Plug-In Solar PV

Solar for all - a deep-dive on a fast-emerging PV segment

SolarPower Europe

solarpowereurope.eu

ENPHASE

IQ Balcony Solar System

A simple, powerful and easy to install plug-in solution.

To know more, visit **www.enphase.com**.

Contents

SolarPower Europe Briefing Paper

Project lead:
Michael Schmela, SolarPower Europe

Project manager:
Leah Le Pénuizic, SolarPower Europe

Market intelligence and internal co-authors:
Leah Le Pénuizic, Raffaele Rossi & Michael Schmela, SolarPower Europe

Please cite as:
SolarPower Europe (2025): *Plug-In Solar PV*

For media use and queries:
Adrien Rodrigues, SolarPower Europe. a.rodrigues@solarpowereurope.org

Date of publication:
March 2025

ISBN:
9789464669251

Contact:
info@solarpowereurope.org.

Design:
Onehemisphere AB, Sweden. contact@onehemisphere.se

Cover image:
© Mariana Serdynska/Shutterstock.com

Thanks to our Sponsor Members:

Plug-in PV has emerged as an affordable and easy-access technology which has the potential to democratise access to low-cost solar power across the EU

Plug-in solar photovoltaic (PV) is a fast-growing and popular form of renewable energy generation. It has established itself quickly in the German market, and is increasingly present in other markets, such as the Netherlands or France. In 2025 it will be legalised in Belgium. The idea of plug-in PV is this: by simply connecting 1-2 PV modules to the home circuit using a microinverter and a cable with a standard plug, prosumers can install a small PV generation system by themselves, saving money and time.

With recent significant module price decreases, plug-in PV has emerged as an affordable and easy-access technology which has the potential to democratise access to low-cost solar power across the EU, expanding the market from property owners to tenants. This comes with its own challenges - while demand is significant and the market is growing rapidly, low-cost products are increasingly present on this market, and product standards and regulations are only slowly being developed. In Germany alone, by the end of 2024, more than 780,000 plug-in solar systems were officially connected to the grid. **Although the "real" number of systems on the market is difficult to establish, some estimates see up to 4 million plug-in PV installations already connected to the grid** in Germany alone, most of which are not registered, raising the issue of transparency and visibility for grid operators across the EU.

This report is a "State of Play" market brief and policy overview of existing regulatory frameworks and best practices for plug-in solar PV across selected EU Member States. SolarPower Europe's modelling in this report also shows that plug-in systems have limited interaction with the grid as most of the electricity generated is self-consumed, even in countries like Spain with very favourable irradiation-levels.

The present research identifies an urgent need to develop strict standards against which responsible manufacturers can certify their products. Today's technology, such as power control systems (PCS), can use software to limit all relevant parameters to levels deemed as safe by regulators and standardisation bodies. The industry will hopefully see such a first standard developed by the German VDE in 2025.

Table 1

Plug-in PV pros and concerns

Pros	Concerns
Democratising the energy transition ▪ **Expanding the solar PV market:** plug-in solar PV can help reach more citizens, including tenants and lower income households. ▪ **Easy access to solar:** plug-in PV is designed to be installed by the system owner, saving on cost and time. ▪ **Affordable access to solar:** plug-in PV's low cost compared to standard systems and reasonable pay-back period enables a broader segment of society to invest in renewable energy generation. ▪ **Furthering acceptance of solar:** given its accessibility and visibility, plug-in PV can contribute to furthering the acceptance of renewable energy within society. **Blueprint available for further growth** The learnings gathered from the pioneer **German market** could enable a fast expansion into other EU countries.	**Limited self-consumption potential** The small system size and oftentimes sub-optimal azimuth and angle of installations can limit the potential to cover large parts of household electricity demand. **Potential competition for larger residential rooftop systems** Many plug-in systems are installed on garages, for example where larger traditional rooftop systems could be installed. **Grid friendliness & registration** Plug-in PV systems generally have limited interaction with the grid.[8] However, given recent market uptake and large number of unregistered systems, easy registration of systems, especially if combined with storage solutions, is essential for ensuring grid-friendliness and visibility for national regulatory authorities and system operators. To facilitate this, the amending Directive EU/2024/1711[9] of the new Electricity Market Design already includes recommendations for streamlining installations of "plug-in mini solar systems." **Quality & safety:** In general there is no high DC voltage in plug-in systems, making them safe to use. However, standardisation and certification are needed to increase the quality and safety of the products and thus consumer trust.

Key **enablers** for plug-in PV

- Guidelines for safe installations
- New EU product standards

Key **obstacles** for plug-in PV

- Legislative or regulatory bans,
- Mandatory installation by an electrician,
- Burdensome administrative procedures (approval by the landlord, DSO, municipality)
- Limitations on the DC side, which negatively impacts the use and business case

600 W plug-in PV, flexible solar panels installed on balcony, Berlin, Germany

01

© Mariana Serdynska/Shutterstock.com

Solar Panels on apartment balconies, Berlin, Germany

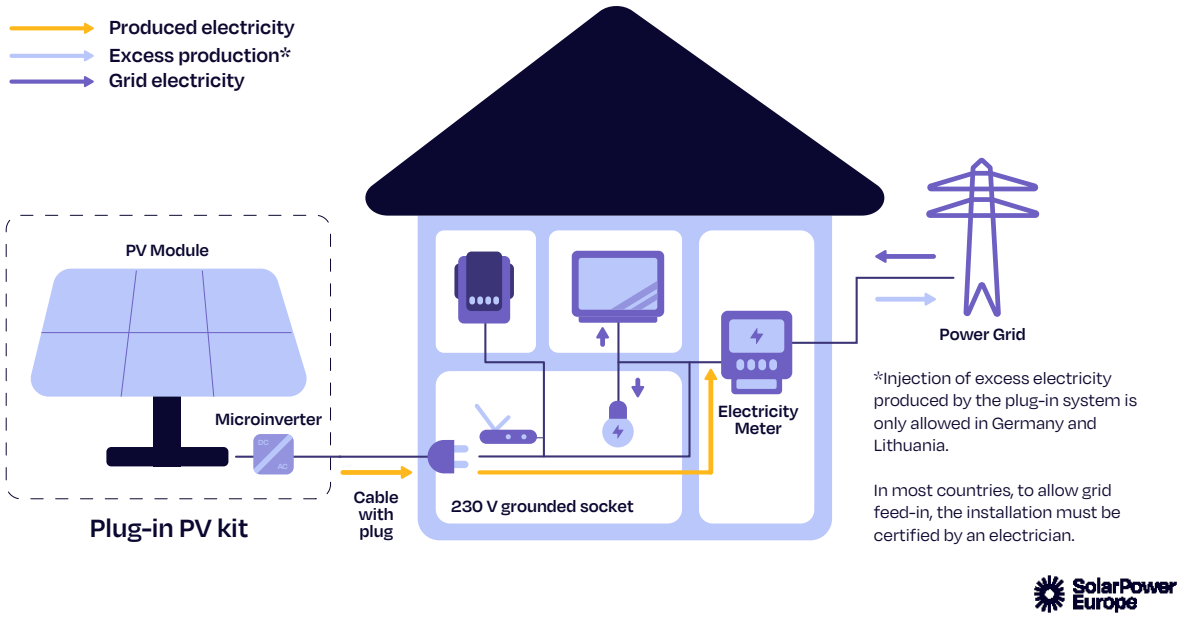
Introduction

What is plug-in solar PV?

Plug-in solar power plants, also known as **balcony solar**, **micro-PV/micro-generators**, or **plug-and-play solar**, are small-scale photovoltaic (PV) systems, of usually one or two modules[1], which can be plugged into a grounded home power socket. Easily installed on balconies, terraces, gardens, walls or rooftops, the system is connected to the home's end circuit, and generated electricity is either consumed directly by appliances in the household, or, in some cases, fed back into the power grid as surplus generation via the electricity meter (Fig. 1). At this scale, these systems typically help power a household's continuous baseload during the day (100-300 W), including refrigerators, Wi-Fi routers, and other standby appliances, and more during peak production hours.

Figure 1

Plug-in PV system in connection to the home network and grid



The popular term "balcony solar," originates from Germany, the oldest and largest plug-in PV market, where these systems are often visible on apartment balconies. However, "balcony" and "plug-in" solar are not interchangeable.

1 Recent dynamics see increasing number of panels, up to 4 or more, depending on the market

In fact, one 2022 market study by the HTW Berlin University of Applied Sciences[2] found that less than a third of plug-in systems sold on the German market were installed on balconies, with other popular locations including rooftops, gardens, terraces, or façades (Fig. 2 and Fig. 3). In today's market, it is estimated that this share is going up as the use-case for balconies in apartment buildings is rising rapidly.

Figure 2

Plug-in PV standard installation locations

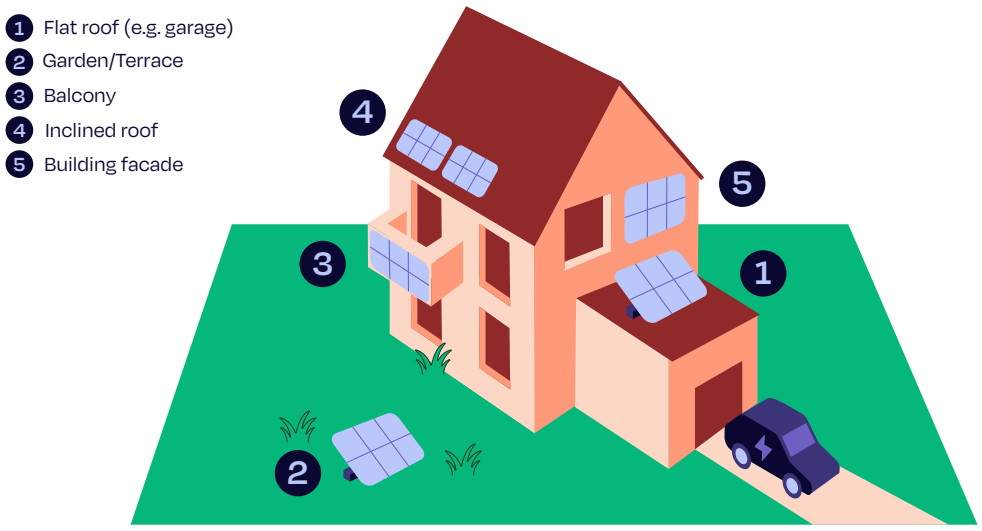
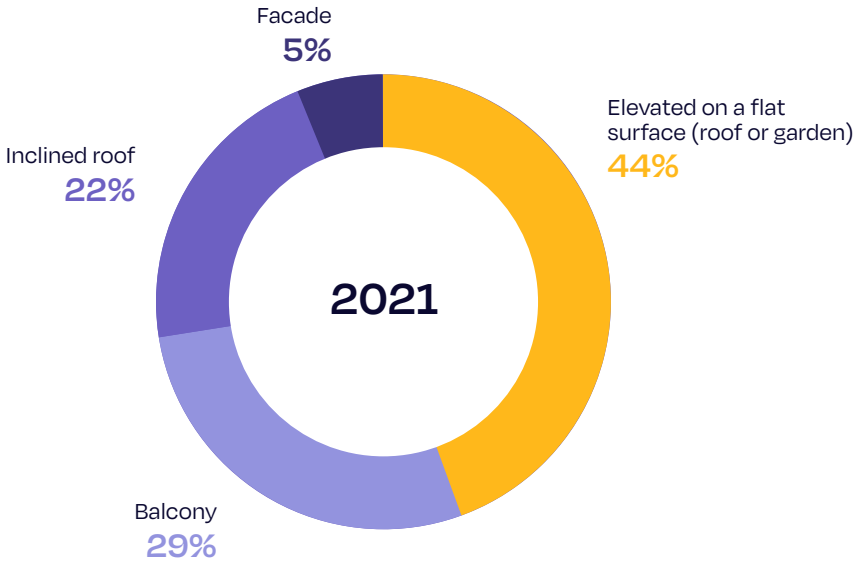


Figure 3

Installation locations for plug-in PV in Germany



Source: HTW Berlin, 2022

2 Hochschule für Technik und Wirtschaft (HWT) Berlin, (2022): "Der Markt für Steckersolargeräte" (The market for plug-in solar PV)

Moreover, these systems are popular with tenants and apartment dwellers who do not have access or ownership of their roof and therefore cannot have their own standard residential PV installation. In 2023, more than half of the population (52.4%) of Germany lived in rented accommodation.[3] While there are special tenant solar schemes for traditional grid-connections available in some member countries, these are often limited, rather complicated and usually not very popular. In Germany, Europe's largest solar market, only 1970 such systems were installed in 2024, compared to 1700 in 2023.[4]

Increasingly available in large retail outlets and DIY shops across EU Member States, plug-in PV systems are an easy-access introduction to solar PV, offering a simple way for tenants and homeowners to generate parts of their electricity demand and to actively participate in the clean energy transition.

Box 1: Kit contents

Plug-in PV systems are often sold in kits which typically include:

Table 2

Plug-in PV Kit contents

Kit contents	Description
~1-5 PV modules	The installed capacity is approximately 400 – 2000 W_{DC}.[5] Modules are either solid or can come in lightweight, flexible formats, with versatile installation possibilities.
Microinverter(s)	In order to convert direct current (DC) to alternating current (AC), which is used in the household and fed back into the public grid if there is an electricity surplus, one or more microinverters are needed. They can ensure the maximum feed-in limit of e.g. 800 W_{AC}.
Mounting structure(s)	Whether installed on a balcony, terrace, garden, wall, flat or inclined roof, the type of mounting structure and inclination can differ. For example, plug-in balcony systems can be attached vertically to the railing (90°) or be mounted with an added inclination to optimise the production of PV electricity.
Cabling	Cables connect the microinverters with each other and connect the plug-in system to the socket.

3 German Federal Statistical Office, EU: Germany the highest proportion of rental tenants
4 Landlord Advisor: Expansion PV in Germany in 2024
5 Dependent on each Member State's regulation – German law currently allows up to 2,000 W_{DC} limit for plug-in PV, while 800 W_{AC} is the EU limit, according to the New Electricity Directive for Electricity Market Design, 2024/1711(see Chapter on EU regulations: III)

Box 2: System costs

Prices for plug-in solar have been dropping dramatically in recent months, and while average prices for a one module kit (~400 W) were previously in the €300–€500 range, some products on the German market now start as low as €200, and go up to €1,500 for larger or more sophisticated systems, higher if including battery storage. Some start-ups also offer re-furbished second-life solar modules for use in plug-in/balcony systems.

A plug-in installation can contribute **5-25% of a household's annual electricity needs, with a payback time between 2-6 years**, depending on product cost, system size, local solar irradiance levels, orientation/inclination of the modules and local energy prices. In many cases, given that it can be easily moved (these systems are often called "mobile PV plants"), users can take their system with them if they change homes. Plug-in systems are generally optimised for self-consumption, as the surplus fed into the grid is minimal and usually less financially advantageous.

Outside of economic benefits, contributing to the energy transition and increasing autonomy and self-consumption of energy are often strong motivations for installing plug-in solar systems.

Although the main use of plug-in solar is feeding the generated electricity directly into the home's end-circuit, **some systems can also operate off-grid or offer back-up power in case the grid is down**. In some countries, excess electricity produced by the system cannot be injected to the power grid, requiring the installation of an additional device (as is the case in Spain), or an additional administrative procedure (in France).[6]

Additionally, plug-in systems are now also available with integrated **battery storage solutions in the 1-5 kWh** range. Although such small-scale storage systems were not previously considered a financially beneficial investment for plug-in PV, given their high upfront costs, decreasing module and battery prices have contributed to an increase in demand for these systems, at least in the German market, as seen from registration data from the Core Energy Market Register for 2024 (see the German market chapter p. 17).[7]

© Enphase

6 See Chapter 3. Summary of regulations in European countries, page 32
7 See German Market Section, page 19

Opportunities and challenges

While the market for plug-in PV systems has been growing very rapidly for good reasons in Germany, Europe's largest market, there are also concerns about this new business segment (see Table 3).

Table 3

Plug-in PV pros and concerns

Pros	Concerns
Democratising the energy transition ▪ **Expanding the solar PV market:** plug-in solar PV can help reach more citizens, including tenants and lower income households. ▪ **Easy access to solar:** plug-in PV is designed to be installed by the system owner, saving on cost and time. ▪ **Affordable access to solar:** plug-in PV's low cost compared to standard systems and reasonable pay-back period enables a broader segment of society to invest in renewable energy generation. ▪ **Furthering acceptance of solar:** given its accessibility and visibility, plug-in PV can contribute to furthering the acceptance of renewable energy within society. **Blueprint available for further growth** The learnings gathered from the pioneer **German market** could enable a fast expansion into other EU countries.	**Limited self-consumption potential** The small system size and oftentimes sub-optimal azimuth and angle of installations can limit the potential to cover large parts of household electricity demand. **Potential competition for larger residential rooftop systems** Many plug-in systems are installed on garages, for example where larger traditional rooftop systems could be installed. **Grid friendliness & registration** Plug-in PV systems generally have limited interaction with the grid.[8] However, given recent market uptake and large number of unregistered systems, easy registration of systems, especially if combined with storage solutions, is essential for ensuring grid-friendliness and visibility for national regulatory authorities and system operators. To facilitate this, the amending Directive EU/2024/1711[9] of the new Electricity Market Design already includes recommendations for streamlining installations of "plug-in mini solar systems." **Quality & safety:** In general there is no high DC voltage in plug-in systems, making them safe to use. However, standardisation and certification are needed to increase the quality and safety of the products and thus consumer trust.

In order to ensure the safe deployment and operation of these systems, any risks to prosumers, the general public, and the grid must be understood and minimised through respective regulations and technical standards.

Some examples of safety-related aspects that are under discussion by regulators like the German VDE[10] are:

- **Clear rules for injecting power in the home circuit:** Static and/or dynamic limits of feed-in power to the home circuit according to parameters deemed as safe by the regulator or the standardisation body. A key question, especially relevant for plug-in PV systems that include a battery, is how long a system should be allowed to feed in 800 W_{AC} into the home circuit. By using a so-called power control system[11] a respective dynamic feed-in limit can be guaranteed through software.

- **Number of plug-in systems connected to the home circuit:** most countries with regulations governing plug-in solar kits include a cap on the maximum output at the inverter and/or installed capacity, but not necessarily on allowed number of kits installed. While the VDE's latest draft for the plug-in standard aims to set this limit to one system connected per household, recommendations in other countries like France specify that several systems could be connected in parallel to the household circuit provided the output is limited to 800 W at the inverter.[12]

8 See SolarPower Europe's modelling, page 16, Table 2
9 Directive - EU - 2024/1711 - EN - EUR-Lex
10 Product standard for balcony power plants: VDE publishes second draft
11 Reference to SPE PCS definition and Article 5 of the EMD on FCAs
12 guide-kit-photovoltaique-autoconsom-plug-play.pdf

- Clear rules for allowing the use of a standard (Schuko) plug.

- **Installation and mounting guidelines:** Aside from technical concerns surrounding the safety of the electrical circuit and grid feed-in, other safety concerns include the quality of the installation in terms of placement, connection, and durability of the mount. It is important to secure systems with suitable weights or binders, so that they do not fly away or fall from a balcony taking into account the weight of the panels or weather conditions such as rain and snow. For example, weights filled with water should be checked in hot weather for evaporation. In snowy areas, kits should be designed to withstand these weather conditions. Kits must be connected to an earthed/grounded socket, not to a multi-socket adaptor, etc.

Given the ongoing conversations around safety rules and standards for plug-in PV systems, Member State regulations sometimes:

- **Require** (e.g. in Spain, Sweden, some cases in Austria) /recommend (e.g in some cases in Germany) users to **seek assistance from a professional electrician**, and/or install the system to a separate circuit, which removes the "plug-in" concept and incurs additional costs for the prosumer, reducing the attractiveness of the business case;

- Or, **do not allow excess electricity to be injected into the public power grid** (in Spain, the installation of an additional zero-discharge device is required).[13, 14]

© embeki/Shutterstock.com

13 Robinsun: Certification or zero discharge - how do you save more?
14 Litmus Energy: What is a zero pour device and how to set it up with Shelly?

Modelling of a plug-in PV system

Grid operators have several concerns about plug-in solar PV systems, mainly related to grid stability, safety, and regulatory compliance. In terms of grid stability, given their easy-installation and, if the systems are not registered, lack of visibility for grid operators, the rapid growth of plug-in solar could potentially generate uncontrolled power exports to the grid, impacting grid stability.

To understand the implications of plug-in solar generation for the grid, SolarPower Europe has modelled the basic behaviour of an 800 W_{DC} plug-in PV system (800 W module power rating, 800 W microinverter) in two different European locations: Madrid, Spain and Berlin, Germany.[15] By comparing hourly PV production of such a system with an hourly standard electricity load for a 2-person household in both countries, the model can determine the amount of produced electricity which is self-consumed by the household and the amount of excess production, in each location, over a year, or within a single day.

The capacity of plug-in PV plants up to 800 W_{DC} is usually considered too small for excess produced electricity to significantly affect distribution grids.[16] In order to illustrate a "high scenario" case, shown below are the model results for the day in the year with the highest excess of PV production compared to electricity load, on a sunny day.[17]

Box 3: Plug-in Model Methodology

- **Daily electricity load data:**
  - Type of household: 1-2 people household, detached house
  - Yearly electricity consumption:
    - Spain: 4,000 kWh
    - Germany: 4,500 kWh
  - Daily load data sourced from TSOs and National Associations
- **PV production:**
  - Data sourced using site-specific historical PV data from the European Commission PV calculator (JRC). Modelling a day with the maximum excess electricity produced by the system.
  - **System size: 800 W_{DC}**
  - **Orientation/azimuth: South**
  - **Angle: 35°**

Note that the following modelling is **fixed for a system with an optimal inclination and orientation of PV modules**, which is not the reality for most plug-in installations, especially balcony systems which are usually installed at a vertical 90° angle, not always oriented southward, and may have additional shading. The PV production of an average plug-in system will therefore be lower than represented here. In more "vertical" configurations, system losses compared to optimal angle and orientation can range from 30-60%.[18] Although such configurations lead to a lower annual yield, they result in a more even distribution of production over the year and therefore tend to result in higher self-consumption.[19]

Additionally, standard electricity load will vary by type of household, and although the following is modelled for a detached house, the market for plug-in solar also massively includes apartment dwellers, which generally have lower energy needs.

15 Average plug-in system sizes in Germany were 800 W_{DC} in 2023
16 Fraunhofer ISE (2019) "Steckerfertige, Netzgekoppelte Kleinst-PV-Anlagen, Studie Für e-control Austria"
17 In both cases (Spain and Germany), this day in the model falls towards the end of May
18 International Journal of Photoenergy, Wiley Online Library, Laveyne (2020) "Impact of Solar Panel Orientation on the Integration of Solar Energy in Low-Voltage Distribution Grids"
19 Fraunhofer ISE (2019) "Steckerfertige, Netzgekoppelte Kleinst-PV-Anlagen, Studie Für e-control Austria"

Results

Both in Spain and in Germany, an 800 W_{DC} plug-in system can contribute significantly to household self-consumption of electricity and injects relatively little excess production in distribution grids. Since electricity needs are generally higher in households in Germany than in Spain, and irradiance levels are lower, plug-in PV plants produce less excess electricity in Germany, compared to Spain. According to SolarPower Europe's model, over a year, an 800 W_{DC} system in Madrid produces around 1,200 kWh of electricity, almost a third of household annual electricity needs, of which 93% goes to self-consumption. In Berlin, the plant will produce around 900 kWh over the entire year, i.e. 20% of annual electricity needs, and has 99% self-consumption rate. Considering losses from vertical orientation, shading and other factors, we can expect to lose up to 60% of generated PV production as the above-mentioned optimal conditions are rarely reached. This would then translate to yearly PV production output between 400-800 kWh, providing closer to 10-20% of the household's annual electricity consumption in Spain, and 8-13% of the German household's needs..

For larger systems, in both cases, we can observe that annual self-consumption rates decrease and grid feed-in increases, assuming that consumption behaviours do not change and that excess energy is not stored in a battery.

Table 4

Plug-in PV model results

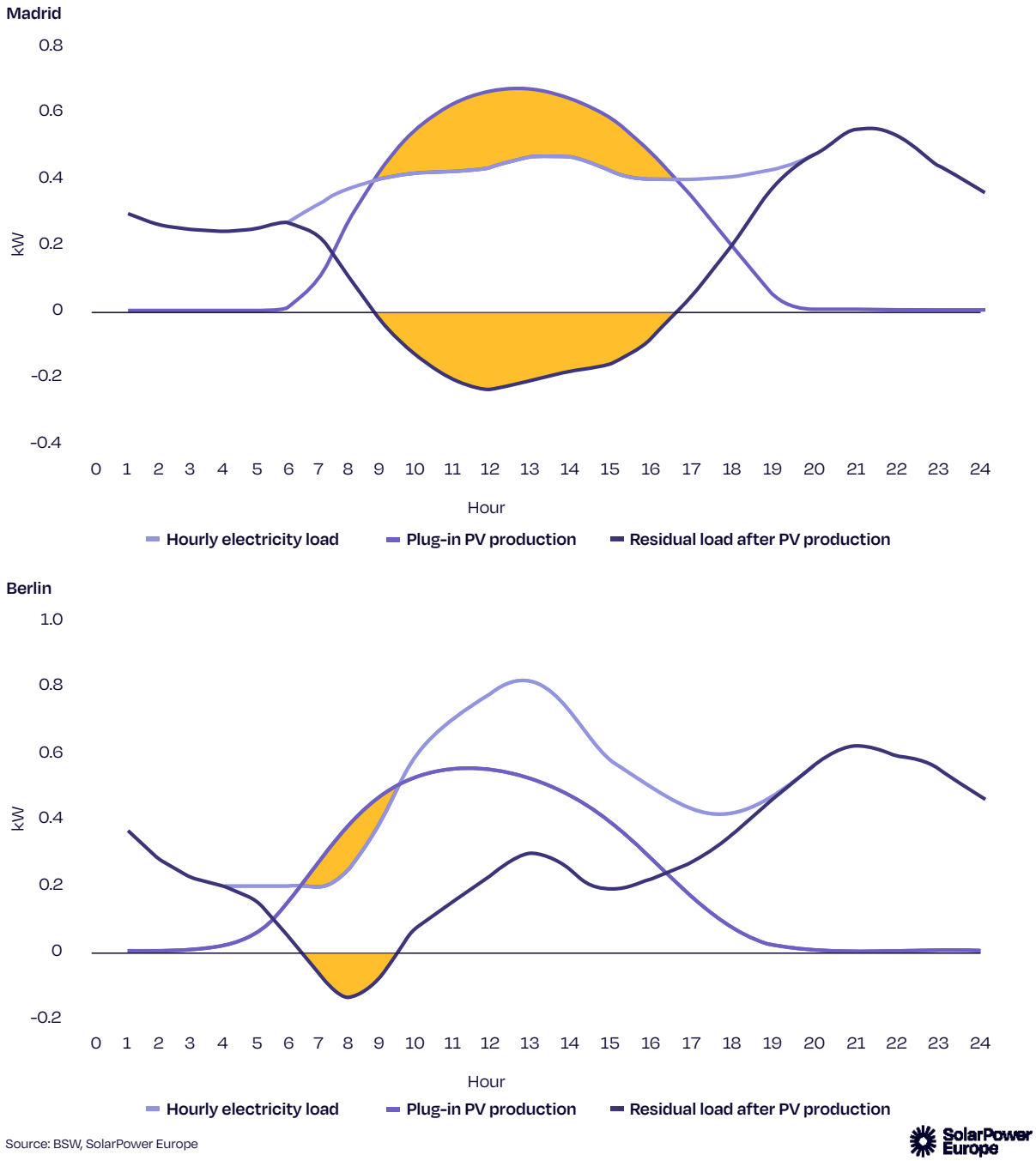
System parameters	Madrid, Spain		Berlin, Germany	
	Model	Adjusted for losses	Model	Adjusted for losses
Module capacity	800 W_{DC}		800 W_{DC}	
Inverter capacity	800 W_{AC}		800 W_{AC}	
Yearly generated electricity	1,200 kWh	400-800 kWh	900 kWh	360-600 kWh
Solar share of annual electricity needs	31%	10-20%	20%	8-13%
Self-consumption rates	93%	~100%	99%	~100%

Garage plug-in solar, Italy

Looking specifically at the day with the highest excess PV production (Fig. 4), Spain reaches a maximum excess of just over 200 W_{AC} during the hours of peak solar generation assuming ideal conditions for azimuth and panel angle. In Germany, the maximum is 100 W_{AC} under the same conditions

Figure 4

Hourly output of a 800 W_{DC} plug-in solar PV plant, on a hot sunny day



Source: BSW, SolarPower Europe

For a 800 W installation, the excess production of plug-in solar not consumed by household appliances during peak production hours therefore goes up to a maximum of 200 W_{AC}.

While the behaviour of a single system may have limited impact on the grid, uncontrolled growth in the number of plug-in grid-connected devices could lead to unforeseen impacts on the grid, such as voltage instability and frequency deviation in the grid.

These are key points currently under discussion in the German VDE 0126-95 standard under development. The latest available draft sets the following requirements to ensure grid stability in Germany:

1. **Compliance with VDE-AR-N 4105:** plug-in solar devices should comply with Germany's grid connection rules, specifically **VDE-AR-N 4105**, which sets technical requirements for small-scale power generation units operating in parallel with the low-voltage grid.

2. **Power and current limitations:** To ensure grid stability, a **maximum apparent power of 800 VA** and an **injection current limit of 3.5 A** is specified. These restrictions help avoid overloading local circuits and prevent instability in the grid.

3. **Grid Disconnection (Anti-Islanding Protection):** Plug-in solar devices **must immediately disconnect from the grid** in the event of a power outage to prevent islanding effects.

4. **Voltage and frequency control:** The devices must adhere to grid voltage and frequency response regulations, including reactive power settings and frequency-dependent power reduction (e.g., at 50.2 Hz).

5. **Electromagnetic Compatibility (EMC):** The document requires compliance with electromagnetic interference standards (DIN EN IEC 61000-6-1, DIN EN IEC 61000-6-3, and DIN EN 62920) to ensure plug-in solar devices do not disrupt grid operations.

Pragmatic solutions here to limit stress on the grid include the use of grid-friendly smart inverters which include anti-islanding protection, voltage and frequency stabilisation, and reactive power support, or zero-export devices that limit plug-in solar excess to the grid.

BECOME A MEMBER OF SOLARPOWER EUROPE

SolarPower Europe is the leading European solar association. Join our solar community today to unlock a world of shining benefits for your organisation.

Industry Influence

Help us shape the solar policy framework in Europe, by joining forces with industry leaders.

Networking Opportunities

Connect with 300+ members from across the entire solar value chain. Join exclusive networking opportunities at our events.

Expert Knowledge

Get access to the latest solar best practices, comprehensive market intelligence, weekly policy update, quarterly market updates webinars and knowledge exchange within our workstreams.

Visibility and Promotion

Be visible in front of an engaged solar audience of 25K+ monthly unique visitors on our website, 85K+ followers on social media, 27K+ newsletter subscribers, and more.

Amazing Discounts

Get exclusive member discounts for SolarPower Europe and partner events, advertising on partner media outlets, sponsorship opportunities and more.

Join SolarPower Europe today

www.solarpowereurope.org/membership

SolarPower Europe

© Enphase

02

Plug-in solar PV in EU markets

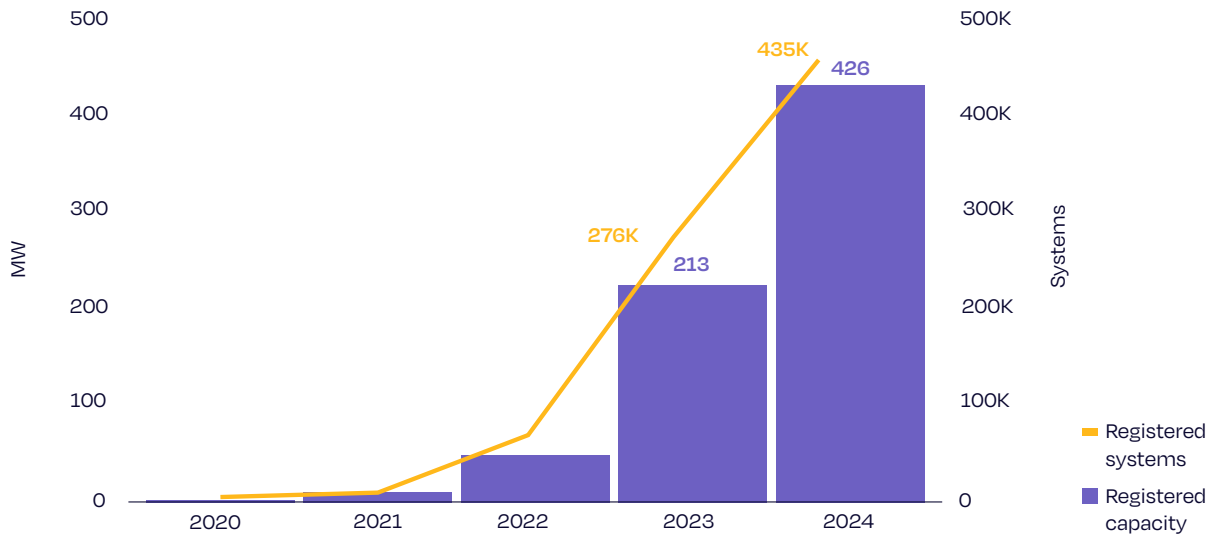
Germany – the birthplace of plug-in PV

Registered systems

Germany is the oldest and largest market for plug-in solar PV, with commercial products circulating at least since 2010. Official registration data shows that there has been a significant increase in plug-in PV installations and capacity in recent years (Fig. 5).

Figure 5

Annual plug-in PV registrations, Germany, 2020-2024



Source: BSW Solar, SolarPower Europe

Note: BSW Solar's own calculations are based on MaStR as of January 23rd 2025, accounting for expected late registrations. Further revisions to be expected due to late registrations.

The latest numbers from BSW Solar[20] show that 435,000 plug-in PV installations were registered to the German network regulator's Core Energy Market Register (MaStR) in 2024, out of a total 1 million new PV systems, compared to 276,000 plug-in installations in 2023. This means that for **every five PV systems installed in 2024, at least two were plug-in solar PV**. In 2023, this was the case for one in four PV systems.

More plug-in grid connections were registered in 2024 alone than in all years prior, since data is available. Average installation size has increased, from 800 W in 2023, to close to 1000 W in 2024. In 2024 the annual market for plug-in PV was then around 426 MW, i.e. **2.6% of all 16.1 GW of solar PV annually installed capacity in 2024.**[21] The total number of plug-in installations registered by the end of 2024 was more than 780,000 with around 700 MW cumulative capacity. Based on this registration data, after multiplying by 5 the annual market for plug-in PV between 2022 and 2023, it almost doubled from 2023 to 2024.

In Germany, May 2024 was marked by the adoption of the "Solar Paket 1", which streamlined the registration process for plug-in PV devices to a simple online notification with the MaStR. Beyond driving market growth, this change could also reveal:

1. A more accurate representation of the market from buyers registering their new kits,
2. A potential backlog of users registering their solar plug-in kits bought prior to 2024.

20 German Solar Association (BSW-Solar) (December 2024), Berlin: "Statistical data on the German Solar Power (Photovoltaic) Market"
21 2024 annual installed capacity taken from SolarPower Europe's EMO 2024 report. BSW data indicates 17 GW

Unregistered systems

Given their easy installation and prior lack of regulation, many plug-in solar kits have historically been connected to the grid illegally, in "*guerilla*" mode, without being declared to any regulatory body. Consequently, registration data prior to 2020 is scarce. It is likely that many systems are still unreported.

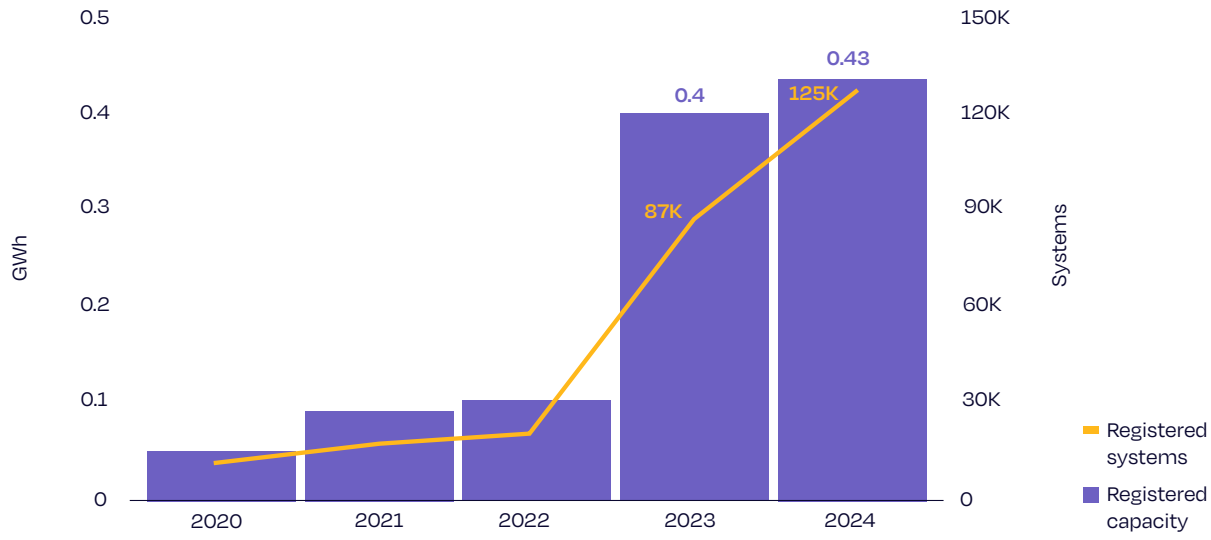
As a result, the total number of connected solar plug-in PV is likely higher than what available registration data shows. Some industry sources indicate: "*For every registered system, there may be two to three times more actually in use on the market.*" For instance, while HTW Berlin's 2022 market study[22] estimated that up to a 190,000 plug-in devices were already connected to the German grid by the end of 2021, equivalent to 66 MW of capacity, only around 10,000 devices and less than 10 MW cumulative plug-in PV capacity were officially registered with the Federal Network Agency, (Bundesnetzagentur). A recent publication from HTW Berlin[23] estimates between 1.5 and 4 million plug-in solar kits are now connected to the German grid. Insiders report that the German Environmental Agency ("Umweltbundesamt") has recently commissioned an expert task force to quantify the stock and deployment of solar plug-in, while correctly accounting for the challenges. Estimates by this expert group organised by ZSW[24] are expected to be published later this year but were not available at the time of publication of this report.

Plug-in PV and storage

Another notable development in the German market is the growth of the small storage segment, particularly for systems with a capacity of less than 5 kWh, which, among other possible applications, can store excess production from plug-in solar. Figure 6 below shows the evolution of small battery storage solutions of less than 5 kWh in Germany in recent years, with a 300% YoY market growth for the segment between 2022 and 2023, and continued 7.5% year on year growth from 2023 to 2024. This can also be understood in the general context of the solar boom experienced in Germany and Europe generally in 2023, and continued in 2024.

Figure 6

Small battery storage systems < 5 kWh installed in Germany, 2020-2024



Source: BSW Solar, SolarPower Europe

Note: BSW Solar's own calculations are based on MaStR as of January 23rd 2025, accounting for expected late registrations. Further revisions to be expected due to late registrations.

22 Hochschule für Technik und Wirtschaft (2022), Berlin: "Der Markt für Steckersolargeräte" (The market for plug-in solar PV)
23 HTW Berlin: Short report: Plug-in solar 800 W
24 https://www.zsw-bw.de/

The under 2 kWh segment in particular, which specifically targets storage solutions for small, 1-2 module "Steckersolargeräten" has also seen a significant increase. According to available data from the MaStR, this segment grew an astonishing 24-fold between 2023 and 2024 rising from just over 1,000 systems to more than 30,000. **Out of 580,000 storage systems installed in Germany in 2024,[25] more than 5% of them fell within the < 2 kWh range, compared to less than 1% in 2023.**[26]

These are key indicators of the growing demand for storage for plug-in PV, and shows how plug-in PV is now a key driver of market dynamics across other solar segments.

On the market, this dynamic is visible from:

1. A growing number of battery and inverter providers offering 1-5 kWh products designed for plug-in solar systems or other household appliances.

2. Plug-in PV providers directly offering integrated battery storage solutions in partnership with battery providers. Given the recent boom in Germany, and continuously decreasing battery prices, many companies now offer plug-in products with storage with capacities in the 1-5 kWh range.

Demand in this segment is such that the VDE, Germany's technical regulator, also plans to develop a specific plug-in standard in the future which includes rules for plug-in storage, since this segment is currently not clearly regulated.

Plug-in PV Outlook

With German legislation becoming increasingly supportive of plug-in PV deployment, public enthusiasm for solar technology remaining high, and more companies entering this market, the German plug-in solar sector is poised for continued growth in the coming years. Given Germany's role as a pioneer and worldwide leading market for this technology in the past, a quickly-evolving regulatory framework and the ongoing development of the first product standard for the technology by the German standardisation committee DKE/VDE, there is a solid blueprint to learn from when striving to enable plug-in PV growth in other EU markets.

25 German Solar Association (BSW-Solar) (2025), Berlin: "Statistical data on the German Solar Battery Storage and E-mobility Market"
26 Based on data from SolarPower Europe's European Market Outlook for Battery Storage, 2024-2028, and SolarPower Europe's own analysis based on the MaStR, Core Energy Market Register as of 27th February 2025

The German Solar Association (BSW Solar) and other PV stakeholders anticipate solar plug-in devices to play an important role in allowing tenants of apartment buildings to reap the benefits of solar energy and to partake in the energy transition. According to Thomas Seltmann, BSW policy expert and one of the initiators and co-authors of the plug-in solar device technical standard, "the most important step now and last missing piece for bringing the potential of solar electricity into every household is a timely definition of the product standard. The sophisticated draft that has recently gone through an intense appeal consultation will finally be decided on in summer 2025. The main focus of this standard is to establish plug-in solar devices as power producing household appliances that can be safely and easily handled by a customer – unlike regular PV systems that have to be installed by a professional. To this end, it has been crucial to define technical features that allow for the usage of Type F household plugs ("Schuko"), making them safe and easy-to-use products that further increase the popularity, public approval and political support of the solar energy transition. This intuitive implementation of plug-in solar devices will guarantee a successful market roll-out in the medium and long term. BSW-Solar also advocates for a clear distinction between plug-in solar devices and standard PV systems, as it provides transparency, reliable safety procedures and legal certainty to prosumers and installers but also regulators and suppliers."

With consumer interest in plug-in solar devices unabated and its ability to allow for investments into solar energy with a smaller household budget, plug-in solar devices may even be able to weather a phase of relative consumer restraint in Germany's economy. Public acceptance of the technology has been further accelerated by public support programs at the federal state or municipal level, sometimes specifically targeting low-income households. Consequently, the devices are already a common sight in supermarkets, hardware stores and online shops. Solar companies, associations, consumer organisations and public institutions have accompanied this momentum by providing guidance and online resources for interested customers, which - in combination with sound product standards - facilitate ambitious market scaling without compromising safety needs. Examples include handbooks (e.g. by "Stiftung Warentest"), online guides by consumer organisations (e.g. https://www.verbraucherzentrale.nrw/steckersolar) and websites such as the one developed by EmpowerSource with support from the European Climate Foundation (https://plugin-solar.eu/). These sources readily provide information on best-practices, installation advice and background information with the goal of maximising citizen and consumer outreach in Germany's already maturing plug-in solar device market.

Other EU markets

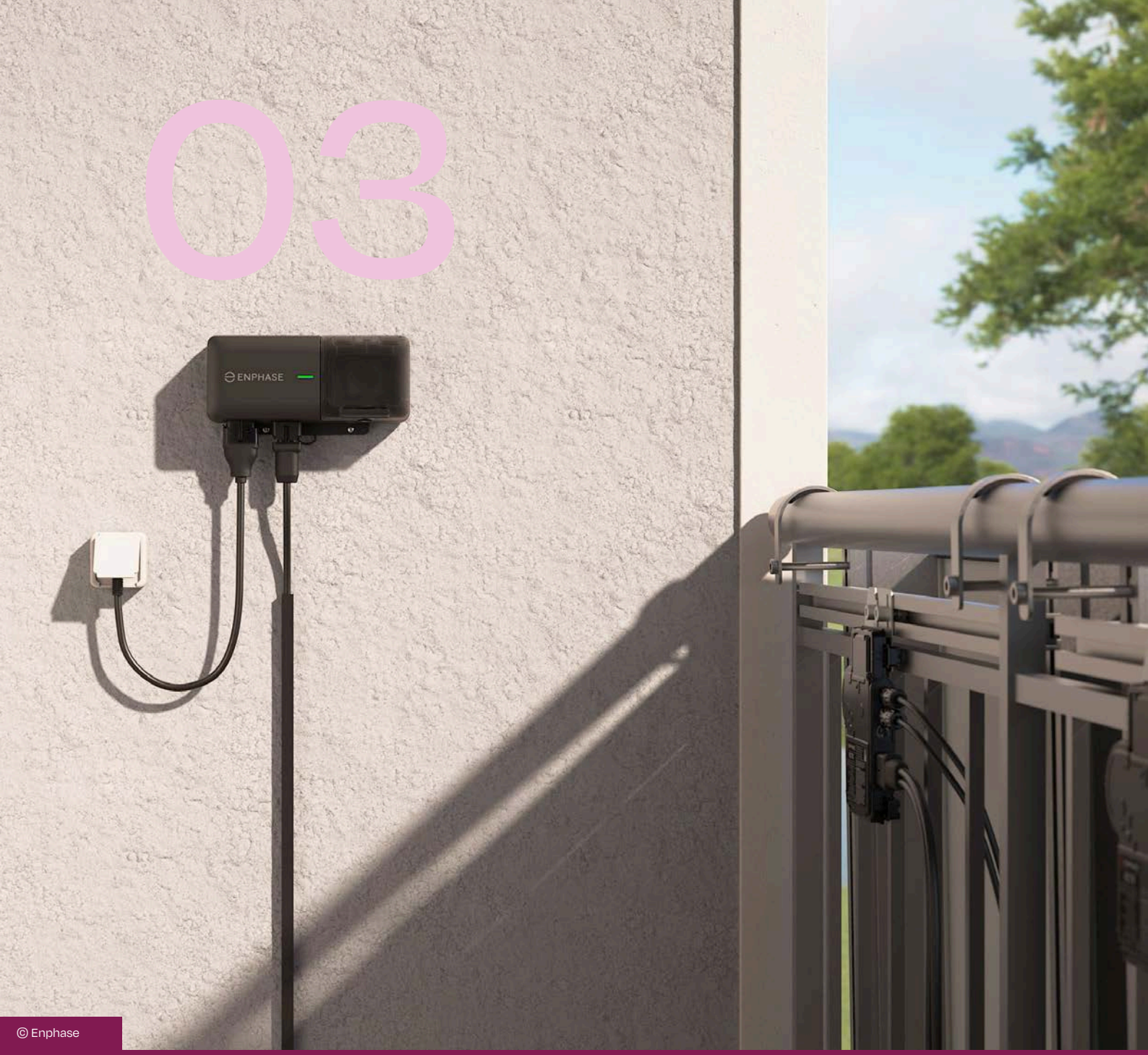
Aside from Germany, few markets publicly share data specifically tracking plug-in PV installations, and most other EU markets are relatively small. Although not specifically identified as "plug-in PV", the **French** DSO (ENEDIS) tracks up to 34 MW of cumulative PV capacity for systems < 1 kW by the end of 2024. In **Austria**, the annual market for "micro-PV" systems in 2023 and 2024 is within the 10-15 MW range,[27] with around 20,000 micro-systems registered per year, and growing. In **Lithuania**, since legalising the technology in early 2023, an estimated 350 plug-in PV users have been registered by the DSO.

Although market data for this PV segment in most other EU Member States is scarce, industry sources report increased activities and growing markets in **France, Spain, the Netherlands, Poland, Italy**, and other key EU solar markets.

The recently created German Association for Plug-in PV estimates **up to 4-5 million plug-in PV systems are already operating on homes and businesses across Europe.** Considering HTW Berlin's estimate seeing between 1.5 – 4 million in Germany alone, this is another example of the lack of visibility of the market development for plug-in solar in the leading market and across the EU.

27 Quartalsbericht Erhebung Netzanschluss, Berichtszeitraum 01.07.2024 – 30.09.2024. Q3/2024, E-Control (2024). Reports - E-Control

03



© Enphase

EU regulatory landscape for plug-in solar

EU regulatory landscape

The **EU Network Code Requirements for Generators (RfG Regulation)**[28] sets harmonised rules for grid connection across Europe of power generation modules of 800 W_{AC} in capacity or greater. Systems under 800 W_{AC} are considered too small to have a significant impact on grid stability and are not covered explicitly by the RfG, meaning there is no EU-wide regulation specifically covering the registration and technical requirements for plug-in solar systems, and Member States can therefore determine their own rules.

However, **the New Electricity Directive for Electricity Market Design (2024/1711)**[29] provides guidance specifically aimed at facilitating the integration of small-scale renewables, including plug-in PV systems, into EU's electricity framework. Article 15a on the right to energy sharing states that: *"Member States may promote the introduction of plug-in mini-solar systems of up to 800 W capacity in and on buildings."* Recital 25 specifically advocates for **streamlined and straightforward installation of "plug-in mini solar systems"**, and minimal bureaucracy, to help reduce administrative and technical burden and accelerate the adoption of renewables at a local and residential level. Specifically, on the topic of *grid feed-in* (allowing PV production from plug-in solar plants to be injected back into the distribution grid):

"Regulatory authorities should be able to set the network tariffs for the injection of electricity coming from plug-in mini-solar systems or to establish the methodology for calculating those tariffs. Depending on the situation in a Member State, it would be possible for the tariffs to be very low or even zero, while being cost-reflective, transparent and non-discriminatory."

These guidance documents and recommendations still allow Member States a lot of flexibility in determining how they regulate and support small plug-in PV systems, especially regarding system size, registration, grid injection and technical compliance.

Solar panels mounted on an apartment building in Kyiv, Ukraine

28 Regulation - 2016/631 - EN - EUR-Lex
29 Directive - EU - 2024/1711 - EN - EUR-Lex

National frameworks for plug-in solar

1. For or against: From technology bans to financial incentives for deployment

Plug-in solar today is legal in all 27 EU Member States except in Sweden and Hungary. Belgium will legalise it in April 2025.

Technology ban

A common case for plug-in PV in Member State regulation is that they are often considered electrical installations, and not electrical appliances, meaning that they cannot be connected to the home circuit using a standard plug. This is the case in **Sweden**, where standard Schuko plugs cannot legally be used for electricity production – only for consumption of grid electricity. A small 1-2 module PV system is considered the same as any other residential PV installation, requiring an electrician's intervention and a separate circuitry. While no regulatory changes have been initiated to alter this yet, the Swedish Electrical Safety Authority voiced safety concerns about the technology in 2023, considered to pose a fire hazard and risks of electrical shocks. For this reason, plug-in systems are allowed to operate off-grid, as long as they comply with building codes. Additional requirements also exist for mounting PV systems ensuring they withstand wind and snow loads.

Plug-in PV systems are also banned in **Hungary**. This restriction was recently further reinforced when, on 1 October 2024, the Hungarian Government issued a decree on the basic regulations of settlement planning and construction requirements, explicitly prohibiting the installation of solar panels on balconies or agricultural land.[30] According to the decree, solar panels may only be installed if they are integrated into a building's architectural façade. They cannot be placed on balconies, whether on independent supporting structures or built into the balcony itself.

As for **Belgium**, the regulatory framework is evolving to accommodate plug-and-play solar and storage devices. Synergrid, the Belgian Federation of DSOs, announced that starting April 17, 2025, homologated plug-in devices can legally be connected to electrical installations in Belgium. This follows the publication of amendment 2.2 to technical prescription C10/11 on October 17, 2024.[31] Manufacturers are required to apply for C10/26 homologation, ensuring their products meet specific safety and technical standards, which include proper internal installation and automatic disconnection during power outages to protect users and the grid. Manufacturers, importers, and distributors are required to provide clear operating instructions, including guidance on connecting devices to the prosumer's electrical system. Users should be informed about potential risks, especially when multiple devices are plugged into the same socket. Plug-in systems will be viewed as mobile electrical equipment and therefore will not require inspection from the Belgian electrical safety regulator (AREI), as is usually done for standard rooftop installations. The AREI is still considering whether additional limits should be implemented or not (such as AC and/or DC power limits).

Support schemes

Among countries who do allow plug-in PV, financial support mechanisms for the uptake of the technology exist in Germany, Austria, and Lithuania. They take the form either of upfront financial support such as CAPEX subsidies or VAT cuts, or injection support, in the form of feed-in tariffs (FITs) or net metering.

30 KCG Partners Law Firm: "Hungarian Government forbids solar panels on balconies and agricultural lands"
31 INFO_fabrikanten_2024.11_C10-11_ed2.3_plug-and-play_EN.pdf

Upfront support: In Germany, CAPEX subsidies are often managed at the state or municipal level. For instance in Berlin, as well as in the state of Mecklenburg-Vorpommern, each household is entitled to a discount of up to €500 for the installation of a plug-in system. Such upfront CAPEX support schemes are often limited in time or through programme budgets. Given the already low cost of plug-in PV, some schemes are optimised to specifically target low-income households to give broader access to solar energy and increase participation in the clean energy transition. Bonn, Dortmund and Heidelberg have designed their plug-in PV schemes to offer larger subsidies to low-income households. Bonn reimburses 90% of the cost of a kit for low-income households, compared to 60% for other residents, a similar model also applied in Dortmund. The city of Heidelberg goes one step further and provides plug-in PV systems in the form of "care-packages," eliminating upfront costs entirely and removing additional barriers to solar access.[32] Although Lithuania's plug-in PV market remains small, the Environmental Project Management Agency (APVA) launched a subsidy scheme in July 2024 that allowed residents to apply for a €102 subsidy for the installation of a 400 W plug-in solar power system, or €204 for an 800 W system. Applications were accepted until December 2024. While all solar systems up to 30 kW are exempt from VAT in Germany, in Austria, VAT is currently waived on systems under 35 kW installed in 2024/2025.

Injection support: In Germany, under the Renewable Energy Sources Act (EEG 2023), a feed-in-tariff of €8.43 cent EUR/kWh is applicable to all solar PV systems under 10 kW, including plug-in PV systems. In Lithuania, net metering is available for plug-in systems: once the user has registered the plug-in PV system with the Energy Distribution Operator (ESO) (Lithuanian DSO), ESO then changes the standard electricity meter to a smart meter, free of charge. A standard meter would misread electricity production as consumption, requiring owners to pay for the energy they generate. The smart meter eliminates this issue, ensuring accurate billing.

Façade plug-in solar, Valencia, Spain

32 CityTalk: "Fair public financing: German cities push forward with attempts to make subsidy schemes more equitable"

2. Administrative procedures

Registration requirements

In countries where plug-in solar is authorised, installation typically requires notification or approval from one or more entities, such as DSOs, national regulatory agencies, municipalities, multi-apartment building stakeholders, or landlords. Bottlenecks can then arise in this "permitting" stage, creating an administrative barrier to deployment.

While excessive bureaucracy is sometimes identified as a barrier to the deployment of plug-in PV systems, Germany and Lithuania are both pioneers in accelerating their deployment by reducing administrative hurdles.

Case study – Germany

Registration simplification

The **SolarPaket 1** regulatory package adopted in May 2024 in Germany included some provisions for streamlining the installation of small plug-in PV systems. While it was previously mandatory to register the system with the grid operator, the procedure is now reduced to a single, simple online registration with the Federal Network Regulator's Core Energy Market Data Register. This significantly simplifies the registration process and could explain in part the exceptionally high number of plug-in systems registered in the German Energy Market Registry in 2024. Facilitating deployment and registration procedures of mini-PV systems is important to create visibility and transparency for grid operators and to enable grid stability.

Case study – Lithuania

Until recently in Lithuania, residents who wanted to install a small solar power plant needed to obtain a construction permit for simple repairs. Such a permit could raise the total cost of installing a plug-in power system by over €500.

However, from 1 November 2024, amendments to the Law on Construction of the Republic of Lithuania now preclude users who wish to hang a solar power plant on their balcony from the need to coordinate the project with the city architect. This essentially reduces administrative requirements to a civil notification to neighbours, and a free and simple online registration with the DSO. Documents authorising construction will be mandatory when carrying out repairs of a special or non-special structure in a conservation priority or complex protected area, in the territory of a cultural heritage object or a cultural heritage site, and for a cultural heritage building. In all other cases, it will be enough for residents to obtain consent from the residents of their house community, neighbours.[33]

33 Agnė Baltrunaitė, Alfa.lt. (11/2024): "Balcony Solar power plants that have proven themselves in Germany are also gaining popularity in Lithuania: Will we get a breakthrough? [Article accessed and translated from the original Lithuanian in 02/2025]

Landlord approval

One common administrative procedure for plug-in is the need for tenants to get their landlord's approval to install a system on their balcony, terrace etc. However, landlords can sometimes outright deny the request without providing any justification. Once again, Germany is leading the acceleration of plug-in PV system deployment by removing this bottleneck.

Case study – Germany

Until recently, tenants and flat owners in Germany needed the permission from their landlords or the condominium association[34, 35] (homeowner association of neighbours in the same building) to install a plug-in solar system, which has created some barriers to uptake of the technology in cases where landlords refuse the request for installation.

A recent amendment to **Rental Contract Law** (BGB § 554 / English not changed as of 17.10.24) and the law governing Condominiums (§ 20 WEG) which took effect in October 2024, changes the precedent for plug-in systems. Now including balcony systems in a list of "privileged measures", the law **guarantees tenants and flat owners across Germany the right to obtain approval from their landlords or condominium association** respectively if they want to install a plug-in solar system.

Once the tenant/flat owner notifies the landlord/homeowner association in writing, **the landlord/association have the legal obligation to approve/vote in favour of the installation, unless they can provide legitimate concerns** that the systems are impossible/unsafe to use, with documented evidence. Outside of this, residents are then responsible for complying with any building guidelines but cannot be required to meet excessive or unnecessary demands.

© Mariana Serdynska/Shutterstock.com

34 Reuters (07/2024): Germany gives apartment-dwellers legal right to solar power
35 Alles über Steckersolar, Balkonkraftwerke & mehr Solar!: "Germany Grants Renters the Right to Install Solar Systems on Balconies"

3. Technical requirements and best practices

Size limit of installation (module output capacity on the DC side)

While the AC output of a balcony PV system is usually limited to 800 W_{AC}, as per the RfG Regulation, some countries also set a DC capacity limit, usually between 400-2,000 W, i.e. a limit to the number of panels that can be installed. Limiting the DC side close to the AC side can be problematic for all users with sub-optimal conditions regarding azimuth and angle, as they cannot oversize the system on the DC side to effectively generate 800 W_{AC}.

The VDE, the German technical regulator, is currently pioneering the development of the most advanced requirements for plug-in PV installations. The VDE has previously stated concerns about older installations, in which higher module outputs could lead to cables overheating or even fires in very unfavourable load cases. In the latest available draft of the VDE 0126 95 standard for plug-in systems (May 2024), the maximum value for installed DC power is limited to 960 W. This differs from federal legislation, Solarpaket 1, which sets a 2 kW limit.[36] Additionally, a recently published study by HTW Berlin - university of applied sciences comes to the conclusion that a 2 kW DC limit is indeed safe.[37] Although VDE product standards are not a legal requirement per se, they can and most likely will be referenced by landlords and insurance policies. Thus, connecting products not certifying to this standard would open questions regarding liability in case of accidents. The final draft of the standard is expected for publication in the third quarter of 2025 – hopefully bridging the gap between the law and the technical regulator, therefore providing clarity for consumers through uniform regulations.

Rooftop plug-in solar, Alenquer, Portugal

36 It is worth noting that the standard developed by the VDE for the German market would constitute the first product standard for plug-in systems and may eventually be used as a reference in other Member States

37 HTW Berlin: Short report: Plug-in solar 800 W

While plug-in systems have historically been 1-2 modules in size, they are now increasingly available in larger capacities. This is mostly driven by recent steep module price decreases; additionally, more panels help users maximise PV production (given the sometimes sub-optimal orientation of the systems and variable weather conditions), therefore improving the business case for plug-in systems, especially in Member States where irradiation levels are lower. Adding battery storage further increases the incentive for larger installed capacity, going beyond 2 kW. Plug-in products available on the European market today go up to 6 kW total output and up to 25 kWh storage option still using an energy management system which caps public grid feed-in at 800 W.[38] Since oversizing plug-in installations is a source of concerns for some regulators due to fire risks, this highlights the need to develop clear rules and limits in order to allow products to circulate safely.

Modern PV systems, smart inverters and energy management systems allow for DC oversizing while controlling the currents and limiting the AC output to the required maximum at the plug-in PV installation or the grid connection point with either software, hardware or both. This ensures that the feed-in power never exceeds the AC limit. The EU Electricity Market Design acknowledges this functionality under the term "Power Control Systems" (PCS) in the context of flexible connection agreements.[39]

Installation by a professional and use of plugs

Regulators and researchers have different opinions on whether an installation should be carried out by a professional, and what kind of plug can be used.

The discussion on plugs mostly concerns the choice between the Wieland and a Schuko-plug (standard household plug in most EU Member States). However, the obligatory installation of a Wieland socket or similar means that the predicate "plug and play" is no longer valid, as an expert must be consulted for the installation. Any type of required professional installation reduces the business case for plug-in systems and poses a barrier to deployment.

Garden plug-in solar

38 pv magazine International: "German companies launch 'world's largest' plug-in PV system"
39 Directive - EU - 2024/1711 - EN - EUR-Lex

A Fraunhofer study from 2019[40] concludes that a requirement for special plugs / special sockets for plug-in PV systems is not absolutely necessary, since commercially available inverters ensure immediate, rapid shutdown when the system is disconnected from the power grid.[41]

Case study - Technical Requirements for Plug-in PV grid connection in Spain vs Germany

Spain

According to Spanish legislation, plug-in installations require a separate circuit and must be performed alongside the issuance of an electrical installation certificate by a qualified professional.

This procedure represents added costs for the user. Solar kits can operate without a grid connection if a customer installs a zero-discharge device on the household's main power line, ensuring no surplus goes to the grid.

Germany

In past German regulation and under previous drafts of the VDE 0126 95 standard, plug-in PV systems were required to use a special feed-in socket and be connected via a separate line to the apartment's distribution system with a dedicated circuit breaker. The VDE classified plug-in PV power systems not as electrical equipment but as a generation system, which made a specific plug and socket necessary. This type of power socket had to be installed by a qualified electrician in most cases and connected with its own supply line. This restriction hasn't stopped users in the past from buying products with the standard Schuko / type F plug, which is the dominant choice on the market.

Following the release of SolarPaket 1, the use of a standard Schuko household plug is now "tolerated", although not officially endorsed yet by the VDE. The second draft of the standard published in May 2024[42] now allows plug-in solar systems to be connected using Schuko plugs, provided certain protective measures are in place. These measures include mechanical or electromechanical safeguards to ensure basic protection and prevent contact with live parts. Still in the final round of consultation and comments, the final draft of the standard is expected to be published in Q3 2025.

40 Fraunhofer ISE (2019): "Steckerfertige, Netzgekoppelte Kleinst-PV-Anlagen, Studie Für e-control Austria", translated to English via Google translate
41 Fraunhofer ISE (2019): "Steckerfertige, Netzgekoppelte Kleinst-PV-Anlagen, Studie Für e-control Austria", translated to English via Google translate
42 "Product standard for balcony power plants: VDE publishes second draft", 07.05.2023

Guidelines and best practices for safe installation

While there are not yet any EU-wide standardised rules for the installation of plug-in systems, some best practice guidelines, recommendations and assessments exist at a national level. TÜV Rheinland, the German testing, inspection and certification association, has previously provided some general tips and guidelines to users for installing plug-in systems in Germany.[43] There are also comprehensive summaries available from the General German Automobile Club (ADAC)[44] and an FAQ of the German Consumer Organization (Verbraucherzentrale).[45]

In France, the national association for Solar PV and for Renewables (Enerplan and SER respectively), collaborated on and released in 2022 a best-practice guidelines document for "Plug and Play" PV,[46] for the attention of plug-in PV developers/businesses. The document aims to ensure that prosumer individuals have access to plug and play solar self-consumption solutions with sufficient levels of intrinsic electrical safety.

Across documents, best-practice guidelines generally cover the following:

- Making sure the balcony/terrace/garden/roof/exterior wall is **suitable for installation** (presence of outdoor/grounded power socket, optimal orientation/dimensions);
- Only using quality products (modules, microinverters, and cabling) that comply with **existing EU or national product standards** and that have been certified and tested for safety;
- Ensuring the panels are **safely attached with suitable mounting equipment** which will withstand wind, snow, heat, moisture, UV radiation, mechanical stress, etc;
- Making sure the installation of the plug-in systems complies with **building regulations**, obtaining permission from the **landlord**, and other **administrative compliance**;
- Connecting a limit of **one plug-in system into the home circuit**, via a grounded socket, and/or detailing other strict rules on the dimensioning of the circuit.

Instructions and safety guidelines for installing balcony PV systems are usually provided directly by manufacturers for the prosumer. These guidelines can vary depending on the type of product, including differences in panel weight, the number of panels, and other installation factors.

Façade plug-in solar, Mirandela, Portugal

43 pv magazine International: "TÜV offers guidance on plug-in balcony solar panels"
44 ADAC, 2025: "Jetzt bis 800 Watt Leistung erlaubt: 2025 ein Balkonkraftwerk kaufen?"
45 Verbraucherzentrale, 2025: FAQ Steckersolar
46 SER, 2022: "Guide kit photovoltaïque autoconsommation plug & play"

4. Plug-in PV frameworks - Conclusions

Next to the impressive market uptake of plug-in PV in the pioneering market Germany, and to a lesser extent in the newer markets of France and Austria, there is an overall increased interest in this solar application in many European countries. Plug-in PV solar democratises solar power by enabling European citizens that do not own houses to invest in their own renewable energy system to reduce their electricity bill. Quality and safety concerns must be addressed in respective product standardisation efforts. To ensure a sufficient level of visibility, plug-in systems should be registered through an easy online process of either the regulator or the system operator. Several barriers to the deployment of mass adoption of solar plug-in systems across Europe remain.

These barriers include (but are not limited to):

- **A patchwork of regulation and standardisation throughout the EU:** This lack of clarity and harmonisation is causing uncertainty for manufacturers and prosumers.
- **The obligation in some cases to have an electrician install the plug-in system, to use Wieland plugs, or to use a separate circuit**, is often costly and hence diminishes the business case for plug-in solar. Technical solutions, such as power control systems, exist to guarantee all the parameters of a plug-in system deemed as safe by the regulator or standardisation body.
- **Administrative burden** and bottlenecks can arise at different stages for the prosumer:
  - Approval by landlords and/or neighbours
  - Approval by the municipality (following building laws and architectural constraints)
  - Approval by the local grid operator.

Garage plug-in solar, Portugal

Summary of regulations in place in EU Member States

The following table summarises the regulatory situation for plug-in systems in other key EU solar markets (non-exhaustive).

Table 5

Plug-in PV regulations across Member States

System	DC and AC limit	Registration	Installation by a professional	Incentives	Grid feed-in	Certification
Germany	DC: 2,000 W AC: 800 W	• Simple online registration with the federal network regulator's core energy market data register	• Not required, although sometimes needed for the installation of a Wieland plug or similar	• Some localised subsidy schemes • 0% VAT since 2023 on all systems <30 kW • FIT for systems <10 kW	• Permitted and eligible for FITs according to EEG (8,43 c/kWh for systems below 10 kW)	• Although not a legal requirement, products should be certified against VDE standards for insurance purposes
Austria	AC: 800 W	• Simple notification to the grid operator	• Depends on the local grid operator. Sometimes required	• No subsidies for installation, but VAT will be waived on systems up to 35 kW if installed in 2024/2025	• Not intended, not regulated	...
Spain	AC: 800 W	• Solar kits can operate without the certification which allows for grid feed-in if the customer installs a zero-discharge device on the household's main power line, ensuring no surplus goes to the grid	• Mandatory installation and certification by an electrician to allow grid feed-in. This involves plugging the kit into a dedicated circuit • Costly, with added regional taxes to be paid on top	• Systems of less than 15 kW in urban areas no longer require a permit	• Only allowed in the case of installation by an electrician via a separate circuit. Surplus not compensated	• Licensing requirements for kits or individual components can differ per region

Table 5 - continued

Plug-in PV regulations across Member States

System	DC and AC limit	Registration	Installation by a professional	Incentives	Grid feed-in	Certification
France	DC: 3,000 W AC: 600 W	• Under 3 kW and for installations less than 1.80m in height, there is no permitting or urban planning requirement, except in protected building zones only where it must be declared to the municipality • The user must sign a "Convention of self-consumption without injection to the grid" with the network operator	• Not required, except if injecting excess feed-in to the grid		• Not allowed – the user must sign a "Convention of self-consumption without injection to the grid" with the network operator • In the case of grid feed-in, need for a certification provided by an electrician	• Relevant French and European safety norms for each component, as listed in SER's best practice guidelines report[47]
Sweden	AC: 800 W	• Technically not allowed in "plug-in" format, unless off-grid. Require approval by landlord and grid operator	• Yes, unless off-grid. Also need for a snow & wind load calculation and robust mounting		• Yes if installed by an electrician. Otherwise off-grid	
Lithuania	AC: 800 W	• Simple notification to the DSO. Approvals may be required (landlord, neighbours, municipality) if modules are installed stationary. In the case of mobile or semiflex modules no approvals are required	• Not required	• CAPEX subsidy of 203 € per 0.8 kW	• Yes	• Certificates of the equipment (CE)
Greece	AC: 800 W	• Approval by neighbours and grid operator	• Not	• None		

47 SER, 2022: "Guide kit photovoltaïque autoconsommation plug & play"

Table 5 - continued

Plug-in PV regulations across Member States

System	DC and AC limit	Registration	Installation by a professional	Incentives	Grid feed-in	Certification
Slovenia	AC: 800 W	• Simple notification/ registration with the grid operator			• No: Only allowed in self-consumption mode	• Slovenian guidelines under SONDSEE and European standards, such as the VDE, indicate that components of systems up to 800 W (inverters, mounting hardware, and connectors) should meet international certification standards such as the VDE, EN, or IEC
Portugal	AC: 800 W	• < 700 W: No requirements to register • > 700 W: Need to communicate the kit installation to the power grid regulator		• Reduced (4%) VAT on solar systems in Portuguese islands[48]		
Italy	AC: 800 W	• Must register with the grid operator				
Hungary		• Banned				
Belgium (from April 2025)	AC: 800 W	• Same permitting rules as for standard PV. • For multi-owner building, a permission from the Owners Association • Potential need for landlord permission	• Will not require inspection from the Belgian electrical safety regulator (AREI)			• Manufacturers need to be homologated under Synergrid requirements[49]
Switzerland (non-EU)	DC: 600 W / 2.6 A AC: 800 W	• Registration required with the local network operator				• A declaration of conformity listing all relevant standards is required for the product

48 Portugal - Corporate - Other taxes
49 INFO_fabrikanten_2024.11_C10-11_ed2.3_plug-and-play_EN.pdf

SolarPower Europe

9 789464 669251

SolarPower Europe
Leading the Energy Transition

SolarPower Europe, the premier association for the European solar PV sector, unites 320+ organisations. Collaborating with members, we shape regulations and business landscapes for solar's growth.

Our dedicated policy experts lead focused workstreams, addressing key issues and influencing legislation. Based in Brussels, we build strong relationships, ensuring solar's pivotal role in the European energy transition.

As co-founders of the RE-Source Platform, Renewable Hydrogen Coalition, and the European Solar Initiative, we actively engage in EU and international projects, fostering partnerships with 40+ organizations globally.

SolarPower Europe's top analysts provide market intelligence through reports like the Global Market Outlook for Solar Power and EU Solar Jobs Report. Our events, including the SolarPower Summit and RE-Source, bring policymakers and stakeholders together for networking and business opportunities.

Quick Facts

SolarPower Europe was established in April 1985 – we will celebrate our 40th anniversary in 2025!

SolarPower Europe represents over 40 national solar energy associations across Europe

Almost 90% of our members are European headquartered companies

SolarPower Europe won 'European Association of the Year' at the International & European Association Success Awards 2024

Rond-point Robert Schuman 3,
1040 Brussels, Belgium

info@solarpowereurope.org
www.solarpowereurope.org