COMMERZ REAL

Renewable energies in focus
Spotlight on solar

Photovoltaics as a technology and investment

Whitepaper — 06.2024

Foreword

Dr Nicole Arnold
Member of the Management Board,
Commerz Real

Dear Readers,

Climate change, the increasing energy needs of a growing global population and the necessity of decarbonisation make energy generation one of the central issues of our time. Renewable energies play a key role in many respects. Photovoltaics is a particularly strong example of the transition to a more sustainable and resilient energy supply.

With the sun, we have a virtually inexhaustible source for generating electricity and heat. Thanks to increasingly efficient and cost-effective technologies, photovoltaics has become a global cornerstone of the energy transition – and will become even more important in the future.

Here at Commerz Real, we have around 20 years of experience in photovoltaics and have successfully launched numerous investment products for both private and institutional investors. Our employees and their expertise represent an unparalleled source of experience.

This whitepaper is intended to provide interested parties with an easy-to-understand introduction to the topic and illustrate how photovoltaics works – as a technology and investment.

I hope you enjoy reading it.

Nicole Arnold

Contents

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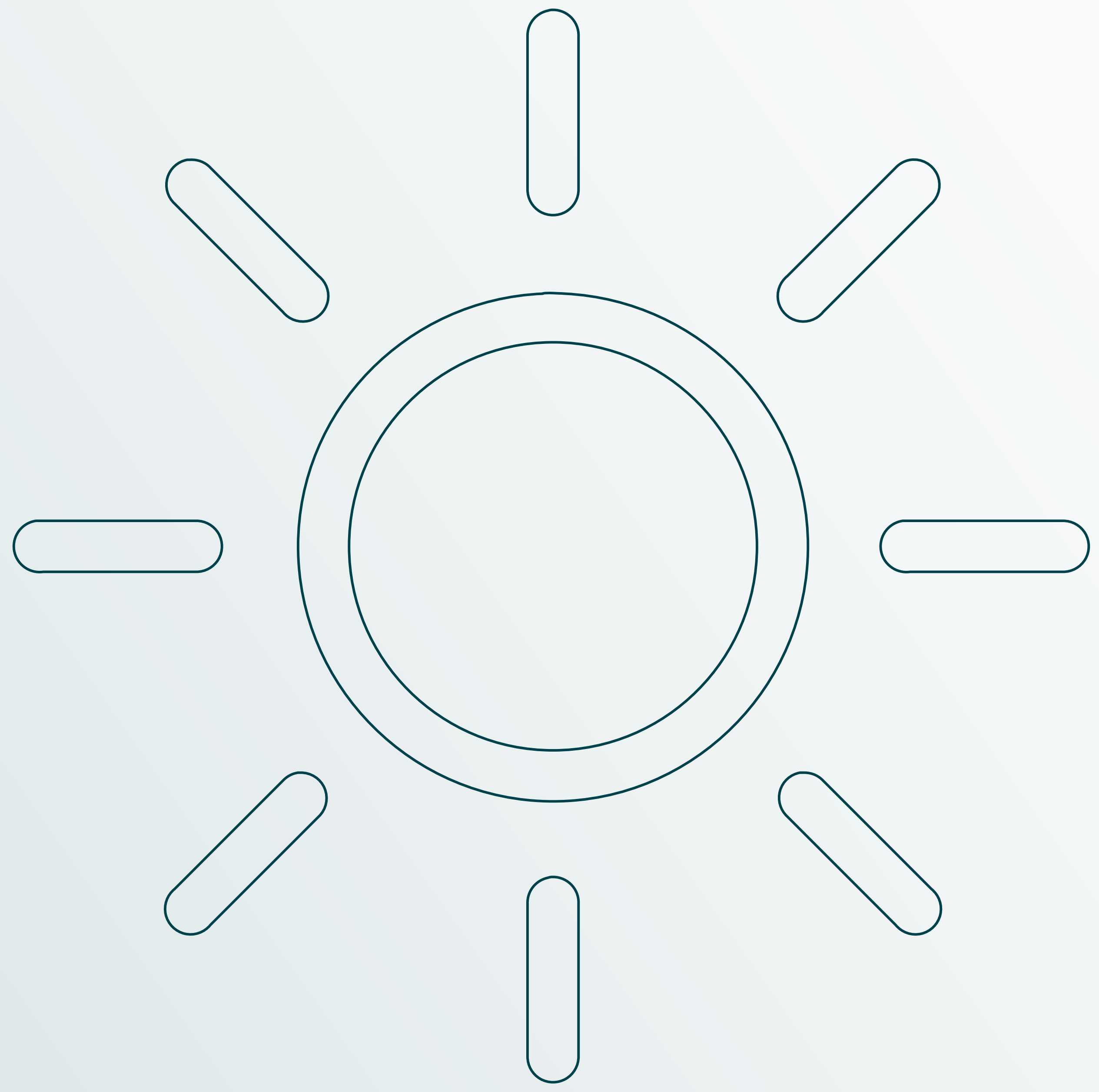
Clear information
Smart investments

In this whitepaper, we examine the status quo and prospects of photovoltaics in the energy supply, discuss the opportunities for photovoltaic parks as an investment and why we at Commerz Real have long regarded solar power as an investment with a bright future.

‘We are seeing record growth in photovoltaics in Germany and once again enormous interest in solar energy in Europe from around the world.’

German Solar Association, 2023



Status Quo

Renewable energies in focus.
Renewable energies are now one of the most important sources of electricity in Germany, and significant growth has also been recorded in the European Union in recent years. In 2023, wind energy exceeded the share of gas in electricity production in the EU for the first time, and photovoltaics also experienced a substantial increase. This is an important signal for the further expansion of renewables as a central pillar of the energy transition. Unlike oil, coal and gas, solar, wind, biomass, geothermal energy and hydropower are almost inexhaustible and their production causes far fewer environmentally damaging greenhouse gas emissions. As they can also be generated directly in Germany and Europe, they make us less dependent on imported fossil fuels.

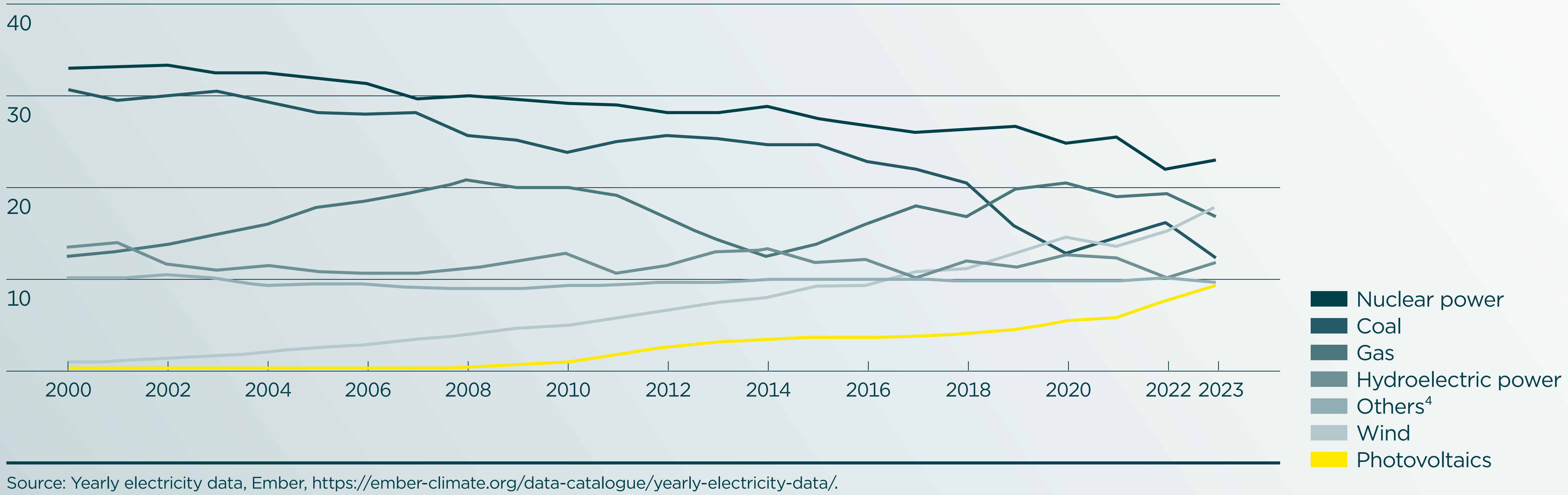
Spotlight on photovoltaics.
Photovoltaics is now one of the cheapest ways of generating electricity. According to the Fraunhofer Institute for Solar Energy Systems, a kilowatt hour of electricity incurred costs of between 3 and 11 euro cents in Germany (2021 study). The costs for brown coal-fired power plants were between 10 and 15 cents, and between 11 and 28 cents for gasfired power plants.[1] The spectrum of installations is diverse and ranges from photovoltaic systems on the roofs of residential and commercial properties for self-sufficiency and/or feeding into the public grid to the use of solar panels on let residential properties to generate electricity for tenants and large ground-mounted solar parks.

Signs of growth.
The construction of new photovoltaic systems is progressing rapidly. According to the German Environment Agency, almost twice as many new solar installations were built in 2023 as in 2022.[2] However, the newly installed capacity is more important than the number of installations. In Germany, this amounted to 14.3 GW in 2023, significantly exceeding the federal government's expansion target of 9 GW and also breaking Italy's twelve-year record of 9.3 GW within the EU. Overall, an annual growth rate of over 40% was achieved in the EU for the third year in a row in 2023, with a total of 55.9 GW newly installed.[3] Another record that now needs to be broken if the targets set are to be met.

[1] https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/studie-stromgestehungskosten-erneuerbare-energien.html.
[2] https://www.bundesregierung.de/breg-de/aktuelles/solarpaket-photovoltaik-balkonkraftwerke-2213726.
[3] EU Market Outlook for Solar Power 2023-2027 – SolarPower Europe.

Solar and wind are replacing fossil fuels

Share of EU electricity generation by source (%)



Source: Yearly electricity data, Ember, https://ember-climate.org/data-catalogue/yearly-electricity-data/.

[4] Includes bioenergy, other fossil fuels and other renewable energies.

PHOTOVOLTAICS IN GERMANY

59.8%[5]

Electricity from renewable energies in Germany in 2023. Nuclear power 1.5% and fossil fuels 38.7%[5].

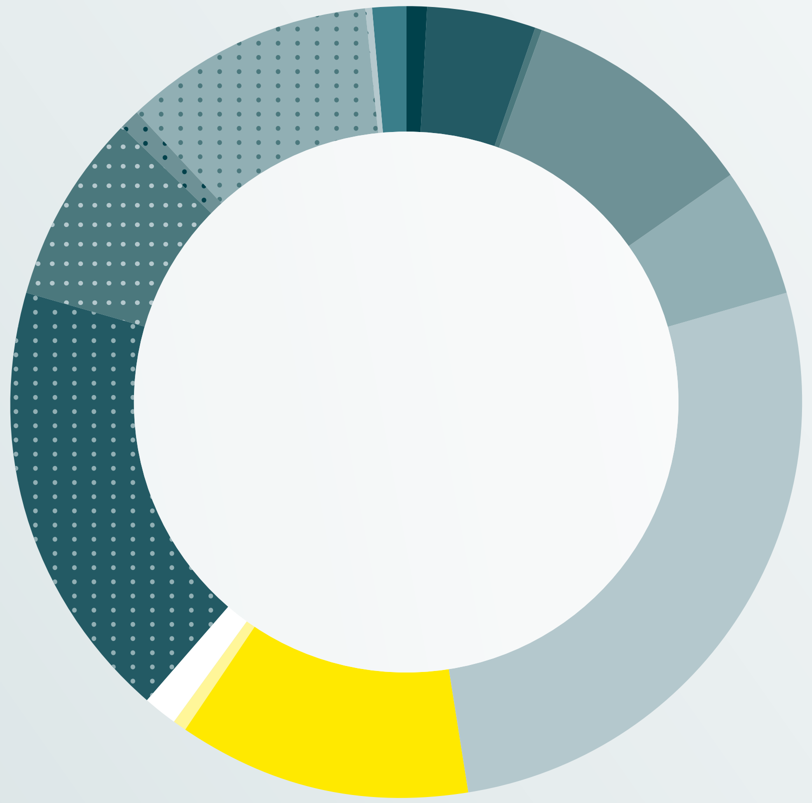
Photovoltaic electricity currently contributes 20% of renewable electricity to the electricity mix and accounts for 12% of total net electricity generation.

With a record 59.8%, more than half of the total net electricity generated in Germany was derived from renewable energies for the first time. In Europe, this figure was 43%. And rising. The target is for at least 80% of the electricity consumed in Germany to come from renewable sources by 2030, the aim being to achieve the goal of becoming the first industrialised nation to be climate-neutral by 2045 and to assume a leading role on the road to Europe's goal of climate neutrality by 2050.

Up to now, wind turbines have made the biggest contribution to electricity generation – especially onshore. The fossil fuels brown/black coal, along with nuclear power, only accounted for 27% in 2023. In 2013, this figure was 64%; in 2003, it was 81%.[5]

Net public electricity generation in Germany in 2023[5]

in %

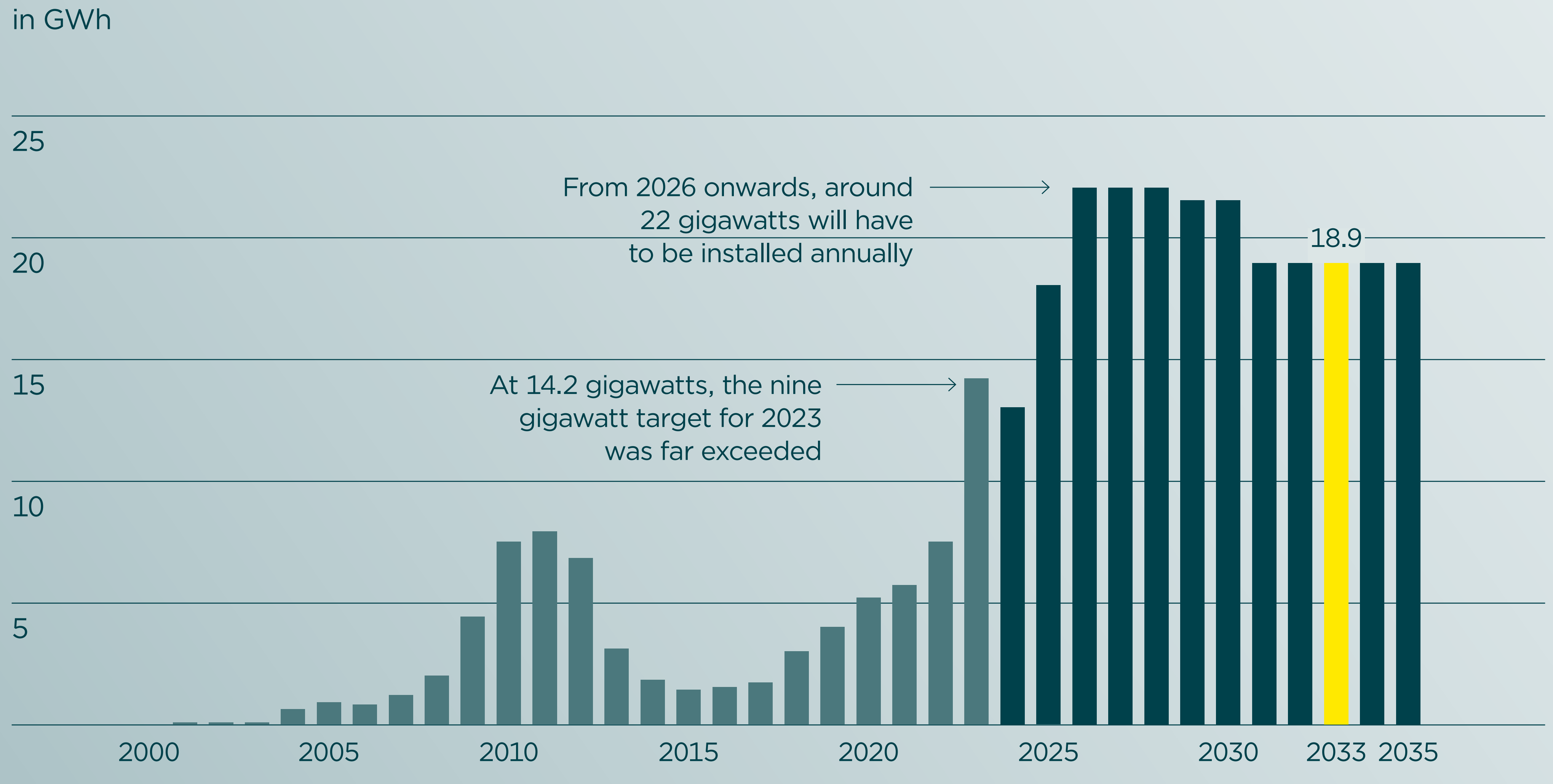


1.0	Renewable waste
4.5	Run-of-the-river hydropower
0.2	Pump-storage hydropower
9.6	Biomass
5.4	Wind (offshore)
26.8	Wind (onshore)
12.1	Solar (EEG grid feed-in)
0.3	Solar (other grid feed-in)
1.6	Nuclear power
17.9	Brown coal
7.9	Black coal
0.7	Oil
10.2	Natural gas
0.4	Other
1.2	Non-renewable waste

[5] Fraunhofer Institute for Solar Energy Systems, https://energy-charts.info/charts/energy_pie/chart.htm?l=de&c=DE&interval=year&year=2023.

PHOTOVOLTAICS IN GERMANY

Level of current and future solar power expansion required to meet the federal government's statutory targets

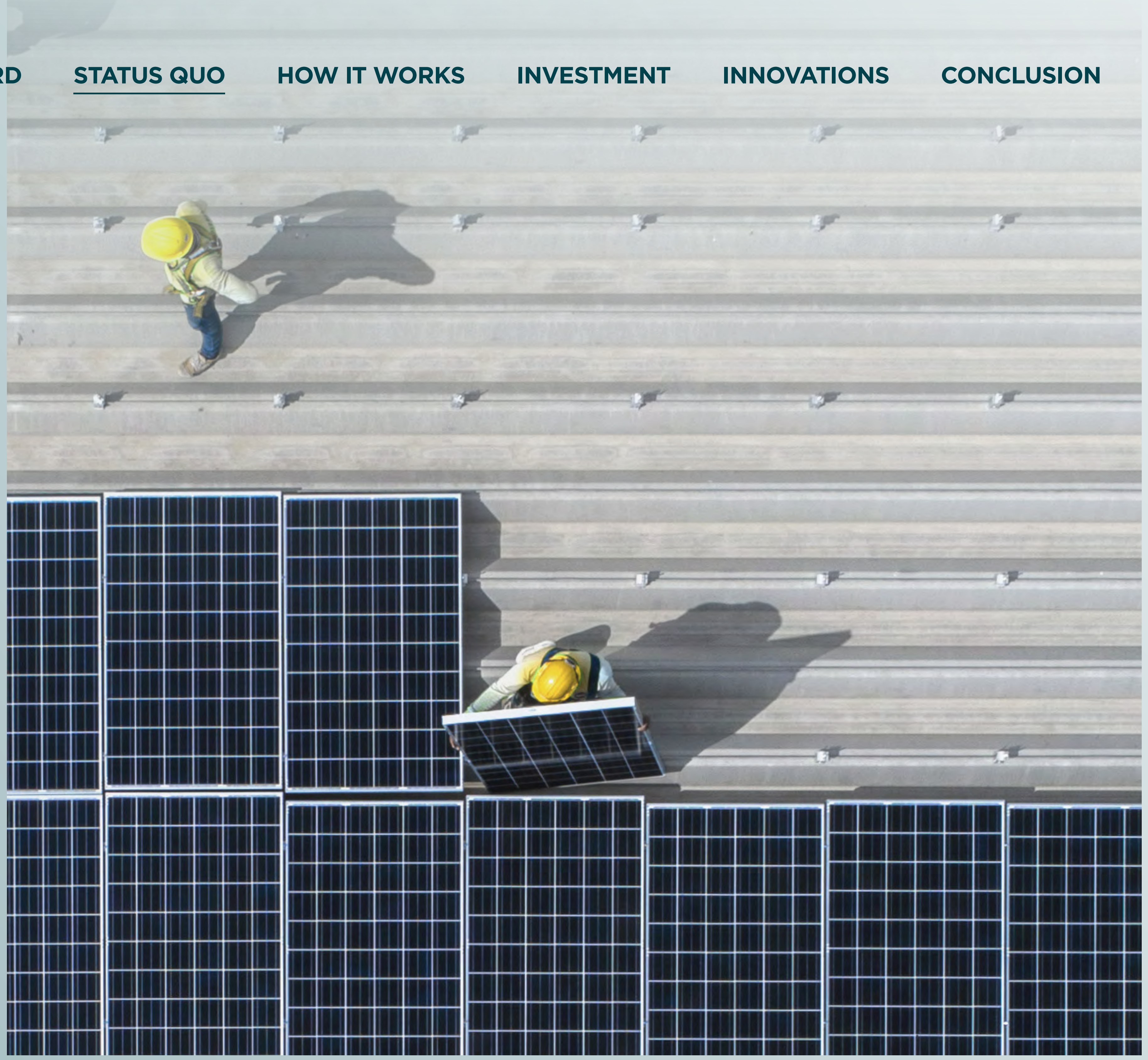


Source: German Federal Ministry for Economic Affairs and Climate, Agora Energiewende, own calculation, as of: 31 December 2023.

With its **Solar Package I**, the German federal government is seeking to reduce bureaucracy in the construction and operation of photovoltaic systems and further accelerate the construction of new systems. For example, so-called 'balcony power plants'[6] will become much easier to install and operate for private households. The annual expansion targets were also raised again: an increase in solar output of 13 GW is planned for 2024; this figure is then set to rise to 18 GW in 2025 and 22 GW annually from 2026. By 2030, a total nominal output of 215 GWp ('gigawatt peak') is scheduled to be achieved, of which roughly half is to come from ground- and roof-mounted installations.[7]

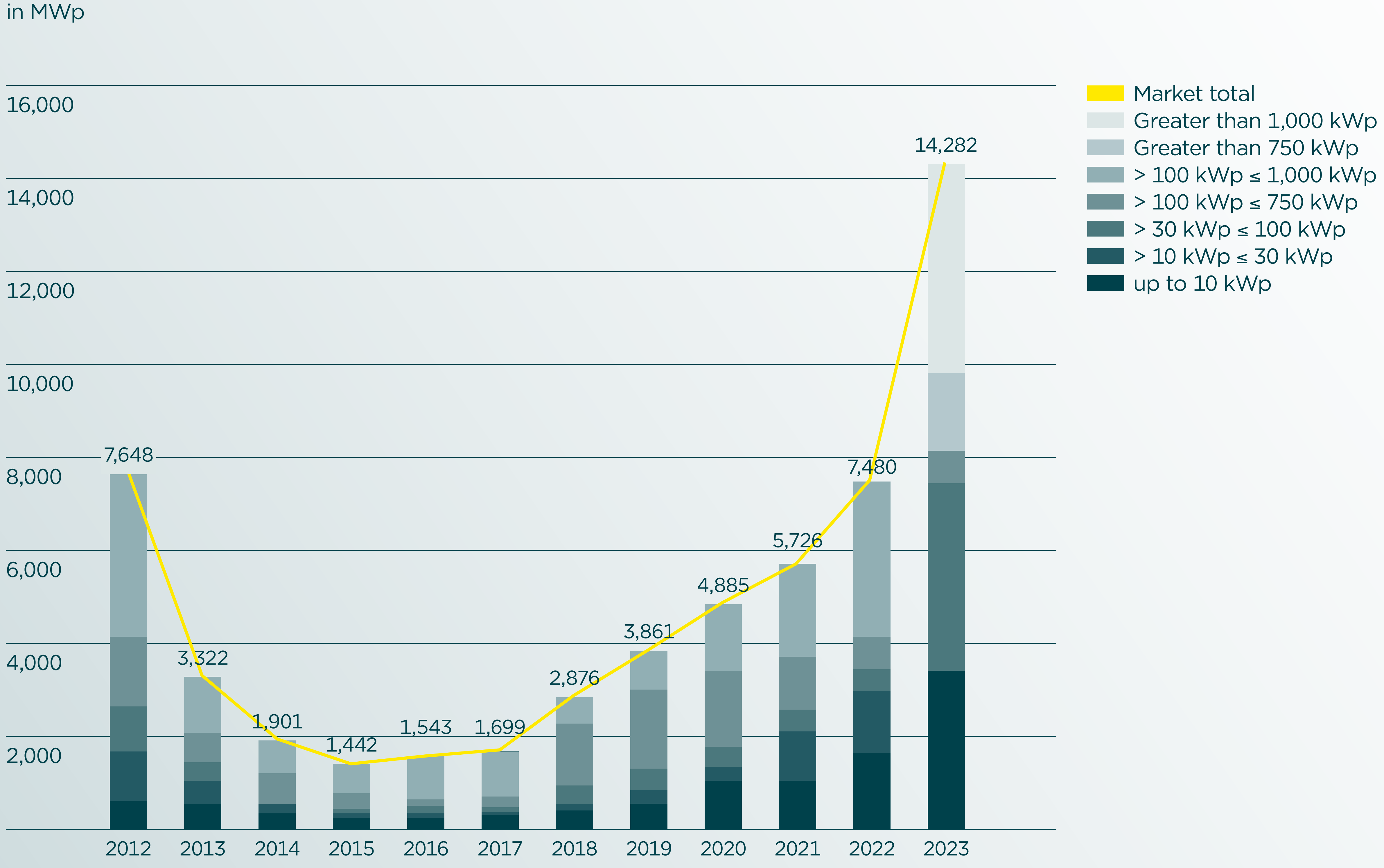
[6] A balcony power plant is a small, usually plug-in photovoltaic system that is installed on balconies, terraces or house facades. It enables households to generate their own solar power and feed it directly into their homes in order to reduce energy consumption from the public grid.
[7] https://www.bundesregierung.de/breg-de/aktuelles/solarpaket-photovoltaik-balkonkraftwerke-2213726.

PHOTOVOLTAICS IN GERMANY



In 2012, changes to the subsidy programmes for photovoltaics by the German federal government caused a drastic decline in Germany's photovoltaic industry, which was then still leading the world. Chinese companies, which had been in the process of transferring technology expertise to their country for some time, used this opportunity to flood the market with panels at dumping prices. Import tariffs, which were introduced as a response by the EU to protect domestic industry, failed to avert the severe crisis in the sector. Today, the expansion in photovoltaics is hardly conceivable without Asian suppliers.[8]

Market for installed PV capacity by size class



Source: Bundesnetzagentur, https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/ErneuerbareEnergien/ZahlenDatenInformationen/EEStatistikMaStR.pdf?__blob=publicationFile&v=13.

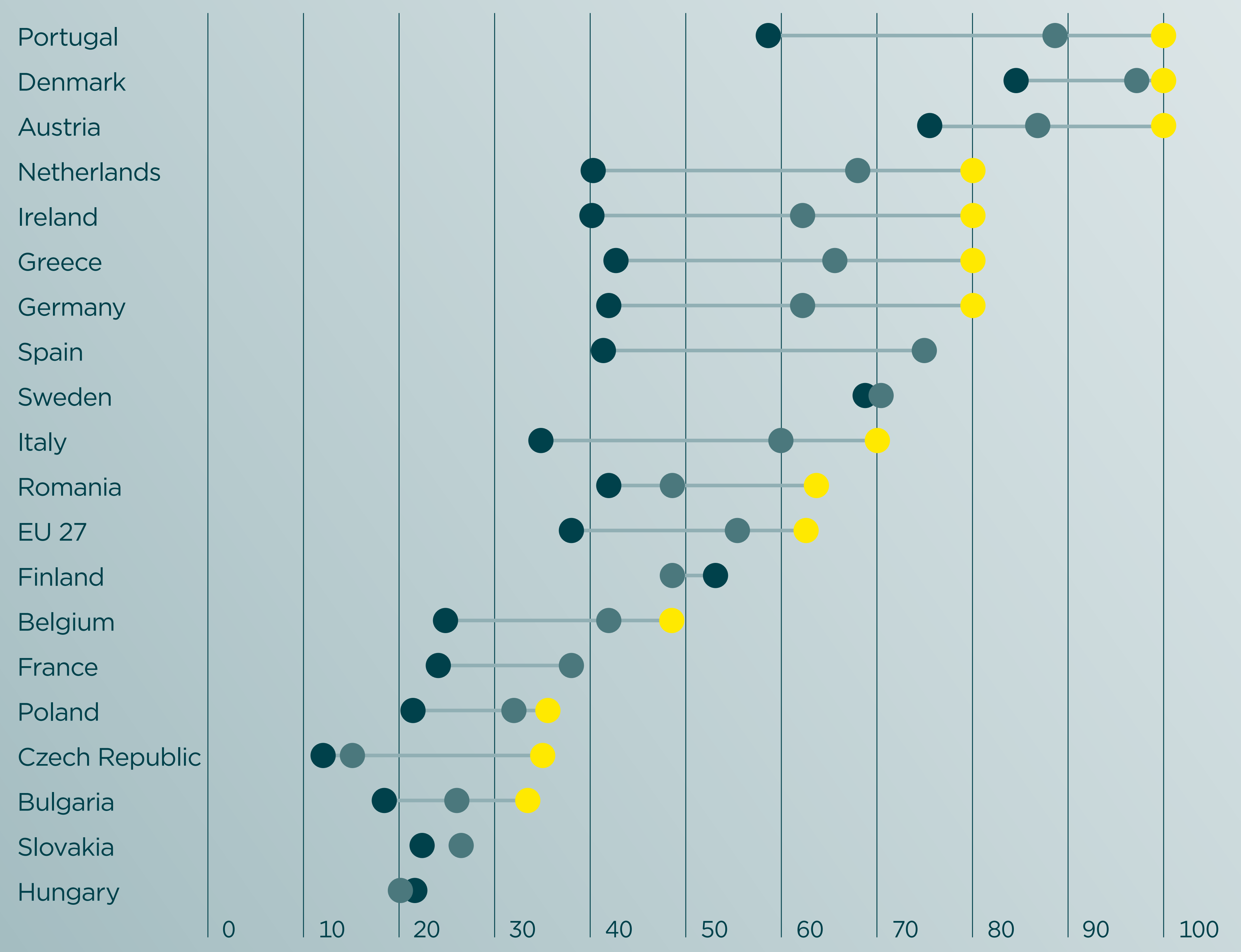
[8] German Bundestag, parliamentary group concerned about the dependence on China for solar panels, https://www.bundestag.de/dokumente/textarchiv/2024/kw15-de-aktuelle-stunde-solarmodule-997412.

Expansion targets in Europe

Climate targets and energy security as key drivers of the energy transition

Planned share of renewable energies in electricity generation[10]

in %



- 2022 figures
- National energy and climate plans since 2019
- Latest national policy announcements

45 %

EU renewable energy target for 2030[11]

€140 billion

need to be invested annually by 2030, and another €100 billion a year by 2040, to achieve 100% energy independence[12]

Many EU countries have revised their expansion targets upwards.

[10] EU Power Sector 2023 Targets Tracker, https://ember-climate.org/data/data-tools/european-renewables-target-tracker/, version dated 28.09.2023.
[11] German Federal Government, EU climate protection package Fit For 55, Internet publication: https://www.bundesregierung.de/breg-de/themen/europa/fit-for-55-eu-194240#:~:text=Europa.
[12] EU Power Sovereignty through Renewables by 2023 – Study coordinated by the Potsdam Institute for Climate Impact Research, October 2023

From yellow to green

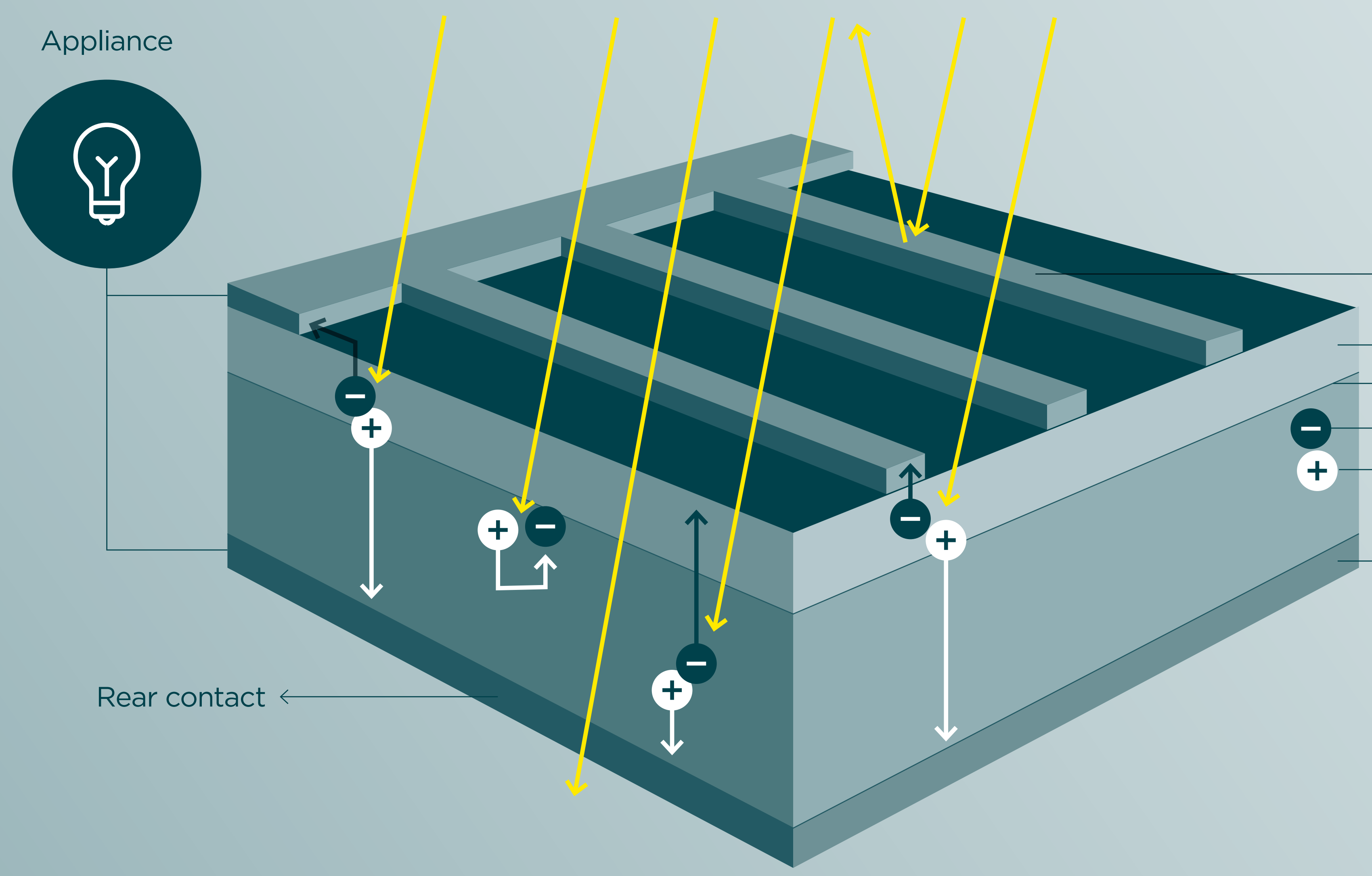
How is solar power actually used to produce 'green' electricity and why is photovoltaics not just a cutting-edge technology, but a cornerstone of the energy transition? The following section provides an overview and answers to these questions.

‘This rapid growth confirms our confidence in the enormous potential of solar energy.’

Kadri Simson, European Commissioner for Energy, 2023[13]

[13] EU Market Outlook for Solar Power 2023–2027, https://www.solarpowereurope.org/insights/outlooks/eu-market-outlook-for-solar-power-2023-2027/detail.

Photovoltaics: technology, design and function.



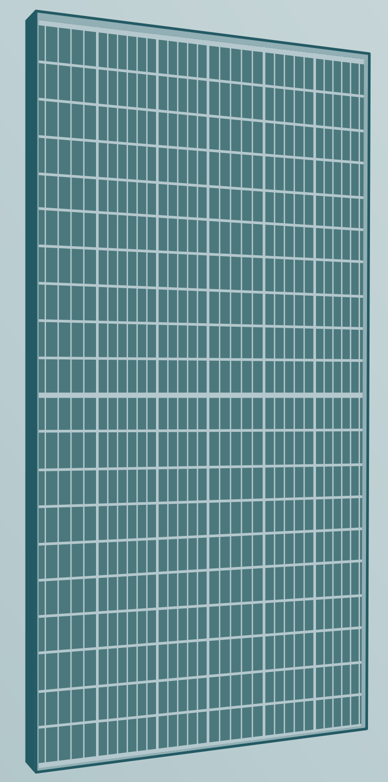
Solar energy is the energy of solar radiation, which is generated by nuclear fusion inside the sun and reaches the earth as electromagnetic radiation. This more or less inexhaustible energy source is used to generate electricity (photovoltaics) and heat (solar thermal). It is the largest natural source of energy in our solar system. Every year, many times the world's energy requirements reach the earth in the form of sunlight.[14]

Photovoltaic cells work using the **'photoelectric effect'** (or 'photo effect' for short). This occurs in semiconductors such as silicon, which is used in most photovoltaic cells. In this process, a light particle (photon) moving in the form of an energy packet is absorbed by an electron, thereby releasing the electron from its bond. Due to the special construction of a photovoltaic cell, with a positively and negatively doped semiconductor layer and the resulting electric field in the cell (at the boundary layer between p- & n-doping), this electron is now 'free' and moves towards the negative pole. Here, the electrons accumulate with increasing light intensity, creating an electrical voltage in the cell. By connecting the metal contacts of the negatively charged side (negative pole) and the positive pole, electrons flow – and direct current can now run.

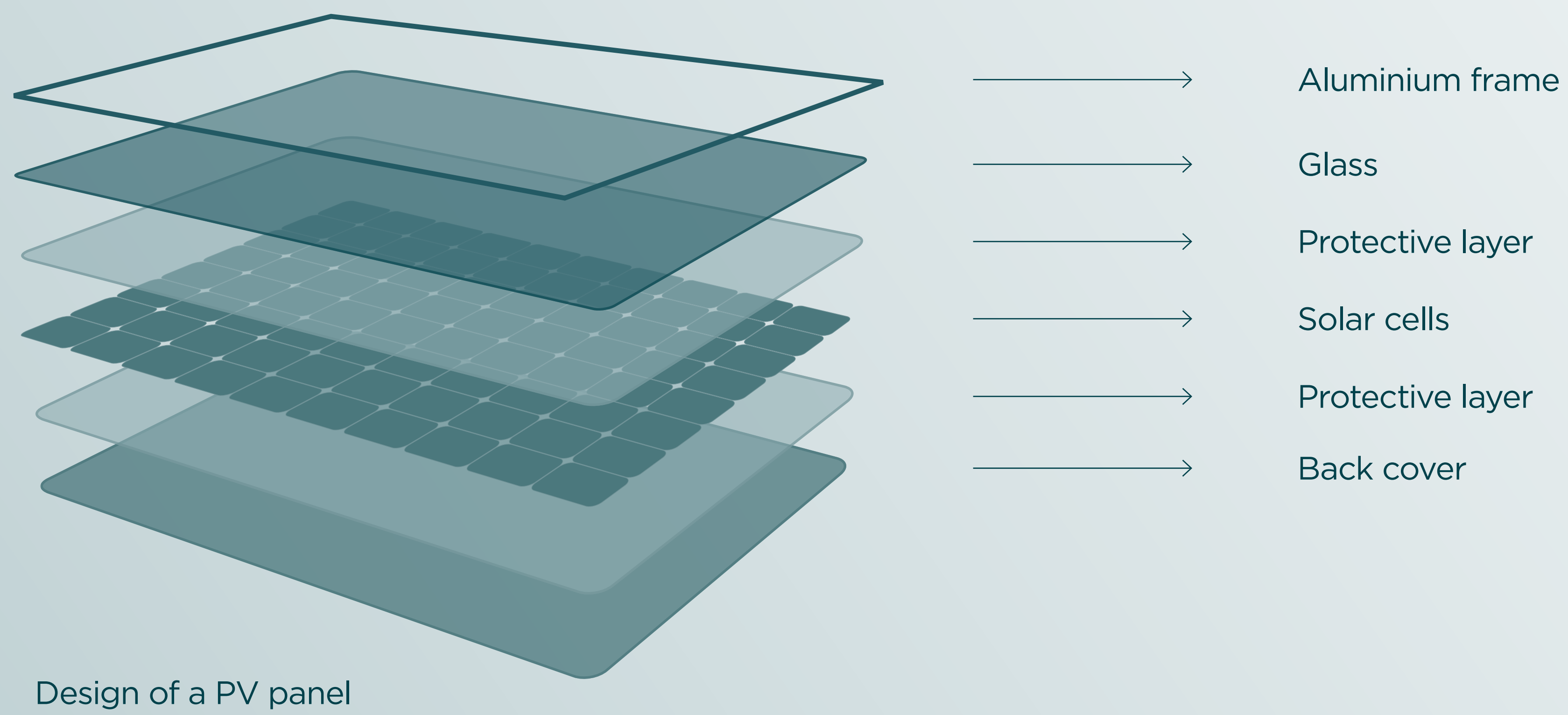
Dieses technologische Grundprinzip wurde im This basic technological principle has been continuously developed over time, and today there are many variants. The cell architecture that currently dominates the market is the so-called **'PERC' technology**. In its current forecast from 2023, however, the VDMA (German Mechanical and Plant Engineering Association) expects TOPCon technology to gain significant market shares in the coming years and that heterojunction technology will also expand its share, with the result that PERC cells will gradually be pushed out of the market.[15] In addition, **tandem-cell architecture** is an exciting innovation with promising efficiencies, but this technology is still in the research and development phase. We will now summarise the most important components of a photovoltaic system and how they work.

→

[14] Solarenergie.de, 'Kann die Sonne den Weltenergiebedarf decken?' https://solarenergie.de/hintergrundwissen/solarenergie-nutzen/weltenergiebedarf.
[15] Solarserver, VDMA: Silicon and TOPCon solar cells dominate photovoltaics, https://www.solarserver.de/2024/06/04/vdma-silizium-und-topcon-solarzellen-dominieren-photovoltaik/.



PV panel



Design of a PV panel

In practice, 60 or 72 solar cells are usually connected to form larger units, photovoltaic panels. Each panel is wrapped with films and covered with a glass plate to protect it from environmental influences. A metal frame provides an additional mounting option. Each panel generates a certain amount of direct current. To generate more energy, several panels can be connected to form a photovoltaic system.

Depending on the wiring, either the voltage (series connection) or the current (parallel connection) increases. **The voltage serves as the driving force for the current** (the flow of electrons). The direct current produced by a photovoltaic system can then be converted into alternating current, which is used in our power grid, by an inverter. In addition, aluminium stands/mountings are usually selected to align and support the panels (often also for cable routing). In the case of large systems, an additional transfer station is installed to enable grid connection; this uses a transformer to bring the alternating current up to the voltage level of the respective grid and is equipped with an electricity meter. This station also contains safety units that trigger in the event of a fault (on the mains or system side) and are intended to protect all components from destruction.

When planning a system with the aim of maximising energy yield, it is important to align the panels as perpendicular to the solar radiation incidence as possible. **Accordingly, the orientation and inclination of the panels, as well as the efficiency of the panels used, are decisive for their yield.** This is, of course, not possible due to the constant change in the position of the sun. Solar-tracking systems offer the best option here, but are correspondingly more expensive to build and require energy for tracking, which should be taken into account in the calculation. Other important aspects are the shading and rear ventilation of the panels, as they lose efficiency the warmer they are (approx. 0.2–0.4% per degree when the 25-degree mark is exceeded). It is not the ambient temperature that counts here, but the panel temperature, which can reach up to 70 degrees Celsius on hot summer days. Accordingly, the highest solar yields can be expected in spring, when the sun is already higher in the sky, but the temperatures are still milder.

In the area of home supply, the aim is to achieve the highest possible self-consumption rate. Of course, it always depends on the specific location, building and consumption conditions, but an east–west orientation can help to achieve a higher level of self-consumption. In the case of a ground-mounted installation, such an orientation would be more beneficial to the grid, because generation would be more steady throughout the day and the simultaneity factor (midday peak) would be equalised. In addition to orientation, the combination with an electricity storage system as buffer storage can also serve to achieve better market prices than at the time of actual generation. In the home sector, the use of an electricity storage system can further increase the self-consumption rate of the PV electricity generated.

Today, photovoltaic systems have a service life of a good 30 years, and even longer with appropriate maintenance. This enables them to exhibit significant economic and environmental benefits over a long period of time. During this time, they yield a harvest factor of 11 to 18, i.e. they produce 11 to 18 times as much energy as was required for their production, and the trend is rising.[16] The following describes the particularities of the life cycle of a photovoltaic system and what happens after the end of operational life.

Degradation

Due to ageing and material stress, the performance of PV panels deteriorates over time, as they are permanently exposed to sunlight and the effects of the weather. Nevertheless, ground-mounted installations usually still provide about 85% of their initial yield, even at the end of their life. According to the Fraunhofer Institute for Solar Energy Systems, degradation is around 0.15% per year, but operators often make conservative calculations of up to 0.5%.[16] The technology-specific recommendations of scientific institutes should be taken into account when making calculations.

Repowering

By repowering the system at the end of its calculated service life (new, more effective panels can usually double the yield of the same area), infrastructures can continue to be used cost-effectively (following review and any necessary repairs/extensions). This requires new calculations and the updating or renewal of existing contracts (insurance, leases, technical operations, etc.), but at the same time offers opportunities – via PPAs or by adding a storage system – to generate higher returns and preserve the location.

If a decision is made against retaining the site, the ground-mounted installation will be dismantled. In this context, the European WEEE Directive (Waste Electrical and Electronic Equipment Directive, 2012), which was implemented in Germany with the introduction of the Electrical and Electronic Equipment Act (ElektroG, 2015), is intended to regulate the return of panels and impose obligations on both manufacturers and operators. It sets out a mandatory collection rate of 85%, of which a recycling rate of 80% is to be achieved. In general, 95% of a PV panel can be recycled. Nowadays, the aluminium frame, the junction box (copper) and, in some cases, the glass of the panels are already returned to the material cycle.[17] Recycling the cell composites, which contain silver, silicon, copper and other valuable resources, is technologically feasible, but not yet economically viable.

[16] 'Aktuelle Fakten zur Photovoltaik in Deutschland' – Fraunhofer ISE, https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/aktuelle-fakten-zur-photovoltaik-in-deutschland.html.

[17] Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, Directive 2012/19/EU on Waste Electrical and Electronic Equipment, https://www.bmuv.de/gesetz/richtlinie-2012-19-eu-ueber-elektro-und-elektronik-altgeraete.

QUESTIONS ABOUT THE CURRENT CHALLENGES AND OPPORTUNITIES IN THE SOLAR INDUSTRY FOR

Dr Thorsten Blanke

CEO, BELECTRIC GmbH

'Some of the biggest challenges are hidden in the ground.'

BELECTRIC specialises in the planning, construction and operation of solar power plants. Since its founding in 2001, the company from the Lower Franconia region has installed more than 500 PV systems with a total output of 4.8 gigawatts and is one of Europe's largest service providers in the field of operation and maintenance (O&M).

belectric.com

— What are the challenges when planning and selecting the location of a solar park?
Increased requirements in terms of species conservation, nature conservation, landscape conservation, monument conservation, protection of people and soil/water conservation are greatly limiting the choice of possible locations. In addition, we have to deal with closely defined municipal criteria catalogues, a construction management procedure that is long in practice and an increased number of statements from the public. Even locations that meet all the requirements can often not be realised because connecting to the grid is challenging and projects thus become uneconomical.

Furthermore, the overloading of medium- and high-voltage grids is a major obstacle to integration into the power grid, which often means that solar parks cannot be connected at all or can only be connected at a great distance, which is associated with enormous costs. In order to meet these requirements, we at BELECTRIC focus on informing and involving all project participants at an early stage.

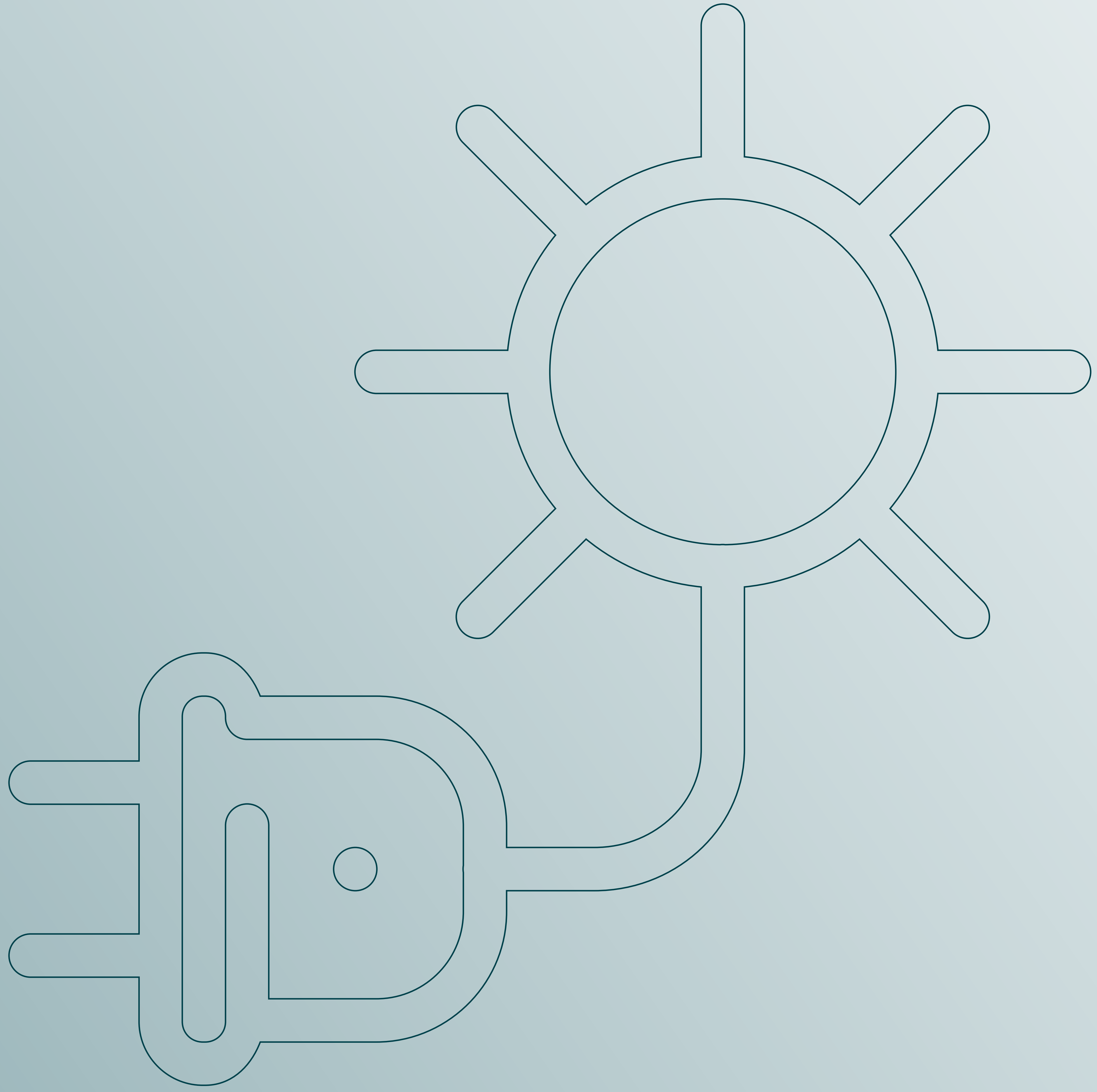
— How long do you currently expect the construction of solar power plants to take in Germany?
Two years can easily elapse from the municipality's decision to install the solar park and the decision to apply for planning permission to grid connection and the commissioning of the solar park. This is why the costs of pre-financing the projects are extremely high. In the case of larger ground-mounted plants, which require the construction of a substation to connect to the grid, implementation may take another year or so.

— What are the technical challenges during the construction phase of a solar park?
Some of the biggest challenges are hidden in the ground. Nobody wants to bear the soil risk in solar projects, which is why we at BELECTRIC determine the condition of the subsoil in advance by means of intensive geotechnical studies and pull-out tests. This allows us to determine the materials to be used and to define the installation process more precisely. However, the greatest risk of late completion lies in grid connection. The reasons are manifold: specific requirements of the operators, long delivery times for grid connection components, especially transformers, and lengthy approval processes due to staff shortages, amongst other things.

— How do you overcome operational and maintenance challenges to ensure high performance and efficiency of the solar park?
In Germany alone, four of our locations specialise in operations and maintenance (O&M). At our headquarters in Kolitzheim, we have an in-house control room in which we closely monitor all our power plants in Europe and Israel. This enables us to minimise reaction times and downtimes. We continuously train our highly specialised employees in order to benefit from new developments and trends. Thanks to our innovation teams, we always bring the best out of the latest technologies for our customers.

From solar park to investment opportunity

Photovoltaics has established itself in the green energy supply and has proven its mettle time and again as an investment over the years. A brief overview explains how photovoltaic systems can pay off for both operators and investors.



‘By 2050, solar energy will dominate the market.’

Study 10/23, Nature Communications

Invest sustainably. Benefit from the energy transition.

Photovoltaics is no longer an innovation and has established itself as an attractive method of generating electricity. Photovoltaics has also long proven its worth as an investment. The Commerz Real Group's first solar fund was launched back in 2005.

The technology is mature and delivers stable yields over the long term. This makes photovoltaics an investment opportunity that can be of interest to a wide range of investor groups. The prospect of stable cash flows from the sale of electricity offers planning security, which is particularly appreciated by long-term investors such as pension funds and insurance companies. Even if the amount of sunlight varies from day to day, the solar yield at a particular location can be predicted relatively reliably over the long term. Solar parks are also less complex in terms of planning and construction than many other infrastructure projects. Photovoltaics also lends itself to diversification: both securities and property portfolios can be supplemented with infrastructure investments for greater diversity. The prospects for renewables as an asset class are good: the increasing electrification of heating and transport, for example, will massively increase the demand for electricity, not only of households but also of businesses, and the associated electrification of many energy-consuming devices, meaning that electricity from renewable sources will be in demand in the long term.

Diversify widely. Safeguard returns.

The first solar funds were entrepreneurial investments in individual solar parks. With these fund models, providers initially raise capital to invest in solar projects that are already operational or yet to be built. Investors receive repayments from the sale of electricity over a fixed term and, at the end of the term, from the sale of the parks. This model has proven to be quite robust over the years. However, closed-end funds have fallen somewhat out of fashion for private investors due to new regulations.

On the other hand, new fund models such as the ELTIF (European Long-Term Investment Fund) are enjoying growing popularity. Here, investors can invest in clean energy portfolios, some of which are extremely broadly diversified. The early redemption of units to the fund is also possible and offers investors a certain amount of liquidity.

Regulated marketing. Numerous options.

In addition to power generation, the decisive investment case for a PV investment is also the marketing of the solar power, which should not only cover the investment costs, but also generate an adequate return for investors.

There are various options for marketing electricity:

1

Utilisation of statutory funding mechanisms, depending on the performance class:

GERMAN RENEWABLE ENERGY SOURCES ACT – EEG

2

Sale and direct marketing of electricity:

ELECTRICITY EXCHANGE

3

Individual electricity supply contracts with industrial customers:

POWER PURCHASE AGREEMENTS – PPAS

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1 GERMAN RENEWABLE ENERGY SOURCES ACT – EEG

Statutory feed-in. Guaranteed prices.

Germany passed the Renewable Energy Sources Act (EEG) back in 2000. This piece of legislation regulates the **priority feed-in of renewable energies into the power grid** and guaranteed producers fixed purchase prices for a long time. The aim was to support the expansion of renewable electricity generation. Over the years, the EEG has been revised and developed again and again.

For a long time, the statutory feed-in tariff was well above the market price. This is why many solar funds in Germany relied entirely on feed-in at the statutory feed-in tariff. For large-scale plants, however, the fixed feed-in tariff was **practically** abolished a few years ago and gave way to a tendering procedure with its market premium model.

In this case, the difference is calculated between the so-called 'market value' (on a monthly basis) achieved by direct marketing on the electricity exchange and the amount of subsidy awarded in the specific tendering procedure for the installation, the so-called 'fair value', and the subsidy amount is adjusted accordingly on a monthly basis. Today, due to market prices that are regularly higher than the feed-in tariff, the tariff should be seen as a lower hedging limit. Smaller systems or private system operators can continue to receive a guaranteed feed-in tariff for their electricity in accordance with the EEG; this tariff is staggered according to the power class and feed-in variant of the system. However, since this is now much lower than the operator's own electricity procurement costs, it is more worthwhile to use the electricity for self-sufficiency as far as possible.

Fluctuating prices. Increasing opportunities.

As feed-in tariff rates fall, commercial electricity producers such as solar funds are **increasingly keen to market their electricity directly on the electricity exchange**. If the electricity is only marketed directly, it is sold at flexible prices, which can sometimes lead to higher returns than the feed-in tariff. In practice, however, there is little focus on direct marketing alone and the feed-in tariff is used as a 'floor', i.e. downward price hedging, to mitigate price risks. This is because prices on the electricity market fluctuate depending on the time of day and the weather, very much in accordance with the principle of supply and demand. While they are usually lower on summer days, for example, when large amounts of photovoltaic electricity are fed in, they often increase when the fluctuating supply of renewable energies decreases due to weather influences. In terms of marketing, battery storage offers good opportunities to feed some of the electricity generated from renewable energy into the grid at a later date in order to achieve higher prices. In addition to higher market prices, this also contributes to grid stability by better distributing the feed-in throughout the day.

2 — ELECTRICITY EXCHANGE

Future marketing. Great potential.

3 POWER PURCHASE AGREEMENTS – PPAS

The 'new normal' in the sale of electricity from large plants is primarily shaped by power purchase agreements (PPAs). These are individually negotiable fixed-term purchase agreements between producers and consumers, such as large industrial companies, power suppliers and data centres. The most common terms are between ten and 15 years. A PPA regulates the supply of a certain amount of electricity and the guarantee of a required base load against a fixed tariff. However, in the event of non-delivery due to weather conditions, producers face contractual penalties or additional costs as a result of external procurement. It is possible and advantageous for the two contracting parties to have a physical connection in order to supply the electricity directly. This is not necessary, however, as billing is also possible via the public electricity grid.

The rise of PPAs began in the US, but they are now an integral part of the EU market. In Germany, too, their importance is steadily increasing: the state-owned German Energy Agency (Dena) estimates that up to 25% of all electricity generated in Germany could be marketed via PPAs by 2030.[18]

Amongst the large number of variants and specific adaptation options, there are three basic concepts:

a **On-site PPA:** Electricity is supplied via a direct connection between the plant and the customer (behind the meter, without transport through the grid).

b **Physical PPA:** Electricity is transported via the grid, so there is no need for the plant and the customer to be in the immediate vicinity of each other.

c **Synthetic PPA:** Indirect electricity purchasing; here, the focus is on financial compensation payments in the form of a contract for difference (CFD), the aim being to maximise price hedging on both sides.

[18] German Energy Agency, 'PPA-Markt hat Potenzial bis zu 25 Prozent des Strombedarfs 2030 zu decken', https://www.dena.de/newsroom/meldungen/2023/ppa-markt-hat-potenzial-bis-zu-25-prozent-des-strombedarf/.

QUESTIONS ABOUT THE CURRENT CHALLENGES AND OPPORTUNITIES IN THE SOLAR INDUSTRY FOR

Marc Böhnke

Managing Director, Evergy Engineering GmbH

Evergy Engineering GmbH in Munich is a leading provider of technical consulting services in the energy sector. With a strong focus on renewable energies, the company offers innovative technical services for the development, financing and delivery of energy projects. Its dedicated team of experts works closely with clients to deliver bespoke solutions that meet their individual needs and are based on quality, reliability and client satisfaction.

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— Photovoltaics in the energy mix: how do you assess the status quo and the outlook? What development do you expect?
Photovoltaics makes a decisive contribution to the energy supply in Germany. In 2023, it accounted for around 12% of electricity generation (Europe 9%). However, in order to achieve our climate targets and become independent of fossil fuels, we need to expand even more. The prerequisites were created with the adoption of the Federal Climate Change Act. As early as 2024, the proportion of photovoltaics is set to increase to 20–25%.[19] To achieve this, sufficient land must be developed, solar panels must perform more efficiently, public acceptance must be maintained and the repowering and recycling of solar parks must be promoted.

— Which technological developments do you consider to be the most important at the moment?
Continuous cost reduction in panel production. Experts expect manufacturing costs to come down by a further third by the end of the decade.[19] Another important factor will be improving cell efficiency. The silicon panels that currently dominate the market for commercial PV systems are constantly being enhanced through gradual improvements in materials, manufacturing processes and cell architectures. Further market penetration of n-type and bifacial panels will further increase efficiency in the future.

Further research in the field of thin-film technology and different material combinations (tandem cells) will lead to major efficiency gains in the medium term due to better utilisation of the frequency spectrum, sunlight, longer service lives and cost reductions in manufacturing. One example is perovskite solar cells, which are expected to increase efficiency by up to 29% in the medium to long term (currently around 19–22%).

— How do you assess the long-term profitability of photovoltaics for producers and investors?
This depends on a number of factors. It is clear that falling feed-in tariffs and increasing market saturation, particularly due to the high simultaneity factor of PV (all installations generate electricity at the same time), have a negative impact on PV profitability when these factors are considered in isolation. However, there are numerous developments that are counteracting this. The

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[19] Source: Fraunhofer ISE

industry is characterised by a high rate of innovation and technological progress. The continuous improvement of system components, the optimisation of technical planning to make the best possible use of space and grid connection, and the integration of storage solutions are all leading to lower generation costs for electricity and will support/increase its market value in the medium term.

With the increasing feed-in of electricity from renewable energies, the Leipzig electricity exchange became a residual electricity exchange that generates a price for the needs-based supplementation of renewable electricity generation and no longer reflects the true price of electricity, especially green electricity. Over the next few years, the restructuring of the electricity market (currently the merit order principle) will become increasingly important. It is expected that the new electricity market design, which currently only exists in rough sketches, will also have a supporting effect on the price of green electricity. In summary, we expect photovoltaic profitability to remain stable over the long term for producers and investors.

— What role do PPAs play and how will this market develop?

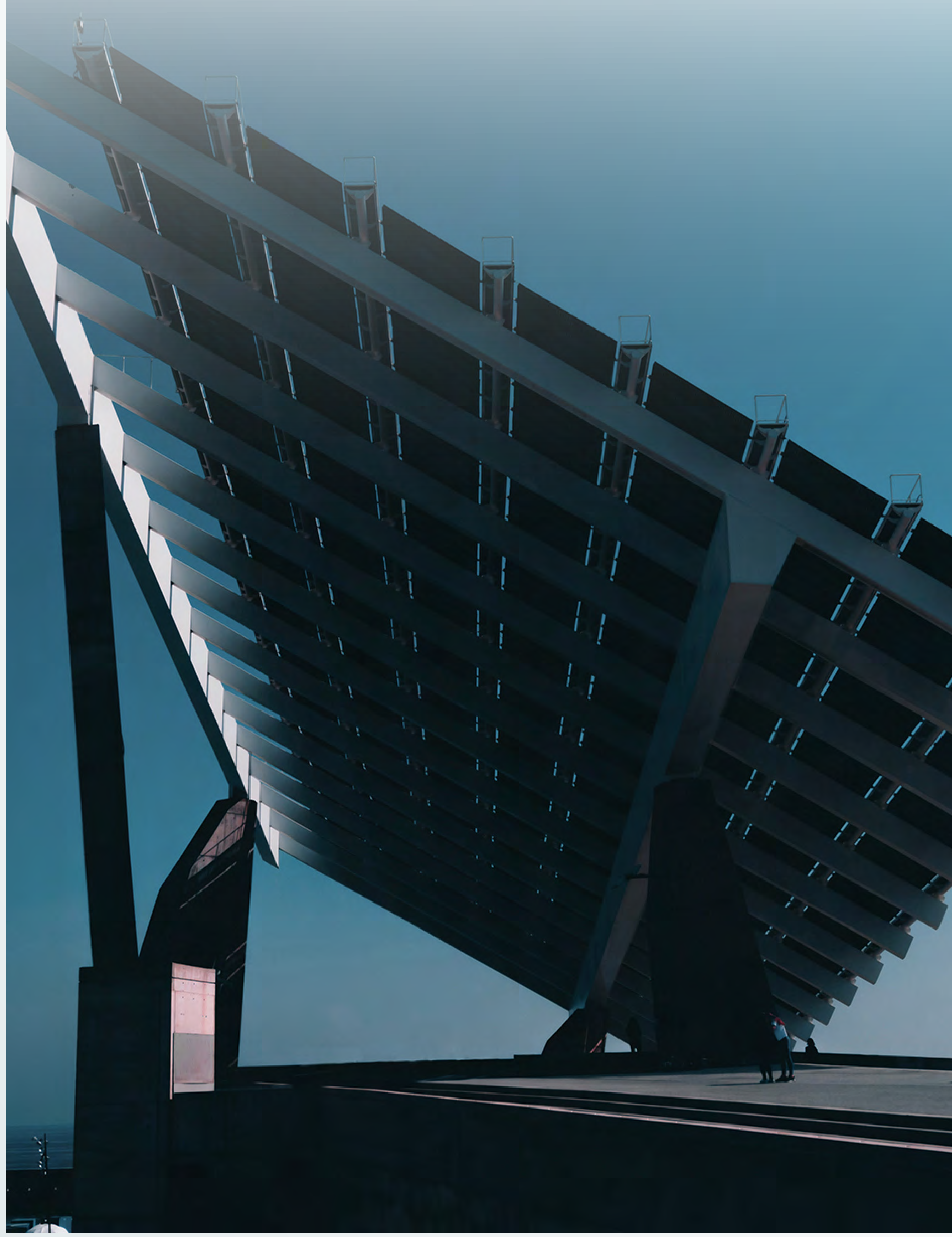
In Europe, power purchase agreements (PPAs) have become an important pillar of growth in the PV sector alongside tenders and self-consumption. In Germany alone, the market for PPAs grew by more than 300% between 2022 and 2023, primarily driven by PV and offshore wind.[20] In addition to Germany, Denmark, Sweden and Poland also recorded strong growth. The most important market in Europe is Spain.

Another driver lies in the conditions for producing green hydrogen in the EU. The required high temporal and geographical correlation between electricity and hydrogen production forces operators of electrolysers in Germany to conclude a PPA for the generation of renewable hydrogen.

Over the next few years, we expect PPAs for hydrogen production to continue to establish themselves on the market. With the increasing number of wind turbines whose (EEG) subsidies are coming to an end, we expect a further increase in the number of post-EEG PPAs, enabling wind turbine operators to secure their income once the subsidies have expired.

On the other hand, we are seeing a decline in short-term PPAs, which allow operators of tariff-subsidised plants to increase their revenues. Due to the fall in market prices, the tariffs awarded in the tendering processes have recently mostly been higher than the PPA prices.

Overall, we expect continued strong growth in the market, as PPAs offer many benefits, including price stability, long-term revenue planning, the fulfilment of sustainability goals and an easing of the strain on public coffers and taxpayers caused by unnecessary tariff incentives. Thanks to their suitability for outside financing, they are an important instrument for scaling up the renewable energy market more quickly and achieving expansion targets.



‘Power purchase agreements have become an important pillar of growth in the photovoltaic sector in Europe.’

[20] Source: German Energy Agency.

Innovations that radiate promise

A look at innovations in PV and how space can be used even more efficiently. Integrated PV solutions, in particular, are currently being promoted. They make it possible to open up previously unused areas for solar power generation.

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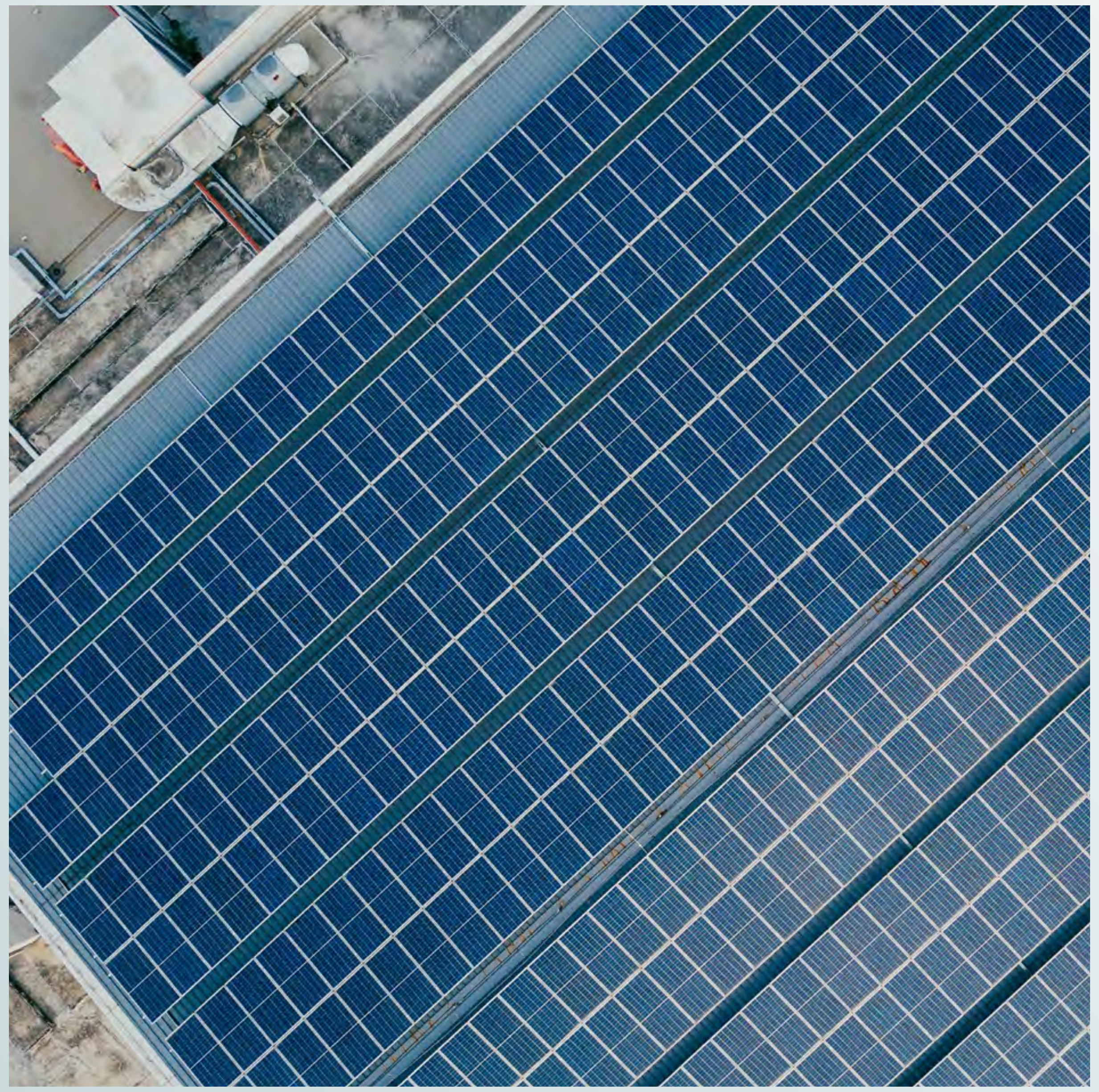
Concepts that open up new possibilities

1 Floating-PV

2 Agrivoltaics

3 Building-integrated PV



4 Transport-integrated PV

Floating current

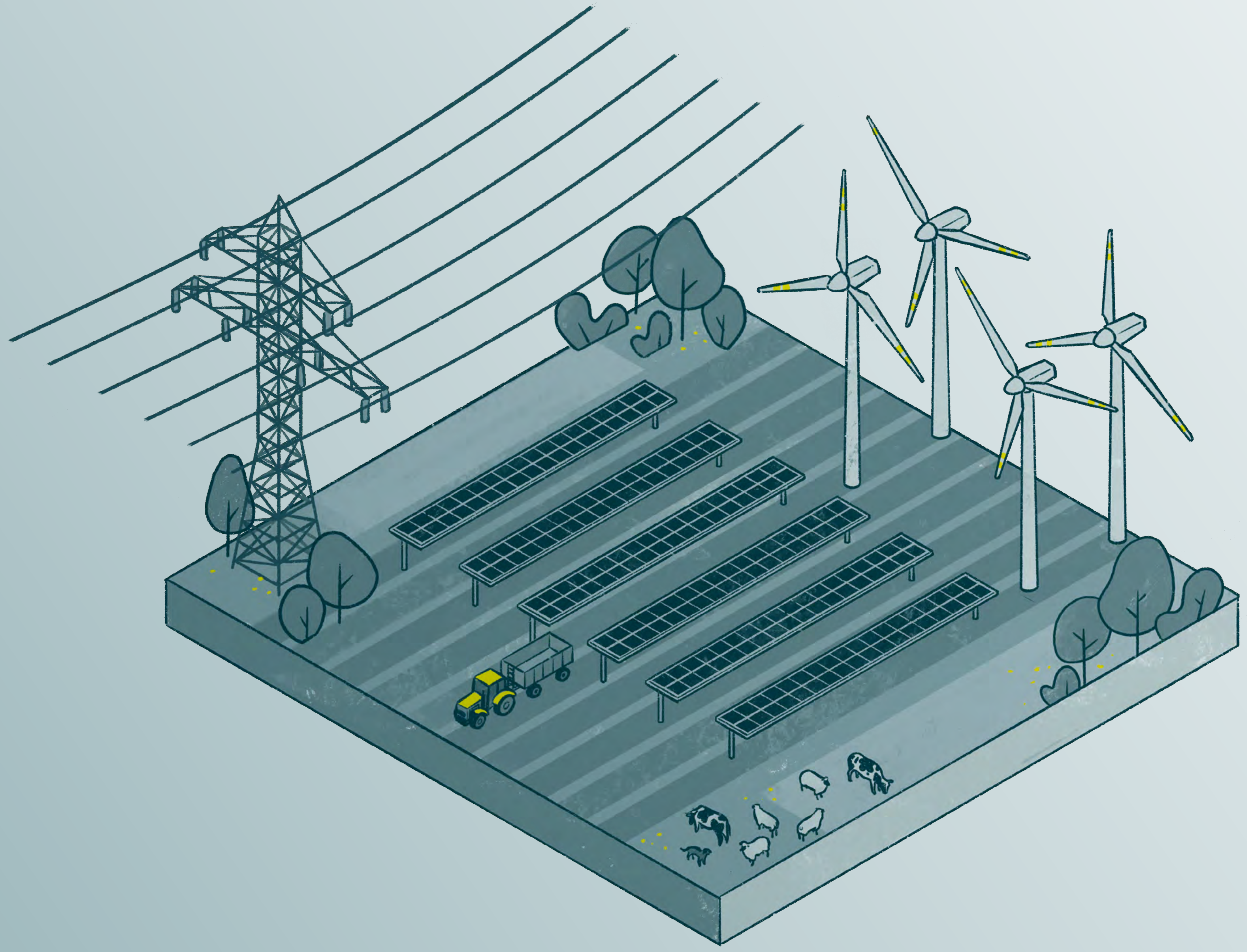
These PV systems float on water. This makes it possible to use water bodies effectively for the generation of electricity, especially in the industrial sector (artificial dredging and gravel lakes). The benefits are clear to see. There is much less competition for space on the water, as industrial water areas are already owned by an operator who has an interest in in-house power generation. In addition, the shade ratio on the water is lower and, in some cases, a higher usage density can be achieved. The cooling effects of the water on the PV panels also contribute to an increase in yield compared to ground-mounted PV. At the same time, shading and the reduction of wind turbulence directly above the water surface reduces the evaporation process; here, synergies could be leveraged with pump-storage hydropower plants or drinking water reservoirs.

With regard to water quality and aquatic ecology, there have been no negative impacts to date. Taking certain rules into account (distance to the bank, only partial occupancy), people tend to talk about advantages in this context.[21] Due to the lack of results from long-term studies, however, the German government issued new regulations in the Water Resources Act of 2022, which allow a distance to the bank of 40 m and an occupancy rate of max. 15%. As a result, fully planned projects could no longer be implemented. Many experts consider the measures to be excessive and assume that expansion in this innovation segment will be significantly limited.[22]

The technical potential is impressive:
The promising technical potential on German inland waters totalling 44 GWp is therefore unlikely to be fully exploited for the time being.[22] The long-term stability of the systems in the offshore sector has not yet been sufficiently tested.

[21] BayWa r.e., ‘Erste Erkenntnisse zu Umweltauswirkungen von Floating-PV’, https://solar-distribution.baywa-re.lu/de/ueber-uns/news/details/erste-erkenntnisse-zu-umweltauswirkungen-von-floating-pv.
[22] Fraunhofer Institute for Solar Energy Systems, ‘Schwimmende Photovoltaik’, https://www.ise.fraunhofer.de/de/leitthemen/integrierte-photovoltaik/schwimmende-photovoltaik-fpv.html.

Good agricultural sense



Agrivoltaics refers to the dual use of agricultural land. Farmers can use framed photovoltaic systems to produce energy, reducing farm costs by generating additional income. As a result, the space is used more efficiently. Targeted planning ensures that crops underneath the PV systems are not exposed to too much shade. On the contrary: especially in hot and dry summers, the shade protects the plants from excessive sunlight and reduces the amount of water needed. The systems also offer additional protection in the event of severe weather events such as storms or hail.[23]

At present, approval procedures are even more complex than for other PV systems and yields are more difficult to estimate. The authorisation situation, at least, could improve in the long term from a regulatory perspective, as the efficient dual use of space is also politically desired.[23]

The potential is certainly there:
It is calculated that up to 1,700 GWp could be harnessed by agrivoltaics.[24]

[23] Fraunhofer Institute for Solar Energy Systems, 'AgriPhotovoltaik: Doppelt ernten', https://www.ise.fraunhofer.de/content/dam/ise/de/documents/infomaterial/brochures/23_de_ISE_Flyer_Agri-PV_Doppelt_ernten.pdf.
[24] Fraunhofer Institute for Solar Energy Systems, 'Agri-Photovoltaik: Chance für Landwirtschaft und Energiewende', https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/APV-Leitfaden.pdf.

CONCEPT: BUILDING-INTEGRATED PV

Smart by design

This is probably the most obvious innovation in PV: Building-integrated PV uses facades, windows and balconies and thus completes the spectrum of usable areas. The near-consumption generation of photovoltaic electricity in direct proximity to the customer not only shortens the transport routes for energy, but can also offer additional insulation, protection against weather events and design options in terms of the architecture. Even if the energy yield is potentially lower than with conventional roof-mounted systems due to a higher shade ratio and a less than optimal orientation towards the sun (in summer), the space potential is extremely attractive. The disadvantage in summer becomes an advantage in winter: thanks to their horizontal orientation on the facade, higher yields can be achieved in winter, when the sun moves low above the horizon, than with roof-mounted systems.[25]

The technical potential is impressive:
Up to 1,000 GWp can be harnessed by building-integrated PV systems.[25]

[25] Fraunhofer Institute for Solar Energy Systems, 'Bauwerkintegrierte Photovoltaik', https://www.ise.fraunhofer.de/de/leitthemen/integrierte-photovoltaik/bauwerkintegrierte-photovoltaik-bipv.html.

Transport-integrated PV: From km/h to kWh

The dual use of transport areas such as motorways, car parks, motorway service stations, shopping centres, multi-storey car parks and noise barriers not only offers efficiency benefits, but also great potential: transport routes account for 5% of the total area in Germany.[26] The potential in generation for transport routes alone is thus up to 300 GWp, while noise barriers on motorways and rail lines could deliver around 5 GWp and parking spaces around 59 GWp.[26] With PV systems integrated into transport, it would be possible to supply the surrounding transport infrastructure (service stations, charging infrastructure for EVs, communication infrastructure) and nearby consumers with green electricity. Other benefits include the surface's effective weather protection function, which extends its service life. In addition, an integrated solution for noise protection would also be conceivable. However, installation is complex: the systems require both particularly stable substructures that can withstand traffic accidents and integration into existing operational processes. The demands placed on the panels are also increasing: they must be non-glare and sound-absorbent.[27]

[26] Fraunhofer Institute for Solar Energy Systems, 'Photovoltaik in Verkehrswegen', https://www.ise.fraunhofer.de/de/leitthemen/integrierte-photovoltaik/verkehrswege-photovoltaik-ripv.html.
[27] Fraunhofer Institute for Solar Energy Systems ISE, 'Verkehrsflächen produzieren Solarenergie', https://www.ise.fraunhofer.de/content/dam/ise/de/documents/infomaterial/brochures/21_de_ISE_RIPV.pdf.

Light and shade

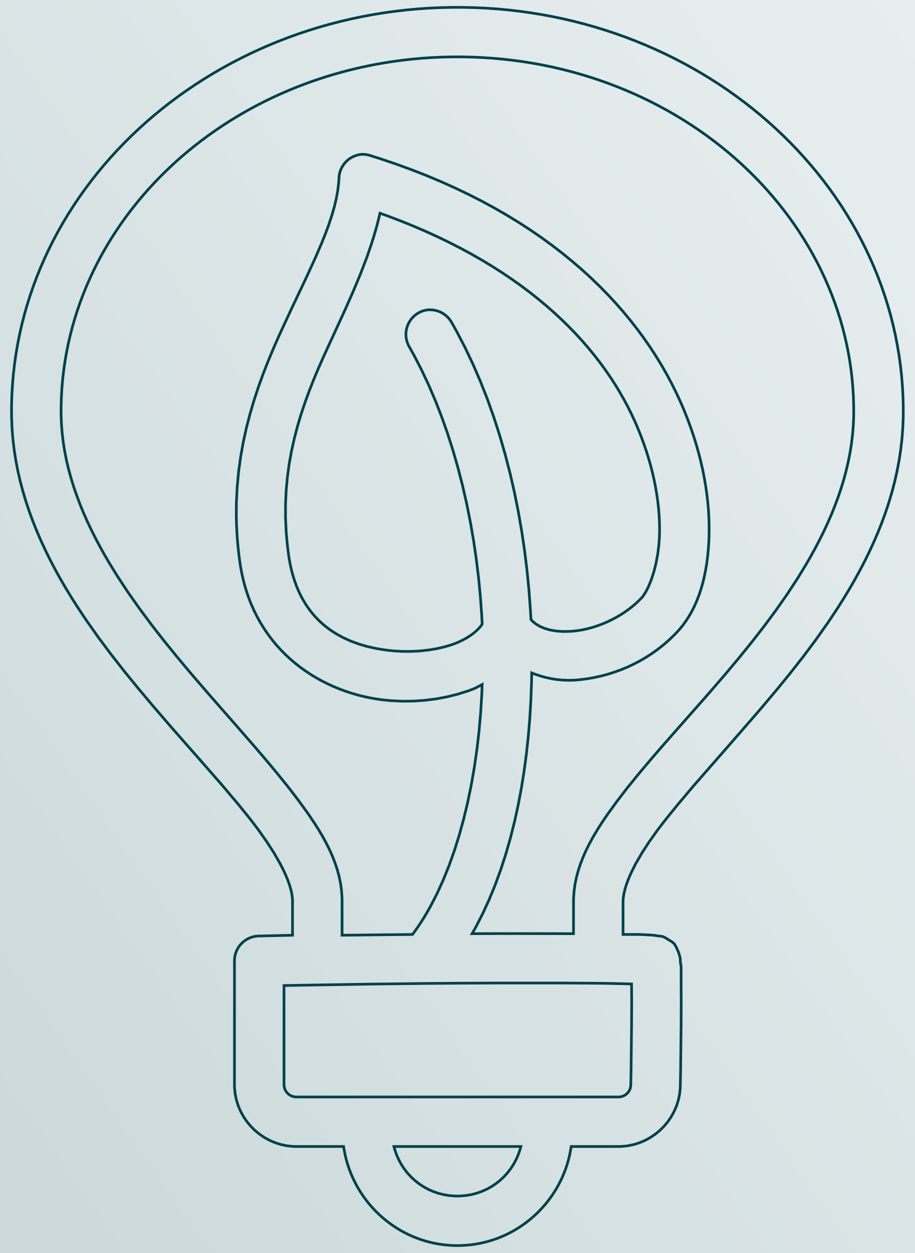
In our conclusion, we highlight the strengths and weaknesses, opportunities and risks of photovoltaics.

Strengths

- Electricity generation with low greenhouse gas emissions
- No waste materials to be disposed of during operation
- Low operating and maintenance costs
- Stable long-term returns
- Low electricity generation costs
- Political support for the energy transition at national and EU level
- Decades of experience and high standardisation (construction and operation)

Opportunities

- Sustainable investment attractive for investors and the environment
- Versatile use possible on various areas, some of which were previously unused (PV on agricultural, water, transport and facade areas)
- Increasing global demand
- High level of acceptance amongst companies and consumers
- Low-cost (re)financing possible when interest rates fall
- Low electricity generation costs



Weaknesses

- Space requirement, competition with agriculture for ground-mounted installations
- Weather-dependent fluctuations

Risks

- Dependence on international suppliers, especially China
- Internationalised supply chain causes solar projects to be delayed
- Fluctuating electricity prices (depending on marketing model)
- Partly opaque supply chains through international suppliers/manufacturers

QUESTIONS ON WHY PV IS AN IMPORTANT BUILDING BLOCK WITHIN KLIMAVEST AND HOW HE ANALYSES SOLAR PROJECTS AS A FUND MANAGER – FOR

Timo Werner

Fund Manager, klimaVest

‘Planning is essential.’

— What is your strategy as the klimaVest Fund Manager?
Our investment strategy has two objectives: in addition to the targeted financial returns, the fund aims to make a positive, measurable[28] contribution to the achievement of environmental objectives within the meaning of Article 9 of the EU Sustainability-Related Disclosures Regulation – in particular climate protection and adaptation. To this end, klimaVest is investing in infrastructure for the energy transition, specifically in wind and photovoltaic power plants. Investments in transmission grids and storage facilities are also possible. Since the fund’s launch in 2020, we have invested in 43[29] wind and solar parks and have also secured several development projects, i.e. parks currently in the planning stage.

— Why is photovoltaics a key component of the klimaVest portfolio?
Photovoltaics is an important pillar of our investment strategy for several reasons. PV parks deliver reliable electricity, which means predictable income for the fund. The technology is mature and has long been proven. When it comes to planning and operating the parks, we have access to a broad network of specialist partners, and Commerz Real itself has around 20 years of experience in PV investments. In addition, PV investments offer many opportunities to diversify the portfolio within the asset class and thus spread risks more broadly – for example, by combining different marketing models for the electricity produced and locations in different countries. klimaVest currently has investments in Finland, France, Spain and Sweden in addition to Germany.

— How do you deal with risks and uncertainties when investing in solar projects?
In addition to the diversification mentioned above, careful planning is essential. This includes forward-looking contractual arrangements and the selection of suitable partners. When we review an investment, we rely on several yield assessments in order to reliably estimate how much electricity the plant will generate. Of course, the risk is higher in the case of development projects than in the case of plants that are already connected to the grid. This is why we usually secure a right of withdrawal for projects that are not yet ready for construction, allowing us react flexibly in the event of delays or other problems.

[28] Statements about ‘avoidance’ or ‘measurability’ of CO_2 emissions or similar statements concerning CO_2 and/or CO_2e are generally to be read and understood in connection with the methodology explained at https://klimavest.de/messbar/. Statements about achieved or planned CO_2e avoidance are not a reliable indicator of actual future CO_2e avoidance. Targets can be either exceeded or undershot. klimaVest promotes electricity generation from renewable energies and records the associated CO_2e avoidance on the basis of country-specific avoidance factors of the Technical Working Group of International Financial Institutions (IFI) based on the Combined Margin Approach of the United Nations Framework Convention on Climate Change (UNFCCC), taking into account sector-specific CO_2e upstream emission factors of the German Environment Agency. Avoidance factors will decline in the future due to the expected increase in the proportion of electricity generated from renewable sources in the electricity mix.
[29] Transfer of benefits and encumbrances for three Swedish photovoltaic development projects of Helios Nordic Energy has not yet taken place.

Real projects

We present three innovative solar parks from Commerz Real’s renewables portfolio as best practices that demonstrate in different ways how we can benefit from PV as a technology and investment in equal measure, today and in the future.

CARTUJA – Solar park with connected wind park development project in Jerez de la Frontera, Spain

With its connected wind park development, the Cartuja solar park in Jerez de la Frontera near Cádiz, Spain, represents an innovative combination in the field of renewable energies. The solar power plant with a capacity of 50 MWp, which has been operational since 2021, and the onshore wind park under development with a planned capacity of 30 MW by 2027 are setting new standards together: This hybrid solution will enable a more constant power supply in the future and thus contribute to grid stability. The electricity produced annually by the two parks is expected to meet the needs of 35,000 average Spanish households.[30] Since February 2024, Cartuja has been part of Commerz Real's renewables portfolio, with Everwood Capital and PE Abei Energy as the vendors. The latter will continue to be responsible for the technical maintenance of the solar park and the development of the wind project.

[30] Calculated on the basis of average electricity consumption of households in the respective investment countries. Data basis: Enerdata (2019), targets may be exceeded or undershot.

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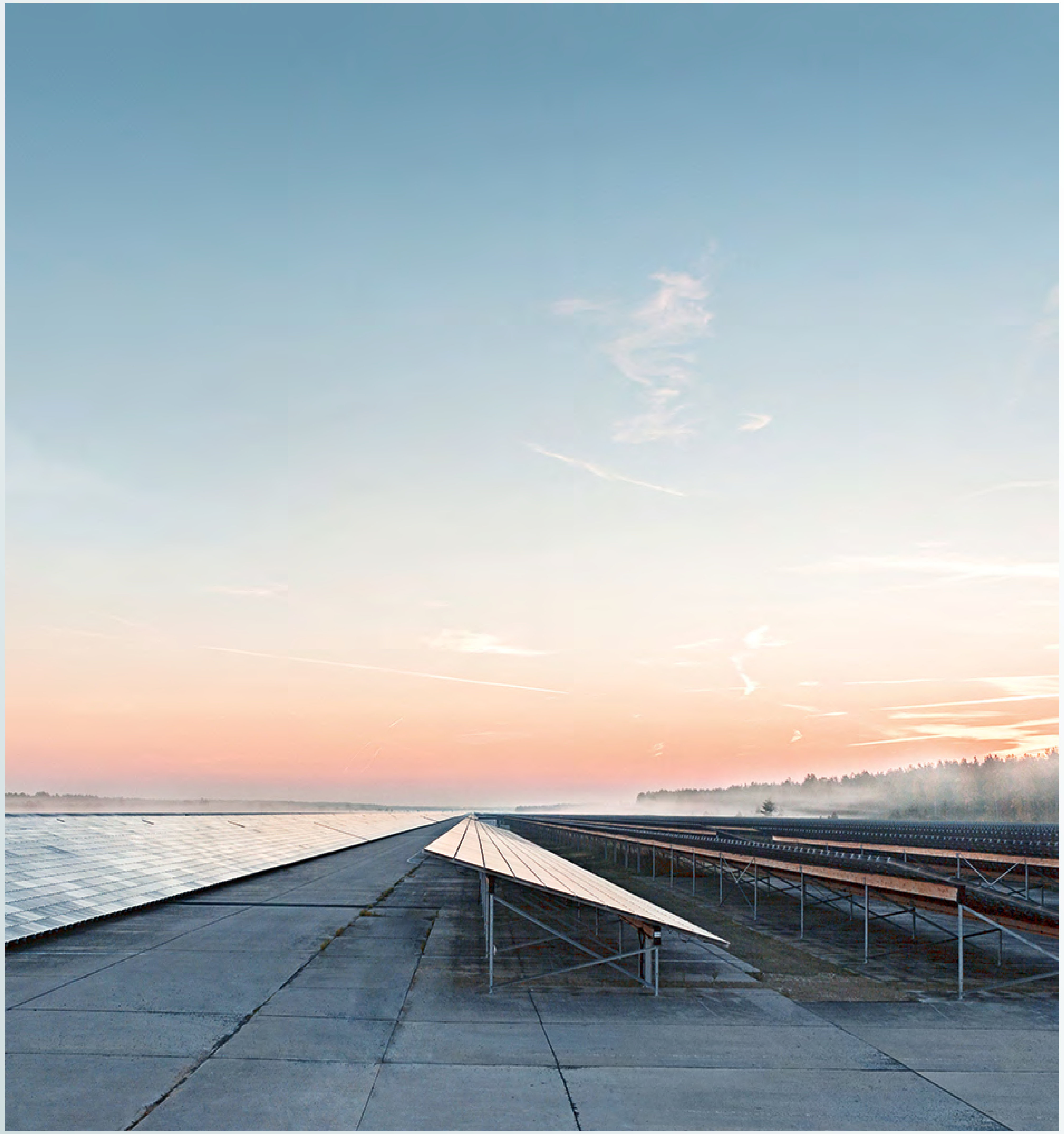
KING'S ROAR – solar park in Västerås, Sweden

The King's Roar solar park in Västerås, central Sweden, was commissioned in February 2024 and, with a capacity of 22 MWp, is an important building block in the region's sustainable energy generation. The power plant covers a 25-hectare site and is equipped with 32,500 solar panels and is designed to meet the annual electricity needs of around 2,300 average Swedish households.[31] The solar park was added to Commerz Real's renewables portfolio in April 2022, with Helios Nordic Energy responsible for project development.

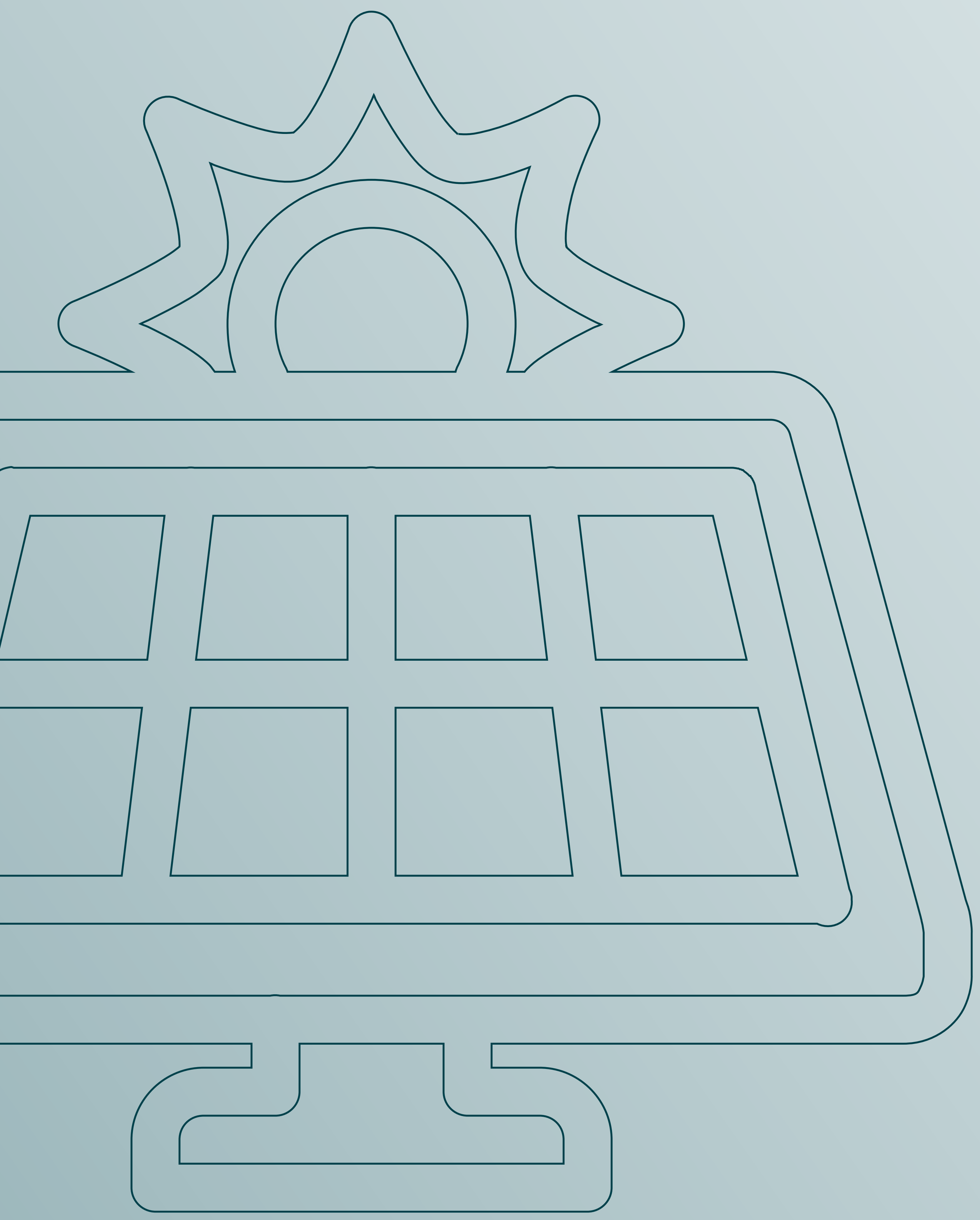
[31] Berechnet anhand des durchschnittlichen Stromverbrauchs von Haushalten in den jeweiligen Investitionsländern. Datenbasis Enerdata (2019), Zielsetzungen können sowohl über- als auch unterschritten werden.

BELECTRIC solar park in Templin/Groß Dölln, Germany



The BELECTRIC solar park in Templin/Groß Dölln, Germany, is an example of the conversion of former military sites through sustainable energy projects. With an installed capacity of 128 MWp, generated by 1.5 million solar panels on a 214-hectare site, the power plant makes a significant contribution to the region's energy supply. It is able to cover the calculated annual electricity requirements of around 36,000 average German households.[32] The solar park has been part of Commerz Real's renewables portfolio since March 2013. Planning, construction and operational management are the responsibility of the experienced firm BELECTRIC Solarkraftwerke GmbH.

[32] Calculated on the basis of average electricity consumption of households in the respective investment countries. Data basis: Enerdata (2019), targets may be exceeded or undershot.



‘By 2030, the solar industry in Europe is expected to grow to four times its current size.’

Industry association Solar Power Europe, 2024

Glossary

Direct marketing
In the case of direct marketing, the solar power generated is sold on the spot market or the electricity exchange at daily prices, irrespective of the feed-in tariff. In this way, better prices can sometimes be achieved than with the feed-in tariff.

Self-consumption
A PV system for self-consumption is usually used by private households and companies to generate electricity that they use themselves. The aim is to reduce external electricity requirements or make them obsolete and to receive possible remuneration through the sale of any surpluses.

Feed-in tariff
The feed-in tariff is part of the Renewable Energy Sources Act (EEG), which guarantees the purchase of electricity fed into the grid at fixed prices.

Energy yield
The energy yield of a PV system is the amount of electricity that it can theoretically generate or actually generate over a certain period of time.

Kilowatt hour (kWh)
One kilowatt hour is the energy consumed or produced by an appliance or system with an output of one kilowatt in one hour.

Kilowatt peak (kWp)
The kilowatt peak is the unit of measurement for the performance of photovoltaic systems under standard test conditions.

Grid parity
Once grid parity has been reached, the costs of generating electricity from renewable energy sources or photovoltaics are the same as those from conventionally generated energy sources.

Peak sun hours
The peak sun hours are a measure of the intensity of the solar radiation at the location and indicate the optimum that can be achieved with the system. This is an important metric when planning solar installations and calculating their potential yield.

Photovoltaics (PV)
PV describes the conversion of sunlight into electrical energy by means of solar cells.

Power purchase agreement (PPA)
A PPA is a contract for the long-term direct purchasing of electricity. There are different types of PPA, such as on-site PPA, physical PPA and synthetic PPA. With an on-site PPA, electricity is delivered on-site. This means that the system is not connected to the grid, but directly to the consumer. Physical PPAs regulate the transport of electricity over the grid from generator to consumer. Synthetic PPAs are even more indirect: contracts for difference (CFDs) are used to supplement transport over the grid with compensatory payments, which are intended to ensure the best possible price hedging for both parties.

Solar cell
A solar cell is the basic building block of a solar panel. The conversion of light into electricity takes place in the cell.

Solar panel
A solar panel connects several solar cells to form a larger module. A panel usually consists of 60 to 72 cells.

Power storage
Power storage systems can be battery or accumulator systems that store surpluses in order to feed them into the grid when production is low or non-existent.

Inverter
Inverters convert the direct current generated by PV systems into alternating current, allowing private households to consume it.

About us

WHAT SPURS US ON

We create sustainable living environments that inspire. Success through responsibility.

Commerz Real
Commerz Real is the Commerzbank Group's asset manager for investments in tangible assets and has over 50 years of international market experience. More than 800 employees manage assets of around 34 billion euros at the headquarters in Wiesbaden and 17 other sites and subsidiaries in Germany and abroad. Commerz Real combines comprehensive asset management know-how and broad structuring expertise to create its characteristic range of tangible asset-oriented fund products and individual financing solutions. Our portfolio also includes entrepreneurial investments with investments in tangible assets in the key segments of real estate and renewable energies. In its role as the leasing service provider of the Commerzbank Group, Commerz Real also offers tailored equipment leasing concepts.

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