AgriPV Systems

short payback period even without subsidies!

GRID PARITY
next generation photovoltaic

All systems comply with DIN SPEC 91434

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

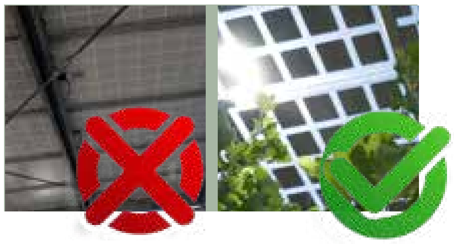
www.agripv.de

AGRI PV
brand of GridParity AG

We defy climate change & produce the electricity for the energy transition!

AgriPV fact check

AgriPV is more than a few modules elevated!
Photovoltaics on agricultural land must take into account that without a minimum amount of light, sufficient growth in crops is not possible. This fact is underestimated by quite a few suppliers. Standard modules let practically no light through and even fully occupied double glass modules only about 5 % and not 15 % as is often claimed. Depending on the plant species, a light quantity of 50 - 80 % must therefore be available (see p. 7 - *no growth without light*).



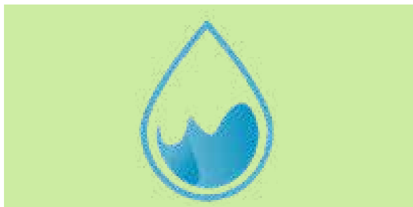
DIN SPEC 91434 specifies the criteria!
DIN SPEC 91434 was adopted to prevent the risk of improper designation of unsuitable plants with the term Agri-PV and to minimize associated deadweight losses and Agri-PV acceptance losses among the general public. Banks and licensing authorities require compliance with it. Our plants meet the requirements. We assist in the development of the prescribed agricultural use concept.

AgriPV is part of the agriculture of the future!
Climate change places particular demands on agriculture through drought and extreme weather events such as hail and heavy rain. Without protection, such an event can destroy the entire crop and often livelihood in a matter of hours. AgriPV (high) offers at least partial protection and optimizes production conditions by potentially reducing the use of water and sprays.

AgriPV can help reduce climate anot!
AgriPV (high) offers plants protection from excessive solar radiation. What we are experiencing in Germany today is only a small foretaste of the developments to come. The German Weather Service has determined not 1.5° but 3.5 - 5.9 ° in its long-term forecast credible. From 2070 on, the hot summer of 2022 will seem cool to our children and they would wish for it.

AgriPV can revitalize abandoned farmland!
According to a conservative estimate, 10 million hectares of agricultural land in southern Europe can already no longer be farmed using traditional agricultural methods. Irrigation is no longer sufficiently possible due to the lowered water table, as the weather immediately evaporates the water. Drip irrigation under AgriPV saves up to 95% of the water and allows the soil to recover through cultivation.

AgriPV can help solve the water shortage!
In 2 case studies, we have investigated the extent to which AgriPV systems can also contribute to water harvesting by making water collected from rooftops available for storage on other land. The presentations break new ground - nothing has yet been built in this direction. But the concepts are at least plausible and first farmers are thinking about investing in such plants.



AgriPV is self-financing!
This is perhaps the most interesting aspect of all the necessary investments for climate protection. Most of the investments can be financed by the energy obtained free of charge, quasi as „by-catch“. Think of the fruit farmers whose fruits are often completely destroyed by hailstorms or the farmer who lets his apple harvest rot because he can no longer finance the costs for 6 months of cooling until the sale in spring. Both can solve their problems with AgriPV and help our society out of the energy emergency.

AgriPV, the future of agriculture!

10 years of experience: solar energy generation, tested in the hot climate of Egypt

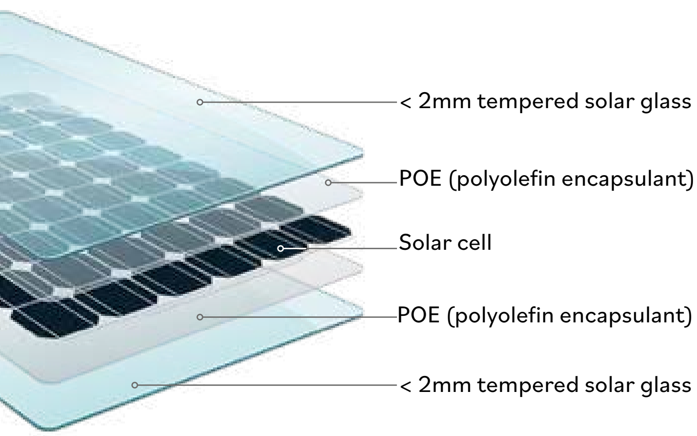
Heliopolis University (development in 2013)

- 15 kWp with 84 Almaden Premium Glass- Glass Modules M40
- 40% transparency provides optimal light transmission for plant growth
- 3-4 harvests per year
- Direct use of electricity for water pumps and desalination plants

Wahat Desert, Egypt (construction in 2014)

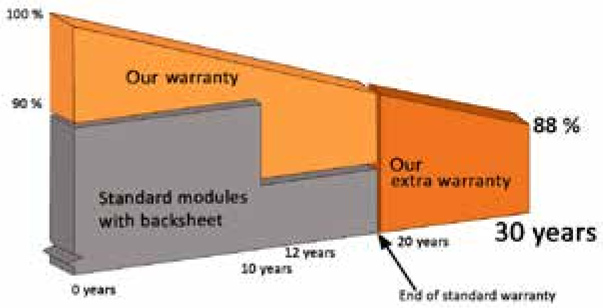
- 53 kWp with Almaden Premium Glass- Glass Modules M40
- 40% transparency provides optimal light transmission for plant growth
- 3-4 harvests per year
- Power generation is sufficient for the operation of 2 Lorentz pumps of 15 hp and 25 hp
- The water pumped from great depth (pump 1) is pumped directly into the desalination plant (pump 2)

2 mm tempered solar glass with extremely durable anti-reflective coating



Outstanding features of our modules

- Slim Module Design - Ultra Thin - Ultralight
- Highly transparent double glass design
- Excellent wind/snow resilience performance
- Resistant to environmental influences
- Easy cleaning
- Highest resistance to microcracks
- Fire resistance
- Excellent performance in low light
- Extended warranty
- Positive power tolerance (plus sorting)
- PID free



MADE IN EUROPE

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Test report EN12600

German Quality Engineering

MADE IN EUROPE

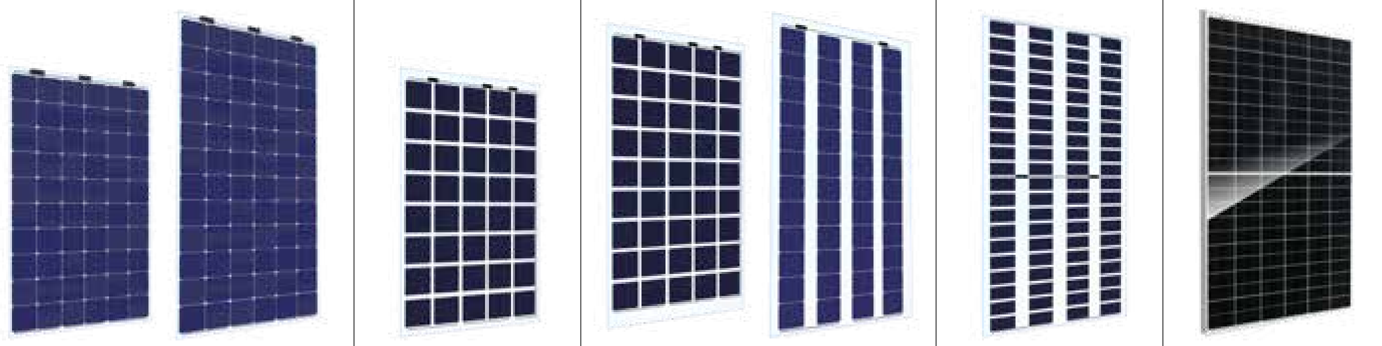
Our premium double glass modules

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

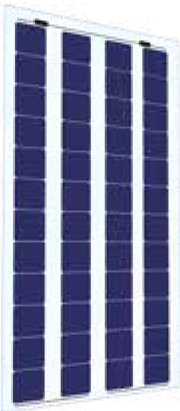
25 JAHRE PRODUKT-GARANTIE

Lifetime 30 YEARS Guarantee

The right degree of transparency for every plant



5%		35%	40%		50%	TrackerPV
B60/6 (370Wp) **1765 x 1043 mm**	B72/6 (450Wp) **2000 x 1002 mm**	B40 (250Wp) **1684 x 1002 mm**	B45 (275Wp) **2000 x 1002 mm**	B48/6 (300Wp) **2105 x 1043 mm**	B80-HC (250Wp) **2105 x 1043 mm**	B132-HC (670Wp) **2384 x 1303 x 35 mm**



ca. 40% transparency

B48/6 (300Wp)

Art.Nr: M2430

Mechanical specifications	
Solar cells	Bifacial, 9BB
Number of cells	48 (4 x 12)
Dimensions	2105 x 1043 x 5 mm
Weight	26 kg
Fire protection	class C

Electrical specifications	
Maximum power (Pmax)	300 Wp
Optimum operating voltage (Vmp)	29.7 V
Optimum operating current (Imp)	10.11 A
Open circuit voltage (Voc)	34.2 V
Short circuit current (Isc)	11.26 A
Maximum system voltage	1500 V DC (IEC)
Maximum series protection	20 A
Power tolerance	0/+5 W

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

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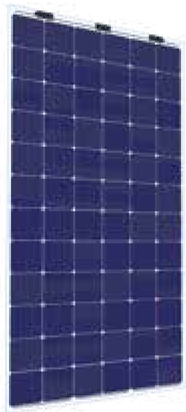

ca. 5% transparency

B72/6 (450Wp)

Art.Nr: M2745

Mechanical specifications	
Solar cells	Bifacial, 9BB
Number of cells	72 (6 x 12)
Dimensions	2105 x 1043 x 5 mm
Weight	26 kg
Fire protection	class C

Electrical specifications	
Maximum power (Pmax)	450 Wp
Optimum operating voltage (Vmp)	44.5 V
Optimum operating current (Imp)	10.11 A
Open circuit voltage (Voc)	51.0 V
Short circuit current (Isc)	11.33 A
Maximum system voltage	1500 V DC (IEC)
Maximum series protection	20 A
Power tolerance	0/+5 W

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

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ca. 35% transparency

B40 (250Wp)

Art.Nr: M2325

Mechanical specifications	
Solar cells	M6 Bifacial, 9BB
Number of cells	40 (5 x 8)
Dimensions	1684 x 1002 x 5 mm
Weight	20 kg
Fire protection	class C

Electrical specifications	
Maximum power (Pmax)	250 Wp
Optimum operating voltage (Vmp)	24.8 V
Optimum operating current (Imp)	10.08 A
Open circuit voltage (Voc)	28.4 V
Short circuit current (Isc)	11.1 A
Maximum system voltage	1500 V DC (IEC)
Maximum series protection	20 A
Power tolerance	0/+5 W

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

CE MADE IN EUROPE

ca. 40% transparency

B45 (275Wp)

Art.Nr: M2427

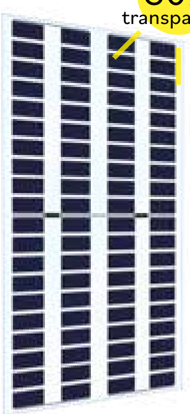
Mechanical specifications	
Solar cells	M6 Bifacial, 9BB
Number of cells	45 (5 x 9)
Dimensions	2000 x 1002 x 5 mm
Weight	24 kg
Fire protection	class C

Electrical specifications	
Maximum power (Pmax)	275 Wp
Optimum operating voltage (Vmp)	27.5 V
Optimum operating current (Imp)	10.0 A
Open circuit voltage (Voc)	31.6 V
Short circuit current (Isc)	10.28 A
Maximum system voltage	1500 V DC (IEC)
Maximum series protection	20 A
Power tolerance	0/+5 W

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

CE MADE IN EUROPE

ca. 50% transparency



B80-HC (250Wp)

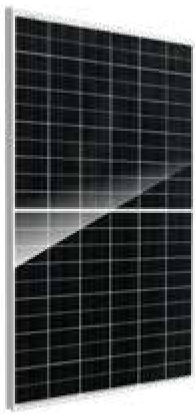
Art.Nr: M2825

Mechanical specifications	
Solar cells	Halfcut Bifacial, 9BB
Number of cells	80
Dimensions	2105 x 1043 x 5 mm
Weight	26 kg
Fire protection	class C

Electrical specifications	
Maximum power (Pmax)	250 Wp
Optimum operating voltage (Vmp)	23.1 V
Optimum operating current (Imp)	10.82 A
Open circuit voltage (Voc)	27.7 V
Short circuit current (Isc)	11.36 A
Maximum system voltage	1500 V DC (IEC)
Maximum series protection	20 A
Power tolerance	0/+5 W

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

CE MADE IN EUROPE



B132-HC (670Wp)

Art.Nr: M4667

Mechanical specifications	
Solar cells	Halfcut Bifacial, 9BB
Number of cells	132
Dimensions	2384 x 1303 x 35 mm
Weight	38.7 kg
Fire protection	class C

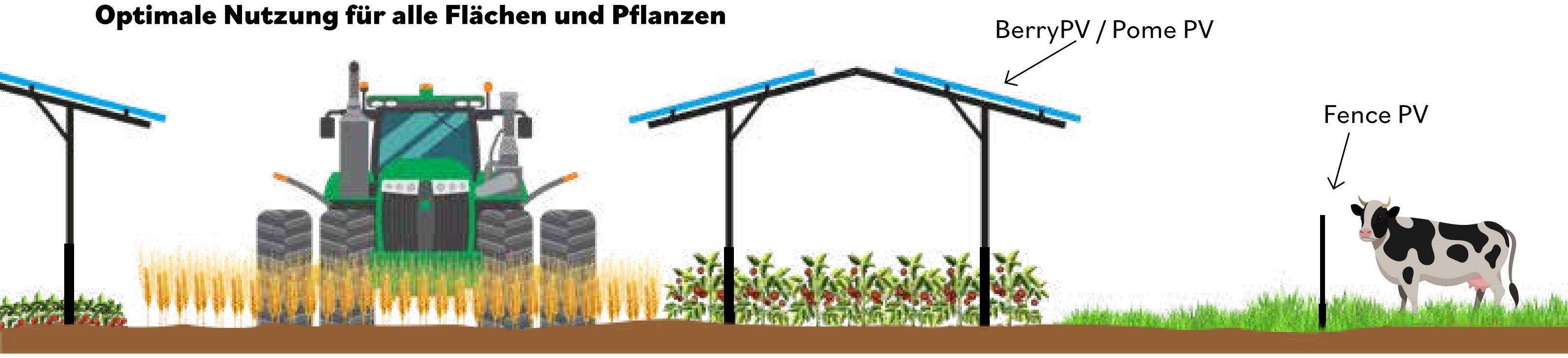
Electrical specifications	
Maximum power (Pmax)	670 Wp
Optimum operating voltage (Vmp)	38.4 V
Optimum operating current (Imp)	17.45 A
Open circuit voltage (Voc)	45.9 V
Short circuit current (Isc)	18.62 A
Maximum system voltage	1500 V DC (IEC)
Maximum series protection	30 A
Power tolerance	0/+5 W

CERTIFIED DOUBLE GLASS MODULES ACCORDING TO EN12600 FOR OVERHEAD MOUNTING

CE MADE IN EUROPE

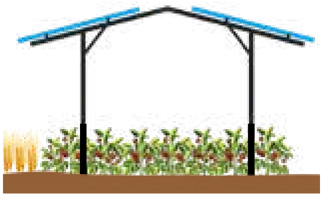
GridParity AgriPV: As Versatile as Agriculture

Optimale Nutzung für alle Flächen und Pflanzen



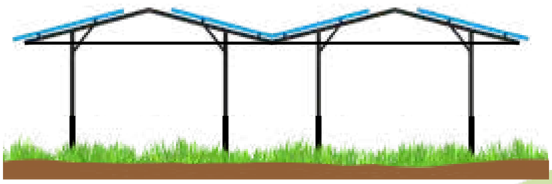
AgriPV systems can increase yields. While fruit and vegetable plants thrive protected under the AgriPV racks, normal farming operations can continue and at the same time electricity is generated with the help of the PV modules. This electricity can in turn be used for cold storage or electrically powered tractors and harvesters, among other things.

1 BERRY PV & POME PV



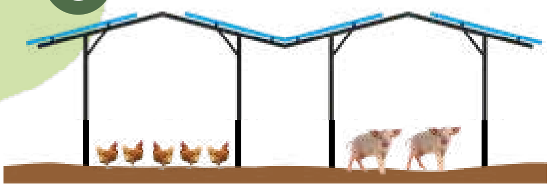
elevated AgriPV plants for protected cultivation of fruits and vegetables with double glass modules in different degrees of transparency

2 FIELD PV



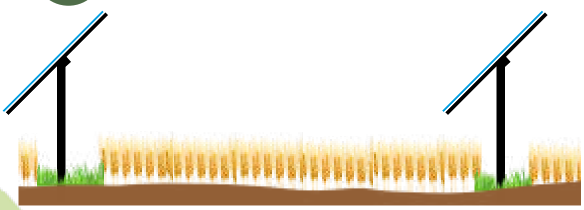
elevated AgriPV systems for large field plantations with robust and transparent double glass modules for protected crop cultivation and simultaneous energy generation.

3 ANIMAL PV



elevated AgriPV systems for protected animal housing with transparent double glass modules

4 TRACKER PV



tracker systems that follow the sun during the course of the day and thus generate optimal electricity yields. At the same time, large harvesting machines can drive between the individual trackers and cultivate the arable land. Ideal also for animal husbandry.

5 FENCE PV

PV fences with bifacial double glass modules. Well suited for fencing livestock pastures or energetic enhancement of green areas. At the same time, large harvesting machines can pass between the fence rows.

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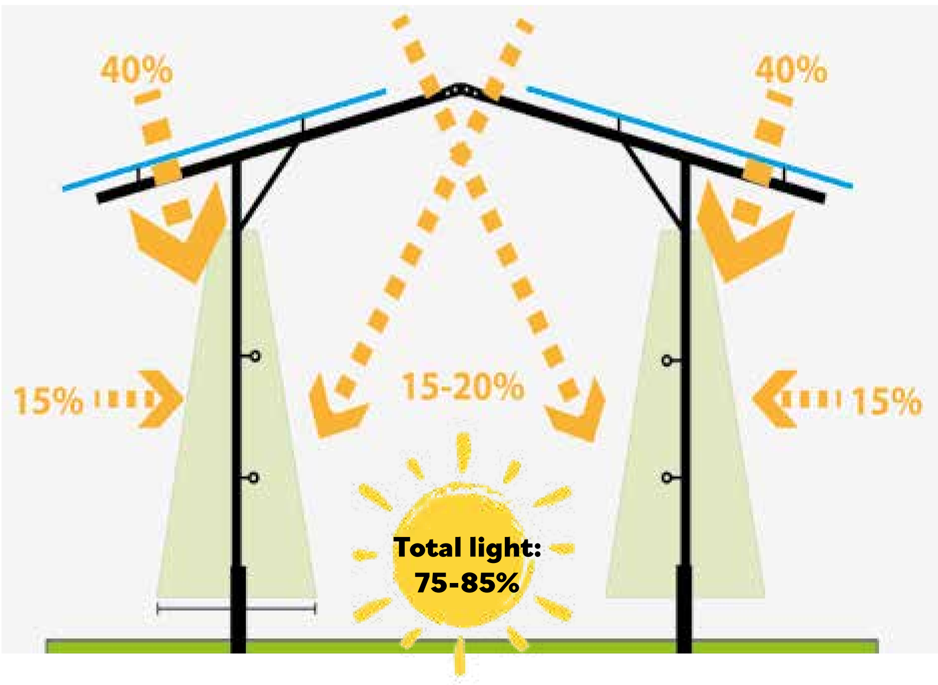
German Quality Engineering

AgriPV: No growth without light!

For a long time, the reservations of farmers and fruit growers were about the reduction in the amount of light available to the plants caused by the PV modules. Too little attention was paid to the fact that there are large differences in the amount of light required depending on the type of plant and its cultivation. We have made a rough categorization in the table below.In general, it is true that due to climate change, more and more plants can no longer tolerate full sunlight at all and must be protected from too much sun on a large scale, e.g. by foil tunnels.Further differences exist in the growth cycle. Young plants, for example, are usually very sensitive to too much (UV) sunlight and thrive better when shaded. However, even berries that need a lot of sun according to the table have produced a net yield that is about 6 percent higher than conventional raspberry cultivation under foil tunnels in practical tests on a 3.3-hectare raspberry farm in Babberich, the Netherlands.

Less sun	**Intermediate range**	**Medium sun**	**Intermediate range**	**Strong sun**
Field crops: e.g. potatoes, beets, beans	Onions, cucumbers, zucchini	Rapeseed, oats, carrots, cabbage	young plants, berries, pome fruit, stone fruit	Wheat, corn, sunflowers, pumpkins



A further finding from the many scientific studies on the subject of AgriPV is the fact that when there is sufficient water, shading leads to lower yields for many arable crops, but when there is drought, the opposite effect occurs. This is related to the fact that when there is sunlight, plant growth is enhanced. Plenty of light ensures high biomass yields. However, under intense sunlight with high evaporation rates and low precipitation, this turns into the opposite. Plants stop growing to survive.When shaded, e.g. by AgriPV, many plants increase the growth of their photosynthetically active aboveground leaf material to compensate for the reduction in light. This explains that in vegetables and lettuces, for example, AgriPV shading provides benefits because the aboveground portion of the crop is economically attractive. Berries, fruits and fruiting vegetables (e.g. zucchini, eggplants, peppers) benefit from shading by elevated AgriPV.As a conclusion, it can be stated that most plants tolerate shading up to about 15 % without significant yield losses.This roughly corresponds to the climatic fluctuations of different crop years.At a higher shading than 20 %, the yields of the following crops suffer: forage crops, leafy vegetables, tubers and root crops, as well as most cereal species.

1 BerryPV & PomePV

Case study: Solar power above the apple orchard in Kressbronn

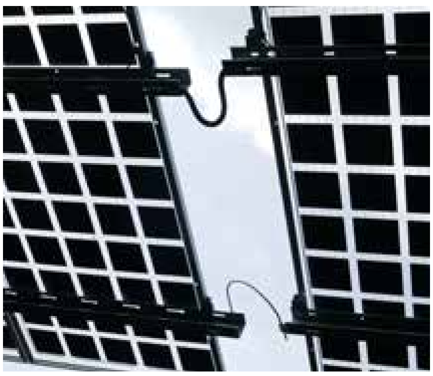
The Agri-PV pilot plant above the apple orchard of the Bernhard fruit farm consists of a metal framework

on which solar modules are mounted. These are particularly stable Almaden double-glass modules with a transparency of approx. 40%. The green electricity generated is fed into the grid of the energy provider Regionalwerk Bodensee. „Agri-photovoltaics is a great opportunity for agriculture, sustainability and energy supply,“ said Minister President Kretschmann, who attended the inauguration of the plant. It provides protection against weather events such as hail, heavy rain or night frost. The system is also designed to reduce the use of pesticides, plant diseases and pest infestations.

up to 1080 MWh per ha p.a.

In the first construction phase of the AgriPV project in Kressbronn, more than 1100 Almaden M50 double-glass modules with 40% transparency were installed. In further construction phases, more powerful modules or modules with higher transparency will be used. The experience so far has been very positive both in terms of electrical yield and fruit growth. Based on this, the fruit company is already planning another plant on up to 7 hectares in the surrounding area.

easy fixation of tension wires.



Simple electrical connection of the module tables

Safe mounting of inverters

AgriPV for the future of fruit growing

AgriPV for fruit and horticulture

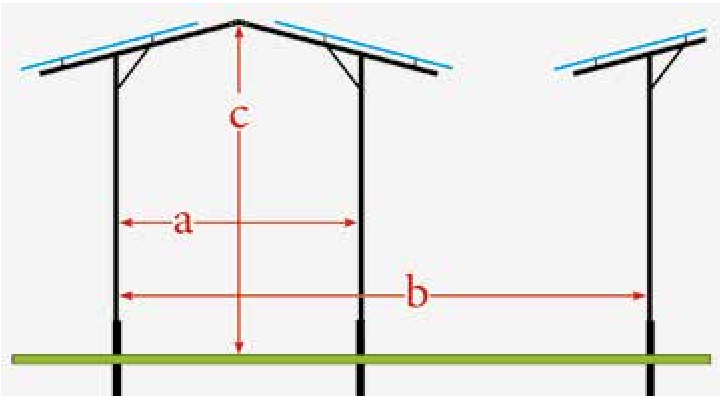
The row spacing is mainly determined by the type of fruit grown, and the division into two groups has proven itself in practice:Lower elevations for berry crops or horticulture and higher elevations for tree crops such as pome or stone fruit crops.For both types of installation, the row spacing is 5-6 m, so that the high connected loads per hectare (ha) shown in the table below also result here.

Row width in m	5	6
Rows per ha	20	17
kWp/Row*	55	55
KWp/ha*	1.100	917

*Basic: B48-300 Wp modules with 40% transparency

Row width (m)	5	6
Power yield kWh per ha*	1.083.500	902.917
Power yield/ha at € 0.18 kWh	€ 195.030 p.a.	€ 162.525 p.a.
Amortization of the investment in years	5,8	6,9
*Lake Constance area 985 kWh/kWp		

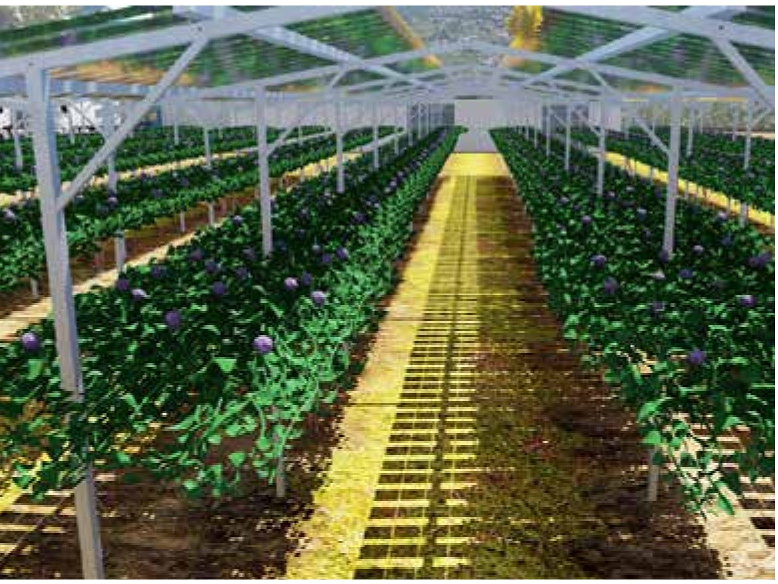
The use of bifacial modules even results in additional yields of 10-15 %.A system above a pome fruit orchard (e.g. apple trees) yields approx. 985 kWh/KWp in the Lake Constance area and over 1200 kWh/KWp in South Tyrol.



Standard dimensions: a = 3m
c = 3,1 m (BerryPV); c = 4 m (PomePV)

The row width **(b)** is chosen to match the plantings. At 5m, the racks are close together.

Eggplant cultivation



Peaches cultivation

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AgriPV in fruit growing

Pear cultivation

Cultivation of pomegranates

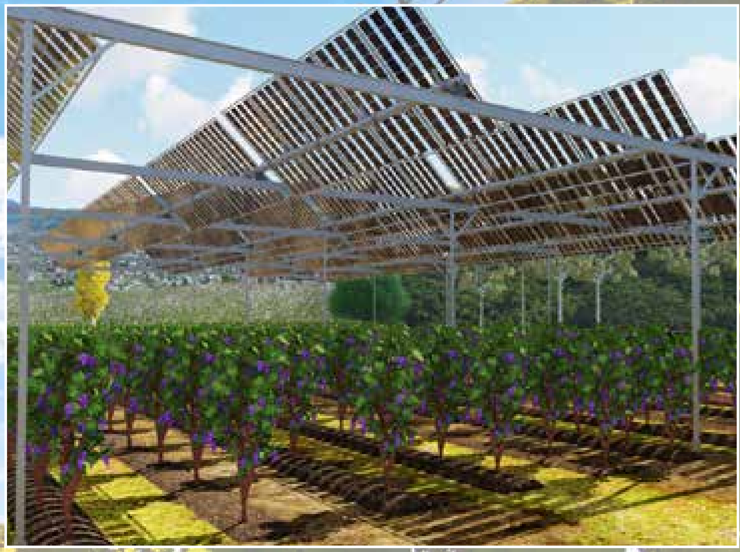
Bergamot cultivation

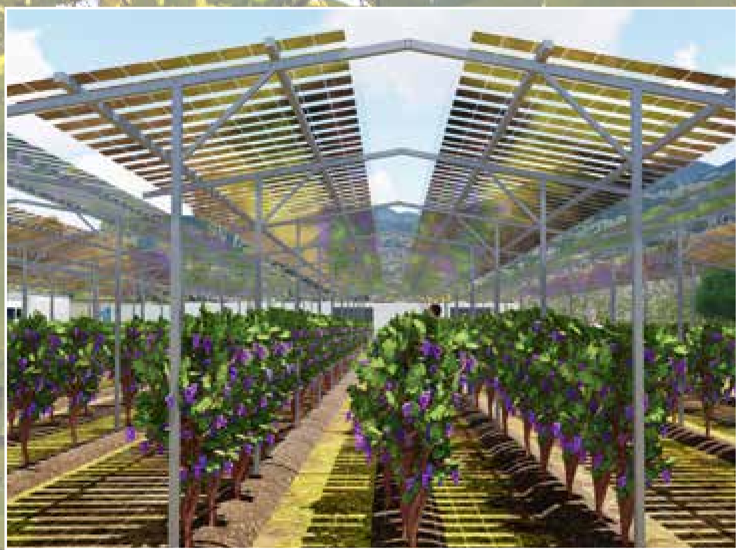
Blueberries cultivation

Almond cultivation

Passion fruit cultivation

AgriPV in viticulture





② Field PV - ST (up to 7m span)

up to 1400 MWh per ha p.a.

Example: Cabbage cultivation

Ideal for growing crops
Our FieldPV includes two variants depending on the desired width of use:

VARIANT 1

The ST system allows a width of use of 7 m. 2 double rows with our B40/6 modules are used to allow a high light transparency

Partial shading results in agricultural yields that, in many cases, are higher than in comparison fields without FieldPV systems due to protection from climate extremes.

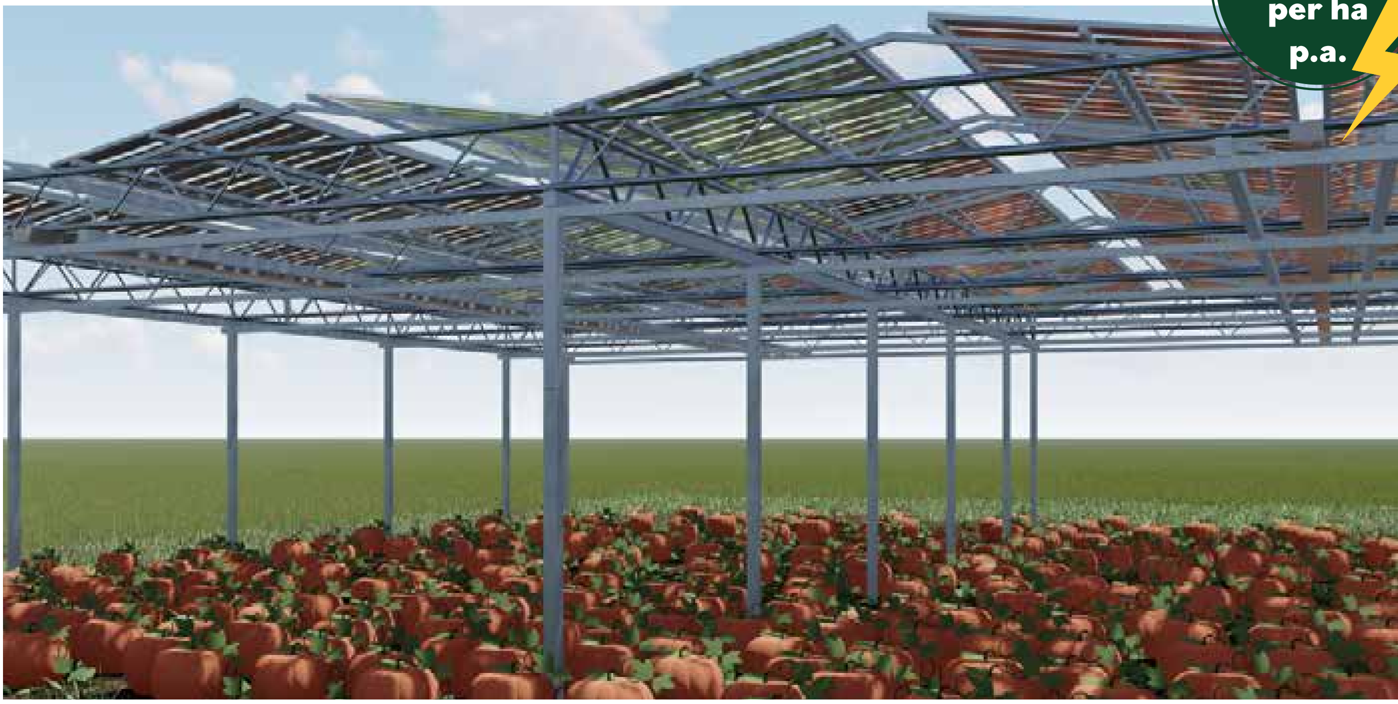
FieldPV -ST	
Distance between rows in m	7
Number of rows/ha*	14,3
KWp/row	92
Modules/ha	5257
KWp/ha	1.314
Costs in € / kWh**	0,049

* Length of the row 100 m
** for a term of 20 years

suitable for many types of vegetables and fruits, depending on the selected degree of transparency of the modules:

Field PV - GT (up to 10m span)

up to 1400 MWh per ha p.a.



Example: pumpkin farming

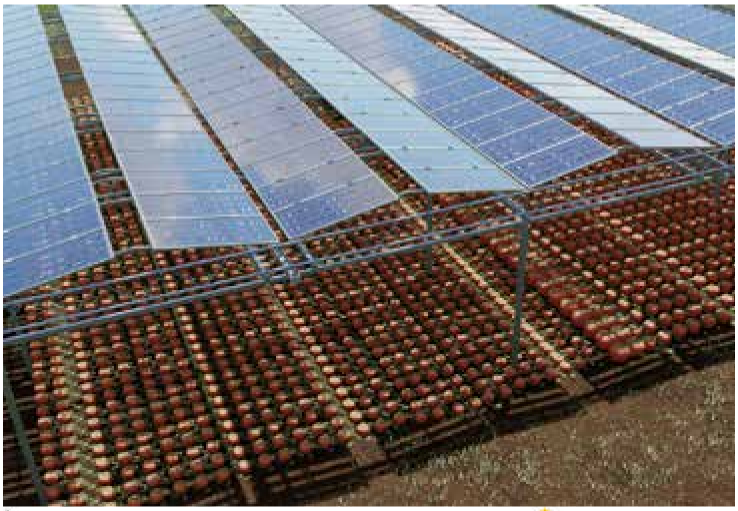
VARIANT 2

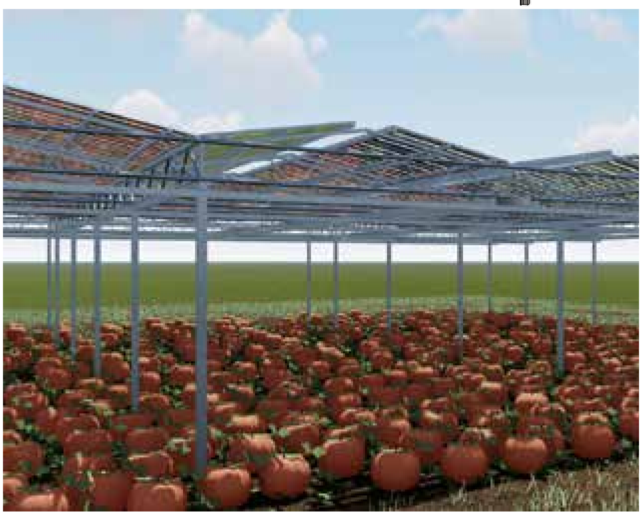
The GT system allows a use width of up to approx. 10 m. 2 double rows with our B48/6 modules are used to enable high light transparency

The wide rows allow the use of many harvesting machines and thus high agricultural productivity. The partial shading leads to agricultural yields that are in many cases higher than comparative fields without FieldPV systems due to the protection from climate extremes.

FieldPV -GT				
Distance between rows in m	7	8	9	10
Number of rows/ha*	14,3	12,5	11,1	10,0
kWp/row	92	92	110	110
Modules/ha	5257	4600	4089	3680
KWp/ha	1.314	1.150	1.227	1.104
Costs in € / kWh**	0,049	0,050	0,050	0,051

* Length of the row 100 m
** for a term of 20 years





3 Animal PV

up to 1500 MWh per ha p.a.

1.1 ha chicken outdoor enclosure with barn and water supply: 5 m row spacing, 1,100 kWp/ha, investment without grid connection approx. € 1,265,000, electricity yield p.a. up to 1,160 MWh = € 232,000 at € 0.20 kWh. Rainwater harvesting in Brandenburg (590 mm precipitation) 5,300 m³ water surplus p.a., sufficient for 2.5 ha irrigation.

Pig farming

Turkey farming

Fish farm

Experience area plant cultivation

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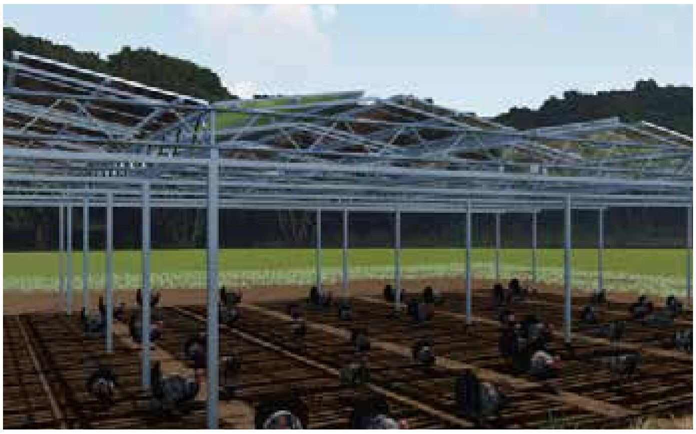
Animal PV

up to
1400 MWh
per ha
p.a.

1.1 ha shelter for cattle with barn and water supply: 10 m row spacing, 1,100 kWp/ha, investment without grid connection approx. € 1,265,000, electricity yield p.a. up to 1,160 MWh = € 232,000 at € 0.20 kWh.Rainwater harvesting in Brandenburg (590 mm precipitation) 5,300 m³ water surplus p.a., sufficient for 2.5 ha irrigation.

More examples of our AnimalPV installations:



4 Tracker PV

High consistent yield

Unlike, for example, a fence system with vertically mounted modules, the continuous alignment to the sun results in a relatively uniform yield profile as well as a significantly higher output of up to 30%.The control can be done separately for each row and places the modules in a vertical position, e.g. for tillage or harvesting. A wind sensor moves the modules to a horizontal position in the event of a storm. The inverters are normally placed in the middle of each row.The solid design of all components allows a warranty of 20 years with regular maintenance!

Tracker PV	Distance between rows				
Distance between rows	6	8	10	12	14
Number of rows/ha*	16,7	12,5	10,0	8,3	7,1
KWp/ha	793	595	476	396	340
Modules/ha	1183	888	710	592	507
MWh per ha p.a.	1,340	1,004	0,804	0,670	0,575
Costs in € / kWh**	0,025	0,030	0,033	0,035	0,039

* Length of the row 100m ** for a term of 20 years

Powerful bifacial modules

Our AgriTrackers are optimized for the use of bifacial modules with an output of 670 watts. The construction is uncomplicated. Depending on the static calculation, they are divided into fields of 4-5 modules. Each field is held by a support pillar. The row length is up to 120 m. The centrally mounted motor turns the particularly stable axis on which the modules are solidly mounted with a patented support arm.Compared to trackers for free-field systems, a higher elevation (up to 3.5 m) and an extended row width according to the requirements for agricultural processing, which is largely possible without restrictions. Only a biodiverse planted strip under the modules is not harvested with and improves the species richness of agriculture.

Module B132-HC (670Wp), 2384 x 1303 x 35 mm

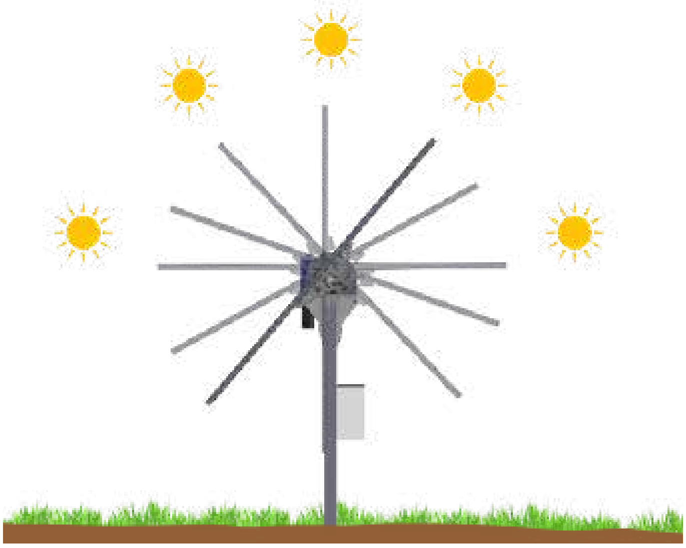
Ideal also for animal husbandry

Due to the higher position and the variable distances, our TrackerPV systems are ideal for animal husbandry: cows or horses can pass unhindered and find sufficient shade, especially in the hot midday hours, due to the almost horizontal position of the modules. The microclimate under the systems is good for plant growth due to the reduction of evaporation and the protection from intensive solar radiation.

Robust and durable drive on solid foundation according to static calculation

Tracker PV

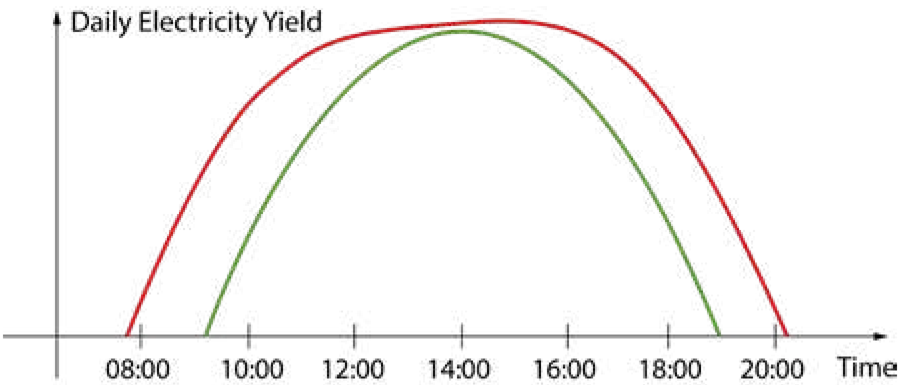
Suitable for large areas



Our TrackerPV system combines many advantages

- State-of-the-art trackers and controls enable almost unrestricted agricultural use with up to 30% more power yield compared to fence systems
- Optimized design for bifacial modules of different sizes due to variable row widths
- Adaptable to soil conditions
- Terrain specific 3D backtracking
- Independent series control
- Galvanized steel structure „Made in Germany
- Fast and safe assembly

The power yield of TrackerPV is approx. 30% higher than that of permanently mounted modules. It is almost constant during the course of the day.



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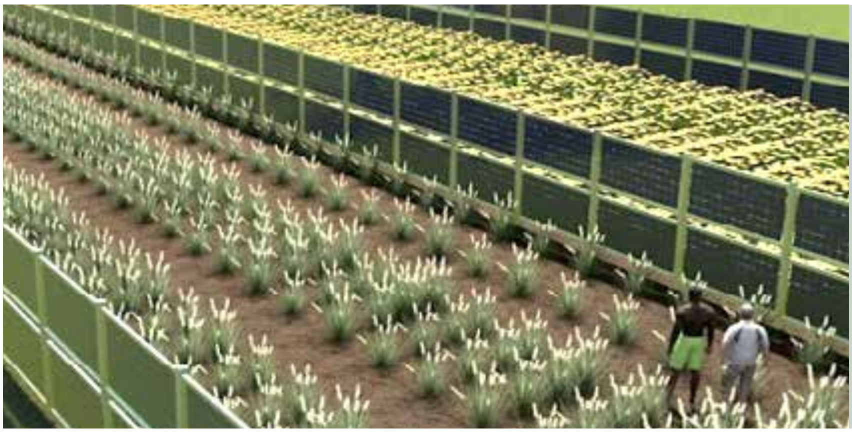
5 FencePV

up to 900 MWh per ha p.a.

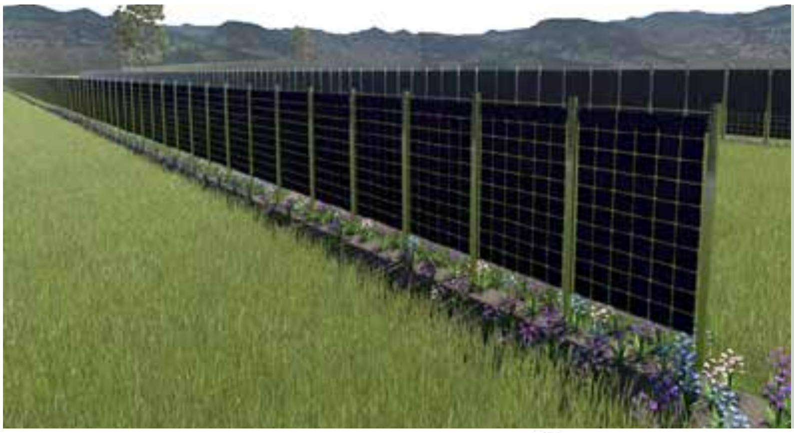
Case studies solar fence (horizontal, double row)
The choice of spacing between fences can take into account the requirements of agricultural production.If spacing of 10 m or more is chosen, larger processing and harvesting machines can also be operated. A border strip of approx. 80 cm serves to protect the plant and ensures biodiversity with appropriate seeding. However, this reduces the electrical yield.



Garden plants:
10 m row spacing, 450 kWp/ha, investment without grid connection approx. 490.000 €
electricity yield p.a.up to 405 MWh
= 81.000 € at 0,20 €/kWh

Fallbeispiele Solar Zaun (vertikal)

The solar fence with vertically mounted modules is available with and without upper cross bracing.Without the cross bracing results in an aesthetically particularly attractive image (see pictures).Due to the posts rammed at a small distance results in a very high stability so that the construction is possible even in areas with high wind loads. A cross bracing at the top provides additional protection of the modules and even greater stability.Available are 2 different heights by using the modules B60/6 or B72/. The total height of the fences is determined by the distance to the ground. It varies from 1.85 up to 2.4 m.

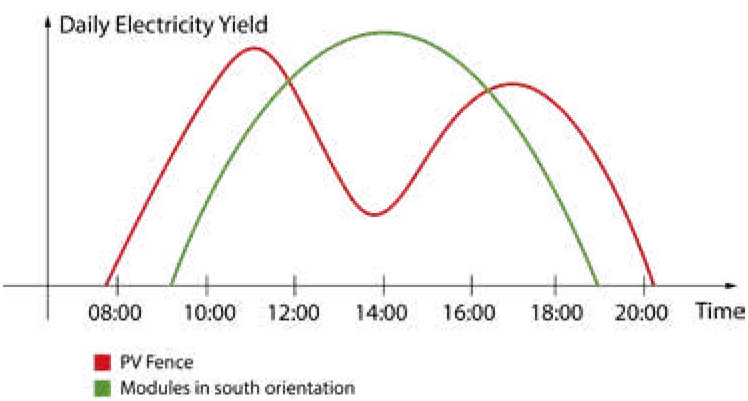


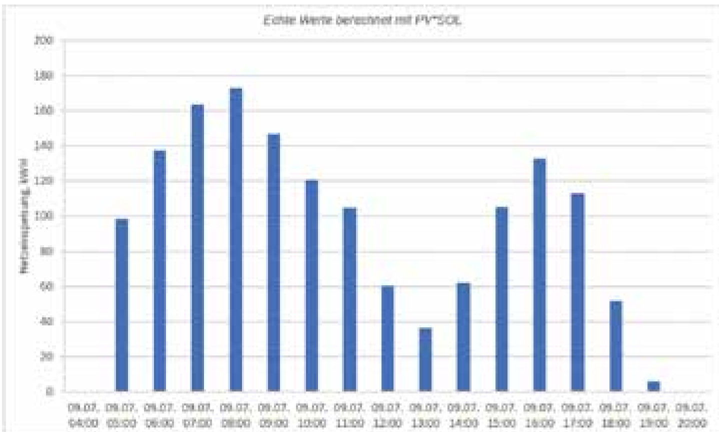
System vertical size 1:
Green area: 10 m row spacing, 354 kWp/ha, investment without grid connection approx. 480.000 €, electricity yield p.a. up to 285 MWh = 57.000 € at 0,20 €/kWh

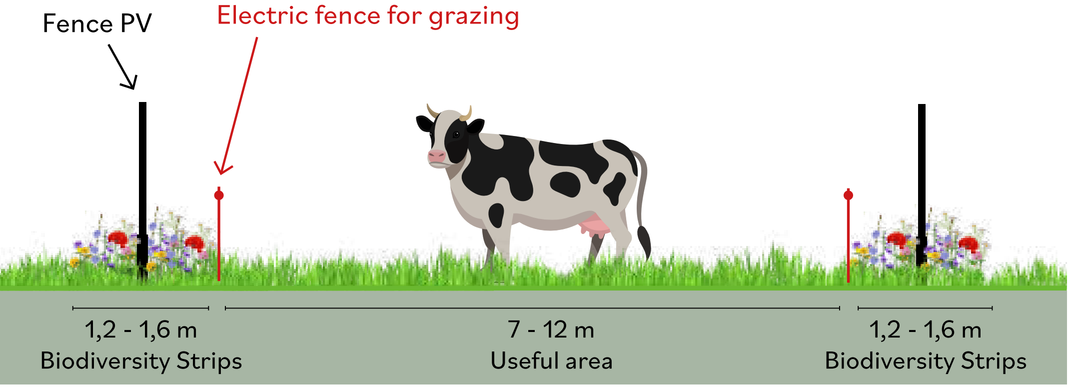
AgriPV fence system

Innovative mounting system
AGORA premium double-glazed bifacial PV modules are used. The steel profiles are driven into the ground to ensure stability. The system includes only three parts and is therefore quick and at the same time stable to assemble. Available as single and double row system.

Our AgriPV fencing system enables practically double yields:
Both the yield from agricultural use, as well as the significant electricity yield. The bifacial modules used have an output of up to 450 Wp on the front side. Since we use special cells, the power on the back is only slightly lower. This is important for a vertical installation, as the sun shines on both sides in succession during the day. The yield curve is also different from a „normal“ installation and has two distinct peaks. Our installations allow short pay-back times of the investment!







The possible installation per hectare (ha) depends on the spacing of the rows, as shown in the tables below. A biodiversity strip of about 60 to 80 cm should be considered, which is not regularly harvested. This is sown with meadow flowers or even other plants; this creates an interesting small biotope that provides habitat for many insects and field animals.

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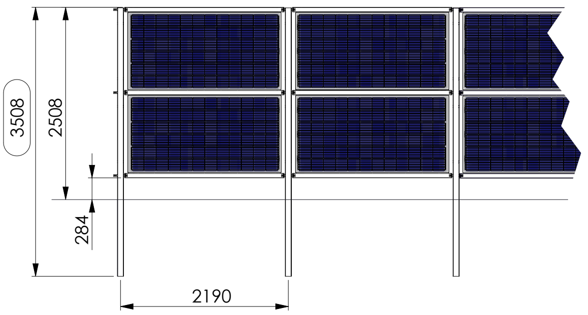
bis zu 900 MWh pro ha p.a.

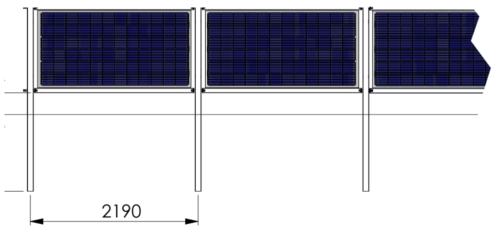
In order to achieve a high yield from both sides, shading at all times of the day (with different angles of solar radiation) must be avoided. Therefore, only frameless bifacial modules with a high output can be considered. The yield per hectare (ha) also depends on the spacing of the rows, as shown in the following table:



double row system crosswise

Row distance in m	6	8	10	12
Rows per ha	18	14	11	9
kWp/row*	41	41	41	41
KWp/ha*	724	554	451	383
kWh p.a.*	688.117	525.825	428.450	363.533

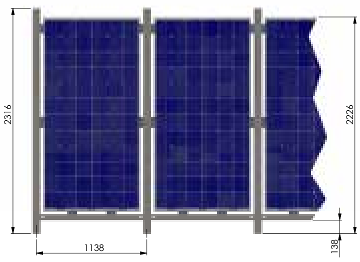
* double row system with B72/6 - 450 Wp modules per field



single row system crosswise

Row distance in m	6	8	10	12
Rows per ha	18	14	11	9
kWp/row*	20,5	20,5	20,5	20,5
KWp/ha*	362	277	226	191
kWh p.a.*	344.058	262.913	214.225	181.767

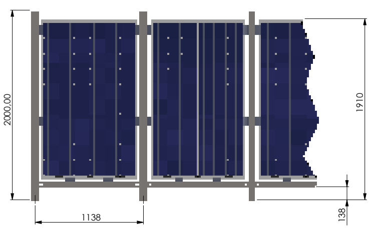
* single row system with B72/6 - 450 Wp modules per field



System vertical size 2

Row distance in m	6	8	10	12
Rows per ha	18	14	11	9
kWp/row*	39	39	39	39
KWp/ha*	689	527	429	364
kWh p.a.*	654.550	500.175	407.550	345.800

* single row system with B72/6 - 450 Wp modules per field



System vertical size 1

Row distance in m	6	8	10	12
Rows per ha	18	14	11	9
kWp/row*	32,2	32,2	32,2	32,2
KWp/ha*	569	435	354	301
kWh p.a.*	540.423	412.965	336.490	285.507

* single row system with B60/6 - 370 Wp modules per field

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Technical structure

up to 1080 MWh per ha p.a.

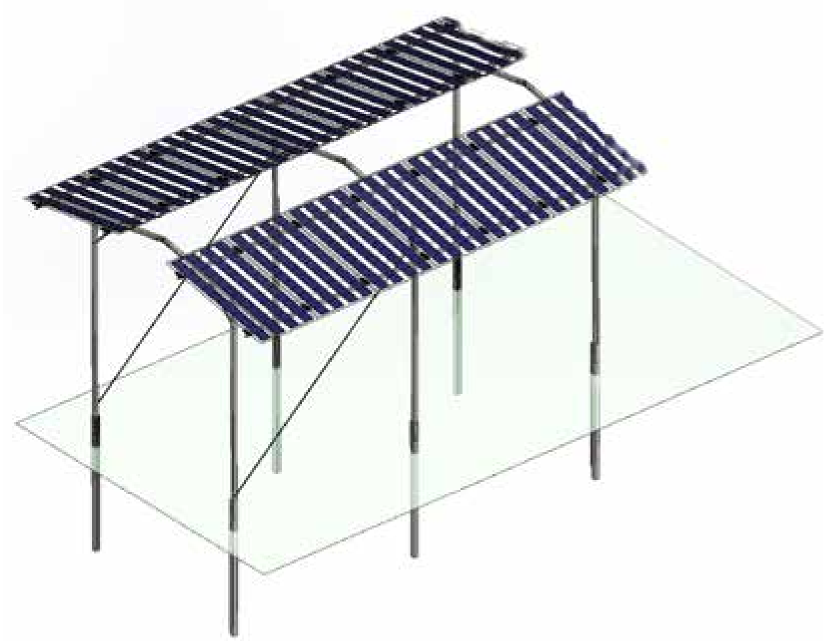
BerryPV

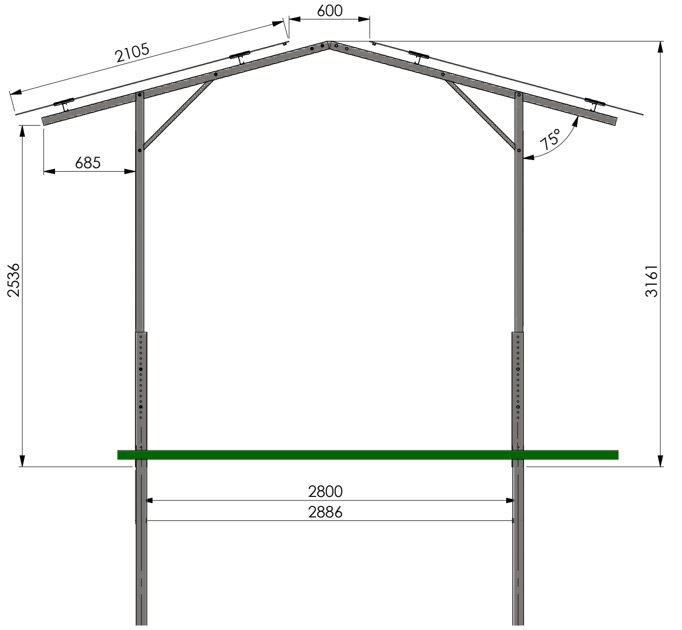
Art. Nr. G5660

Large plants up to 10 MWp and more

Turnkey solution
incl. frame according to static calculation, modules, inverter, cabling and assembly

Height support: variable from approx. 2.20 to 2.6 m
Height center: support + approx. 30cm





Strong steel profiles are anchored in the ground.
Depth according to the static calculation

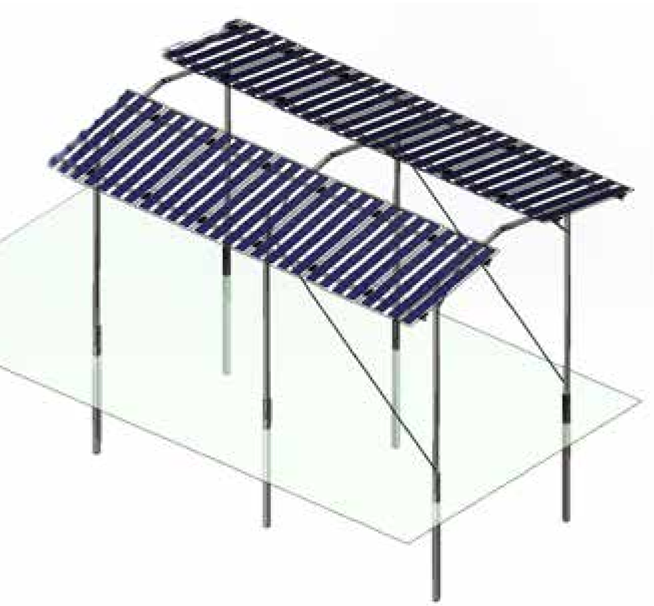
PomePV

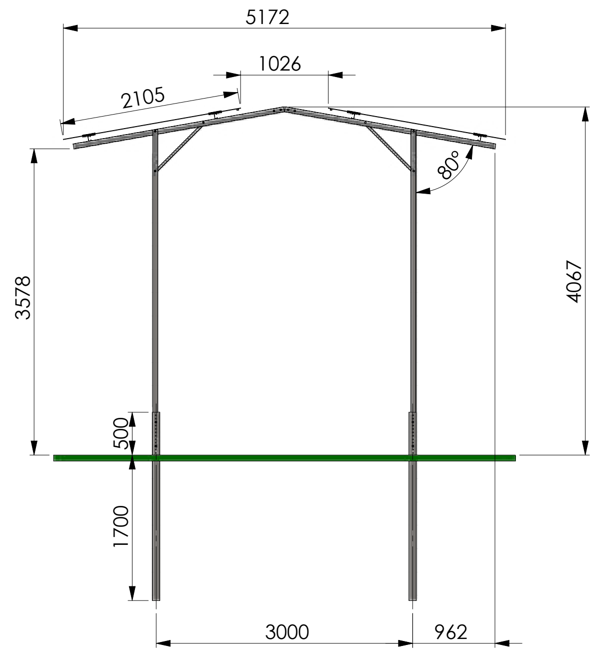
Art. Nr. G6660

Power generation from 5 cents/kWh!

Turnkey solution
incl. frame according to static calculation, modules, inverter, cabling and assembly

Height support: variable from approx. 3.30 to 4m
Height center: support + about 30cm





Strong steel profiles are anchored in the ground.
Depth according to the static calculation

Height adjustable according to plant size

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German Quality Engineering

Interpretation Berry and PomePV

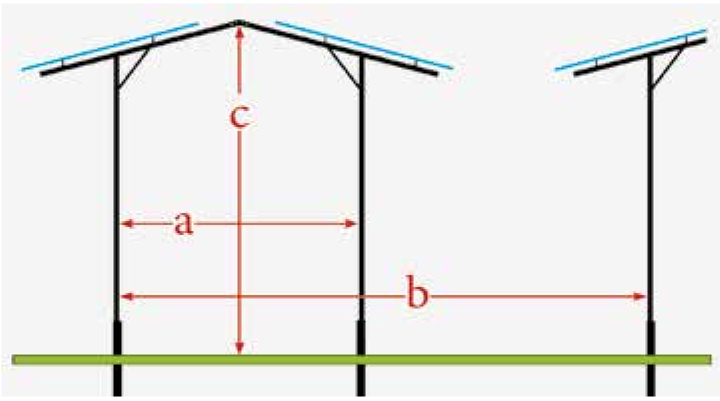
Row spacing according to the usage concept

According to the type of plant (berries, stone fruit, vegetables), the layout is in rows with different widths (a) of the racks and the distances (b) between the rows (see figure). Both are largely determined by the type of fruit grown and the method of cultivation. In existing orchards, compromises have to be made, while in new plantings both aspects are taken into account.

The height (c) is determined by the growth height of the plants. Above approx. 4 m, the static loads and thus the costs increase sharply. The row spacing (b) determines the possible installation of PV modules on the surfaces. If the row spacings are relatively close together at 5-6 m, this results in the installation volume per hectare (ha) shown in the table on page 9.

Lower heights for berry crops or horticulture

Berry crops (e.g., raspberries, blackberries, blueberries, strawberries grown on high ground) are grown with closer row and plant spacing. Again, climate change requires protective measures that can be achieved through AgriPV systems. The closer spacing of the rows also provides the opportunity for such crops to connect the individual rows to form a partially enclosed greenhouse.

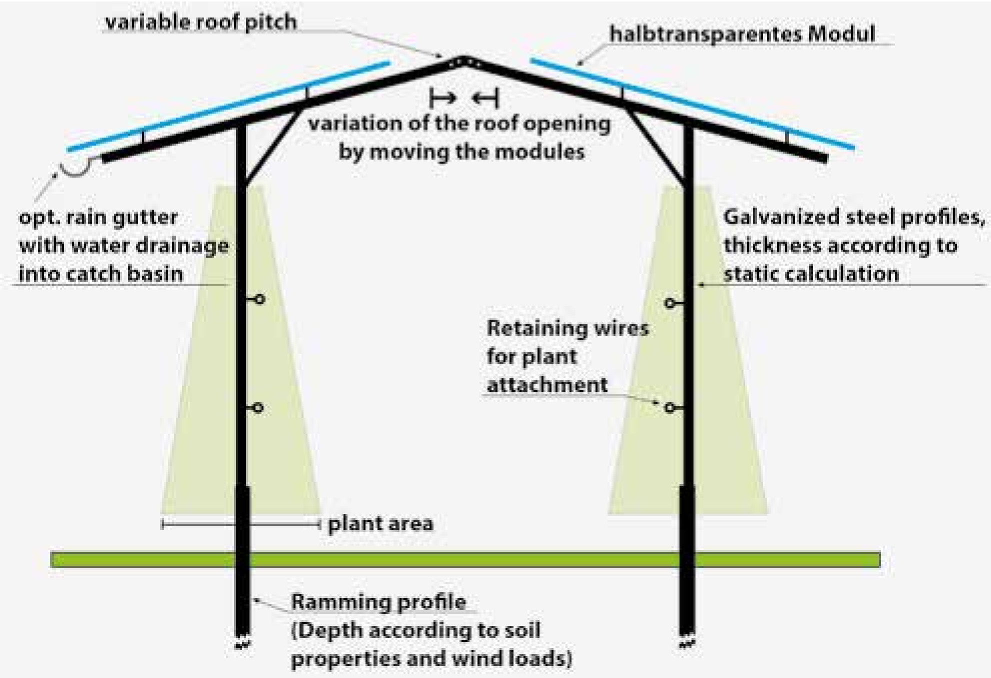


Standard dimensions: a = 3m
c = 3,1 m (BerryPV); c = 4 m (PomePV)

The row width (b) is chosen to match the plantings. At 5m, the racks are close together.

Highest quality for durability

Design principles: BerryPV & PomePV

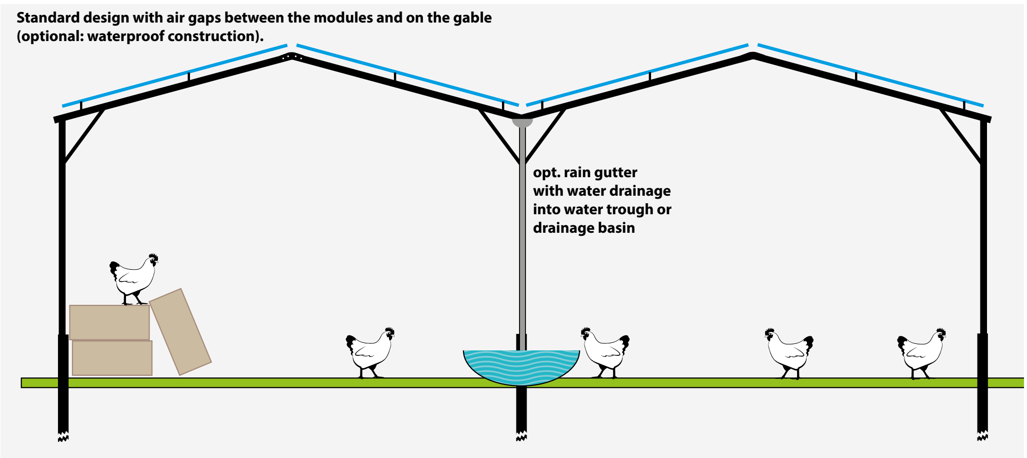



Pomegranate cultivation


Blueberry cultivation


Peach cultivation

Design principles: AnimalPV




Pig breeding

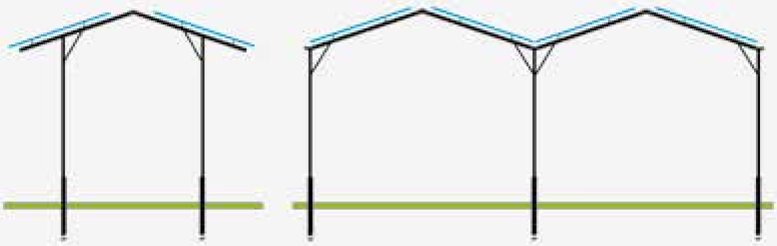

Turkey / chicken breeding

AnimalPV installations are designed individually according to the specific needs. The parameters concern

1. **The openings between the modules and on the ridge as ventilation.** A waterproof closed version can also be offered as an option. In this case, sufficient cross ventilation should be ensured.
2. **The desired transparency of the plant.** In the standard version, the semi-transparent double glass modules B48/6 with 40% light transmission are used. Alternatively, the B72/6 modules can be used. These allow a 50% higher current generation; however, also only a low transparency of approx. 4%. Depending on the length of the fields, there is usually enough additional light coming from the side.

Project Management

In addition to the rows of racks installed at a distance (A), the units can also be connected Figure (B). Here, however, it should be noted that the light input is significantly lower and must be coordinated with the utilization concept.

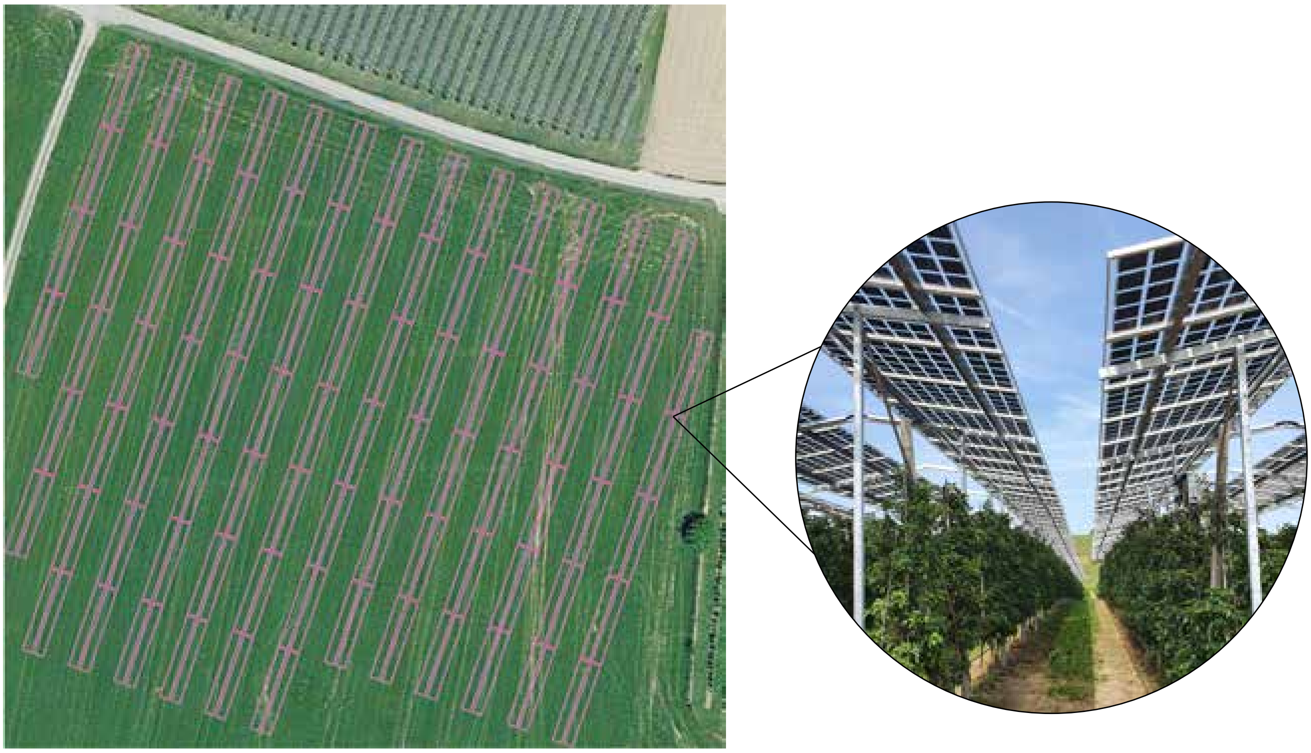


open design (A)   closed construction through connected units (B)

Row width b (m)	5	6
Rows per ha*	20	17
kWp/row**	55	55
kWp/ha	1.100	917

* Model design with 100m row length
** Base B48-300 Wp modules with 40% transparency

Design based on digital terrain data
The plants should be able to flexibly compensate for different terrain conditions, i.e. inclines, unevenness and slopes. Such digital 3D planning is of extreme importance. Errors in this phase can only be corrected later at great expense.

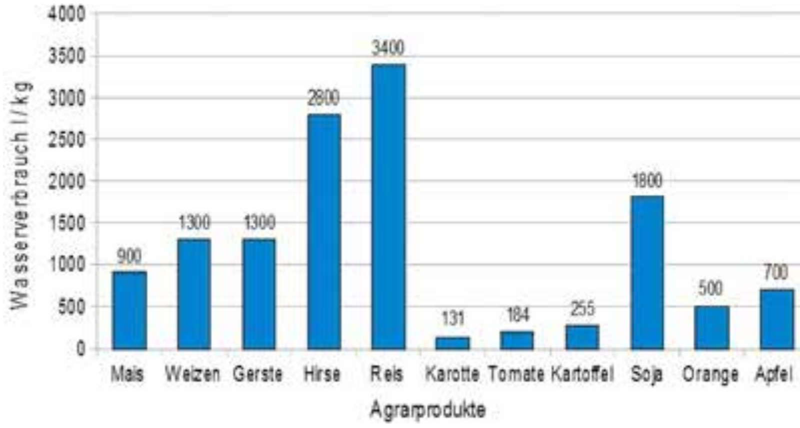


Project related statics
The statics of the frames must also withstand considerable snow and wind loads. The design, together with further information (e.g. the ground conditions to determine the pile-driving depths), is then the basis for the creation of a project-specific structural analysis.The detailed planning created afterwards also contains the cable plans and location of the electrical components such as the inverters. By optimizing the cable runs and their cross-sections, the yield of the plant can be significantly improved by avoiding considerable line losses.

AgriPV for water storage

AgriPV for water collection, storage and use for irrigation in dry seasons.

Through AgriPV, triple land use is possible - even in very dry regions.In the systems installed so far, the focus has been on the cultivation of food (1) together with solar power (2)and this is the only way to achieve this. Thereby, rainwater harvesting and storage (3) is additionally possible above the installed solar modules with little additional effort. Thus, the previous dual use of agri-photovoltaics can be expanded to include water management. Even in the driest regions of Germany, where in an extreme case only 314 mm of precipitation fell in 2019, these amounts would in principle be sufficient to meet the water needs of most crops. This has been investigated for almost all crops in countless studies. It depends to a considerable extent on environmental conditions, especially the types of cultivation, soil properties and evaporation. The large differences are shown in the adjacent figure.

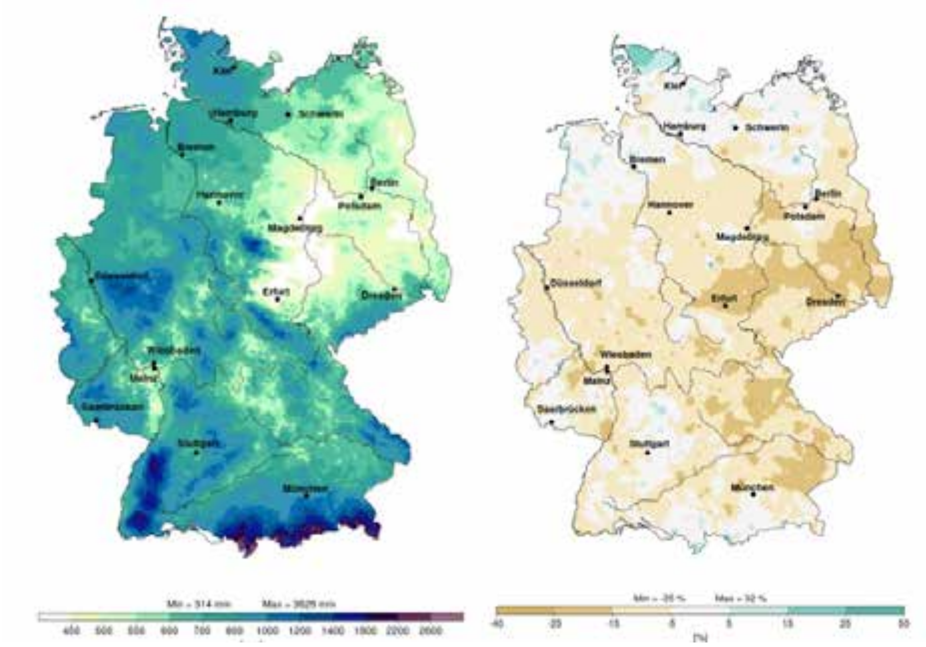


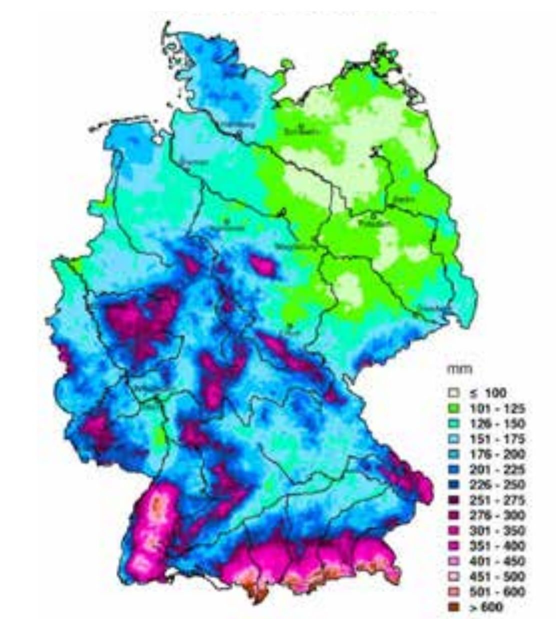
Wasserverbrauch je kg Fruchtgewicht

Precipitation amounts in Germany

The records of the German Weather Service (DWD) show the considerable differences in precipitation in Germany (here in 2019) based on the colors in the maps below. The highest precipitation is recorded in the dark blue colored federal states of Bavaria, Baden Württemberg and parts of Lower Saxony as well as Schleswig Holstein. Relatively low precipitation is shown by almost all eastern German states. There, the deviations from long-term mean values (1971-2000), shown in brown, are also particularly large, with up to minus 40 % (shown in brown).

Even more serious is the change in weather conditions in the spring, which is crucial for plant growth. Over the past 12 years, April precipitation in eastern states has ranged from 30 to as much as 70 percent below the historical average. For example, the map of spring precipitation (precipitation) in 2019 (shown below right) shows how extreme the differences are.

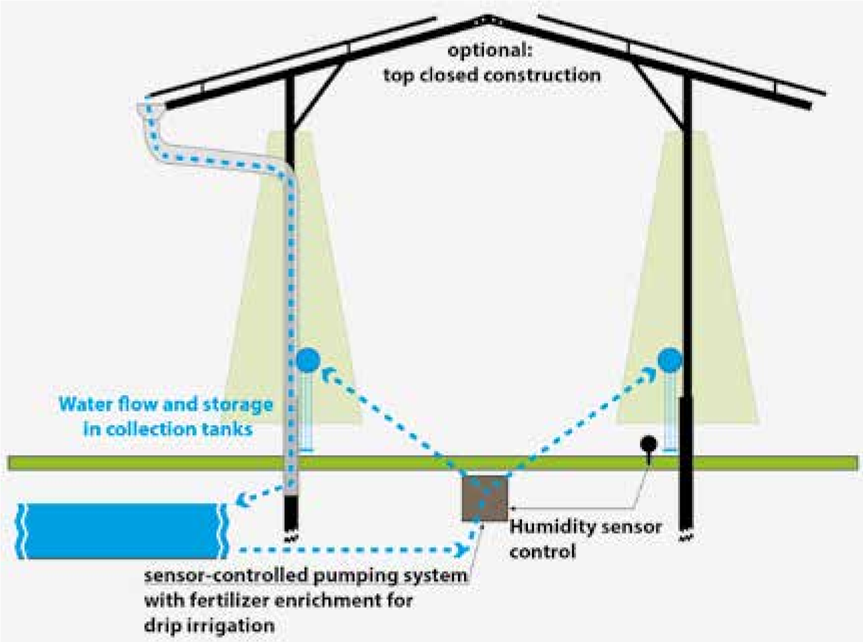




Spring precipitation (precipitation) in Germany in 2019

Precipitation amounts in D in 2019 and change compared to mean values (1971-2000), source DWD

Rainwater harvesting & irrigation



A combination with rainwater harvesting systems makes sense for AgriPV systems. In this case, the rainwater is directed into catch basins using the gutters (see figure on the left). From there, it can be used for drip irrigation, enriched with nutrients if necessary, via hoses attached to the supports. If irrigation is controlled by moisture sensors in the soil, up to 90% of the increasingly precious water can be saved.

AgriPV Water storage capacities

It has already been shown that AgriPV enables water storage. Even in areas with low precipitation, storage usually exceeds the needs of the crops grown. The extent to which this enables irrigation of areas outside the AgriPV system was investigated in a case study. A water scarce area in Mecklenburg-Vorpommern with only 480 mm precipitation p.a. served as test area. The area covered 10 ha with a 5 ha AgriPV area for growing fruits and crops in open systems (3 ha) as well as small animal husbandry and growing forage crops. Water ponds were also covered (2 ha). For area 1 (10 ha of agricultural land), the water storage of 100 mm per m³ should be available to use in the growing season in spring. The water needed for this purpose must be collected in areas 2 and 3. The table shows that if water is used sparingly in the AgriPV areas (e.g., drip irrigation), almost 20,000 m3 of water can be collected and stored. Allowing for losses, this amount is sufficient for spring irrigation of Area 1. However, storage reservoirs of 4,250 m3 are necessary. In the yellow fields the electricity yield of more than 5,000 MWh p.a. is shown which, at € 0.18, corresponds to a yield of more than € 0.9 million per year and, together with the otherwise hardly possible agricultural yields, makes it possible to finance the investment.

AgriPV Case study 15 ha agricultural area in Mecklenburg-Western Pomerania							
	low water, 480 mm/m² p.a., deficit spring 100 mm per m²	ha	Reservoir **	Irrigation	Water demand. m³	MWp	MWh p.a.*
Area			m³ p.a.	m³ H_2O/m² p.a.			
1	Area without AgriPV Spring supplemental irrigation through reservoirs	10		0,10	10.000		
2	open a): fruit trees, berries, field crops	3	10.800	0,10	3.000	2,9	2.881
3	closed b): small animals / food plants / water basin	2	9.120	0,20	4.000	2,2	2.136
Total		15	19.920	Storage needs	17.000	5,1	5.018
Total storage after loss			17.928	**Surplus m³**	**928**		
			Storage size at 4 m depth:		4.250 m²		

** 980 - 1090 kWh/kWp p.a.* *** Precipitation 480 mm / p.a. 10% loss / evaporation*

Drip irrigation

Drip irrigation, both above-ground and below-ground, has become established in fruit growing. Compared to overhead irrigation, up to 40% irrigation water can be saved.

Drip irrigation
In drip irrigation, the water is distributed concentrically in the soil from the drip point. As the distance from the drip point increases, the soil moisture decreases. The shape of the irrigation bulb thus formed is highly round in light soils and spherical to flat round in heavy soils. Moisture is greatest inside the irrigation bulb.Polyethylene (PE) drip tubes with a diameter of 16 to 20 mm are laid on the ground along the rows of trees or attached to the wire at a height of 40 cm (see figure below). Depending on the type of drippers, about 2 to 4 liters of water are released per hour at 1.0 to 1.5 bar pressure, which corresponds to a water consumption of 160 l/min and ha (with 2400 drippers).

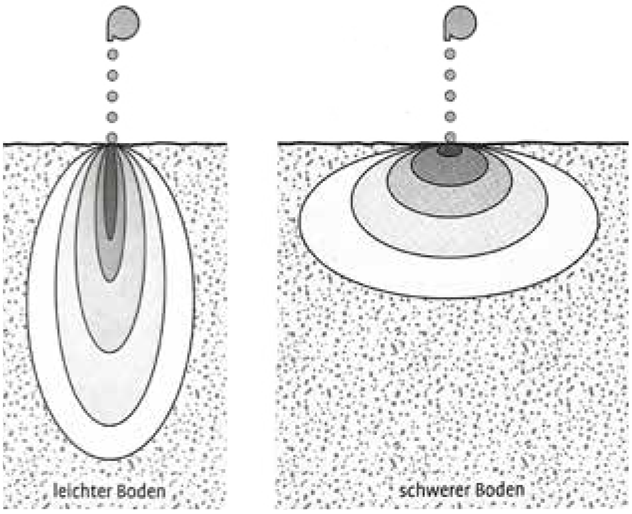


Figure: Soil moisture distribution in different soils with trickle irrigation. (*Source: Büchele, Lucas' Anleitung zum Obstbau, 2018, S. 277*).

Integration of irrigation hoses

The schematic structure of a drip irrigation system is shown in the following diagram.

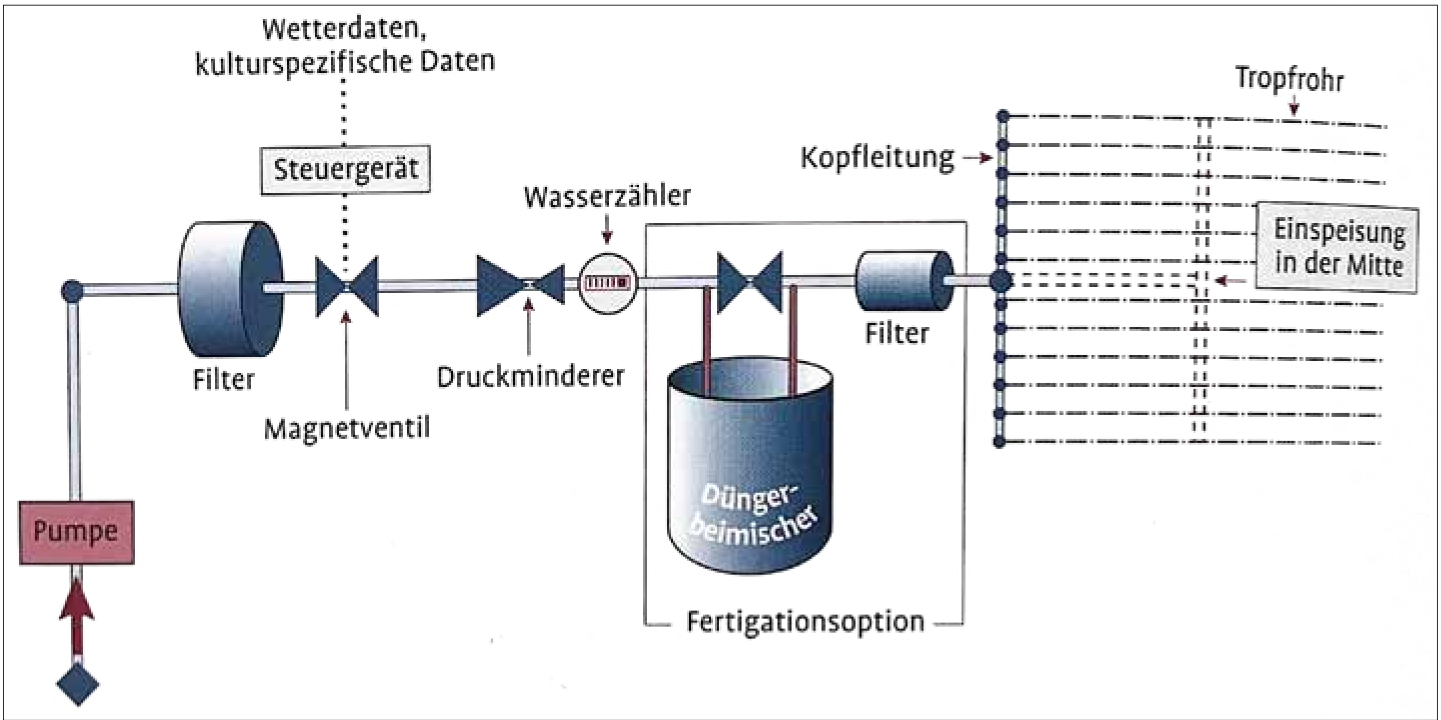


Figure: Schematic structure of a drip irrigation system (source: Büchele, Lucas' Guide to Fruit Growing, 2018, p. 276).

AgriPV in closed loop

Energy production and biodiversity in the permaculture greenhouse

The term permaculture, derived from the English term „permanent (agri)culture“, translates as „permanent agriculture or culture“. Since the 1970s, this method has been significantly influenced by the Australian Bill Mollison, who is considered the father of permaculture. Independently of Mollison, the Japanese Masanobu Fukuoka also developed a similar principle.

Basically, the principle of permaculture is to create your own stable and sustainable ecosystem, which is modeled on natural processes. Last but not least, the responsible use and perception of valuable natural resources such as water is an important aspect.

Thus, in the holistic principle of permaculture, the focus is on natural and closed cycles and the consideration of all functions of individual elements. The principles established by Mollison are:

The goal is to develop and maintain an interconnected and multifunctional ecosystem. In doing so, existing resources are to be used efficiently and their consumption and energy consumption reduced.

Similar concepts can also be implemented in fully or partially closed agri-PV systems with circuits for water and nutrients. Substrate is used in containers (pots), which are filled with single or multiple plants. Irrigation is carried out in a closed circuit in which rainwater is collected, stored and used for irrigation with fresh water if the quantity is insufficient. Excess liquid from the substrate is collected, treated and returned to the circuit. This saves a lot of fertilizer that would otherwise end up in the groundwater.

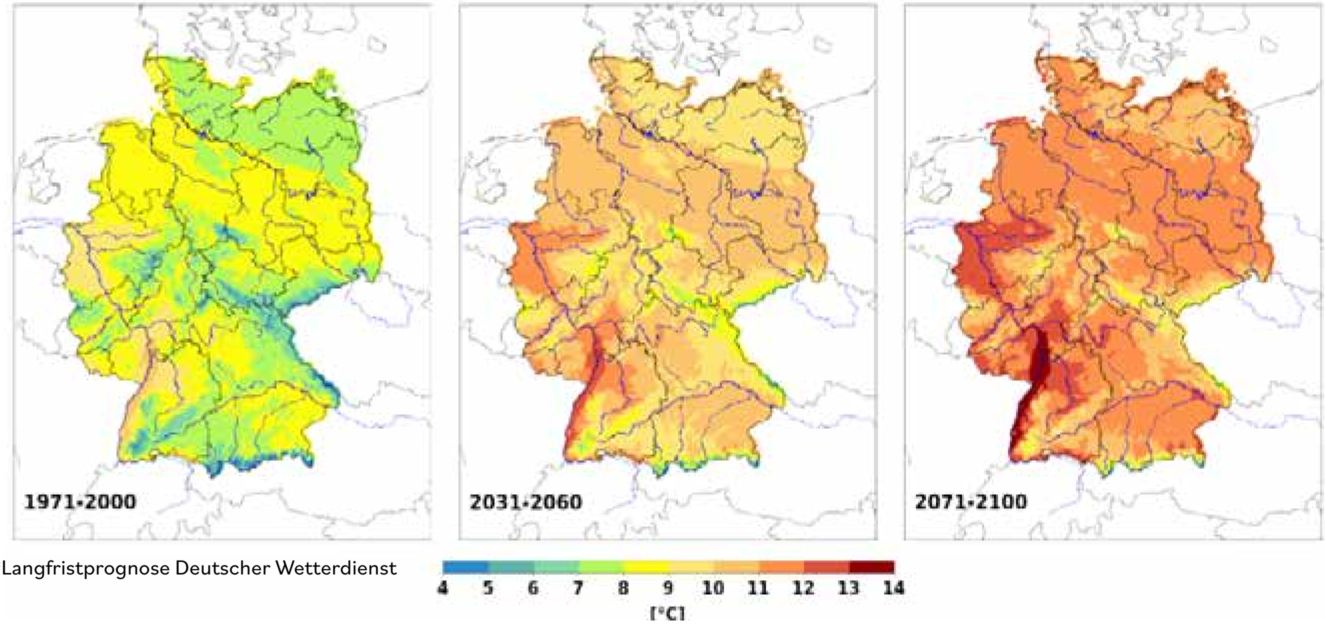
AgriPV Multipurpose halls

Fruit and vegetables can be marketed less and less without refrigeration in view of rising temperatures.Apples and potatoes, for example, are refrigerated for an average of 3-6 months and only then sold in stores. The energy consumption required for months of electrical refrigeration makes the products massively more expensive. One solution is to generate electricity directly in processing and marketing halls, including local markets whose PV-covered stalls generate enough electricity to power the cold storage.

Europe‘s agriculture needs AgriPV

Climate change in Germany - stronger than expected

The forecast of the German Weather Service (DWD)* shows a temperature increase in Germany of 3.1 °C to 4.7 °C for the period starting in 2071 (current evaluation of climate projections for the climate scenario RCP8.5).



*Langfristprognose Deutscher Wetterdienst

Europe is warming particularly quickly - a 1.5°C increase is no longer realistic!The temperature increase in Europe is significantly higher than in the rest of the world. This is due to the fact that the European region consists mainly of land masses. Over land, global warming is proceeding faster than over the oceans. There are also many feedbacks between the Arctic, which is warming even faster, and the European region. According to the climate report by the UN‘s World Meteorological Organization (WMO) and the EU‘s Copernicus Climate Change Service, temperatures in Europe have risen more than twice as fast as the global average over the past 30 years. As a result, Europe has the highest value of any continent, the WMO reported. Some areas of Italy and Spain expect a climate like today‘s in the Sahel in 2050. Then, exceptional heat, forest fires and floods would further damage populations, economies and ecosystems, the report‘s authors predict.So far, we notice little of global warming because the global atmosphere still contains a lot of aerosols from industrial emissions. They dampen warming considerably, possibly by half. So, unintentionally, humanity is delaying global warming, but with each major economic crisis or well-intentioned political decision to reduce fuel consumption, this aerosol haze may disappear - and global warming may accelerate dramatically.

Temperature changes in the Mediterranean region

The Mediterranean region is seen as the most important hotspot of future climate change in Europe, along with northeastern Europe, with a significant risk of droughts and heat waves. Most model projections show a 4°C increase in Mediterranean summer temperatures by the end of the century, well above the global average, with some as high as 6°C. The model calculations are based on IPCC scenario A1B. One reason is the sharp decrease in summer precipitation by 25% or more and the associated drying of the soil, which intensifies the warming. More than the average temperatures, the high daytime temperatures are likely to increase. These temperatures are expected to increase by up to 7 °C by 2100 according to scenario A2, and by as much as 8.5 °C for the 5% highest daily maxima. Here, too, desiccation of the soil plays a clearly amplifying role. Since the coastal areas now already have relatively high temperatures in summer compared to the higher inland areas, there is a particular threat of many days here when temperatures exceed a very dangerous threshold, which can be seen at around 40 °C depending on the humidity.

Source: Christensen, O.B., et.al. Scalability of regional climate change in Europe for high-end scenarios, Climate Research 64, 25-38

No plant without DIN SPEC 91434

The DIN regulates the requirements of AgriPV for agricultural use. It was adopted in 2021 and compliance is now required by most banks and licensing authorities since the beginning of 2022.

DIN SPEC 91434

AgriPV systems are classified into two categories:

1. **Elevations with clear height and management under the plant (category I)**
   The clear height here must be at least 2.1 m. The agricultural area can be fully or partially covered with modules.
2. **Ground level elevation with cultivation between the rows of plants (category II)**
   A distinction is made here between systems that track vertically or at a specific angle or with a tracker system.

Agricultural use of the area

The previous agricultural usability of the area must be maintained, taking into account the loss of land. The planned land use and crop production must be outlined in an agricultural usability concept that covers the next 3 years or a crop rotation cycle. The options for cultivating the land must be adapted to the crops and listed accordingly in the agricultural usability concept. The continuous agricultural usability of the area can be checked via the field index, or as part of other checks.

The following criteria are explicitly examined:

- **Elevated Construction** ⇨ the previous land use and crop production must be preserved
- **Loss of area** ⇨ the loss of cultivated area must not exceed 10% for cat. I and 15% for cat. II amount
- **Machinability** ⇨ the entire surface must be machinable
- **Light availability and homogeneity** ⇨ adequate light homogeneity and availability must exist
- **Water availability** ⇨ Sufficient amounts of water and homogeneous distribution should be ensured
- **Soil erosion** ⇨ soil erosion must be prevented by measures such as drip edges on the modules
- **Residue-free assembly and disassembly** ⇨ the installations must be able to be removed without residue at the end of agricultural use
- **Calculation of profitability** ⇨ a viable utilization concept from the farmer‘s point of view must be presented
- **Land Use Efficiency** ⇨ despite reduction of the area and shading, the reference yield must be 66%.

GridParity will work with the farmer/investor to create a concept that addresses the above points.

Financing options

Several public and private banks offer financing for AgriPV plants.
Special AgriPV with special conditions is offered by Rentenbank, which belongs to the federal government, in the public interest: www.rentenbank.de.
The application must be made through the house bank.

GridParity AG
next generation photovoltaic

Ohmstr. 7, 85757 Karlsfeld
GERMANY

www.gridparity.ag
agripv@gridparity.ag
Tel: +49 (0) 8131 3307 560
Fax: +49 (0) 8131 3307 737