The Labarde solar power plant sited in the Bordeaux conurbation (France), has 59 MW of installed capacity, making it Europe's largest urban solar farm.

JPEE

195 413.2 MW

Cumulative photovoltaic capacity in the European Union in 2022

PHOTOVOLTAIC BAROMETER

A study carried out by EurObserv'ER.

Solar photovoltaic energy is keeping its shine. Initial assessments of the net maximum capacity connected to grids worldwide in the twelve months to the end of 2022 indicate at least 191.5 GWac (ac for alternative current), which would take global capacity up to 1 046.6 GWAC. The expansion of industrial module and electrochemical storage manufacturing capacities is hastening solarization of the global electricity mix. The European Union, having connected at least 32.8 GWac of net maximum capacity in 2022 and 195.4 GWac of capacity to date, is eyeing new heights. Its combined solar power output of 205.2 TWh, boosted by the record sunshine levels of 2022, increased by 29.6% (by 46.9 TWh) on its 2021 performance.

205.2 TWh

Photovoltaic electricity generated in the EU during the year 2022

32 818.6 MW

Photovoltaic capacity installed in the EU during the year 2022

Not so long ago, yearly global photovoltaic capacity increases were in the range of a few tens of MW. The visionary American columnist Paul Maycock, editor of **PV News**, a monthly newsletter set up in 1981 to track global photovoltaic production and its markets, put the figure at 90 MW in 1996… whose use broke down as 43 MW in decentralized industrial applications (telephony, GPS systems, etc.), 22 MW in assorted consumer goods (calculators, solar watches, battery chargers, and so on), 15 MW in systems used in developing countries for decentralized rural electrification projects (solar lamps, solar refrigerators, solar pumps for market gardening) and only 10 MW in grid-connected systems, strongly shored up by the rollout of Japan's scheme to install 70 000 solar roofs in 1994. Shortly afterwards, and thanks to the American Million Solar Roofs Initiative (goal for 2010) rolled out in June 1997, grid-connected systems were soon to take on the mantle of main driver of global growth. Hard on its heels came Germany's 100 000 solar roofs programme that kicked off on 1 January 1999 and achieved its goal in just under 4 years. Twenty-three years later, solar photovoltaic technology (alongside the other clean technologies such as wind energy, biogas, heat pumps, electrolysers, lithium, and sodium batteries, and EVs) has become one of the main "game changers" of the global electricity system. Fatih Birol, Executive Director of the **International Energy Agency** (IEA) recently recalled this observation in an opinion piece published in the Financial Times on 13 April 2023 entitled, "Clean energy is moving faster than you think". He used this column to declare that over the past two years, global deployment of solar power has been fast enough to align fully with the rate envisaged in the IEA's ambitious pathway to net zero emissions by 2050. He also explains that inertia is a powerful force in energy systems and a key challenge for efforts to transition economies to clean energy and tackle climate change, but that the ongoing energy security crisis has demonstrated how shocks can shake systems out of inertia. Russia's efforts to gain political and economic advantage by pushing energy prices higher have spurred a major response by governments — not just in the EU but in many countries around the world — to expedite the deployment of cleaner and more secure alternatives. He believes that the effects of all this are becoming clearer by the day. Six months ago, the IEA showed that the repercussions of the war in Ukraine were reshaping the future of global energy, with fossil fuel demand clearly peaking for the first time and set to happen before this decade draws to a close.

A floating power plant at Peyrolles-en-Provence, Bouches-du-Rhône with 12 MW of capacity. It is placed on the site of a disused water of an abandoned gravel quarry. This 12-hectare power plant, with its 43 000 photovoltaic panels is anchored to the bottom of the lake.

BORALEX

GLOBAL CAPACITY CROSSED THE TERAWATT THRESHOLD IN 2022

A few figures can demonstrate that changes to the global electricity system are picking up speed and that solar energy appears to be leading the way. On the basis of the international organizations' reports, **IRENA**, the International Renewable Energy Agency, asserts that global solar photovoltaic installed capacity to date starting from its 855.2 GWac level in 2021 had passed the one terawatt (TW) threshold (1 046.6 GWac) by the end of 2022. More than half of this capacity is based in Asia (57% in 2022), 21.5% in Europe, 11.9% in North America and 9.5% elsewhere in the world. Thus, 191.5 GWac was added between 2021 and 2022… a 35.5% year-on-year increase (from 141.2 GWac in 2021). Asia installed 58.5% of the additional global solar photovoltaic capacity, Europe 19.7%, and North America 10.1%. The world's other regions added 11.8% of the capacity – South America (6.3%), Oceania including

Table No. 1

Installed and cumulated solar photovoltaic capacity* in the European Union at the end of 2022 (MW)**

	2021 cumulated	2022 cumulated	Installed during the year 2022
Germany	60 108.0	67 399.0	7 304.0
Italy	22 594.3	25 060.0	2 490.0
Netherlands	14 910.7	18 849.0	3 938.3
Spain	13 715.2	17 195.0	3 480.2
France	14 810.4	17 168.9	2 385.0
Poland	7 415.5	12 189.1	4 773.6
Belgium	6 012.4	6 490.0	477.6
Greece	4 277.4	5 270.0	992.6
Hungary	2 968.0	4 056.0	1 088.0
Austria	2 782.6	3 791.7	1 009.1
Denmark	1 704.0	3 069.9	1 365.9
Portugal	1 701.0	2 563.0	868.0
Czechia	2 246.1	2 535.0	288.9
Sweden	1 600.7	2 404.5	803.8
Bulgaria	1 274.7	1 726.0	451.3
Romania	1 393.9	1 414.0	20.1
Slovenia	461.2	632.0	170.8
Finland	425.0	591.0	166.0
Lithuania	255.0	572.0	317.0
Slovakia***	537.0	537.0	0.0
Estonia	394.8	506.0	111.2
Cyprus	314.5	464.0	149.5
Luxembourg	276.0	317.0	41.0
Malta***	205.7	205.7	0.0
Croatia	138.3	182.0	43.7
Ireland	135.3	169.5	34.2
Latvia	7.2	56.0	48.8
Total EU 27	**162 664.8**	**195 413.2**	**32 818.6**

** Net maximum electrical capacity, off-grid included. ** Estimation. Note: 6 MW decommissioned in Portugal, 26.5 MW in France, 24.3 MW in Italy, 13 MW in Germany, 0.5 MW in Spain.*
**** national data not available. IRENA source used.* ***Sources: EurObserv'ER 2023***

Australia (2.1%), the Middle East (1.7%), Eurasia including Russia and Turkey (1%), Africa (0.5%) and Central America and the Caribbean (0.2%).
Incidentally, the net electrical maximum capacity (NEMC), in alternative current, is the indicator used by the official national and international statistical bodies such as Eurostat and the IEA, to compare the various production sectors' electrical capacity trends. The net maximum electrical capacity refers to the maximum amount of electricity which can be produced in a year for one given resource; assuming that all plants produce electricity at maximum capacity 24h/24h 365 days per year. It differs from the nominal rating of direct current photovoltaic panels (also expressed as peak watts) which expresses the theoretical maximum output capacity of PV installations. The NEMC indicator expressed in alternating current, makes allowance for the capacity lost when converting direct current into alternating current and the regulations that limit photovoltaic installations' output capacity to the grid. It offers the advantage of being in phase with actual electricity production.
Direct current nominal rating indicators (GWdc or GWp), tend to be used by manufacturers and professional associations such as SolarPower Europe and certain international organizations such as the IEA PVPS. By way of comparison, the latter's publication, "Snapshot of Global PV market 2023", puts aggregate global capacity in the region of 1 185 GWp with 240 GWp of new systems installed (of which China is responsible for 106 GWp) compared to 175 GWp of new systems installed in 2021 (of which China can lay claim to 54.9 GWp). There are no international standards for converting direct current solar capacity into inverter output capacity. The IEA PVPS pitches the AC-DC ratio of most of the large-scale power plants constructed in 2022 between 1.1 and 1.6. It also points out that some grid regulations restrict power injections to 70% of the peak capacity of recently installed residential photovoltaic systems.

Table No. 2

Gross electricity production from solar photovoltaic in the European Union countries in 2021 and 2022* (in TWh)

	2021	2022
Germany	49.340	60.787
Spain	21.992	29.617
Italy	25.039	28.100
France	15.732	20.607
Netherlands	11.495	17.650
Poland	3.934	8.008
Belgium	5.618	7.062
Greece	5.251	7.047
Hungary	3.796	4.649
Austria	2.783	3.791
Portugal	2.237	3.471
Czechia	2.316	2.614
Denmark	1.309	2.181
Bulgaria	1.467	2.023
Sweden	1.120	1.963
Romania	1.703	1.772
Slovakia	0.671	0.700
Slovenia	0.453	0.601
Cyprus	0.468	0.506
Estonia	0.354	0.506
Finland	0.298	0.381
Lithuania	0.191	0.317
Malta	0.256	0.267
Luxembourg	0.180	0.208
Croatia	0.149	0.192
Ireland	0.093	0.108
Latvia	0.007	0.027
Total EU 27	158.252	205.156

** Estimation. Note: For Sweden, 2021 data has been consolidated by Statistics Sweden, now with a monthly production figure of what has entered the grid and model that calculates self-consumption.*
Source: EurObserv'ER 2023

CHINA'S UNSTOPPABLE DEVELOPMENT OF SOLAR ENERGY

In 2022, China stepped up its solar photovoltaic installation efforts. The **NEA** (National Energy Administration) press release of 17 February 2022 claims that China connected 87.4 GWac of new capacity to the grid (59.3% more than in 2021) ... centralized photovoltaic adding 36.3 GWac (41.8% more than in 2021) and distributed solar capacity adding 51.1 GWac (74.5% more over the twelve-month period). These new installations take the cumulated solar photovoltaic capacity connected to China's grid to 392 GWac (234.4 GWac centralized and 157.6 GWac distributed). By way of reminder, the term "centralized solar" covers large-scale ground-based PV energy production systems, while "distributed solar" covers photovoltaic energy generating systems on industrial factory and residential roofs. The **China Electricity Council** (CEC) analysis and forecast report on the electricity supply and demand situation for 2023, concludes that by the end of the year, its grid-connected solar energy capacity will reach 490 GW and for the first time, will exceed national hydropower capacity. The **China Photovoltaic Industry Association** (CPIA) suggests that solar energy capacity in China could post 95–120 GW of growth in 2023. The association hints that the market's growth is fettered by a few obstacles

Athos III solar + storage project, also known as Blythe Mesa, was fully commissioned in Q4 2022. Intersect Power developed this Californian 224 MW solar + 112 MW/448 MWh storage project.

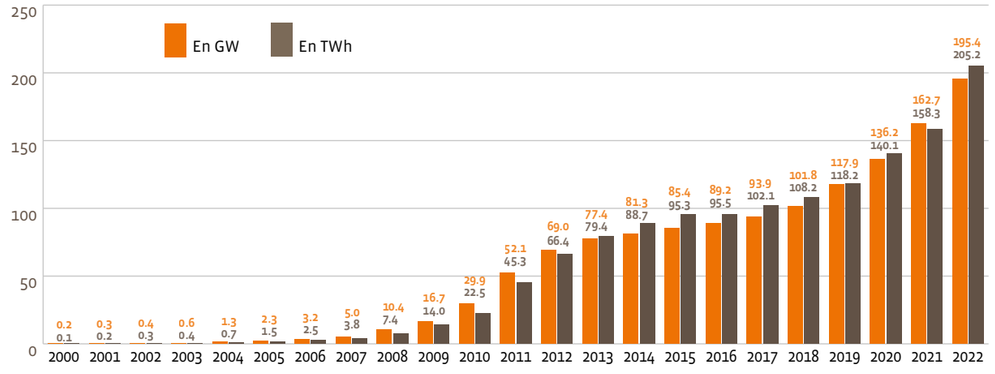
such as the obligation imposed by several local governments to install energy storage facilities by the solar farms, and restrictions on the use of land and water as part of Beijing's increasing efforts to protect farming land. These constraints are responsible for the build-up of the stationary storage market in China. The NEA claims that the installed capacity of new types of stationary energy storage projects in service rose to 8.7 GW in 2022, namely a 100% increase on the 2021 level. As for output, the NEA has indicated that for the first time, China's wind energy and solar photovoltaic production, making no distinction between them, exceeded 1 000 billion kWh, to reach 1 190 billion kWh (i.e., 1 190 TWh) ... a 207.3-TWh year-on-year increase (annual growth of 21%). Bloomberg's reckons that the country now produces almost enough solar and wind power to cover every Chinese household's demand.

THE SOLAR AND STORAGE TANDEM MAKES STRONG HEADWAY IN THE US

IRENA, which draws its findings from preliminary official estimates, reports that the US installed 17.6 GWac of additional NMC in 2022 (19.2 GWac was added in 2021, i.e., a year-on-year fall of 8.3%) which takes the United States' aggregate solar photovoltaic capacity to 111.5 GWac. For the reasons given earlier, these figures do not match those of the **Solar Energy Industry association**,

Graph No. 1

Evolution of photovoltaic capacity installed* (in GW) and gross photovoltaic electricity production (in TWh) from 2000 to 2022 in the EU 27**



** Net maximum electrical capacity. ** Estimation.* ***Sources : Years 2000-2020 (Eurostat), Year 2021 and 2022 (EurObserv'ER).***

which in its annual report puts the additional installed capacity for 2022 at 20.2 GWdc (a 16% year-on-year fall), resulting in a cumulated total of 142.3 GWdc at the end of 2022. The SEAI claims that solar energy accounted for 50% of all the new electricity generating capacity of the United States in 2022. Residential solar energy enjoyed a record year with almost 6 GWdc of installations, amounting to annual growth of 40%, while the other market segments declined because of major supply chain issues. Utility scale solar energy in particular, fell by 31% on the previous year's level. Despite these problems, the passing of the Inflation Reduction Act (IRA) created a significant rise in the long-term solar forecasts by guaranteeing manufacturers 15 years of visibility. The SEAI believes that the United States' solar industry will grow to five times its current size over the upcoming decade, with a total solar fleet of over 700 GWdc by 2033.

Another factor is the expansion of stationary storage – Utility-scale Battery storage – in the United States. The **American Clean Power Association's** Q4 report claims that 4 027 MW of these systems were installed in 2022 across 88 projects (48 coupled with solar or wind power, and 40 standalone systems) giving a combined total of 9 054 MW (for 25 195 GWh of storage capacity). The Crimson Battery Storage project, part of the Crimson Solar + Recurrent Energy Storage project, was the biggest battery storage project to be commissioned in 2022 in MW and MWh capacity terms. This 350-MW lithium-ion battery system offers four hours of storage and 1 400 MWh of total energy storage capacity. The capacity of hybrid solar-storage systems is surging. The connection figures for 2022 were 10 230 MW of fully connected hybrid solar-storage projects, 2 740 MW of partly connected projects and 30 276 MW awaiting approval (for a total of 43 245 MW of hybrid solar-storage projects). A case in point is the Athos III solar + storage project, also known as Blythe Mesa, which was fully commissioned in Q4 2022. Intersect Power developed this Californian 224 MW solar + 112 MW/448 MWh storage project. What is more, Terra-Gen is currently constructing the world's biggest solar plus storage project, the Edwards & Sanborn Solar and Energy Storage project to be equipped with 1 118 MW of solar photovoltaic capacity and 2 165 MWh of energy storage capacity in 2023.

The 3rd, 4th, and 5th places in the rankings (Japan with 78.8 GWac, Germany with 67.4 GWac and India with 62.8 GWac respectively) should rapidly change given the positive dynamics of India's market, which currently stands in 5th place for aggregate installed capacity. IRENA reports that India added 13.5 GWac of connected NMC in 2022, compared to Japan's 4.6 GWac and Germany's 7.3 GWac (quoting AGEE-Stat, see below). Consultants JMK Research reckons that India could add 16.8 GW of capacity in 2023, divided between 14 GW of ground-based solar farms and 2.8 GW of solar roofs.

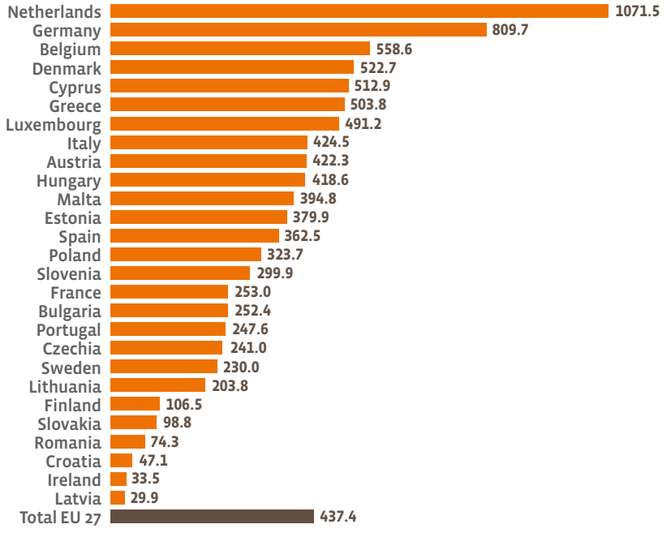
THE EU UNLEASHES ITS SOLAR ENERGY POTENTIAL

Solar energy enjoyed a good year in the European Union, as 2022 was perhaps the first year that the European solar photovoltaic sector fully realized its potential. The EurObserv'ER assessment, based on the initial official estimates available (listed at the end of this barometer), is that the European Union installed 32.8 GW over the calendar year, which, once allowance for decommissioned capacity is made, brings the connected NEMC to 195.4 GWac. There was a sharp year-on-year increase in the amount of capacity connected (32.7 GW between 2022 and 2021 to 26.5 GW between 2021 and 2020), equating to a 23.6% increase. As for the 2022 rankings, Germany still leads the field with 7.3 GW connected, followed by Poland with 4.8 GW, the Netherlands with 3.9 GW and Spain with 3.5 GW, chased by Italy (2.5 GW) and France (2.4 GW). Three other countries connected more than one GW of capacity – Denmark (1.4 GW), Hungary (1.1 GW) and Austria (1 GW). Most of the Member States are actively pursuing installation drives now that Russia's war of aggression has spurred them into action.

The European market's performance has been lifted by several factors. Firstly, high wholesale electricity prices have boosted the financial appeal of solar power, despite the hike in solar energy

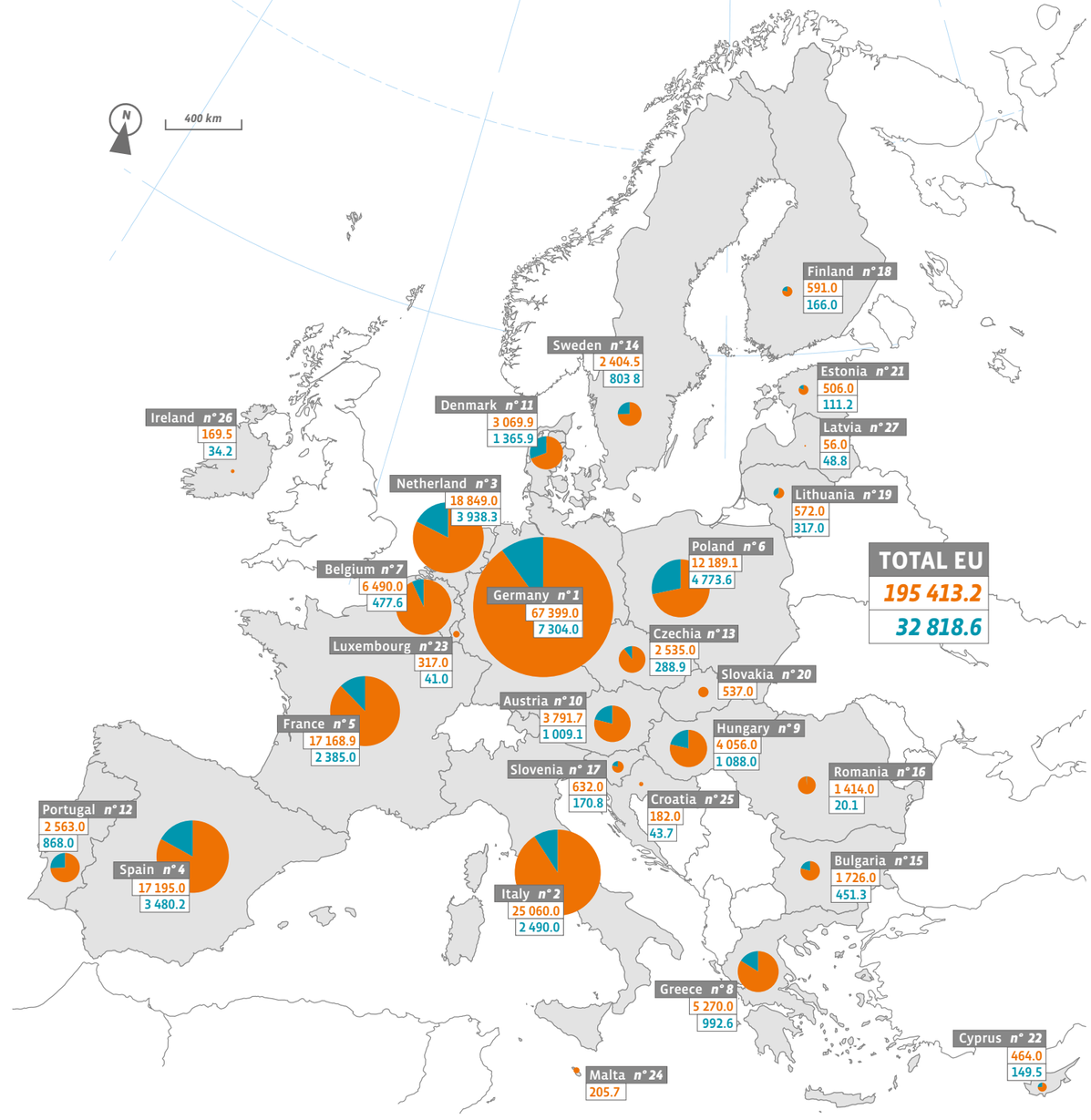
Graph No. 2

Photovoltaic capacity per inhabitant (W/inhab.) for each EU country in 2022



** Estimation.* ***Source: EurObserv'ER 2023.***

Installed and cumulated solar photovoltaic capacity* in the European Union at the end of 2022** (MW)



Key

195 413.2 Cumulated photovoltaic capacity in the EU 27 at the end of 2022 (in MW)

32 818.6 Photovoltaic capacity installed in the EU 27 countries during the year 2022 (MW)

** Net maximum electrical capacity, off-grid included. ** Estimation.*
Note : 6 MW decommissioned in Portugal, 26.5 MW in France, 24.3 MW in Italy, 13 MW in Germany, 0.5 MW in Spain. ***Source: EurObserv'ER 2023.***

The Compagnie nationale du Rhône (CNR) has commissioned a demonstrator with vertical bifacial modules on the Sablons dyke (Isère). It is deployed over 350 metres with 104 kW of installed capacity. These 3-metre high panels are more resilient and watertight than classic ground-based PV panels.

production costs. Solar energy's surge can also be attributed to geopolitical tensions vis-à-vis Russia, by persuading the Europeans to set up a major solar component in the REPowerEU plan to terminate the EU's reliance on Russian fossil fuels. Perceptions of solar photovoltaic energy have also changed. The sector is viewed as having extremely fast deployment capabilities, whose speed in reducing dependency on Russian fossil fuels is unequalled. Furthermore, the supply chain bottlenecks stemming from COVID-19 pandemic-related restrictions that plagued demand in 2021 are no longer so penalizing.

RECORD SUNSHINE DURATION AND PV ELECTRICITY PRODUCTION IN THE EU

The European State of the Climate (ESOTC 2022) annual report compiled by the Copernicus Programme confirms that Europe experienced its highest recorded sunshine duration (over 40 years) with 130 more sunshine hours than average (compared to 31 more sunshine hours than average in 2021). This record indicates a marked trend toward longer sunshine duration. Over the past 8 years, 5 have had 100 more sunshine hours than average and none have had fewer than average sunshine hours. We need to turn the clock back ten years (2013) to the last (slightly) lower than average sunshine duration. This record sunshine duration, coupled with the record amount of capacity installed in Europe, has led to solar electricity production records in the EU. The EurObserv'ER assessment, based on available initial official estimates is that solar photovoltaic electricity output increased by 29.6% between 2021 and 2022 to reach 205.2 TWh, which is 46.9 TWh more than in 2021. The vast majority of EU countries enjoyed double-digit

Table No. 3

Projects of expansion and creation of photovoltaic solar production capacities announced by European companies* by 2025

	Solar polysilicon	Ingot and wafer	Solar cell	Solar module
Wacker	53 GW by 2025 (+25.4)	–	–	–
NorSun	–	5 GW by 2025 (+4) (Ingot and wafer)	–	–
Norweigan Crystal	–	4.1 GW by 2025 (+3.6) (Ingot)	–	–
Nexwafe	–	3 GW by 2025 (+2.8) (wafer)	–	–
Meyer Burger	–	–	4.2 GW by 2025 (+3.8)	4.1 GW by 2025 (+3.8)
Enel	–	–	3 GW by 2024 (+2.8)	3 GW by 2024 (+2.8)
Oxford PV	–	–	2 GW by 2024 (+1.8)	2 GW by 2024 (+1.8)
Valoe	–	–	0.1 GW by 2024 (+0.1)	–
Voltec Solar	–	–	–	0.5 GW by 2023 (+0.3)
SoliTek	–	–	–	0.6 GW by 2023/2024 (+0.4)
SolarWatt	–	–	–	2 GW by 2023 (+1.7)
FuturaSun	–	–	–	1 GW by 2023 (+1)
CARBON**	–	5 GW by 2025 (+5) (Ingot and wafer)	5 GW by 2025 (+5)	3.5 GW by 2025 (+3.5)
AstraSun Solar**	–	1.8 GW by 2025 (+1.8) (Ingot and wafer)	1.8 GW by 2025 (+1.8)	3.5 GW by 2025 (+3.5)
MCPV**	–	–	5 GW by 2025 (+5)	5 GW by 2025 (+5)

** No exhaustive list. **Start-up.* ***Sources: According Fraunhofer Institute for Solar Energy Systems ISE ; Intersolar Europe 2022***

In March 2023, a self-consumption roof-mounted power plant went on stream on the University of Grenoble campus. It is installed on the roof of the GreEn-ER building, that accommodates an engineering school and a research laboratory. This 195-kW power plant will cover 10–15% of the building's electricity demand (23 000 m² and 2 000 occupants).

production increases. Poland, which sharply increased its production capacities in 2021 and 2022, went so far as to double its production within the space of a year. The solar PV share of total gross electricity output is gradually increasing in the EU countries. If we factor in the number of inhabitants in the Netherlands, which is the most solarized country of Europe, solar photovoltaic accounted for 15% of the country's electricity output in 2022 (9.4% in 2021) according to Statistics Netherlands… a European and global record. The solar power share exceeded 10% in Germany (10.5% in 2022, compared to 8.4% in 2021 according to the AGEB (AG Energiebilanzen). It increased to 13.1% in Hungary according to the MEKH (10.6% in 2021). EurObserv'ER reckons that the PV component should be about 10.8% for Spain (9.9% in 2021) and 12.8% for Greece (9.6% in 2021).

THE NETHERLANDS AND GERMANY LEAD THE WAY

Germany targets 215 GW in 2030

Germany has always been forward-rather than backward-looking when it comes to solar power. According to AGEE-Stat, it connected an impressive 7.3 GW in 2022 (6.4 GW in 2021) which took the country's net connected capacity to 67.4 GW at the end of 2022. It accounts for more than a third (34.5%) of the installed capacity and 22.3% of total connected capacity of the European Union. Its 2023 installation pace will be even faster, for in the first three months an increase in connected capacity can be seen. The online Energy-chart monitoring tool set up by the Fraunhofer ISE records that Germany connected 2.7 GW including almost 1 GW (943.7 MW) in March alone. In the first quarter, Germany had installed just over 2 GW, with 842.4 MW installed in March. On 6 April 2022, the government announced that it was raising its clean energy target to 80% of the electricity mix from 2030 onwards from the previous 65%, and a share approaching 100% in 2035. That implies that a minimum of 600 terawatt-hours per annum must be generated from renewable energies by that timeline. The publication of the

new renewable energy law, which came into force on 1 July 2022, was brought forward because of Russia's invasion of Ukraine. Robert Habeck, Federal Minister for Economic Affairs and Climate Action said: "It is the largest energy policy revision for decades." The law contains a clause that identifies renewable energies as being in the interest of public security. Tenders, which were sometimes under-subscribed in previous years, will be significantly increased. For solar photovoltaic, they will rise from about 6 GW in 2022 to 22 GW per annum from 2026 onwards through to at least 2035. At this pace, the country's photovoltaic capacity should rise to at least 215 GW by the end of the decade. As for bids for tenders, the last tender published in March 2023 was heavily oversubscribed with 2.9 GW of bids presented for a volume of 1.95 GW. The average value assignment has increased. It reached 7.03 euro cents per kWh (the lowest evaluated bid was for 5.29 euro cents per kWh and the highest for 7.30 euro cents per kWh) with the tender price capped at 7.37 euro cents per kWh. The mean price observed has risen sharply from the two previous bids of 2022 (5.80 euro cents per kWh for the 1 November bid and 5.51 euro cents per kWh for that of 1 June). These increases have been caused by module price hikes and the higher cost of capital, which has risen 2–3 points because of higher interest rates. Another reality affecting the German market is the upturn in the solar energy storage battery market. According to BSW Solar (the German solar energy association), 214 000 new batteries were installed during 2022 (141 000 in 2021 and 88 000 in 2020) taking the total battery fleet to 627 000. Another photovoltaic growth vector should be the future law, currently being drafted, banning sales of gas boilers from 2024 onwards, which should boost sales of systems combining HPs, PV panels and storage systems.

The Netherlands removes VAT on residential photovoltaic panels

The Netherlands should be viewed as a textbook case for gauging solar power's potential for development in a country's electricity mix. Although solar power accounted for less than 1% of the Dutch electricity mix in 2014 (a 0.61% share of total gross electricity output), its share was 15% in 2022 (source: Statistics Netherlands). This rapid increase in production can be correlated to that of installed capacity, as connected capacity has risen from 1 GW in 2014 to 18.8 GW at the end of 2022 (11.6 GW between 2019 and 2022). The number of solar systems installed in the Netherlands was put at more than 1.7 million in 2021 by Statistics Netherlands and in view of market growth, is set to exceed 2 million in 2022, which is fairly high for a country of 17.6 million inhabitants. By way of comparison, at the end of 2022, Germany had 2.65 million installations for 83.2 million inhabitants according to the BSW. Hence, the Netherlands leads the installed capacity rankings and is the first country to have a per capita solar capacity level of more than one kW (1.1 kW in 2022), ahead of Germany (0.8 kW) and Belgium (0.6 kW). The main solar photovoltaic drivers in the Netherlands are firstly, the net invoicing system for the residential and small business segments, and secondly, the SDE+ tendering system in the large power plant and major commercial systems segments, where solar photovoltaic competes with other renewable energy sources. SolarPower Europe feels that the Netherlands' market could be bigger, but at least 12 GW of projects are held back, facing challenges to secure connections and sites. The Dutch government, as authorized by European legislation, took another major step when it cut the value-added tax applied to photovoltaic systems used in residential applications from 21% to 0% starting on 1 January 2023. By the way, the Netherlands was a champion of the European Commission's decision to permit this kind of tax exemption.

Vattenfall's Haringvliet energy park in the Netherlands went on stream on 23 March 2022. It is a hybrid power plant that combines wind, solar power and battery storage.

NEW CAPACITIES TO MEET GLOBAL DEMAND

IRENA's latest publication, "World Energy Transitions Outlook", forecasts that in a 1.5 °C scenario, cumulated solar photovoltaic capacity should rise above 14 000 GW by 2050 (it was just over 1 046 GW at the end of 2022). This capacity should be added to over 8 100 GW of onshore and offshore wind energy output by the same timeline, along with other renewable energy contributions such as hydropower, biomass, geothermal energy, concentrated solar power (CSP) and ocean energies. Thus, the development potential of the global industrial sector for the PV component is still very high with the American, Indian, and even European players set on making up for lost time, while China's industry is ideally positioned to meet global demand. The Chinese players realized over a decade ago, that the photovoltaic market was more a volume market than a high technology market. It is the gigantic size of its plants, the construction of gigafactories, that has enabled China's industry to dominate the global market, with generous support from China's state banks, acting as the armed wings of the country's industrial policy, that have facilitated access to investments, and through the vertical integration of its industry (from silicon to module).

The declared goal of the other major industrial nations – the United States, India, Europe, and Japan – is to break this dependency on China in an increasingly tense geopolitical context. It is now accepted that solar power will have a central role to play. China remains the world's main photovoltaic powerhouse while this readjustment is underway. According to Ministry of Industry and Information Technology data, quoted in the **Economic Daily**, national production in 2022 of polysilicon, silicon wafers, cells and modules reached 827 000 metric tons, 357 GW, 318 GW and 288.7 GW respectively and this year, the photovoltaic industry's total output value will exceed 1 400 billion yuan (183.5 billion euros or >202 billion dollars). The same source claims that in 2022, China exported more than 51.2 billion dollars' worth of photovoltaic products... an annual increase of >80%. In volume terms, 153.6 GW of photovoltaic modules, 36.3 GW of silicon wafers and 23.8 GW of solar cells were exported. These increases have been achieved in quantity and quality with mass production of very high yield cells, be they P-type PERC, N-type TOPCon (tunnel oxide passivated contacts) or heterojunction cells. The Chinese companies have accelerated their investments. LONGi the solar panel manufacturer, for instance, has announced a 45-billion yuan project (6 billion euros) to construct a production facility with annual design capacity of 100 GW of silicon wafers and 50 GW of solar cells. This new site, which will be the world's biggest solar production facility, should come on stream during Q3 of 2024. The company aimed to increase its manufacturing capacity to 150 GW of silicon wafers by the end of 2022 compared to 105 GW at the end of 2021, 85 GW of modules (60 GW at the end of 2021) and 60 GW of cells (37 GW at the end of 2021). Another example is JA Solar, which announced a low-carbon industrial park project for a complete photovoltaic chain at Ordos, Inner Mongolia, for a 40-billion yuan investment. The site is intended to fully integrate the value chain including the production of 100 000–150 000 tons of silicon, 20 GW of ingots (and silicon wafers), 30 GW of solar cells and 10 GW of solar modules. TCL Zhonghuan, the silicon wafer market leader, has also announced a project to construct a 35-GW ultra-thin monocrystalline silicon wafer plant, and a 25-GW N-type TOPCon cell manufacturing plant for an investment of 4.1 billion yuan, which should come on stream during Q4 of 2023. TCL also intends to increase its silicon wafer production capacity to 180 GW by the end of 2023, after increasing it by 59% between 2021 and 2022 to 140 GW. The additional 40 GW will be provided when its Ningxia Phase VI plant comes on stream at the end of the year. TCL reported sales worth 67 billion RMB (9.75 billion dollars) with a net 6.8 billion RMB (1 billion dollars) profit attributable to the parent company. According to AECEA (Asia Europe Clean Energy Advisory), China's total annual solar cell and module production capacity could rise from 361 GW to 600 GW in the 12 months

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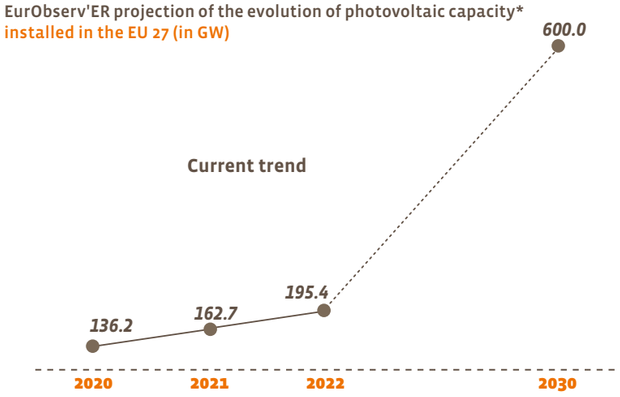
TSE/JULIEN BRU STUDIO

In 2022, TSE, the independent solar energy producer, inaugurated its first agrivoltaic demonstrator on field crops at Amance, in the Haute-Saône. The project is integrated at the heart of an 850-hectare farm. The canopy covers 3 hectares of crops including : soya, wheat, forage rye, winter barley and rapeseed with 2.4 MW of generating capacity.

to the end of 2022.
India's ambitions for its solar power sector are to be self-sufficient for its internal demand and also to take a share of the global market. A report by the Institute for Energy Economics and Financial Analysis and JMK Research forecasts that India should achieve manufacturing capacity for 110 GW of PV modules by 2026, along with 59 GW for cells, 56 GW for ingots/wafers and 38 GW for polycrystalline silicon. In the 12 months to March 2023, India's module manufacturing capacity rose from 18 to 38 GW. The "PLI" (Production-Linked Incentive scheme), an industrial investment programme set up in November 2020 under the Atmanirbhar Bharat ('Self-Reliant India') programme, awards subsidies to Indian productions in ten or more sectors viewed as strategic including photovoltaic and electrochemical batteries and has galvanized India's manufacturers into action. On the demand side, the government has drawn up a Ministry of New and Renewable Energy (MNRE) Approved List of Models and Manufacturers of photovoltaic modules and cells that can be used for Indian solar projects. Since March 2022, the ALMM no longer features a single foreign manufacturer, and a year later, listed >70 domestic manufacturers with a total of 22.4 GW of manufacturing capacity.
In the United States, the Inflation Reduction Act (IRA), adopted by the Biden administration last summer, will also create breathing space for solar photovoltaic investors. PV Magazine International, holds that two of the IRA flagship measures are likely to be game-changing for equipment manufacturers. The first refers to advanced manufacturing production credit – AMPC, eligible to RES equipment manufacturers for manufacturing in the USA. The second measure refers to the advantages awarded to American renewable energy project developers so that they buy American equipment, coupled with additional tax credit if they adhere to the thresholds set by the domestic content requirements (DCR). To be eligible, 40% of all the equipment must be manufactured in the United States for projects installed prior to 2025.
The European Commission officially launched the European Solar Photovoltaic Industry Alliance in December 2022, aiming to create a European solar photovoltaic ecosystem capable of securing and diversifying solar module procurement. The EU has already defined an annual 30 GW photovoltaic manufacturing procurement goal by 2025. But the risk for Europe is that projects will be cancelled through outsourcing to the United States or India, as happened with Norway's REC Solar project. The manufacturer slipped into the clutches of the Indian conglomerate "Reliance" in the autumn of 2021, and planned to invest in Moselle, France. In December 2022, the Rec Solar group officially announced that it was pulling out of its project in France. For the time being, European companies have announced factory extension or creation projects for about 20 GW by 2025, but the prospects for success are dependent on subsidies and with small-scale volumes compared to China's extension projects. It is too early to gauge the impact of the European Commission's draft Net Zero Industry Act to relaunch its strategic industries for carbon neutrality (see Wind Energy barometer 2023). By definition, the NZIA project, is less generous than that of the United States, because the European Union is not directly involved with tax matters. Thus, it will fall to the European Member States to introduce measures, such as tax credits on investment to enable new factories to be constructed.

Graph No. 3

EurObserv'ER projection of the evolution of photovoltaic capacity* installed in the EU 27 (in GW)



** Net maximum electrical capacity, off-grid included.* ***Source: EurObserv'ER 2022.***

THE TECHNOLOGICAL CHALLENGE OF STORAGE FOR AFTER 2030

As recently as 30 March, the European Union came to an agreement on the revamped RES Directive. It at last set the new target for renewable energy in final energy consumption at 42.5% by 2030 (compared to just under 22% in 2021) in a development framework that is coherent with its European Green Deal package. The revamped Directive's biomass energy rules will be much stricter, making this challenge much tougher. Subsequently, part of the bioenergy contribution will be shifted to wind power (offshore and onshore) and even more to solar photovoltaic, which is definitely the RES sector with the fastest and highest development potential. Russia's aggression at the European Union's gates has amplified this need for speed and prioritized the EU's independence from Russian fossil fuels, accelerating the electrification and replacement of fossil fuels in heat production for industry, buildings, and transport.
This vital independence puts the REPowerEU plan and its EU Strategy for solar energy on the right track. We recall that the strategy aims to put more than 320 GWac of solar photovoltaic power on the grid by 2025 (i.e., more than double the 2020 figure) and about 600 GWac by 2030. The SolarPower EU Market Outlook projections for 2022-2026 were optimistic at the end of 2022. Its Medium Scenario forecasts that the EU's new ambitions set under the terms of the REPowerEU plan, and the need to combat current high electricity prices, will take the sector to 53.6 GWdc in 2023. SolarPower's Medium Scenario for Europe forecasts a 16% growth rate to 62.3 GWdc in 2024, followed by 74.1 GWdc in 2025 and 85.2 GWdc in 2026 – more than double the current market size. The issue of storage (in addition to investments in grid infrastructures capable of absorbing this new output) will soon become central to accompany this phenomenal "variable" renewable energy expansion in the electricity system through to 2030. Storage technologies, be they designed for daily, weekly or interseasonal needs, will become crucial in supplying the flexibility, stability and reliability needed by tomorrow's energy system. System flexibility is particularly critical in the EU's electricity system whose RES share should reach about 69% by 2030 and 80% by 2050. With 2.8 GW (3.3 GWh) of large-scale energy storage of the "utility scale" type newly deployed in 2022 (compared to 4 GW in the USA according to American Clean Power), the Commission feels that many European energy storage markets are already enjoying high growth. Storage will also entail the generalization of residential storage and V2G ("vehicle to grid") EVs.
Thus, the EU needs to implement an energy storage technology industrial value chain that is sound, sustainable, and resilient. The European Commission issued a dozen recommendations on storage development on 14 March 2023, to support a decarbonized, safe EU energy system. They aim to ensure more widescale deployment of energy storage, accompanied by a services working document, which gives an overview of the EU's current regulatory, commercial. and financial framework for storage and identifies the obstacles, opportunities and best practices for its development and roll-out. Acceleration of the renewable energy installation pace will make the issue of storage crucial, much sooner than expected. Stationary storage adapted to daily storage needs is already on track, but the issue of interseasonal to large-scale storage, and thus the origin of green gas and ammonia, will become more pressing for those countries aiming for very high penetration rates in the second half of this decade. □

Sources: AGEE-Stat (Germany), GSE-Terna (Italy), SDES (France), MITECO (Spain), Statistics Netherlands, Statistics Austria, SPF Economie (Belgium), CRES (Greece), Mavir (Hungary), MEHK (Hungary), ESO (Bulgaria), ARE (Poland), DGEG (Portugal), INS (Romania), Statistics Sweden, Ministry of Industry and trade (Czechia), Statistics Lithuania, Elering (Estonia), Finnish Energy, Danish Energy Agency (Denmark), Eirgridgroup (Ireland), STATEC (Luxembourg), IRENA.

the next barometer will cover solar thermal and concentrated solar power.

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