and pear trees).

  This type of installations can also be used in animal husbandry. The modules are then installed above pastures. Photovoltaic panels provide shade, for example, to protect the animals from sunlight.



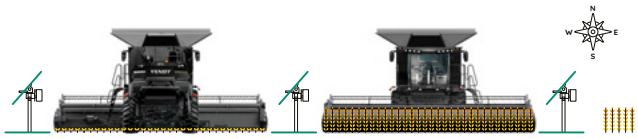
Source: BayWa r.e. AG, AgriPV above crops a) single row installation b) multi-row installation

Source: BayWa r.e. AG, AgriPV above crops a) single row installation b) multi-row installation

Agri-PV The future of farming

- **AgriPV between crop rows.** This type of installation is ground-mounted, similarly to traditional large-scale PV installations. The difference is that the panels take up approximately 15-30% of the surface area (depending on whether panels are fixed or installed on trackers[1]), and the remaining surface continues to fulfil its original function. PV between crop rows leaves space for large agricultural machinery to pass between panel rows and for agricultural production to continue, while allowing for generation of electricity. This type of installation protects the land from excessive erosion and improves biodiversity and microclimate of the crops by preserving wild meadow vegetation directly under the panels.

- **Greenhouse-integrated AgriPV.** This solution is based on covering greenhouses with PV modules. For the time being it is not very popular; scientists are working on the problem of the most favourable distribution of light absorbed for electricity generation and light reaching the plants.



Source: BayWa r.e. AG – AgriPV installation between crop rows allows agricultural machinery to pass through and agricultural production to continue unchanged

Source: RWA/Imre Antal. AgriPV between crop rows, Pöchlarn, Austria

Benefits for farmers

With progressive climate change, adverse weather events such as droughts, heatwaves, hail, violent and torrential rains are becoming more frequent. PV panels installed over crops help shield them from these undesirable atmospheric factors. Moreover, PV panels can help significantly reduce the use of plastic film, a short-lived material that is costly, time-consuming and environmentally unfriendly to install and replace every few years.

The agricultural sector also requires large amounts of water, which is limited in Poland. PV panels reduce evaporation and transpiration of water, and a properly designed system helps collect and manage rainwater. This is important, because with the increasing frequency of heavy rainfall, crops are unable to absorb all the water, which without additional installations would evaporate very quickly. In order not to lose valuable water, additional equipment is needed to collect the water retained on the panels. Rainwater harvesting and management is possible for both above-crop and between-crop installations.

The shade and ventilation provided by AgriPV systems help to lower the temperature below the panels on hot days and raise the temperature on cooler days, thus optimising vegetation conditions. This makes it possible, for example, to regulate the vegetation period so that harvesting occurs when it makes most economic

sense. The environmental benefits also include less soil erosion, by sheltering it from the wind, and thus an increase in biodiversity. The green belts preserved under the rows of PV modules provide good habitat for many species of insects and birds. In this way, farmers contribute to the restoration of ecosystems and the creation of a more sustainable economy, while maintaining land use.

One thing to bear in mind is that the primary task of any type of AgriPV installation is to generate electricity, the sale of which brings financial benefits. Efficiency and energy yields become even greater when using bifacial PV modules. The two active sides of the modules face east and west, thus allowing energy production in the morning and evening peak hours.

„We observe that many farmers suffer from the same problem: global warming and changing weather conditions. This means that crops need to be increasingly protected from adverse weather events such as storms, strong winds and drought. AgriPV technology can become part of the solution to these problems, a strategy for the farmers to adapt to climate change. Farmers can double the use of their land and better protect their crops, while generating less waste, having less work and enjoying additional profits from electricity production."

Stephan Schindele, Head of AgriPV Product Management at BayWa r.e., has been involved in climate change issues and the use of PV in agriculture in his career, including at the United Nations Framework Convention on Climate Change and the Fraunhofer Institute for Solar Energy Systems ISE

BayWa r.e. is a leading developer, distributor and provider of renewable energy services and solutions, operating in 30 countries. We have already built and connected installations with a capacity of 5 GW and manage more than 10.5 GW of assets.

With its AgriPV projects in Europe (the Netherlands, Germany and Austria), BayWa r.e. is a pioneer in the field of agrivoltaics, involved in standardisation for this technology since 2019. The aim of this work is to define the quality of standards for AgriPV systems and ultimately to achieve technical risk reduction for all project stakeholders, with particular emphasis on the farmers.

BayWa r.e. Poland Sp. z o.o. has been operating since 2009, providing solutions for renewable energy, tailored to the needs of specific stakeholders, reducing the carbon footprint and lowering energy costs.

Comprehensive activities mainly include the development of wind and solar energy, as well as energy storage. BayWa r.e. Poland's portfolio includes the first non-subsidised and one of the largest PV plants in Poland, located in the municipality of Witnica, with a total capacity of 64.6 MWp, and a wind farm in Kamionka with a capacity of 30 MW.

Since 2016, under the global BayWa r.e. brand, a sales team has been operating in Poland, dealing with distribution in the solar power sector (PV wholesaler cooperating with installation companies – Baywa r.e. Solar Systems Sp. z o.o.).

3. Regulatory framework in EU legislation

PV is the fastest growing energy source in the EU. In 2020, the EU's solar market has grown by 18 GW and the cost of solar energy has dropped by 82% over the past decade. Emerging new regulations such as the European Green Deal, the REPowerEU plan and the EU's strategy for PV, are making PV panels one of the most competitive sources of electricity in many EU regions. In this context, AgriPV is a method to achieve additional synergies between agriculture and energy production and will be a component of the energy transition.

The European Green Deal and its implications

One of the main objectives of the European Green Deal is to coordinate the reform of the Common Agricultural Policy (hereafter: CAP) with EU's climate ambitions. This is to be achieved in part by ensuring that at least 40% of the total CAP budget contributes to climate action. In addition to this, the CAP includes funding and measures to support rural development, including stimulating the implementation of existing AgriPV systems, while supporting innovative solutions in this area. On 02 December 2021 the agreement on the CAP reform, which is due to enter into force in 2023, has been formally adopted, paving the way for a greener agricultural policy. The funds allocated to the CAP for the period 2021-27 amount to EUR 387 billion. This funding will come from two different funds: The European Agricultural Guarantee Fund (EAGF), which is set at €291.1 billion and covers direct support to farmers, and the European Agricultural Fund for Rural Development (EAFRD), targeted at sustainable rural development and amounting to €95.5 billion. The aim is to modernize the EU's agricultural policy and make it "greener", in order to adapt it to the changing environment of agricultural activity, energy and climate change. In this respect, AgriPV offers the opportunity to simultaneously implement the European Green Deal, meet the EU's decarbonisation targets and achieve the objectives of the CAP.

REPowerEU and the EU strategy for PV vs the development of the AgriPV sector

As a further step to increase the role of solar energy under EU legislation, the European Commission presented a plan to make Europe

Source: BayWa r.e. AG, Babberich, the Netherlands, 2.67 MWp, 31,000 raspberry seedlings; the electricity produced is equivalent to the energy consumption of 875 average Dutch households.

independent of Russian fossil fuels by 2030. This plan also outlines a number of measures to respond to rising energy prices in Europe and replenish gas reserves for next winter. One of the main points is to set the REPowerEU target of installing more than 320 GW of new PV panels by 2025, more than double the current level, and almost 600 GW by 2030. The Commission plans to allocate approximately EUR 86 billion to solar and wind power. The consequences of the introduction of REPowerEU include a higher renewable energy target of 45% under the revised Renewable Energy Directive, guidelines for power purchase agreements and the Solar Energy Strategy. This May, a communication from the European Commission entitled “EU Solar Energy Strategy” was published, fulfilling the announcements made under the REPowerEU plan. One of its main points was the introduction of “Innovative forms of implementation – multiple use of land”, including incentives for the development of AgriPV installations. The Commission notes that agricultural land use can be combined with PV power generation, and such activities can enable synergies whereby photovoltaic systems can contribute to crop protection and stabilization of yields, with agriculture remaining the primary land use. The Commission calls on Member States to take incentives for AgriPV into account when developing their national strategic plans for the Common Agricultural Policy, as well as a support framework for solar energy (e.g. by including AgriPV installations in renewable energy tenders/auctions).

Polish
Photovoltaics
Association

Source: BayWa r.e. AG, Seifertshofen, Germany, 6.5 MWp, installation forming part of the Barth project with a total capacity of 35 MWp.

4. Regulatory framework in Poland

Legal framework for development of AgriPV

Agrivoltaics is a technology still in the development phase and the current Polish legislation does not contain dedicated regulations for it. The Agreement on Cooperation for the PV Sector of 16 December 2021 (PV Sector Deal), which explicitly indicates the intention to develop the PV sector in Poland and to eliminate barriers to such development, provides a realistic basis for expecting adequate legislative changes.

At the same time, despite the lack of dedicated regulation, the first projects combining solar electricity generation with cultivation of plants or animal husbandry are being developed. We have examples of bear garlic cultivation, melliferous flower meadows, bee and sheep farming on PV farms[1]). Development of this type of projects is possible within the legal framework provided for traditional PV installations. Advanced AgriPV installations, due to their design features, allow for cultivation of a much wider range of crops (including, for example, raspberries, as well as fruit orchards). Therefore, the specific features of AgriPV installations that do not exclude the possibility for agricultural production should be taken into account in the legislation.

At the same time, it is worth pointing out that treating AgriPV installations on an equal footing with conventional PV installations may be unhelpful for the former, as it does not take into account and promote their additional agricultural potential.

In this section we point out the relevant regulatory areas and directions for their adaptation (or the possibility to introduce dedicated ones) required to create an optimal framework for the development of AgriPV in Poland, taking into account good practices and experiences from other countries.

Planning conditions and the future of the planning permit decision (WZ)

Developing an AgriPV projects requires planning conditions to be determined. These planning conditions may be established on the basis of a local zoning plan (hereinafter referred to as local plans) or on the basis of a decision on building conditions / planning permit (for areas for which no local plan is in force).

However, an amendment to the Spatial Planning and Development Act is currently under way, according to which RES installations are to be located only on the basis of local zoning plans. According to the current draft, this obligation is expected to apply from 1 January 2026. This means that, if the amendment enters into force in its current form, then until the end of 2025 the possibility of locating PV projects on the basis of a planning permit (“WZ”) (which is currently a common way of PV project development) will remain in place. AgriPV could also benefit from these regulations.

For AgriPV projects, it may prove problematic to determine the land use in a planning instrument (ultimately, according to the amendment, only in the local zoning plan, now also in the planning permit/WZ). By standard, the designation of land for PV projects is defined as production areas – photovoltaic installations (or similar). Another land use is related to farm-

[1] https://globenergia.pl/czosnek-niedzwiedzi-laki-kwietne-i-pszczoly-na-farmach-fotowoltaicznych-w-polsce/. See also Conclusions below.

ing. AgriPV requires a combination of these two types of land use.

However, dual land use (simultaneous agricultural and productive use, without grading of these uses) is not regulated by law. By contrast, the regulations provide for the possibility of specifying the use of land in the local zoning plan in terms of orders, prohibitions, approvals and restrictions. Permitting may take the form of specifying an ancillary, supplementary land use (specifying a primary land use with a permitted land use).

One possibility to be taken into account is locating AgriPV installations in areas of agricultural use with the permissible location of technical infrastructure facilities. At present, in the absence of specific regulations, there are arguments for allowing for location of AgriPV installations on this type of land. However, due to divergence in case law as to the qualification of PV installations as technical infrastructure facilities and possible doubts as to the validity of such a designation of land use and the location of AgriPV installations on it, this may now be a source of interpretation problems regarding the application of local laws.

In rulings on location of wind farms, in some cases the courts indicated that the conversion of land to agricultural use with the permissibility of wind turbines is not allowed, because energy production is not linked to agricultural production. Sites with different land uses should be clearly distinguished in the local with demarcation lines. A similar view is also expressed in one line of case law concerning zoning decisions for PV installations, under which the designation of the site for PV installations excludes agricultural use of the land. There are also some dissenting voices, but the uncertainty in this area is an unnecessary area of risk for investors.

Arguments about the lack of connection between agricultural production and solar energy production and the mutually exclusive nature of the two types of land use (agricultural and PV) should not, however, apply in the case of AgriPV. AgriPV installations are intended to serve agricultural production by protecting crops from excessive sunlight (particularly in the case of installations that allow crop shading to be controlled), protecting against adverse weather conditions (e.g. hail) and improving water management. Therefore, the previously presented positions on the contradiction between agricultural and productive (PV) land use should be considered irrelevant for AgriPV. The specifics of AgriPV installations should exclude concerns about the impossibility of combining solar and agricultural production on the same site. Such an approach should be regulated in statutory provisions or at least in the practice of the authorities (and subsequently in case law).

In Germany, for example, a stable practice has been established, whereby land for AgriPV projects is designated in the local plan as “special areas - agrivoltaics”. Such designation of land use is unquestionable and most suited to the specifics of the project.

The location of photovoltaic installations on the basis of planning permits has recently been restricted by an unfavourable (and at least controversial) line of case law.[2] This line of case law may also have negative consequences for the possibility of issuing planning permit decisions for AgriPV. In no way should this line be continued or turned into an acceptable practice.

Exclusion of land from agricultural production

The exclusion from agricultural production land with soils of mineral and organic origin, classified as Class I-III, and Class IV-VI agricultural land with soils of organic origin and designated for non-agricultural purposes, requires a decision on exclusion from agricultural production. Moreover, a change of use of agricultural land constituting Class I-III farmland – requires the consent of the minister responsible for rural development and an amendment to

the local zoning plan. In addition, the exclusion of land from agricultural production involves the obligation to pay fees (a one-off payment and annual fees over a 10-year period).

Restrictions related to the change of designation of Class I-III farmland and the obligation to pay fees for the exclusion of land from agricultural production cause that, in practice, PV investors decide to carry out their projects mainly on land that is not subject to the regime of exclusion from agricultural production, i.e. on land with Class IV-VI soils of mineral origin. This both limits the pool of attractive land for PV projects and makes it difficult to access the electricity grid in the vicinity of protected land.

AgriPV may be the answer to these constraints. It is about preserving the agricultural use of land at the PV project site. Therefore, in contrast to conventional PV installations, the location of AgriPV installations will not lead to the exclusion of land from agricultural production.

Ensuring that land can be used for AgriPV purposes without having to be taken out of agricultural production would contribute to increasing the installed PV capacity in Poland by increasing the availability of land and the associated availability of connection capacity. This solution is undoubtedly attractive to investors, but clear statutory regulations would be required for it to be implemented without controversy.

As for examples from neighbouring countries – similar regulations on the protection of agricultural land and associated barriers to PV development are identified in the Czech Republic. There have already been initial attempts to alleviate these barriers in the form of a draft amendment to the Agricultural Land Fund Protection Act, introducing, among other things, a new definition of so-called agrivoltaic power plants and allows the use of agricultural land for the construction of an AgriPV plant without the obligation to pay a fee (normally required for the use of agricultural land). The draft amendment is currently in the early stages of the legislative procedure and we do not know what shape it will ultimately take. The Czech path, however, shows desirable directions for the development of legal regulations that can also be implemented in Poland.

Direct payments and AgriPV

It is also important to decide whether AgriPV affects the right to receive direct payments for farmers operating in the area where the installation is located. In our view, properly planned and implemented shared use of land for agricultural and AgriPV purposes does not affect the farmers' right to receive direct payments (in particular, it does not deprive them of this right). This position, based on EU regulations, has also been asserted in judgements of German courts.

As per the EU regulation on direct payments[3], support is granted for so-called eligible hectares. An eligible hectare is agricultural land (...) used exclusively or mainly for agricultural activities. This means that the use of land for non-agricultural activities (while maintaining a

[2] Part of the jurisprudence is of the opinion that PV farms with a capacity of more than 500 kW should be implemented on the basis of local plans or, in the case of planning permits, taking into account the examination of the principle of good neighbourly relations. Meanwhile, examination of the principle of good neighbourliness is explicitly excluded in the case of planning permit decisions issued for renewable energy sources (as amended by the Act from 29 August 2019). There is no doubt that PV installations are renewable energy source installations and, consequently, examination of the good neighbourly relations principle is excluded. However, part of the jurisprudential line has developed in the opposite direction, unfavourable for investors. In our view, the interpretation that the issuing of a planning permit for PV installations does not require examination of the principle of good neighbourly relation should be regarded as correct, and this view is also defensible in the light of the current, still divergent case law.

predominantly agricultural use of the land), is not an obstacle to receive support in the form of direct payments.

The regulation also indicates the criteria for assessing whether land is still primarily used for agricultural production. An area shall be considered to be used predominantly for agricultural activities provided that such activities are not significantly hampered by the intensity, nature, duration and timing of the non-agricultural activities. This means that the location of a PV installation would exclude farmers' rights to subsidies if the operation of the installation significantly impedes agricultural production. However, it is possible and ultimately desirable to plan PV installations in such a way that it both does not impede agricultural production and also supports it, e.g. by protecting crops from unfavourable weather conditions. Thus, AgriPV installations should not affect the farmers' rights to direct payments.

This was upheld by the court in Regensburg[4], which stated that an agricultural area built-up with PV panels remains primarily used for agricultural activities. Consequently, such an area is an eligible hectare for which the farmer can receive direct payments.

The facts decided by the court concerned sheep grazing around PV panels. As the court pointed out, the decisive factor for the assessment of the right to subsidies is whether the non-agricultural (PV) activity impedes the agricultural activity on the property (and not, for example, which of these activities is of key importance on the land in question).

[3] Regulation of the European Parliament and of the Council (EU) No 1307/2013 of 17 December 2013 laying down rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009.

The court stated that the operation of the PV panels does not impede the grazing of sheep and consequently does not affect the title to the related subsidies.

The court's position is even more favourable as there was a rule in Germany (enacted on the basis of an EU regulation), according to which areas under PV panels are not primarily used for agricultural activities (and are therefore not eligible for subsidies). The court found that the national provision exceeded the mandate of the regulation and was therefore not applicable. By doing so, the court confirmed that the allocation of the right to payments should be decided taking into account the principles under the EU regulation.

Strictly speaking, AgriPV is intended to support agriculture, including, for example, protecting crops from hail, regulating shade and light (through specially designed translucent panels). AgriPV developed in such a way will not hinder agricultural activities. The land built up with AgriPV installations should therefore be eligible for subsidies.

Further incentives

In order to utilise the potential of agrivoltaics, it is also worth considering further incentives for this type of projects. For example, it is possible to facilitate building permit procedures for AgriPV.

In Germany, AgriPV installations can qualify as preferred projects under the building law if they meet certain conditions. According to the case law, one of the conditions is the purpose of the energy produced by the installation – if the energy is used for agricultural activities, the agrivoltaic installation can be a preferred project. In most cases, however, this condition will not be met and the installation will not enjoy preferential treatment. However, it is possible to establish the conditions to treat projects differently and to grant preferences to all AgriPV projects that support agricultural land use by definition.

Another important component in creating the conditions for the development of AgriPV is establishing a dedicated support system. Agrivoltaics can benefit from the existing support scheme in the form of RES auctions, but a separate, dedicated auction basket would be desirable to ensure the competitiveness of installations. This would allow the level of reference prices to be determined individually for AgriPV installations.

Auctions for AgriPV have already been carried out in France. Recently, projects with a total capacity of 40 MW[5] have won the auction. Auctions are dedicated to innovative AgriPV installations with a capacity from 100 kWp to 3 MW. Auctions are organised on a competitive basis, where participants place bids with a price in Euro/MWh (within the limits specified for the auction). A similar system could also operate in Poland.

It is also worth noting that in Germany, a comprehensive amendment to the Renewable Energy Act (Erneuerbare-Energien-Gesetz) has been enacted, providing measures to promote AgriPV installations taking into account the specific features of the three possible types of agricultural land use. The broad acceptability of the location of Agri-PV installations on almost all types of agricultural land, together with newly enacted promotion schemes, paves the way for large-scale development of agrivoltaics in Germany.

[4] Judgment of the Administrative Court (Verwaltungsgericht) in Regensburg of 15.11.2018, ref. no.: RO 5 K 17.1331.
[5] https://www.solarplaza.com/resource/12204/advantages-agrivoltaics-france/

Interdepartmental cooperation

Agrivoltaics, due to its unique scope, is potentially of interest to two ministries – the minister responsible for agriculture and the minister responsible for energy. The creation of the legislative framework, as well as the subsequent support and handling of agrivoltaics, would require cooperation between representatives of these two ministries. Division of competences and lack of integration of regulation can be challenging for the development of a dedicated legal framework for AgriPV.

In addition, we also recognise that there may be a wide range of stakeholders interested in public consultation in the legislative process for PV solutions. These will include both those involved in agriculture and the RES industry. As a result, public consultation can be on a large scale and the process can be lengthy and demanding due to the need to reconcile the interests of two sectors. This is why it is so important to design the process in a proper way that would mitigate potential conflicts, and highlight cooperation and mutually beneficial opportunities.

Nevertheless, the above procedural challenges are not insurmountable. The conclusion of the 2021 PV Sector Deal, with parties including the Minister for Climate and Environment and the Minister for Agriculture and Rural Development (as well as tens of other stakeholders, including ministers) shows that large-scale cooperation is possible. The agreed assumptions are yet to be translated into concrete legislative solutions that will have a chance to enter into force.

Conclusions and evaluation of early experiences

The French Environment and Energy Agency (ADEME) has prepared a publication summarising the experiences and setting the directions for AgriPV[6]. The report shows that agrivoltaics is meant to be an answer to the problems identified in agriculture, it is meant to indirectly serve agricultural production, among other things, by protecting against hazards or improving animal welfare. In this context, the aforementioned projects combining PV production with crop farming or animal husbandry may not qualify as AgriPV installations in the ultimate sense of the term. With a developed agricultural sector and a developed PV segment in Poland, can we afford not to develop a strong agrivoltaic segment?

PV projects combined with crop cultivation or animal husbandry are undoubtedly a significant step towards the full, optimal use of land, increasing the capacity of existing PV installations, increasing agricultural production, as well as developing principles of cooperation and good practice regarding the activities of PV investors on land actively used for agricultural purposes. However, if these projects are developed on class IV-VI soils, somewhat in addition to and without compromising agricultural production, they do not yet realise the full potential of AgriPV.

Such a full potential can be expressed in the fact that photovoltaic panels, of appropriate design and construction (e.g. translucent panels on raised support structures), will serve

[6] https://librairie.ademe.fr/energies-renouvelables-reseaux-et-stockage/4992-caracteriser-les-projets-photovoltaiques-sur-terrains-agricoles-et-l-agrivoltaisme.html

to facilitate, enhance or otherwise optimise agricultural cultivation, while development of AgriPV installations on agricultural land should be allowed on a broader scale, including land of higher classes, without having to bear the burden of administrative law regulations. Achieving this potential requires adaptation of the legal framework. However, if AgriPV is to combine the interests of two sectors: agriculture and energy production, it would seem to be in the interests of both stakeholders to adapt the legal framework.

Paweł Puacz, Legal Adviser (Partner, Head of the Energy and Natural Resources Group)

Anna Pawłowska, Legal Adviser (Senior Counsel, Energy and Natural Resources Group)

CLIFFORD
CHANCE

Clifford Chance is an international law firm, one of the leaders of the legal market in Poland. Currently, more than 110 lawyers work in it, including 11 partners and many highly regarded specialists. Clifford Chance has been supporting Polish and international companies in the implementation of their market strategies. in the implementation of their market strategies for 30 years. It advises leading banks and financial institutions as well as the largest corporations and investment funds. Its clients benefit from the extensive experience of the global Clifford Chance network and from the Warsaw lawyers' in-depth knowledge of the regulations and economic conditions in Poland. Thanks to its involvement in the largest and most high-profile transactions, projects and litigation in Poland, Clifford Chance is considered the number 1 law firm in all key areas of law in Poland by the most prestigious international rankings of law firms: Chambers Global, Chambers Europe, Legal 500 EMEA and IFLR1000.

5. Main barriers to the development of AgriPV in Poland. Proposed regulatory solutions to support AgriPV in Poland

The place of AgriPV on the Polish RES market

The development of renewable energy sources in Poland has so far been monolithic – based on a single technology, dominating in a given period. This was due not so much to natural conditions as to the regulatory environment that was driving investors at the time towards specific technologies.

Between 2005 and 2016 the dominating technology in the Polish RES market was wind energy, supplemented by smaller-scale biogas plants. Both of these technologies received support under the green certificate scheme. In 2016, with the entry into force of the Wind Power Investment Act, which introduced the so-called 10H rule, making the location of new wind projects virtually impossible, the further development of this sector became questionable. For biogas plants, despite the promotion of the technology by subsequent governments, the inadequacy of the support system based on green certificates to the characteristics of biogas projects has been detrimental to their development.

From 2016, PV gradually took over the dominance of the RES market, with strongest growth between 2019 and 2022. PV initially proved to be the main beneficiary of the RES auctions, a new support scheme that was supposed to rectify the shortcomings of the previous green certificate system.

The future lies in hybrid solutions, based on interoperation between different technologies and, going further, in coupling different sectors. Such solutions can be found, for example, in the increasingly popular grid / cable pooling (combination of wind and PV) or the adaptation of energy storage.

Another solution that builds additional value in the sector is AgriPV, benefiting from the integration of two strong economic sectors in Poland: agriculture, deeply rooted in the Polish economy both historically and today, and renewable energy production. AgriPV may offer a remedy to the upcoming problems for PV, including in particular the limited land availability near available and attractive grid connection points, or the need for cost and revenue optimisation of projects.

At the same time, renewables are not the only sector facing the need to change and redefine its development pathway. Similar needs can be observed in agriculture, where maximising good crop quality and ensuring profitability remain priority issues and require regular optimisation.

The answers to these challenges could be found in interdisciplinary solutions using the potential of different technologies and the specifics of the activity.

New development directions

One solution that could help achieve Poland's RES ambitions is to further regulate the status of hybrid installations. Another expected legislative solution is the regulation of the status of energy storage facilities, including the rules for their grid connection. Legal framework for the operation of and development of energy storage in Poland was created by an appropriate amendment to the law.

PV has also adopted specific development directions. In order to minimise development costs of installations (of various scales) and due to the limited availability of grid connection capacity, *behind-the-meter* solutions are increasingly sought after and explored, including, among others, rooftop PV installations. These solutions are also popular in other countries, especially those with limited areas of agricultural land (e.g. Belgium, the Netherlands). In Poland, the areas of agricultural land are incomparably larger – the challenge is therefore not about the physical shortage of land, but the possibility for its optimal, hybrid use (including for AgriPV).

Agrivoltaics as the way forward for PV

On 16 December 2021, a Sector Deal on co-operation for the photovoltaic sector (hereinafter referred to as the "PV Sector Deal") was concluded, agreed by representatives of the government administration and stakeholders involved in the development of the PV sector in Poland, i.e. financial institutions, PV development organisations, investors, industry and the education sector. The PV Sector Deal defines the framework and directions for development of the PV sector in Poland. AgriPV is one of the directions indicated for PV development. In order to overcome the barriers to its growth, it is planned to set up a working group with the aim to define AgriPV and, consequently, develop solutions to enable the implementation of investment projects taking into account their specific nature, primarily to maintain the continuity of agricultural production.

Under the PV Sector Deal, in addition to agrivoltaics, other segments for PV development include hybrid RES installations, PV systems integrated with hydrogen technologies, building-integrated PV and floating PV installations. The potential of hybrid installations is certainly already being explored. Of the other segments, AgriPV installations appear to be particularly suited to Poland's economic profile, with a strong agricultural sector.

In the time of the energy crisis, it is becoming clear that conventional energy sources are not sufficient to meet the demand for energy. The expansion of the renewable energy system is a key pillar for ensuring energy security. It also perfectly fits the trend towards decentralisation of energy generation. This is the way forward for climate and environmental protection, which is also a priority in Polish and EU policies. Once we know the potential of wind and solar

power, it is important to look for further areas allowing for intensification and optimisation of activities towards the development of renewables. One such area could be AgriPV.

The well-developed PV market in Poland is an excellent base of experience from which AgriPV can benefit. Of course, there will also be new challenges, such as the need to develop the principles of cooperation between the AgriPV investor and the operator of agricultural activities at the project site. In order to ensure the comfort and security of project development, legal regulations also need to be adapted. However, Poland will not have to blaze any trails on its own and can make use of solutions tested in other countries.

CLIFFORD
CHANCE

6. Taxation of PV installations coexisting with agricultural production

A new phenomenon

Agrivoltaics is a new solution, unknown to the Polish tax law, combining agricultural production with generation of electricity from PV panels at the same site. Currently, there are no tax and legal regulations dedicated to AgriPV and taking into account its specific features. It is, however, very different from traditional PV farms, the siting of which on agricultural land means its automatic exclusion from agricultural production with all the related consequences, including taxation.

The idea of an AgriPV installation is to simultaneously use agricultural land for both solar energy generation in adequately designed facilities, as well as for the realisation – in the presence of these facilities – of appropriately selected crops, the productivity of which does not have to differ from typical agricultural production. In some cases, even positive yield results are recorded, e.g. when shading caused by the presence of PV panels improves the water management of the farmland. Nevertheless, the essence of AgriPV is the generation of electricity on land that is not excluded from agricultural production, i.e. land that is both actually farmed and maintains its status as agricultural land for administrative, settlement, legal, inheritance or tax purposes. Adopting adequate legal regulations for the AgriPV sector therefore implies certain administrative consequences resulting from the classification of land, but above all it opens up previously inaccessible land of higher quality classes for energy generation activities and creates completely new development perspectives for both agriculture and the energy sector.

As there have been no projects of this type in Poland so far, the topic of AgriPV has not yet been addressed from a tax perspective in the case law of the administrative courts or the tax authorities' decisions. When analysing the potential tax implications of AgriPV, reference should be made by analogy to the norms and practice for traditional PV farms, as well as to the experiences of foreign jurisdictions, more advanced in the implementation of AgriPV solutions.

Property tax / agricultural tax

The most significant aspect of the taxation of PV installations is the real estate tax (hereafter also: RET), where the subject of taxation is land, buildings or parts thereof and structures or parts thereof, if they are connected with business activity. Real estate tax is also levied on agricultural land, i.e. land listed as agricultural in the land registry of a municipality, if it is actually used for non-agricultural business activities.

The owner of real estate (land, buildings or structures), the autonomous possessor or the perpetual usufruct holder of the land, among others, is liable for RET and agricultural tax. It is worth noting that tenants of private land are generally not subject to the obligations related to real estate tax, which is not always clear to parties involved in RES projects in our country.

Taxation of land

Agricultural land may be subject to agricultural tax – if agricultural cultivation is carried out on it – and to real estate tax – if it is occupied for the purposes of business activity.

For conventional PV farms it is assumed that, irrespective of the registered status of the land, the entire area within the boundaries of which the location of the PV installation has been geodesically determined, generally including internal roads, fencing, etc., is occupied for the purpose of the business activity. Land thus classified as occupied for business activity ceases to be subject to agricultural tax and becomes subject to RET at a much higher rate.

For comparison, the agricultural tax rates in 2022 for the example municipality (a municipality in the Wielkopolskie / Greater Poland Voivodeship) are:

- up to PLN 140 per calculated hectare of farmland,
- up to PLN 280 per hectare of other land.

In turn, the real estate tax rate in 2022 for land used for business activities is PLN 1.03 per 1 m^2 of surface area, which for one hectare means a tax burden of up to PLN 10,300!

The above approach seems reasonable given the design of traditional PV farms, which generally leaves no room for any or at least no significant agricultural activity within the farm area. The situation is significantly different for AgriPV. This is because the land remains occupied all the time and almost entirely for agricultural production, while energy production takes place in the space above the land itself, organised in such a way that it does not interfere with agricultural activities carried out below the plane of the solar panels. This circumstance supports the need for a different classification of land occupied for AgriPV, as it is in fact used twice, with one of the uses retaining the character of a full-scale agricultural activity.

It is worth noting that, in the past, similar considerations applied to overhead power lines running above forested areas, where the final position was that the land under such lines should be treated as occupied for business purposes. In this situation, however, it was conclusive that forestry activities under transmission lines could not be carried out or could only be carried out to a very limited extent. However, for AgriPV, with the right choice of crops, farming can be carried out on all or almost all of the farm's area. Importantly, from 2019 onwards, the legislator has introduced an explicit regulation according to which land under transmission lines retains for tax purposes its original character (agricultural or forestry). For these reasons, it seems reasonable to demand that a similar regulation be enacted for AgriPV farms in relation to the total area of the farm, as is the case for transmission lines, under which there is currently no indication of land occupied for business purposes.

Unfortunately, we are aware of a single decision of a provincial administrative court in a situation where, in addition to a PV farm (above-ground PV installation with support structures), agricultural activity was carried out on separated (fenced) and leased land. In such a case, the court found that the land was occupied for business purposes, with the consequence that a higher RET rate had to be applied.

Taxation of building structures

Building structures are subject to RET if they are related to business activity. This condition will be met by a commercial PV installation (for the purposes of this publication we disregard small-scale prosumer PV farm projects developed by natural persons).

According to the currently prevailing line of case law of administrative courts, PV panels as well as the accompanying technical infrastructuredo not meet the definition of a building structure and is therefore not subject to RET. Only the construction parts of PV farms, if any, are to be considered as building structures, and only for these elements will PT taxation occur.

In the case of AgriPV, similarly to traditional PV farms, the taxation of building structures will also depend on the way in which the panels and the accompanying structure are connected to the ground. Foundations and other structural elements permanently fixed to the ground should be considered construction parts of the entire PV plant which will be subject to RET as building structures. In contrast, some types of support structures may be characterised by the absence of building parts, e.g. in the case of easily disassembled plant foundations in/on the ground. In such a case, the object of real estate tax may not appear in the form of a building structure, while it should be pointed out that structures such as roads, fences, lighting installations, transformers, etc. are or may also be structures.

The real estate tax rate for building structures is 2% of the value of the structure, determined in principle as the initial value of the structure for depreciation purposes.

Taxation of buildings

Buildings, if they are located within the AgriPV farm, e.g. substation building, are also subject to real estate tax.

The RET rate for buildings depends on their area and the nature of its use. For example, for buildings related to business activity, the maximum tax rate in 2022 is PLN 25.74 per square metre.

Excise tax

Under current legislation, the sale of electricity to the final offtaker is subject to excise duty. Therefore an energy producer, selling to an entrepreneur who does not hold an electricity generation, transmission, distribution or trade licence, is obliged to pay excise duty by the 25th day of the month following the month in which the differential settlement for the period in question was made. The current excise tax rate is 5 PLN/MWh. Excise duty does not apply when electricity is sold to a licensed entity (e.g. a trading company), in which case the excise duty is generally transferred to that entity.

Tax solutions for AgriPV in other countries

Other European countries have already started to introduce dedicated legal solutions for agrivoltaics. Examples include the Netherlands (where restrictions on the availability of land for conventional PV have led to increased interest in AgriPV or floating PV farms), Italy or France.

From a taxation perspective, it may be interesting to note the solution introduced this year in Bavaria, Germany, where it was decided that the land occupied by AgriPV farms was considered occupied entirely for agricultural and forestry activities.

7. Potential for cooperation between the agricultural and renewable energy sectors in Poland

Poland is simultaneously facing the problem of an almost permanent agricultural drought, but also the need to transform its emissions-intensive energy system. In such a situation, the dissemination and implementation of concepts for cooperation between the agricultural and renewable energy sectors has potential benefits, both for landowners and renewable energy entrepreneurs.

Importance of cultivation and husbandry

According to data from the Central Statistical Office of 2021, collected at the time of the last agricultural census, arable land in Poland covers nearly 58% of the country's area, i.e. 18.4 million hectares. Of this, just over 14 million ha (76.3%) is arable, 2.35 million ha (12.8%) is grassland, 1.69 million ha (9.2%) is pasture and orchards account for almost 0.30 million ha (1.6%).

Livestock farming and agriculture are vital to environmental sustainability and meeting food demand. At the same time, they face increasing needs, challenges and risks.

Requirements and risks for agricultural farms

Poland has nearly 1.3 million farms, undergoing continuous development and modernization.

The result is an increasing consumption of electricity, so access to affordable energy is becoming a key development factor. At the same time, we are facing an energy crisis and rising electricity prices, forcing farm owners - farmers and breeders – to look for possible savings. Such savings can be generated by renewable energy sources, including solar panels.

Another significant factor is climate change that the farmers increasingly have to face. This includes extreme weather events such as heavy rainfall, hail, gusty winds, heat waves and droughts. All these weather phenomena significantly affect crop and livestock efficiency. Rain and hailstorms destroy crops and prevent animals from grazing freely. Gusty winds also restrict cultivation and cause the need for additional feeding of animals that cannot freely use meadows and wastelands.

Heat waves, on the other hand, force farmers to use additional artificial irrigation. This requires tapping into limited water resources. Excessive sunlight and high temperatures cause the plants to die even before they bear fruit or yield. All this contributes to reduced agricultural productivity.

However, extreme weather events are not the only threat to agriculture and livestock husbandry. Other threats include ongoing degradation of the environment, decline in biodiversity and air pollution affecting the quality of production. Environmental changes also negatively impact the population of bees, whose presence is essential for plant reproduction and fruiting.

There are also problems associated with groundwater levels that should not be forgotten. Not only are their levels constantly decreasing, but they are also becoming increasingly polluted. This pollution translates into the quality and

quantity of crops and the condition of livestock.

At the very least, these risks can be mitigated by combining traditional husbandry and cultivation with zero-carbon power generation from PV farms operating on farmland.

Benefits of AgriPV

PV installations on farmland do not only offer the possibility to generate electricity without emitting greenhouse gases causing ongoing environmental degradation.

They also create a specific microclimate around the farm, reducing water evaporation and providing shelter for plants and animals. This requires a suitable mounting method for the modules, and such methods are already being tested in Belgium, the Netherlands and Germany.

A typical AgriPV project involves four stages of preparation:

1. Analysis of environmental and climate data, allowing the site to be divided into smaller sections;

2. Based on the information gathered, it is possible to design a feasible PV system and determine the type of crop that will give the highest yields;

3. The next step is the dimensioning of the PV system; synchronising climate data and the needed level of illumination of the crop;

4. Finally, performance indicators need to be estimated both with regard to energy yield and benefits compared to unbundled production.

The analysis should show that, for a typical site, much more profit can be generated for the farm by combining a PV installation with crops or husbandry. As mentioned, the modules can be mounted in rows, with the area used for farming between them, offering freedom for cultivation or breeding. In the case of modules stretched above the crop area, their installation at the appropriate height does not interfere with the harvest. Importantly, shade-loving plants can be selected that are not affected by the reduced amount of light reaching them. Potatoes, raspberries, broccoli, courgettes, aubergines, asparagus and legumes are well-suited to such conditions.

A study carried out this April by researchers at Chonnam National University in South Korea, published in the scientific journal Agronomy, showed that plants grown under this type of PV module canopy did not differ from others in terms of green colour. They have also retained their flavour and nutritional value. This means that the canopy of PV modules did not have an adverse effect on the crop.

Benefits of dual land use

According to very conservative estimates, the unit income from dual-use acreage – for crops or livestock and for PV – can even be doubled. This is because a PV installation allows for farming to be carried out even in adverse conditions, resulting in greater efficiency and productivity of the farm. The presence of AgriPV farm translates into the creation of a specific microclimate and an increase in biodiversity. The state of the environment improves, the demand for water decreases and there are even opportunities for water storage. The PV panels protect the plants from excessive sunlight, rain, hail and wind. And the farm owner gains an additional source of income – either from the sale of energy or in the lease of land for the farm.

EC Group is a leading distributor of photovoltaic modules in the Polish market. Since the beginning of its activity the company has selected only premium products, the quality of which is guaranteed by manufacturers and confirmed by the experience of numerous satisfied customers. The company's mission is not only to supply high efficiency modules, but also to educate and train mounting and investment groups in terms of technical parameters, correct installation and safety of the projects.

We are constantly observing the global photovoltaic market, following the latest solutions and implemented technologies in order to be able to offer innovative solutions used all over the world. We draw inspiration from the research of international experts and adapt our offer to the changing reality.

Our goal is to support investors at every stage of the investment - from understanding the needs, through selection of appropriate and eligible modules, professional trainings, to technical advice and warranty services. We are committed to building long-lasting and rewarding business relations, therefore we carefully listen to our customers and respond to their expectations. As a member of the Polish Photovoltaics Association, we want to lobby for the adoption of the law on agrivoltaics (APV), which has not been legally regulated in our country.

Source: BayWa r.e. AG, Babberich, the Netherlands, 2.67 MWp, 31,000 raspberry seedlings; the electricity produced is equivalent to the energy consumption of 875 average Dutch households.

8. Characteristics of current technological solutions for construction of AgriPV installations

In September 2022, the installed capacity of PV in the Polish electricity system was more than 11.06 GW, of which almost 8.36 GW were prosumer installations and 2.7 GW large-scale PV farms[7]. PV farms are an environmentally non-intrusive and socially acceptable source of electricity. With typical ground-mounted solutions, PV modules face south at an angle of 20-35 degrees ° and the spacing between individual rows is up to several metres, depending on the geographical location and mounting structures used. Due to the nature of the projects, aimed at maximising the energy yield from a given area, it is not technically feasible to have simultaneous and efficient agricultural use of the land. These two functions are therefore mutually exclusive and, as a result, there is only one type of activity in the area. Agrivoltaics (other names: agriphotovoltaics, AgroPV, AgriPV, APV) is thus a solution for allowing for agricultural activities to continue while producing electricity.

AgriPV structures

The categorisation of the types of agrivoltaic structures in Europe was first undertaken in the specification DIN 91434:2021-05 ‚Agri-photovoltaic systems - Requirements for primary agricultural use', also available in Polish[8]. The document distinguishes between two main categories of APV installations:

Category I
- tall structures with cultivation under the panels [Figure 1],

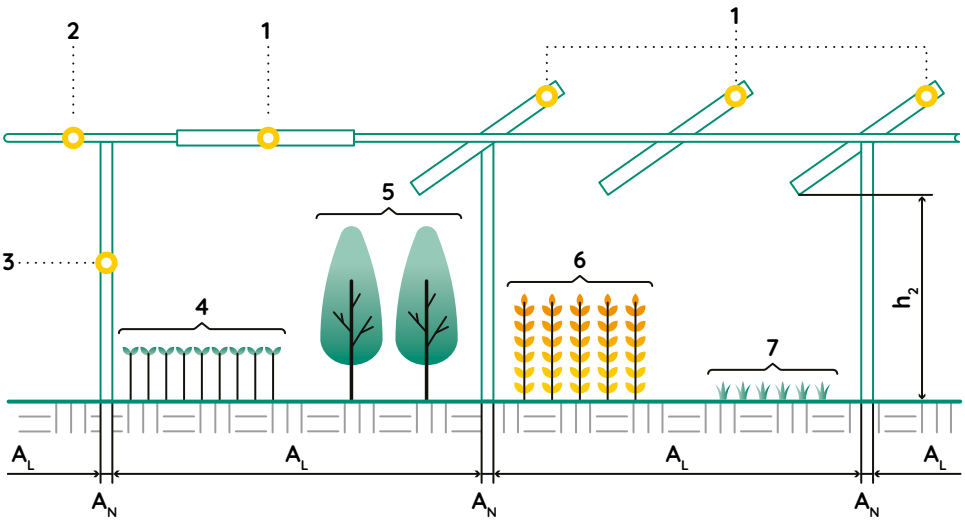


Figure 1. Category I AgriPV construction according to DIN91434, where: A_L - area in agricultural use, A_N - area occupied by the structure, h_2 - distance from the ground above 2,10 m, 1 - photovoltaic panels, 2,3 - structure, 4-7 - example crops [2]

[7] Energy Market Agency S.A., Statistical Information on Electricity, IS 1232-5457 No. 9 (345), September 2022
[8] DIN SPEC 91434, Agrivoltaic systems - Requirements for primary agricultural use, May 2021

Category II
- ground-mounted structures with crops between panels [Figure 2].

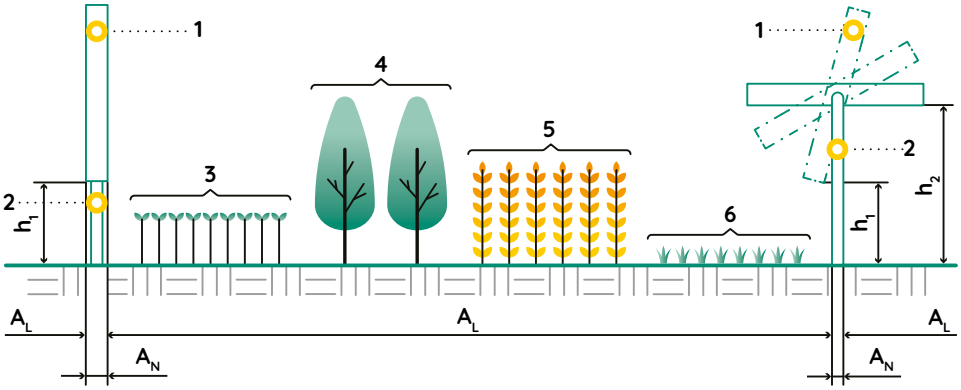


Figure 2. Category II AgriPV construction according to DIN91434, where: A_L - area in agricultural use, A_N - area occupied by the structure, h_1 – distance from ground less than 2,10 m, h_2 - distance from ground more than 2,10 m, 1 - photovoltaic panels, 2 - structure, 3-6 - example crops [2]

In both cases, tracking systems, so-called single and dual-axis trackers, can also be used. Agrivoltaic installations can be used wherever agricultural activities are carried out: on annual crops, perennial crops, permanent crops, grassland and livestock pastures[9].

Figure 3. Visualisation of a planned AgriPV farm in the Pomeranian Voivodship (Kelfield)

The specification also indicates what requirements should be met by an installation to be classified as AgriPV, such as:

- ensuring even access to sunlight and irrigation, adapted to the needs of the specific crop,
- the yield obtained from agricultural use after the installation of the AgriPV system should be at least 66% of the average yield obtained over the previous three years.

[9] Agri-PV-combination of agriculture and photovoltaics, Gerhards C., Schubert L., Fraunhofer IMW, et al., Saxony State Office for the Environment, Agriculture and Geology, Publication 01/2022

Similar criteria have recently been developed in France (2021) and Italy (2022). No specification of this type has been formulated in Poland yet.

Vertical AgriPV farms

The basic premise of AgriPV farms with a vertical structure is that the rows of photovoltaic modules are spaced at such a distance that the space between the rows can still be used for agricultural purposes [Figure 4].

The final row spacing, which is min. 8 m, is the result of a number of factors, including the shape of the terrain, the permissible installation gradient of the structure, the drop in electricity production caused by the mutual shading of the rows in the early morning and late afternoon, as well as keeping an appropriate distance from forests, often bordering on farmland. The main requirement to be met is to provide sufficient space for agricultural machinery to pass between the rows of panels and to turn around on the periphery of the farm. Obviously, as a result of such a land-use plan, the installed capacity will be less than that of a conventional PV farm on the same plot of land. However, it must be taken into account that in an AgriPV farm, the same agricultural land has two functions at the same time primary - agricultural production, and secondary - electricity generation.

A typical steel structure consists of two vertical poles driven into the ground, which are connected with three horizontal cross-bars [Figure 5]. Overall height of the structure depends on the width of the photovoltaic panels used in the project and is approximately 3.5 m. The depth in the ground is approximately 1.5 m, with exact values determined for each project on the basis of geotechnical surveys and wind conditions, which, in addition to the size and weight of the panels, have a direct impact on the dimensions of the steel structure. The challenge faced by engineers and designers is to technically optimise the structure in such a way that the shade cast by the structure itself on the PV module is minimized.

Figure 4. Visualisation of a planned AgriPV farm in the Pomeranian Voivodship (Kelfield)

Vertical support structures occupy a very small area in relation to the total area of farmland. Even taking into account the area for ancillary infrastructure such as a transformer station, the usable area for crops is between 95 and up to 99% of the agricultural land, allowing it to retain its previous use.

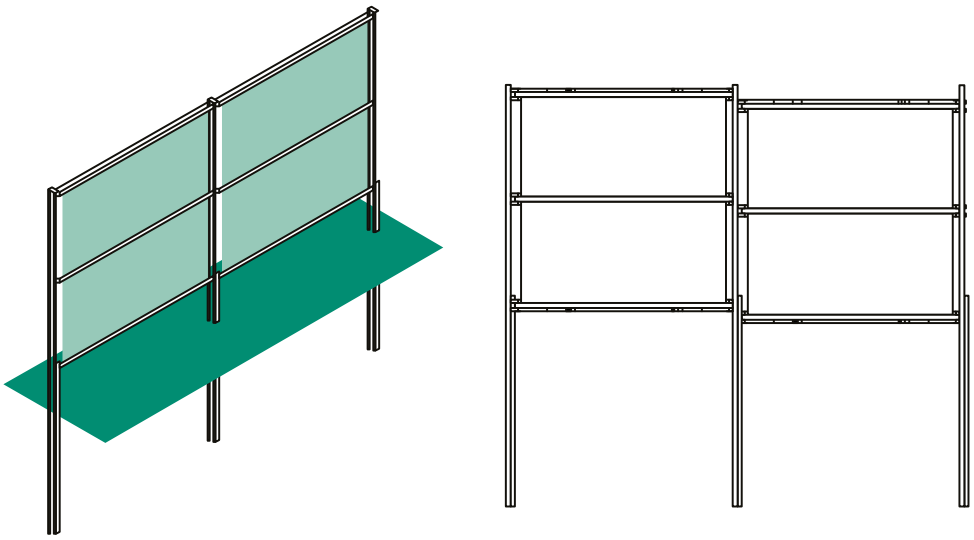


Figure 5. View of a typical support structure for bifacial PV modules for AgriPV farms [4]

Bifacial panels

Due to the significant spacing between rows and the use of bifacial modules, agrivoltaic farms with vertical structures also use solar radiation reflected from the ground to produce electricity. Double-sided (bifacial) photovoltaic panels are used to ensure high efficiency. A characteristic parameter of bifacial panels is the bifaciality factor defined as the ratio of the rated (nominal) power of the rear side of the module to the nominal power of the front side of the module. For the solutions offered on the market, this ratio is as follows, depending on the technology: PERC 65-75%, n-type 80-90%, HJT 90% or up to 95%[10]. Another key factor is the albedo of the ground, i.e. the ratio of reflected to incident radiation. The albedo value changes depending on whether there is snow cover on the agricultural area (0.8-0.9), the crop growth period is ongoing (0.25) or it is post-harvest (0.15-0.25)[11]. Reflected radiation will be greatest in the winter months, especially with fresh snow, although in these months the general electricity production from AgriPV farms will be the lowest. Vertical agrivoltaic farms are already being built in western Europe (Germany, the Netherlands, Austria, France) and Asia (Japan)[12] [13]. As the modules are mounted perpendicular to the ground, the orientation of the rows has a direct impact on the electricity production profile. When the row of modules is oriented along the north-south axis and the sides to the east and west, two generation peaks are obtained: morning and afternoon. These peaks can be almost symmetrical or adapted to the needs of the consumers, for example by placing more modules with the front side facing west in order to reinforce the generation of electricity in the afternoon, when production from conventional photovoltaic farms decreases [Figure 6]. This makes it possible to equalise the energy production profile of the grid to which the farm is connected [Figure 7].

The use of AgriPV farms with an east-west vertical design is therefore a viable alternative to electricity storage in grids with high saturation of conventional PV farms[14].

[10] IEA PVPS, Bifacial photovoltaic modules and systems: experience and results from international research and pilot applications, Report IEA-PVPS T13-14:2021, Kwiecień 2021
[11] https://www.pvsyst.com/help/albedo.htm (accessed on: 05 September 2022)
[12] https://www.pv-magazine.com/2022/04/26/japans-first-vertical-agrivoltaic-project/ (accessed on: 05 September 2022)
[13] https://www.pv-magazine.com/2020/10/08/agrivoltaic-project-with-vertically-mounted-bifacial-panels-goes-online-in-germany/ (accessed on: 05 September 2022)
[14] Integration of vertical solar power plants into a future German energy system, S.Reker, J.Schneider, C.Gerhards, Smart Energy 7, 2022

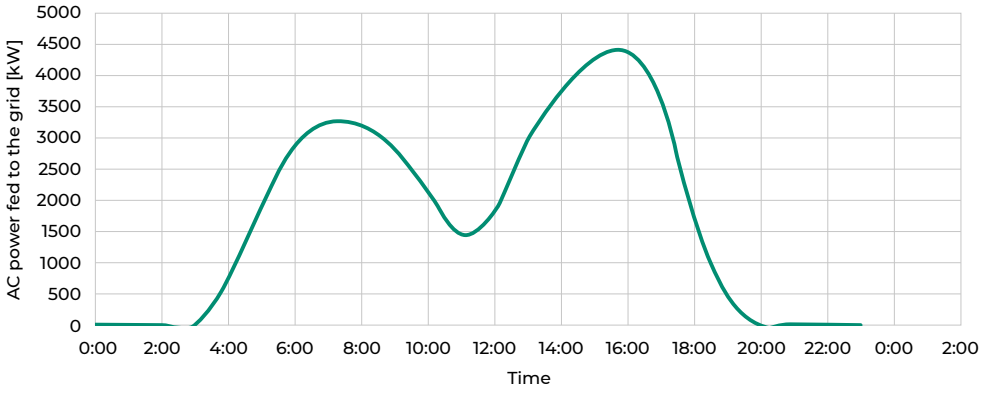


Figure 6. Typical daily electricity production from a vertical AgriPV farm, bifacial panel facing west (Kelfield)

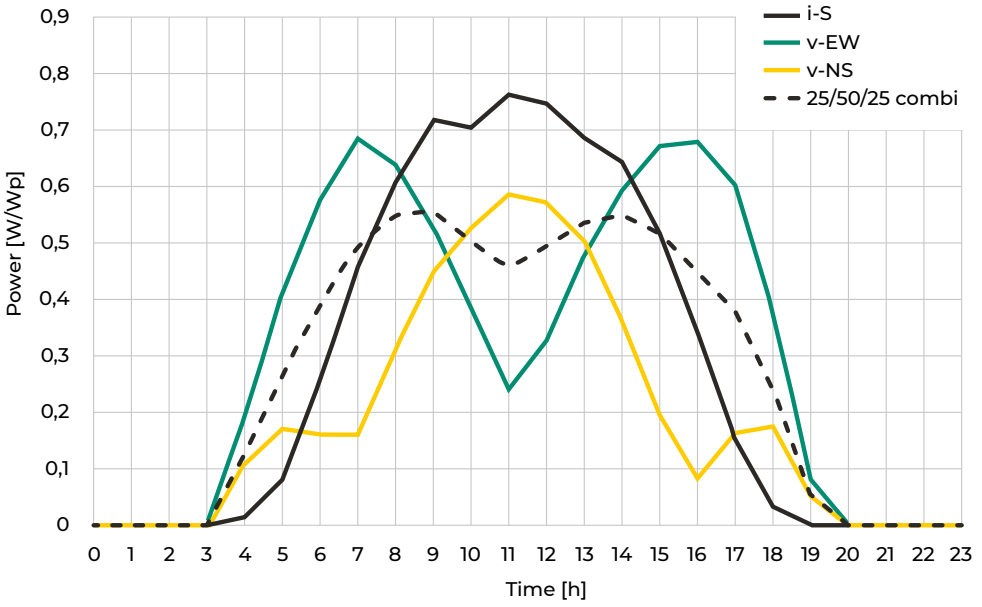


Figure 7. Daily electricity production profile, where: i-S – panels facing south, v-EW bifacial panels facing east-west, v-NS: bifacial panels facing north-south 25/50/25 combi – resulting characteristics with 25%, 50% and 25% share of installations, based on: [9]

New opportunities for agriculture

Droughts in Poland, caused by climate change, result in increasing problems for farmers. As reported by the Institute of Fertilization and Soil Science of the National Research Institute (IUNG- -PIB), water shortage for crops occurred in the entire country from 1 July till 31 August 2022. During the growing season – from 21 March to 31 August – water shortages were found causing yields to be at least 20% lower than those obtained under average weather conditions for numerous types of crops: spring cereals, winter cereals, rapeseed and agrimony, strawberries, fruit bushes, grain maize, silage maize, legumes, tobacco, ground vegetables, fruit trees, hops and potatoes.[15]

In the context of increasing water shortages, it is crucial to reduce evaporation through

[15] https://susza.iung.pulawy.pl/komentarz/2022,11/ (accessed on: 06 September 2022)

shading and to prevent wind erosion of topsoil. These are precisely the effects that can be achieved with AgriPV installations on farmland.

The spaces directly under the panels can provide a good place to create microclimates or for targeted planting.

In addition to droughts and other adverse weather events such as hail and storms, farmers also face economic challenges. Russia's invasion on Ukraine caused increased prices of energy and natural gas, and therefore of fertilizers produced using gas. These higher prices are a significant burden to the farmers' budgets. Manyfold price increases of fertilizers are a threat to continuity of agricultural production. Therefore, the right direction is to diversify the sources of revenue from farmland; AgriPV is one of possible solutions.

Moreover, AgriPV installations leave up to 95% of surface area available for agricultural production This means that for this type of installations the main agricultural function of the site remains unaffected[16], which is a strong argument in favour of keeping the direct payments for such land.

Apart from renewable electricity generation, a possible source of revenue for farmers in the longer term is the implementation of carbon farming practices.[17] [18] In simple terms, it is about sequestration of carbon dioxide (CO2) in the soil and selling carbon credits to companies obliged to demonstrate their carbon footprint reductions, for whom direct investments in emission reductions may be economically unfeasible. This solution certainly has a very high potential and farmers should receive specialized support in this field.

AgriPV ensures the most efficient, multifunctional use of farmland, especially with regard to energy transition and strengthening domestic agricultural producers. The benefits of integrating farming and AgriPV farms include:

- continued agricultural use of the site with simultaneous electricity production;
- reduced water evaporation;
- preventing soil erosion due to wind;
- new revenue opportunities for farmers, generation of clean electricity, carbon credits,
- new areas for electrification and automation in farming,
- smoothing the profile of electricity generation in the grid.

Given the complexity of integrating agricultural crops with electricity production, the most optimal solutions will be introduced by specialised operators capable of effectively combining agricultural and technology know-how. Synergies in the form of AgriPV will yield the best results provided that the overarching goal of research and projects is to ensure the long-term active use of agricultural land.

[16] Regulation (EU) no. 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) no. 637/2008 and Council Regulation (EC) no. 73/2009

[17] https://wyborcza.biz/biznes/7,147584,27861370,the-new-york-times-najnowszy-hit-w-rolnictwie-kredyty-weglowe.html?disableRedirects=true (accessed on: 01 September 2022)

[18] COWI, Ecologic Institute and IEEP (2021) Technical Guidance Handbook - setting up and implementing result-based carbon farming mechanisms in the EU Report to the European Commission, DG Climate Action, under Contract No. CLIMA/C.3/ETU/2018/007. COWI, Kongens Lyngby.

Kelfield.
Polskie Centrum Agrofotowoltaiki®

Kelfield was founded in 2019 by the von Wieding family, running a farm in Poland for the past 30 years.

The company develops renewable energy projects. Its main objective is to diversify the local agricultural production by using state-of-the-art solutions combining modern farming and energy transition trends.

Kelfield's team of experts combines experience and knowledge from renewable energy, including onshore and offshore wind, agriculture, and energy sector. Kelfield's pioneer project is the construction of an agrivoltaic farm with vertical support structures for bifacial PV modules.

Kelfield's innovative solution includes integration of zero-carbon solar power with agricultural production by developing AgriPV farm projects, allowing for over 95% of biologically active surface area to be maintained.

Complementing Kelfield's activities is the development of agrivoltaics (APV) in combination with carbon farming to offer new income opportunities for farmers and landowners.

9. Potential of Polish companies in the supply chain – case study of Energy5's solutions

Which AgriPV designs are worth choosing and what is the performance of such systems?

An example of an innovative approach would be structures that follow the movement of the sun, i.e. positioning the panels in the optimum position. The manufacturer of one such system – Energy5, a company based in Gostynin,

Photo 1:
Photovoltaic farm on Energy5 tracker

Poland – claims that its application increases energy yield by up to 30% compared to production from fixed structures. The system uses bifacial modules and trackers, moving the panels to the most favourable position in relation to the sun. The manufacturer highlights that, due to the relatively small number of assembly elements, the cost of building a large-scale project remains attractive.

A crop-specific PV system

PV trackers allow for a wide range of agricultural applications. The distance of the module above the ground and the distance between the rows of structures are selected individually, allowing the system to be adapted to the specific crop. Importantly, installation of the system is possible on any type of terrain. In the case of hilly areas, it is possible to produce the legs of the structure with different lengths and driving them in to different depths.

PV trackers are a good solution for crops that do not like strong or direct sunlight. PV modules mounted above the crops are intended to optimise their growth and protect them from heavy rainfall, wind and hail, but also from heat waves and excessive dryness.

Photo 2:
Energy5 PV tracker

PV tracker features and capabilities

A fully maintenance-free solar tracking system allows modules to be installed in a single row up to a maximum length of 98 m. The tracking system is controlled automatically with an algorithm based on the astronomical almanac and using sensors to monitor weather conditions.

Using a weather station allows for the wind speed and direction to be monitored in real time. When the critical values are exceeded, the station automatically forces the panels into a safe position. If heavy rainfall is detected, the trackers will switch automatic snow removal/cleaning mode and position the structures at an angle that allows the snow to slide off or the modules to be cleaned.

The intelligent mounting structure is also equipped with 3D backtracking, so that successive rows of modules do not cause mutual shading. This function allows the panels to be rotated to a position where the shadow cast is shorter and avoids subsequent rows, ensuring that the highest efficiency of the PV tracker is achieved.

The system sends alerts and alarms allowing for continuous monitoring of data such as: battery charge level, peak motor current, wind speed, axle lock, communication, motor overload.

Safety and durability of the system

The PV tracker is made of black steel with an anti-corrosive metallic coating. The research trials identified the optimal set-up of the tracker during normal and above-normal wind speeds using a set number of shock absorbers and their location. Importantly, the tests also confirmed the correctness of the PV module mounting in wind speeds of up to 120 km/h. The solar tracker has thus received a positive report from the Testing Laboratory regarding the structure's resistance to changing weather conditions.

The tracker was also tested in the company's measurement laboratory; the Energy5 solar system performed 22,000 duty cycles without fail, corresponding to 60 years of continuous tracker operation. During this time, all the components of the tracker responsible for its functionality were also observed. Energy5's first photovoltaic tracker has been installed on a solar farm in north-western Poland.

Energy5 is a company specialized in the design and manufacturing of photovoltaic structures, operating dynamically in Central and Eastern Europe. So far, the company has delivered systems for the construction of multi-megawatt solar farms, as well as rooftop installations with a capacity of nearly 4.5 GW. Energy5 has been operating in the market continuously for eight years. The company's annual production capacity is as high as 1,800 MW, which is achieved through its own machine parks. Modern plants, located in Central Poland, provide the company with full production independence and efficient order processing. The production of free-standing systems is based on high-quality steel with an innovative metallic coating which exhibits excellent corrosion protection properties - even in aggressive environmental conditions up to C5 corrosion class! The company's strategy is based on providing quality and safe PV structures, tested at leading test facilities. Proprietary solutions tailored to customers' needs are the result of advanced research and innovations implemented by the R&D Department. Energy5 focuses its activities on the development and modernisation of fasteners, adapting products to the ever-changing expectations of investors. It offers state-of-the-art technology such as solar trackers or elevated aerodynamic systems for flat roofs. With a system that follows the sun, solar yields can be increased by up to 30%!

10. Application of AgriPV solutions in the face of climate change

CO_2 emissions are a major factor contributing to global warming – this is the current scientific consensus. At the same time, CO_2 accounts for approx. 80% of all greenhouse gas emissions in the EU. Reducing carbon dioxide emissions into the atmosphere is therefore very important in the fight against global warming. Between 2017 and 2020, the EU's total CO_2 emissions followed a downward trend and fell by around 17%. However, as early as 2021, they increased by approximately 6.5% on the previous year, or by ca. 166 million tonnes. Poland was responsible for 15% of this growth.

It is worth noting that the largest single CO_2 emitter in the entire European Union is the power plant in Bełchatów. The Kozienice power plant is in 8th place on this list.

EU's priority in the coming years is an energy policy based on energy savings, improved energy efficiency and development of renewables. Development of PV installations is one of the ways to reduce greenhouse gas emissions. By decentralising energy sources, the country's energy security can also be improved.

PV power plants contribute to reducing CO_2 emissions in several ways. They use an inexhaustible source of energy – the sun. They don't use fuel, so there is no need to transport or store it, which translates into avoided emissions during transport. Good quality PV plant components have a minimum lifetime of 25 years, reducing the carbon footprint of production. The operation of this type of source itself does not have a major environmental impact. What's more, PV plants are resistant to extreme weather conditions. Low temperatures improve the efficiency of converting solar radiation into electricity, and the output does not drop significantly in hot weather. The temperature of a PV module in continuous operation can range from -40°C to as much as +85°C, so the panel is resistant to large temperature fluctuations that often occur with climate change.

Climate change is forcing a change of approach in the way farming is carried out.

By using the concept of agrivoltaics it is possible to combine two functions. AgriPV systems are based on the concept of harvesting solar energy and producing food from the same area, while maintaining fertile arable land and controlling the efficiency of PV farms and photosynthesis by managing the light reaching the plants.

The first photovoltaic farms were built in desert areas, where solar irradiation is the highest. At the time, no consideration was given to the use of space under the panels for growing plants. However, it has turned out, if only from Nagashima's research, that not all plants need strong direct sunlight to grow properly and can be successfully grown in partially shaded areas. This opens up the possibility of using the same area in a dual way, i.e. for simultaneous agricultural production and for electricity from PV panels.

In recent years, research into the selection of suitable plant species and defining the conditions for their cultivation on AgriPV farms has gained momentum. Its results show that certain types of plants grow even better in the conditions existing under the panels. Results

have already been implemented successfully for various types of crops. In South Korea, for example, broccoli grown in these conditions has a more intense green colour than those from traditional crops. In the US state of Colorado, carrots, tomatoes, garlic, beetroot and lettuce are successfully grown. It is worth mentioning that agrivoltaic crops need not be limited to plant species edible to humans. There are no obstacles to meadow-like cultivation, providing food for farm animals and a habitat for insects.

The structure itself is usually driven into the ground to a depth of approx. 1.5 m, without concrete foundations. Panel frame height and their spacing can easily be adapted to the type of crop. This allows for optimum shading and protection from excessive water evaporation from the soil, which in turn reduces the amount of water required for growth. "Covering" crops with panels also allows plants to be protected from the devastating effects of phenomena such as hail or strong winds that cause crop damage.

The wind load of typical support structures is 0.48 kN/m^2, and snow load – up to 1.5 kN/m^2. All components of a PV system have a certain degree of water resistance, and in the event of heavy rainfall over a prolonged period, the equipment is protected against the ingress of water and from electrical system failure. During an emergency situation, such as a flood, the installation is simply shut down.

The efficient use of the same area in two ways through the use of AgriPV seems to be the right direction for the future. It will make it possible not only to mitigate the adverse effects of climate change, but also to increase energy security and further improve the economic conditions of agricultural farms.

Source: BayWa r.e. AG, Tordesillas, Spain, 41.7 MWp, Tordesillas is a habitat for animals and vegetation; currently more than 500 sheep graze on the farm.

Alseva Group is one of the leaders in the area of renewable energy development in Poland – since 2015 we have been a provider of innovative solutions for the energy sector and actively support the green transition in our country. We specialise in large-scale PV farms, for which we provide professional services for the entire project at all its stages – we carry out all design and construction work exclusively with our own resources – both in terms of employees and equipment, allowing us to be 100% independent and deliver projects on time. Our market presence includes operating as a developer of renewable energy projects, as a general EPC contractor of large-scale solar power plants and energy storage, as well as an independent power producer from renewable energy sources. We are currently developing projects with a capacity of more than 7GW, of which a significant proportion are already highly advanced. We carry out orders for demanding clients, including key companies in the Polish energy sector – every year we commission new facilities with a total capacity of 150 MW. We offer support, knowledge, experience and strategic advice in every phase of project development and operation of PV farms with associated projects. Our largest project to date is a 60 MW facility located in Rzezawa (Bochnia County, Małopolska).

11. Case study of a project in Babberich, the Netherlands

Raspberry farm, Babberich, the Netherlands

The Netherlands is the clear European leader in the AgriPV sector. In the town of Babberich, on a 3.3-hectare farm, raspberries are successfully grown under a 2.67 MW commercial agriPV plant. The use of AgriPV increased the quality of the harvested fruit compared to conventional raspberry cultivation techniques using polytunnels, while still allowing the production of electricity. The Dutch Wageningen University also runs research into the use of AgriPV alongside soft fruit production, showing that equalization of temperature under the panels and improved evaporation and irrigation have a positive effect on the quality of the fruit produced.

Concept

Fruit growing is an important part of the Dutch agricultural sector. The local climate is conducive to a wide range of crops, from soft fruits such as raspberries and strawberries to apple and pear orchards. The same climate it is also a challenge for fruit growers, who have to protect their crops from extreme weather events such as heavy rain, hail or strong, direct sunlight. Furthermore, these extreme weather events are expected to increase due to climate change. Commonly used in the Netherlands, protective film-based structures protecting fruit crops often deteriorate due to weather events or everyday wear and tear, requiring

Photo 3: AgriPV on a raspberry farm, Babberich, the Netherlands.
Source: BayWa r.e. AG

regular replacement and disposal. This process is costly and time-consuming for farmers.

Due to the fact that orchard farms typically occupy relatively flat terrain, which is also a favourable location for PV, global renewable energy company BayWa r.e. decided to see if solar power generation and orchards could co-exist, bringing dual benefits.

Challenge

Identifying new opportunities for renewable energy generation is a key challenge for the renewables industry that the company seeks to respond to. AgriPV is certainly one of such solutions, allowing dual use of land and additional benefits for crops.

In 2019 BayWa r.e. with its Dutch subsidiary GroenLeven carried out a successful pilot of an AgriPV project on raspberry crops, and a year later a fully commercial project was launched at Piet Albers' fruit farm in Babberich. The project covered an area of 3.3 ha with 31,000 raspberry bushes. 10,250 PV panels were installed with a total capacity of 2.67 MWp, creating one of the largest AgriPV projects in Europe.

One of the advantages of PV installations mounted above crops is the increased protection against extreme weather conditions, such as heavy rain or gusty winds. However, the plants must still have access to sufficient sunlight and rainwater for proper growth and harvesting.

Taking these requirements into account, BayWa r.e. has developed a solution with unique translucent PV modules, allowing sufficient sunlight to pass through to the plants while maintaining the efficiency of the photovoltaic process. Monitoring during the Babberich project showed that the conditions under the panels provided good air circulation. The presence of the panels translates into lower temperatures around the plants and also protects the crops from adverse weather events.

Results

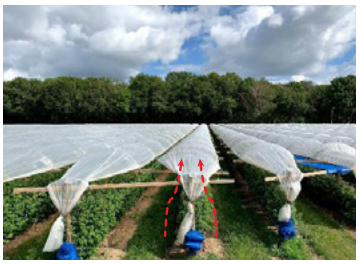
BayWa r.e.'s first AgriPV project of this scale in Europe generates enough electricity to cover the consumption of more than 1,200 households.

Piet Albers' farm has also established a partnership with Wageningen University in order to study the results on other crops. Redcurrant, blueberries, blackberries and strawberries were selected for testing. The test group consists of fruit grown under PV panels and the reference group are those grown in plastic tunnels.

The project is being implemented as part of the Dutch Innovation Programme and includes 4-year analyses of the effects of the presence of panels on microclimate, plant health and fruit growth.[19] The first results for the entire vegetation cycle indicate that equalisation of temperature under the panels and improved evaporation, transpiration and irrigation have a positive effect on fruit quality.

[19] LINK to Polish version of the video: AgriPV - the future of agriculture: https://youtu.be/gLcwJgwrcEU

Before **After** **Potential**



HIGH TEMPERATURES

LOW TEMPERATURES

Air circulation in crops protected by plastic sheets and using agrivoltaics.

Source:
BayWa r.e. AG

One of the biggest benefits shown in the study was a reduction in plant damage during high temperatures and about 24% less irrigation water used during July-August. The difference in raspberry production was only 5% in favour of the reference conditions, i.e. plant not growing under the panels. Considering the scale of the benefits – additional energy production or reduced evaporation from the plants – this is an exceptionally good result and confirms the validity of taking a closer look at the possibilities of agrivoltaics mounted above crops, also for other fruits.

Conclusion

BayWa r.e. is involved in further pilot and commercial projects, including apple and pear cultivation. Large-scale implementation of AgriPV projects provides support to the farmers in adapting to climate change and adverse weather events caused by global warming. The ultimate goal, however, is to demonstrate through research and monitoring of AgriPV projects that they actually improve fruit quality and reduce production costs.

BayWa r.e.

12. Examples of AgriPV installations in France

Fish farming – Mezos – the first AgriPV plant in France

In 2011, UNITe built and commissioned a facility that is a prime example of the synergy of agriculture and energy, implemented on a complex of fish ponds.

UNITe's partner, Europe's leading producer of farmed trout, has owned a complex of fish ponds in the Landes region of France since the 1970s. The installation of PV panels on the shading structure above the ponds is an excellent example of the synergy between the core activity, fish farming and secondary activities, i.e. renewable energy production.

The shade provided by PV panels offers numerous qualitative and quantitative benefits for fish farming:

- The shade prevents excessive heating of the water, which would be detrimental to the fish being reared and would also lead to harmful algae growth;
- Solar panels help avoid sudden variations in solar irradiation, which can stress the fish and affect their well-being and proper growth;

- Shading structures, complete with nets, protect trout from birds of prey that could reduce production or carry disease-causing agents;
- The fee paid by UNITe to the farm is an additional fixed and stable long-term income.

Characteristics of the Mezos plant:

- In an area of 8 hectares, the shading structures have a peak power of more than 4 MWp.
- The annual production is approximately 5,000,000 kWh/year, which corresponds to the consumption of approximately 20,000 inhabitants.
- This plant is operated by UNITe, which carried out the investment and maintains and operates the power plant.

UNITe and the fish farming partner are satisfied with their cooperation, which has confirmed the long-term synergy between the two companies' activities and the absence of conflicts in the use of space.

AgriPV aviaries – free range poultry farming

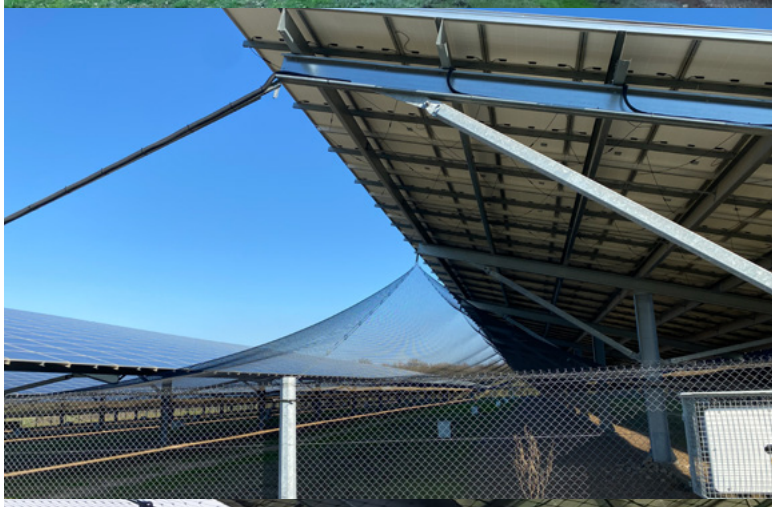
Free-range poultry farming requires protection, which is usually provided by nets installed quickly and cheaply, offering varying degrees of reliability.

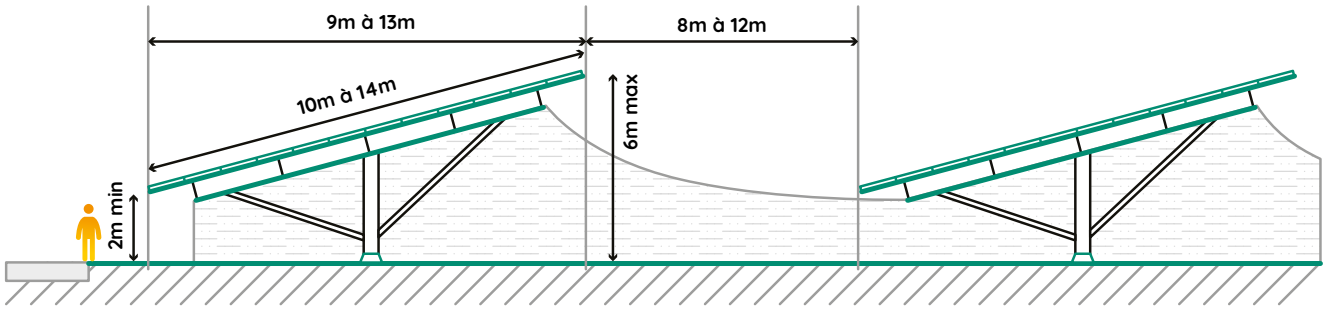
The purpose of this protection is to:

- Protect the birds from external predators;
- Protect the birds from intrusion of animals potentially carrying diseases such as bird flu.

Installing an AgriPV above the aviary has multiple benefits:

- Robust structures, resistant to adverse weather conditions, provide long-term protection;
- Shade allows birds to shelter from the sun, rain and high temperatures;
- Elevated location of panels improves animal welfare and working conditions of personnel;
- Protection from feces from birds flying above the aviary, potentially carrying infectious diseases;

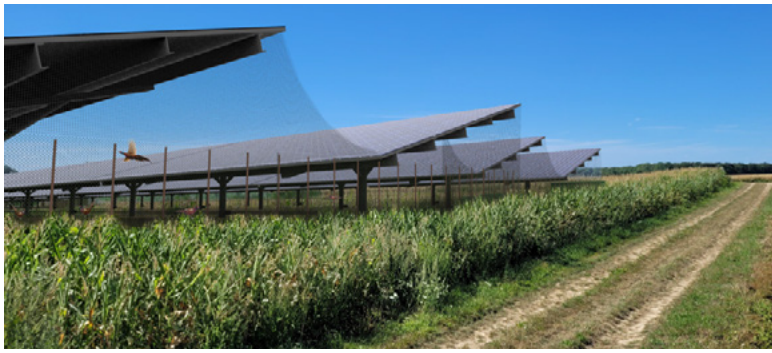




Electricity production is not the priority for this project, yet it provides tangible financial benefits:

- Self-funding for robust protective and shading structures;
- Additional revenue generated for the farmer by annual lease payments.

With more than 10 years of experience in looking for synergies between agriculture and energy, UNITe is one of French pioneers in AgriPV.



2022 12 Vidão TV7 Aqualande - UNITe

UNITe – a proven leader in renewable energy

UNITe is a leader in French renewable energy - for over 35 years we have been designing, building and operating hydro, wind and PV power plants. Being a socially responsible, proven partner for local agricultural producers, first in France, for more than ten years we have been successfully developing AgriPV projects, combining farming and husbandry with renewable energy generation. We currently operate 47 hydro power plants, 5 wind farms and 16 PV installations with a total installed capacity of over 120 MW and annual production of over 350 GWh of zero-carbon electricity.

13. Environmental protection

AgriPV and the environment

Biodiversity is of enormous importance to humans and the natural environment. Maintaining biodiversity can affect the quality of crops, air quality, circulation of elements or climate regulation. That is why it is so important for us to take actions to protect it.

Changes in agricultural land use in Poland have significantly affected the population of species of plants and animals related to the farming environment. In most cases, these numbers drop due to increasingly intensive farming, reduced landscape diversity and habitat loss. Removal of midfield trees and

shrubs, wastelands and boundary strips leads to increased fragmentation and degradation of these habitats. High level of intensive farming results in destruction or significant transformation of many natural ecosystems and contributes to appearance of new problems or exacerbation of existing ones. Agriculture combined with electricity generation is a possible response to some of these issues.

Supporting conventional agricultural production: perennial flower strips

Flower strips are linear, midfield plantings, aimed at supporting agricultural production and increasing biodiversity of farmland.

The character of the flower strips is reminiscent of the old field boundary strips. They are made up of long-lasting perennial flowering plants, mainly native species found wild in Polish nature. Flower strips are important compensation areas and valuable landscape elements with relatively high biodiversity. They are also an important tool in the protection of crops and fruit, providing, among other things, habitat (shelter and breeding site) and a source of food both for natural enemies (e.g. ladybugs, parasitic wasps, predatory bugs, birds) of crop pests and for wild plant-pollinating insects (solitary bees, bumblebees and many others). Flower strips help to maintain soil moisture by creating dense and shaded plant patches; they also improve the physical and chemical properties of the soil. They also form a barrier and natural filter for local pollutants associated with fertilisation of fields and the use of plant protection products.

Since 2023, planting perennial flower strips is subsidised under the Intervention: Biodiversity on arable land. In option 1, perennial flower strips can be created and maintained on arable land (3 to 9 m wide and with an area of at least 0.1 ha) sown with native herbaceous species (a mixture of at least 10 plant species). Sowing of the mixture should take place between 15 August and 31 October (in the year preceding the year of commencement of the commitment) or between 1 April and 15 May. The planned payment rate for perennial flower strip intervention is expected to be PLN 3,501 /ha.

Agricultural production supporting the environment: regenerative agriculture

Regenerative agriculture is a set of practices that focus to the same extent on achieving high yield results as on preserving the natural potential and respecting the ecosystem.

Regenerative agriculture uses of a number of elements of integrated, organic and precision agriculture. The main practices include no-till farming, growing plants for green manure and increasing water retention in the soil. The result is an accumulation of humus in the topsoil, an increase in the stability of the structure and the development of a macroporosity system, also in the deeper layers.

Farming practices to mitigate climate change in agriculture include the management of both land and livestock, all carbon resources in soils, materials and vegetation, as well as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) streams. Regenerative agriculture involves the removal of carbon (sequestration

and permanent storage of carbon in soil and biomass), emissions avoidance (preventing the loss of carbon already stored) and emissions reduction (i.e. reducing greenhouse gases below current farm emissions).

Agricultural production involving the use of elements of regenerative agriculture from 2023 will be supported by a new type of direct payment as so-called eco-schemes. Area eco-schemes will include:

1. Carbon farming and nutrient management (payment rates dependent on scoring by implementing some of the 8 available practices).

2. Areas with melliferous plants (estimated basic payment rate – approx. EUR 269.21/ha).

3. Conducting crop production under the system of Integrated Plant Production (estimated basic payment rate – approx. EUR 292.13/ha).

4. Biological crop protection (estimated basic payment rate – approx. 89.89 EUR/ha).

5. Water retention on permanent pastures (estimated basic payment rate – approx. EUR 63.15/ha).

Properly managed agriculture combined with carbon-free electricity production can have a positive impact on biodiversity and the ecosystem. Parallel rows of modules reduce wind speed at ground level and thus erosion and drying of the soil, and the shade provided by the installation can further counteract soil drying. Thanks to less water evaporation from the ground, but also by allowing rainwater collection, the need for irrigation and water consumption can be significantly reduced. Agrivoltaics appears to be an attractive alternative to conventional agricultural production, but the real environmental impact needs to be researched and assessed in terms of the impact on the different animal groups of the rural landscape in order to draw reliable conclusions.

Kwietna Foundation is a non-governmental organisation aimed at increasing biodiversity, protecting Polish nature and adaptation to climate change. We specialise in nature-based solutions (NBS), consult on projects and network business representatives, experts and contractors of green initiatives.

We support companies with ESG strategies and the implementation of pro-sustainability initiatives. We help create biocenotic gardens, flower meadows, pocket forests, rain gardens and nesting aids for wild pollinators.

Together with other NGOs and the media, we implement social campaigns and change our environment for the better.

We cooperate with European companies in the large-scale solar energy industry generating clean green energy, who can also provide actual support for the environment. PV farms on agricultural and former industrial sites are an environmentally friendly alternative to intensive farming and land degradation. Properly implemented investment projects significantly increase biodiversity by providing rich and diverse habitats for bees, butterflies, birds and other small fauna. Large-scale PV farms have a positive impact on soil quality, and appropriately selected plant species accelerate the regeneration process, including phytoremediation, i.e. the purification of soil from undesirable substances and elements.

Please contact us to jointly design and implement green solutions for the PV industry.

14. Experiences in AgriPV project development in Europe and worldwide

Q&A with Mor Yigaely – Head of Agrivoltaic at Shikun & Binui Energy

Poland is only planning to develop AgriPV, but globally the development of AgriPV is already very advanced. **Shikun&Binui** is Israel's leading infrastructure and real estate company – a global corporation that operates through its subsidiaries in Israel and across the world.

Active in more than 20 countries on four continents, Shikun & Binui is involved in various fields, including Arivoltaics development. **Mor Yigaely** heads the Agvoltaic at Shikun & Binui and is responsible for developing and implementing AgriPV projects worldwide

How long has Shikun&Binui been involved in the development of agrivoltaic projects? How many projects are in operation and under development? What are the plans for further growth?

In the last two years Shikun & Binui develops APV in Israel and worldwide. We won a tender of minister of agriculture and energy in Israel on 37 projects (more the 600 dunam, 21 different type of crops with 7 research institutes). More than that we develop more 8 large projects in

Israel in the next upcoming years. We develop more projects in EU (Italy and Romania) and USA. We have our own experiment AgriPV site. We see it with no limits but we have to do it smart way – type of crops, scale up correctly and chose the right tech – energy and agri. That is the future for climate, energy, agri and land as a limited resource. We believe that we will see more countries choose this solution.

In which countries is AgriPV developed? How do you assess the experience in these countries?

I observe an increase in commercial Agrivoltaics plants since 2014. In 2020, there have been approx. 2,800 APV plants in operation, with the total installed capacity of approx. 3 GW. This is still below 1% of the PV capacity installed globally. APV is most developed in East Asia: Japan, China, South Korea. Western countries leading in APV are France, Germany, Italy, and some states in the US. There is also an ongoing discussion on the APV development in India, Germany, the Netherlands, Switzerland, Austria, Fiji, and California state. APV development in further countries depends on the regulatory framework. The experiences with APV in different countries depend on the regulatory framework that the governments give us. Also on the price that we can get on such APV projects.

What are the differences between AgriPV projects and classic PV projects?

In AgriPV projects, we need to combine PV power generation with agricultural production. Agrivoltaic solutions should serve agricultural production by, for example, protecting crops from hail and other adverse weather conditions. AgriPV technology must be adapted to such needs. For example, in the case of agrivoltaics combined with animal husbandry, special types of fencing and inverters must be installed to be safe for the animals. All these factors influence each other and must be synchronised, which goes beyond the scope of classic PV projects. The special features of agrovoltaics affect the operational costs of the project – which is why the operation and maintenance costs are higher compared to classic PV projects. This is the cost we have to bear in order to benefit from AgriPV solutions.

How is the development of agrivoltaics supported?

There are research institutes with which we cooperate on APV projects development. But apart from that, we also implement commercial APV projects.

What solutions work best in AgriPV projects?

We develop APV projects over different types of crops: big scale open field projects, projects on orchards. For each individual project there is a tailored suit. One needs to combine an appropriate type of crops, plus environmental and regulatory aspects. To create a great APV project you have to use different types of discipline – that way you can find the balance.

What challenges do you face when developing agrivoltaic projects?

These are mainly related to higher development and operation costs and the many technical solutions that we need to implement to adapt to the needs of farmers (tools, machinery, etc.). There is a customised set of solutions for each project, with some projects simply requiring more specific adaptations than others.

What solutions would you recommend (e.g. regulatory or other) to facilitate the implementation of agrivoltaic projects?

Quick and simple regulations, better price for electricity. On top of that, subsidies for agrivoltaic research institutes involved in the development of such projects, contributing to the improvement of applied technologies and solutions.

Which countries do you think will be the next targets for further development of AgriPV? What characteristics make a location attractive for such projects?

We check out new countries all the time. Key factors include the regulatory environment, climate (relevant to the type of crops we can work with – currently we do not work with all types of crops) and price efficiency.

Interview in cooperation with Clifford Chance.

CLIFFORD
CHANCE

SHIKUN&BINUI
Energy

The Polish Photovoltaic Association
Zlota 59/632
00-120 Warsaw, Poland

NIP: 9291994664; KRS: 0000781325; Regon: 383070564