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Photovoltaic power station

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[](https://en.wikipedia.org/wiki/File:Energiepark_Lauingen_Gehrlicher_Solar_AG.JPG)

The 25.7 MW [Lauingen Energy Park](https://en.wikipedia.org/wiki/Lauingen_Energy_Park) in [Bavarian Swabia](https://en.wikipedia.org/wiki/Bavarian_Swabia), Germany

A **photovoltaic power station**, also known as a **solar park**, is a large-scale [photovoltaic system](https://en.wikipedia.org/wiki/Photovoltaic_system) (PV system) designed for the supply of [merchant power](https://en.wikipedia.org/wiki/Electricity_market#Wholesale_electricity_market) into the [electricity grid](https://en.wikipedia.org/wiki/Electrical_grid). They are differentiated from most building-mounted and other decentralised solar power applications because they supply power at the [utility](https://en.wikipedia.org/wiki/Utility) level, rather than to a local user or users. They are sometimes also referred to as **solar farms** or **solar ranches**, especially when sited in agricultural areas. The generic expression **utility-scale solar** is sometimes used to describe this type of project.

The [solar power](https://en.wikipedia.org/wiki/Solar_power) source is via [photovoltaic modules](https://en.wikipedia.org/wiki/Solar_panel) that convert light directly to electricity. However, this differs from, and should not be confused with [concentrated solar power](https://en.wikipedia.org/wiki/Concentrated_solar_power), the other large-scale solar generation technology, which uses heat to drive a variety of conventional generator systems. Both approaches have their own advantages and disadvantages, but to date, for a variety of reasons, [photovoltaic](https://en.wikipedia.org/wiki/Photovoltaic) technology has seen much wider use in the field. As of 2013, PV systems outnumber concentrators by about 40 to 1.

In some countries, the [nameplate capacity](https://en.wikipedia.org/wiki/Nameplate_capacity) of a photovoltaic power stations is rated in [megawatt-peak](https://en.wikipedia.org/wiki/Megawatt-peak) (MWp), which refers to the solar array's [DC](https://en.wikipedia.org/wiki/Direct_current) power output. However, Canada, Japan, Spain and some parts of the United States often specify using the converted lower nominal power output in [MWAC](https://en.wikipedia.org/wiki/Watt-peak_AC); a measure directly comparable to other forms of power generation. A third and less common rating is the [mega volt-amperes](https://en.wikipedia.org/wiki/Volt-ampere) (MVA). Most solar parks are developed at a scale of at least 1 MWp. As of 2015, the [world's largest](https://en.wikipedia.org/wiki/List_of_photovoltaic_power_stations) operating photovoltaic power stations have capacities of close to 600 [megawatts](https://en.wikipedia.org/wiki/Megawatt) and projects up to 1 [gigawatt](https://en.wikipedia.org/wiki/Gigawatt) are planned. As at the end of 2015, about 3,400 projects with a combined capacity of 60 GWAC were solar farms larger than 4 MW.[[1]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-1)

Most of the existing large-scale photovoltaic power stations are owned and operated by independent power producers, but the involvement of community- and utility-owned projects is increasing. To date, almost all have been supported at least in part by regulatory incentives such as [feed-in tariffs](https://en.wikipedia.org/wiki/Feed-in_tariff) or [tax credits](https://en.wikipedia.org/wiki/Tax_credit#Renewable_Energy.2FInvestment_Tax_Credit_.28ITC.29), but as [levelized costs](https://en.wikipedia.org/wiki/Levelized_cost) have fallen significantly in the last decade and [grid parity](https://en.wikipedia.org/wiki/Grid_parity) has been reached in an increasing number of markets, it may not be long before external incentives cease to exist.

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* [1History](https://en.wikipedia.org/wiki/Photovoltaic_power_station#History)

History[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=1" \o "Edit section: History)]

The first 1 MWp solar park was built by Arco Solar at Lugo near [Hesperia, California](https://en.wikipedia.org/wiki/Hesperia,_California) at the end of 1982,[[2]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Lugo-2) followed in 1984 by a 5.2 MWp installation in [Carrizo Plain](https://en.wikipedia.org/wiki/Carrizo_Plain).[[3]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Carrisa-3) Both have since been decommissioned, though Carrizo Plain is the site for several large plants now being constructed[[4]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Topaz-4) or planned. The next stage followed the 2004 revisions[[5]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-EEG2004-5) to the [feed-in tariffs in Germany](https://en.wikipedia.org/wiki/Feed-in_tariffs_in_Germany)[[6]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-solarplaza-6) when a substantial volume of solar parks were constructed.[[6]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-solarplaza-6)

[](https://en.wikipedia.org/wiki/File:SolarPowerPlantSerpa.jpg)

Serpa Solar Park built in Portugal in 2006

Several hundred installations over 1 MWp have been since been installed in Germany, of which more than 50 are over 10 MWp.[[7]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wiki-Germany-7) With its introduction of feed-in tariffs in 2008, Spain became briefly the largest market, with some 60 solar parks over 10 MW,[[8]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Spain_map-8) but these incentives have since been withdrawn.[[9]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-9) The USA,[[10]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-USA_map-10) China[[11]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-China_map-11) India,[[12]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-India_map-12) France,[[13]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-France_map-13) Canada,[[14]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Canada_map-14) and Italy,[[15]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Italy_map-15) amongst others, have also become major markets as shown on the [list of photovoltaic power stations](https://en.wikipedia.org/wiki/List_of_photovoltaic_power_stations).

The largest sites under construction have capacities of hundreds of MWp and projects at a scale of 1 GWp are being planned.[[4]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Topaz-4)[[16]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-16)[[17]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-17)

Siting and land use[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=2" \o "Edit section: Siting and land use)]

The land area required for a desired power output, varies depending on the location,[[18]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Statistics-18) and on the efficiency of the solar modules,[[19]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-19) the slope of the site[[20]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-20) and the type of mounting used. Fixed tilt solar arrays using typical modules of about 15% efficiency[[21]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-21) on horizontal sites, need about 1 [hectare](https://en.wikipedia.org/wiki/Hectare)/MW in the tropics and this figure rises to over 2 [hectares](https://en.wikipedia.org/wiki/Hectare) in northern Europe.[[18]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Statistics-18)

Because of the longer shadow the array casts when tilted at a steeper angle,[[22]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-tilt_spacing-22) this area is typically about 10% higher for an adjustable tilt array or a single axis tracker, and 20% higher for a 2-axis tracker,[[23]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wolfe_book-23) though these figures will vary depending on the latitude and topography.[[24]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-24)

The best locations for solar parks in terms of land use are held to be brown field sites, or where there is no other valuable land use.[[25]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-25) Even in cultivated areas, a significant proportion of the site of a solar farm can also be devoted to other productive uses, such as crop growing[[26]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-26)[[27]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-27) or biodiversity.[[28]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-28)

**Agrivoltaics**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=3" \o "Edit section: Agrivoltaics)]

[Agrivoltaics](https://en.wikipedia.org/wiki/Agrivoltaics) is co-developing the same area of [land](https://en.wikipedia.org/wiki/Land) for both solar [photovoltaic](https://en.wikipedia.org/wiki/Photovoltaic) power as well as for conventional [agriculture](https://en.wikipedia.org/wiki/Agriculture). A recent study found that the value of solar generated electricity coupled to shade-tolerant crop production created an over 30% increase in economic value from farms deploying agrivoltaic systems instead of conventional agriculture. [[29]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-29)

**Co-location**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=4" \o "Edit section: Co-location)]

In some cases several different solar power stations, with separate owners and contractors, are developed on adjacent sites.[[30]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-30) This can offer the advantage of the projects sharing the cost and risks of project infrastructure such as grid connections and planning approval.[[31]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-31) Solar farms can also be co-located with wind farms.[[32]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-32) Sometimes the title 'solar park' is used, rather than an individual solar power station.[[33]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-33)[[34]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-34)

Some examples of such solar clusters are the [Charanka Solar Park](https://en.wikipedia.org/wiki/Charanka_Solar_Park), where there are 17 different generation projects; Neuhardenberg,[[35]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Neuhardenberg-35)[[36]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-36) with eleven plants, and the Golmud solar parks with total reported capacity over 500MW.[[37]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-37)[[38]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Golmud-38) An extreme example is calling all of the solar farms in the [Gujarat](https://en.wikipedia.org/wiki/Gujarat) state of India a single solar park, the [Gujarat Solar Park](https://en.wikipedia.org/wiki/Gujarat_Solar_Park).

Technology[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=5" \o "Edit section: Technology)]

Most Solar parks are [ground mounted](https://en.wikipedia.org/wiki/Photovoltaic_mounting_system#Ground_mounted) PV systems, also known as free-field solar power plants.[[39]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Free_field-39) They can either be fixed tilt or use a single axis or dual axis [solar tracker](https://en.wikipedia.org/wiki/Solar_tracker).[[40]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-mounting_tilt-40)While tracking improves the overall performance, it also increases the system's installation and maintenance cost.[[41]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-41)[[42]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-42) A [solar inverter](https://en.wikipedia.org/wiki/Solar_inverter) converts the array's power output from [DC](https://en.wikipedia.org/wiki/Direct_current) to [AC](https://en.wikipedia.org/wiki/Alternating_current), and connection to the [utility grid](https://en.wikipedia.org/wiki/Utility_grid) is made through a high voltage, three phase step up [transformer](https://en.wikipedia.org/wiki/Transformer) of typically 10 [kV](https://en.wikipedia.org/wiki/Kilovolt) and above.[[43]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-transformer-43)[[44]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Grid_voltage-44)

**Solar array arrangements**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=6" \o "Edit section: Solar array arrangements)]

The [solar arrays](https://en.wikipedia.org/wiki/Solar_array) are the subsystems which convert incoming light into electrical energy.[[45]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-45) They comprise a multitude of [solar modules](https://en.wikipedia.org/wiki/Solar_module), mounted on support structures and interconnected to deliver a power output to electronic power conditioning subsystems.[[46]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-system_schematic-46)

A minority of utility-scale solar parks are configured on buildings[[47]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-SolarServer-47) and so use [building-mounted](https://en.wikipedia.org/wiki/Bipv) solar arrays. The majority are 'free field' systems using ground-mounted structures,[[39]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Free_field-39) usually of one of the following types:

**Fixed arrays**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=7" \o "Edit section: Fixed arrays)]

[](https://en.wikipedia.org/wiki/File:Dual-glass_solar_panels.jpg)

Double glass photovoltaic solar modules, installed on a fixed support structure.

Many projects use mounting structures where the solar modules are mounted at a [fixed](https://en.wikipedia.org/wiki/Solar_tracker#Fixed_mount) inclination calculated to provide the optimum annual output profile.[[40]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-mounting_tilt-40) The modules are normally oriented towards the Equator, at a tilt angle slightly less than the latitude of the site.[[48]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-48) In some cases, depending on local climatic, topographical or electricity pricing regimes, different tilt angles can be used, or the arrays might be offset from the normal East-West axis to favour morning or evening output.[[49]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-SEAI-49)

A variant on this design is the use of arrays, whose tilt angle can be adjusted twice or four times annually to optimise seasonal output.[[40]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-mounting_tilt-40) They also require more land area to reduce internal shading at the steeper winter tilt angle.[[22]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-tilt_spacing-22) Because the increased output is typically only a few percent, it seldom justifies the increased cost and complexity of this design.[[23]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wolfe_book-23)

**Dual axis trackers**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=8" \o "Edit section: Dual axis trackers)]

[](https://en.wikipedia.org/wiki/File:Parc_fotovoltaic_de_Bellpuig_I.JPG)

Bellpuig Solar Park near [Lerida, Spain](https://en.wikipedia.org/wiki/Lerida) uses pole-mounted 2-axis trackers

To maximise the intensity of incoming direct radiation, solar panels should be orientated normal to the sun's rays.[[50]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-50) To achieve this, arrays can be designed using [two-axis trackers](https://en.wikipedia.org/wiki/Solar_tracker#Dual_axis_trackers), capable of tracking the sun in its daily orbit across the sky, and as its elevation changes throughout the year.[[51]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-51)

These arrays need to be spaced out to reduce inter-shading as the sun moves and the array orientations change, so need more land area.[[52]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Trackers_REW-52) They also require more complex mechanisms to maintain the array surface at the required angle. The increased output can be of the order of 30%[[53]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Trackers-53) in locations with high levels of [direct radiation](https://en.wikipedia.org/wiki/Direct_insolation), but the increase is lower in temperate climates or those with more significant [diffuse radiation](https://en.wikipedia.org/wiki/Diffuse_sky_radiation), due to overcast conditions. For this reason, dual axis trackers are most commonly used in subtropical regions,[[52]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Trackers_REW-52) and were first deployed at utility scale at the Lugo plant.[[2]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Lugo-2)

**Single axis trackers**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=9" \o "Edit section: Single axis trackers)]

A third approach achieves some of the output benefits of tracking, with a lesser penalty in terms of land area, capital and operating cost. This involves tracking the sun in one dimension – in its daily journey across the sky – but not adjusting for the seasons.[[54]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-NREL_tracker-54) The angle of the axis is normally horizontal, though some, such as the solar park at Nellis Airforce Base, which have a 20° tilt,[[55]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-55) incline the axis towards the equator in a north-south orientation – effectively a hybrid between tracking and fixed tilt.[[56]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-56)

[Single axis tracking systems](https://en.wikipedia.org/wiki/Solar_tracker#Single_axis_trackers) are aligned along axes roughly North-South.[[57]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-57) Some use linkages between rows so that the same actuator can adjust the angle of several rows at once.[[54]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-NREL_tracker-54)

**Power conversion**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=10" \o "Edit section: Power conversion)]

Solar panels produce [direct current](https://en.wikipedia.org/wiki/Direct_current) (DC) electricity, so solar parks need conversion equipment[[46]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-system_schematic-46) to convert this to [alternating current](https://en.wikipedia.org/wiki/Alternating_current) (AC), which is the form transmitted by the electricity grid. This conversion is done by [inverters](https://en.wikipedia.org/wiki/Inverter). To maximise their efficiency, solar power plants also incorporate [maximum power point trackers](https://en.wikipedia.org/wiki/Maximum_power_point_trackers), either within the inverters or as separate units. These devices keep each solar array string close to its [peak power point](https://en.wikipedia.org/wiki/Solar_cell_efficiency#Maximum_power_point).[[58]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-58)

There are two primary alternatives for configuring this conversion equipment; centralised and string inverters,[[59]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-59) although in some cases individual, or [micro-inverters](https://en.wikipedia.org/wiki/Solar_micro-inverter) are used.[[60]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-60) Single inverters allows optimizing the output of each panel, and multiple inverters increases the reliability by limiting the loss of output when an inverter fails.[[61]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-casestudy-61)

**Centralised inverters**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=11" \o "Edit section: Centralised inverters)]

[](https://en.wikipedia.org/wiki/File:Juwi_PV_Field.jpg)

[Waldpolenz Solar Park](https://en.wikipedia.org/wiki/Waldpolenz_Solar_Park)[[62]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Waldpolenz-62) is divided into blocks, each with a centralised inverter

These units have relatively high capacity, typically of the order of 1 MW,[[63]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-inverters_REW-63) so they condition that the output of a substantial block of solar arrays, up to perhaps 2 hectares (4.9 acres) in area.[[64]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-64) Solar parks using centralised inverters are often configured in discrete rectangular blocks, with the related inverter in one corner, or the centre of the block.[[65]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-65)[[66]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-66)[[67]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-67)

**String inverters**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=12" \o "Edit section: String inverters)]

[String inverters](https://en.wikipedia.org/wiki/String_inverter) are substantially lower in capacity, of the order of 10 kW,[[63]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-inverters_REW-63)[[68]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-68) and condition the output of a single array string. This is normally a whole, or part of, a row of solar arrays within the overall plant. String inverters can enhance the efficiency of solar parks, where different parts of the array are experiencing different levels of insolation, for example where arranged at different orientations, or closely packed to minimise site area.[[61]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-casestudy-61)

**Transformers**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=13" \o "Edit section: Transformers)]

The system inverters typically provide power output at voltages of the order of 480 VAC.[[69]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-69)[[70]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-planning-70) [Electricity grids](https://en.wikipedia.org/wiki/Electrical_grid) operate at much higher voltages of the order of tens or hundreds of thousands of volts,[[71]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-71) so transformers are incorporated to deliver the required output to the grid.[[44]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Grid_voltage-44) Due to the long lead time, the [Long Island Solar Farm](https://en.wikipedia.org/wiki/Long_Island_Solar_Farm) chose to keep a spare transformer onsite, as transformer failure would have kept the solar farm offline for a long period.[[72]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-72) Transformers typically have a life of 25 to 75 years, and normally do not require replacement during the life of a photovoltaic power station.[[73]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-73)

**System performance**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=14" \o "Edit section: System performance)]

The performance of a solar park is a function of the climatic conditions, the equipment used and the system configuration. The primary energy input is the global light irradiance in the plane of the solar arrays, and this in turn is a combination of the direct and the diffuse radiation.[[74]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-74)

A key determinant of the output of the system is the conversion efficiency of the solar modules, which will depend in particular on the type of [solar cell](https://en.wikipedia.org/wiki/Solar_cell) used.[[75]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-75)

There will be losses between the DC output of the solar modules and the AC power delivered to the grid, due to a wide range of factors such as light absorption losses, mismatch, cable voltage drop, conversion efficiencies, and other parasitic losses.[[76]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-76) A parameter called the 'performance ratio'[[77]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-PerfRatio-77) has been developed to evaluate the total value of these losses. The performance ratio gives a measure of the output AC power delivered as a proportion of the total DC power which the solar modules should be able to deliver under the ambient climatic conditions. In modern solar parks the performance ratio should typically be in excess of 80%.[[78]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-78)[[79]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-79)

**System degradation**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=15" \o "Edit section: System degradation)]

Early photovoltaic systems output decreased as much as 10%/year,[[3]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Carrisa-3) but as of 2010 the median degradation rate was 0.5%/year, with modules made after 2000 having a significantly lower degradation rate, so that a system would lose only 12% of its output performance in 25 years. A system using modules which degrade 4%/year will lose 64% of its output during the same period.[[80]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-80) Many panel makers offer a performance guarantee, typically 90% in ten years and 80% over 25 years. The output of all panels is typically warranteed at plus or minus 3% during the first year of operation.[[81]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-81)

The business of developing solar parks[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=16" \o "Edit section: The business of developing solar parks)]

[](https://en.wikipedia.org/wiki/File:Westmill_Solar_Cooperative_1.jpg)

[Westmill Solar Park](https://en.wikipedia.org/wiki/Westmill_Solar_Park)[[82]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-WSC-82) is the world's largest community-owned solar power station[[83]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Westmill-83)

Solar power plants are developed to deliver merchant electricity into the grid as an alternative to other renewable, fossil or nuclear generating stations.[[84]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-84)

The plant owner is an electricity generator. Most solar power plants today are owned by [independent power producers](https://en.wikipedia.org/wiki/Independent_power_producer)(IPP's),[[85]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-85) though some are held by [investor-](https://en.wikipedia.org/wiki/Investor-owned_utility) or [community-owned](https://en.wikipedia.org/wiki/Utility_cooperative) utilities.[[86]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-86)

Some of these power producers develop their own portfolio of power plants,[[87]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-87) but most solar parks are initially designed and constructed by specialist project developers.[[88]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-88) Typically the developer will plan the project, obtain planning and connection consents, and arrange financing for the capital required.[[89]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-89) The actual construction work is normally contracted to one or more [EPC](https://en.wikipedia.org/w/index.php?title=EPC_(contract)&action=edit&redlink=1) (engineering, procurement and construction) contractors.[[90]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-90)

Major milestones in the development of a new photovoltaic power plant are planning consent,[[91]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-91) grid connection approval,[[92]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-92)financial close,[[93]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-SunEdison_SA-93) construction,[[94]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-94) connection and commissioning.[[95]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-95) At each stage in the process, the developer will be able to update estimates of the anticipated performance and costs of the plant and the financial returns it should be able to deliver.[[96]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-96)

**Planning approval**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=17" \o "Edit section: Planning approval)]

Photovoltaic power stations occupy at least one [hectare](https://en.wikipedia.org/wiki/Hectare) for each megawatt of rated output,[[97]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-97) so require a substantial land area; which is subject to planning approval. The chances of obtaining consent, and the related time, cost and conditions, varying from jurisdiction to jurisdiction and location to location. Many planning approvals will also apply conditions on the treatment of the site after the station has been decommissioned in the future.[[70]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-planning-70) A professional health, safety and environment assessment is usually undertaken during the design of a PV power station in order to ensure the facility is designed and planned in accordance with all [HSE](https://en.wikipedia.org/wiki/Health,_Safety_and_Environment) regulations.

**Grid connection**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=18" \o "Edit section: Grid connection)]

The availability, locality and capacity of the connection to the grid is a major consideration in planning a new solar park, and can be a significant contributor to the cost.[[98]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-98)

Most stations are sited within a few kilometres of a suitable grid connection point. This network needs to be capable of absorbing the output of the solar park when operating at its maximum capacity. The project developer will normally have to absorb the cost of providing power lines to this point and making the connection; in addition often to any costs associated with upgrading the grid, so it can accommodate the output from the plant.[[99]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-99)

**Operation and maintenance**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=19" \o "Edit section: Operation and maintenance)]

Once the solar park has been commissioned, the owner usually enters into a contract with a suitable counterparty to undertake operation and maintenance (O&M).[[100]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-100) In many cases this may be fulfilled by the original EPC contractor.[[101]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-101)

Solar plants' reliable solid-state systems require minimal maintenance, compared to rotating machinery for example.[[102]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-low_maintenance-102) A major aspect of the O&M contract will be continuous monitoring of the performance of the plant and all of its primary subsystems,[[103]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-OandM-103) which is normally undertaken remotely.[[104]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-104) This enables performance to be compared with the anticipated output under the climatic conditions actually experienced.[[93]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-SunEdison_SA-93) It also provides data to enable the scheduling of both rectification and preventive maintenance.[[105]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-105) A small number of large solar farms use a separate inverter[[106]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-106)[[107]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-107) or maximizer[[108]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-108) for each solar panel, which provide individual performance data that can be monitored. For other solar farms, thermal imaging is a tool that is used to identify non-performing panels for replacement.[[109]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-pv2012-109)

**Power delivery**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=20" \o "Edit section: Power delivery)]

A solar park's income derives from the sales of electricity to the grid, and so its output is metered in real-time with readings of its energy output provided, typically on a half-hourly basis, for balancing and settlement within the electricity market.[[110]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-110)

Income is affected by the reliability of equipment within the plant and also by the availability of the grid network to which it is exporting.[[111]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-111) Some connection contracts allow the [transmission system operator](https://en.wikipedia.org/wiki/Transmission_system_operator) to constrain the output of a solar park, for example at times of low demand or high availability of other generators.[[112]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-112) Some countries make statutory provision for priority access to the grid[[113]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Priority_access-113) for renewable generators, such as that under the European [Renewable Energy Directive](https://en.wikipedia.org/wiki/Renewables_Directive).[[114]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-114)

Economics and Finance[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=21" \o "Edit section: Economics and Finance)]

In recent years, PV technology has improved its electricity generating [efficiency](https://en.wikipedia.org/wiki/Solar_cell_efficiency), reduced the installation [cost per watt](https://en.wikipedia.org/wiki/Price_per_watt) as well as its [energy payback time](https://en.wikipedia.org/wiki/Energy_payback_time) (EPBT), and has reached [grid parity](https://en.wikipedia.org/wiki/Grid_parity) in at least 19 different markets by 2014.[[115]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-115)[[116]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-116) Photovoltaics is increasingly becoming a viable source of mainstream power.[[117]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-117) However, prices for PV systems show strong regional variations, much more than solar cells and panels, which tend to be global commodities. In 2013, utility-scale system prices in highly penetrated markets such as China and Germany were significantly lower ($1.40/W) than in the United States ($3.30/W). The [IEA](https://en.wikipedia.org/wiki/International_Energy_Agency) explains these discrepancies due to differences in "soft costs", which include customer acquisition, permitting, inspection and interconnection, installation labor and financing costs.[[118]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-IEA-roadmap-PV-2014-118):14

| **Utility-scale PV system prices** | |
| --- | --- |
| **Country** | **Cost ($/W)** |
| [Australia](https://en.wikipedia.org/wiki/Solar_power_in_Australia) | 2.0 |
| [China](https://en.wikipedia.org/wiki/Solar_power_in_China) | 1.4 |
| [France](https://en.wikipedia.org/wiki/Solar_power_in_France) | 2.2 |
| [Germany](https://en.wikipedia.org/wiki/Solar_power_in_Germany) | 1.4 |
| [Italy](https://en.wikipedia.org/wiki/Solar_power_in_Italy) | 1.5 |
| [Japan](https://en.wikipedia.org/wiki/Solar_power_in_Japan) | 2.9 |
| [United Kingdom](https://en.wikipedia.org/wiki/Solar_power_in_the_United_Kingdom) | 1.9 |
| [United States](https://en.wikipedia.org/wiki/Solar_power_in_the_United_States) | 3.3 |
| For utility-scale [PV systems](https://en.wikipedia.org/wiki/PV_system) in 2013[[118]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-IEA-roadmap-PV-2014-118):15 | |

**Grid parity**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=22" \o "Edit section: Grid parity)]

*Main article:*[*Grid parity*](https://en.wikipedia.org/wiki/Grid_parity)

Solar generating stations have become progressively cheaper in recent years, and this trend is expected to continue.[[119]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-119) Meanwhile, traditional electricity generation is becoming progressively more expensive.[[120]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-120) These trends are expected to lead to a crossover point when the levelised cost of energy from solar parks, historically more expensive, matches the cost of traditional electricity generation.[[121]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-121)This point is commonly referred to as grid parity.[[122]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-122)

For merchant solar power stations, where the electricity is being sold into the electricity transmission network, the levelised cost of solar energy will need to match the wholesale electricity price. This point is sometimes called 'wholesale grid parity' or 'busbar parity'.[[123]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-UN-Energy-2012-123)

Some photovoltaic systems, such as rooftop installations, can supply power directly to an electricity user. In these cases, the installation can be competitive when the output cost matches the price at which the user pays for his electricity consumption. This situation is sometimes called 'retail grid parity', 'socket parity' or 'dynamic grid parity'.[[124]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-EPIA-124) Research carried out by [UN-Energy](https://en.wikipedia.org/wiki/UN-Energy) in 2012 suggests areas of sunny countries with high electricity prices, such as Italy, Spain and Australia, and areas using diesel generators, have reached retail grid parity.[[123]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-UN-Energy-2012-123)

**Incentive mechanisms**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=23" \o "Edit section: Incentive mechanisms)]

Because the point of grid parity has not yet been reached in many parts of the world, solar generating stations need some form of financial incentive to compete for the supply of electricity.[[125]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-125) Many legislatures around the world have introduced such incentives to support the deployment of solar power stations.[[126]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-126)

**Feed-in tariffs**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=24" \o "Edit section: Feed-in tariffs)]

*Main article:*[*Feed-in tariff*](https://en.wikipedia.org/wiki/Feed-in_tariff)

Feed in tariffs are designated prices which must be paid by utility companies for each kilowatt hour of renewable electricity produced by qualifying generators and fed into the grid.[[127]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-127) These tariffs normally represent a premium on wholesale electricity prices and offer a guaranteed revenue stream to help the power producer finance the project.[[128]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-128)

**Renewable portfolio standards and supplier obligations**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=25" \o "Edit section: Renewable portfolio standards and supplier obligations)]

*Main article:*[*Renewable portfolio standard*](https://en.wikipedia.org/wiki/Renewable_portfolio_standard)

These standards are obligations on utility companies to source a proportion of their electricity from renewable generators.[[129]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-129) In most cases, they do not prescribe which technology should be used and the utility is free to select the most appropriate renewable sources.[[130]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-130)

There are some exceptions where solar technologies are allocated a proportion of the RPS in what is sometimes referred to as a 'solar set aside'.[[131]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-131)

**Loan guarantees and other capital incentives**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=26" \o "Edit section: Loan guarantees and other capital incentives)]

*Main article:*[*Loan guarantee*](https://en.wikipedia.org/wiki/Loan_guarantee)

Some countries and states adopt less targeted financial incentives, available for a wide range of infrastructure investment, such as the US Department of Energy loan guarantee scheme,[[132]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-132) which stimulated a number of investments in the solar power plant in 2010 and 2011.[[133]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-133)

**Tax credits and other fiscal incentives**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=27" \o "Edit section: Tax credits and other fiscal incentives)]

*Main article:*[*Tax credit*](https://en.wikipedia.org/wiki/Tax_credit)

Another form of indirect incentive which has been used to stimulate investment in solar power plant was tax credits available to investors. In some cases the credits were linked to the energy produced by the installations, such as the Production Tax Credits.[[134]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-134) In other cases the credits were related to the capital investment such as the Investment Tax Credits[[135]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-135)

**International, national and regional programmes**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=28" \o "Edit section: International, national and regional programmes)]

In addition to free market commercial incentives, some countries and regions have specific programs to support the deployment of solar energy installations.

The [European Union](https://en.wikipedia.org/wiki/European_Union)'s [Renewables Directive](https://en.wikipedia.org/wiki/Renewables_Directive)[[136]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-136) sets targets for increasing levels of deployment of renewable energy in all member states. Each has been required to develop a [National Renewable Energy Action Plan](https://en.wikipedia.org/wiki/National_Renewable_Energy_Action_Plan) showing how these targets would be met, and many of these have specific support measures for solar energy deployment.[[137]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-137) The directive also allows states to develop projects outside their national boundaries, and this may lead to bilateral programs such as the Helios project.[[138]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-138)

The [Clean Development Mechanism](https://en.wikipedia.org/wiki/Clean_Development_Mechanism)[[139]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-139) of the [UNFCCC](https://en.wikipedia.org/wiki/UNFCCC) is an international programme under which solar generating stations in certain qualifying countries can be supported.[[140]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-140)

Additionally many other countries have specific solar energy development programmes. Some examples are [India](https://en.wikipedia.org/wiki/India)'s [JNNSM](https://en.wikipedia.org/wiki/Jawaharlal_Nehru_National_Solar_Mission),[[141]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-141) the Flagship Program in [Australia](https://en.wikipedia.org/wiki/Australia),[[142]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-142) and similar projects in [South Africa](https://en.wikipedia.org/wiki/South_Africa)[[143]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-143) and [Israel](https://en.wikipedia.org/wiki/Israel).[[144]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-144)

**Financial performance**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=29" \o "Edit section: Financial performance)]

The financial performance of the solar power plant is a function of its income and its costs.[[23]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wolfe_book-23)

The electrical output of a solar park will be related to the solar radiation, the capacity of the plant and its performance ratio.[[77]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-PerfRatio-77) The income derived from this electrical output will come primarily from the sale of the electricity,[[145]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-145) and any incentive payments such as those under Feed-in Tariffs or other support mechanisms.[[146]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-146)

Electricity prices may vary at different times of day, giving a higher price at times of high demand.[[147]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-147) This may influence the design of the plant to increase its output at such times.[[148]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-148)

The dominant costs of solar power plants are the capital cost, and therefore any associated financing and depreciation.[[149]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-149) Though operating costs are typically relatively low, especially as no fuel is required,[[102]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-low_maintenance-102) most operators will want to ensure that adequate operation and maintenance cover[[103]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-OandM-103) is available to maximise the availability of the plant and thereby optimise the income to cost ratio.[[150]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-150)

Geography[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=30" \o "Edit section: Geography)]

*Main articles:*[*Solar power by country*](https://en.wikipedia.org/wiki/Solar_power_by_country)*and*[*Growth of photovoltaics*](https://en.wikipedia.org/wiki/Growth_of_photovoltaics)

The first places to reach grid parity were those with high traditional electricity prices and high levels of solar radiation.[[18]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Statistics-18) Currently, more capacity is being installed in the [rooftop](https://en.wikipedia.org/wiki/Rooftop_photovoltaic_power_station)than in the utility-scale segment. However, the worldwide distribution of solar parks is expected to change as different regions achieve grid parity.[[151]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-151) This transition also includes a shift from rooftop towards utility-scale plants, since the focus of new PV deployment has changed from Europe towards the *Sunbelt markets* where ground-mounted PV systems are favored.[[152]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-epia-2014-152):43

Because of the economic background, large-scale systems are presently distributed where the support regimes have been the most consistent, or the most advantageous.[[153]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-153)Total capacity of worldwide PV plants above 4 MWAC was assessed by [Wiki-Solar](https://en.wikipedia.org/wiki/Wiki-Solar) as 36 GW in c. 2,300 installations at the end of 2014[[154]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-154) and represents about 25 percent of total global PV capacity of 139 GW.[[152]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-epia-2014-152):17 The countries which had the most capacity, in descending order, were the [United States](https://en.wikipedia.org/wiki/Solar_power_in_the_United_States), [China](https://en.wikipedia.org/wiki/Solar_power_in_China), [Germany](https://en.wikipedia.org/wiki/Solar_power_in_Germany), [India](https://en.wikipedia.org/wiki/Solar_power_in_India), [United Kingdom](https://en.wikipedia.org/wiki/Solar_power_in_the_United_Kingdom), [Spain](https://en.wikipedia.org/wiki/Solar_power_in_Spain), [Italy](https://en.wikipedia.org/wiki/Solar_power_in_Italy), [Canada](https://en.wikipedia.org/wiki/Solar_power_in_Canada) and [South Africa](https://en.wikipedia.org/wiki/Solar_power_in_South_Africa).[[155]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-155) Activities in the key markets are reviewed individually below.

**China**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=31" \o "Edit section: China)]

*Main article:*[*Solar power in China*](https://en.wikipedia.org/wiki/Solar_power_in_China)

China was reported in early 2013 to have overtaken Germany as the nation with the most utility-scale solar capacity.[[156]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Capacity_2013-156) Much of this has been supported by the [Clean Development Mechanism](https://en.wikipedia.org/wiki/Clean_Development_Mechanism).[[157]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-157) The distribution of power plants around the country is quite broad, with the highest concentration in the Gobi desert[[11]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-China_map-11) and connected to the Northwest China Power Grid.[[158]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-158)

**Germany**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=32" \o "Edit section: Germany)]

*Main article:*[*Solar power in Germany*](https://en.wikipedia.org/wiki/Solar_power_in_Germany)

The first multi-megawatt plant in Europe was the 4.2 MW community-owned project at Hemau, commissioned in 2003.[[159]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Hemau-159) But it was the revisions to the German feed-in tariffs in 2004,[[5]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-EEG2004-5) which gave the strongest impetus to the establishment of utility-scale solar power plants.[[160]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-160) The first to be completed under this programme was the Leipziger Land solar park developed by Geosol.[[161]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Leipziger_Land-161) Several dozen plants were built between 2004 and 2011, several of which were at the time the [largest in the world](https://en.wikipedia.org/wiki/Photovoltaic_power_station#Noteworthy_solar_parks). The [EEG](https://en.wikipedia.org/wiki/German_Renewable_Energy_Act), the law which establishes Germany’s feed-in tariffs, provides the legislative basis not just for the compensation levels, but other regulatory factors, such as priority access to the grid.[[113]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Priority_access-113) The law was amended in 2010 to restrict the use of agricultural land,[[162]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-162) since which time most solar parks have been built on so-called ‘development land’, such as former military sites.[[35]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Neuhardenberg-35) Partly for this reason, the geographic distribution of photovoltaic power plants in Germany[[7]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-Wiki-Germany-7) is biased towards the former Eastern Germany.[[163]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-163)[[164]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-164) As of February 2012, Germany had 1.1 million photovoltaic power plants (most are small kW roof mounted).[[165]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-165)

**India**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=33" \o "Edit section: India)]

*Main article:*[*Solar power in India*](https://en.wikipedia.org/wiki/Solar_power_in_India)

India has been rising up the leading nations for the installation of utility-scale solar capacity.[[156]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Capacity_2013-156) The [Charanka Solar Park](https://en.wikipedia.org/wiki/Charanka_Solar_Park) in [Gujarat](https://en.wikipedia.org/wiki/Gujarat) was opened officially in April 2012[[166]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-166) and was at the time the [largest group of solar power plants](https://en.wikipedia.org/wiki/Photovoltaic_power_station#Noteworthy_solar_parks) in the world. Geographically the majority of the stations are located in [Gujarat](https://en.wikipedia.org/wiki/Gujarat) and [Maharashtra](https://en.wikipedia.org/wiki/Maharashtra).[[12]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-India_map-12) [Rajasthan](https://en.wikipedia.org/wiki/Rajasthan) has successfully been attempting to attract solar development.[[167]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-167) Rajasthan and Gujarat share the [Thar Desert](https://en.wikipedia.org/wiki/Thar_Desert), along with Pakistan.

**Italy**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=34" \o "Edit section: Italy)]

*Main article:*[*Solar power in Italy*](https://en.wikipedia.org/wiki/Solar_power_in_Italy)

Italy has a very large number of photovoltaic power plants, the largest of which is the 84 MW [Montalto di Castro project](https://en.wikipedia.org/wiki/Montalto_di_Castro_Photovoltaic_Power_Station).[[168]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-168)

**Spain**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=35" \o "Edit section: Spain)]

*Main article:*[*Solar power in Spain*](https://en.wikipedia.org/wiki/Solar_power_in_Spain)

The majority of the deployment of solar power stations in Spain to date occurred during the boom market of 2007-8.[[169]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-169) The stations are well distributed around the country, with some concentration in [Extremadura](https://en.wikipedia.org/wiki/Extremadura), [Castile-La Mancha](https://en.wikipedia.org/wiki/Castile-La_Mancha) and [Murcia](https://en.wikipedia.org/wiki/Murcia).[[8]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Spain_map-8)

**United Kingdom**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=36" \o "Edit section: United Kingdom)]

*Main article:*[*Solar power in the United Kingdom*](https://en.wikipedia.org/wiki/Solar_power_in_the_United_Kingdom)

The introduction of [Feed-in tariffs in the United Kingdom](https://en.wikipedia.org/wiki/Feed-in_tariffs_in_the_United_Kingdom) in 2010 stimulated the first wave of utility-scale projects,[[170]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-WolfeWare-170) with c. 20 plants being completed[[171]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-171) before tariffs were reduced on 1 August 2011 following the 'Fast Track Review'.[[172]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-172) A second wave of installations was undertaken under the UK's [Renewables Obligation](https://en.wikipedia.org/wiki/Renewables_Obligation), with the total number of plants connected by the end of March 2013 reaching 86.[[173]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-173) This is reported to have made the UK Europe's best market in the first quarter of 2013.[[174]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-174)

UK projects were originally concentrated in the South West, but have more recently spread across the South of England and into East Anglia and the Midlands.[[175]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-UK_map-175) The first solar park in Wales came on stream in 2011 at [Rhosygilwen](https://en.wikipedia.org/wiki/Rhoshill,_Pembrokeshire), north [Pembrokeshire](https://en.wikipedia.org/wiki/Pembrokeshire).[[176]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-176) As of June 2014 there were 18 schemes generating more than 5 MW and 34 in planning or construction in Wales.[[177]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-177)

**United States**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=37" \o "Edit section: United States)]

*Main article:*[*Solar power in the United States*](https://en.wikipedia.org/wiki/Solar_power_in_the_United_States)

The US deployment of photovoltaic power stations is largely concentrated in southwestern states.[[10]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-USA_map-10) The Renewable Portfolio Standards in California[[178]](https://en.wikipedia.org/wiki/Photovoltaic_power_station" \l "cite_note-178) and surrounding states[[179]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-179)[[180]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-180) provide a particular incentive. The volume of projects under construction in early 2013 has led to the forecast that the US will become the leading market.[[156]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Capacity_2013-156)

**Noteworthy solar parks**[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=38" \o "Edit section: Noteworthy solar parks)]

*Main article:*[*List of photovoltaic power stations*](https://en.wikipedia.org/wiki/List_of_photovoltaic_power_stations)

The following solar parks were, at the time they became operational, the largest in the world or their continent, or are notable for the reasons given:

| **Noteworthy solar power plants** | | | | |
| --- | --- | --- | --- | --- |
| **Name** | **Country**[[181]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wiki-Solar_maps-181) | **Nominal power (**[**MW**](https://en.wikipedia.org/wiki/Watt-peak)**)**[[182]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-MW_rating-182)[[183]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-183) | **Commissioned** | **Notes** |
| Lugo,[[2]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Lugo-2) San Bernardino County, California | USA | 1 MW | Dec 1982 | First MW plant |
| Carrisa Plain[[3]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Carrisa-3) | USA | 5.6 MW | Dec 1985 | Formerly world's largest |
| Hemau[[159]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Hemau-159) | Germany | 4.0 MW | Apr 2003 | Formerly Europe’s largest community-owned facility[[159]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Hemau-159) |
| Leipziger Land[[161]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Leipziger_Land-161) | Germany | 4.2 MW | Aug 2004 | Formerly Europe’s largest; first under FITs[[23]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wolfe_book-23)[[161]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Leipziger_Land-161) |
| [Pocking](https://en.wikipedia.org/wiki/Pocking_Solar_Park)[[184]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-184) | Germany | 10 MW | Apr 2006 | [Briefly](https://en.wikipedia.org/wiki/Erlasee_Solar_Park) the world's largest |
| [Nellis Air Force Base, Nevada](https://en.wikipedia.org/wiki/Nellis_Solar_Power_Plant)[[185]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-185) | USA | 14 MW | Dec 2007 | Formerly America's largest |
| [Olmedilla](https://en.wikipedia.org/wiki/Olmedilla_Photovoltaic_Park)[[186]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-186) | Spain | 60 MW | Jul 2008 | Formerly world's and Europe's largest |
| [Sinan](https://en.wikipedia.org/wiki/Sinan_Solar_Power_Plant)[[187]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-187) | Korea | 24 MW | Aug 2008 | Formerly Asia's largest |
| [Waldpolenz, Saxony](https://en.wikipedia.org/wiki/Waldpolenz_Solar_Park)[[62]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Waldpolenz-62) | Germany | 40 MW | Dec 2008 | World's largest thin film plant. Extended to 52 MW in 2011[[23]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wolfe_book-23) |
| [DeSoto, Florida](https://en.wikipedia.org/wiki/DeSoto_Next_Generation_Solar_Energy_Center)[[188]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-188) | USA | 25 MW | Oct 2009 | Formerly America's largest |
| La Roseraye[[189]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-189) | Reunion | 11 MW | Apr 2010 | Africa's first 10 MW+ plant |
| [Sarnia, Ontario](https://en.wikipedia.org/wiki/Sarnia_Photovoltaic_Power_Plant)[[190]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-190) | Canada | 97 MWP | Sep 2010 | Formerly world's largest. Corresponds to 80 MWAC. |
| [Golmud, Qinghai](https://en.wikipedia.org/wiki/Huanghe_Hydropower_Golmud_Solar_Park),[[191]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-191) | China | 200 MW | Oct 2011 | Formerly world's largest |
| [Finow Tower](https://en.wikipedia.org/wiki/Solarpark_Finow_Tower)[[192]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-192) | Germany | 85 MW | Dec 2011 | Extension takes it to Europe's largest |
| [Lopburi](https://en.wikipedia.org/wiki/Lopburi_Solar_Farm)[[193]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-193) | Thailand | 73 MW | Dec 2011 | Formerly Asia's largest (outside China)[[23]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Wolfe_book-23) |
| [Perovo, Crimea](https://en.wikipedia.org/wiki/Perovo_Solar_Park)[[194]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-194) | Ukraine | 100 MW | Dec 2011 | Becomes Europe's largest |
| [Charanka, Gujarat](https://en.wikipedia.org/wiki/Charanka_Solar_Park)[[195]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-195)[[196]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-196) | India | 221 MW | Apr 2012 | Asia's largest solar park |
| [Agua Caliente, Arizona](https://en.wikipedia.org/wiki/Agua_Caliente_Solar_Project)[[197]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Agua_Caliente-197) | USA | 290 MW[AC](https://en.wikipedia.org/wiki/Watt-peak_AC) | Jul 2012 | Formerly world's largest solar plant |
| [Neuhardenberg, Brandenburg](https://en.wikipedia.org/wiki/Neuhardenberg_Solar_Park)[[35]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Neuhardenberg-35) | Germany | 145 MW | Sep 2012 | Becomes Europe's largest solar cluster |
| [Greenhough River, Western Australia](https://en.wikipedia.org/wiki/Greenough_River_Solar_Farm),[[198]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Greenough-198) | Australia | 10 MW | Oct 2012 | Australasia's first 10 MW+ plant |
| Majes and Repartición | Peru | 22 MW | Oct 2012 | First utility-scale plants in South America[[199]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-199)[[200]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-200) |
| [Westmill Solar Park](https://en.wikipedia.org/wiki/Westmill_Solar_Park), Oxfordshire[[82]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-WSC-82) | United Kingdom | 5 MW | Oct 2012 | Acquired by [Westmill Solar Co-operative](https://en.wikipedia.org/wiki/Westmill_Solar_Co-operative) to become world's largest community-owned solar power station[[83]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Westmill-83) |
| San Miguel Power, Colorado | USA | 1.1 MW | Dec 2012 | Biggest community-owned plant in USA[[201]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-201) |
| Sheikh Zayed, [Nouakchott](https://en.wikipedia.org/wiki/Nouakchott)[[202]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-202) | Mauritania | 15 MW | Apr 2013 | Largest solar power plant in Africa[[203]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-203) |
| [Topaz](https://en.wikipedia.org/wiki/Topaz_Solar_Farm),[[4]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-Topaz-4) Riverside County, California | USA | 550 MW[AC](https://en.wikipedia.org/wiki/Watt-peak_AC) | Nov 2013 | Formerly the world's largest solar park[[204]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-204) |
| Amanacer, [Copiapó](https://en.wikipedia.org/wiki/Copiap%C3%B3), [Atacama](https://en.wikipedia.org/wiki/Atacama) | Chile | 93.7 MW | Jan 2014 | Formerly largest plant in South America[[205]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-205) |
| Jasper, [Postmasburg](https://en.wikipedia.org/wiki/Postmasburg), [Northern Cape](https://en.wikipedia.org/wiki/Northern_Cape) | South Africa | 88 MW | Nov 2014 | Largest plant in Africa |
| Longyangxia PV/Hydro power project, [Gonghe](https://en.wikipedia.org/wiki/Gonghe), [Qinghai](https://en.wikipedia.org/wiki/Qinghai) | China | 850 MWP | Dec 2014 | Phase II of 530 MW added to 320 MW Phase I (2013)[[206]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-206) makes this the world's largest solar power station |
| Nyngan, [New South Wales](https://en.wikipedia.org/wiki/New_South_Wales) | Australia | 102 MW | Jun 2015 | Becomes largest plant in Australasia and Oceania |
| [Solar Star](https://en.wikipedia.org/wiki/Solar_Star),[[207]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-207) Los Angeles County, California | USA | 579 MW[AC](https://en.wikipedia.org/wiki/Watt-peak_AC) | Jun 2015 | Becomes the [world's largest solar farm](https://en.wikipedia.org/wiki/List_of_photovoltaic_power_stations#World.27s_largest_photovoltaic_power_stations) installation project (Longyanxia having been constructed in two phases) |
| Cestas, [Aquitaine](https://en.wikipedia.org/wiki/Aquitaine) | France | 300 MW | Dec 2015 | Largest PV plant in Europe[[208]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-208) |
| Finis Terrae, María Elena, [Tocopilla](https://en.wikipedia.org/wiki/Tocopilla) | Chile | 138 MWAC | May 2016 | Becomes largest plant in South America[[209]](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_note-209) |

Solar power plants under development are not included here, but may be on [this list](https://en.wikipedia.org/wiki/List_of_photovoltaic_power_stations#Large_systems_under_construction_or_in_planning).

See also[[edit](https://en.wikipedia.org/w/index.php?title=Photovoltaic_power_station&action=edit&section=39" \o "Edit section: See also)]

|  |  |
| --- | --- |
| * [Growth of photovoltaics](https://en.wikipedia.org/wiki/Growth_of_photovoltaics) * [List of photovoltaic power stations](https://en.wikipedia.org/wiki/List_of_photovoltaic_power_stations) * [List of monitored photovoltaic power stations](https://en.wikipedia.org/wiki/List_of_monitored_photovoltaic_power_stations) * [List of photovoltaics companies](https://en.wikipedia.org/wiki/List_of_photovoltaics_companies) * [List of solar cell manufacturers](https://en.wikipedia.org/wiki/List_of_solar_cell_manufacturers) | * ***[icon](https://en.wikipedia.org/wiki/File:Crystal_energy.svg)***[***Energy portal***](https://en.wikipedia.org/wiki/Portal:Energy) * ***[icon](https://en.wikipedia.org/wiki/File:Wind-turbine-icon.svg)***[***Renewable energy portal***](https://en.wikipedia.org/wiki/Portal:Renewable_energy) * [Photovoltaics](https://en.wikipedia.org/wiki/Photovoltaics) * [Photovoltaic system](https://en.wikipedia.org/wiki/Photovoltaic_system) * [Solar energy](https://en.wikipedia.org/wiki/Solar_energy) * [Solar power by country](https://en.wikipedia.org/wiki/Solar_power_by_country) * [Theory of solar cell](https://en.wikipedia.org/wiki/Theory_of_solar_cell) |

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  2. ^ [Jump up to:***a***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Lugo_2-0) [***b***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Lugo_2-1) [***c***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Lugo_2-2) *Arnett, J.C.; Schaffer, L. A.; Rumberg, J. P.; Tolbert, R. E. L.; et al. (1984). "Design, installation and performance of the ARCO Solar one-megawatt power plant". Proceedings of the Fifth International Conference, Athens, Greece. EC Photovoltaic Solar Energy Conference: 314.*[*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:[1984pvse.conf..314A](http://adsabs.harvard.edu/abs/1984pvse.conf..314A).*
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  7. ^ [Jump up to:***a***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Wiki-Germany_7-0) [***b***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Wiki-Germany_7-1) [*"Solar parks map - Germany"*](http://www.wiki-solar.org/map/country/index.html?Germany?u-uN-DE)*. Wiki-Solar. Retrieved 5 March 2015.*
  8. ^ [Jump up to:***a***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Spain_map_8-0) [***b***](https://en.wikipedia.org/wiki/Photovoltaic_power_station#cite_ref-Spain_map_8-1) [*"Solar parks map - Spain"*](http://www.wiki-solar.org/map/country/index.html?Spain?u-uW-ES)*. Wiki-Solar. Retrieved 13 April 2013.*
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