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SolarPower Europe

Global Market Outlook

For Solar Power

2023 - 2027

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Foreword

Welcome to the Global Market Outlook for Solar Power 2023-2027.

Solar is on the fast track. In 2022, the world installed 239 GW of new solar, finally surpassing the TW-scale. That's 45% more solar power capacity than the year before. The positive market developments in the first months of 2023 promise another solar boom year, expected to result in 341 GW of newly-added solar to the grid, by the end of the year – equal to 43% growth.

This solar rush comes after more modest progress in preceding years, which were characterised by pandemic triggered lockdowns, supply chain turbulence, and high product prices along the value chain. However, even in trickier times, the solar industry demonstrated very strong resilience, with newly installed global capacities increasing by 19% in 2020 and 18% in 2021.

The reasons for this spectacular performance are obvious. It comes down to the unmatched versatility of solar – powering individual energy self-sufficiency and comparatively quick-deploying utility-scale projects at competitive low cost. Despite solar's levelised cost of electricity (LCOE) sliding upwards – for the first time – due to supply chain issues and inflation, it remains profoundly cheaper to produce electricity from solar than from new fossil fuel and nuclear power sources.

What changed for solar power in 2022 – and why we consider the year an inflection point – is the technology's newly discovered image by a growing number of policymakers. Solar power now enjoys widespread acceptance as the key tool to achieve local energy security in the midterm. During the recent fossil fuel sparked energy crisis, the International Energy Agency (IEA) used two reports to highlight solar's critical role to reduce the European Union's dependence on Russian gas. The EU Solar Strategy of May 2022 even called solar the 'kingpin' of the continent's effort to get off Russian gas. Such geostrategic considerations are applicable for other energy importing countries as well. In other words, solar has now untangled what was previously considered a gordian knot – the so-called energy trilemma of sustainability, affordability, and security of supply.

The annual Global Market Outlook for Solar Power is a project that comes to life with the support and in-depth knowledge of the world's major regional and local solar industry associations. These organisations are working hard to improve the policy frameworks that are essential for solar power to thrive around the world. From these organisations, this report contains in-depth features on the 26 countries that added at least 1 GW of solar in 2022. There are nine more GW-scale solar markets in 2022, compared to the 17 in 2021. The number of the world's serious solar markets will more than double to over 50 by 2025.

This edition has both a regional and a topical focus – this time on Southeast Asia and PPAs in emerging markets. The idea was to highlight advances and challenges in countries that are often not on the global solar map. These features have been created in cooperation between SolarPower Europe, the Global Solar Council (GSC), through its member, the Asian Photovoltaic Industry Association (APVIA), and GET.invest.

With global supply chain issues largely overcome, and gigantic PV production capacities being built up, prices have dropped significantly across the value chain in recent months and are expected to dip below pre-pandemic levels soon. That will propel demand to the next level. In general, we are more confident than ever that solar will remain on the fast track in the years to come. How fast will depend on the regulatory environment needed to enable that growth – from simpler permitting and stronger grid capacities, to supported solar-storage hybrid solutions. Our 2023 High Scenario foresees 402 GW new solar this year and close to 800 GW in 2027. Having achieved over 1 TW of total solar capacity in 2022, we now see the potential for an annual TW-scale market by 2030.

Enjoy reading our Global Market Outlook.

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Methodology: SolarPower Europe's five-year forecast consists of Low, Medium and High Scenarios. The Medium scenario anticipates the most likely development given the current state of play of the market. The Low Scenario forecast is based on the assumption that policymakers halt solar support and other issues arise, including interest rate hikes and severe financial crisis situations. Conversely, the High Scenario forecasts the best optimal case in which policy support, financial conditions and other factors are enhanced.

Segmentation is based on the following system size: Residential (<10 kW); Commercial (<250 kW); Industrial (<1000 kW); Utility-scale (>1000 kW, ground-mounted). SolarPower Europe's methodology includes only grid-connected systems. Installed capacity is always expressed in DC, unless otherwise stated.

All figures are based on SolarPower Europe's best knowledge at the time of publication.

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Executive summary

2022 will be remembered as the year when solar deployment, driven by soaring energy prices, supply chain stabilisation, and post-pandemic recovery programs, entered a new growth dimension. In 2022 the world connected 239 GW of new solar capacity to the grid, marking yet another all-time record and registering an impressive 45% annual growth rate, the highest since 2016. As a consequence, total global installed solar capacity crossed the Terawatt threshold in early 2022 and amounted to almost 1.2 TW by the end of the year, with a 25% increase compared to 2021 levels.

Solar's expansion has no match across other power generation technologies. Solar PV claimed two-thirds of all new renewable power capacity installed last year, and the highest growth rate in terms of electricity generation across any power generation technology (24%). At the same time, however, solar still only meets 4.5% of global electricity demand, while over 70% is provided by non-renewable sources.

In 2022, significant supply chain disturbances, lingering COVID-19 effects, and inflationary pressure, sparked by the war in Ukraine, caused the first increase in solar's levelised cost of electricity (LCOE) in over a decade. That, however, does not pose a challenge to cost competitiveness; solar PV remains significantly cheaper than new fossil fuels and nuclear, and product prices already began to decline in recent months and are largely expected to return to pre-crisis levels soon.

Record installations in 2022 were driven by a remarkable performance in China, the undisputed world-leading solar market, with almost 100 GW added in a single year and a huge 72% annual growth rate. The US experienced a turbulent year in 2022, but kept its spot as the second largest market despite a 6% annual decrease to 21.9 GW, while India's rebound continued in 2022, with 17.4 GW of new installed capacity and a 23% growth. Closing the 2022 top 5 countries, Brazil doubled its installation rate with 10.9 GW, while Spain became the largest European market with 8.4 GW. At the regional level, China's dominance increased the Asia-Pacific share to 60%, while Europe remained stable at 19% and the Americas declined to 17%. In terms of installed solar capacity per capita, Australia remains in the lead with almost 1.2 kW/capita, while the Netherlands also crossed the kW/capita threshold, compared to a global average of an estimated 144 W/capita.

All solar analysts are confident that, following an exceptional 2022, there is no question that strong growth will continue in 2023 – the question is rather how much. Our Medium Scenario anticipates that 341 GW of new solar capacity will be installed worldwide in 2023, equivalent to a 43% growth that basically repeats the extraordinary performance of 2022. With improved market conditions, however, installations could go above 400 GW already in 2023. Solar deployment is expected to continue in the following four years, with 401 GW added in 2024 and a 617 GW market reached in 2027. This will bring total operating capacities above 2 TW in early 2025 and 3.5 TW by the end of 2027.

The strong expansion of 2022 delivered a record number of largely 'developed' solar markets. The number of GW-scale solar markets – countries installing at least 1 GW – jumped from 17 in 2021 to 26 in 2022. We forecast 32 GW-scale markets in 2023, 39 in 2024, and at least 53 in 2025.

This year's regional focus is on Southeast Asia. With the support of the Global Solar Council (GSC), we have provided an in-depth analysis of PV deployment in the region, which holds significant solar potential. We expect the regional market to grow to 3.8 GW this year, up 13% from 2022, and expand to 13.3 GW by 2027 under a Medium Scenario.

Another feature is on corporate PPAs in emerging countries, examining the drivers and challenges corporates face in Sub-Saharan Africa and South-East Asia. There are a few promising initiatives for corporate solar PPAs, but in most countries policy frameworks need to be established to tap the gigantic potential of bilateral solar power purchase agreements.

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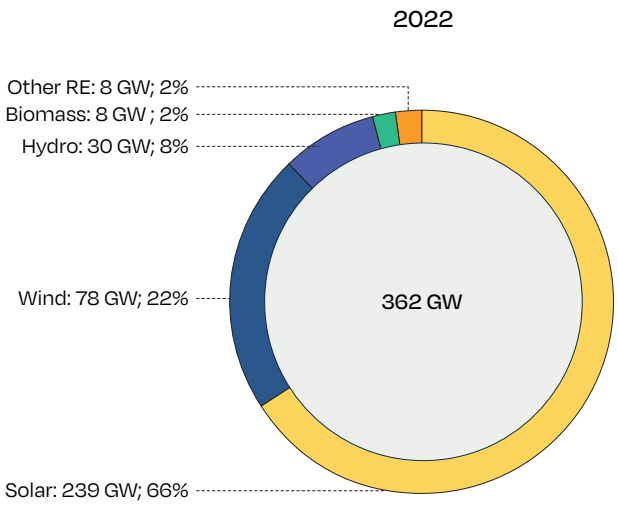
1 Global solar market

50 MW Hybrid plant, El Andévalo, Spain. © Iberdrola

Solar power continued to dominate the newly added global power generation capacity in 2022, claiming yet another year at the top spot among renewable energy sources. Out of 362 GW of new renewable (RES) capacity added last year, solar PV accounted for 66%, connecting 239 GW to the grid (see Fig. 1). Solar's share of new renewable capacity increased substantially from the 56% contributed in 2021. This highlights the growing prominence of solar in the global energy transition, installing about two times the capacity than all other renewable technologies combined.

FIGURE 1 NET RENEWABLE POWER GENERATING CAPACITY INSTALLED IN 2022



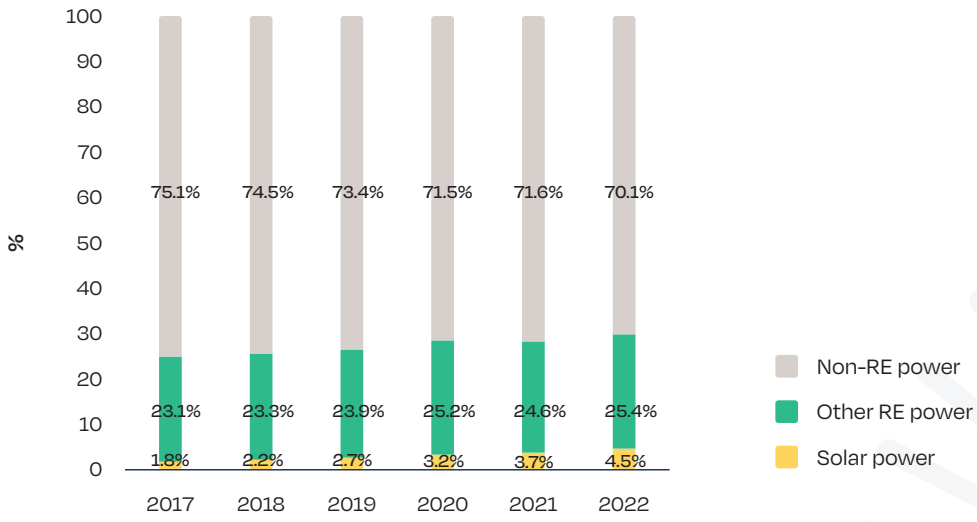
SOURCES: GWEC (2023), IRENA (2023).

10 IEA (2020): *World Energy Outlook 2020.*

The overall trend for renewable capacity additions has been consistently upward in recent years, pushed by the global energy crisis and policy support. Total renewable capacity additions are 56 GW higher than last year, an 18% increase from 306 GW in 2021. The surge of solar PV in 2022 has more than covered the decrease in wind annual installations, dropping from 95.3 GW in 2020, to 93.6 in 2021, down to 77.6 GW in 2022.

However, it is important to keep these positive developments in perspective. Solar power still contributes a minor share of total electricity demand, accounting for only 4.5% of global power production in 2022, increasing from 3.7% in the previous year (see Fig. 2). Though still relatively small, we observe a clear growth acceleration – solar's share increased by 0.8 percentage points or 22% in 2022, compared to 0.5 percentage points or 16% in 2021. This is much faster than the growth of other renewable sources, which collectively provided around 25.4% of the world's power generation, representing about 3% growth from the 24.6% share in 2021. Non-renewable sources maintained their dominant position with a 70.1% share. Nevertheless, their share decreased by 1.6 percentage points in 2022, and is at an all-time low.

FIGURE 2 SOLAR AND RENEWABLE POWER AS A SHARE OF GLOBAL POWER 2017-2022

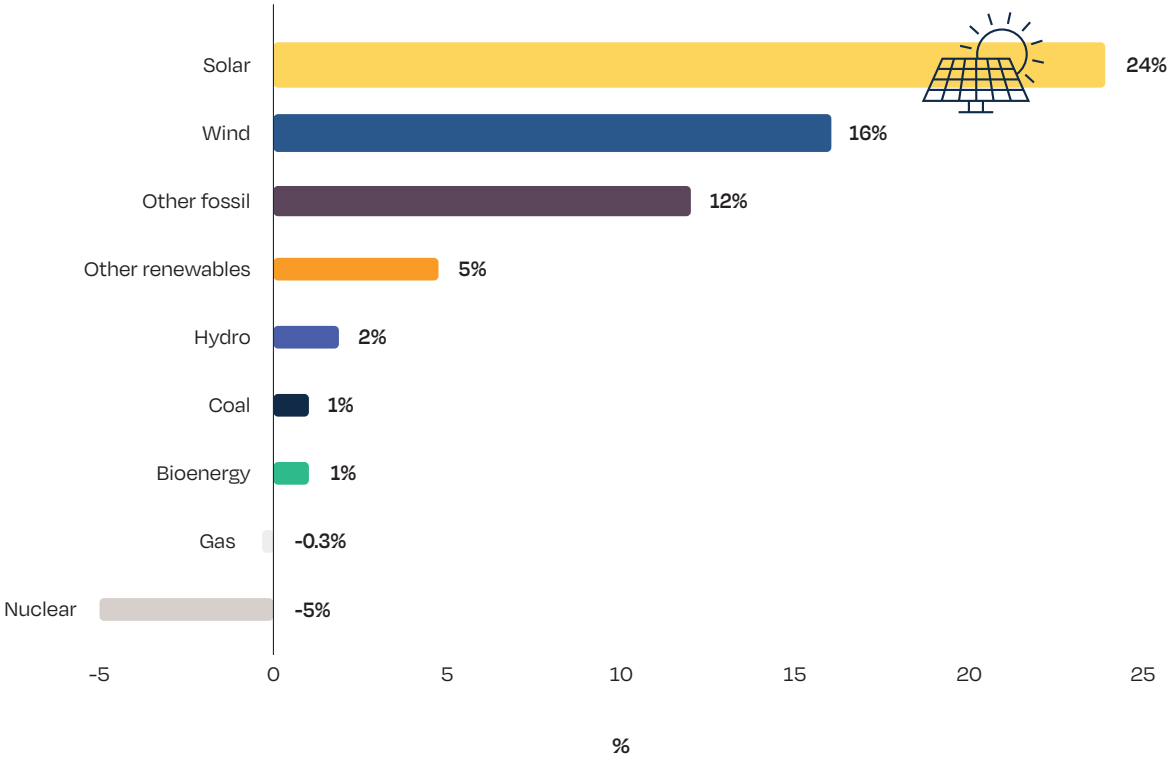


SOURCE: Ember (2023).

1 Global solar market / continued

The immense market potential of solar and its cost leadership indicate that it will continue to capture a larger share than any other power generation technology and further lead the global energy transition. As the spearhead of the movement to renewables, solar generated 1,289 TWh in 2022, up 24% from the 1,040 TWh it generated in 2021 (see Fig. 3). Wind is the second fastest growing technology when it comes to global power generation, with a 16% growth rate. In the meantime, electricity generated by coal, the dirtiest source of power generation, grew by 1%, while gas-powered electricity marginally declined, and nuclear electricity decreased by 5%.

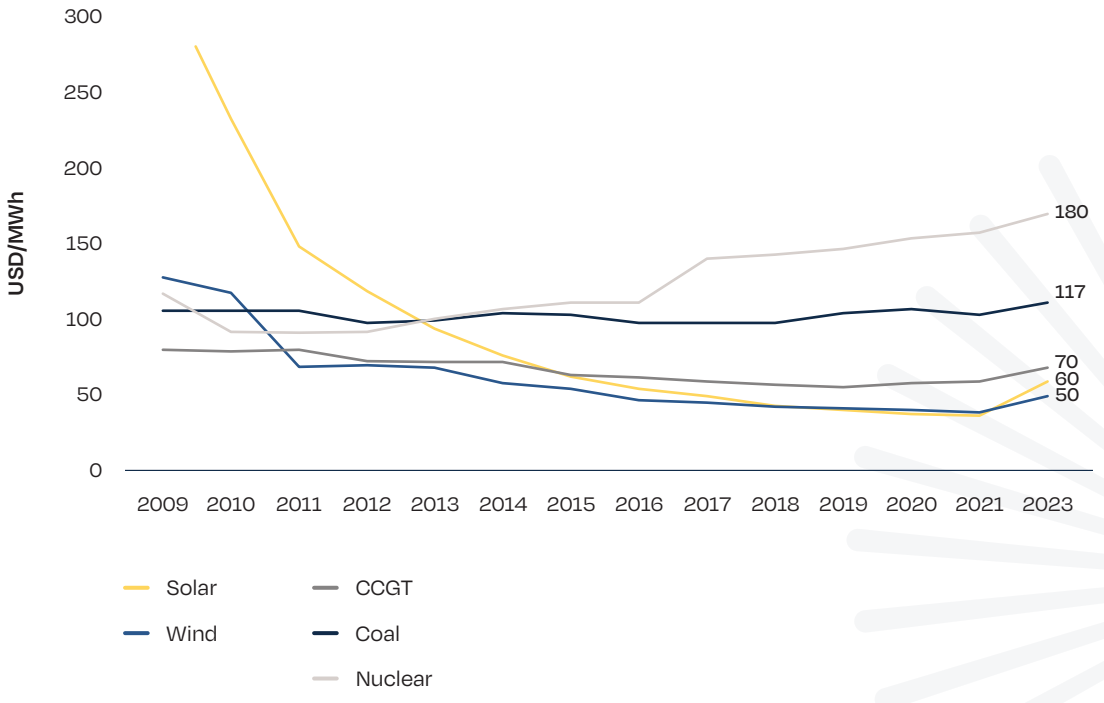
FIGURE 3 ELECTRICITY GENERATION GROWTH RATE FROM 2021 TO 2022, BY TECHNOLOGY



SOURCE: Ember (2023).

Solar's exceptional success can be attributed to various factors, but a key driver is its significant cost reduction over the past decade, propelling it to become the global leader in terms of cost competitiveness (Fig. 4). However, the past two years have witnessed significant disruptions in global supply chains, causing significant price increases. Lingering effects from the COVID-19 pandemic and the last lockdown in Shanghai in 2022 have led to increased shipping costs, while the war in Ukraine has sparked inflationary pressure worldwide. Specifically in the solar industry, the price of polysilicon had been on an upward trajectory for the past two years, peaking at around 38 USD/kg in December 2022, compared to just below 10 USD/kg in early 2021, according to BloombergBNEF, while other product prices along the value chain soared as well. All this has resulted in the first increase in solar PV's Levelised Cost of Electricity (LCOE) after a decade of uninterrupted decline, rising from 36 USD/MWh in 2021 to 60 USD/MWh in 2023, the sharpest increase among all power technologies.[1] Despite this increase, solar power remained significantly cheaper than any fossil fuels and nuclear, considering the overall rise in technology prices. While solar power had become cheaper than wind power in 2021, the relationship has reversed in 2023. However, with the significant increase in production capacity and the improvement of global supply chains, prices for solar products have decreased considerably along the value chain, from silicon to modules in recent months – and are anticipated to reach pre-crisis levels this year.

FIGURE 4 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH OTHER POWER SOURCES 2009-2023

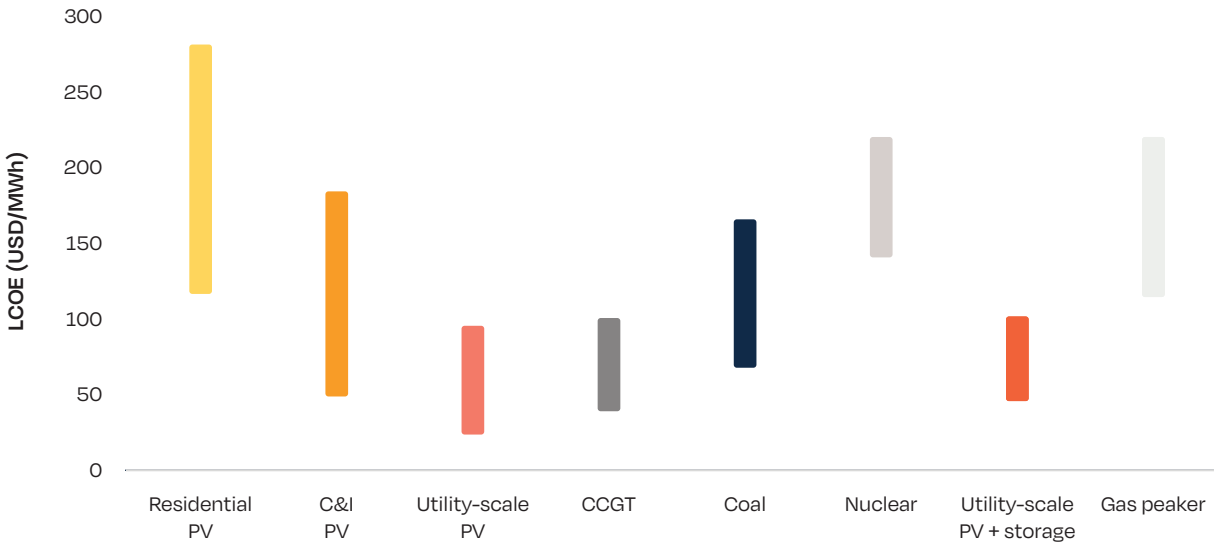


SOURCE: Lazard (2023). Historical mean unsubsidised LCOE values (nominal terms, post-tax).

2 Lazard (2023): 2023 Levelised Cost of Energy. Available at https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/

1 Global solar market - Update 2000-2022

FIGURE 5 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH CONVENTIONAL POWER SOURCES 2023



SOURCE: Lazard (2023). Nominal terms, post-tax.

Regardless of the recent solar power price increase, utility-scale solar power remains more affordable than newly established conventional power generation sources (Fig. 5). Additionally, the cost-competitiveness of combining solar power with storage, in comparison to using gas turbines to meet peak demand, is unquestionable. This can be seen in an increasing number of countries worldwide setting hybrid renewable auctions. Such auctions involve the co-location of different renewable energy sources alongside battery storage, offering a flexible and versatile solution to meet energy requirements.

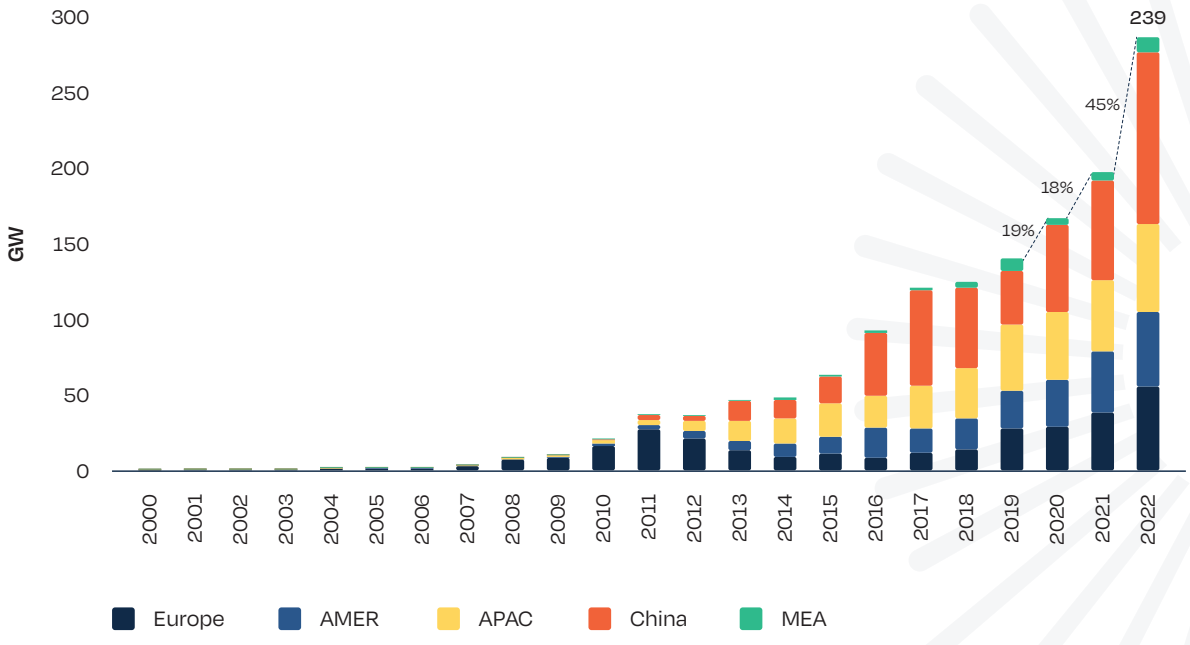
UPDATE 2000-2022

In 2022, the world grid-connected 239 GW of new solar capacity, marking a substantial growth of 45% compared to the previous year's addition of 165 GW (refer to Fig. 6). This surge in solar capacity can be attributed to a combination of factors, including the stabilisation of supply chains as the world recovered from COVID-19, new manufacturing capacities coming online, and the many post-pandemic economic recovery programs implemented worldwide. However, the undisputed main driver was the global energy crisis that led to soaring electricity prices. In response to that challenge, many individuals and entities turned to solar power as a viable solution to meet their energy needs. The combination of these positive factors brought the best year-on-year growth rate since 2016, when the global market was well below 100 GW.

In our previous edition, we had projected a global sector growth of 229 GW in our Medium Scenario, expecting a 36% year-on-year increase in the market. This optimistic outlook was based on the anticipation of solar's strong performance throughout the economic recovery and the fact that many projects due to be commissioned in 2021 were delayed to 2022 as a consequence of COVID-19. The actual figure of 239 GW is a little above last year's prediction, indicating that our forecast, which might have been considered buoyant one year ago, was in fact too conservative. It is noteworthy, however, that this higher installation capacity was in the range of last year's High Scenario of 271 GW.

China, the undisputed world's largest solar market, entered a new dimension with an annual market close to 100 GW – a 72% growth rate from the 54.9 GW installed in 2021, which was already an all-time high. Moreover, positive dynamics were observed in numerous solar markets across the globe, with notable progress seen in Europe, Brazil, and India.

FIGURE 6 ANNUAL SOLAR PV INSTALLED CAPACITY 2000-2022



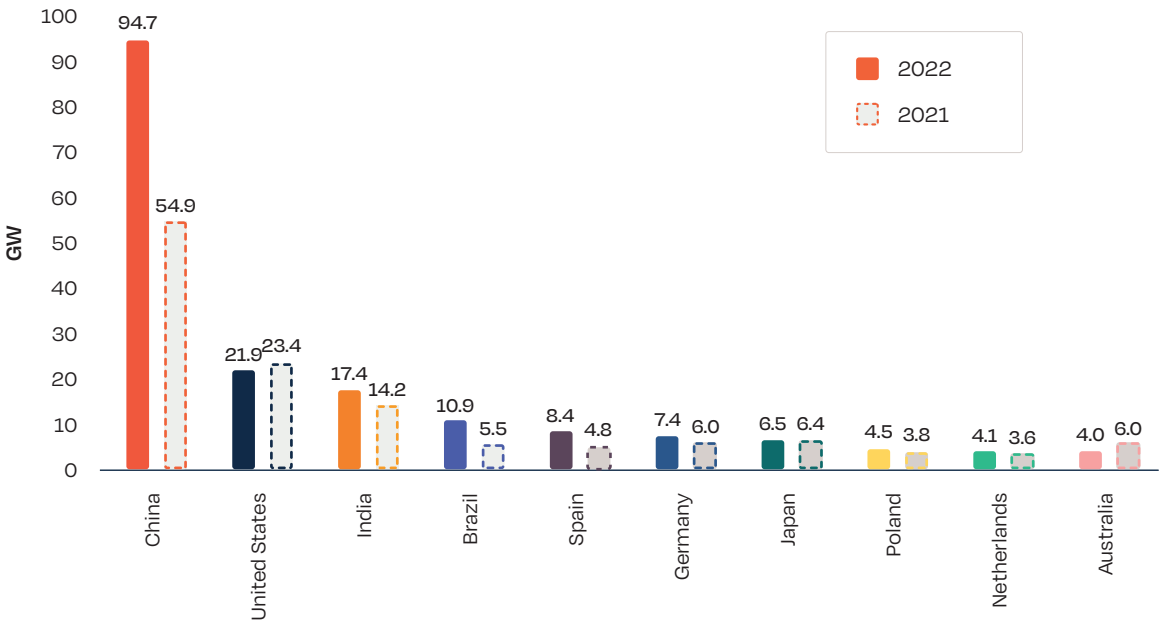
TOP 10 Global Solar Markets

The majority of the top 10 solar markets in 2022 retained their positions from the previous year, although there were significant shifts in rankings and some newcomers due to varying growth dynamics (see Fig. 7).

China doubled-down on its position as the market leader in 2022, installing more than four times as much solar PV capacity as the second-largest market, the United States. China's additions in 2022 actually surpassed the combined capacity added by the other top 9 markets. The Chinese market continued its strong growth - since the slowdown it experienced in 2019 with 30 GW -, with installations bouncing back to 48.2 GW in 2020 (60% annual growth), 54.9 GW in 2021 (14%), and a staggering 94.7 GW (72%) in 2022. While installations in 2021 were slightly above the previous 2017 record of 52.8 GW, 2022 marks a distinct new growth phase. Solar's competitiveness in both utility-scale and distributed solar applications and an increasing awareness for the attractiveness of solar power are driving demand in the world's second largest economy. The Chinese rooftop segment – driven both by residential and C&I, had a 54% market share in 2022, continuing its dominance from 2021, when it contributed 53% to newly installed capacity. In 2022, China also reached a significant milestone by surpassing the 400 GW mark in total solar installations, despite only surpassing the 300 GW mark by a small margin one year earlier.

The United States' solar market experienced a turbulent year in 2022, but kept its spot as the second largest market. The country installed 21.9 GW, a 6% annual decrease in a year marked by the anticircumvention investigations, the Uyghur Forced Labor Protection Act (UFLPA), and the passing of the historical Inflation Reduction Act (IRA). This lacklustre performance put to a halt the uninterrupted growth experienced since 2017. Like in the previous years, the majority of installations came from the utility-scale segment, accounting for 13.8 GW or 63% of the total. However, this is an 18% drop from the 16.8 GW installed in 2021, as the large-scale segment was the most impacted by the detainments of products caused by the US Customs' Withhold Release Order (WRO) and the UFLPA. On the contrary, the rooftop segment flew high and grew 25% to reach 8.1 GW, driven by a strong residential demand.

FIGURE 7 TOP 10 SOLAR PV MARKETS, 2021-2022



India's rebound continued in 2022 – the disappointing 2018-2020 development period seems to be history. Solar demand was on a constant decline from 2017 to 2020, plummeting from 11.5 GW to a mere 3.9 GW. However, after posting a new installation record in 2021, the country added an impressive 17.4 GW of solar capacity in 2022 – beating the 2021 record by over 3 GW. This achievement secured the country the third position it got back in 2021. India experienced a 23% annual growth rate, a path that is expected to continue as the country targets 500 GW of non-fossil fuel electricity capacity by 2030 and its commitment to achieve net-zero carbon emissions by 2070. Despite the impressive progress, India still faces challenges in its solar industry. The country was heavily hit by COVID-19 and several projects remains delayed because of supply chains disruptions. Additionally, with the introduction of the Basic Custom Duty in 2022, imposing a 40% duty on imported modules and 25% on cells, many projects are facing financing challenges. Moreover, the rooftop market remains underdeveloped - only 4.9 GW was added in 2022 presenting a 28% share of annual installations. Rooftop solar was responsible for a cumulative capacity of about 10 GW by end of 2022, which is falling significantly short of the 40 GW target for rooftop solar, and considered the main reason why India missed its 100 GW solar target by a large margin. The country had installed a total of only 77 GW. Overcoming these challenges will be crucial for India to further accelerate its solar adoption and achieve its ambitious renewable energy targets.

After making its debut in the top 10 solar markets in 2021 at the 7th position, **Brazil** has now entered the top 5 at the 4th position – currently the sole representative from Latin America in the top 10. The country installed 10.9 GW of solar capacity in 2022, basically doubling its previous record of 5.5 GW in 2021. The majority of last year's installations, around 8 GW, came from distributed solar systems with a capacity of up to 5 MW. Until the end of last year, the segment enjoyed a very attractive net-metering scheme, whose rules have changed for projects built from 2023 onwards, including new grid-connection fees. This triggered a rush of installations in 2022 from consumers wishing to access the more beneficial scheme. The Brazilian solar sector also saw growth in centralised systems, totalling 1.5 GW and primarily driven by energy auctions for large-scale power plants, as well as the development of some power purchase agreement (PPA) based systems. Brazil's impressive ascent in the solar market highlights the country's potential and growing interest in renewable energy. Despite the challenges posed by its investment-needing transmission system, Brazil's solar sector demonstrated resilience and growth in both

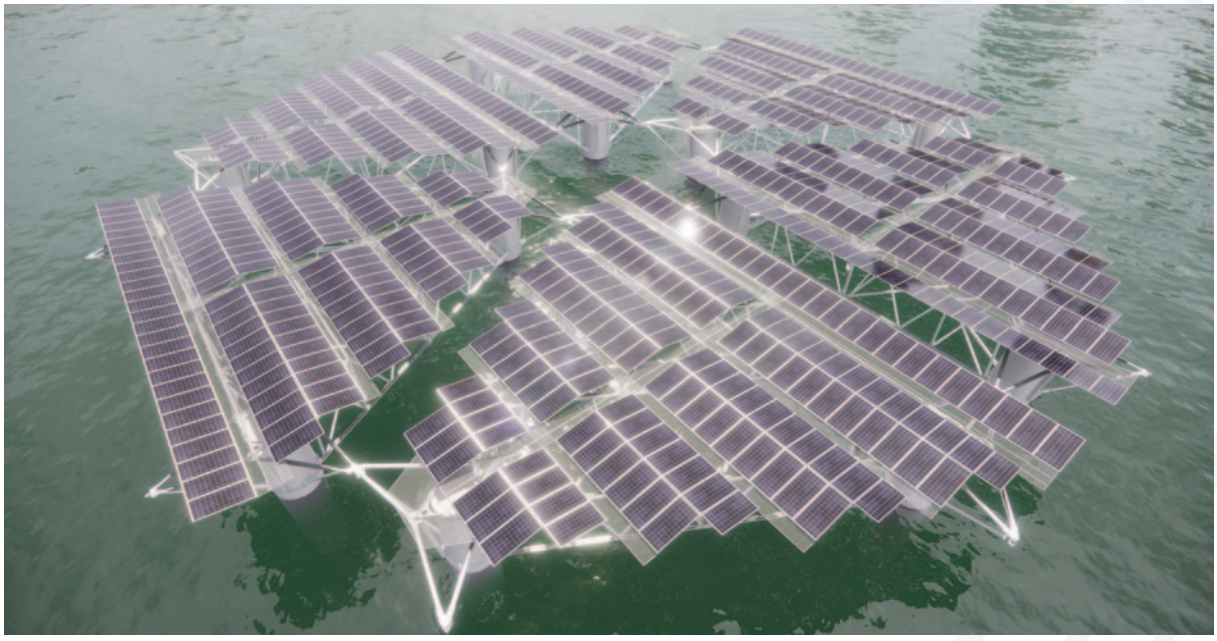
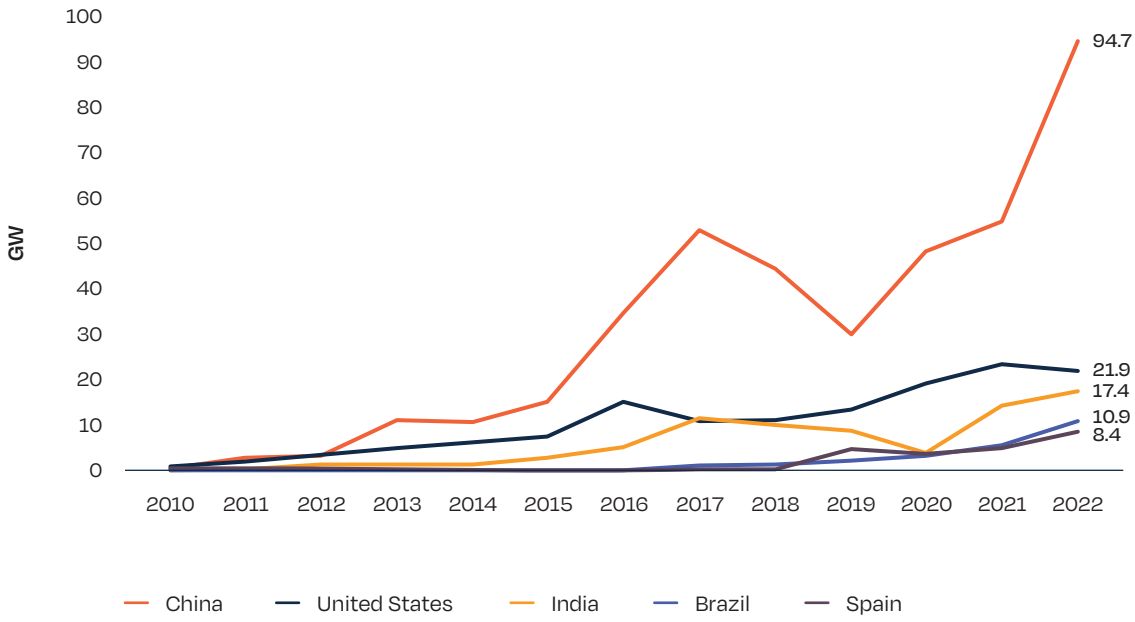


Illustration of 0.5 MW offshore solar project off the coast of Scheveningen, Dutch North Sea.

FIGURE 8 TOP 5 SOLAR PV MARKETS 2010-2022



distributed and centralised solar installations. A market contraction is nevertheless expected in the short-term, in light of the less favourable net-metering rules.

Spain moved up by three positions in the ranking and is now closing the top 5, becoming the leading European market with a newly installed capacity of 8.4 GW in 2022. This represents a notable 76% increase from the 4.8 GW installed the year before. The main bulk of installations continues to be its robust PPA-driven utility-scale segment, which accounted for 5.3 GW of installations in 2022 without relying on any form of subsidies, making Spain one of the largest subsidy-free solar markets globally. This trend is expected to persist as the country streamlined environmental permits for over 25 GW of solar PV plants in early 2023. However, a second key driver behind Spain's progress in 2022 was the significant evolution of its self-consumption rooftop market. In 2022, the rooftop segment achieved 3 GW of new capacity, doubling the market size from one year to the other. Alongside policy improvements, rising electricity prices stemming from the energy crisis have become a strong incentive for homeowners and businesses to adopt solar power. This factor might become even more relevant in 2024 once the price cap on natural gas used for power generation ends, which is planned for at the end of 2023. However, energy prices on the European spot markets have dropped significantly in the spring of 2023.

Within the top 5 markets, significant differences remain (see Fig 8). China took a strong lead in 2016, and no other markets have been close to playing in its league since. The gap between the #1 market and the #3 market is fivefold, while the difference between the #1 and #5 markets exceeds elevenfold. In 2021, the difference between top #1 and #5 was only eightfold.

Coming as the second European market in this ranking, **Germany** maintained its #6 position, the same spot it held in 2021. The country witnessed a 23% growth in grid-connected solar capacity, reaching 7.4 GW in 2022 compared to 6 GW in 2021. Germany's solar sector is mostly based on rooftop installations, which are supported by a reliable feed-in premium scheme and regular tenders for systems larger than 750 kW – a threshold increased to 1 MW since January 2023. Households increasingly find self-consumption

solar PV systems attractive, very often combining their solar investment with battery storage – a factor amplified by the presence of some of the highest residential electricity retail prices in Europe. On the other hand, the increase in tender volumes in 2019 has contributed to the growth of ground-mounted solar capacity, which was further supported by the expansion of PPA systems. The utility-scale segment grew from 2.2 GW in 2021 to 3 GW in 2022. The German government has recognised the significance of solar power and set ambitious targets, aiming for renewables to account for 80% of the total power generation by 2030 and 100% by 2035, and a target of 215 GW of solar PV capacity by 2030.

The flatter trajectory of **Japan's** solar market impacted its ranking, dropping from 4th in 2021 to 7th in 2022. The country installed 6.5 GW in 2022, a similar performance to the 6.4 GW connected in 2021 but a 21% drop from the 8.2 GW in 2020. The majority of the installed capacity in 2022 can be attributed to feed-in tariff (FIT) and feed in premium (FIP) projects that received approval a few years ago. With the end of the FIT era at the end of 2022, the market has entered a transitioning period that is reflected in stagnating installations levels, while new business models based on PPAs and third-party ownership are beginning to gain momentum.

Poland, which emerged as a newcomer on the top 10 list last year, keeps growing and moved up two spots to rank 8th. The country installed 4.5 GW of solar capacity in 2022, a 20% growth compared to the previous year. While the Polish market has now been in the radar of most solar analysts for at least two years, its positive development exceeded again most expectations. The growth of solar in Poland has been primarily driven by small rooftop systems below 50 kW. This segment benefited from a favourable net-metering scheme that was in place until March 2022

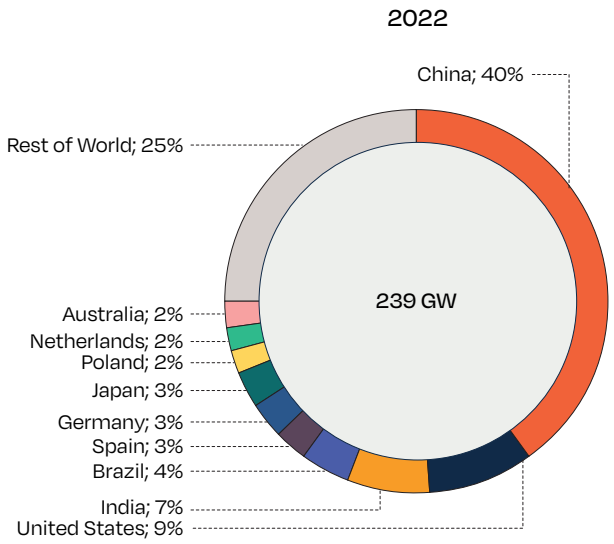
and has been substituted by a net-billing system. In 2022, Poland's rooftop segment was responsible for 78% of the installed capacity. While the future of the small rooftop market remains uncertain, Poland is now shifting its focus towards the large-scale segment. Many companies are eyeing solar PV to secure their energy supply via PPAs. Unlike its wind energy counterpart, solar power in Poland faces fewer significant regulatory barriers and has the potential to meet the country's energy needs within a relatively short timeframe. Still, the aging infrastructure and the amendment to the Spatial Planning and Development Act could pose a challenge for the long-term development of large-scale PV in the country.

A key player on the European playground for now several years, the **Netherlands** made its first entry on the top 10 global scene at the 9th spot in 2022. The country installed 4.1 GW in 2022, accelerating its upward trajectory from the 3.6 GW installed in 2021 (+13% YoY), and 3.5 GW in 2020 (+2% YoY). The growth in the residential segment played a significant role, contributing 1.8 GW or 46% of capacity additions, thanks to the attractive net-metering policy that has been consistently in place. At the same time, the C&I segment faced challenges from the rising technology and logistics costs, resulting in a slight loss of momentum – adding 1.3 GW, its share dropped by 5 percentage points to 37% year on year. However, the Dutch solar market maintains a good balance between its various segments, positioning it as the leading European country in terms of solar capacity per capita. Considering the limited available space for ground-mounted installations, the industry is exploring innovative solutions such as on- and off-shore floating solar, and solar carports, along with increased local participation in renewable energy projects, aimed at enhancing social acceptance and integration.

Losing five places in the global ranking, **Australia** closes the top 10 markets. In 2022 the Australian market took a step backwards, after uninterrupted positive progress since 2014. The country deployed 4 GW in 2022, a 34% decrease from the record 6 GW installed in 2021. Still, Australia remains the country with the highest solar power per capita in the world. The challenging business conditions resulting from the Russian invasion in Ukraine and component price increases limited growth in the sector as a whole. However, the election of a government supportive of renewable and climate action in general is expected to translate into a favourable environment for renewable energy deployment. Also, the improved PV component price conditions in recent months have already resulted in an increase of solar installations in comparison to the first months in 2022.

1.6 MW, Bergen, Norway.

FIGURE 9 TOP 10 COUNTRIES SOLAR SHARE 2022

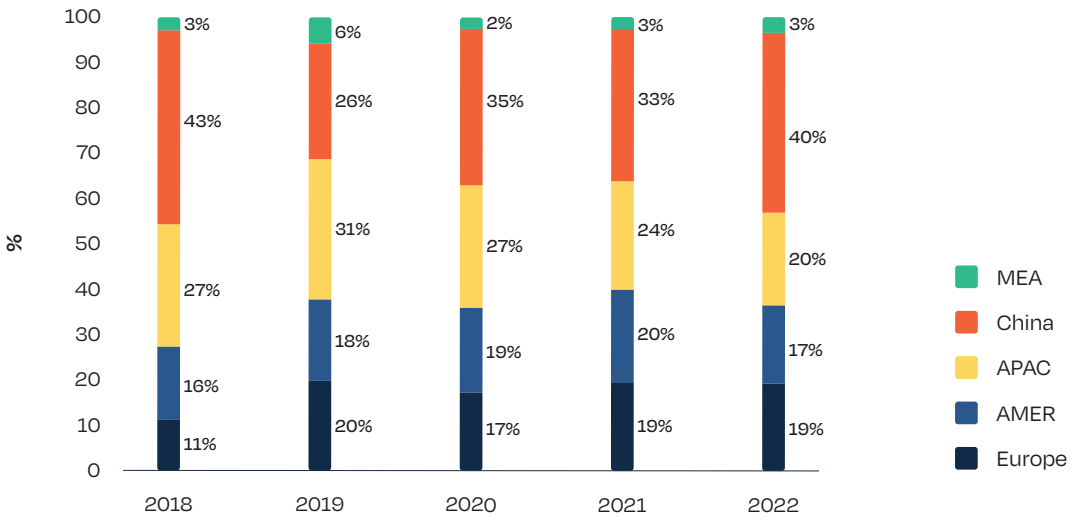


To summarise, 2022 proved to be an exceptionally strong year for solar energy, considering that several countries were still facing COVID-19 related restrictions in the first months of that year. With a 45% annual growth, new installations comfortably passed the 200 GW milestone for the first time in history. Similarly to previous years, growth was primarily driven by China, further cementing its global solar leadership. China alone was responsible for 40% of global annual installations in 2022, up 7 percentage points from the 33% it provided in 2021 (see Fig. 9). Most of the other top 10 markets decreased their global share compared to the previous year, while the portion installed in all remaining countries increased from 22% to 25%, emphasising the increasing recognition of solar power as a crucial solution in combating climate change. This is also reflected in the record number of countries reaching an annual GW-size: in 2022, 26 countries crossed the threshold, compared to 17 the year before. Details on these 26 markets can be found in Chapter 4 where national industry associations active in the solar sector provide analysis on their home markets (see p. 69).

Regional Update

Following the record-breaking solar year in China, the **Asia-Pacific** (APAC) region increased its global solar dominance, gaining 3 percentage points and reaching 60% of annual installed capacity in 2022. However, APAC considered without China lost global market share, dropping from 24% to 20% (see Fig. 19). This reflects the gigantic size of China, whose share increased from 33% to 40% in a single year. Nevertheless, with the addition of 144 GW in 2022, significantly surpassing the 94.3 GW installed in 2021, China together with the other Asia-Pacific countries, which added 48.9 GW, maintain the position as the largest solar market region globally. While China undisputedly continued to drive the whole APAC solar market, when looking at the other key regional players it is notable that the 3.2 GW marginal growth in India was not sufficient to compensate for the slowdown in Australia and South Korea, whose combined annual market decreased by almost 4 GW. The downward trend of APAC without China continues, after the decline already seen in 2021, when its share dropped from 27% to 24% due to the substantial downturn in

FIGURE 10 ANNUAL SOLAR PV INSTALLED CAPACITY SHARES 2018-2022



the Vietnamese market, which dropped 10 GW down to 2 GW and resulted in the loss of its top 10 position. While Vietnam has not recovered, the number of Asian-Pacific countries in the top ten global players have decreased from 5 to 4 in 2022, as South Korea was replaced by the Netherlands.

In **Europe**, the strong performance of the solar industry led to a major increase in annual installed capacity. The region witnessed a year-on-year growth of 14.1 GW or 44% percentage points, after it installed a total of 46.1 GW in 2022, contributing to a global market share of 19%. This outcome sets the Old Continent, which was the global market leader between 2004 and 2012, again as the second largest region in annual solar PV deployment, surpassing the Americas. This result is higher than the Medium Scenario projection from our previous GMO, where we anticipated the continent would add 39.1 GW, which is 7 GW lower than the actual result. Over 80% of European markets installed more solar than the year before. Spain became the new solar champion of the region with 8.4 GW overtaking the sceptre from Germany, which grew by 1.4 GW to 7.4 GW, but that was not enough to defend its European leadership title. Poland (4.5 GW), the Netherlands (4.0 GW), and Italy (2.5 GW) also outperformed their previous year's performance.

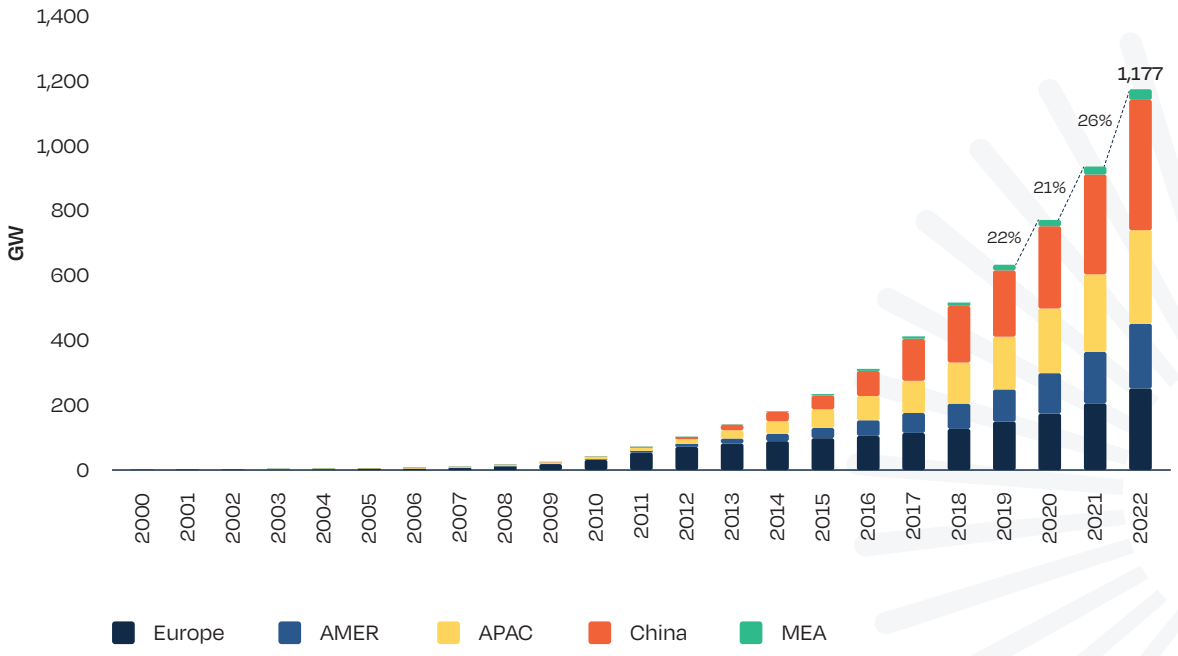
Europe's second spot in the regional ranking, in fact, is not due to an increase in its relative share, which remained stable at 19%, but rather to a decrease in the **Americas**' relative share from 20% to 17%. The region has now dropped to rank #3 in terms of annual solar capacity additions, standing at 41.1 GW – which is still a 22% increase from the 33.6 GW installed the previous year. While the US remained the leading player in the region, the decrease of its annual market size from 23.4 GW to 21.9 GW has somewhat reduced its regional predominance in 2022. The other two-digit GW solar force is now coming from South America – Brazil doubled its annual installed capacity from 5.5 GW in 2021 to 10.9 GW in 2022. While, as in the previous year, both the US and Brazil were the main drivers of solar growth in the region in 2022, Chile has also confirmed its increasingly relevant role in the continent, growing from 1.3 GW to 1.8 GW. Conversely, Mexico, now ranked fourth in the Americas, continued its decline due to unfavourable government policies that prioritise fossil fuels over renewables and the state-owned company CFE over other market players.

Finally, in 2022, the Middle East and Africa (MEA) region witnessed remarkable solar growth, adding 8.3 GW, which represents a 77% increase compared to the previous year. This progress is a new all-time high for the region, breaking MEA's record of 6.7GW in 2019, when multiple large-scale projects were commissioned. Though no MEA countries reached the GW-level in 2021, two markets have achieved this threshold in 2022. Israel emerged as the largest solar market in the Middle East, reaching the GW scale for the first time with just over 1 GW of newly installed capacity, from 935 MW in 2021. On the African continent, South Africa retained its leading position, installing 1.3 GW of solar capacity in 2022 and achieving the GW-scale as forecasted last year.

Total Solar Installations until 2022

By the end of 2022, the global cumulative installed capacity of solar PV systems experienced 25% growth, reaching 1,177 GW compared to 938 GW in 2021, when the solar fleet grew by 21% (Fig. 11). The solar power capacity has multiplied 740 times since the beginning of the millennium, when the grid-connected solar era began with Germany's introduction of the feed-in tariff law. When comparing the capacity in 2022 with the solar fleet at the start of the previous decade, the global on-grid PV capacity has grown 28 times from the 41.4 GW operating in 2010. Major solar market development milestones were 2008, when the 10 GW level was surpassed, and 2012, when the 100 GW was reached. It then took until 2018 to crack the 500 GW, and 4 years until the market doubled to the TW level in 2022.

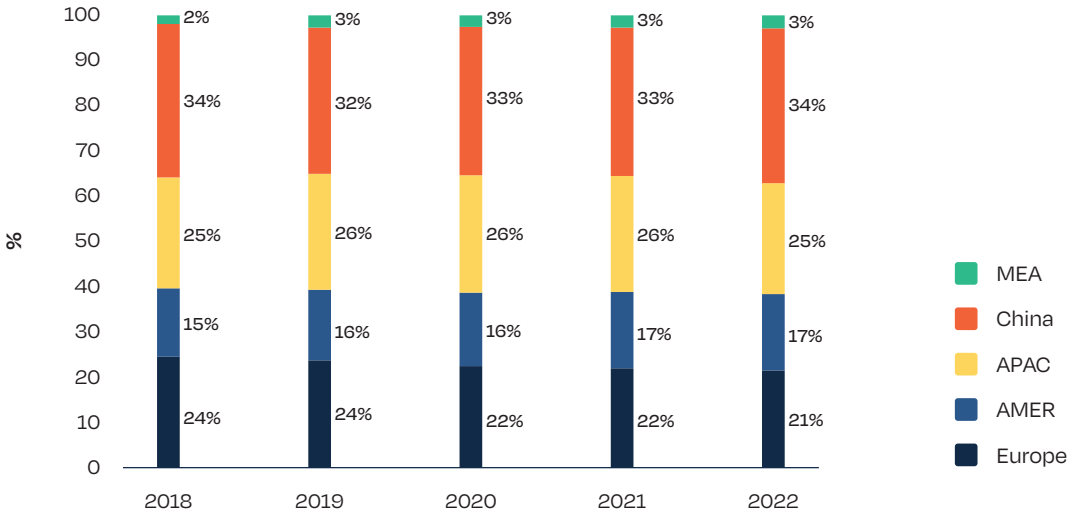
FIGURE 11 TOTAL SOLAR PV INSTALLED CAPACITY 2000-2022



The APAC region, led by China and India, demonstrated sustained growth and maintained its position as the world's solar powerhouse. By end of 2022, the APAC region including China accounted for 59% of global solar power generation capacity, with a total of 692 GW (see Fig. 12). With over 400 GW installed, China alone provided 58% of APAC's solar capacity, while the rest of the region controls the remaining 289 GW. Despite the growth experienced in most of the European solar markets, the region's global market share marginally decreased by 1 percentage point to 21%. Unlike for annual installations, where it regained the second rank, when it comes to the total operating solar fleet, Europe was and remained the No. 2 in 2022. The record-addition of 46.1 GW even allowed Europe to strengthen its second position with a cumulative PV capacity of 252 GW.

The Americas kept its #3 regional ranking in 2022. The region's total installed PV capacity of exactly 200 GW resulted in a global share of 17%, unchanged compared to 2021. Although the Middle East and Africa region witnessed substantial demand growth, it had no major impact on its solar positioning. The region's cumulative solar capacity stood at 33.3 GW, with its global share remaining at 3% in 2022.

FIGURE 12 TOTAL SOLAR PV INSTALLED CAPACITY SHARES 2018-2022

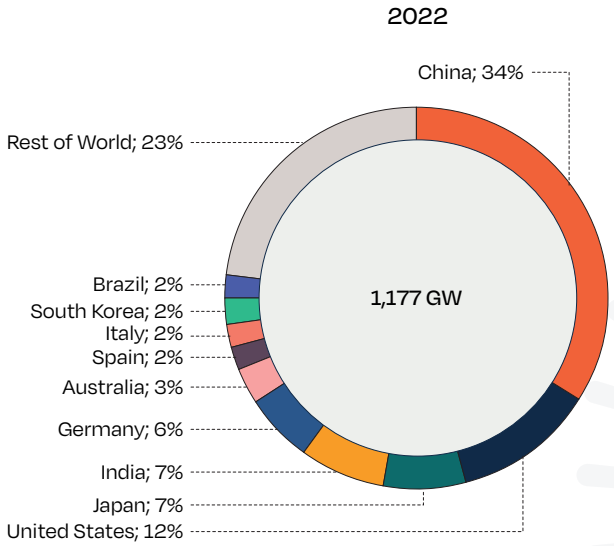


An analysis of individual countries' operating fleets shows once more China's dominant position in the solar world. Thanks to its operational fleet of 403 GW, China alone provided 34% of the world's solar capacity, one percentage point more than in 2021 (Fig. 13). Despite the sheer volume of globally deployed solar PV systems, the country maintains a remarkable influence on global solar dynamics.

The United States comfortably maintained the second position with 141 GW, however its share decreased by one point to 12%. Still, it remains the only country besides China with a double-digit share in global solar power generation capacity and with more than 100 GW installed. Japan kept the third position it held in 2021, but its relative share decreased by one percentage point to 7% with a fleet of 84.1 GW. By contrast, India's second strong year in a row helped the country to surpass Germany and secure the fourth position by the end of 2022. India's total PV installation reached 77.6 GW and its global market share slightly increased from 6% to 7%. Germany dropped by one rank and closes the top 5 in 2022 with an unchanged 6% share and a 68 GW solar fleet.

Members of the top 5 group are longstanding, and are unlikely to change anytime soon. Australia, ranking sixth, as previous year, has less than half the total solar PV capacity of Germany. Among the bottom half of the top 10, notable changes include Spain climbing two steps to reach the seventh position with 27.4 GW, overtaking both Italy – 8th with 24.6 GW – and South Korea – 9th with 24.3 GW. Brazil, a newcomer completing this list and overtaking Vietnam's 10th position, reached 24 GW of total installed capacity.

FIGURE 13 TOP 10 SOLAR PV MARKETS TOTAL INSTALLED SHARES 2022



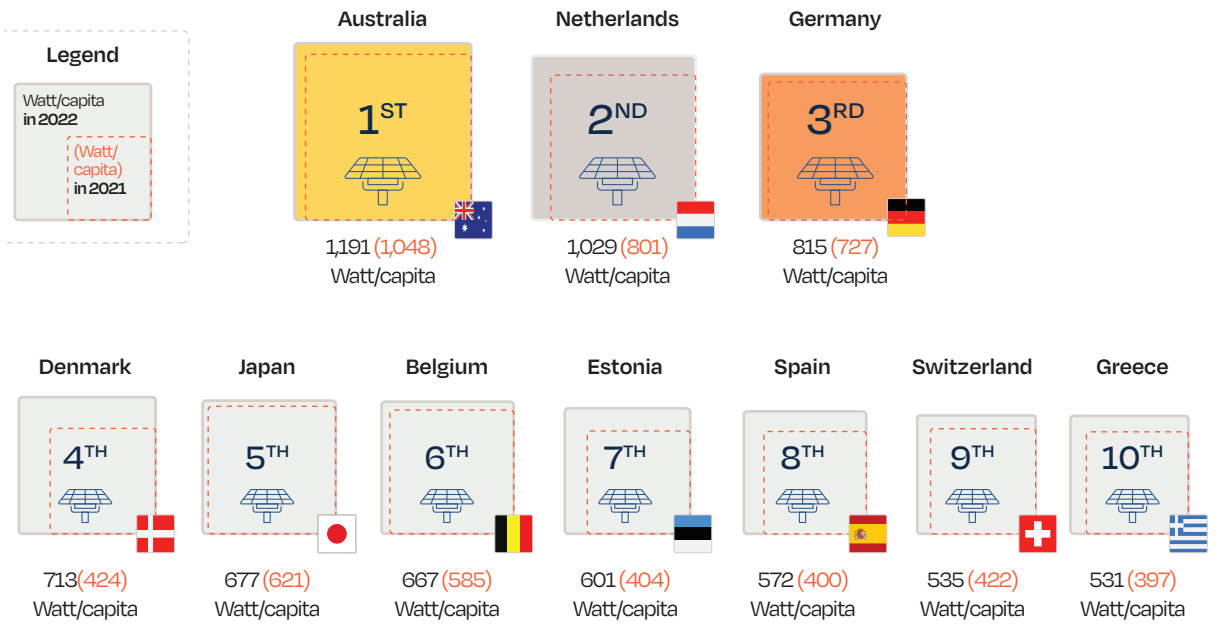
Solar watt per capita – the world seems different

Looking at installed PV capacities from a per-capita perspective, one can find a completely different outlook on the global solar landscape. None of the top three global solar markets, namely China, the US, and India, features in the top 10 list of installed capacity per capita (refer to Fig. 14).

However, compared to last year, we observe that the most prominent players in the global solar market, more and more figure also in the list of highest installed system capacities per inhabitant. In 2021, among the 10 largest annual solar markets, only 4 were also part of the top 10 markets in terms of installed W/capita – namely Australia, Germany, Japan, and South Korea. In 2022, there are now 5 players that feature in both the top 10 of annual markets, and the top 10 of installed watt per capita: Australia, the Netherlands, Germany, Japan and Spain. Europe is now the most represented continent, with three players appearing in both rankings.

Few changes took place in the top 5 markets in terms of installed capacity per inhabitant. The podium remains the same with Australia (1,191 W/capita) leading, ahead of The Netherlands (1,029 W/capita) and Germany (815 W/capita). The Netherlands has joined Australia in the exclusive club of countries that reached installation level of over 1 kW per inhabitant in 2022. Both countries are expected to hold their positions as the per capita solar leaders. On the fourth position, Denmark with 713 W/capita is climbing its way up from the 7th position it held in 2021, relegating Japan at the fifth position with 677 W/capita.

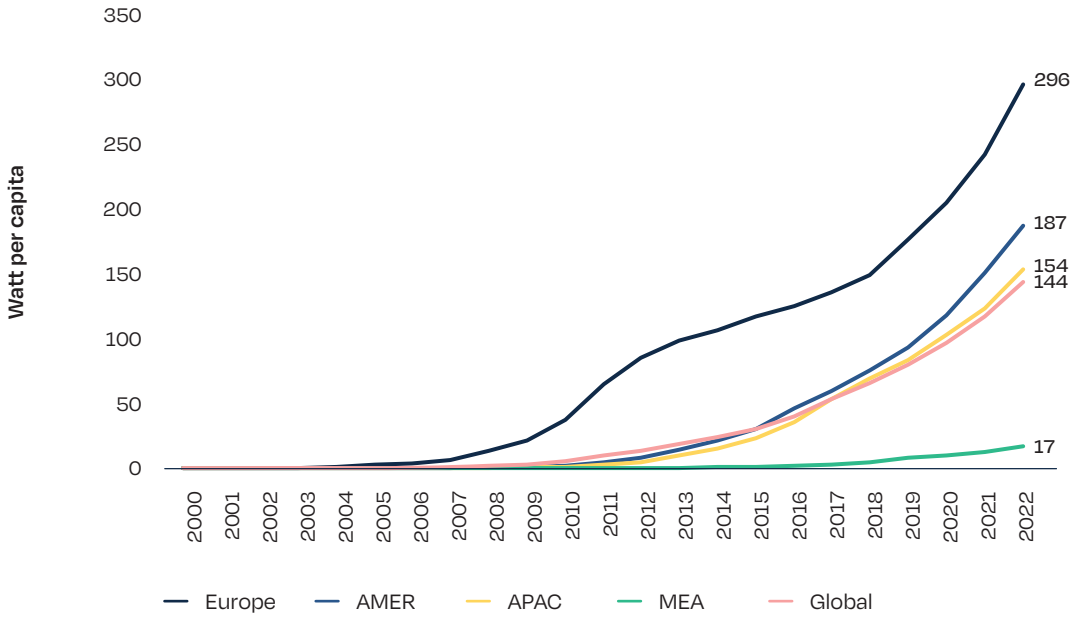
FIGURE 14 WORLD TOP 10 COUNTRIES SOLAR CAPACITY PER CAPITA 2022



Among the largest annual solar markets, China, the United States and India stand at 283, 417, and 55 W/capita, respectively. They hold position 26, 17, and 64 in terms of countries with the highest installed capacity per inhabitant, a striking difference compared to their absolute installation levels.

In 2022, an average of 144 W/capita were installed across the globe, up 23% from the 117 W/capita in 2021 (see Fig. 18). At 296 W/capita, Europe has the highest regional average, followed by the Americas (187 W/capita), APAC (154 W/capita), and MEA (17 W/capita).

FIGURE 15 SOLAR PV WATT PER CAPITA BY REGION, 2000-2022



PROSPECTS 2023 - 2027

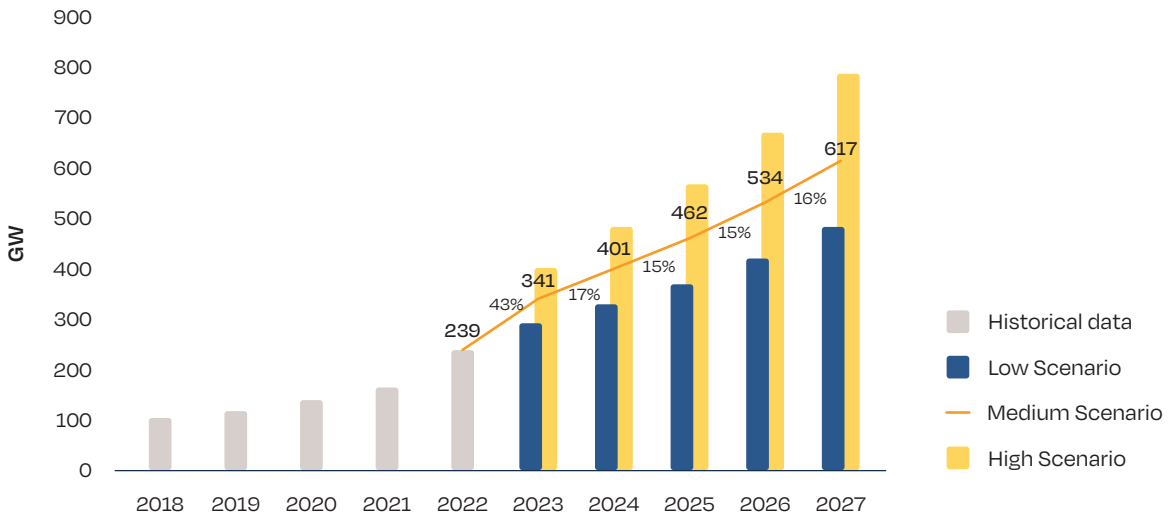
Forecast 2023

At the onset of 2022, there was optimism on the demand side that the high prevailing prices in the solar sector would decrease. However, buyers of solar products had to wait until the second half of 2022 to witness a stabilisation in solar prices, with a downward trend slowly appearing only towards November and December 2022. While the prices of silicon, wafers, cells, and modules are still higher than a couple of years ago, prices came down during the first months of 2023, a relief for the industry after an upward trend lasting almost 18 months. Many analysts are now expecting prices to continue to decrease as new production capacities are coming online, mostly concentrated in China. Additionally, the prediction that many developers would have postponed their projects to 2023 seems to have come true. The first 2023 quarterly numbers of China alone indicate an increase of 155% compared to the first quarter of 2022.

On a wider perspective, the global economy is still impacted by inflation and is grappling with the enduring repercussions of the energy crisis. The Euro area entered 2023 with inflation rates over 8%, now down to 7% as of April 2023. The annual inflation rate in the US also fell to 4.9% in April 2023, its lowest point since the 9.1% of June 2022. The situation is China is less severe, with inflation rates now down to between 0-1%, from 2.8% in September 2022.

In this context, the solar industry is expected to witness remarkable growth in 2023. According to our Medium Scenario, newly installed solar capacity is projected to reach 341 GW, reflecting a growth rate of 43% compared to the 239 GW installed in 2022 (see Fig. 16). Our Medium Scenario estimate might appear slightly more conservative compared to recent forecasts of other solar analysts. End of March, S&P Global (formerly IHS Markit) revised upwards its 2023 forecast by 30 GW to 360 GW, while PV Infolink's market update, also released in March, expects 351 GW of installed capacity in its most probably scenario. In its latest solar market forecast, BloombergNEF became also more ambitious, estimating installations to range between 233 and 380 GW with a mid-point of 344 GW, up from 316 GW assumed in January 2023. There are industry experts who believe the market will absorb as much as 400 GW, while the IEA, which just published its Renewables 2023 report, is standing out on the other side. The IEA also hails solar as the leading force in renewable deployment, but it expects only 286 GW of solar additions in 2023 in its Main case, and slightly above 300 GW in its Accelerated case. However, this is also strongly up from its 2022 installation number of 220 GW, which is also much lower than the estimate of anyone else.

FIGURE 16 WORLD ANNUAL SOLAR PV MARKET SCENARIOS 2023 - 2027



In any case, all analysts' forecasts clearly indicate that solar deployment is proceeding at a strong pace. Our Medium Scenario anticipates that the very high 45% growth rate experienced 2022 will be basically repeated in 2023. What's more, it assumes that the annual market will be more than 100 GW larger than last year – such steep pace of deployment was outside anyone's radar until very recently (see our comparison with previous forecasts on p. 40).

Modelling the worst case for 2023, our Low Scenario anticipates market growth of 292 GW, that would be still up 22% from 2022. This lower estimate is very unlikely to turn into reality given the strong demand for solar in the first months of the year around the world. When we wrote the previous GMO edition, Shanghai was still under Lockdown, but today any strict COVID-19 restrictions seem inconceivable, after China ended its zero-COVID policy in December 2022 that was followed by a massive infection wave. An expansion of the Russian war against Ukraine to other countries is a possibility, but a big spill over seems rather unlikely in the near future.

Much more likely is a market development in direction of our High Scenario, which anticipates solar additions of up to 402 GW this year – a number that is higher than the upside potential estimated by BNEF and S&P (both at around 380 GW). With energy security still high on the agenda of many countries, and the record-high energy prices from last year still on policy makers' mind, they continue their work on implementing measures to ease development, installation and grid-connection of solar systems ahead of the next winter. And with product prices falling along the value chain now for several months – and no end in sight when looking at the industry's overcapacities that are only growing, this price development trend will trigger demand, and likely be reflected already in this year's numbers.

Regional market developments 2023

The market in **Asia-Pacific** will continue to be dominated by the two largest countries, China and India, representing a combined 79% of the region's 2023 installations. The market in China has now finalised its transitional phase from feed-in tariffs to auctions and non-subsidised systems. It showed astonishing resilience throughout the pandemic and reached 48 GW in 2020, then 54.9 GW in 2021, and 2022 marked again a record year of 94.7 GW, a 72% year-on-year growth rate. This was significantly higher than the global solar PV market expansion rate, which stood at 45% in 2022. In our previous assessment, we had estimated the Chinese solar market to grow by 59% in 2022 to reach 87.2 GW.

Industry analysts widely agree that 2023 will witness a new level of solar demand in China, being pushed upward by growing electricity needs, lower PV product prices, and political targets for renewable development. Our Medium Scenario for China leans more towards the optimistic side, anticipating 141 GW, a 49% YoY growth rate. Our upbeat expectations stem from the fact that in the first quarter of 2023 China connected a record-breaking 33.6 GW_{AC} (38.7 GW_{DC})[2] of PV capacity to the grid, a 155% growth from the same period in 2022. By the end of April 2023, it installed 48.3 GW_{AC} (55.5 GW_{DC}), according to China's National Energy Administration. Projections from various analysts show a wide range, but are all north of 100 GW. While the China Photovoltaic Industry Association (CPIA) expects the market to be somewhere between 95 GW and 120 GW, TrendForce forecasts 148 GW. The booming solar rooftop sector, which was even bigger than the ground-mounted systems segment in the last two years, has become a major driver of growth in China's solar market, extending beyond residential areas and making its mark in the commercial and industrial segment, where rising power prices have been posing a strong incentive for solar investments.

China has a history of surpassing its renewable targets. The solar sector outperformed the development goals set in the three previous national Five-Year Plans (FYPs). The current 14th FYP published in July 2022 has set an increase in the renewable share in the electricity mix from 28.8% by the end of 2020 to 33% by 2025. The Nationally Determined Contribution (NDC) is also very likely to be reached 5 years earlier. The NDC is targeting 1,200 GW of wind and solar capacity by 2030, but the country currently has already around 810 GW installed (380 GW of wind and 430 GW of solar). The country also has programmes for developing wind and solar in desert regions, with a target of installing 450 GW of wind and solar. As of March 2023, 97 GW have already been grid-connected, and construction of other solar locations are progressing smoothly, according to China Global Television Network (CGTN). The termination of the country's 'Zero-COVID' strategy has also cut the overall economy some slack, with positive repercussions on large-scale solar projects. If China's solar market achieves the projected 49% annual growth in 2023, as outlined in our Medium Scenario, its global market share will rise to 41%. Under our High Scenario, the market could grow up to 158 GW. This ambitious projection would stem from the grid-connection of many projects that got stacked in queue during the 2021-2022 and a big boost through prices for modules collapsing in early summer.

Following the rebound experienced in 2021 with installations of 14.2 GW and a 265% growth rate, **India's** progression continued but slowed down, reaching 17.4 GW in 2022. We anticipate a relatively slower growth year in 2023, with approximately 20 GW of newly installed capacity, representing a 15% growth compared to the previous year. The market keeps expanding, but it is important to consider India's historical sensitivity to PV product prices. The implementation of a basic customs duty of 25% on solar cells and 40% on modules from April 1st 2022 may result in project delays. There were also little module imports from China in the first months of the year. As a result, our Low Scenario assumes no growth in annual installations. On the other hand, after India failed to meet its 100 GW target by the end of 2022, the government is implementing various measures to reach its ambitious goal of 280 GW of solar PV by 2030. Accomplishing this target would require the annual market to experience rapid growth, averaging 25 GW per year between 2023 and 2030. Considering India's gigantic solar potential and the government easing its protective measures for the moment to bridge the gap until large volumes of home-made products will be available, our High Scenario projects an increase to 27 GW installed in 2023.

2 China solar PV capacity is typically expressed in DC for rooftop systems and in AC for utility-scale systems. For utility-scale, a 1.15 AC/DC conversion factor has been used in our analysis.

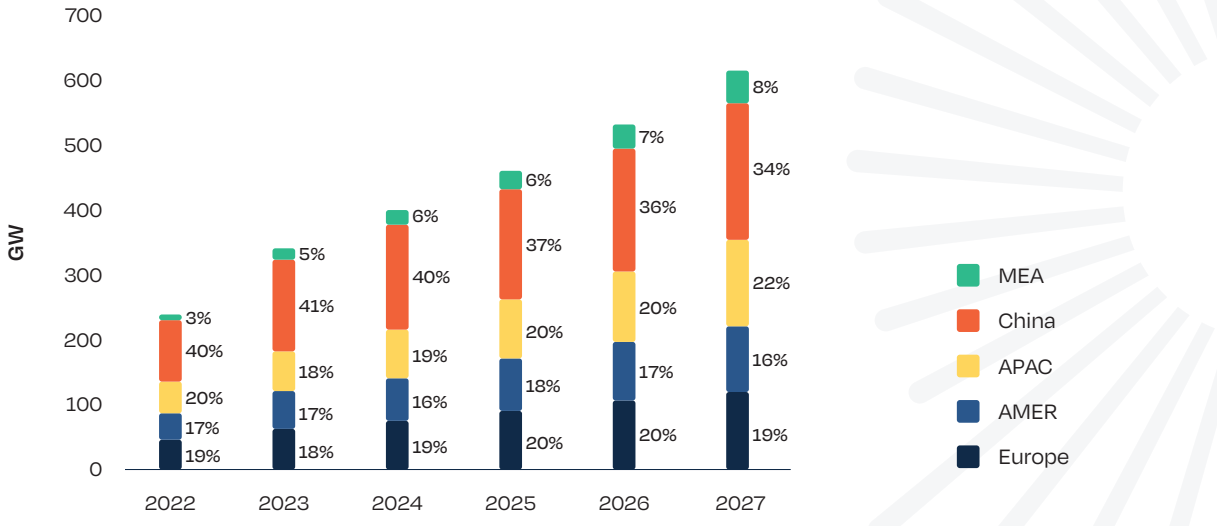
Different developments are expected across most Asia-Pacific GW markets in 2023, with Australia projected to grow by 65% to 6.5 GW, **Taiwan** continuing its positive trajectory from 2 GW in 2022 to 2.6 GW in 2023, and Pakistan, which just crossed the GW-scale for the first time in 2022, now anticipated to reach 1.3 GW in 2023. A heavyweight in the region from the beginning of the solar on-grid era, **Japan** was projected to shrink in 2022 but in fact managed to remain stable at 6.5 GW. As the country continues its transition away from the feed-in tariffs period toward more diverse business models, the market is expected to grow only marginally to 6.7 GW in 2023. On the contrary, South Korea's political shift towards inflexible nuclear and the reduction of its renewable target from 30.2% to 21.6% by 2030 has negatively impacted its solar market. The downturn experienced in 2022 is expected to stay, with the market further dropping to 2.4 GW in 2023, a 17% annual reduction.

The APAC region as a whole will continue to dominate global demand, accounting for 60% of total installations in 2023 (see Fig. 17). However, when considering only the installations in countries other than China, the region's share is projected to decline by 2 percentage points.

Europe's market is projected to experience substantial growth in 2023. It added 46.1 GW in 2022, a plus of 14.1 GW from 2021, and is assumed to add 62.4 GW in 2023, a 35% annual increase. However, due to China's dominance, the continent's market share will likely shrink a little by 1 percentage point to 18%. The European Union (EU) is driving solar growth through its Green Deal and REPowerEU initiatives and the aim for carbon neutrality by 2050. The invasion of Ukraine by Russia has motivated several European countries to prioritise low-cost and versatile solar power as an important means to reduce dependence on Russian gas and improve energy security.

Within the EU-27, all but one member state, **Denmark**, are projected to install more solar capacity than the year before. The outlooks for **Germany** and **Spain** are particularly optimistic – both are modelled to grid-connect 11.8 GW and 11.4 GW, respectively. The strong deployment in the first quarter of 2023 in Germany projects a market almost 3 GW above the government target, and surpassing the 10 GW annual installation level for the first time. Despite the fact that conditions for the major residential solar & storage incentive programme have worsened, Italy is also assumed to be on track for further growth, from 2.5 GW in 2022 to just above 4 GW in 2023. Over 1 GW was deployed in

FIGURE 17 EVOLUTION OF GLOBAL ANNUAL SOLAR PV MARKET SHARES UNTIL 2027



the first quarter, backed by installations below 20 kW, which added 647 MW. C&I installations represent the second largest segment, while utility-scale still needs to find its sweet spot for larger growth. Other European countries, including **Poland**, the **Netherlands**, **France**, **Greece**, **Austria**, **Belgium**, **Hungary** and **Sweden** are also anticipated to contribute meaningfully to the solar market this year. Among the non-EU countries, **Türkiye** is believed to install 2.1 GW, while the United Kingdom, reappearing on the GW map in 2022 after five years of absence, is back for good and is anticipated to grow to 1.8 GW in 2023. Rooftop-driven Switzerland closes the picture with new additions of 1.2 GW in 2023. Overall, Europe's solar market is poised for growth, driven by legislative initiatives, energy transition plans, and the desire for energy independence from Russian gas. Despite facing challenges such as permits, grid capacity, and skills shortages, Europe will remain a major player on the global solar map in 2023 and beyond.

The **Americas**' market share will remain stable at 17% in 2023, allowing the continent to keep its position as the third largest region for solar installations, at 58.5 GW. The main driving force behind solar adoption in the Americas is the United States, which is expected to hold a 60% share in 2023, up from 53% in 2022. The passing of the Inflation Reduction Act (IRA) in August 2022 manifests the Biden Administration's strategy to turn the US into a global clean energy power house. The recent legislation raised the investment tax credit (ITC), which serves as the primary investment mechanism for solar projects in the country, from 26% to 30% for both commercial and residential initiatives and will remain in effect until the end of 2032. That will provide the basis to turn the substantial development pipeline of utility-scale projects into real power plants, while the rooftop sector will continue to thrive, even if discussion about net metering modification might pose challenges. The legislation is also aiming to spark a new chapter in solar manufacturing via both support on the Capex and Opex side. Following the IRA announcement in August 2022, large investments in new factories have been announced – from domestic companies but also from solar technology leaders in Europe, Korea, and China, among others.

Furthermore, a previously significant source of uncertainty for solar growth has now become less critical. Last year, the US Department of Commerce (DOC)'s investigation into the potential imposition of anti-circumvention tariffs on crystalline silicon PV modules and cells from Cambodia, Malaysia, Thailand, and Vietnam put a question mark on future PV deployment rates. However, in June 2022, President

7.5 MW, Pfaffenweiler, Baden-Württemberg, Germany.

Biden introduced a tariff exemption for two years on solar modules manufactured in these countries. This measure is aimed to support solar installers until substantial domestic manufacturing capacities are ready to support local demand. While the tariff exemption has been recently confirmed by the White House and will remain in place until June 2024, other policy and trade issues are still causing headaches to solar developers in the US. The implementation of a Withhold Release Order (WRO) in June 2021 empowers US Customs and Border Protection to detain solar module imports from China based on forced labour allegations. Missing administrational procedures have led to large volumes of solar modules being locked in warehouses, while module imports from Chinese leading suppliers have been reduced to very small amounts as companies shy away from the import risks.

Despite these obstacles, the United States are probably the world's most attractive location for solar investments today; the IRA is a historical piece of legislation in the country's clean energy policy, supporting both the downstream and upstream solar sector, including balance of system manufacturers. Our Medium Scenario predicts 60% growth in solar capacity to 34.9 GW this year, while acknowledging the difficulties faced mostly by the WRO, which is accounted for in our Low Scenario with a projected capacity of 27.9 GW.

In **Brazil**, the second most important market in the Americas, the outlook for this year appears somewhat less promising than last year. Brazil still benefits from an established and relatively consistent power tender scheme and there is a rapidly growing corporate solar market without subsidies. Nevertheless, starting from 2023, modifications have been made to the terms of the very lucrative net-metering program for systems up to 5 MW. These changes, which encompass a progressive fee for using the grid when electricity is injected, led to run for the money in 2022. As a result, after growing by 99% last year, the Brazilian market is not foreseen to grow further in 2023 - at 10.6 GW, however, it will likely stay at the previous year's high level, accounting for 18% of the American continent.

On a less positive line, **Mexico**, another long-standing GW-level solar market in the Americas, though a much lower level, continues to encounter challenges in its political environment for renewable energy deployment. Consequently, solar installations in Mexico are expected to slightly decline by 8% to 1.1 GW in 2023.

On the other hand, **Chile** is becoming increasingly a key player in the region, with over 1.8 GW installed in 2022 and strong growth expectations of 38% to 2.5 GW in 2023. The South American country, now the third largest in the region, will account for 4% of the market in 2023. The nation possesses one of the most abundant solar irradiations globally: its northern region, characterised by elevated altitude, frequent absence of clouds, and comparatively low levels of ozone and water vapor, stands as one of the prime locations on the planet for photovoltaics. Nonetheless, the country's lack of transmission lines poses a challenge to solar deployment in the mid-run.

The increase in installations in 2022 did translate into a market share gain for **Middle East and Africa (MEA)**, from 2.8% to 3.5%. The situation is expected to be similar this year. With the addition of 17.1 GW, the region will experience an impressive growth rate of 106%, largely surpassing the record levels achieved in 2019. According to our Medium Scenario, the MEA region is projected to expand by 1.5 percentage points, reaching a global market share of 5%. This growth will be primarily driven by the United Arab Emirates (UAE) and South Africa. While the latter was already a GW market in 2022 with the deployment of several corporate procurement projects, the UAE was focused on bringing its 2 GW Al Dhafra project online this year. The last panels have been installed in April 2023 and the project will be commissioned this year, ahead of the upcoming COP28 event in the country. A new addition on our GW-scale radar in 2022, Israel will very likely continue its upward trend in 2023. Numerous countries in the region, all blessed with very favourable irradiation conditions, are increasingly recognising the cost advantages, business and energy security potential of solar power, leading to an upsurge in solar activities throughout the area.

Global Solar Market Developments 2024 to 2027

The mid-term global economic outlook is uncertain and heavily dependent on extent of the financial sector turmoil, the level of inflation, and the unfolding of the conflict in Ukraine. Not only predicts the International Monetary Fund (IMF) in its April released World Economic Outlook a slowdown in global growth for this year, which is supposed to drop from 3.4% in 2022 to 2.8% in 2023, and in advanced economies fall from 2.7% to 1.3%, and potentially even below 1% in the same period; it outlines a "rocky recovery" after 3 years of COVID-19, projecting very little growth for 2024 – up to 3% in average worldwide, and 0.1% points in advanced economies. While global headline inflation is believed to fall from 8.7% to 7.0% as a result of lower commodity prices, the IMF sees the underlying core inflation to decline slower, and mostly unlikely to return to target before 2025.

Despite these economic challenges, and as we can already experience in 2023, there will be significant demand for solar PV power in the coming years thanks to strong product price decreases and the multiple benefits the technology offers. As the climate emergency remains on the radar of governments, again and again reminded through climate disaster events, energy security is a fairly new argument to support the solar case. Both priorities were reflected in the commitment of the G7 during their summit in April 2023 in Japan, when the group of 7 leading industrial nations agreed to add combined solar capacity of more than 1 TW by 2030, along with 150 GW offshore wind.

Compared to the previous GMO, solar PV forecasts for the years from 2024 onwards have been notably increased. The market in these years is expected to continue expanding in the low two-digit range, after the extraordinary boost that took place in 2022 and 2023. Demand will be supported by the ongoing gigantic expansion of solar production capacities along the whole value chain, with established manufacturers investing heavily in additional capacities and many new players entering the market. As the emphasis on local production hubs has grown in light of global trade frictions and the increasing recognition of solar as a crucial technology for energy independence, the majority of the leading Chinese companies have already announced to expand abroad.

The Medium Scenario projects the global solar market to reach the 400 GW milestone in 2024. This represents a 17% growth rate compared to the 341 GW to be added in 2023.

Between 2024 and 2027, the world's top three solar markets, China, the United States, and India, will account for 51-57% of global solar demand, declining from the 58% projected in 2023. Each of these countries is expected to install more than 20 GW in 2024, with China leading at 161 GW, followed by the USA at 42.1 GW, and India at 24.5 GW. In 2027, these three countries are forecasted to reach a combined installation capacity of 313 GW, with China being the only country surpassing the annual installation level of 200 GW, the US exceeding 60 GW, and India remaining slightly below 40 GW. Germany is the only other country globally installing more than 20 GW in 2026, closely followed by Spain at 18.1 GW.

The Chinese government's solar strategy for the majority of the GMO forecast period until 2027 is based on its 14th FYP (2021-2025). This Five-Year Plan aims for 50% growth in renewable energy generation - from 2.2 trillion kWh in 2020 to 3.3 trillion kWh in 2025, strives for a 2025 renewable electricity consumption share of 33%, up from 28.8% in 2020, and targets over 50% of China's incremental electricity and energy consumption to be sourced from renewables between 2021 and 2025. The Medium Scenario anticipates that the Chinese PV market will grow to 170 GW in 2025, reach 189 GW in 2026, and further increase demand to 211 GW in 2027.

Regardless of the ongoing discussions surrounding import tariffs and the WRO, the United States is poised to continue its solar growth trajectory in the coming years. The momentum that the IRA is building for clean energy expansion is massive and the prolongation of the Investment Tax Credit until 2032 will transform the country's future energy development. According to our Medium Scenario, the US is projected to grow from 42.1 GW in 2024 to 63.5 GW in 2027. Even in our worst-case scenario, we still anticipate a growth to 41.3 GW by 2027, and up to 85.7 GW in the most optimistic case.

India faced a setback in missing its 100 GW (AC) National Target by the end of 2022. However, in the upcoming years, India will be fully focused on meeting its 500 GW of installed renewable capacity, out of which 280 GW are from solar power. We predict that

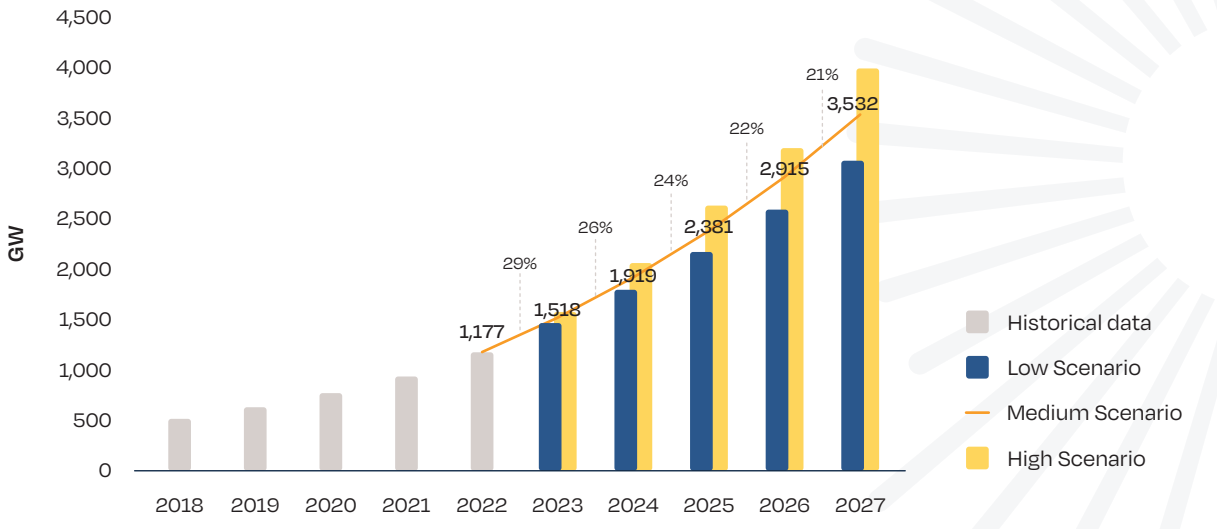
India will add 24.5 GW in 2024 and 28.4 GW in 2025 and up to 38.3 GW in 2027. While the utility-scale sector will continue to be the primary driver of solar growth in India, there is an expectation that the distributed segment, which played the key role in falling short of the 2022 target, will transition away from its niche status in the medium to long-term.

Looking ahead from 2024 to 2027, there will be a redistribution of market shares among different regions. After gaining significant market share in 2023 reaching 41%, China is expected to revert to its 2020 level with a 34% annual installation share in 2027. The Americas will experience a slight decline, dropping from 17% in 2023 to 16% in 2027. On the other hand, APAC excluding China, MEA, and Europe are all expected to gain some market shares in the 2023-2027 period. The APAC region will experience the largest gain, growing from 18% to 22%, reflecting the development of solar in many countries outside China. The MEA region shall gain 3 percentage points from 5% to 8% driven by major projects in the Middle East and Saudi Arabia's commitment to achieving its '40 GW by 2030' target. Europe's growth will rely on the European Union's efforts to enhance its 2030 renewable targets and further reduce dependence on Russian energy imports through the REPowerEU plan. Europe is expected to reach a 19% share of global solar, by adding 120 GW in 2027.

Less than a decade since it surpassed the 100 GW milestone in 2012, the world's total operating on-grid solar capacity has exceeded 1 TW in early Q2/2022. According to our Medium Scenario, it is projected to comfortably cross the 2 TW landmark in early 2025 (Fig. 18). The current period of strong prices reduction for raw materials and PV products will boost demand for solar power. Concerns about energy security resulting from the Russian war against Ukraine will further expedite the global shift towards solar energy. The milestones for global installed PV generation capacity over the next five years are projected as follows: 1.5 TW in 2023, 1.9 TW in 2024, 2.4 TW in 2025, 2.9 TW in 2026, and 3.5 TW in 2027. Under optimal conditions, the PV fleet could pass the 2 TW level already in 2024, and reach up to 3.9 TW by 2027. Under our Medium and High Scenarios, the global operating solar PV fleet almost doubles every 3 years.

The top 20 markets with the highest 5-year installation potential only see small changes compared to the previous edition (see Fig. 19). The top four markets, namely China, the US, India, and Germany, remain in the same order, while the absolute additions are substantially higher. It is noteworthy that in the Medium Scenario, the top 3 countries are still the only ones expected to install over 100 GW each. China is leading at 873 GW (+367 GW compared to 2022 edition), followed by the US at 252 GW (+63

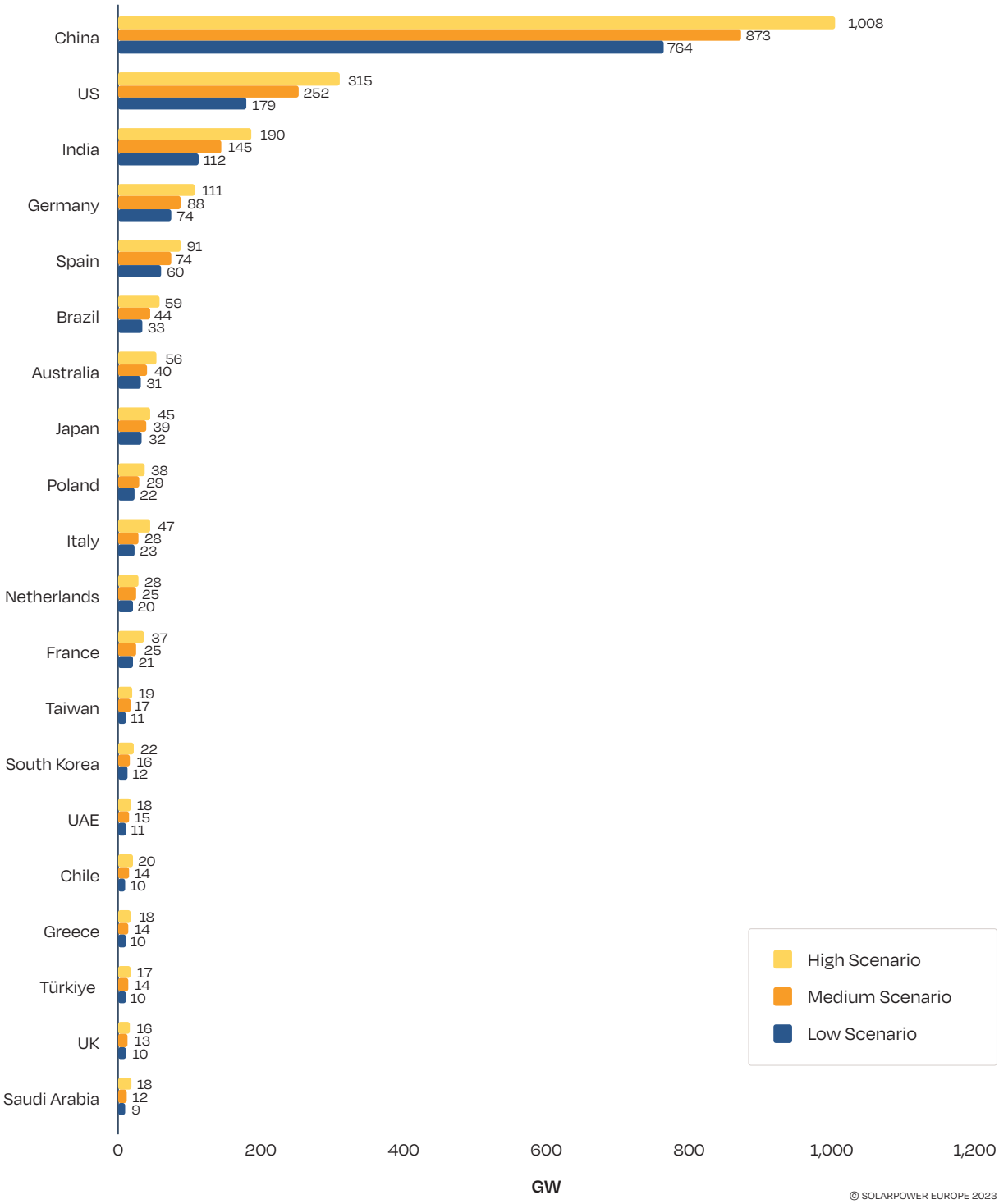
FIGURE 18 GLOBAL TOTAL SOLAR PV MARKET SCENARIOS 2023 - 2027



GW), and India at 145 GW (+29 GW). The number of countries expected to add at least 20 GW in the next five years is the same as last year: 12, with Italy pushing South Korea out of the list.

However, according to the Medium Scenario, all the top 20 markets are projected to install at least 10 GW each from 2023 to 2027. An increase from last year when only 17 markets were anticipated to reach that

FIGURE 19 TOP 20 MARKETS SOLAR PV ADDITIONS 2023-2027



threshold. The range of new capacity additions varies widely within this group, from 873 GW in China to 12 GW in Saudi Arabia, which is again significantly higher than the previous year's edition.

The members of the top 20 list are very similar to last year's, with only one notable substitution: the UK is coming back at the 19th position, replacing Vietnam, which stood at the 16th position last year. To enter the top 20 market prospects, capacity volumes of at least

FIGURE 20 TOP SOLAR PV MARKETS' PROSPECTS

Country	**2022** Total capacity (MW)	**By 2027** Total capacity Medium Scenario (MW)	**2023-2027** New capacity (MW)	**2023-2027** Compound annual growth rate (%)	Political support prospects
China	402,945	1,275,725	872,780	26%	
United States	140,773	393,268	252,495	23%	
India	77,548	222,117	144,569	23%	
Germany	67,964	155,651	87,687	18%	
Spain	27,406	101,621	74,215	30%	
Brazil	24,023	68,028	44,005	23%	
Australia	31,024	71,208	40,184	18%	
Japan	84,136	122,976	38,840	8%	
Poland	12,189	40,811	28,622	27%	
Italy	24,610	53,033	28,423	17%	
Netherlands	18,051	42,977	24,926	19%	
France	15,710	40,400	24,690	21%	
Taiwan	9,749	26,275	16,526	22%	
South Korea	24,284	40,476	16,192	11%	
UAE	3,682	18,385	14,703	38%	
Chile	6,514	20,921	14,407	26%	
Greece	5,524	19,671	14,147	29%	
Türkiye	9,525	23,111	13,586	19%	
United Kingdom	15,912	28,881	12,969	13%	
Saudi Arabia	1,236	13,279	12,043	61%	

12 GW are now required, compared to 8 GW in the previous year. In the High Scenario, China is expected to install 1,008 GW, breaking the 1 TW level. Under the Medium Scenario, China will install more capacity than the 16 following countries, and more than 3 times what the United States is projected to install in the 2023-2027 period. Altogether, the top 20 markets are expected to grid-connect 1.8 TW or 83% of the total, a substantial increase from our GMO 2022, when we estimated the group to install 1.2 TW over the coming five years (2022-2026), and the 0.9 TW between 2021-2025 in our GMO 2021. Under the Low Scenario, the top 20 markets are forecasted to add 1.5 TW, while in the High Scenario they now surpass the 2 TW level with 2.2 TW expected to be brought online by 2027.

Politicians are facing increasing pressure to address the climate crisis, as severe weather events become more frequent and affect larger swathes of the population worldwide. Under this perspective, the 1 TW solar target by the G7 is a political acknowledgment of the paramount role that solar plays in reducing global emissions. Solar energy is being recognised not only for its potential to combat climate change, but also for its ability to create local job opportunities and ensure energy security. Within this context, our weather forecast for the top 20 countries predicts an increasingly brighter future, with only three countries facing some clouds on the horizon, and with all but one expected to experience double-digit annual growth rates (Fig. 20).

While the majority of the countries in this list expects compound annual growth rates (CAGRs) around 20% or above, as last year, the highest 5-year growth rate is expected in Saudi Arabia, with an impressive 61% CAGR. While the country's current solar capacity is still small, the completion of numerous GW-scale projects will be a turnaround point and is expected to pave the way for Saudi Arabia's ambitious goal of reaching 40 GW by 2030. At the other end of the spectrum, Japan stands out with a relatively low CAGR of only 8%, the same as last year, making it the only country in the top 20 with a single-digit growth rate. Still, Japan is a mature solar market, ranked 5th globally in terms of installed capacity per capita, and its growth projections for the next five years indicate the addition of approximately 39 GW in the Medium Scenario.

Türkiye and Brazil are the only two countries with uncertain prospects. In the case of Türkiye, although the government supports solar deployment through auctions and net-metering policies, the overall financial situation of the country could prove challenging. Türkiye has been grappling with very high inflation rates, which can make project financing difficult. In Brazil, the introduction of a grid tariff for net-metering conditions at the beginning of 2023 has

50 MW Margariti solar farm, Greece.

lowered the attractiveness of this very appealing scheme. While Brazil witnessed a surge in solar installations in 2022 that is expected to continue in 2023 until projects are completed, a slower pace of installations is anticipated from 2024 onwards. Despite these challenges, Brazil and Türkiye are expecting a CAGR of 23% and 19% respectively and should bring online over 44 GW and 14 GW each.

South Korea is the only country for which we forecast real bad weather conditions for its solar sector. The country's decision to prioritise the expansion of its nuclear capacity to the detriment of renewables has come at the expense of solar deployment. South Korea has reduced its overall renewable energy target from 30.2% to 21.6% by 2030. As a result, the country has dropped from the 9th position to the 14th position in the rankings. Its CAGR has decreased from 17% to 11%, and the projected installations for the next 5 years have decreased from 26.3 GW to 16.2 GW.

Overall, our weather forecast is sunnier compared to last year. As a surprise to some, the United States had a cloudy forecast because of potential tariffs resulting from the anti-circumvention investigations and the WRO, which materialised into lower installations in 2022. However, the forecast for the country is now fully bright after the introduction of the IRA, which is expected to turbocharge renewable deployment in the country. Italy was also under clouds last year, but the positive legislative evolutions regarding commercial systems and the strong deployment of the first half in 2023 is confirming our views toward the renaissance of the Italian market – we now assume 28 GW of new installations over the coming 5 years, compared to 13 GW in the last edition. But as the conditions of the very generous incentive for residential systems have worsened, it remains to be seen if this sunny picture can be maintained next year.

SEGMENTS 2023 – 2027

Both the rooftop and utility-scale segments experienced strong growth in 2022. The energy crisis played its role and the reaction from citizens was immediate: the rooftop market increased by 50% in 2022, with installations reaching 118 GW, from 79 GW the year before. The increasing adoption of solar by residential and commercial sectors demonstrates a strong interest to generate and self-consume electricity and reduce dependence on the grid, thereby mitigating the impact of power price fluctuations caused primarily by fossil fuels but also nuclear, as an aging fleet in the world's leading atomic power nation France resulted in many of these power plants had to be taken off-grid for maintenance in 2022. At the same time, utility-scale solar PV installations grew by 41% to reach 121 GW, despite high module prices in 2021 and 2022. Large-scale systems remained the main contributor to the total capacity, but the shares of utility and rooftop solar have not been this close to each in three years; utility-scale contributed to 50.5% of total installations and rooftop contributed to 49.5%.

The growth of utility-scale solar could have been higher if it were not for the lingering effects of COVID-19 on supply chains and the increase in prices of PV components. Utility-scale developers are more sensitive to price fluctuations than households for two main reasons. First, the impact of component price increases is more pronounced for larger installations due to their larger scale, which much better absorb installation cost. Second, utility-scale projects are typically driven by commercial purposes and financial gains, making cost increases significantly affect their overall financial viability. By contrast, while residential customers are also seeking financial benefits from solar installations, they do not necessarily rely on their residential systems to establish such a robust business case. Ground-mount systems have to compete in auctions and wholesale markets at completely different price levels.

The growth of the rooftop segment varied across different countries. Among the top 20 solar markets, only Australia, South Korea, and Japan installed less rooftops than the year before. Australia experienced the sharpest decline, with 2.3 GW less than 2021 (-46%), South Korea installed 1.1 GW less in 2021 (-33%) and Japan's rooftop sector decreased by less than 0.5 GW (-9%). All the other largest markets experienced strong growth. The most impressive progress could be witnessed in Brazil, which added an additional 5.3 GW. This giant 193% growth rate from 2021 was pushed by the rush of installations that sought to benefit for the generous conditions of the net-metering scheme before the rule changes in 2023. Two Mediterranean countries, Italy and Spain, also made significant progress. Their rooftop markets increased by 127% and 105% respectively. In both countries, the improvement resulted from policy support, on top of the energy crisis

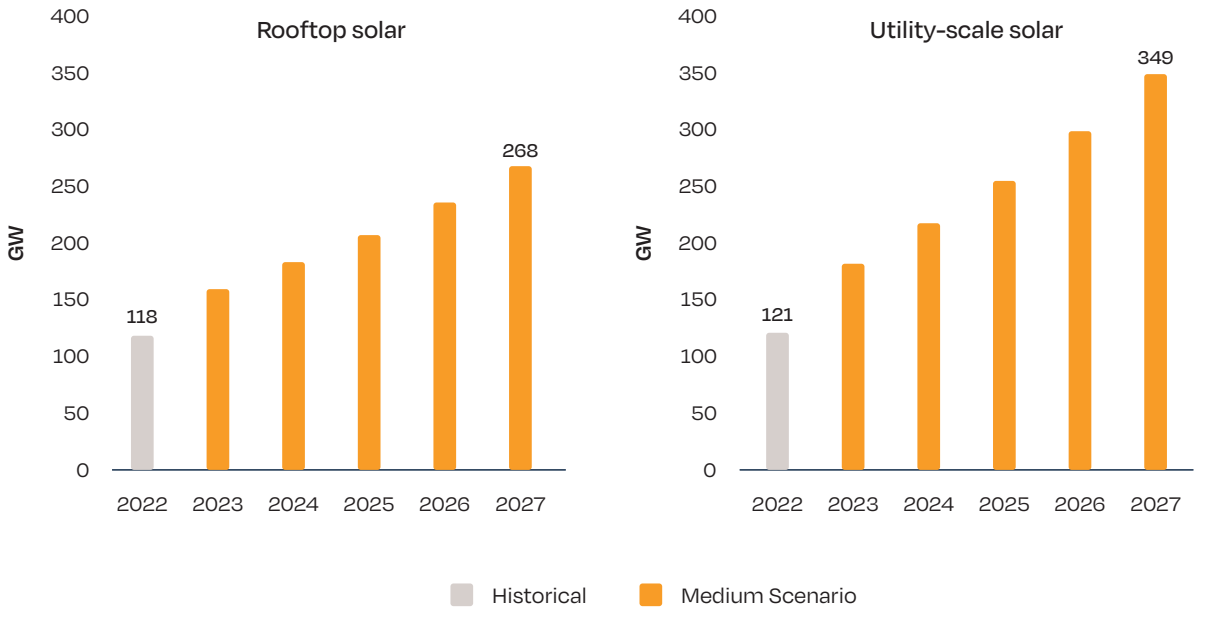
effect. In Italy, the Superbonus has pushed residential installations, while Spain has been working on improving its overall framework for self-consumption since the removal of the so-called 'Sun Tax'. Other notable markets are improving with annual growth rates over 50%: Denmark, India, Austria, China, Greece, and South Africa. Again, the major influencer here was China, where 51.1 GW, representing 54% of its 2022 installation were rooftop systems, up 29.1 GW from its 2021 rooftop installations in absolute terms.

In 2023, the rooftop segment is expected to further increase to 159 GW, a 35% growth from 2022. In the following years, as energy prices are expected to return to lower levels – a development we could already see in recent months, we expect a slight slowdown in the growth rate of rooftops, with annual levels ranging from 13% to 15%. The annual installed rooftop capacity is forecasted to increase to 183 GW in 2024, and up to 268 GW in 2027 in our Medium Scenario, a 126% growth from 2022 levels. The introduction of solar mandates in several countries, however, could provide a new boost to the rooftop market, as does the electrification of heating sector, with several countries pushing heat pumps to decarbonise heat.

In 2022, among the top 20 markets, only one country managed to double its large-scale installations from the previous year: Italy. The country struggled in 2021 with less than 100 MW installed but the segment experienced an impressive +500% growth in 2022 to reach 571 MW of annual installed capacity. Prospects are very bright as we are expecting this segment to double in 2023 and 2024 as well. On the lower end, the United States's utility-scale segment experienced a 18% decrease in annual installations in 2022, reflecting the different trade and supply struggles the country is going through. Nevertheless, boosted by the support offered by the IRA, the US large-scale segment is anticipated to grow strongly and to reach 27.3 GW in 2023, from 13.8 GW in 2022. The growth is expected to continue and reach 46.9 GW in 2027, remaining the second largest utility-scale market in the world after China.

Across the globe, the utility-scale segment is forecasted to reach 182 GW in 2023, a 51% growth rate as module prices are about to reach new record level lows soon. The forecast for 2024 estimates utility-scale installations to reach 218 GW. Over the following years until 2027, the share of utility-scale

FIGURE 21 SOLAR PV ROOFTOP AND UTILITY-SCALE SEGMENTS SCENARIOS 2023-2027



installations is predicted to gradually increase, representing almost 350 GW globally and making up approximately 57% of the total annual installed capacity. Very large-scale ground-mounted power plants, especially those related to green hydrogen production, are likely to contribute to this trend in the latter half of the decade.

However, recent factors such as high electricity prices and the war in Ukraine have led to a shift in plans, with distributed solar seen as a means to enhance energy independence.

The EU-27 region, in particular, needs a rapid response to compensate for the reduction in Russian gas imports. While utility-scale solar has shown resilience during the pandemic, rooftop installations can provide a more immediate contribution, especially given the longer installation time for utility-scale projects. That's why the IEA had already asked in a 10-Points Plan to reduce EU reliance on Russian gas in March 2022, that renewables, and in particular rooftop solar, are needed to bring down gas usage, and suggested a financial support programme for PV rooftop installations. Although the fear-driven run on rooftop solar seems over for the moment as summer is about to start, the IEA has already warned in a recent report on how the EU can avoid gas shortages in 2023 that 60 GW of solar would be needed – more than anticipated in our Medium Scenario – to get safely through the next winter. They also pointed at fast-tracking permitting for renewable power plants and an increase of auctions. Distributed solar is expected to remain the major pillar of the EU-27 for the next two years.

Additionally, residential and commercial power consumers are evolving into prosumers, solar panels are becoming integral building materials, and smart cities are embracing small-scale distributed solar combined with storage and digital solutions. Several sub-national actors have followed California's example of mandating solar installations in new-build homes, and Germany has established rooftop PV mandates in various regions. Consequently, the forecast for rooftop solar development is optimistic, with the rooftop segment projected to maintain a stable share of around 47% until 2023. In the longer term, starting from 2024, rooftop solar may slightly decrease to 43% as permitting issues for utility-scale will have been better managed and it will benefit from lower product prices and its increasing cost advantage over its centralised fossil and nuclear power generation peers. However, even though large-scale solar's share will increase to 57% in 2027, up from 51% in 2022, in absolute terms the rooftop solar market is expected to expand significantly, reaching 268 GW in 2027 from 118 GW in 2022.

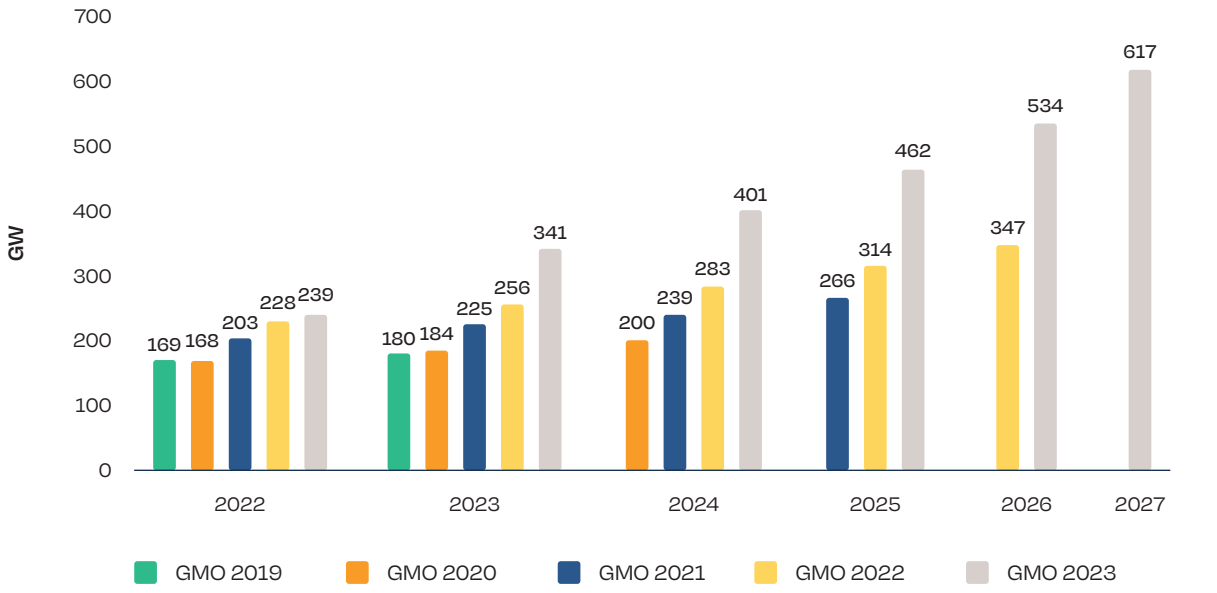
CONCLUSIONS

The GMO 2023 report presents an even more optimistic outlook compared to the GMO 2022 projections, which were published during a time of much higher uncertainty caused by the beginning of the Russian war against Ukraine as well as supply chain disruptions and high product prices affecting the solar industry.

Similar to the previous year's Global Market Outlook, the growth rate predicted in this year's report is larger compared to the previous edition's projections. For 2023, we foresee a deployment rate that is 33% higher than what we predicted in the GMO 2022, reflecting the improved situation on product availability and PV prices. The global energy crisis in 2022 has also dramatically increased policymakers' awareness about the necessity to develop local renewable power generation capacities, not only for climate reasons, but also for energy security and price volatility reasons; and solar has been very high in the rankings because of its unmatched versatility. Operating solar power capacity has reached the TW-scale in 2022, and it looks like it is well on its way to an annual TW level by 2030. Our expectations for 2024 have been further increased by 42%, reflecting our growing confidence in supply and demand of the sector. Additionally, our Medium Scenario outlook for 2025 of 432 GW is 47% higher and the 2026 number of 534 GW even 54% higher compared to the GMO 2022 report.

In terms of installed capacity for 2023, this edition's forecast surpasses the previous year's 256 GW projection by 85 GW, now expecting a market of 341 GW. Looking one edition backward, the milestone of 300 GW was only anticipated to be surpassed in 2025. We now believe that already in 2024 the 400 GW annual installation mark will be reached. To put numbers into perspective, just six years ago in 2017, the total installed global solar power generation capacity was at this level.

FIGURE 22 COMPARISON MEDIUM SCENARIO GMO 2023 VS PREVIOUS GMO EDITIONS

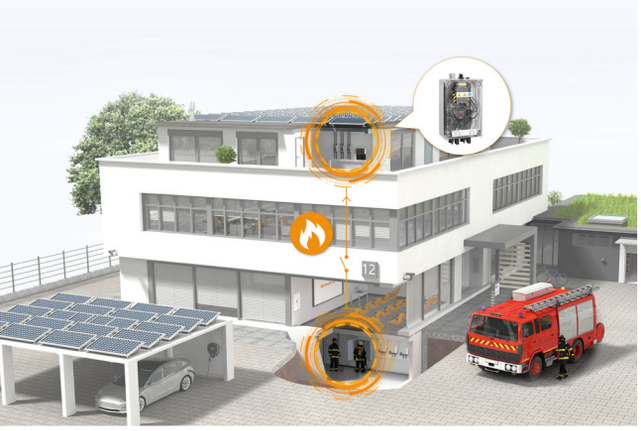


Our growing optimism is rooted in solar's new position as a key actor on the geopolitical energy map. Solar's versatility sets itself apart from other power generation sources, enabling its deployment in various forms such as centralised utility-scale power plants, including innovative variations like agri-PV and floating solar; distributed commercial and residential rooftops, as well as quickly advancing applications in the built environment like building-integrated systems, plug-in solar systems, car parks as well as off-grid solutions, and mobile power applications. Furthermore, when combined with other renewables and storage, today hybrid solar power plants can provide 24/7 power – and offer ancillary services in power markets. If combined with heat pumps, solar power also enables electrification and decarbonisation of the heating and transport sector, at the same empowering consumers at the local level, something no other power generation technology is capable of.

Despite temporary product price increases stemming from the supply chain issue during the pandemic, solar still surpassed fossil fuels and nuclear energy in unsubsidised investment cases throughout 2022. This cost advantage is expected to improve again now that issues in product supply and logistics have been largely overcome. The International Energy Agency expects about 380 billion USD will be invested into solar in 2023, leaving behind investment in oil for the first time.[3]

Each crisis is unique, and although the COVID-19 pandemic has resulted in setbacks in the battle against climate change, the recent energy crisis has yielded the opposite outcome. The spotlight has largely shifted towards renewable energy sources, and solar as its main pillar, to reduce dependence on fossil fuels, the majority which is owned by a few countries. Instead, solar power is freely accessible, and the means to do that can be even manufactured locally if a region or a country really wants it – and in addition to global leader China, the US now does, as the historic IRA legislation shows, for example. However, despite solar power's impressive nearly 50% growth rate in 2022, again surpassing all other power generation technologies, its share in the global power output currently stands at only 4.5%. It needs more ambitious approaches around the world to harvest the gigantic potential of power much faster as time's running out in the race to meet the Paris Climate Agreement.

3 IEA (2023), World Energy Investment 2023.



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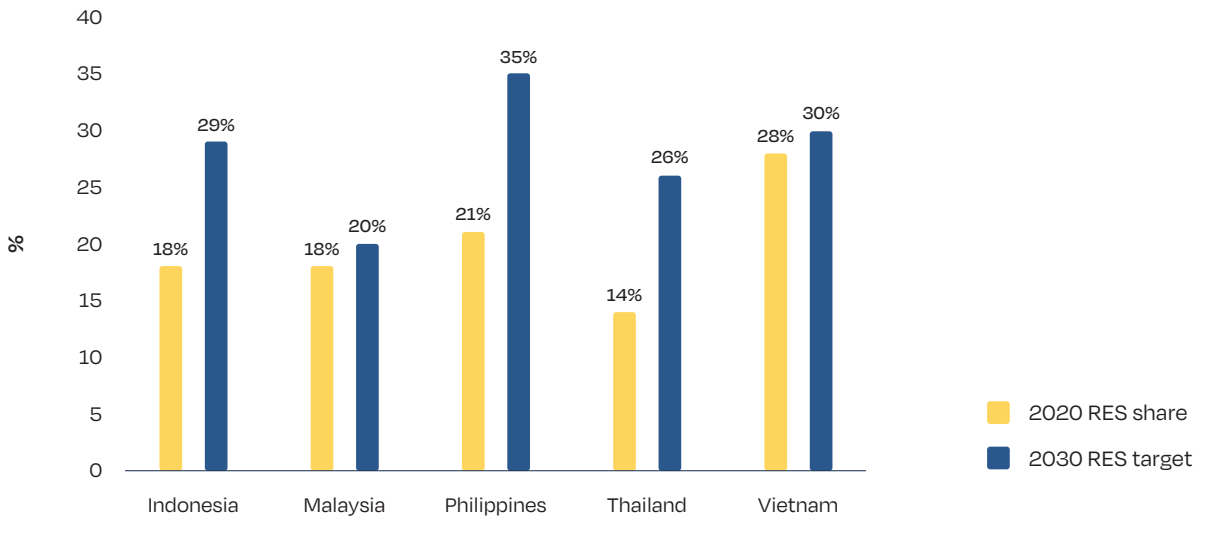
Introduction

The Southeast Asia[3] (SEA) region has witnessed tremendous growth in renewable energy deployment, driven by supportive policies, increased investments, and technological advancements. Solar energy, in particular, has emerged as a key player in the regional energy landscape, with countries like Vietnam, Malaysia, and the Philippines leading the charge. Its growth has been driven by international commitments to reduce greenhouse gas emissions under the Paris Agreement and further accelerated by unpredictable fossil fuel prices that are susceptible to external shocks. Moreover, governments in SEA offered an extra push by setting ambitious renewable energy targets. As shown in Figure 23, the leading SEA countries aim to substantially increase the share of renewables in their energy mix for the next decade.

FIGURE 23 RES SHARES AND 2030 RES TARGETS IN LEADING SEA COUNTRIES



3 The SE Asia region contains 11 countries: Brunei, Burma (Myanmar), Cambodia, Timor-Leste, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam.

As of 2022, the operating solar capacity in the SEA region was estimated to be nearly 32 GW, with a 12% increase over the previous year (Figure 24). A large bulk of this capacity was installed in a single year, 2020, when very favourable policy conditions skyrocketed capacity additions in the region's solar leader, Vietnam. Since the abrupt end of Vietnam's feed-in tariff regime, annual installations in the region have decreased significantly, with a 68% market contraction to 4.2 GW in 2021.

In 2022, significant solar growth took place in most of the countries across the region, but that was not enough to make up for the worsened market conditions in Vietnam. As a result, a further 19% decrease was observed, bringing newly installed capacity to 3.4 GW. Even though the market shrunk over the last two years, positive growth prospects can be seen, considering that new capacity is well distributed across different countries and the regional market no longer depends on one single contributor.

The rapid growth in solar capacity can be attributed to several factors, including favourable policy frameworks, attractive financial incentives, and declining technology costs. Governments have introduced feed-in tariffs, tax incentives, and other support mechanisms to encourage investment in solar energy projects. In addition, the cost of solar technology has declined significantly, making solar power more competitive compared to traditional energy sources.

Furthermore, global trends such as the climate crisis, the COVID-19 pandemic, supply chain bottlenecks, and trade tensions have highlighted the need for a more resilient and sustainable energy system, spurring countries to accelerate their renewable energy development. Many governments have announced stimulus packages and green recovery plans that prioritise renewable energy investment, including solar energy. This has further contributed to the growth of solar capacity in the region.

Another contributing factor is the increasing demand for electricity in the SEA region, driven by rapid urbanisation, industrialisation, and population growth. Solar energy has emerged as a viable solution to meet this growing demand, as it can be deployed relatively quickly and has minimal environmental impacts compared to conventional energy sources. As a result, SEA countries have begun to integrate solar power into their energy policies and long-term energy plans.

FIGURE 24 SOUTHEAST ASIA ANNUAL AND CUMULATIVE SOLAR PV CAPACITY 2017-2022

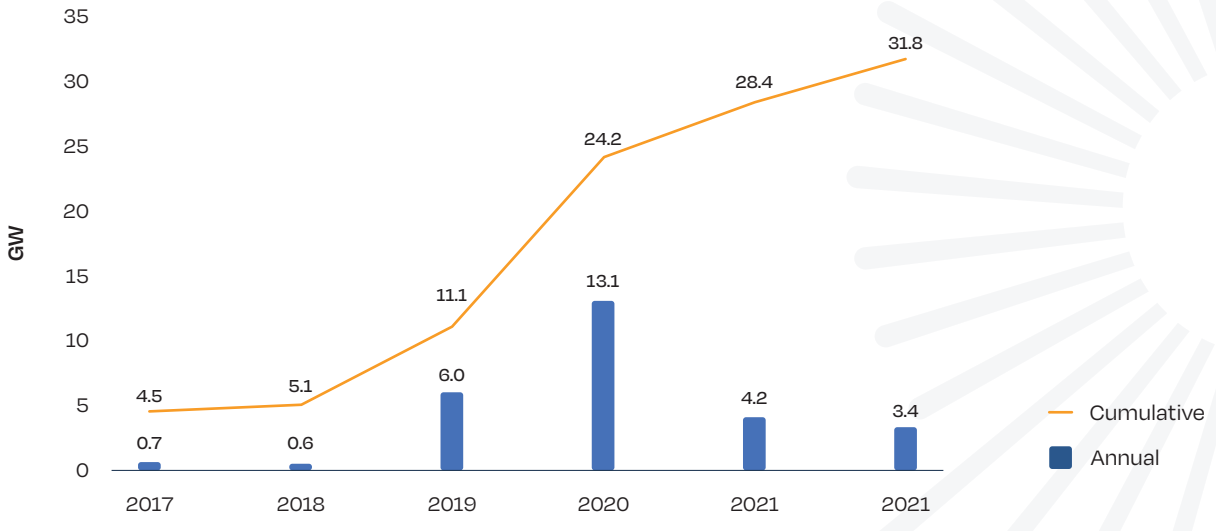
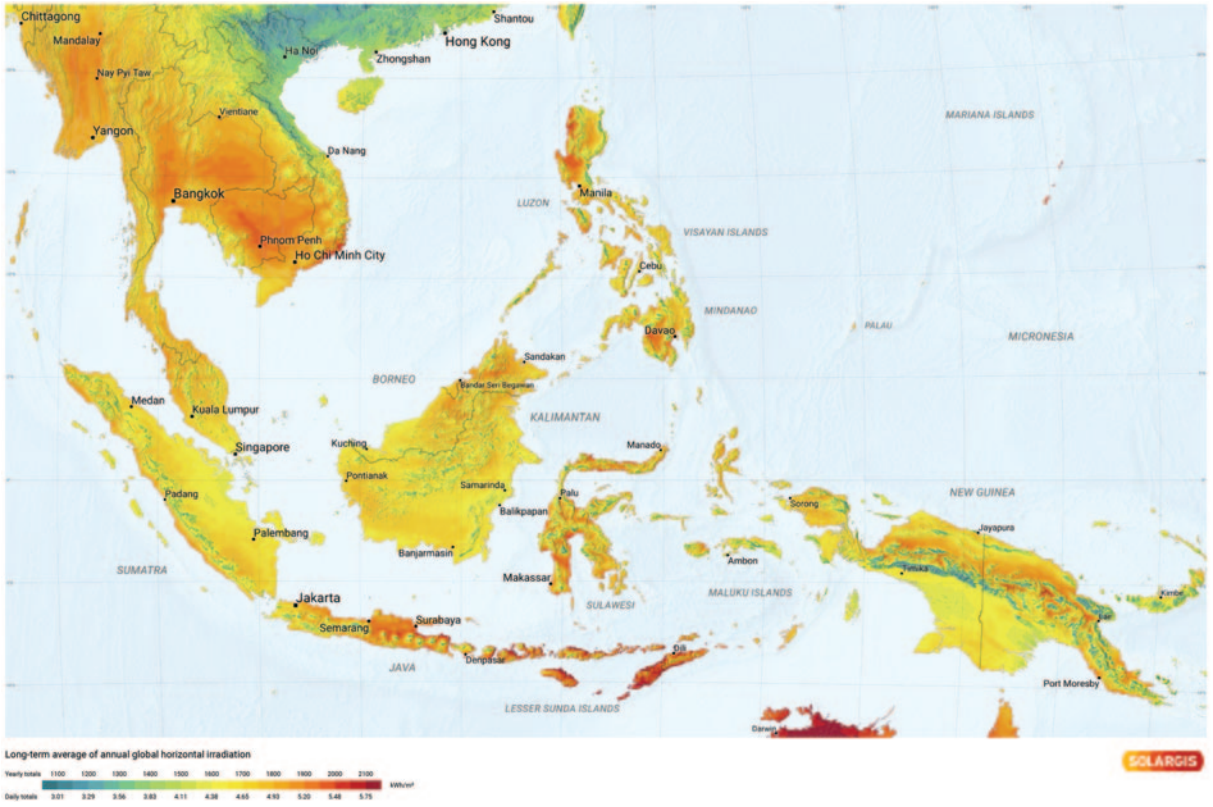


FIGURE 25 SOUTHEAST ASIA'S GLOBAL HORIZONTAL IRRADIATION



SOURCE: Solargis 2019.

Lastly, the SEA region's abundant solar resources have also played a significant role in the growth of solar capacity. Depicted in Figure 25, the region has an average solar irradiance of approximately 5 kWh/m^2/day, which indicates the immense potential for harnessing solar energy to meet energy needs. This potential, coupled with the declining costs of solar technology and supportive government policies, has set the stage for the continued expansion of solar capacity.

Utility-Scale, Rooftop, and Floating Solar

Utility-scale solar energy has been the primary driver of solar capacity growth in the SEA region, with large-scale solar farms being developed in countries such as Vietnam, Indonesia, and Malaysia. These projects, often supported by government incentives and public-private partnerships, have contributed to the rapid expansion of solar energy in the region. Large-scale solar projects are usually supported through auctions involving a competitive bidding process whereby winning projects are offered long-term PPA contracts. In more recent times, corporate PPAs between private off-takers and renewable energy producers have also emerged. In Vietnam, support to large-scale solar has not been through auctions, but rather with attractive and uncapped feed-in tariffs, which led to the record growth registered in 2019 and 2020. Vietnam's Dau Tieng Solar Power Plant, with a capacity of 420 MW, is the largest solar power facility in Southeast Asia.

Rooftop solar energy has also gained momentum in the SEA region, driven by the increasing demand for clean, decentralised energy solutions and the declining costs of solar technology. Countries such as

Malaysia, Indonesia, Thailand, and Singapore have net-metering schemes in place and other incentives to promote rooftop solar installations in the residential, commercial, and industrial sectors. In the Philippines, the net-metering programme has successfully facilitated the adoption of rooftop solar systems, with over 64.2 MW of installed capacity. Vietnam's 'FiT 2' feed-in tariff regime, valid between May and December 2020, offered very attractive rates for rooftop systems, which were higher than the average retail electricity tariff. During this limited amount of time, more than 7 GW of rooftop capacity was installed in the country. In addition to direct support schemes, other types of support to rooftop solar are available in the form of fiscal and financial incentives, typically targeting the C&I sector.

Floating solar installations have emerged as a promising and innovative solution in the SEA region, particularly in countries with limited land availability for large-scale solar projects. Floating solar systems are located on bodies of water, freeing up valuable land resources and also offering additional benefits such as reduced water evaporation and improved panel efficiency due to the cooling effect of water. Countries like Thailand and Singapore are already seeing floating PV installations come online. In the Philippines, over 2 GW of installed capacity is set to be developed in Laguna Lake, Southeast Asia's third largest lake, while in Indonesia a 2.2 GW floating solar project located in Batam is at the planning phase.

To complete the picture, the integration of energy storage systems, such as battery energy storage, is becoming increasingly important in the SEA solar energy landscape, as it helps to address the variable nature of solar power. Several utility-scale solar projects in the region are incorporating energy storage solutions to optimise their solar energy output.

Regional PV Supply Chain Trends

The PV value chain in the SEA region has experienced significant growth and diversification in recent years and several trends have emerged, continuing to shape the regional PV supply chain landscape.

The SEA region has witnessed the rise of domestic PV manufacturing capabilities to meet the growing demand for solar. Countries such as Malaysia, Thailand, and Vietnam have emerged as important players in the global PV manufacturing market, particularly in the production of solar cells and modules. In a global cell market dominated by China (80%), Southeast Asia and South Korea account for 18% of the worldwide production capacity, with the remaining 2% produced elsewhere. These countries have attracted investments from both local and global solar companies, boosting their PV manufacturing capacity and creating jobs in the sector.

The PV supply chain in the region has become more vertically integrated, as companies seek to optimise their operations and reduce costs. This integration includes the entire value chain, from the production of raw materials such as polysilicon, to the manufacturing of solar cells and modules, and the development of solar projects. Vertical integration allows companies to have better control over the quality, cost, and supply of their products, enhancing their competitiveness in the global solar market.

The SEA PV supply chain has seen increased collaboration and cooperation between countries in the region, as well as between SEA countries and external partners. This collaboration has taken various forms, including joint ventures, technology transfers, and knowledge exchange programs. For instance, the ASEAN-India initiative aims to facilitate the exchange of renewable energy, including solar power, between SEA countries and India.

There has been a growing focus on sustainability and environmental considerations within the PV supply chain in the SEA region. Companies are increasingly adopting measures to minimise the environmental impact of PV manufacturing processes, such as reducing waste, improving energy efficiency, and adopting circular economy principles. Governments in the region are also implementing policies and regulations to promote sustainable PV supply chain practices, such as the Malaysian Sustainable Energy Development Authority's (SEDA) guidelines for sustainable solar manufacturing.

Notably, the SEA solar PV supply chain has been influenced by the global trade dynamics in the solar market, particularly the trade tensions between China and the United States. These tensions have led to shifts in the global solar PV supply chain, with some companies relocating their manufacturing facilities to SEA countries to circumvent trade barriers. In 2022, the United States government announced the intention to introduce anti-circumvention tariffs on

the import of cells and modules from Cambodia, Malaysia, Thailand and Vietnam, as a measure to support its local manufacturing industry. However, the tariffs will only enter into force in June 2024, as recently confirmed by President Biden.

Overall, the regional PV supply chain in the SEA region has evolved rapidly in response to the growing solar energy market, with countries in the region emerging as important players in the global solar industry. The trends of domestic manufacturing, vertical integration, regional collaboration, sustainability, and global trade dynamics will continue to shape the SEA PV supply chain in the coming years.

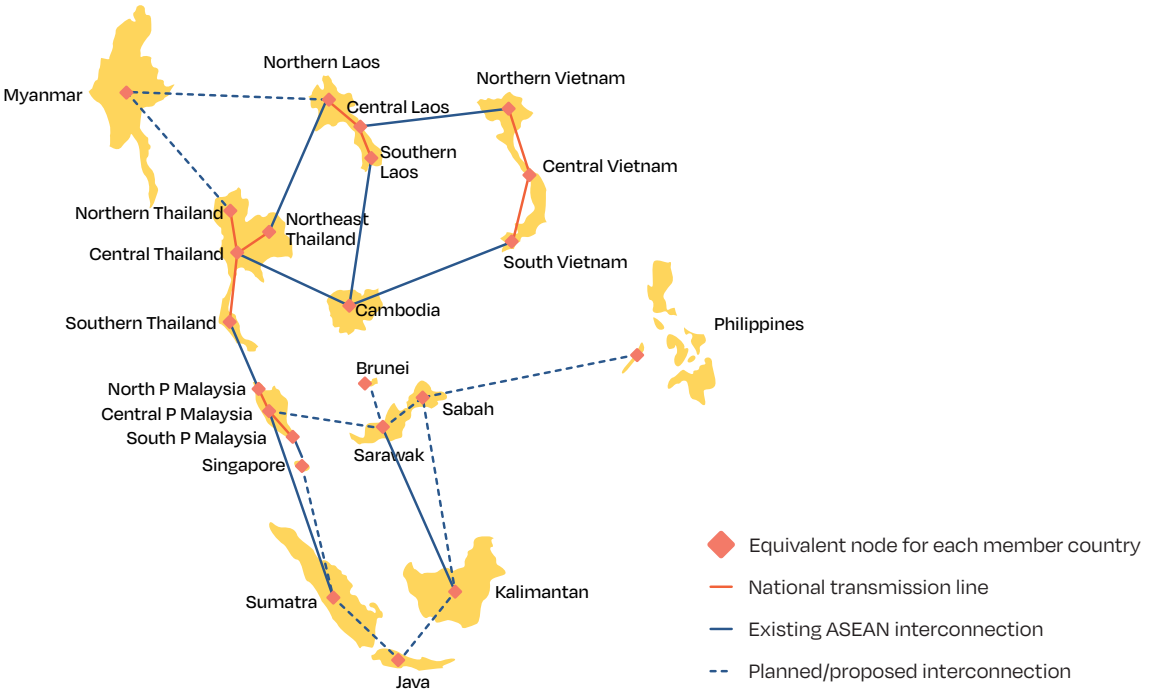
Key Regional Challenges

Despite the significant growth and potential of solar energy in the SEA region, several challenges need to be addressed to ensure the continued expansion and integration of solar power into the energy mix.

Grid infrastructure: The limitations on grid infrastructure pose a major challenge to large-scale deployment. Many countries in the region have aging grid infrastructure, which is not designed to accommodate the variable and decentralised nature of solar power. The lack of grid capacity, coupled with inadequate interconnections between countries, can lead to grid instability and the curtailment of solar power generation. To enable further solar growth, the interconnection infrastructure in the region must be strengthened. An ASEAN Power Grid blueprint illustrated in Figure 26 was developed by the ASEAN Centre for Energy to begin regional discussions and cross-border electricity transactions. This proposed integrated grid would allow high level variable renewable energy to be absorbed by grid.

Financing: The availability of financing for solar projects remains a challenge in many SEA countries. Despite the declining costs of solar technology, the high initial capital investment required for solar projects can be a barrier to entry for many investors. As solar is a CAPEX-intensive technology, cost of capital plays a key role in determining the viability of investments. To achieve the bold decarbonisation goals, substantial financial

FIGURE 26 ASEAN INTERCONNECTION MASTER PLAN STUDY



backing must be allocated to SEA nations. For instance, a considerable increase in renewable energy investments in Indonesia is necessary, rising from 2 billion USD (1.9 billion EUR) annually to approximately 10 billion USD (9.3 billion EUR) per year to attain its 2030 target. Meanwhile, the Philippines requires a total investment of 28 billion USD (26.1 billion EUR) over seven years to accomplish its planned renewable energy expansion by 2030.

Land availability: One of the growing concerns for the development of utility-scale solar projects in the SEA region, particularly in densely populated countries such as Singapore and the Philippines, is land availability. The competition for land among various industries and the need to preserve agricultural land and natural habitats can limit the space available for large-scale solar installations. This challenge has led to the exploration of alternative solutions, such as floating solar systems, to overcome land constraints.

Workforce: The lack of skilled labour and technical expertise in the solar sector is hindering the growth of the industry in the SEA region. The rapid expansion of solar capacity requires a skilled workforce to design, install, and maintain solar systems. However, many countries in the region face a shortage of skilled labour in the solar sector, which can affect the quality and efficiency of solar projects.

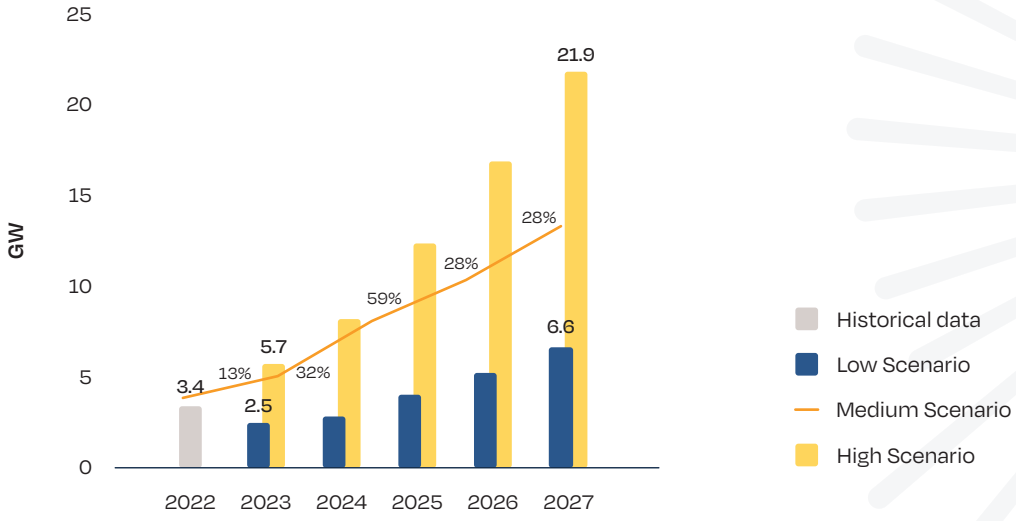
Policy and Regulatory Framework: Policy and regulatory challenges can impede the development of solar energy in the SEA region. In some cases, the lack of clear and consistent policy frameworks, as well as bureaucratic hurdles, can create uncertainty for investors and hinder the growth of the solar market. Furthermore, the integration of solar power into existing energy policies and regulatory frameworks can be challenging, particularly in countries with heavily subsidised fossil fuel industries. An overview of country-specific policy and regulatory challenges is provided in the following section.

In conclusion, addressing these key regional challenges – grid infrastructure limitations, financing availability, land constraints, skilled labour shortages, and policy and regulatory barriers – will be critical to ensuring the continued growth and success of the solar energy sector in the SEA region.

Prospects 2023-2027

After two years of market contraction following the regulatory changes in the Vietnamese solar market, new capacity additions in the SEA region are expected to restart their upward trend starting from 2023. As solar investment conditions improve in the majority

FIGURE 27 SOUTHEAST ASIA ANNUAL SOLAR PV MARKET SCENARIOS 2023-2027



of Southeast Asian countries, the market is expected to grow 13% to 3.8 GW this year. However, there is still a large degree of uncertainty regarding the direction the market will take, since several countries are at a turnaround point in their solar stories. As most SEA nations are still gearing up their solar programmes – such as the impressive Green Energy Auctions (GEA) auctions in the Philippines, with over 9 GW of solar capacity to be tendered – the question is how fast solar deployment will take place across the region. In SolarPower Europe's High Scenario, several countries pass the GW threshold of annual additions already in 2023, bringing regional installations to 5.7 GW. By contrast, in a Low Scenario characterised by slow uptake and hurdled by financial and other challenges, the market contracts further to 2.5 GW. An overview of the market dynamics in the most prominent SEA countries is provided in the following section.

Starting from 2024, a high pace of growth is expected across the region. With a 32% growth, annual installations are forecasted to reach 5.1 GW. In the following years, the result of solar programmes becomes more apparent, bringing the regional market to 8.1 GW in 2025 (+59%), 10.4 GW in 2026 (+28%), and 13.3 GW in 2027 under a Medium Scenario. If key challenges persist, installation volumes in 2027 could remain as low as 6.6 GW; however, the market would grow up to 21.9 GW under a High Scenario.

Top 5 SEA solar markets

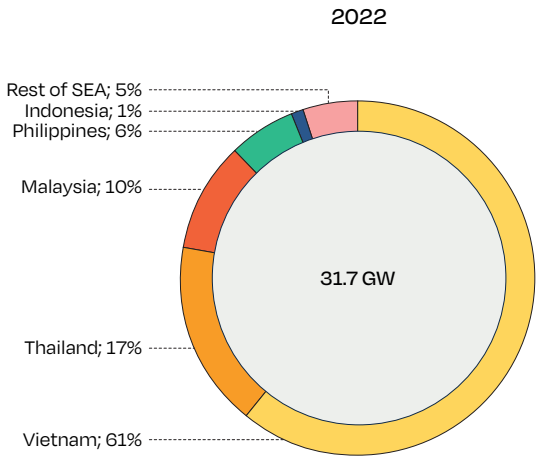
Southeast Asia has experienced exponential PV capacity expansion in the last years, driven by its largest markets Vietnam, Thailand, Malaysia, Philippines, and Indonesia. Together, these countries host 95% of the region's operating PV capacity (Figure 28). Most of these countries have surpassed 1 GW of installed PV capacity, whereas other markets in the region like Cambodia, Laos, Myanmar and Singapore are expected to reach that level by no later than 2027, the end of our forecasting period. An overview of the most relevant solar markets in the region is provided in the following section.

VIETNAM

Vietnam has experienced rapid growth in solar energy adoption in recent years. By 2023, the country is one of the leading players in the Southeast Asian solar energy market.

Vietnam's installed solar PV capacity has grown dramatically in the last five years, reaching approximately 19 GW by 2022. The substantial growth

FIGURE 28 SEA CUMULATIVE SOLAR PV CAPACITY 2022



can be attributed to supportive government policies, attractive feed-in tariffs (FITs), and the country's excellent solar resources. Vietnam's solar boom took place between 2017 and 2020, driven by the introduction of a very attractive FIT (at initial rate of 0.0935 USD/kWh (0.087 EUR/kWh), for projects completed before 30 June 2019. A second FIT framework was set from 1 July 2019, with 0.0709 USD/kWh (0.066 EUR/kWh) for solar farms, 0.0769 USD/kWh (0.072 EUR/kWh) for floating solar and 0.0838 USD/kWh (0.078 EUR/kWh) for rooftop solar power, applicable to projects completed by end of 2020. As a result of these two FIT frameworks, PV capacity grew by 16 GW in the 2019-2020 period alone.

Vietnam slowly became the victim of its own success. The share of solar power in Vietnam's power system amounted to 24% in 2020, amongst the highest the world. The lack of flexibility solutions to integrate large solar generation put further pressure on the grid. In recent years, the market contracted significantly following the end of FIT and relevant regulatory changes. As the prospect of new on-grid utility-scale solar project seems dimmed, many players started increasing their activities in rooftop projects.

The lengthy negotiations over the country's eighth Power Development Plan (PDP8) created a policy vacuum that lasted from the termination of the second FIT in December 2020 until very recently. In May 2023, the Vietnamese government announced the publication of PDP8, re-establishing regulatory clarity for renewable energy, with deployment targets until 2030 and a long-term vision of the country's power system to 2050. However, PDP8 is a mixed result for solar, with the focus being on behind-the-meter rooftop solar deployment, and no new grid-connected solar parks are envisioned until after 2030. According to the new plan, the only solar projects allowed to begin operations and feed electricity into the grid are some transitional projects that did not begin operations in time for the previous FIT deadline. This is only a portion of the several gigawatts of projects that did not meet the FIT deadline and have not been put in operation – all the rest is pending until 2030 to limit the stress on the grid.

PDP8 outlines that new solar installations by 2030, including both grid-connected solar farms and solar for self-consumption, will amount to 4.1 GW. The plan also states that self-consumption solar projects are permitted at unlimited capacity, provided that they do not require grid updates, and come at a reasonable price. The strategy aims to ensure that, by 2030, 50% of office buildings and residential houses with rooftop solar do not sell electricity to the grid and only use power for self-consumption.

After a challenging year for solar players in 2022, the newly introduced regulatory framework will eventually bring clarity to the sector. However, severe limitations to new solar projects feeding into the electricity network, based on concerns of grid saturation, will pose a significant limit to solar development in Vietnam. With the market expected to fully rely on the self-consumption segment, it is difficult to imagine that new solar additions will repeat the record years in 2019 and 2020, and should remain below or slightly above the GW range in the next few years.

THAILAND

Thailand has emerged as one of the leading countries in Southeast Asia for solar energy development, driven by its abundant solar resources, supportive government policies, and growing energy demand. Thailand was the first country in the region to introduce a FIT scheme in 2007, which was revised and adjusted several times in the following years. In 2013, a new FIT scheme was adopted, providing different rates depending on system size, ensuring continued capacity expansion during the decade.

Anticipating a dynamic market and decreasing solar prices, the Energy Regulatory Commission of Thailand launched a pilot project focusing on self-consumption for rooftop solar installations. In May 2019, a net-metering scheme was introduced for residential rooftop solar PV systems with an upper limit system size of 10 kW. Under this scheme, compensation is provided for excess electricity generated over a ten-year period, and a grid connection fee is charged to the investor. The government aims to add 100 MW of capacity per year from 2019 to 2027 through this initiative.

In October 2022, the government introduced a new FIT scheme for renewable energy, in which utility-scale solar and storage are among the targeted technologies. This came as a surprise, since no mention of the scheme was made in the country's power development plan. With capacity quotas being set for each

technology every year, the scheme is expected to be largely oversubscribed. Solar has a total allocated capacity of 2.6 GW between 2024 and 2030.

The government is currently working on its new National Energy Plan (NEP), a progressive strategy outlining the country's energy system trajectory until the 2040s. Designed to provide policy direction for both governmental agencies and private enterprises, the NEP 2022 is expected to be approved in 2023. One action plan included in this comprehensive plan is the PDP 2018 Revision 1 (2018-2037), which aims to raise the country's total generation capacity from 46 GW to 77 GW by 2037. The forthcoming PDP is designed to cover the period from 2023 to 2037, superseding the existing plan that commenced in 2018 and underwent several revisions to align with evolving energy policies. This new policy necessitates that the country restructures its energy management to reduce its reliance on fossil fuels. Under the updated plan, Thailand aspires to achieve a 50% renewable energy share in electricity generation by 2036. As of 2021, renewable energy accounted for 11% of the energy mix.

MALAYSIA

Malaysia has been actively promoting the growth of its solar energy sector to diversify its energy mix and reduce its reliance on fossil fuels. Malaysia's solar energy landscape in 2023 is characterised by rapid growth fuelled by ambitious renewable energy targets, supportive government policies, and significant investments from both international and domestic sources. In terms of efficiency and intensity, the country aims to achieve 52 TWh of electricity savings between 2016 and 2025, compared to a business-as-usual scenario, resulting in an 8% reduction in electricity demand growth by the end of the plan.

The introduction of the National Renewable Energy Policy and Action Plan in 2011 marked a significant turning point in Malaysia's solar PV deployment. With ambitious targets for renewable energy and the introduction of a solar FIT scheme, the country's PV market started gaining traction. A Renewable Energy Fund was established to finance the FIT scheme through a 1% to 1.6% contribution from consumers' electricity bills. The programme, however, was discontinued in 2017 and substituted with a net-metering scheme (NEM), which, not being financially attractive at its start, resulted in a slowdown of solar growth. In more recent times, the government introduced NEM 3.0, a program allocating a 500 MW quota from 2021 to 2023, which has supported solar expansion. The market added 454 MW solar PV in 2020, growing to new installations of 712 MW in 2022, resulting in a total installed capacity of 3.9 GW by end of 2022.

To encourage further solar growth, the government has rolled out the Corporate Green Power Program, a large-scale solar program that allows private solar power producers to develop and operate solar farms and sell the green power virtually to corporate customers via contracts for difference. A first come, first serve basis is rolled out for an 800 MW_{AC} subscription starting from 9 May 2023 until the end of the year, or until it is fully subscribed.

The Malaysian Government launched in 2022 its National Energy Policy 2022-2040, with the objective of enhancing macroeconomic resilience and energy security, achieving social equitability and affordability, and ensuring environmental sustainability. The NEP is a live document subject to periodic reviews every three years to ensure that the targets are achievable and to keep in line with international development in the energy transition space. The NEP includes a target of achieving 31% renewable energy in the country's electricity generation mix by 2025 and 40% by 2035, compared to the current 23% share. According to the government plans, another 1.2 GW of capacity is needed to achieve the energy mix of 31% RE by 2025, out of which solar covers 1.1 GW. However, according to our estimates, the market will grow to a total of 6.4 GW in 2025.

PHILIPPINES

The Philippines offers a compelling investment opportunity for solar energy development. This is due to its strategic location near the equator, which provides ample sunlight, one of the highest electricity tariffs globally, and a government commitment to the Paris Agreement in reducing carbon emissions. Despite challenges related to the grid and regulatory implementation uncertainties, the Philippine government has enacted and continues to administer policy frameworks that aim to promote energy security, equity, and sustainability. As a result, solar PV has emerged as a key driver in the country's energy transition. The Philippines is determined to advance

its energy policies and targets, with an emphasis on expanding access, enhancing efficiency, and promoting renewable energy sources. In terms of access, the country's goal is to achieve a 100% household electrification rate by 2022. Regarding efficiency and intensity, the Philippines aims to reduce the energy generated from oil products, and electricity consumption, by 2040 by 5%, compared to a business-as-usual scenario. The Philippines also aims to reach a 10% penetration rate for electric vehicles in road transportation, including motorcycles, cars, and jeepneys, by 2040. As for renewables, the Philippines is committed to increasing the renewable energy share in its power generation mix to 35% by 2030 and 50% by 2040, as well as implementing a 5% biodiesel blending initiative starting in 2022 through its Philippine Energy Plan 2020-2040.

The Philippine Energy Plan 2020-2040 supports the country's long-term vision (Ambisyon Natin 2040), targeting a clean energy future with ambitious renewable energy goals. With peak demand and electricity sales projected to increase four-fold, the country's total installed capacity must reach 95.7 GW by 2040. The Clean Energy Scenario requires 92.3 GW of generation capacity additions, with renewables accounting for 80%. Solar energy drives capacity growth with a target installation capacity of 18.6 GW by 2030.

The Philippines has seen significant growth over the years in the deployment of solar energy driven by the factors such as supportive government policies, technological advancements, and increasing investments in the sector. In 2016, the Philippines achieved a significant milestone with the solar PV capacity increasing to 765 MW from 165 MW, mainly due to the development of large-scale solar farms. By the end of 2019, the cumulative solar PV capacity in the Philippines reached approximately 1 GW, with the growth driven by the expansion of both utility-scale and rooftop solar projects. It is estimated that solar PV total capacity has grown to close to 2 GW by the end of 2022.

A key driver for solar growth in the country is the Renewable Portfolio Standards (RPS) program, introduced in 2017. This program rules to promote renewable energy development. The RPS, coupled with a Renewable Energy Market, sets a minimum RE proportion for electricity sales. The annual requirement of the RPS is at least 1% annual increase in the country's renewable energy output. In order to realistically achieve its RES targets, however, the government decided to increase the annual increase from 1% to 2.52% starting in 2023. Investment rules have also been amended to allow 100% foreign capital in RES projects, while only up to 40% was allowed before.

Last year, the Energy Regulatory Commission approved the draft Rules for Distributed Energy Resources (DERs) to promote renewable energy and reduce dependence on fossil fuels. The rules include guidelines, interconnection standards, and pricing methods, among other provisions. With the DER Rules, consumers can supplement their power supply, helping to mitigate the impact of rising fuel prices on electricity rates. Adopted rules allow DER end-users using renewable energy to export up to 30% of their excess capacity and receive compensation.

Large solar capacity volumes are expected to come online in the coming years through the GEA auction scheme started in June 2022, when GEA-1 awarded 1.5 GW of solar projects. While it is unclear whether all of the awarded capacity will come online, due to limited financial attractiveness and other challenges, the government is moving forward with the next auction rounds GEA-2, whereby 7.6 GW of solar capacity is planned to be auctioned in June 2023 with project completion expected between 2024 and 2026.

With an ambitious solar target of 18.6 GW by 2030 and massive auction volumes currently in the pipeline, Philippines's solar PV capacity is expected to raise its growth trajectory in the next years. It is expected that the country will become the regional market leader by no later than 2025.

INDONESIA

Indonesia, the world's largest archipelago, possesses significant potential for solar energy development due to its equatorial location, providing abundant sunlight throughout the year. Indonesia is committed to implementing progressive energy policies and targets, focused on expanding access, enhancing efficiency, and promoting renewable energy. The country seeks to increase the renewable energy share to 23% of primary energy supply by 2025, and 31% by 2050, and accomplish a 19.6% share of renewable energy in

electricity production by 2030. The Indonesian government has recognised the critical role of renewable energy in the country's energy transition and has set these ambitious targets to increase the share of renewable energy in the power generation mix and achieve a net-zero future.

The Indonesian regulatory framework encourages private companies to establish independent microgrid utilities in remote areas, creating opportunities in sectors like solar, biofuel, waste-to-energy, and electric vehicles. Solar power, specifically rooftop solar PV technology, has the largest potential capacity of approximately 200 GW.

The growth phase of solar PV deployment in Indonesia began in 2011, driven by the introduction of feed-in tariffs, net-metering schemes and other incentives to promote renewable energy development. These policies, however, have resulted in limited solar uptake in the country. Despite a population of 274 million and the largest GDP of the region, operating solar PV capacity remains below the GW level at present. Addressing this situation, new regulations, such as Presidential Regulation 112/2022, have set benchmark costs for power generation in each region, pushing renewable energy projects to compete economically. This presents a significant opportunity to boost the renewable energy sector in the following years. However, the realisation of this potential hinges on state electricity company PLN to initiate energy procurement processes, and renewable energy developers have expressed concerns about the attractiveness of such projects.

While still in the starting phase of its solar deployment trajectory, it is anticipated that the solar market in Indonesia will take off and reach sizeable volumes in the coming years. Several players have announced projects that would significantly increase the country's solar capacity, including a 3.5 GW project aimed at exporting green energy to neighbouring Singapore. As soon as this and other projects come to completion, the country will enter a new growth phase. According to the SolarPower Europe High Scenario, the annual GW level could be already reached next year. However, as indicated by IRENA's Renewable Energy Outlook for ASEAN, Indonesia boasts a large potential for solar energy generation in the region, amounting to 2,898 GW.

Authors: Global Solar Council (GSC) & Asian Photovoltaic Industry Association (APVIA).

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3 Corporate PPAs in emerging markets

9 MW, Reunion Island, France. ©LeStudioEphemere

1. Introduction

As fossil fuel prices continue to rise globally, and the energy transition gathers pace, businesses all over the world are increasingly faced with key questions about how they source energy and electricity for their operations. Corporate clean energy procurement can be an attractive alternative to grid-sourced electricity for several reasons - it can secure a reliable, stable supply of renewable electricity for a company that can help it achieve its decarbonisation or sustainability goals, and it can also be an attractive economic option given the comparatively low Levelised Cost of Electricity (LCOE) of solar PV to fossil fuels. According to S&P Global, in 2022, the annual global corporate renewable power purchase agreement (PPA) market stood at over 51 GW, growing by 60% year-on-year. Of this total, 25.5 GW were for solar PV. Traditionally, the PPA market has been dominated by North America. However, in 2022 for the first time the Asia Pacific emerged as the largest region for PPAs, with 38% of the global market, and tripling in size from 2021. This highlights the attraction and appetite amongst corporates for solar PPAs. On a country level the US leads globally in this field, Spain is the European frontrunner in corporate PPAs, and in Asia-Pacific, notable renewable PPA markets are India, China, Bangladesh. While the frontrunners of global PPA markets are still at an early state, there are also significant opportunities elsewhere in the world for PPA growth.[4] Especially, this can be seen in rapidly developing regions such as Southeast Asia and Sub-Saharan Africa, where growth in population, GDP, and power demand will lead to increasing strain on already stretched electricity grids, potentially incentivising businesses to secure their own sources of electricity to safeguard and expand their operations. With the Sub-Saharan African region at the start of its journey into corporate sourcing, there is comparatively little experience on how to attract investment into PPAs. Southeast Asia, a step further ahead in the development of PPA markets, can already point to several lessons learned as its national markets have recently grown significantly. Applying some of these lessons in Sub-Saharan Africa could be the key to unlocking further PPA market growth, and the full realisation of Africa's solar potential.

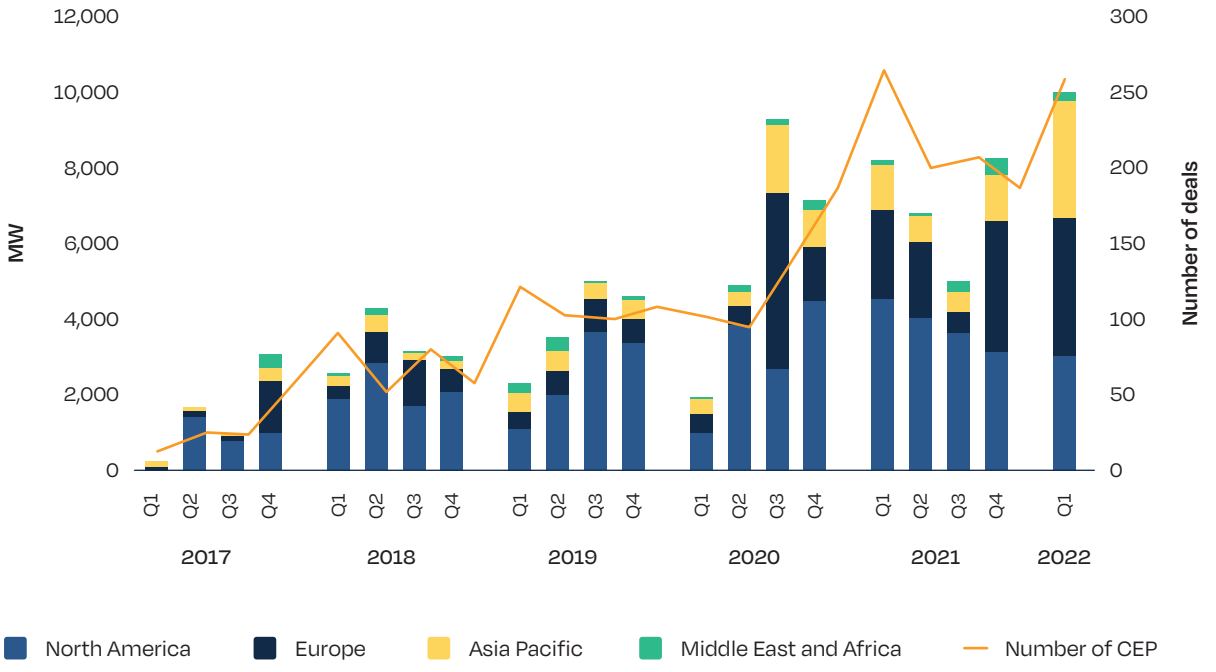
This chapter is supported by GET.invest, a European programme that mobilises investment in renewable energy, supported by the European Union, Germany, Sweden, the Netherlands, and Austria.

GET.invest
Mobilising Renewable Energy Investments

4 Chauhan, A (2023), *Global corporate clean energy procurement crosses 50 GW with Asia as the largest region in 2022*. 2 March, 2023, https://www.spglobal.com/commodityinsights/en/ci/research-analysis/global-corporate-clean-energy-procurement-crosses-50-gw.html

3 Corporate PPA in developing countries / continued

FIGURE 29 CORPORATE PPAS ANNOUNCED PER REGION, FROM Q1 2017 TO Q1 2022[5]



Corporate PPA business models

There are several PPA business models that are already used worldwide. They can be divided broadly into two groups, on-site and off-site models.[6]

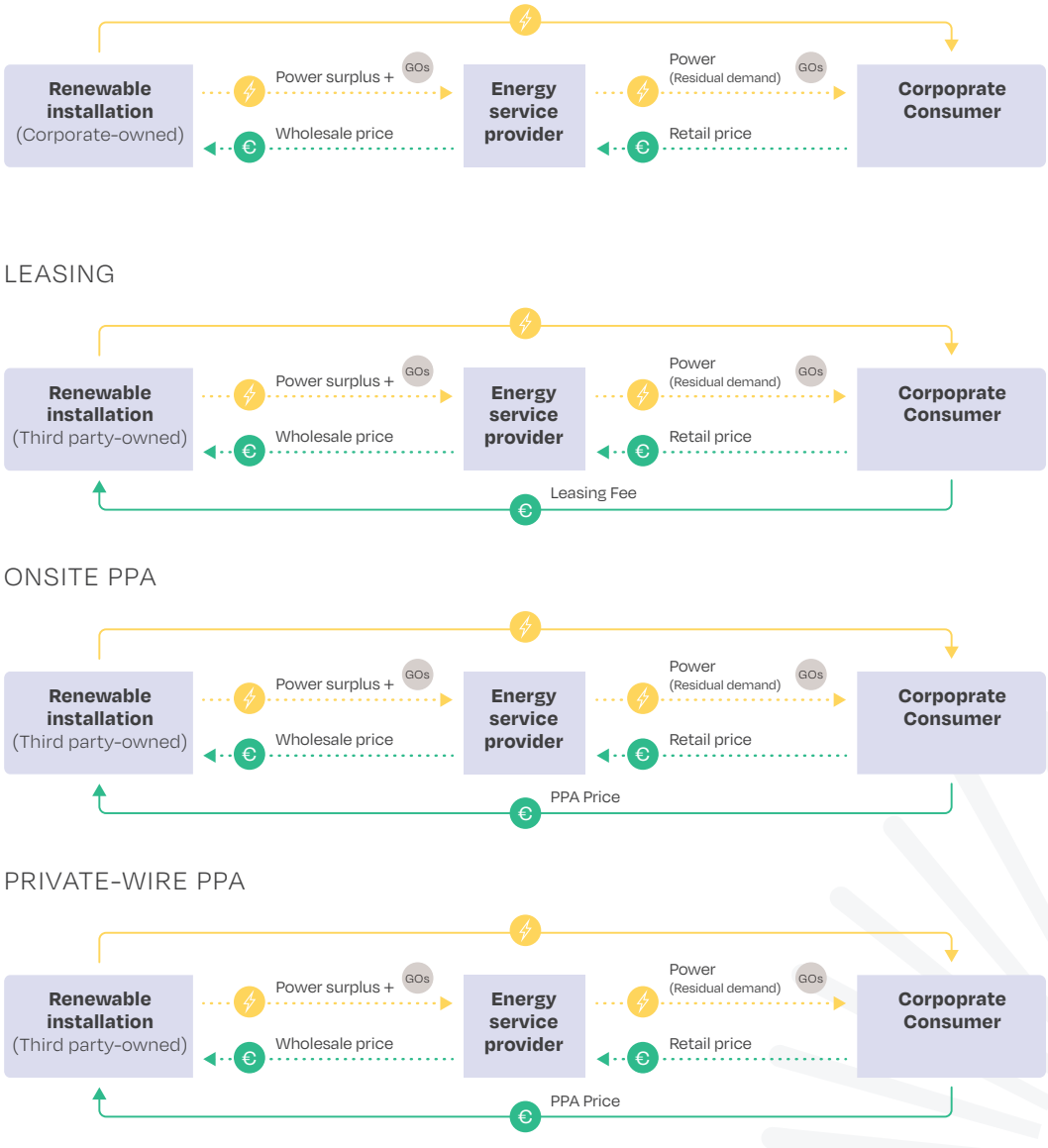
On-site PPA models

Provided there is adequate land, roof space, or carports available, a C&I customer may take the decision to maximise the renewable energy resources in their surroundings by installing renewable energy assets on their land. This offers the significant advantage of inexpensive renewable electricity, and avoids extra costs for transmission and distribution that are bundled into tariffs for electricity supplied from a grid. Within the on-site PPA grouping, there are four distinctive types of arrangements: self-owned, leasing, on-site PPA, and private-wire PPA. Under a **self-owned** model, a C&I entity would have full ownership over the renewable energy installation, and consume the electricity it produces (behind-the-meter generation). In essence, this is no different to a residential rooftop installation (other than in size), as there is no agreement concluded between two parties, although it does constitute a form of corporate sourcing of RES. If the upfront CAPEX of a renewable energy asset is too high, a company might choose to allow a third party to develop, and own an asset on its property, paying a leasing fee for use of the electricity the asset produces. This can be referred to either as a **leasing** or **on-site PPA**. Finally, a renewable energy installation can be built off-site and connected to the corporate end-user via a '**private wire**', allowing for behind-the-meter consumption. However, managing surplus electricity may require a grid connection at the installation, or the power consumer site, which would also be reflected in the electricity price of the PPA.

5 S&P Global (formerly IHS Markit), Global Corporate Clean Energy Procurement Market Briefing, June 2022. https://cdn.ihsmarkit.com/www/pdf/0822/Global-Corporate-Clean-Energy-Procurement-Market-Briefing-June-2022-final.pdf

6 RE-Source Platform (2020), *Introduction to Corporate Sourcing of Renewable Electricity in Europe*, January 2020, https://resource-platform.eu/wp-content/uploads/files/statements/RE-Source-introduction-to-corporate-sourcing.pdf

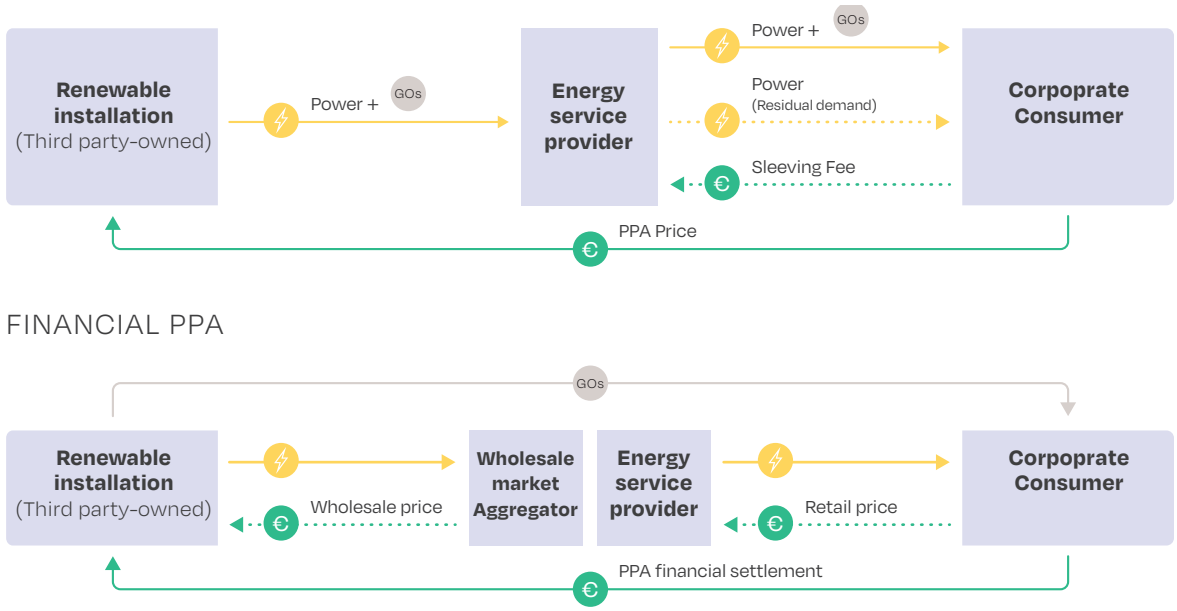
FIGURE 30 ON-SITE PPA MODELS



Off-site PPAs

When space and renewable energy sources are limited, a C&I customer may decide to make use of renewable resources from an installation off-site. With this model, a C&I customer can purchase larger volumes of power than with the on-site model, as there is no space constraint on the asset. Within the off-site PPA grouping, there are two distinctive types of arrangements: physical and financial PPAs. Under a **physical** corporate PPA model, a third-party owns, operates, and maintains the installation off-site and sells the electricity generated by the asset to the corporate entity. The asset is connected to the consumer via the electricity grid. A utility will then transport the electricity to the off-taker via the electricity grid in a process called wheeling. They will usually charge an additional fee, or 'sleeving fee', for the transmission and balancing of the electricity injected into the grid from the offsite installation. This fee is commonly specified in the PPA. Transmission and distribution fees also need to be paid. A **financial**,

FIGURE 31 OFF-SITE PPA MODELS



or **virtual** PPA involves a financial contract without physical transmission of power between the producer and the C&I consumer. The electricity price is set under a Contract for Difference (CfD) between the asset owner and an energy service provider, providing the C&I consumer with a financial hedge against long-term electricity price fluctuation. Additionally, a separate PPA is signed by the installation owner to sell the physical power to the market.

2. Corporate PPAs in Sub-Saharan Africa

Sub-Saharan Africa has a persistent lack of electricity access, partly due to underinvestment in electricity infrastructure. Many of its publicly owned utility companies are loss-making and have only limited resources to maintain current generation assets, often meaning there is no money for investment into new ones. This has consequential effects on power supply, reliability, and affordability. Partial liberalisation efforts have seen increased investments in generation capacity, but upgrades in transmission and distribution networks have not followed suit, further constraining ailing utilities' ability to effectively integrate future generation projects into outdated electricity grids. Combined with predicted rapid population and economic growth, it is clear that fundamental changes will need to take place in the electricity sector in order to keep up with power demand. This presents an enormous opportunity for the PPA market to be a driver of this economic growth, responding to demand where the grid cannot. In this section we will explore some of Sub-Saharan Africa's most dynamic solar markets – South Africa, Angola, and Ghana – and assess the potential for PPAs moving forward.

SOUTH AFRICA

The South African energy sector is governed by the Department of Mineral Resources and Energy, and electricity tariffs are overseen by the National Energy Regulator of South Africa (NERSA). Eskom is the national public utility. In 2019, due to critical debt levels, the South African government announced plans to unbundle Eskom into three separate entities responsible for generation, transmission, and distribution; the process is still ongoing. Due to its economic size, South Africa can boast significant industrial presence within its borders. This also makes it the most dynamic PPA market in Sub-Saharan Africa.

1.3 MW, Alrode Brewery, AB InBev, Johannesburg, South Africa. © SOLA Group.

PPA growth in South Africa has been largely driven by the various power crises that the country has faced since 2008, a result of maintenance problems in Eskom-owned power plants, and a lack of investment in transmission and distribution infrastructure. These have led to a dearth of power generation capacity and, since 2016, load shedding has become increasingly severe in the country, leading corporate off-takers to search for alternative means of securing their electricity supply.

The South African PPA market has a diverse range of players involved, from small C&I customers to large mining companies. Initially, in 2017, deployment of PPAs was supported via a cancellation of the requirement for a licensing fee for projects under 1 MW in size. While this did not immediately catalyse a PPA gold rush, steady growth was recorded. For instance, in 2018, SOVENTIX developed a 998 kW solar system for SIEMENS headquarters in South Africa. Prompted by the increasing severity of load shedding, increasing numbers of industrial players entered the PPA market, signing larger agreements. In 2020, the African branch of AB InBev, signed a PPA with the SOLA Group, a solar company, to provide 8.7 MW of electricity for seven breweries. In the mining sector there was a reported 585 MW project pipeline from gold and platinum mines, seeking to secure power for their operations. Steel company ArcelorMittal released a tender for 150 MW of solar later in 2020, as did chemicals company Sasol (for 600 MW). Wheeling is allowed by Eskom under certain conditions and for a fee. The first solar wheeling project was developed in November 2021 by the SOLA Group. The 10 MW project provides electricity to a local unit of Amazon through the national grid.

The latest amendment of the Electricity Regulation Act (ERA), in August 2021, increased the exemption threshold for generation licences to 100 MW, to further ease the energy crisis in the country, before removing the licence threshold entirely in December 2022. After this policy development, in January 2023, South Africa's National Energy Crisis Committee revealed that a 9 GW pipeline of unsubsidised, distributed generation projects, across more than 100 sites was under development. So far in 2023, over 1.4 GW of PV installations have been registered with NERSA, showing the opportunity for PPAs with large industrial players, made possible because of the national energy crisis and the removal of the generation licence requirement. These include two 100 MW solar plants in the North-West of the country, by the SOLA Group, to supply electricity to Tronox's five mining operation sites through wheeling agreements. In June 2022, Vantage Data Centres entered a 20-year PPA with SolarAfrica to provide 87 MW of solar-generated electricity.

Municipal support has the potential to be a key driver for the deployment of small-scale solar PV installations, less than 1 MW, in the C&I sector. According to the Status of Small-Scale Embedded Generation (SSEG) in South African Municipalities 2020 report, registered C&I systems accounted for a

Biopio (189 MW) solar farm in Angola. © Verangola

total capacity of 282 MW in municipalities across the country, as of November 2020. Municipalities purchase electricity from Eskom, and resell it to local customers. Many have specific tariffs for C&I users, and purchase excess electricity injected into the grid by C&I users. To combat increasingly severe load shedding, Cape Town introduced its Cash for Power programme in January 2023. This programme enables owners of PV rooftop systems to sell their excess electricity to the municipality for cash, on top of an existing credit on their monthly electricity bills. Through the Cash for Power programme, and the credit scheme, commercial customers can sell their excess green electricity to the city for 0.7387 ZAR/kWh (0.036 EUR/kWh), on top of a 0.25 ZAR/kWh (0.012 EUR/kWh) credit on their electricity bills. However, unless a lack of capacity for addressing SSEG applications is addressed, municipal support could turn into a bottleneck for PPAs. Currently, in Cape Town, it can take between four to six months for an SSEG application to be approved. Nevertheless, the effect of these two measures has seen applications for rooftop solar installations soar since the start of 2023, with the city receiving 1,040 applications in the first two months of the year, highlighting the enormous potential for PPAs under this scheme.

New policy developments are expected to increase the growth of the C&I market. In March 2023, South Africa introduced a new rebate scheme for rooftop PV projects above 1 MW. Businesses can reduce their taxable income by 125% of the cost of an investment in renewables. This change represents a major shift from the previous scheme, which allowed businesses to deduct 50% of their investment in the first year, 30% in the second, and 20% in the third. However, the most important policy development for PPAs has been the removal of the cap on generation facilities requiring a generation licence. This has enabled large scale embedded projects to be developed for mining and other energy intensive industries. Since the start of 2022, 397 MW worth of embedded solar PV projects have been registered with NERSA, the majority of which have been mines.

ANGOLA

The energy sector in Angola is largely state owned, and is considered strategically important under the Law on the Delimitation of Economic Activity (2021). The Ministry of Energy and Water (MINEA) is the competent Ministry for the electricity sector in Angola, and is responsible for the licensing of electricity installations. Transmission is controlled by Empresa Rede Nacional de Transporte de Electricidade (RNT), distribution is managed by Empresa Nacional de Distribuição de Electricidade (ENDE), and Empresa Pública de Produção de Electricidade (PRODEL) is the generation utility; they are all publicly owned. The electricity sector permits private sector participation by means of concession contracts. An independent regulatory body, the Regulatory Institute for Electricity

and Water Services (IRSEA), was established in 2016, and the Energy Project Implementation Support Unit (EPISU) was created in 2018 to support the development of IPP projects.

Solar PV deployment has typically been low in Angola, with installed capacity reaching 16 MW in 2021; the country's target of reaching 200 MW of solar PV by 2025 appeared overly ambitious. However, in 2022, 285 MW of utility-scale solar PV came online, catapulting the country to one of the largest African solar markets for that year and signalling its entry as an important African solar player. Due to the early development stage of the market, PPAs are uncommon. There is some scope for corporate entities to purchase electricity directly from a renewable energy installation, or from a range of suppliers, if they have approval to do so from IRSEA. The agreement for a PPA would have to be made between the contracting parties.

Angola's economy experienced an accelerated growth in 2022, estimated at 3.5%, showing the country's recovery from its 2016 recession is underway. Angola's economy is characterised by its dependence on extraction activities, in particular oil, natural gas, diamond, phosphates, gold, and other minerals. However, efforts are underway to diversify with a focus on the energy transition, agriculture and industry. In 2018, the Angolan government launched the Production Support, Export Diversification and Import Substitution Program (PRODESI), to foster private sector-led economic diversification and competitiveness. Under PRODESI, the trade and distribution sectors and agriculture are expected to grow, and play a bigger role in the economy. In 2021, the update of the Private Investment Law lifted the 35% local content obligation for foreign investments. Additionally, Angola's structural reforms for macroeconomic stabilisation have contributed to strengthening the banking sector.

Angola's energy sector benefits from international support, including the G7 Partnership for Global Infrastructure and Investment, the African Development Bank, USAID, and the World Bank. Angola is part of the Southern Africa Power Pool, and has announced plans to interconnect its grid with Namibia, and potentially with the Democratic Republic of Congo. Significant steps have been taken to diversify the energy mix under the "Angola Energy 2025" strategy; in 2020, the government approved the construction by Sun Africa and MCA of seven solar PV plants totalling 370 MW. Two of these plants have been installed in 2022. More PV projects are expected to be developed by Eni, Total Eren, Sun Africa, MCA, Sonangol, and Elsewedy Electric for around 1 GW. These were all awarded via concessions, with a PPA to be signed between the developers and RNT for the sale of electricity. While these initiatives indicate that the Angolan solar market has become quite active in recent times, on the corporate PPA front there is yet to be significant movement.

C&I entities are covered as Non-integrated Electricity Systems under the General Electricity Law. That is to say, PPAs are allowed for self-consumption and supply to isolated private systems. Systems over 100 kW need to be registered and can enter a PPA agreement with the regulator to sell their excess electricity. While electricity tariffs are currently lower than in the rest of Sub-Saharan Africa in Angola, the government is expected to make progress toward achieving cost-reflective tariffs by 2025.

Growth in the non-oil economy, especially in agriculture, services and construction, is expected to remain robust. Government support for solar deployment, positive economic perspectives, and enhanced investment terms represent an opportunity for the solar PPA market to grow, especially on-site and private-wire PPAs. These have the potential to provide reliable and cost-effective electricity to companies, as well as meet their net-zero targets.

GHANA

The electricity sector in Ghana is characterised by a gap between the total generating capacity and peak demand, high electricity tariffs, high levels of transmission and distribution losses, and high occurrence of grid downtime. The C&I sector accounts for around half of all electricity consumed in the country.

In 2004, the Government of Ghana unbundled the electricity sector. The state-owned Volta River Authority (VRA), the Bui Power Authority (BPA), and IPPs are responsible for electricity generation. Electricity transmission is managed by the state-owned Ghana Grid Company (GRIDCo). Electricity distribution is geographically divided, in the South it is managed by the Electricity Company of Ghana (ECG), in the North by the Northern Electricity Distribution Company (NEDCo), and by the privately-owned Enclave Power Ltd (EPL) in the Tema Free Zone Enclave.

Most corporate sourcing in Ghana is done following on-site models for small-scale projects under 1 MW for manufacturing facilities. Updates in regulations are

705 kW on-site leasing PPA on plastic recycling company, Miniplast's factory in Accra, Ghana. © Bilanol/Shutterstock

still needed to enable other business models to flourish. PPAs have been signed between international manufacturing companies as well as Ghanaian entities. Manufacturing industries include plastic, PVC, bottling, cocoa and nut agro-processor companies.

In 2011, the Government of Ghana introduced the Renewable Energy Act, where it established the requirement for a licence for C&I projects over 1 MW. A net-metering scheme was established in 2016 and updated in 2022. Other incentives include tax rebates, waivers of VAT and import duties on for materials and components. As of 2019, the country had around 7 MW of C&I solar capacity installed, composed of individual project capacities of less than 1 MW.

In 2019, Ghana released its Renewable Energy Master Plan, outlining an investment plan until 2030 and setting a renewable energy generation target of 1,363 MW by 2030. The Master Plan also includes the promotion of local content and local participation in the renewable energy industry under which foreign companies applying for a licence are required to have at least 15% local ownership, and 60% of engineering and procurement activities involving Ghanaian companies.

The Public Utility Regulatory Commission (PURC) allows for financial off-site PPAs under a wholesale electricity supply licence to a C&I consumer classified as "bulk customer," with an average monthly maximum demand exceeding 500 kW over three consecutive months, or a minimum annual energy consumption of 1 GWh. This category includes mining, aluminium, and manufacturing companies. The supplier pays a wheeling fee to the transmission company, opening the door to off-site PPA models, and further market diversification in terms of off-takers. Currently, few companies qualify for a wholesale licence. However, despite a current decrease in GDP growth rates (from 5.4% in 2021 to 1.6% in 2023), the World Bank predicts a return to strong economic growth by 2024, suggesting that power demand will increase in the near future, expanding the pool of addressable customers for the wholesale electricity supply licence.

Outlook for Sub-Saharan Africa corporate PPA markets

South Africa represents the most mature C&I solar market in Sub-Saharan Africa. Energy intensive industries in the country represent a key addressable market for corporate PPAs, especially because of the ongoing power crisis. The removal of the generation licence requirement threshold in South Africa has enabled these types of companies to deploy solar installations to support their operations. This segment has a significant growth potential due to the presence of several mining companies, such as Anglo American Platinum and Sibanye Stillwater, with significant operations in the country. Ghana is the largest producer of gold in Africa, and extracts manganese, bauxite, and more recently lithium. PPAs are slowly

developing, but have significant growth potential. For instance, in 2018, Newmont Mining Corporation installed a 120 kW re-deployable Nomad solar PV tracker, from Cambridge Energy Partners, at its Akyem gold mine. To further support the growth of the segment in Ghana, the "bulk customer" regulation will have to be adapted to ensure more companies can qualify for the licence. Angola's diamond and minerals extraction operations can also benefit from the development of the PPA market.

Manufacturing activities also have the potential to participate in the growth of the PPA market. Recent policy developments in South Africa will contribute to the growth of the market. While there are several examples of small-scale manufacturing C&I customers in Ghana, this segment is expected to continue to expand due to high electricity tariffs, and growing power demand. The growth of larger scale projects is restricted by local content rules, and high interest rates for loans. As Angola expects to achieve cost-reflective tariffs by 2025, electricity prices will increase for C&I customers. PPAs offer reliable, high-quality power, available at a competitive cost, resulting in improved business operations, and contributing to the diversification of the economy in a sustainable manner.

The growth of the PPA market in Sub-Saharan Africa requires public and private investments. Multilateral and bilateral development finance institutions, as well as investment funds, have taken steps to unlock the solar potential of the region. The 100 million EUR fund AFRIGREEN Debt Impact Fund, provides project finance and asset-based finance solutions for on- and off-grid solar energy installations for C&I consumers in Africa, with a particular focus on Nigeria, Ivory Coast, Senegal, Ghana and Cameroon. Elsewhere, Empower New Energy, a solar platform investment company, operates a fund of 74 million USD (68.4 million EUR) in equity finance for the development of 150 MW of off-grid and on-grid solar C&I projects across Africa by 2025. Moreover, the Energy and Environment Partnership Trust Fund (EEP Africa) provides early-stage grant and catalytic financing to innovative clean energy projects, technologies, and business models, including C&I customers, in across 16 African countries. It provides grants of up to 500,000 EUR, and loans up to 1 million EUR, with a minimum co-financing requirement of 30%.

In addition to financing, international partners, such as the GET.invest programme, provide support to C&I customers, with the development of financially viable solar projects. The GET.invest programme mobilises investment in renewable energy in developing countries, and supports project developers by linking them with financiers. With 13% of its projects focused on C&I, the programme has helped 66 projects reach financial close for a total investment amounting to 442 million EUR, and it currently has a pipeline of C&I projects in Burundi, Eswatini, and Mozambique.

In South Africa, large commercial banks provide financing for large-scale projects, and have started offering loans for smaller projects, under 1 MW. Absa, First National Bank / Rand Merchant Bank (RMB), Investec, Nedbank and Standard Bank, provide debt and equity financing, hedging and corporate finance. Some EPC service providers also offer financing to reduce upfront costs for C&I customers. However, loans are characterised by high interest rates compared to international standards, thus deterring investments in renewable energy projects. In other countries in the region, very few commercial banks are active in financing solar projects.

Barriers persist to unleashing the full potential of PPAs in Sub-Saharan Africa, including a lack of dedicated financing and de-risking tools for the C&I market. Regulatory challenges include a lack of net-billing regulations, preventing customers from selling their excess electricity, and a lack of transparency surrounding grid access, tariffs and wheeling regulations. Local ownership requirements, and the need for a wholesale electricity supply licence to sell electricity to a bulk customer, is limiting the deployment of larger-scale PV projects in Ghana. Furthermore, the high cost of capital across the region remains a key challenge that should be addressed through dedicated financing schemes.

The South African solar market is the most mature in Sub-Saharan Africa, with a successful history of utility-scale and PPA deployment. The rest of the region presents opportunities and a high potential for solar deployment. Future growth is expected as electricity prices and demand increases. Dependence on oil and hydro for electricity generation represents a risk to reliable electricity supply in Sub-Saharan Africa; solar deployment will help contribute to the diversification of energy mixes and reduce GHG emissions to achieve climate change mitigation targets. The PPA market is driven by the need for reliable and cost-competitive electricity to power the C&I sector, as well as by companies' decarbonisation objectives and governments' commitments to increase the share of renewables in their energy mix.

Solar PV installation on the site of agro-industrial company Cargill in Thailand .

3. Corporate PPAs in Southeast Asia

The Asia-Pacific (APAC) region hosts the world's largest and fastest growing PPA market. In late 2022, energy research company Wood Mackenzie forecasted 7 GW of PPAs for 2022 in APAC, over 80% more than in 2021. Near the end of Q1/2023, S&P Global reported that over 50 GW of PPA announcements had been made in 2022, with over 19 GW of those coming from APAC. Unsurprisingly, technology giants such has Amazon, Google, Microsoft, and Meta are the chief drivers of corporate renewable energy sourcing. However, the increase in projected growth reported by Wood Mackenzie highlights that corporate buyers are becoming more diverse, with manufacturing, materials and retail segments carving out a larger share of the PPA market. This growth can be understood as the result of increasing numbers of firms announcing ambitious decarbonisation targets, new regulations and incentives, coupled with the increasing prices of power supplied from LNG, coal and oil, and the relative inexpensiveness of renewable electricity. While there are several countries in the region that are already advanced in their solar journey (e.g. China, Japan, South Korea, Australia, etc.), this does not mean that there are not significant PPA opportunities in newer markets, particularly in the Southeast Asia region. Thailand, Malaysia, and the Philippines, are all liberalising their electricity sectors, opening the door for different routes to market for solar, including PPAs. This section will explore some of the most exciting developments in these markets, the drivers of their growth, and the biggest players signing corporate PPAs.

THAILAND

Thailand's electricity system is largely state-owned, with the utility, the Electricity Generating Authority of Thailand (EGAT), controlling generation, transmission, and distribution activities. Distribution activities are also undertaken by the Metropolitan Electricity Authority (MEA), and the Provincial Electricity Authority (PEA). However, Thailand permits privately owned rooftop solar installations under two models: either corporate off-takers own the asset and use the electricity generated for self-consumption; or a corporate off-taker leases their roof to a solar developer who then sells them electricity under a corporate PPA.

Initially, most PPA growth came about under the self-owned model, with corporate off-takers owning their own installations, and the C&I rooftop solar market growing in prominence. The growth of the C&I off-taker market was initially driven by a Feed-in-Tariff (FIT) programme started in 2013, which targeted 200 MW of rooftop solar across C&I and residential installations. Through this, 100 MW of commercial scale rooftop solar PPAs were awarded to 193 separate bidders. Since then, support for C&I rooftop solar has been lukewarm. However, the rising prices of EGAT, PEA, MEA-provided electricity, and the decrease in prices of solar equipment have meant that rooftop C&I installations have maintained their appeal.

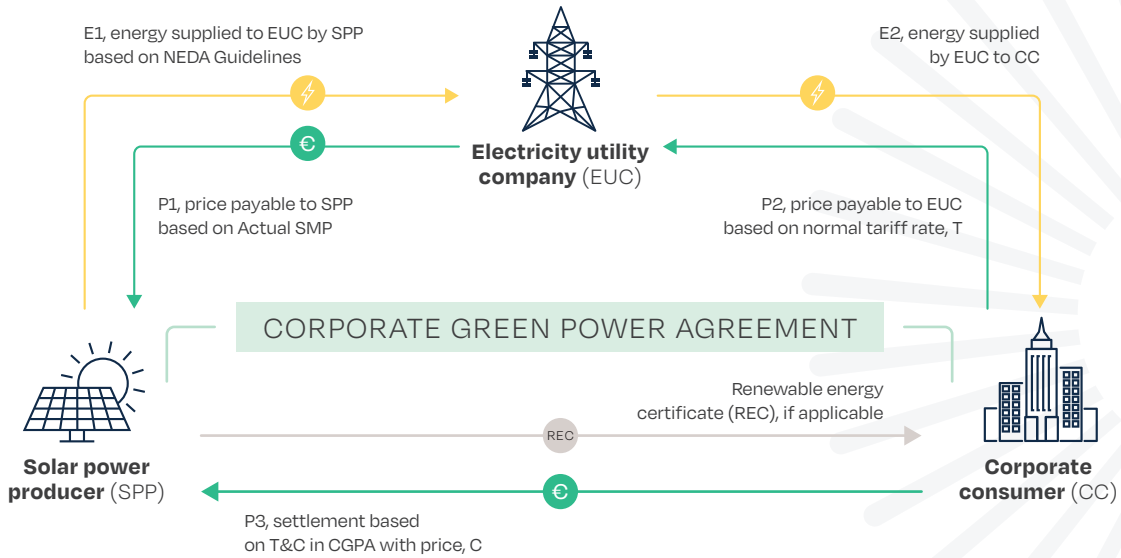
For the time being, most corporate sourcing is done following on-site models. Due to the high CAPEX required at the start of the lifecycle of a solar installation, and a nascent debt market for renewables, leasing is a common practice in Thailand, with companies paying a fixed fee to asset owners that is competitive in comparison to grid-supplied energy. As the PPA is between two private entities, it is subject to general civil law, meaning both parties are free to shape the agreement as they wish (freedom of contract). This offers increased flexibility for both buyers and suppliers, particularly when it comes to financing of the construction, maintenance, and operation of the system.

The Thai PPA market has a diverse range of players involved. From Europe, TotalEnergies signed an agreement with a large food company, Betagro, in 2020 to provide 25 MW of solar rooftops for their 24 facilities in the country. These are governed by 20-year PPA agreements and constitute one of the largest portfolios in Thailand. The Japanese company, Shizen International also has a substantial portfolio of projects in Thailand which demonstrate the range of corporate buyers present in the country. From packaging firms to large industrial conglomerates, such as Panasonic, automotive firms, and industrial parks, Shizen has a 16 MW portfolio of PPAs in operation currently. Other big players include the Thai company Constant Energy, which signed 3 PPAs for Tata Steel Group factories in Thailand, providing 12 MW across the facilities.

MALAYSIA

Malaysia's electricity system has been on a path of gradual liberalisation since 1990, when the National Electricity Board was privatised to form Tenaga Nasional Berhad (TNB), which today remains the single buyer of electricity, transmission, and distribution system operator in the country. IPPs were eventually allowed to participate in the generation market from 1993. The electricity sector is overseen by Suruhanjaya Tenaga, the regulatory body. Malaysia retains an enormous amount of potential for rooftop solar, and the government is now taking several encouraging steps to unleash the potential of an otherwise stagnant C&I market.

FIGURE 32 OVERVIEW OF MALAYSIA'S CGPP PROGRAMME ® SINGLE BUYER



© Single Buyer.

312 kW on-site solar PV system in Shah Alam, Malaysia.

The growth of the C&I segment in Malaysia started with the introduction of a FIT scheme under the Renewable Energy Act of 2011. This enabled C&I customers to generate and sell electricity to TNB. The FIT was replaced in 2016 by a net-metering scheme, with limited success due to unattractive returns, particularly for larger C&I customers. This prompted a new net-metering scheme to be introduced in 2019 to address the lack of engagement with its predecessor and this offered better returns for C&I customers. Whilst this encouraged the development of rooftop installations, with TNB as the single buyer, PPAs are yet to make a proper entrance into the Malaysian market. However, that looks set to change with the Malaysian government's new Corporate Green Power Programme (CGPP).

The CGPP was introduced in 2022 to encourage the adoption of green electricity amongst corporate companies in Malaysia. The CGPP operates using a financial or virtual PPA model, meaning it stops short of being a true conventional agreement shown in the on-site and off-site models at the beginning of this chapter. Under it, companies have a Corporate Green Power Agreement (CGPA) with solar developers. These function along the same lines as a contract for difference, establishing a CGPA price. The solar power producer sells electricity to TNB at the system marginal price and the corporate consumer will procure electricity from the power grid at its point of interconnection. If the tariff rate paid by the corporate off taker is higher than the CGPA price, they must reimburse the solar power producer the difference. Similarly, if the system marginal price received by the solar power producer is higher than the CGPA price, the solar power producer must refund the difference. The current first round of the CGPA started with a total of 600 MW to be awarded. The quota was raised to 800 MW in March, 2023 and a lower limit of 5 MW was imposed on CGPAs, along with an upper limit of 30 MW. The current window is running until 31 December 2023, or until all 800 MW have been awarded. Successful bids will have until 2025 to have their plant fully operational. Applying to the CGPA scheme requires a developer and a corporate off taker to agree a PPA prior to applying to the scheme.

It is not a guarantee that, Malaysia's first foray into PPAs, will be a success. There are several elements that could limit participation in the programme. For example, majority foreign ownership of a project is not permitted (49% is the maximum), and CGPAs can only be signed with companies in either the manufacturing or the service industry, with a credible financial position for the last three years. Particularly in the case of eligibility of corporate customers, it is not clear which sectors are excluded from the CGPP.

PHILIPPINES

The Philippines electricity sector is unique in Southeast Asia due the extent of its liberalisation. Since 2001, successive governments have made efforts to introduce competition and choice over

Robinsons Place Pangasinan, , Philippines.

electricity providers for end customers. Transmission is controlled by the National Grid Corporation of the Philippines (NGCP). The distribution sector is dominated by the privately-owned utility, Meralco, but there are over 100 other privately owned distribution utilities active in the market. Market liberalisation in the Philippines has brought significant benefits to the C&I segment that have given larger power consumers the choice over which electricity providers they use.

The main catalyst for growth of the C&I segment and PPAs in the Philippines came when Retail Competition and Open Access (RCOA) was introduced in the Electric Power Industry Reform Act of 2001. This allowed companies with an average peak demand of at least 500 kW, or an average billing of 950,000 PHP (15,574 EUR) over the past year to negotiate with a pool of retail electricity suppliers, who then transact with power generation companies on behalf of the corporate off-taker. In this sense, something akin to a virtual PPA model developed. This was followed in 2008 by the Renewable Energy Law which included the Green Energy Option Programme (GEOP), allowing companies with at least 100 kW peak demand or an average monthly billing of 190,000 PHP (3,114 EUR) to source renewable energy from a licensed supplier. Furthermore, the Renewable Energy Act also mandated a cancellation of VAT on generation charges for renewable energy sources. Currently, the GEOP has 19 registered renewable energy suppliers and over 230 registered corporate end-users.

The C&I market was further bolstered by a solar PV FIT programme which ran from 2012-2021, offering an initial price of 9.68 PHP/kWh (0.16 EUR/kWh) for an initial 50 MW. However, due to oversubscription, this was altered to 8.69 PHP/kWh (0.14 EUR/kWh) for 500 MW, despite the reduction of the FIT, it was still oversubscribed by 300 MW. Furthermore, a net-metering programme for systems under 100 kW also incentivised commercial solar rooftop growth, particularly under self-owned models and priority dispatch for RES saw that the maximum amount of renewable electricity could be injected into the grid. However, beyond purely self-owned PPAs and the GEOP system, there was no specific regulations that broadened the scope of the PPA market until 2022.

Nevertheless, this did not stop steady growth in the C&I market, with North American renewable energy company UGE International completing nine projects, totalling 3 MW, with corporate off-takers, including retail malls, food companies, and cold storage facilities. Retail malls appeared to drive the C&I market initially, with real estate players Robinsons Land Company installing 12.5 MW of solar atop its malls around the country. Significantly larger projects exist too, with the cement makers Holcim signing a 29 MW on-site PPA with Blueleaf Energy in 2021. European companies are also starting to see success in the Philippines with TotalEnergies currently developing a 13.8 MW system for Asia Brewery Inc. at one of its manufacturing facilities. The agreement will see TotalEnergies build, own, and operate the system,

selling all electricity produced to Asia Brewery Inc. ENGIE is also starting to become active in the market, signing MoUs with Filinvest and medical company, Marasenko, to explore the development of solar PV installations across their sites in the country.

In November 2022, the Electricity Regulatory Commission published new rules for distributed energy resources (DERs) that enhanced the legislative framework for PPAs. Under the rules, end-users can enter into either an on-site, or a leasing PPA of up to 1 MW in size, where 30% of the electricity produced can be exported to the grid and purchased by the distribution utility. Combined with a removal of the 40% ownership cap on foreign investments in clean energy projects, and the demand for inexpensive renewable energy, evidenced through the GEOP programme, these developments are likely to trigger rapid growth in the PPA market.

Outlook for Southeast Asian corporate PPA markets

There are several significant policy developments across the region that are likely to boost PPA markets. As ever, the commitment of governments to national energy transitions and the development of targets for renewable energy sends a clear signal to investors about the long-term ambition of the market. To this effect, Thailand's target of 30% renewables in the country's energy mix by 2037 and 50% by 2050 is a step in the right direction. Malaysia has set itself the ambitious target of carbon neutrality by 2050, including a 31% renewable share in national installed capacity by 2025, which will result in a 45% reduction in GHG emissions by 2030 compared to 2005 levels. Similarly, the Philippines has opted for a target of 35% renewables in its power generation mix by 2030, and 50% by 2040.

Whilst targets provide a long-term outlook for the solar market, the implementation of large, ground-mounted solar projects can be complicated by land availability, complex permitting procedures, and availability of grid interconnections. For businesses facing rising prices from conventional generation sources, PPAs present an ideal opportunity to get access to clean, low-cost electricity, boosting their own corporate carbon footprint and contributing to national targets. Governments in Southeast Asia seem to be latching onto this opportunity, creating specific support programmes for PPAs. Especially, this can be seen in the Philippines, where the new regulations for distributed energy resources allow asset owners to further monetise the electricity produced by their installation by selling up to 30% of it to a distribution utility. Similarly, Malaysia's CGPP can be seen as the first step along the road to full implementation of their Third Party Access framework, a key pillar in promoting alternative business models such as PPAs.

However, there are still some limiting factors to PPA market development in the region. For example, participation in Malaysia's CGPP programme requires Malaysians to be the majority shareholders of a renewable energy project. Thailand's Energy Regulation Committee also published draft laws at the end of 2022 that would limit foreign ownership to 49%. This draft law, if unchanged, would also be applied retroactively meaning foreign businesses in the market may have to restructure their ownership to requalify for commercial licences. Limiting investor participation and creating market uncertainty by introducing regulatory changes retroactively will almost certainly cause current and would-be investors alike to reconsider their position in the market. In opposition to this, the Philippines has recently cancelled its 40% maximum foreign ownership rule, making clear signals that its market is open to foreign investors.

The Southeast Asian PPA market stands to benefit from ambitious national renewable energy targets and the increased liberalisation of electricity systems across the region. Not only will this open more routes to market for solar, but it will provide corporate end-users with greater choice on how to source their electricity. However, it remains to be seen whether progress is made beyond the first few tentative steps, or whether limits on volume, foreign ownership and investment could ultimately lead to a stagnation of the nascent PPA market. What is clear though, is that the demand from corporates for access to affordable, clean electricity is present and unlikely to disappear any time soon.

3. Repeating Southeast Asian success in Sub-Saharan Africa

Sub-Saharan Africa has the natural resources, to become a global solar superpower. However, over the last two decades, the continent has only attracted around 2% of all global renewable energy funding. This dynamic could change if further routes to market for solar, such as PPAs, can be leveraged. In contrast, Southeast Asian solar market growth has been driven in-part by its C&I and rooftop solar segment, with several types of PPA models emerging. These include on-site leasing in Thailand and the Philippines, behind-the-meter consumption, the introduction of virtual PPA schemes in Malaysia, and their previous development in the Philippines. Whether some of the

factors for success behind the Southeast Asian markets can be repeated in Sub-Saharan Africa, could prove the key to unlocking the potential of the PPA market segment in the region.

The clear linchpins of the three Southeast Asian markets' energy transition plans have been ambitious renewables targets and accompanying strategies to realise them. Whilst most Sub-Saharan African markets also have national targets for renewable energy deployment, there is a significant focus on the off-grid and utility-scale segments, with South Africa being the exemption. Whilst this rightly reflects national electrification priorities and increasing power demand, including PPAs and the wider C&I segment in these plans would open new routes to market for solar and further help the attainment of these targets. Initiatives such as net metering, FIT schemes, monetisable renewable energy certificates, and developing contracts for the purchase of excess electricity from distributed solar systems by the single buyer would go a long way to encouraging corporate participation in renewable energy generation, particularly through more traditional on-site PPA models.

The focus on larger grid-connected, ground-mounted solar PV installations in Sub-Saharan Africa, can largely be interpreted as the result of having large, state-owned utilities as the only legal single buyers for the electricity produced. Across several markets in Sub-Saharan Africa, the unbundling process of the electricity system is underway. However, many of these have stalled leaving markets with incomplete, or confusing regulatory frameworks. In contrast, Southeast Asian countries are further ahead in their market liberalisation processes to the extent that governments are introducing support schemes to further encourage private sector participation in electricity markets. These include the introduction of the regulations for distributed energy resources in the Philippines and the introduction of the CGPP for virtual PPAs by the Malaysian government. In markets such as Malaysia with large state-owned utilities, virtual PPAs seem to represent the first step to opening a PPA market and could be useful model for Sub-Saharan African countries.

Countries in Sub-Saharan Africa, such as South Africa, Angola and Ghana, have an abundance of solar resource, and often significant industrial presence on the national territory, particularly when it comes to mining and manufacturing. However, stalled electricity market liberalisation programmes have meant that the PPA potential is yet to be fully realised. Taking the examples offered by Southeast Asian markets including Thailand, the Philippines and Malaysia could help them chart a course towards further private sector participation in their electricity markets. Access to inexpensive, reliable electricity would also act as a draw to further corporate entities, in turn boosting the economy. These processes are already well underway in South Africa as a result of rising fossil fuel prices, instability of supply, and the decarbonisation targets of industry players, and other African markets are sure to follow suit. The question is not if, but when the PPA boom will happen.

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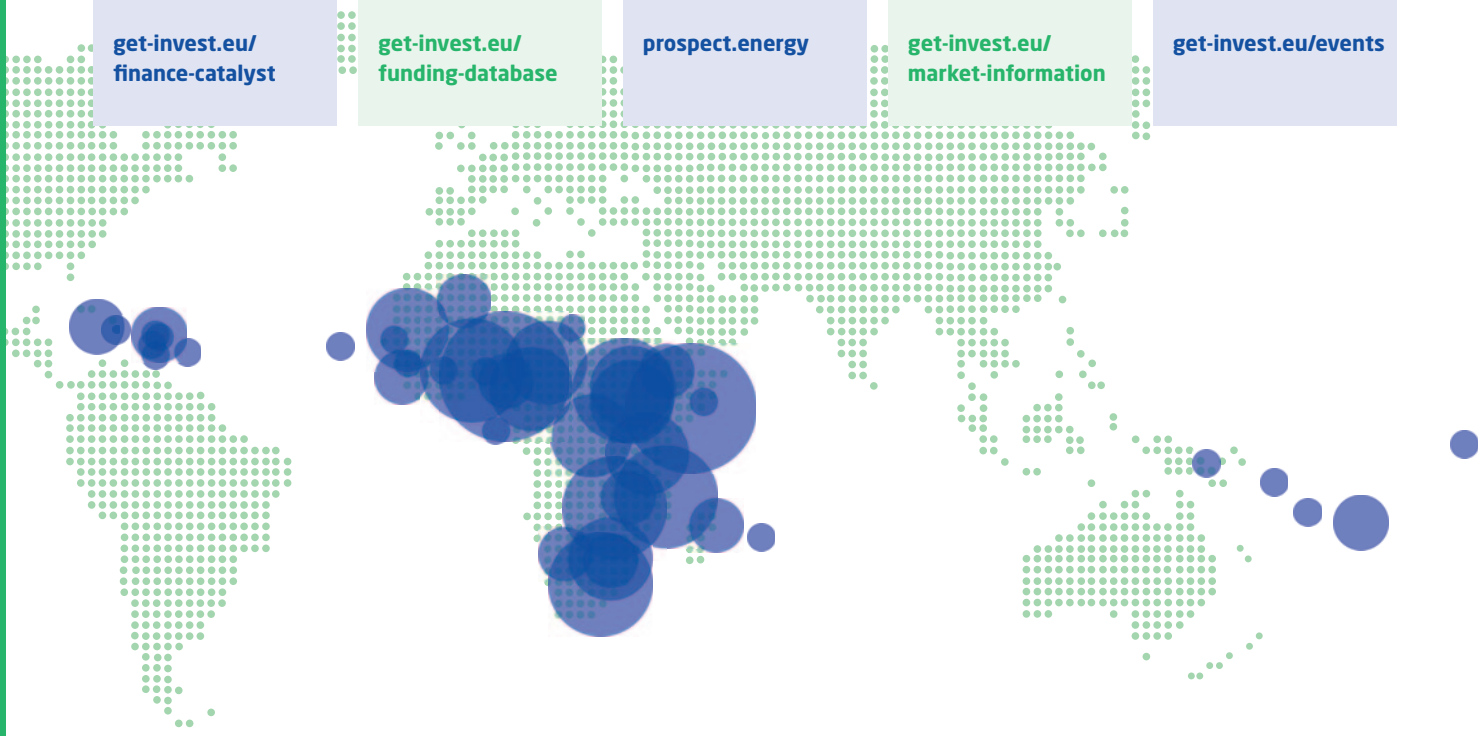
Events & Matchmaking

Opportunities to exchange and connect with potential partners and investors

get-invest.eu/events



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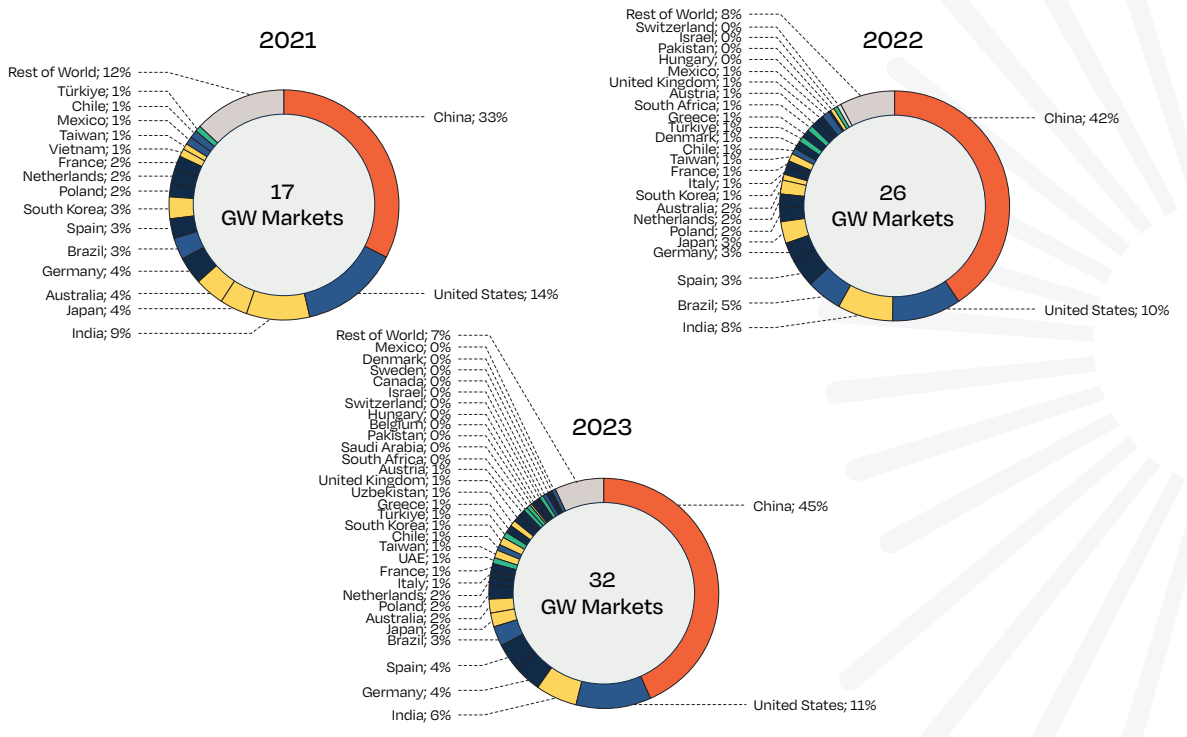
4 GW-scale markets


1.4 MW, Reunion Island, France. © Akuo

In 2022, 26 countries across the world installed more than 1 GW of new solar capacity. This is a surge compared to 2021, when 17 GW-scale solar markets were counted (see Fig. 33). Last year's GMO announced 21 GW markets in 2022, but the reality turned out to be brighter than our expectations, as several newcomers became part of this club. While, contrary to our previous forecast, solar markets in the UAE and Canada did not reach the GW size, a few countries outside of our radar – Austria, Hungary, Pakistan, Israel, Switzerland – crossed this threshold for the very first time. This year's list also includes the United Kingdom again, which returns to the list after its last appearance in 2016, and even Mexico, which despite being a GW market in 2021, we had conservative expectations for.

FIGURE 33 GW-SCALE SOLAR PV MARKETS 2021-2023



4 GW-scale markets / continued

The higher number of 26 GW-scale markets displays the strong momentum of solar, as more countries look to low-cost and versatile solar to shield their economies from electricity price volatility, strengthen their energy sovereignty, and combat climate change. Our outlook forecasts that this sustained growth will continue, reaching 32 GW-scale markets in 2023, when six more countries will join the group – the UAE, Uzbekistan, Saudi Arabia, Belgium, Canada, and Sweden (see Fig 33).

In 2024, we expect 40 GW-scale markets, and at least 53 GW-scale markets in 2025 – these numbers have increased considerably for each year compared to last year's assessment.

As in previous Global Market Outlooks, national solar associations from markets that have added more than 1 GW in the previous year have been invited to present their local expert views on their home markets (which sometimes differ from our estimates that are based on several sources). Many of these associations, like SolarPower Europe, are members of the Global Solar Council (GSC), which is a long-time supporter of the Global Market Outlook.

1.	**CHINA** China Photovoltaic Industry Association (CPIA)
2.	**UNITED STATES** The Solar Energy Industries Association (SEIA)
3.	**INDIA** National Solar Energy Federation of India (NSEFI)
4.	**BRAZIL** Brazilian Photovoltaic Solar Energy Association (ABSOLAR)
5.	**SPAIN** Unión Española Fotovoltaica (UNEF)
6.	**GERMANY** Bundesverband Solarwirtschaft (BSW-Solar)
7.	**JAPAN** Japan Photovoltaic Energy Association (JPEA)
8.	**POLAND** Polskie Stowarzyszenie Fotowoltaiki (PSF) & Polskie Towarzystwo Fotowoltaiki (PV Poland)
9.	**THE NETHERLANDS** Holland Solar
10.	**AUSTRALIA** Smart Energy Council (SEC)
11.	**SOUTH KOREA** Korea Photovoltaic Industry Association (KOPIA)
12.	**ITALY** ANIE Rinnovabili, Elettricità Futura & Italia Solare
13.	**FRANCE** Syndicat des Énergies Renouvelables (SER)
14.	**TAIWAN** Taiwan Photovoltaic Industry Association (TPVIA)
15.	**CHILE** Chilean Solar Association (ACESOL)
16.	**DENMARK** Green Power Denmark & Danish PV Association
17.	**TÜRKIYE** Turkish Solar Energy Association (GÜNDER)
18.	**GREECE** Hellenic Association of Photovoltaic Companies (HELAPCO)
19.	**SOUTH AFRICA** South African PV Industry Association (SAPVIA)
20.	**AUSTRIA** Bundesverband Photovoltaic Austria (PV Austria)
21.	**UNITED KINGDOM** Solar Energy UK (SEUK)
22.	**MEXICO** Mexican Association of Solar Energy (ASOLMEX)
23.	**HUNGARY** Hungarian Photovoltaic Industry Association (MANAP)
24.	**PAKISTAN** Pakistan Solar Association (PSA)
25.	**ISRAEL** Green Energy Association of Israel (GEA-IL)
26.	**SWITZERLAND** Swissolar

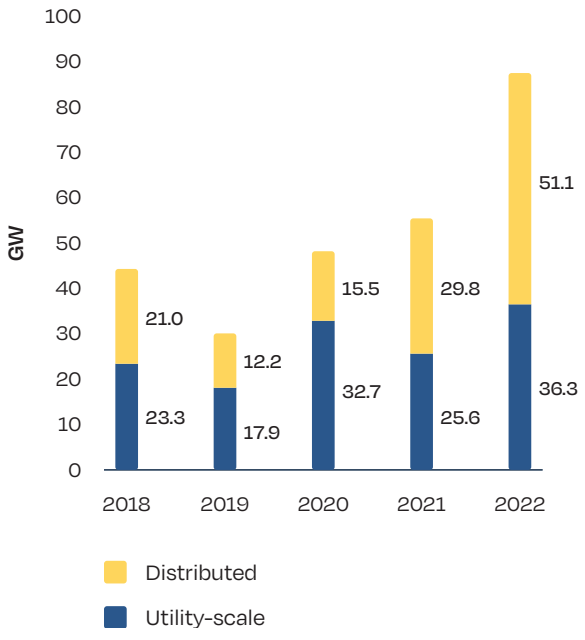
1. China

Overview of PV developments

In 2022, China's new installed PV capacity exceeded 87.4 GW[7], an increase of 59.3% year-on-year. New solar installations reached a new record high, becoming the largest and fastest growing power source in terms of new installations. From the amount of installed capacity, we can see that the rate of new PV installations in China continues to accelerate. By the end of 2022, the cumulative PV capacity reached 392.6 GW, close to the 400 GW milestone, becoming the third largest installed power source. In 2022, PV annual power generation reached 425 TWh, exceeding 400 TWh for the first time, and added about 100 TWh of new power generation. This accounted for 30% of all new power generation.

The manufacturing sector also continued to grow in 2022. By the end of the year, China's polysilicon production stood at about 827,000 tonnes up 63.4% from 2021; wafer production reached 357 GW, an increase of 57.5%; while module production reached 288.7 GW, up 58.8%. Battery production totalled 318 GW, representing an increase of 60.7% from 2021.

FIGURE GW1.1 CHINA ANNUAL SOLAR PV MARKET 2018-2022, BY CPIA



SOURCE: CPIA. © SOLARPOWER EUROPE 2023

National targets for solar PV

In April 2023, the National Energy Administration issued the "Guidance on Energy Work in 2023", providing guidance on the deployment of energy work in addition to development targets. The document highlights a 160 GW target for the annual installed capacity of solar and wind for 2023, with the share of electricity generated by solar and wind power reaching 15.3% of the country's total electricity consumption.

2023 will also be a key year in China's 14th Five-Year Plan. The country will concentrate on consolidating the advantages of the PV industry and expanding the supply of clean, low-carbon energy. There will be an overall push for China to transition to low-carbon energy, both at the local and national level.

Drivers for solar growth

The State Council issued the "Implementation Plan on Promoting the High Quality Development of New Energy in the New Era" to provide policy support for the industry. The construction of large solar and wind capacities in desert areas will bring more opportunities to push the acceleration of solar.

Solar power can integrate seamlessly with various sectors, including construction, transportation, and agriculture. These dual land-use projects allow for the exploration of new PV applications, further broadening solar development. The centralised and distributed solar segments are both becoming key pillars to promote the development of the industry.

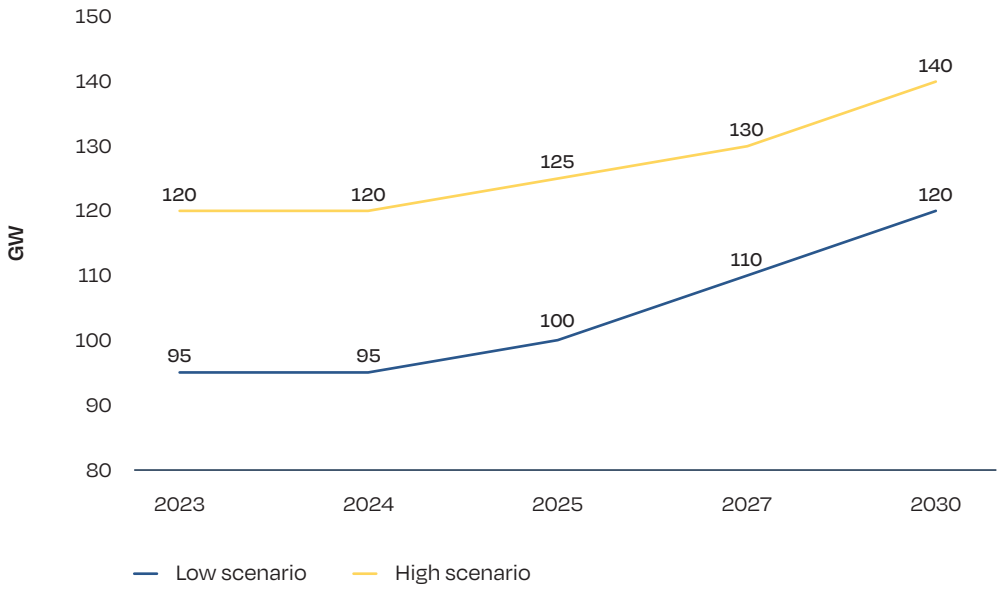
Utility-scale vs. distributed and rooftop developments

In 2022, centralised PV installed capacity reached 36.3 GW, accounting for 41.5% of all installations. The distributed PV annual installed capacity hit 51.1 GW, providing the remaining 58.5% share.

Distributed PV has thus become the main driver behind the country's newly installed PV capacity. The residential segment installed 25.3 GW, accounting for 49.4% of installations, while the C&I segment added 25.9 GW, accounting for 50.6% of installations. Residential installations grew by 17.3% from 2021.

7 Capacity values in this article may be higher when expressed in DC since there is no fixed AC/DC conversion rate.

FIGURE GW1.2 CHINA PV MARKET SCENARIOS 2023-2030, BY CPIA



SOURCE: CPIA.

China's 2022 PV market was well-balanced, and each market segment – centralised, C&I, and residential – accounted for about one-third of the total market.

Challenges for the market

The participation of new energy sources in electricity spot market trading, has caused fluctuations in electricity prices. Unlike medium and long-term trading, spot power market trading altered the previous business model. Additionally, different provinces have different rules for spot power trading, making it difficult to predict PV revenues, which is becoming a new challenge. In the future, under the spot market system, electricity prices will vary because of time and space. Therefore, PV enterprises need to break away from the fixed-price profit model, and explore ways to participate in spot market trading of PV power generation.

Outlook for the years 2023-3027

New installed capacity numbers will grow rapidly if PV power generation costs continue to fall, and the global green recovery continues.

In 2022, China's PV industry made significant progress both in terms of manufacturing and installations. The Chinese Photovoltaic Industry Association expects China's installed PV capacity to reach 95-120 GW in 2023. Each individual segment should also hit new records.

Changes can be expected in 2023. With the balancing of supply and demand, supply chain prices will gradually return to a reasonable range. Secondly, with the development of PV technologies, production capacity will expand, and the proportion of high-efficiency cell technologies will increase.

PV companies will have to consider two factors. Firstly, industry competition will intensify as more markets develop their local PV manufacturing supply chains. Secondly, new energy sources will continue to participate in power market transactions, and as a result, companies may question the revenue potential of PV power projects.

Author: China Photovoltaic Industry Association (CPIA).

2. United States

Powering forward: The challenges and opportunities facing the US solar and storage industry in 2023

Overview of PV developments

Last year was a volatile year for the United States solar market.

Important federal policy changes, like the Inflation Reduction Act (IRA), catalysed a wave of new solar investments and put the solar market in reach of the ambitious clean energy goals set by the industry and the Biden Administration.

However, policy-driven supply constraints, including the US Department of Commerce's investigation into tariff circumvention and equipment detainments by US Customs and Border Protection, have limited solar growth.

This has had a major impact on the industry. According to the Solar Energy Industries Association's (SEIA) Solar Market Insight Report 2022 Year in Review, the United States added 20.2 GW of new solar capacity last year, a 16% decrease from 2021.

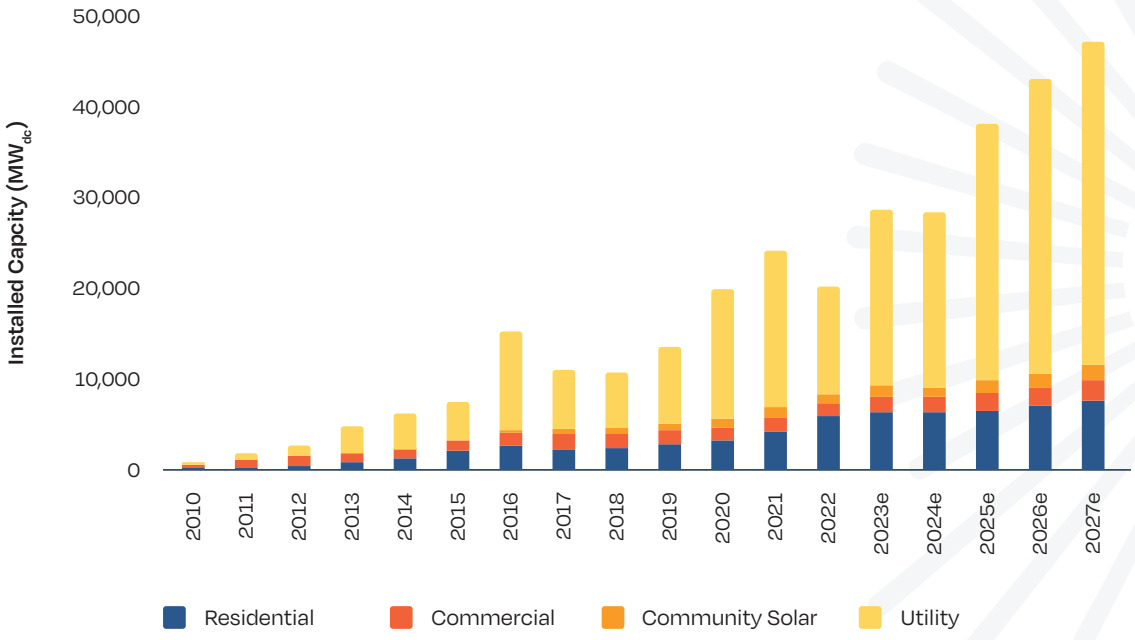
The commercial, community, and utility-scale solar segments were all affected by trade uncertainty, leading to a steep decline in installations. The commercial solar segment installed 1.4 GW, 6% less compared to 2021. The community solar segment installed 1 GW, falling 16% from the previous year. Installations for the utility-scale segment came in at 11.8 GW, 31% below 2021 levels, and the segment's lowest total since 2019.

By contrast, residential solar was less affected by supply chain issues and 700,000 homeowners installed nearly 6 GW of solar capacity in 2022, representing a 40% increase over 2021.

Drivers for solar growth

Despite the broader slowdown in growth, solar remained the dominant new source of electricity generation capacity in 2022, accounting for 50% of all new electricity-generating capacity in the United States. This was the fourth consecutive year that solar was the top technology for new electricity generation.

FIGURE GW2.1 UNITED STATES SOLAR PV DEPLOYMENT FORECAST, BY SEIA



SOURCE: SEIA.

The solar industry has set a goal to reach 30% of US electricity generation by 2030; presently, it is at 5%. Wood Mackenzie projects that over the next decade, the US's solar capacity will grow to 700 GW by 2033, which is five times larger than it is today. This growth is due in large part to the long-term policy certainty created by the IRA, including the ten-year extension of the investment tax credit (ITC).

The Inflation Reduction Act also included new incentives for domestic solar manufacturing. Since the law's passage in August 2022, dozens of companies throughout the solar supply chain have made more than 40 domestic manufacturing announcements valued at more than 13 billion USD (12 billion EUR) . Georgia, South Carolina, and Ohio are quickly becoming hubs for solar manufacturing. Communities in these states are already beginning to see the positive economic impacts.

Today, the solar industry employs 255,000 US workers, supports over 10,000 solar businesses, and is valued at 35 billion USD (32 billion EUR). The industry's manufacturing base is expanding, and consumer demand remains strong.

Challenges

Despite strong solar growth in the United States, trade policy challenges continue to inject uncertainty into the solar market.

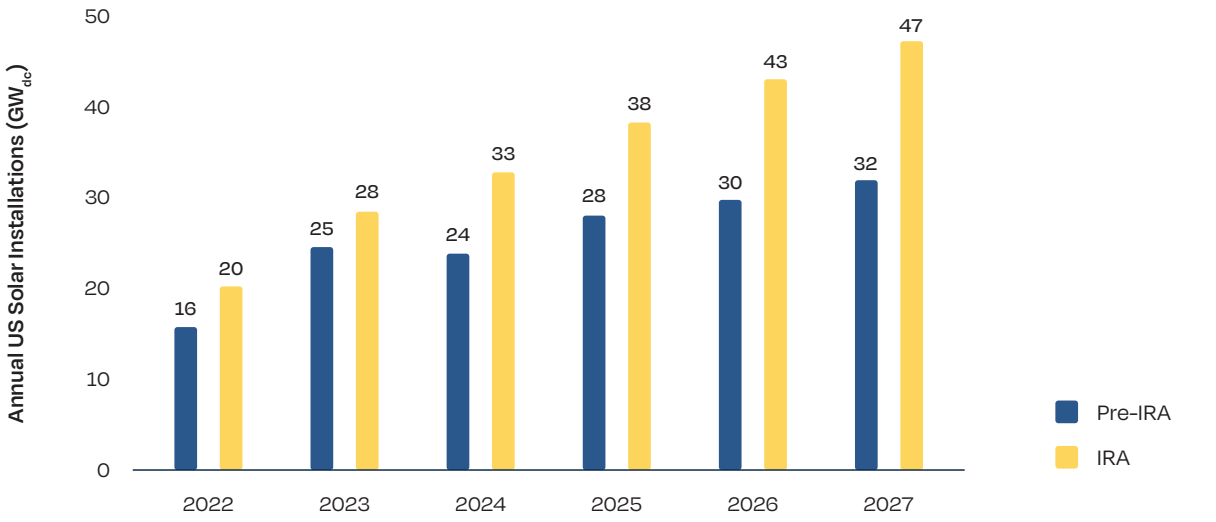
The US Department of Commerce's decision on tariff circumvention is expected in August. This decision could threaten supply chains that US businesses rely on and force companies to pay retroactive duties on imported solar products. While the US solar and storage industry is working to shift supply chains and build out a stronger domestic manufacturing base, these ongoing trade threats could delay deployment.

US policymakers' resolve in providing transparent and realistic timelines will prove decisive in whether the US will achieve its ambitious solar deployment goals. Undermining the IRA by forcing counterproductive trade policy is not the answer.

If lawmakers get this right, the US solar industry will build a clean energy future, while creating well-paying jobs, and economic opportunities in communities across the United States.

Author: The Solar Energy Industries Association (SEIA).

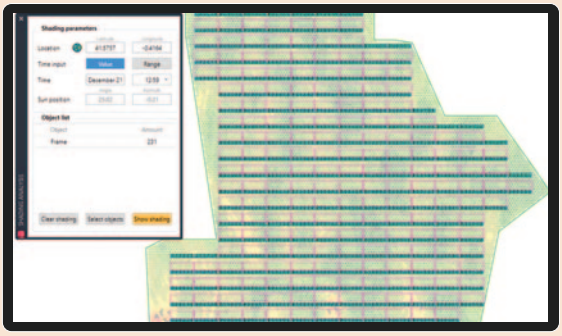
FIGURE GW2.2 US SOLAR MARKET FORECASTS BEFORE AND AFTER THE INFLATION REDUCTION ACT



SOURCE: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight 2022 Year in Review.

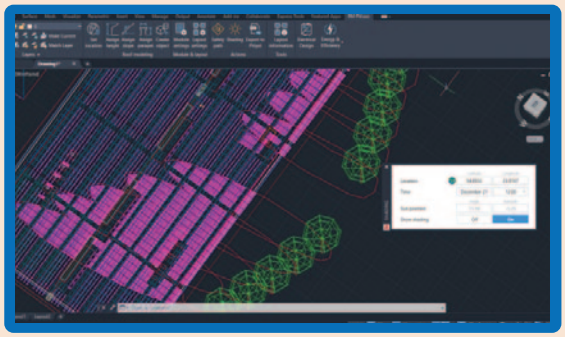
Solar design & yield software suite

Intersolar Europe Booth **A3.350**



PVcase GROUND MOUNT

AutoCAD-based solar design software for **utility-scale ground mount** solar projects. Enables solar engineers to reduce project costs, boost reliability and improve asset performance.



PVcase ROOF MOUNT

AutoCAD-based solar design software for **commercial & industrial rooftop** solar projects. Automation, a high level of precision, and intelligent algorithms improves designs efficiency, accuracy, and quality.

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SCHEDULE DEMO AT INTERSOLAR EUROPE

3. India

Overview of PV developments

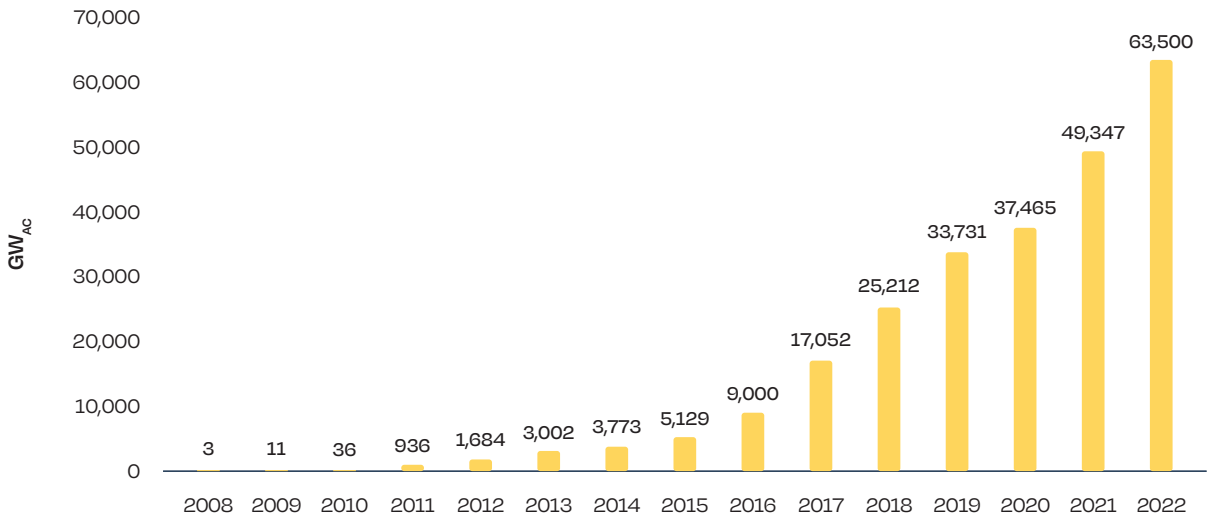
2022 has been an eventful year for the Indian solar industry. India added around 14 GW[8] of solar capacity in 2022, making it the year with the highest annual capacity addition. At the end of December 2022, India's cumulative solar installations stood at 63.5 GW, making India the world's 5th largest country in terms of installed solar capacity. India has revised its 2030 solar target to 300 GW, out of a total 500 GW renewable energy capacity. With this revision, India will witness a solar capacity addition of around 20-30 GW every year from 2023. India's non-utility scale solar also expanded in 2022. While India added around 1.6 GW of rooftop solar, India's commercial and industrial sectors installed around 2.5 GW of solar through open access, which is a 92% annual increase from 2021. Open access solar represents contracts between a solar power producer and consumer, linked via a Power Purchase Agreement (PPA). The Indian government also introduced some ground-breaking reforms which should accelerate India's solar power capacity additions.

Segments progress in 2022

India revised its solar capacity targets in 2014, aiming to reach 60 GW of utility-scale solar by 2022. As of December 2022, the country had a total capacity of 53.8 GW of utility-scale solar, thereby achieving 90% of the set target. Currently, India has 17 solar parks in the pipeline, representing an aggregated capacity of 10 GW. In 2022 about 11.3 GW of new utility-scale solar capacity was installed, a 47% increase from 2021.

In 2022, the Indian government also approved Phase II of the Green Energy Corridor, which will facilitate the grid integration and power transmission of approximately 20 GW of renewable energy projects in seven States. Power evacuation refers to transmission of power from a generating plant to the grid for further transmission. The seven chosen states are Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu, and Uttar Pradesh. The goal is to add 10,750 circuit kilometres of intra-state transmission lines, and 27,500 MVA substations by March 2026. In total, this is estimated to cost 12,031 crore rupees (INR), equal to 1.34 billion EUR; the Central Finance Assistance (CFA) will cover 33% of the project cost.

FIGURE GW3.1 INDIA CUMULATIVE SOLAR PV CAPACITY 2008-2022, BY NSEFI



SOURCE: NSEFI.

8 All values in this article are expressed in AC.

India reached 8.8 GW of cumulative installed solar rooftop capacity at the end of 2022. The state of Gujarat led in deployment with a 24% share of the total solar rooftop installations, followed by Maharashtra (14%), and Rajasthan (9%). In 2022, over 2 GW of solar rooftop tenders were issued, representing a 90% increase.

In 2022, India's Prime Minister Shri Narendra Modi launched a nation-wide Direct Benefit Transfer scheme. This scheme allows consumers who want to install residential rooftop to receive subsidies within 30 days after Distribution Company (Discom) officials have verified the system, and the submission of required documents. The scheme, developed by the Ministry of New and Renewable Energy, allows any residential consumer from any part of the country to apply for rooftop solar without waiting for Discom administrative processes.

In July 2022 the Indian government implemented Green Open Access Rules in the C&I segment, to further accelerate the country's ambitious renewable energy programmes, with the objective of ensuring access to affordable, reliable, sustainable and green energy for all. Through this measure, the limit for open access transactions was reduced from 1 MW to 100 kW; appropriate provisions have also been created for cross-subsidy surcharges, additional surcharges, and standby charges. All together, these measures will help consumers access green power at affordable rates. Through these rules, the government also appointed Grid India (formerly known as Power System Operation Corporation, POSOCO) as the Central Nodal Agency to set up and operate a single window green energy open access system for renewable energy. This prompted the industry to install around 2.5 GW of solar open access in 2022, a 92% increase from the 1.3 GW installed in 2021.

India set a target to install a total capacity of 4,886 MW of small solar power plants co-located with agriculture, under the framework of the KUSUM scheme. These installations range between 500 kW and 2 MW, and are installed on or near farmlands located within a 5 km radius from the substation. As of 2022, 48.2 MW of solar capacity has been installed on or near agriculture farmlands.

Local manufacturing

The Indian government introduced the Production Linked Incentive (PLI) Scheme in 2021, with an outlay of 4,500 crores rupees (503 million EUR), which will add around 10 GW of fully integrated solar manufacturing capacity by December 2024. This scheme received a very encouraging response, and was oversubscribed in 2021. In order to accommodate the increasing demand for solar modules, the government has approved a second tranche of the scheme (PLI II) in 2022. PLI II had a total cost of 19,500 crores rupees (2.18 billion EUR). The government rolled out the bid for this PLI II in November 2022. As of March 2023, the government has allocated a total capacity of 39.6 GW of domestic solar PV module manufacturing to 11 companies.

© Radiance Renewables

Challenges

COVID-19 induced delays and price escalation. Many projects were bid before the COVID-19 pandemic, but their implementation was delayed due to disruptions in supply chains caused by the pandemic. The introduction of the Basic Customs Duty (BCD) on April 1, 2022, which imposes a 40% duty on imported modules and a 25% duty on imported cells, posed a challenge for the projects that were bid before the announcement of the duty on March 9, 2021. Ultimately, projects face an immense financial burden with these high tariffs. The solar industry has requested the government to consider 'grandfathering' these specific projects (of around 20 GW), so that they can import modules based on pre-BCD rates.

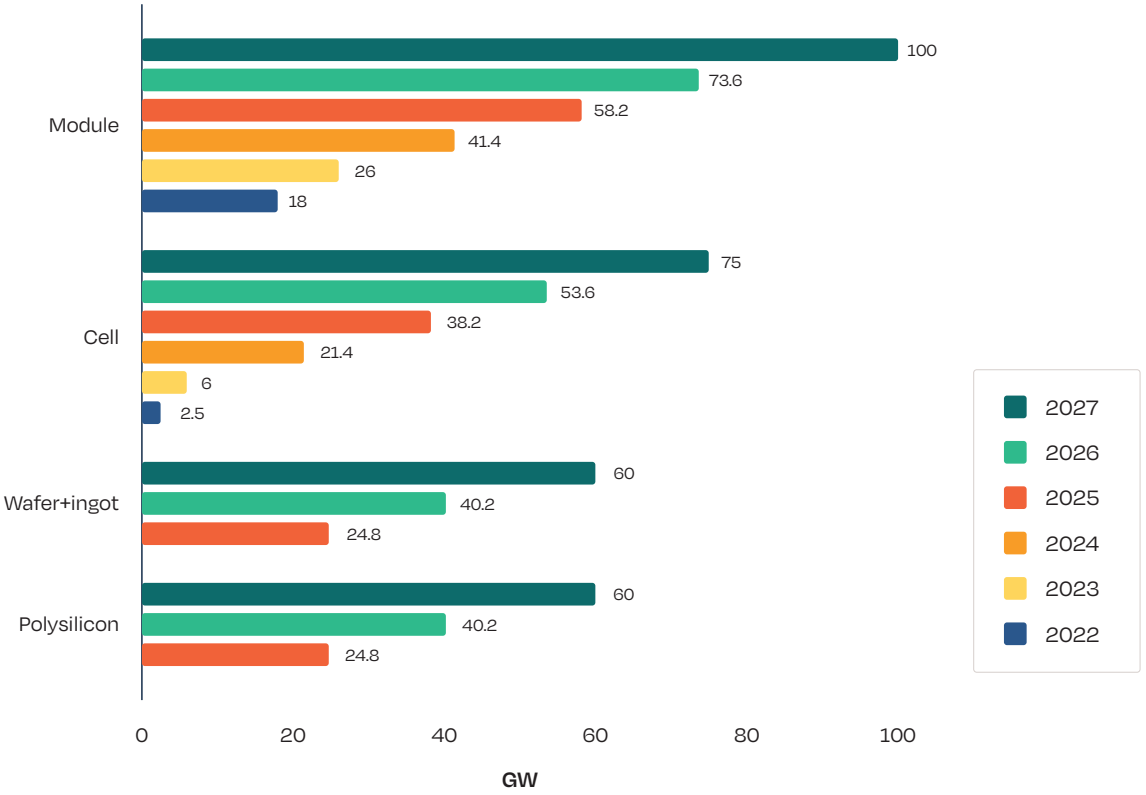
Lack of transmission infrastructure. As the pace of solar installations accelerates, the availability of commensurate transmission infrastructure is a key challenge. There is a significant mismatch in the timelines for solar project commissioning, and transmission line commissioning. This issue needs to be rectified and aligned for India to achieve its ambitious solar targets.

Outlook

To achieve the 280 GW goal by 2030, India needs to add approximately 20-30 GW of solar power every year, beginning from 2023. In March 2023, the Indian government announced a bidding trajectory for renewable energy projects. The Ministry will issue bids for 50 GW of renewable energy projects annually for the financial years 2024-28.

Moreover, India is on track to become one of the largest manufacturing hubs for solar products, due to the implementation of PLI I and PLI II schemes. The country is expected to build 100 GW of solar manufacturing capacity by 2027.

FIGURE GW3.2 INDIA'S INCREASING MANUFACTURING BASE, BY NSEFI

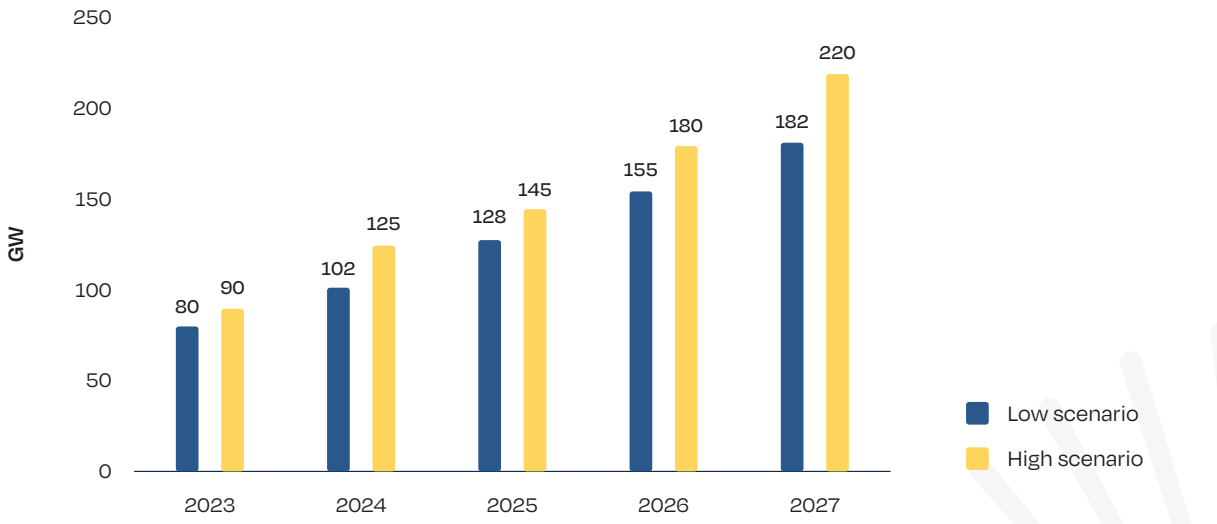


SOURCE: NSEFI.

According to the National Solar Energy Federation of India (NSEFI), there should be a significant increase in solar adoption in the country. Primarily, this will be driven by market forces; India is expected to add at least 20 GW, and potentially up to 35 GW, of solar capacity every year starting from 2023. NSEFI predicts that India will surpass the 100 GW of solar installed capacity by early 2024, making it one of only four countries in the world to achieve this milestone.

Authors: *Subrahmanyam Pulipaka,* CEO; Shubhang Parekh, Manager - International Relations and New Projects; and *Animisha Verma*, National Solar Energy Federation of India (NSEFI).

FIGURE GW3.3 INDIA CUMULATIVE SOLAR PV INSTALLATION OUTLOOK, BY NSEFI



SOURCE: NSEFI.

4. Brazil

Overview

The advancement of solar is essential to Brazil's social, economic, and environmental development. Solar PV helps diversify the country's electricity supply, reduces pressure on limited water resources, and mitigates increases in electricity prices. Solar also accelerates the sustainable energy transition of Brazil.

In 2022, Brazil continued its strong solar PV growth in two main market segments:

1. **Distributed generation:** small- and medium-sized solar PV systems equal to or below 5 MW, taking part in the Brazilian national net-metering program; and
2. **Centralised generation:** large-scale solar PV power plants over 5 MW, that commercialise their electricity through regulated market auctions, held by the Federal Government, or through bilateral power purchase agreements (PPAs) in the free electricity market.

Brazil is becoming an increasingly relevant market in solar PV. Last year, the country reached 25,040 MW of total installed solar PV capacity in operation, surpassing once again all official government projections. In 2022, 10,809 MW was installed in terms of annual capacity additions; this included 8,290 MW in distributed generation, and 2,519 MW in centralised generation.

As a result of this impressive growth, in 2022, Brazil is ranked as the 4th largest solar PV market in terms of added capacity, and 8th largest in terms of cumulative capacity.

This growth has not gone unnoticed by the international community. Numerous foreign and domestic entrepreneurs, financial institutions, and investors have established or increased their presence in the country, contributing to the growth of the market and increasing the technology's competitiveness.

One of the key drivers for success in 2022 was the country's change in the regulatory environment for distributed renewable generation. The approval of the distributed renewable generation Law no. 14,300/2022, brought more legal certainty, stability, and transparency to the market. Yet, the new rules, coming into effect in the beginning of 2023, changed the net-metering conditions to include a gradual fee for the use of the grid when electricity is injected into it. Since this change only applies to new systems requested from 2023 onwards, it created a rush of consumers and investors who submitted new projects before the end of the year, to benefit from the existing net-metering rules. As a result, the distributed generation market boomed to record numbers. For 2023 and beyond, solar PV distributed generation is expected to remain very competitive due to the combination of rising electricity prices and falling system prices.

Fernando de Noronha Archipelago-PE, Brazil. © ABSOLAR

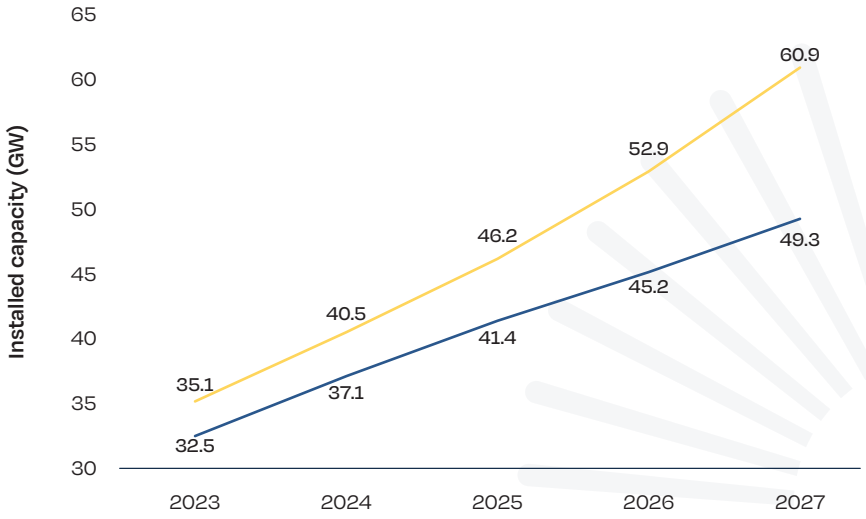
Brazil has also made significant progress in large-scale solar PV power plants. Since 2020, a record pipeline of new centralised generation projects was registered at the Brazilian Electricity Regulatory Agency (ANEEL), mostly targeting the free electricity market. More than 107 GW of large-scale solar power plants have already been granted by ANEEL, reflecting the private sector's strong interest in accelerating solar deals in the country.

Solar PV Forecast

The Brazilian Solar Photovoltaic Energy Association (ABSOLAR) forecasts a robust market performance for solar in 2023, driven by the high cost of electricity, and the benefits provided to consumers. These benefits are a strategic solution to reduce electricity costs, and strengthen the country's sustainability. Solar PV is already the most competitive electricity source in the country, and is becoming increasingly popular to all economic classes, with a positive multiplier effect in the society.

According to ABSOLAR and based on official projections from the Brazilian Energy Research Office (EPE), solar PV may reach between 49,268 MW (Conservative Scenario), and 60,910 MW (Optimistic Scenario) of cumulative installed capacity by 2027. For distributed generation, the accumulated installed capacity until 2027 may reach between 26,728 MW and 35,121 MW. For centralised generation, ABSOLAR projects an average yearly capacity addition of between 3,078 MW and 3,728 MW until 2027. Combining both distributed and centralised generation, the total yearly forecast is between 4,846 MW and 7,174 MW of solar PV added capacity on average between 2023 and 2027.

FIGURE GW4 FORECAST OF SOLAR PV CUMULATIVE INSTALLED CAPACITY IN BRAZIL, BY ABSOLAR



	2023	2024	2025	2026	2027
Distributed Solar Conservative Scenario (MW)	20,720	23,359	25,270	26,118	26,728
Distributed Solar Optimistic Scenario (MW)	23,389	26,315	28,919	31,880	35,121
Centralised Solar Conservative Scenario (MW)	11,781	13,757	16,147	19,040	22,540
Centralised Solar Optimistic Scenario (MW)	11781	14,211	17,248	21,044	25,789
—Total Conservative Scenario (MW)	32,501	37,116	41,417	45,158	49,268
—Total Optimistic Scenario (MW)	35,170	40,526	46,167	52,924	60,910

SOURCE: ABSOLAR (2023) and official projections from EPE (2022).

Challenges and opportunities

Despite this very positive forecast, the future of solar PV in Brazil is still facing challenges. One of the main bottlenecks is the lack of transmission infrastructure in certain regions, which has limited the development of new large-scale projects. Distributed generation is facing a similar issue, with difficulties connecting to the distribution grid. ABSOLAR has been working with the Federal Government and the regulatory agency to find solutions for these problems. To further unlock the immense Brazilian solar potential, it is essential to structure good public policies, programmes and incentives, at the federal, state, and municipal levels.

Considering the new Federal Government's focus on social and environmental developments, ABSOLAR is recommending the use of solar PV in social programs, such as in low-income houses through the "Minha Casa Minha Vida" programme, and solar PV off-grid systems through the "Luz para Todos" and "Mais Luz para a Amazônia" programmes. Additionally, the association proposes the use of the technology in public buildings, such as schools, hospitals, health centres, police stations, libraries, museums and parks, amongst others. With these measures, the Federal Government would also lead by example, strengthening Brazil's international sustainability reputation.

Regarding large solar power plants, ABSOLAR proposes that the Federal Government prioritise solar PV in electricity auctions, since it is the most competitive electricity source in the country, and it can help reduce tariffs for all Brazilians.

The growth of solar PV strengthens the competitiveness and sustainability of all Brazilian productive sectors and consumers, which are increasingly important factors for the country's economy and to achieve its environmental commitments.

In addition to solar, Brazil has an immense untapped potential in energy storage and green hydrogen. A study carried out by the consultancy McKinsey in 2021 indicates that green hydrogen alone may bring more than 200 billion USD in new investments to the country in the next 20 years.

Solar energy holds an immense potential for all sectors of society, and the environment. The sector is ready to do even more and collaborate to advance social programmes and energy transition policies in the country.

Considering these important opportunities and challenges, ABSOLAR will continue to defend Brazil's solar PV, energy storage and green hydrogen sectors, and will continue to develop and implement strategic recommendations to generate widespread sustainable growth in the country.

Authors: *Dr. Rodrigo Lopes Sauaia,* CEO*; Rafael Francisco Marques,* Technical and Regulatory Specialist; ABSOLAR.

Geisse Winery. Rio Grande do Sul-RS, Brazil.

5. Spain

The challenges to our future

Solar power is entering a maturity phase in Spain: with around 8.4 GW of annual installed capacity in 2022, the country experienced its best year ever for solar PV deployment, becoming the largest European PV market in 2022. Since 2020, over 18 GW has been installed, leading to a 156% increase of the solar PV operating fleet in the last 3 years. Spain's leadership in the renewable PPA market, the development of PV capacity assigned in previous renewable auctions, the geostrategic challenge driven by the Russian invasion of Ukraine related to security of supply, and the growth of rooftop PV, are the main factors contributing to the accelerating solar market. However, there is no room for complacency: both policymakers and industry will have to actively protect the country's GW-size industry.

Drivers of solar growth

Following a process that lasted several years, the Spanish Parliament approved the Climate Change Act in May 2021, fixing a dual target for renewables in 2030: a 42% share in final energy consumption, and a 74% share in electricity generation. The law also includes a clause to revise (only upwards) the targets in 2023. In order to meet these targets, the Spanish National Climate and Energy Plan (NECP) currently foresees a solar PV capacity as high as 39.2 GW in 2030. In 2023, this plan is being revised upwards, and new objectives for solar PV capacity may increase, in a range from 50 to 65 GW.

The main driver for solar growth in Spain is its competitiveness, in both ground-mounted plants and self-consumption.

For ground-mounted plants, the economic competitiveness of the technology (favoured by economies of scale), the terrain, and solar resource availability of over 1,900-2,000 kWh/kWp per year, as well as the regulatory stability of recent years, have fostered a supportive ecosystem which has attracted the interest of different actors. These include national utilities, European utilities, companies from the oil & gas sector, independent power producers (IPPs), solar developers, investment funds, etc.

As a result of this ecosystem, a considerable number of developers and IPPs have deployed GW-size portfolios which have been sold to newcomers also pursuing brownfield development. Significant activity in mergers and acquisitions (M&A) is making Spain one of the largest sectors in Europe for transactions in renewables. In addition to M&A operations, several companies are considering going public, highlighting the strong potential of Spanish solar companies.

PPAs have been a main factor in this recent development. All large-scale solar capacity commissioned during 2020 (3.5 GW), 2021 (4.3 GW) and 2022 (5.3 GW), has been developed without any type of

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public aid or regulatory scheme, and all through PPAs or merchant projects. The **stability offered by Power Purchase Agreements is now more valuable than ever.**

The rooftop PV market is developing at an accelerated pace. After the removal of the 'Sun Tax' on self-consumption in 2018, the current framework was only achieved in 2020, with the introduction of automatic surplus remuneration, plus collective and through-the-network facilities. Both companies and the end-consumer market have been gradually gaining pace since then.

Rooftop PV had already been increasing strongly in previous years (+551 MW in 2019, +715 MW in 2020). However, a substantial growth level was reached in 2021, when this market segment grew 102% year-on-year exceeding the GW-level with 1,444 MW of annual installed capacity. This trend continued in 2022, with another 108% increase year-on-year, reaching 3,008 MW. This spectacular growth was especially strong in the industrial segment, which accounted for 47% of the total. The high electricity prices of 2022, and the tax incentives of many municipalities, encouraged many households and businesses across the country to become self-consumers.

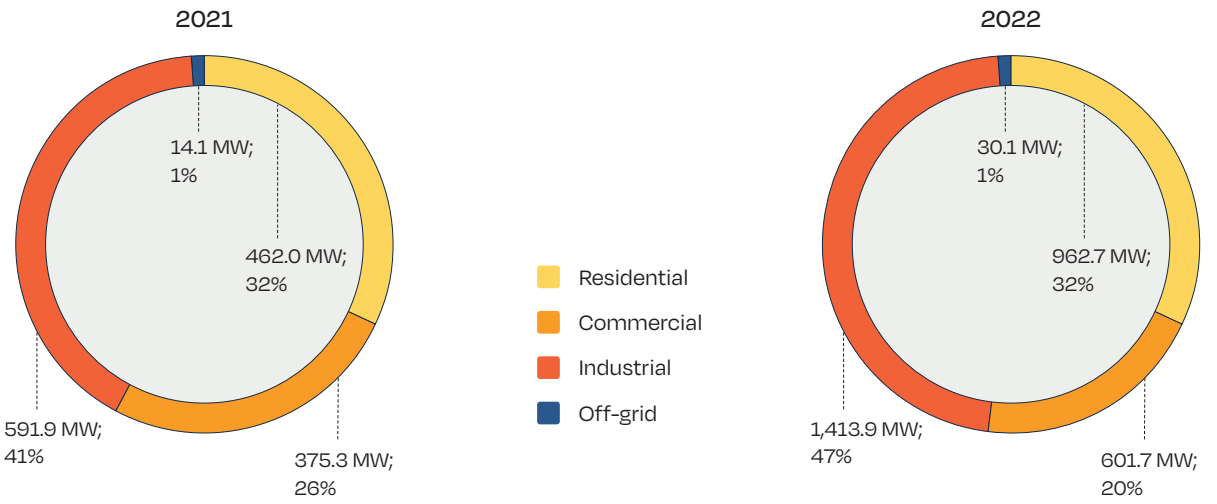
On the policy side, the main driver for the development of the sector is the Roadmap of **Self-Consumption, approved in December 2021**. The document includes measures to foster this segment, and estimates the potential of self-consumption in 2030 as between 9 and 14 GW. Furthermore, in 2022, several policies have been developed to improve self-consumption deployment; in March 2022, 10% of grid access has been reserved for self-consumption, plus Royal Decree 18/2022 has improved the permitting process for small self-consumption installations.

Under Spain's **National Recovery and Resilience Plan**, rooftop PV is considered a priority area in facilitating the energy transition. In fact, in May 2022, the government has amended Royal Decree 477/2021, doubling the 450 million EUR allocated to the sector in 2021.

As mentioned, the main driving force for rooftop PV is the high wholesale electricity prices, serving as a **wake-up call** for industrial and commercial players, as well as for households. All these segments are looking at solar as a means to decrease their energy bills through the use of affordable and green self-consumed electricity.

Additionally, in response to Russia's invasion of Ukraine, the Spanish government introduced a set of measures in April 2022 to decrease fossil fuel dependencies, curb energy prices, and speed up the deployment of renewables. The package of measures includes, among others, a regulatory framework for floating PV, accelerated procedures for PV parks below 150 MW, strengthened distribution grid capacity to absorb 7 GW of self-consumption systems, and regulations for the pipelines of renewable gases, including renewable hydrogen.

FIGURE GW5.1 SPAIN SELF-CONSUMPTION PV CAPACITY INSTALLED IN 2021-2022 (MW)



In terms of **outlook**, expectations are also very positive.

In the ground-mounted segment, as previously stated, the newly installed capacity reached 5.4 GW in 2022, in line with our previous forecasts, and continued to rely upon PPAs. Recently, a large number of new projects obtained their environmental permits and are likely to be installed in the current year. Nevertheless, the deployment of new power generation form ground-mounted plants will depend on the design of the renewable auctions foreseen by 2023, as inflation rates and prices are rising.

For the rooftop PV segment, in 2022, the market grew significantly, by more than 100% again year-on-year, and surpassed the 3 GW barrier, mainly driven, as said before, by national recovery plan funds and high electricity prices.

Challenges

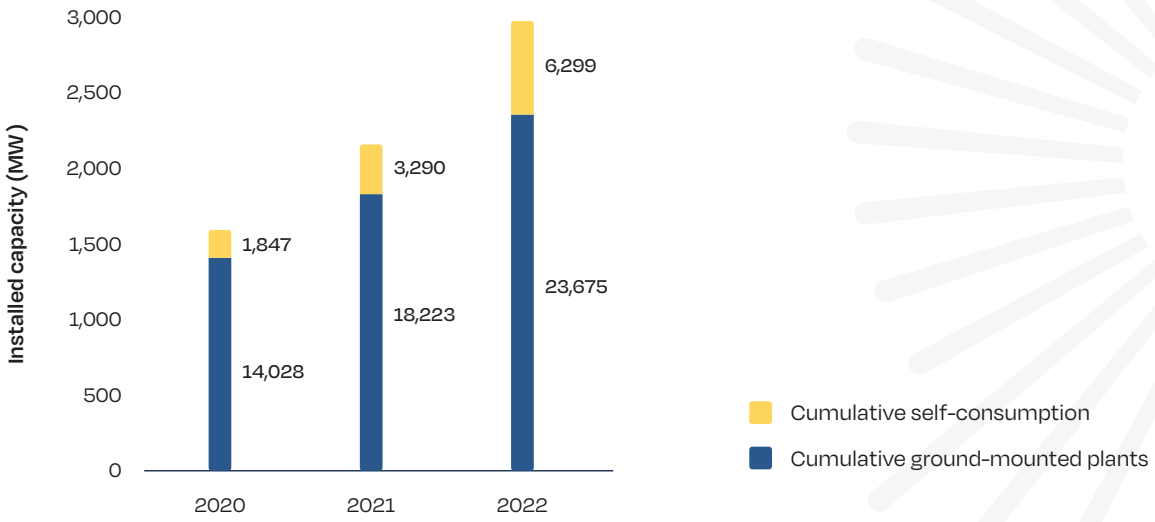
In relation to ground-mounted plants, it is clear that the higher the volume of projects under development, the larger the burden on companies, authorities, local communities and other stakeholders.

This general effect is increased by the Royal Decree-law 23/2020, which imposes strict deadlines on plants under development: all projects with network access permits in force when the decree was approved had to obtain their environmental authorisation before 25 January 2023. This deadline obliged companies to rapidly advance their permitting procedures, and put strong pressure on the administrative authorities, which struggled to process the volume of files. As a result, around 30 GW of renewable technologies received an environmental authorisation and are likely to be deployed within the next three years. Nevertheless, the projects are still waiting for **their administrative and construction permits that need to be obtained before 25 July 2023**, otherwise the projects will be dismissed; these are key milestones needed to fully deploy the power plants.

In 2022 Spain held two auctions (3rd and 4th auctions). While the 3rd auction was a small auction that awarded 31 MW at an average price of 53.88 EUR/MWh, the 4th action was wholly undersubscribed and ended empty as the reserve price set by the government, at 45.12 EUR/MWh, was well below the sector's expectations at around 60 EUR/MWh. In the upcoming auctions expected in 2023, auction design needs to improve to attract interest from developers.

On the local communities' side, the sheer volume of projects going through local permitting (amounting to 2-3 times the NECP targets), is generating a **NIMBY effect**, i.e. a 'not in my backyard' mentality. Certain local associations are opposing utility-scale renewable plants, requiring a significant communication effort from companies and UNEF, about the benefits of solar power on land use and biodiversity.

FIGURE GW5.2 SPAIN SOLAR PV INSTALLED CAPACITY 2020-2022, BY UNEF



SOURCE: UNEF.

For rooftop PV, the main challenge is the **length of permitting times** (both at the administrative and network level), due to diverging processes across municipalities, and reduced permit exemptions for network access for rooftop PV. In addition, delays in the implementation of the national recovery plans' support programmes are slowing down consumers and developers' decision-making processes, who are now waiting for the funds to be available in their region.

Another important challenge for PV development, both ground-mounted plants and rooftop PV, is the lack of a skilled labour force which is driving an increase in salaries. Government professional training programmes must adapt to those new market developments.

Increasing electricity prices are also driving inflation rates, which are having an impact on projects' profitability.

Furthermore, Spain must accelerate its regulatory framework related to storage incentives as proposed by UNEF.

Conclusions

Spain's high NECP targets, and the success of the national solar power market call for **excellence from all parties: companies, the administration, and policymakers. In other words, our ambition has to overcome our challenges to maintain the supportive solar ecosystem** that has placed Spain in the group of the **world's top 10 largest markets.**

On the policy side, it is key to ensure regulatory stability, and to eliminate remaining barriers by streamlining administrative procedures, and network access, especially for smaller PV plants and self-consumption projects. On the sector side, companies need to respond to the growing NIMBY effect, and present projects with the highest standards in terms of environmental sustainability, positive social impacts, and transparency.

Authors: *José Donoso,* Director General, Unión Española Fotovoltaica (UNEF).

6. Germany

PV installations reach new peaks despite adversity

Overview of solar PV developments

According to the database of the German Federal Network Agency (Bundesnetzagentur, BNetzA), a total of 2.74 GW of solar PV has already been put into operation in Germany in the first quarter of 2023, while a total of 7.4 GW of solar PV had been put into operation in 2022.[9] Of these projects, over 6.5 GW benefitted from various schemes within the country's Renewable Energy Sources Act (EEG). Despite disruptions to international supply chains and having to deal with the ramifications of Germany's partial dependence on Russian gas, Germany reached the highest peaks in monthly solar PV additions since 2012. The previous year's highest monthly addition of 844 MW in March 2022 has been upstaged by the recent addition of 1,096 MW of solar PV in March 2023. Overall, the first quarter of 2023 shows steady solar market growth, with 40% more installed capacity than the first quarter of 2022, which in turn showed 39% growth compared to the same period in 2021. This trend implies a continuous growth path for solar PV in Germany.[10] Moreover, the German corporate renewable Power Purchasing Agreement (PPA) market is maturing, with rooftop PPA additions in 2022 doubling to 124 MW compared to the previous year, and ground-mounted PPA additions increasing from 296 MW in 2020 to 640 MW in 2021, and 742 MW in 2022. Furthermore, several GW of merchant solar PV parks of over 10 MW, outside the Renewable Energy Sources Act (EEG) scheme, are in the project pipeline.

Solar PV targets and drivers of growth in Germany

With 70.3 GW of solar PV in operation at the end of March 2023, German installed capacity remains the highest in Europe. Germany seeks to fulfil the commitment of its government coalition formed at the end of 2021 to reach 22 GW of yearly installed solar PV by 2026 targeting a total installed PV capacity of 215 GW by 2030. The so-called 'Easter Package' adopted in July 2022 established these ambitious targets with an aim to reach close to 400 GW by 2040. In the case that the current yearly growth trend continues, the annual capacity of 9 GW envisaged by the Federal Ministry for Economic Affairs and Climate Action for 2023 would indeed be reached, or even exceeded.

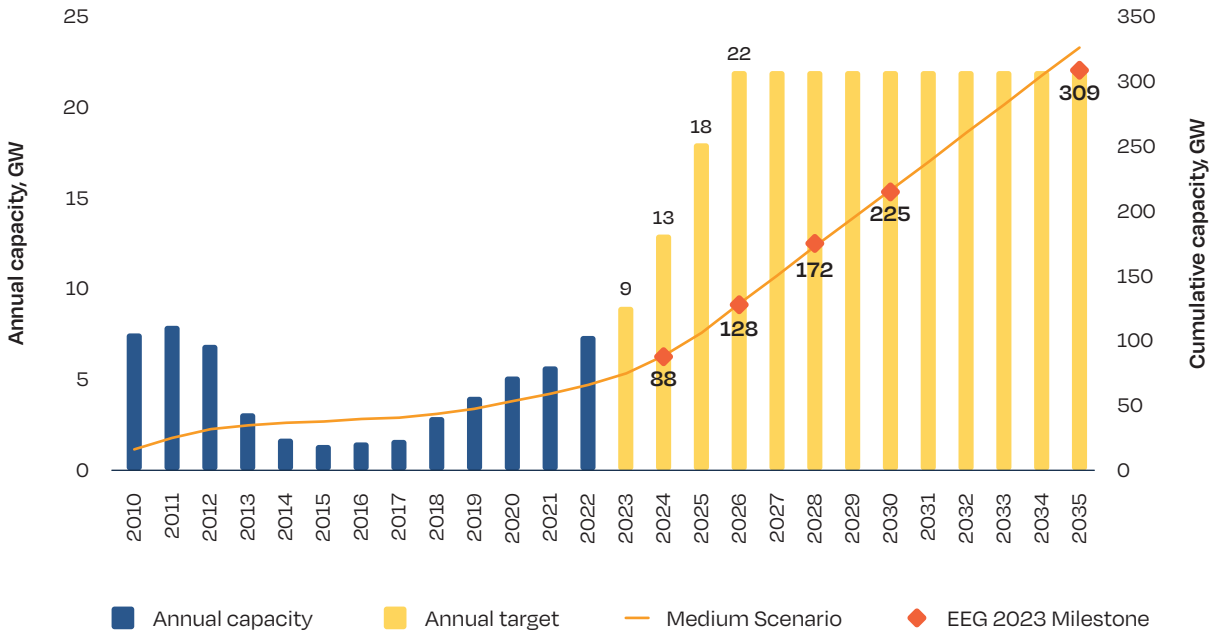
Since June 2021, the Climate Protection Act has also set a binding path to climate neutrality in 2045, while interim GHG emission reduction targets have been raised to 65% by 2030 and to 88% by 2040. Accordingly, the target share of renewable energies has been raised from 65% to 80% of the electricity demand by 2030, with full decarbonisation by 2035. In January 2021, the former government had already introduced a national expansion to the EU-wide Emission Trading System (EU ETS) covering heating and transport fuels. Starting with a CO_2 price of 25 EUR per tonne, prices will increase each year up to 55 EUR per tonne in 2025 leading to an auction system whose long-term CO_2 price floor is targeted to stabilise at 60 EUR.

The year 2022 can justifiably be considered a watershed moment in the German energy transition. With a new coalition and ambitious targets in place but additional constraints arising from Russia's invasion of Ukraine, the commitment of German policymakers to support solar was tested. The government coalition's subsequent vow to increase efforts to speed up the energy transition and to lower Russian gas imports demonstrated its determination to stay its course. The newly combined Federal Ministry for Economic Affairs and Climate Action (BMWK) consequently reacted to the geopolitical crisis with swift amendments to Germany's EEG 2021 regulation and a new EEG 2023 regulation package. With similar commitment, solar businesses across the entire value chain overcame supply chain hurdles to install a capacity just shy of the all-time highest annual value in Germany's solar history, providing consumers with resilient energy solutions that saved citizens significant electricity costs. Meanwhile, after having their operation time extended by 4 months, the last three nuclear plants in Germany were closed in April 2023. This event marks Germany's detachment from nuclear fission technology.

9 In line with recommendations by the BNetzA and the latest revisions to their database, solar PV additions are computed based on the date of initial operation. Therefore, minor deviations from previously calculated values based on reporting dates may occur. This includes the aggregate addition for the year 2022, which can still be subject to further revisions and would have been closer to previous predictions with roughly 7.5 GW according to the previous methodology.

10 This effect is amplified by the fact that numerous PV installations (or at least connections) may have been postponed from December 2022 to the following year to benefit from higher feed-in-tariffs granted from 01.01.23 onwards due to adjusted EEG 2023 regulations. This makes extrapolations of the first quarter growth for a projection of annual capacity additions difficult. A 33% increase over the 2022 capacity addition of 7.4 GW would yield almost 10 GW.

FIGURE GW6 GERMANY PV CAPACITY TARGETS 2023-2035, BY BSW-SOLAR



SOURCE: EEG 2023, BMWK.

To meet the above targets and foster Germany's solar PV ambitions, several auxiliary measures were adopted over the course of 2022. As of July 2022, the EEG 2023 increased the excess solar power feed-in for small rooftop systems to 0.086 EUR/kWh, and the full feed-in tariff to 0.134 EUR/kWh with the monthly FIT degression mechanism frozen until 2024, after which it will restart with increases of 1% at 6-month intervals. The full FIT bonus is aimed at investors whose properties have little or no self-consumption needs and encourages maximum usage of available roof space. Likewise, the feed-in tariff for ground-mounted and other PV systems has been increased to 0.07 EUR/kWh from roughly 0.04 EUR/kWh and eligibility has been extended to systems up to 1 MW. Moreover, the renewable energy surcharge ('EEG Umlage') of 0.037 EUR/kWh has been removed as of July 2022. This means that operators of PV plants no longer have to pay this surcharge for self-consumed solar power. It also means that the EEG remuneration for the development of renewable energies will be financed solely by the Federal Energy and Climate Fund and by revenues from the ETS.

Later in 2022, solar PV systems with less than 30 kW were also granted a VAT exemption, at least reducing the administrative burden for owners, and allowing installers to remove the VAT component from their sales pitches and invoices entirely. Small solar systems of up to 600 W benefit from simplified grid connection procedures and 'balcony solar' became a veritable trend in Germany with over 250,000 systems and 100 MW installed, half of which is accounted for in the market register according to BMWK figures. Further legislative amendments are poised to increase the threshold to 800 W and to allow grid connection via simple electricity sockets. Lastly, bottlenecks in the certification of solar PV systems above 135 kW could be alleviated to some degree by means of a temporary certificate granting tentative grid access as requested by stakeholders and associations.

The attempt to tax windfall profits through a revenue levy was restricted to a limited time window and not applied retroactively as originally planned. Revenue caps nevertheless have the potential to curb the profits that arise from favourable market conditions

and that investors bank on. Their eventual implementation therefore irritated investors who consider ad-hoc revenue caps as a threat to investment security. In light of the ineffectiveness of the implemented cap due to sinking energy prices, the BMWK has consequently announced to let the measure fade out at the end of June 2023.

After an in-depth consultation process with stakeholders and associations over several months, the BMWK released its draft for an even more comprehensive Photovoltaic Strategy on 5th May 2023. This strategy will be cast into regulations and amendments meant to facilitate solar PV deployment, reduce bureaucratic burdens and accelerate grid connections, among many other aspects.

Solar trends: Tenders, utility-scale solar and storage

Since January 2023, solar PV installations below 1 MW have been exempted from mandatory participation in tenders, lifting the previous 750 kW threshold. Germany currently has two types of large-scale auctions whose tenders are specifically designed for solar PV projects. The first segment represents a technology-specific tender for ground-mounted projects between 1 and 20 MW (in 2023 up to 100 MW), and the second one is a tender for rooftop systems above 1 MW. Besides this, there is an auction with two rounds of approximately 400 MW for innovative systems.

Within the first segment for ground-mounted projects, three tenders took place in 2022. The first one in March 2022 awarded a volume of 1,083 MW at an average bidding price of 0.052 EUR/kWh and exhausted the auctioned volume, whereas the remaining tenders awarded 696 MW in June and 609 MW in November, with the latter concluding at an average bidding price of 0.058 EUR/kWh. In reaction to these two rounds being heavily undersubscribed at 62% of 1,126 MW and 68% of 890 MW (due to the volume increases and maximum bids not reflecting rising system prices and financing costs), stakeholders and associations pushed for higher maximum bids. This initiative proved successful; raising the maximum bid from 0.059 EUR/kWh to 0.074 EUR/kWh immediately led to a 50% oversubscribed auction in March 2023 awarding 1.952 GW at an average bidding price of 0.071 EUR/kWh.

Likewise, the rooftop tenders in 2022 were severely undersubscribed before an adjustment of the maximum bidding price from 0.089 EUR/kWh to 0.113 EUR/kWh led to an almost exhausted tender in February 2023. The combined volume of these tenders will be over 6 GW in 2023, adjusted for forfeited successful bids and volumes from past auctions, and will increase to 9 GW by 2027. Following the EEG revision, the subsidies for the development of Agri-PV now fall under the large-scale auction instead of the innovation tenders. The available areas for Agri-PV have also been increased.

21.1 MW, Bad Liebenwerda, Brandenburg, Germany.

According to SolarPower Europe's *European Market Outlook for Residential Battery Storage 2022–2026* and the latest BSW-Solar calculations, Germany continues to be the key European market for home batteries. While in 2021 approximately 140,000 units with a storage capacity of over 1.3 GWh had been installed, 2022 saw the installation of 214,000 units with a total storage capacity of 1.9 GWh increasingly in tandem with PV systems. The latest amendments to the Energy Industry Act in June 2021 included the removal of double charges and levies to battery systems, enabling better utilisation of batteries' flexibility potential in the energy system. For the next 5 years, Germany is expected to remain Europe's biggest market for residential batteries due to a very strong solar market and high retail power prices, combined with high demand for EVs and a quickly increasing number of solar systems dropping out of the 20-year long FIT scheme.

Challenges

The regulatory initiatives related to the EEG 2021 and EEG 2023 frameworks have lifted several barriers to the deployment of solar PV in Germany. With the threshold for mandatory auctions now raised to 1 MW, the removal of the EEG surcharge and increased FIT rates, the rooftop segment is on track to be a major contributor to the country's ambition to be climate and energy independent.

A first challenge concerns the proposal to limit profit margins through a revenue cap, as this has created uncertainty in the market and is disincentivising investments at a time when they are most needed. Secondly, identifying suitable areas and receiving permits to develop large utility-scale volumes represents a persistent challenge. Thirdly, even if Agri-PV is now part of the large-scale tender scheme – instead of the innovation tender – the bonus allocated for Agri-PV is currently insufficient.

Nonetheless, Germany's major market segments are on a promising growth path. This leads to installers and other solar businesses hiring additional talent. There is a need for extra workforce in the sector.

Additionally, establishing sufficient European solar manufacturing capacities across the entire value chain is needed to increase resilience and guarantee that local stakeholders partake in the windfall gains generated in the power sector by the rapid growth of solar PV deployment foreseen in the German market.

Finally, grid congestion is a hurdle that must be addressed. Providing additional flexibility through smart digital solutions and storage can alleviate grid expansion pressure, while the stimulation of the C&I rooftop segment as well as continued support for the adoption of PPAs complement this. The government coalition has demonstrated its willingness to readjust regulations when deployment targets are in jeopardy. The Photovoltaic Strategy announced in May has the potential to accelerate this deployment even further by removing obstructive legacies. With elections coming up in 2025, as well as residential and process heating taking much of the spotlight in the wake of gas supply disruptions, the political capital available for progressive solar PV policies has to be fully activated within the coming months.

The key to continued deployment in line with the target of 215 GW by 2030 is therefore getting all the pieces of the puzzle together quickly. This includes incentivising investors to bring solar onto unused residential rooftops, establish solar energy as the leading means to decarbonise heating and exhaust tendered capacities for utility-scale solar plants as well as C&I rooftops. To install 145 GW over the next 8 years, there are additional hurdles to be tackled. These include smoothing permitting processes, educating a sufficient number of installers, electricians and other skilled workers for the energy transition, as well as keeping the local acceptance as high as it currently is.[11] Lastly, increasing the resilience of the solar supply chain in cooperation with the EU and its Member States can then safeguard the energy transition against geopolitical uncertainty and volatility.

Authors: *Alexander Rohlf & Christian Menke*, Bundesverband Solarwirtschaft e.V. (BSW-Solar).

11 Approval for rooftop solar in Germany is currently above 90% and solar ground-mounted systems enjoy the highest acceptance out of all utility-scale renewable energy applications according to recent Ariadne Project surveys ("Soziales Nachhaltigkeitsbarometer der Energie- und Verkehrswende 2022").

7. Japan

Overview of PV developments

Having achieved record capacity addition of 10.8 GW in 2015, the Japanese PV market has been on a downtrend following the reduced FIT support for solar PV. In 2022, Japan installed around 6.5 GW of new solar PV capacity, roughly the same capacity as in 2021. The cumulative installed capacity at the end of 2022 reached 84.9 GW. Even with the reduced FIT support, Japan's PV market is expected to start trending upward again from 2023, due to the growth in residential and industrial rooftop markets, and new corporate renewable Power Purchasing Agreement (PPA) models. Japan's emissions reduction target of 46–50% by 2030 will require a large increase in the share of renewable energy, in particular solar PV.

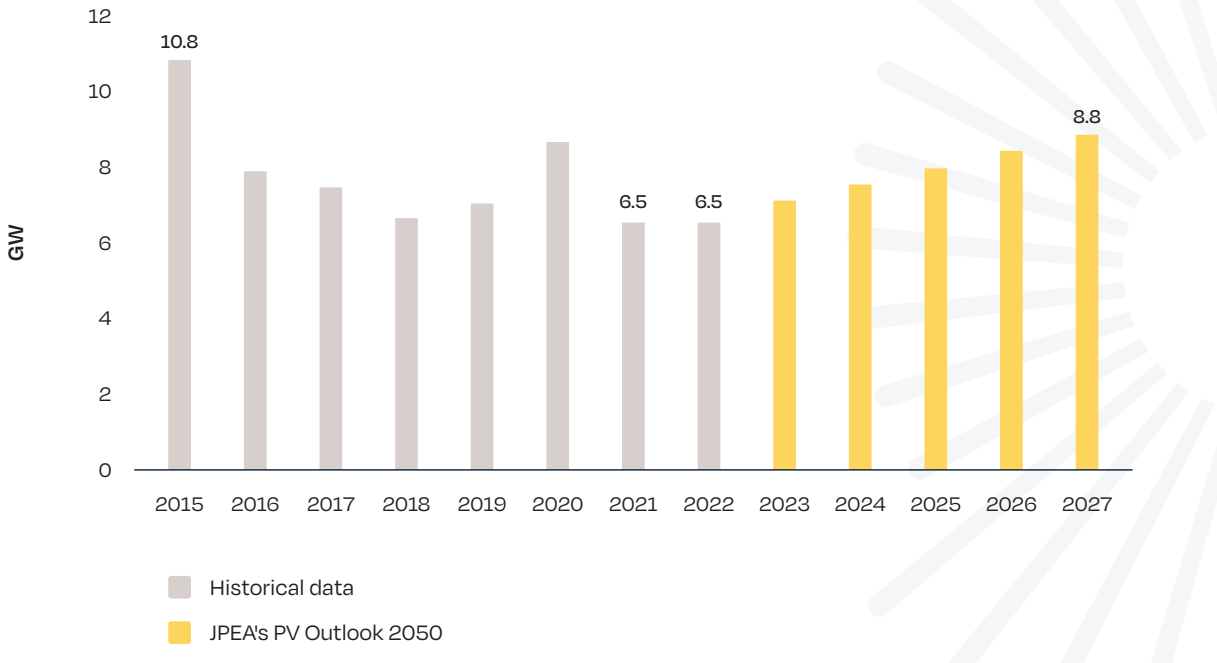
Japanese solar and renewable energy targets

- **The government's PV target:** According to the 'Long-term Energy Supply and Demand Outlook' (Energy Outlook) published by the Ministry of Economy, Trade and Industry (METI) in 2015, the cumulative installed PV capacity target for 2030 was 80 GW. This 'old' target was increased by METI to around 147 GW (118 GW_{AC}) in its most ambitious scenario to meet the new carbon reduction target of up to 50% by 2030.
- **Renewable Energy Target:** In July 2021, METI announced new plans to significantly increase the renewable part of its energy generation mix to 36-38% by 2030, from 20-22% before.
- Japan Photovoltaic Energy Association's **(JPEA) vision (PV OUTLOOK 2050):** In JPEA's PV OUTLOOK 2050, released in May 2020, the cumulative installed PV capacity was expected to be around 120 GW (100 GW_{AC}) in 2030. However, in accordance with the new national GHG reduction target, JPEA has revised this 120 GW target upwards to 154 GW (125 GW_{AC}) by 2030. This new, ambitious target – which is 7 GW higher than METI's projection – means, on average, that around 8.6 GW solar PV will have to be installed every year from 2023 until 2030.

Drivers for solar growth in Japan

The FIT scheme has been the strongest driver of solar growth in Japan since its introduction in July 2012. However, the relevance of this FIT scheme has

FIGURE GW7 JAPANESE SOLAR PV MARKET SCENARIOS 2023-2027 (DC), BY JPEA



decreased, and a more market-oriented Feed in Premium (FIP) has been introduced in April 2022. Instead of setting a fixed feed-in tariff rate, the FIP scheme allocates a certain amount of premium in addition to the wholesale electricity price. This way, the remuneration level is connected to the current electricity prices. The new FIT/FIP scheme is expected to be a new driver for solar demand. Under the new framework, larger projects will be subject to the FIP remuneration, while the FIT is maintained for smaller systems.

The **'self-consumption business model'** for commercial and industrial users is growing rapidly in Japan. On-site, self-consumption PV systems are becoming more attractive to business users, as the LCOE of PV power generation is already competitive with the retail electricity prices of commercial and industrial users.

An additional driver to solar growth stems from policies setting **PV mandates for new buildings**. The Tokyo Metropolitan Government, and Kawasaki City, will make it mandatory to install PV systems on new buildings, including detached houses, starting in 2025. If similar installation mandates spread to municipalities across the country, the PV market, especially residential rooftop, will expand significantly.

In addition to the needs of renewable energy users, **the PPA model** is beginning to gain traction in the Japanese PV market, driven by government subsidies and rising electricity prices.

Utility-scale vs. distributed & rooftop solar developments

In 2022, new residential PV (below 10 kW) capacity additions totalled 1.0 GW, up from 0.8 GW in 2021. We expect this segment to grow further, supported by the FIT and various subsidies for net-zero energy houses (ZEH), battery systems, etc. Beyond 2025, municipal PV installation mandates for new buildings, including those from the Tokyo Metropolitan Government and Kawasaki City, could be a strong driver of residential rooftop market growth.

Distributed solar PV under 1 MW, mostly ground-mounted, is on a downward trend since 2016, mainly due to reduced FIT support. This segment requires a business transformation, for example, from a simple ground-mounted system, to a self-consumption system integrated with renewable energy users' and/or local community's energy demand. The segment is also expected to grow again with the growth of corporate PPAs outside the FIT scheme.

Large solar PV systems of 1 MW and above, including utility-scale systems, are also trending downwards. In addition to the FIT termination, power grid constraints and land availability have also contributed to reduced demand. This segment is likely to start growing again in the medium term, as soon as these constraints are overcome, and with improved cost competitiveness. Following the introduction of the FIP regime, many investors and developers are preferring to wait due to the significant uncertainties about future electricity prices. At the same time, they are turning more and more towards on-site PPAs.

Kawakami-2 Mega-solar project, 31 MW, installed at an altitude of 1,600 meters, Nagano, Japan. © Vena Energy Japan

Challenges

- **Smooth transition from FIT to FIP:** FIPs were introduced in 2022 as a mandatory incentive mechanism for large-scale solar PV (500 kW and above from 2023), and optional for distributed solar PV (50 kW – 500 kW from 2023). One of the biggest challenges for the industry and for policymakers is the smooth transition from FITs to more market-oriented FIPs.
- **Business model transformation:** The role of FIT/FIP will gradually shrink in the coming years. With the emergence of PPA type business models, this decade will see the transition towards a market growth with little reliance on the FIT/FIP regime.
- **Grid constraints:** Limited grid capacity and curtailment risks are the primary causes for the downward market trend in Japan. METI has taken several mitigation measures to maximise grid capacity with existing assets, such as the 'Connect and Manage' programme for transmission and distribution grid levels. Moreover, METI has developed the long-term grid expansion programme to accommodate large amounts of renewable energy.
- **Land availability:** New business models without dedicated land space (e.g., on-site self-consumption models), and utilisation of unused/abandoned farmland are a solution to the limited land availability problem. To date, conversion of unused/abandoned farmland to solar farms is very limited as it requires strict legal procedures, and the local authorities' permission. The government is now tackling those constraints by reforming existing laws and regulations.
- **Cost competitiveness:** The cost of solar PV in Japan is still significantly higher compared to average international levels, mainly due to expensive construction and soft costs. Reduced CAPEX (mostly construction costs) and a longer PV lifespan (e.g., from 20-year life to over 30 years) are key goals for the industry. The FIT for a ground mounted PV system between 10 and 50 kW was set at 10 JPY/kWh (0.068 EUR) and 9.2 JPY/kWh (0.062 EUR), for systems from 50 kW to 250 kW. The government targets a solar PV LCOE of 7 JPY/kWh (0.047 EUR) by 2028.

Author: *Takeaki Masukawa*, Secretary General, Japan Photovoltaic Energy Association (JPEA).

8. Poland

Overview of the solar market

At the beginning of January 2023, over 22.7 GW of renewable energy was installed in Poland, of which 12.4 GW came from solar PV installations. That is a 55% year-on-year growth from the end of January 2022, when total solar capacity amounted to 8 GW. It is also more than 3 times more PV than the 4 GW installed at the end of January 2021. Solar PV covered 6% of the country's final demand for electricity in 2022. Approximately 75% of the installed capacity is provided by micro-installations up to 50 kW.

The success of solar energy in Poland is mostly due to the popularity of home prosumer installations. According to data from the Energy Market Agency, by the end of January 2023, Poland already had over 1.2 million PV micro-installations. The high popularity of home installations is mainly the result of very favourable financial conditions for prosumers, which were in force until the end of March 2022. Specifically, the country's net-metering scheme allowed prosumers with systems of up to 10 kW to feed 1 kWh into the grid, and receive 0.8 kWh for free. For larger installations above 10 kW, this ratio was 1 to 0.7. Moreover, prosumers did not pay the distribution fees for using the grid.

The large growth in the number of micro-installations in Poland turned out to be challenging for distribution networks and led to changes in the policy framework. On 1 April 2022, the net-metering scheme was replaced by a net-billing scheme, whereby the amount of electricity injected and retrieved from the grid is balanced in an hourly settlement using a metering system. Under the new scheme, prosumers are rewarded for surplus energy fed into the grid at the wholesale price, and they pay for the consumed energy just like other electricity consumers. After this change, the popularity of micro-installations somewhat decreased, although solar PV remains an attractive investment for households considering current electricity prices.

A public opinion survey carried out in May 2022 and commissioned by the Polish Photovoltaic Association, showed the continued high public support for solar energy. The survey highlighted that renewable energy sources (RES) rank best in all aspects when compared to any other energy source.

Among renewable energy sources, solar PV obtains the best results, and is the technology that Polish people are the most willing to have in their neighborhood (51% of responses). Nearly 2 in 5 respondents also think that the requirement to install PV systems on all new buildings is a very good idea.

Public solar PV targets

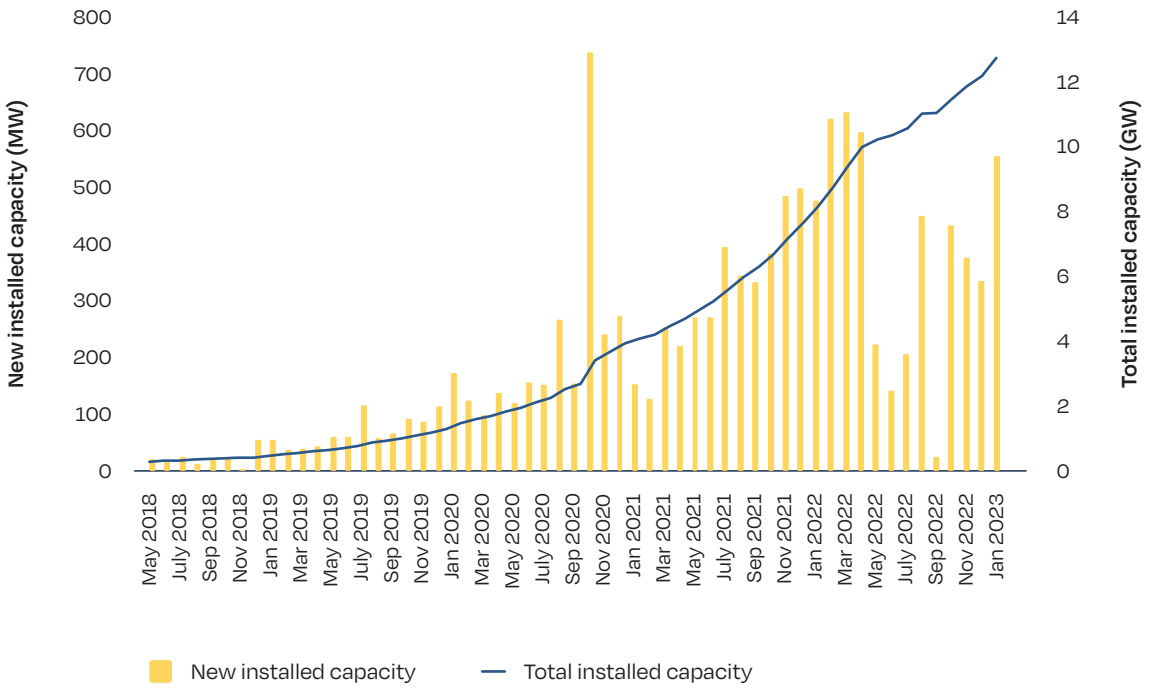
The most up-to-date document defining the RES goals is the Polish Energy Policy 2040, though not yet published at the time of writing this article. According to unofficial information, the document mentions that the capacity of renewable energy sources will constitute 50% of the installed power capacity already in 2025, then 57% in 2030, and reach 68% in 2040. The largest increase in capacity occurs in solar power plants – to the level of approximately 27 GW in 2030, and as much as 45 GW in 2040, which will be driven by the increased number of prosumers and solar farms.

Key drivers for the solar market

In addition to the favourable legal framework, the global energy context is providing a boost to solar deployment. The significant increase in energy prices and the lack of raw materials following Russia's invasion of Ukraine is driving local governments and enterprises to look toward energy self-sufficiency, resulting in new investments in photovoltaics. The country is also observing an increasing interest in the direct sale of market-based RES energy in the form of corporate Power Purchase Agreements (PPAs).

In the small-scale segment, in addition to the change from the previous net-metering framework to the new net-billing scheme, the popular "Moj Prad" (My Electricity) scheme is also being revised. From mid-December 2022 until the end of March 2023, the subsidies towards residential solar were increased by 50% from 4,000 PLN (869 EUR) to 6,000 PLN (1,303 EUR) per system, while the rebates on battery installations were more than doubled to 16,000 PLN

FIGURE GW8 MONTHLY AND CUMULATIVE SOLAR PV INSTALLATION IN POLAND 2018-2023, BY PV POLAND



SOURCE: PSE AND ARE.

(3,475 EUR). Eligible installations range from 2 to 10 kW and grid connection is necessary. The war is quoted as the main reason for providing additional funding. Since the beginning of the scheme in 2019, over 1.7 billion PLN (369 million EUR) have been allocated to over 410,000 projects.

Key challenges for the solar market

The biggest barrier is still the limited capacity to connect new generation sources. Where the grid develops, photovoltaics will quickly replenish power shortages. The grid requires modernisation not only due to the energy transformation, but also due to its age – most of its components are over 25 years old, and a significant amount are over 40 years old.

The act limiting electricity prices recently adopted by the Parliament is very relevant for the PV sector – and the entire Polish energy market. The act implements the European Council Regulation No. 2022/1854, and aims to protect the most vulnerable consumers against uncontrolled price increases. It contains a mechanism that limits the market income of energy producers and energy companies to the amount specified in a separate regulation. While physical PPAs are exempted, virtual PPAs are negatively affected by the cap. The reduction in energy prices is applied until the end of 2023.

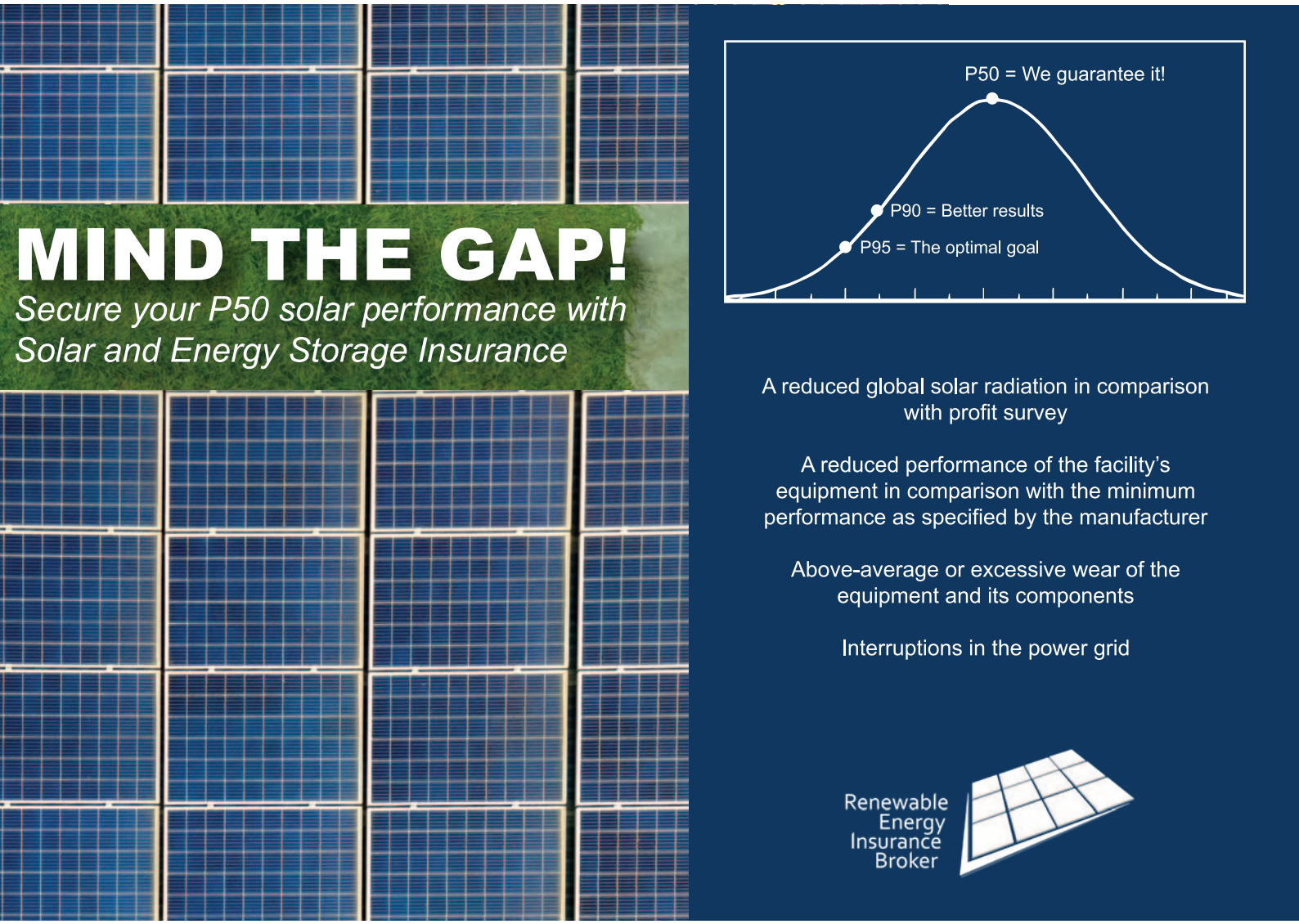
The government's work on amending the Spatial Planning and Development Act is also worrying for the PV industry, and RES in general. Some of the legal solutions proposed in the draft will block further development of renewable energy sources in Poland. The proposed legislation aims to make it more challenging, and prolong the time it takes to invest in class IV agricultural land. Typically, this refers to medium-quality land that is often unsuitable for agricultural production. In the end of May 2023, the draft law was still being deliberated in parliament.

Prospect for the solar market 2023-2027

Despite these challenges, we anticipate further stable development of solar energy. The self-consumption segment is expected to grow, whereas for the development of large-scale PV farms, large investments in power grids will be necessary. Poland is already experiencing a shortage in energy production capacity, and this trend is set to grow. Against this background, PV is currently the only technology that can deliver new energy production capacity within a short timeframe.

Author: *Paulina Wojciechowska,* Communication Officer, Polskie Stowarzyszenie Fotowoltaiki (PSF); *Stanislaw M. Pietruszko,* President, Polskie Towarzystwo Fotowoltaiki (PV Poland).

1 MW, Walcz, Poland.


MIND THE GAP!
Secure your P50 solar performance with Solar and Energy Storage Insurance
P50 = We guarantee it!
P90 = Better results
P95 = The optimal goal
A reduced global solar radiation in comparison with profit survey
A reduced performance of the facility's equipment in comparison with the minimum performance as specified by the manufacturer
Above-average or excessive wear of the equipment and its components
Interruptions in the power grid
Renewable Energy Insurance Broker

9. Netherlands

11 GW project pipeline, the game towards 75% clean electricity in 2030 is on

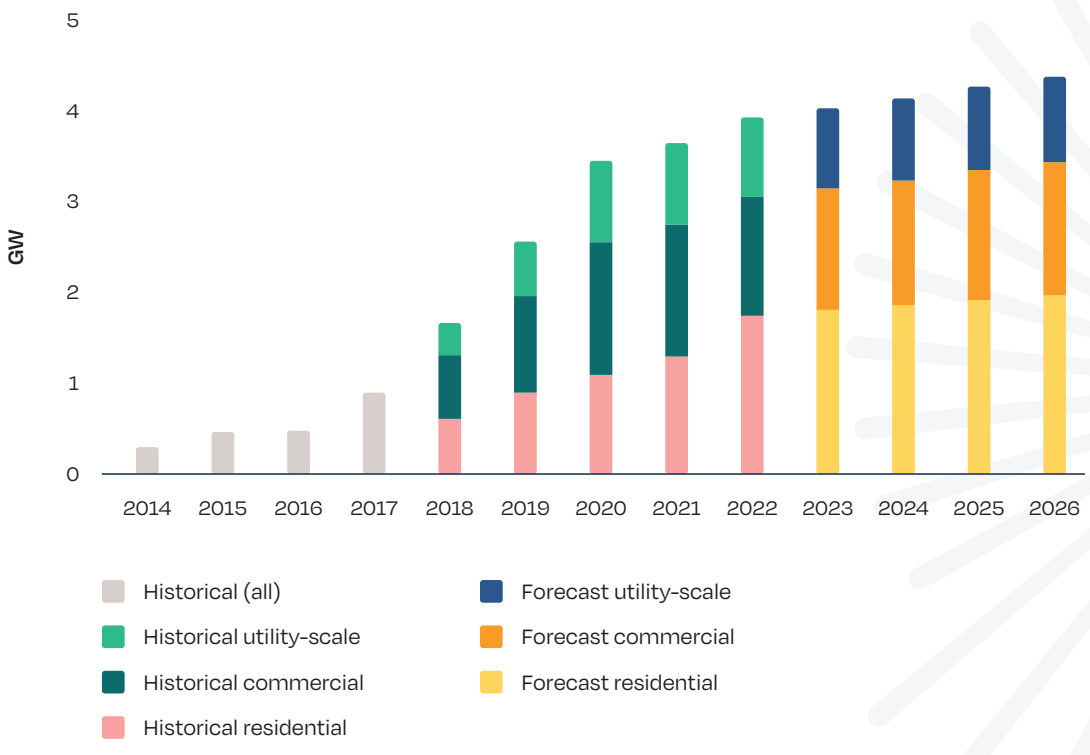
The market in the Netherlands is still developing strongly, with a solar PV capacity addition of 3.9 GW in 2022. This has brought the total Dutch PV fleet to 18.2 GW, including surprisingly high growth from the residential sector, which added 1.8 GW in 2022. The Netherlands also holds a project pipeline of 11 GW from its Sustainable Energy Transition subsidy scheme (SDE++) awarded projects, with even shares of commercial rooftop and ground-mounted projects.

The main challenge in the Netherlands is to ensure that all these projects in the pipeline are going to be built. Currently, around 65% of proposed solar projects reach completion, including a timely grid connection. This percentage will most probably decrease in the coming years mainly due to the increase in project costs, such as material, labour, and financing costs. We expect that commercial rooftop projects will face an expected completion percentage of only 40% or less in the coming years. For ground-mounted solar, project completion will most probably fall from 90% to a potential 80%.

The Dutch government has introduced the option to revoke previous SDE++ bids (2019-2022) and to take part in the SDE++ round of 2023. This year's round accounted for the new financial conditions for the industry (increased module prices, increasing interest rates, etc.). This provides the opportunity to save a large portion of the 11 GW pipeline that was at risk.

Due to new congestion management tools, extra grid capacity and peak shaving requirements, an increase in solar connection capacity was seen in some areas in the Netherlands. Clearly, net capacity issues are still challenging for production and demand projects. Despite this challenge, it is expected that the Dutch solar energy market will continue to grow in 2023 and surpass 4 GW (see Figure GW9).

FIGURE GW9 NETHERLANDS SOLAR PV MARKET SCENARIOS 2023-2026, BY HOLLAND SOLAR



SOURCE: Holland Solar.

New system-size records in 2022

In 2022, the biggest market segment in the Netherlands was the residential rooftop market, with a share of 46% (approx. 1.8 GW) of the total market. The commercial rooftop market had a share of 30% (approx. 1.3 GW) while the market for ground-mounted and floating solar PV accounted for 24% (approx. 0.9 GW). The residential market has had an impressive year-on-year growth of 37% (from 1.3 GW to 1.8 GW) and 10% points market share increase due to the strong increase in electricity consumer price levels. This level is expected to be maintained in 2023, and to stabilise at a level of about 2 GW per year. Residential and commercial rooftop solar is considered an important market segment for the Netherlands and is the most favourable option when it comes to policy, as well as public opinion.

In 2022, the largest project with a new SDE subsidy grant is a 100% locally owned solar park in Haarlemmermeer. Its design and location were developed in co-creation with local citizens. This 136 MW project is expected to be finished in 2023.

Dutch policy and RES targets

The Netherlands has a significant solar pipeline of over 11 GW. With this pipeline, and the successful completion of several wind projects, the government has been assured that the 2030 National Climate Agreement target of 35 TWh/year renewable electricity production on land will be met in time. However, the Dutch National Climate Agreement was agreed upon in 2019, and does not yet consider the higher national targets – being 55% but targeting 60% – related to the EU ambition of 55% greenhouse gas emissions reduction by 2030, or the impact of the Russian invasion in Ukraine. In addition, the target does not include forecasting for the increase in demand for renewable electricity from industry, buildings, and mobility. The government is now discussing what the new national ambitions for renewable energy production on land should be. Studies show that demand for green electricity will grow by 86 TWh by 2030, with 10-20 TWh to be produced on roofs and land. Therefore, it is foreseen that the tender scheme SDE++, or a successor, will stay open for solar and wind projects in 2023-2025, and later into this decade.

8.9 MW, Armhoede solar park, built on a former landfill.

Local participation has a more prominent role in regional energy strategies

As established in the National Climate Agreement, the renewable energy sector is striving for 50% local participation in renewable energy projects. A new subsidy scheme, SCE (Subsidy Cooperative Energy production 2021), has been successfully supporting organised citizens in developing cooperative projects, and will continue to do so adequately. This cooperative sector – 1 million organised citizens with hundreds of projects – accounts for still a small, but growing share of 1.5% of the total installed capacity. Other methods of participation – financial or otherwise – have been deployed as well and will be published in an addendum to the Code of Conduct of the solar sector. In this way, Holland Solar intends to ensure a level-playing field for discussions between commercial project developers and local residents.

Reducing perceived risks of fire for rooftop solar

Assumed risks of fire caused by rooftop solar installations, sparked by the insurance companies, have caused the market for large-scale rooftop solar to slow down. In November 2021, an independent study initiated by the Dutch government proved that risks of fire caused by solar PV installations are limited. Furthermore, the sector met with the national fire brigade, insurance companies, and representatives of the insulation industry to create a new code of conduct for large-scale solar roofs. This new code of conduct, together with a new inspection certification scheme, resulted in considerably higher insurability. It satisfies requirements from insurance companies, and ensures that building owners can be confident their commercial solar installations are fire-safe.

Drivers for solar growth

The growth in the Dutch residential solar market has been driven largely by net metering. There is no limitation or charge for net delivery. A proposal supported by the Dutch solar sector to gradually phase out the net-metering scheme, with a 9% decrease every year up until 2031, is still pending a vote in the senate, after parliament narrowly supported its adoption in early 2023. This degressive path is based on a seven-year payback time for the prosumer, assuming 30% self-consumption and optimal system conditions. Nevertheless, even with the proposed phase out this segment is, and will remain an important driver for continuous growth in the Dutch solar sector, especially in the current context of high electricity prices.

The growth of the commercial and utility-scale solar PV market in the Netherlands has been driven entirely by the SDE++ tendering scheme, whereby solar energy projects compete with other renewable energy projects and other CO_2 reducing technologies such as CCS. In this tendering scheme different maximum capacities are awarded, depending on technology (wind, biomass, solar), size, and application (ground-mounted, rooftop, floating). The ranking in the scheme is based on EUR per $ktCO_2$ avoided. The maximum SDE++ contribution decreases every year, but for the 2023 round it has been increased by about 17%. This increase can be attributed to worsened finance conditions and higher system component prices. In the 2022 round in June, a total of 2.3 GW solar projects applied for a subsidy; nearly all of these projects are expected to be granted a subsidy. About 1 GW of these projects are ground-mounted projects, 38 MW are floating projects, and the other 1.3 GW are large commercial rooftop projects. The next round, in summer 2023, will have a budget of 8 billion EUR. Unlike previous years, it will be allowed to revoke a bid from the period 2019-2022, and rebid in 2023. In the 2023 round, a budget of 750 million EUR will be reserved for projects producing "low temperatures, high temperatures, and molecules." Solar still needs to compete with CCS projects for the remaining budget, but has a better position in the tender.

Challenges

The main challenges for the solar energy sector in the Netherlands are the current cost levels of project development, and securing a timely grid connection. Because of these reasons, the sector expects to face serious delays, and possibly a higher project non-realisation in the coming years. Additional reserve capacity will be put into general use by the grid operators in 2023. Moreover, a recently published congestion management grid code will lead to an increase in connection capacity at the local level.

For the first time, grid operators in the Netherlands have recognised the significant growth of the solar sector, and estimate that between 42-76 GW of solar capacity will be installed by 2030. Former legal limitations to cable pooling, which combines solar and wind projects in co-location with batteries, will likely be resolved in 2023. New projects applying for SDE subsidies (from 2022 onwards) have to comply with a grid connection of maximum 50% of the system's peak capacity to be eligible for applying to a grid connection, and to the subsidy scheme. The yearly loss is compensated in the subsidy level per kWh.

Another challenge the sector faces is the availability of land, especially for utility-scale projects, as well as social acceptance when it comes to using agricultural land for solar energy projects. So far, it was announced that ground-mounted projects will need to include a multi-use component to receive permitting, but the nature of that component is still unclear. More clarity on this aspect should be given by the end of 2023. An example of multi-use ground-mounted projects is the project Armhoede, developed by TP Solar, a project developed on a former landfill. Here, measures are also taken to improve the biodiversity in the area around the park.

The Dutch government has shown a good level of ambition regarding fighting climate change. New actions are being announced to support solar developments, but are not yet in place. Examples include deploying additional support for solar on "unsuitable" rooftops, defining solar-prepared building standards, and outlining possible obligations for solar carports. Increasingly in the last few years, solar carports are being developed within the Netherlands. In 2022, developer Novar, in cooperation with the Lowlands Festival organisers, developed a solar carport in Biddinghuizen, equivalent to the size of 70 football fields.

Recently, at the local level, authorities have been encouraging rooftop owners to use their roofs for the energy transition.

Lastly, the most important step in the near future will be to create effective policies on the electrification of industry, mobility, and heating, which should go hand-in-hand with creating a level playing field for flexible green electricity production. The game is on.

Authors: *Wijnand van Hooff*, General Manager; *Nold Jaeger*, Manager Public Affairs; and *Marinthe Bos*, Communications Officer, Holland Solar.

37.7 MW, Solar carport in Biddinghuizen, the Netherlands. © Novar

10. Australia

Overview of solar PV developments

What a difference a year makes! In May 2022, Australia elected a Labor Party government that actively supports solar and renewables – committing in its first 100 days to having 82% renewables supplying the country's electricity by 2030. They also increased the IPCC commitment to reduce emissions by 43% below 2005 levels by 2030 through a legislated target.

PV deployment has been affected by the supply chain impacts of the Russian invasion of Ukraine, and an increase in module prices for the first time since 2011. Forecasting the Australian PV market is proving difficult as always! In the Global Market Outlook 2022-2026, the Smart Energy Council anticipated an increase in rooftop solar, both residential and C&I, to take place in 2022. A possible increase in large-scale installations was also predicted, contingent upon the formation of a new government. The 2022 rooftop sector added 2.7 GW of new capacity including more than 310,000 households. The total installed rooftop solar capacity is now around 19 GW, which, added to the utility-scale capacity, constitutes a total operating solar PV fleet of just under 30 GW. In contrast, large-scale solar deployment in 2022 was about 850 MW, a 32% fall from the 1,250 MW commissioned in 2021. PV installed capacity at the end of 2022 stood at a world leading 1,166 W per person.

The federal government's Renewable Energy Target remains the primary support for rooftop PV systems under 100 kW. The simple payback period for the most common system size (now about 9 kW), is on average 5 years in most locations. No-interest loans for solar PV and batteries are also available in a number of jurisdictions.

Drivers for solar growth

During 2022, Australia had 35% of residential rooftops equipped with solar PV, representing 3.5 million homes; export tariffs have been reducing as mid-day output increases. Many networks are enforcing export limits, and some are enforcing crude system size limits as penetration exceeds capacity of distribution networks, which need to be modernised. Increases in gas and coal prices have forced further rises in retail prices, in addition to rises resulting from the continued unreliability of an aging coal generation fleet, and higher network costs. The slower start of sales in 2022 following COVID-19 was followed by a rapid increase in the second half of the year. The progressively increasing value of self-consumption over the last few years will continue into 2023.

There was a slower than expected growth in the C&I segment in 2022, increasing slightly in the second half of the year. Rising energy costs drove up interest from businesses; this will also likely result in higher deployment rates in 2023. One principal factor is the significant increase in gas prices in the Eastern States.

Australian Minister for Energy, Chris Bowen (right) at the New England Solar Farm 2022.

Australia is in the top three exporters of fossil gas. However, unlike Western Australia, the East has no domestic gas reservation policy. That means residential and commercial consumers pay global parity prices. As direct government intervention to impose a domestic reservation policy seems unlikely, this will incentivise a faster transition to electrification. This will also lead to a quicker uptake of solar PV, batteries, and heat pumps for heating and cooling, as well as a fast transition from gas to electricity appliances for hot water and cooking.

Alongside the increase in electricity prices, electric vehicle (EV) sales in Australia are still just 2% of total vehicle sales — again because of the national government's policy failure; due to a lack of fuel efficiency standards, there is no incentive for OEMs to ship to Australia. There is a high correlation between EV owners and PV installation that will become another strong driver for uptake in residential and C&I systems as soon as EV sales grow.

Challenges

The Australia-China governmental relationship improved in 2022, and it is expected that this should stabilise PV system supply. Australia is looking to expand its supply chain access, including by increasing its imports from India. The new government seems to be employing a better approach to PV deployment. However, we still face slow regulatory institutions that are not fit for purpose, and a sluggish pace of reform. There are still many barriers to connecting large-scale solar PV; a significant curtailing of solar is caused by grid constraints, which need upgrades for faster transmission. The government has allocated significant funding for this under its Rewiring the Nation policy from 1 July 2023. In July 2022, the Australian Energy Market Operator (AEMO) also published its 2022 Integrated System Plan (ISP), which identifies the need for more than 10,000 km of new transmission lines, and 9 times the large-scale generation the country currently has.

Outlook

The second half of 2022, and the first quarter of 2023, saw increased installation numbers for rooftop solar. Prices of systems and components have levelled off, but workforce constraints are now affecting business capability for deployment at all scales. Given the increased energy prices for consumers, especially gas prices, and the building momentum for electrification, we expect a likely increase to over 3 GW of rooftop PV in 2023. Large scale PV is likely to significantly increase to 4-4.5 GW in 2023, as forecast by the Clean Energy Regulator.

Author: *Steve Blume*, President, Smart Energy Council.

Social housing, Allume Energy.

11. South Korea

Overview of PV developments

The South Korean solar market grew rapidly under the Moon Jae-In's government, thanks to various policies to expand renewable energy. Annual solar installations have expanded from 1.3 GW in 2017, to 4.7 GW in 2020. The cumulative installed capacity also increased from 5.8 GW in 2017, to 22 GW in 2021.

There are three policies that influenced the expansion of renewable energy during the Moon Jae-In government. First, South Korea's Renewable Energy 3020 Plan (RE 3020), announced in October 2017, where the main goal is to increase South Korea's renewable energy share from less than 3% as of 2017, to 20% by 2030. Second, the Korean New Deal, which was announced in July 2020, is a plan to invest 160 trillion KRW (110 billion EUR) to foster green infrastructure, low carbon and distributed renewable energy, as well as innovation in the green industry, and to strengthen the country's climate action. The New Deal is split into three key points: the Digital New Deal (58.2 trillion KRW / 43.5 billion EUR), the Green New Deal (73.4 trillion KRW / 54.9 billion EUR), and the stronger safety net (28.4 trillion KRW / 21.2 billion EUR). These include financial incentives to accelerate research and development of next-generation solar cells, including through local renewable energy businesses, projects, and high-efficiency tandem silicon perovskite cells. The Moon Jae-In government raised the budget of the Korean Deal 2.0 in 2021 from 160 trillion KRW to 220 trillion KRW. Finally, the 2030 Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change, increased South Korea's ambition for reducing its greenhouse gas emissions. The country raised its 2030 target from a 26.3% reduction compared to the 2018 level, up to a 40% reduction from 2018 levels.

However, annual solar installations in 2022 only reached 3 GW, a 40% decrease compared to 2020. As the market shrinks, the domestic solar industry, including module manufacturers, is also shrinking overall. Large companies such as Hanwha Solution and Hyundai Energy Solution are facing continuous growth opportunities through exports to the US and EU markets, but small and medium-sized companies are in a difficult situation.

Samaksan Lake, Gangwon-do, South Korea.

The current government's energy policy direction

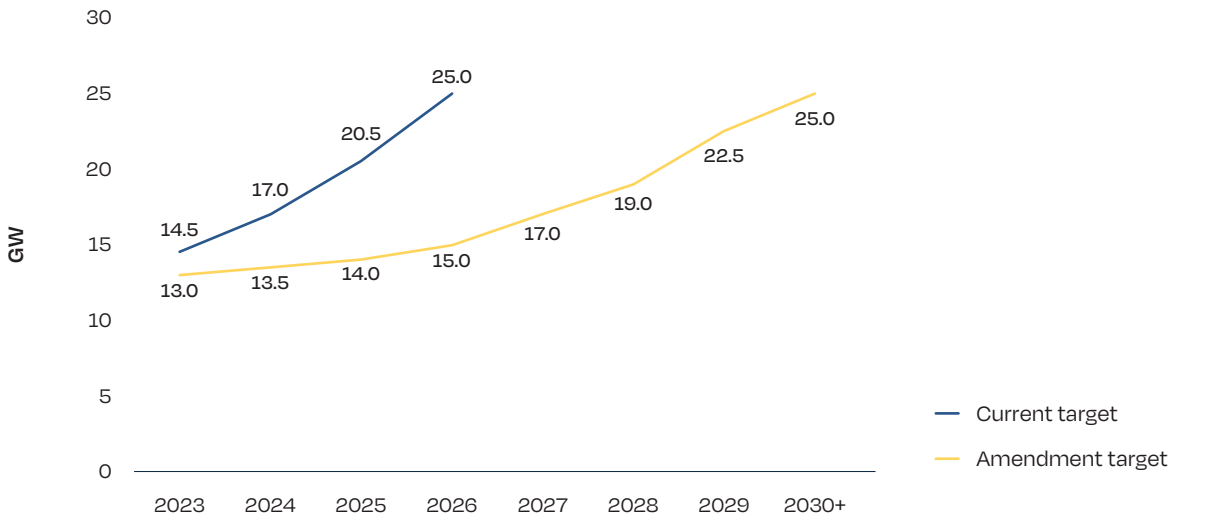
The Yoon Suk-Yeol government's energy policy direction is focused on expanding nuclear power and adjusting renewable energy, which has negatively affected the solar market. Moreover, corruption allegations by the former Moon Jae-in administration regarding the approval of solar projects impacted the reputation of the green energy sector. Since October 2022, the Board of Audit and Inspection has been conducting audits on renewable energy policy enforcement officials and related agencies. The Financial Supervisory Commission has also conducted an investigation into all financial institutions that dealt with renewable energy financing. In addition, the ruling party formed an unprecedented "special committee on finding out the truth about solar corruption".

The energy policy direction of the Yoon Suk-Yeol administration is contained in the 10th Basic Plan for Long-term Electricity Supply and Demand. The plan contains details of the electric power sector over 15 years, from 2022 to 2036, and was finalised in January 2023. According to the basic plan, the proportion of renewable energy generation is expected to increase from 7.5% in 2022, to 21.6% in 2030, and 30.6% in 2036. In particular, solar power is expected to increase from 25 GW in 2022, to 44 GW in 2030, and 65.7 GW in 2036. However, this is a significant step back from the 2030 renewable energy target of 30.2% announced in the NDC submitted to the United Nations in October 2021. According to this new plan, only about 2.9 GW of solar power will be supplied on average year-on-year until 2036.

In addition, the Yoon Suk-Yeol government drastically adjusted the mandatory Renewable Portfolio Standards (RPS) supply ratio. RPS is a system that obliges power companies with a generation capacity of 500 MW or more to supply a certain percentage of electricity from new and renewable power sources. More than 90% of the domestic solar installed capacity falls under that regime. Originally, the power company's obligation to supply renewable energy was expanded to 9% in 2021, 12.5% in 2022, 14.5% in 2023, and 25% in 2026. However, this was significantly lowered to 13% in 2023, and 15% in 2026 in the last amendment.

The lack of grid, which has been hindering the expansion of renewable energy since the previous government, and local governments' regulations on the necessary distance between solar installations, created an even more difficult environment.

FIGURE GW11.1 PERCENTAGE OF RPS MANDATORY SUPPLY BY YEAR, BY KOPIA



SOURCE: KOPIA.

Outlook

Due to the policy influence of the Yoon Suk-Yeol government, skepticism about the possibility of achieving the 2030 NDC is increasing, and complaints from the renewable energy industry are also growing. Samsung Electronics and other companies from the RE100 group (30, as of April 2023), have declared that they are facing difficulties in achieving their goals. There are growing concerns that South Korea may fall behind in the accelerating trend of global industrial and economic carbon neutralisation.

As a result, domestic solar power is expected to shrink at least until the first half of 2024. If there is no change in the government's energy policy, it is predicted that the renewable energy market, including solar power, will be in a weak phase until the first half of 2027, when the Yoon Seok-Yeol administration's term finishes.

The solar industry is making efforts in three major ways to overcome difficulties. Firstly, it is urging the government to change its energy policy. Industry is requesting the government to expand renewable energy, and promote carbon neutrality, and properly believe in, and support renewable energy like solar power. Secondly, the domestic solar industry is putting more effort into exporting solar products such as modules, and discovering overseas power generation businesses. Thirdly, the industry is concentrating on PV on industrial complexes. Industrial complex solar power is free from various civil complaints, system shortages, and separation distance ordinances. As of December 2022, there are 1,274 industrial complexes in South Korea. More than 1.4% of the country's land is occupied by industrial complexes, and new ones are continuously being developed. Considering the current technology level of 1 kW/8m², the industrial complex segment has a capacity of 35 GW, and is estimated to have a theoretical potential of 57 GW by 2030, when the technology level is expected to reach 1 kW/5m² (see Table GW11.1). Considering various circumstances, it is expected that about 40 GW can be supplied with solar power, which represents about 70% of the industrial complex's potential. In particular, the Korea Photovoltaic Industry Association (KOPIA) is making efforts to create a boom in industrial-level solar power under the slogan "2023 is the year of industrial-level solar power."

FIGURE GW11.2 SOUTH KOREA ANNUAL SOLAR PV MARKET SCENARIOS 2023-2027, BY KOPIA

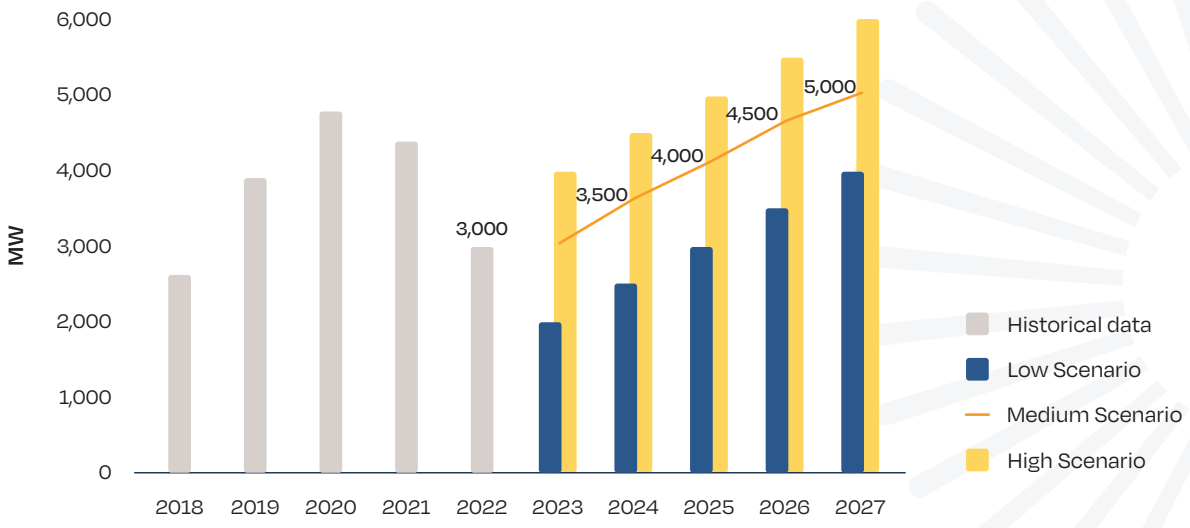


TABLE GW11.1 INDUSTRIAL COMPLEX CONSTRUCTION AREA AND PV SUPPLY POTENTIAL

COMPLEX TYPE	MANAGEMENT AREA (1000 M²)	INDUSTRIAL FACILITIES AREA (1000 M²)		BUILDING AREA (1000 M²) ROOF AREA	SUPPLY POTENTIAL, CURRENT TECHNOLOGY LEVEL (MW)	SUPPLY POTENTIAL, EXPECTED DIFFUSION TECHNOLOGY LEVEL 2030 (MW)	SUPPLY TARGET (MW)
		TOTAL AREA	AREA TO BE SOLD				
Country	487,247	286,004	257,223	119,924	14,990,5	23,984,8	16,789.36
General	549,717	337,243	268,062	140,840	17,605	28,168	19,717.6
City High Tech	11,167	4,914	2,690	1,056	132	211,2	148
Agriculture	77,060	58,474	56,337	24,517	3,064,6	4,903,4	3,436.58
Total	1,125,191	686,635	584,312	286,337	35,792,1	57,267,4	40,091.38
Note: Current technology level in 2023: 1 kW/8m²; Expected diffusion technology level in 2030: 1 kW/5m²; Supply target: 70% of potential.							

SOURCE: Korea Industrial Complex Corporation, reprocessing by KOPIA.

It is hoped that these efforts will reshape the energy policy of the Yoon Suk-Yeol government in the near future, and that the Republic of Korea will contribute to the transformation of the global industry and economy.

Author: *Woo-Sik Jung,* Vice President of Korea Photovoltaic Industry Association.

12. Italy

Overview of the solar market

The Italian solar market had a slow growth between 2014-2021, with on average 500 MW of capacity installed per year. After an improved performance in 2021, when 936 MW was added, at the end of 2022 Italy registered a cumulative capacity of over 25 GW, with a total of over 1.2 million PV systems. This resulted in 2.48 GW of new PV systems installed in 2022. The vast majority of these installations were residential systems (1.1 GW), mostly benefiting from the Superbonus 110% incentive scheme.

In Figure GW12 the distribution of installed PV power plants by size is displayed. PV systems between 200 kW and 999 kW make up most of Italy's installed solar PV capacity, with 8.27 GW (33%).

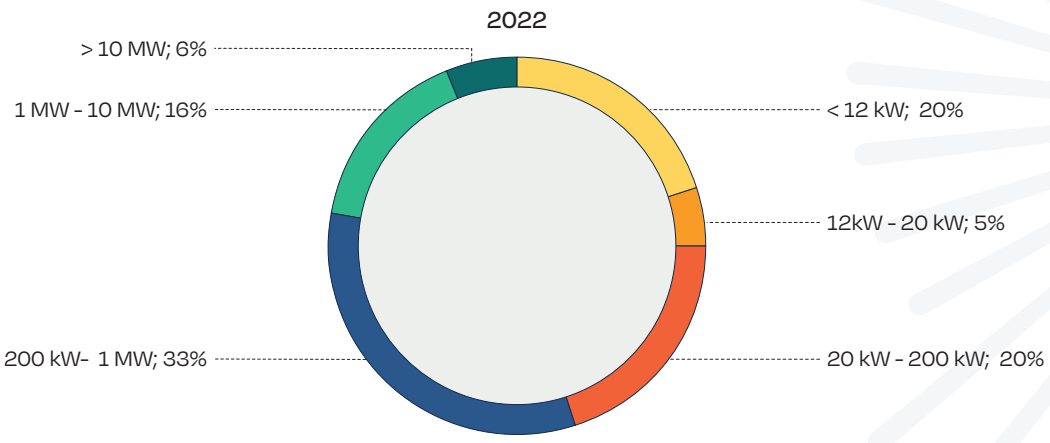
The regions with the highest installed capacity are Apulia, Lombardy, and Emilia-Romagna, while those with the lowest installed capacity are Aosta Valley, Liguria, and Molise.

Public solar PV targets

The current national energy and climate plan (NECP) was drafted in 2018, and sets goals that are no longer relevant, given the current energy and climate crises, and the new EU 2030 targets presented in the Fit for 55 and REPowerEU packages. To reach the 2030 targets, the deployment of renewables must be planned on a local scale. The so-called "Burden Sharing," already stated in the Italian Legislative Decree 199/2021 (embodiment of the RED II Directive in the Italian legislation), defines the distribution of installed power between regions, as well as the systems required for monitoring regional commitments. It also outlines the statistical processing of the collected data.

The Italian renewables energy associations, ANIE Rinnovabili, Elettricità Futura, and Italia Solare agree that Italy must install at least 85 GW of new renewable capacity by 2030 to achieve its REPowerEU targets. They also believe that Italy must install 80 GWh of new large-scale storage capacity to effectively integrate new power into the grid. Solar PV represents 58 GW out of this 85 GW of new renewable energy sources. This scenario will require 320 billion EUR of overall investments in the electricity sector and associated supply chain. It will also lead to 360 billion EUR of overall economic benefits in terms of added value along the electricity sector supply chain, and an increase in domestic spending. This deployment of solar capacity, together with the other RES technologies needed, will also lead to a reduction of 270 million tons of CO_2eq emissions, and up to 540,000 new jobs by 2030.

FIGURE GW12 ITALY CUMULATED SOLAR PV CAPACITY SEGMENTATION IN 2022



SOURCE: Terna.

Savona, Italy. © BayWa r.e.

Key drivers and challenges for the solar market

To reach the 58 GW solar target, it is necessary to overcome some key obstacles. In particular, permitting for large-scale solar projects remains a crucial challenge. The identification of suitable areas for project construction should be supported by regional actors. The policy framework for PPAs and self-consumption must also be improved. The following actions should be urgently undertaken to cultivate further solar growth:

- Finalise the new NECP and the "Opportunity Sharing" planning between the regions;
- Define 'go-to areas' for PV project development;
- Continue simplifying the authorisation procedures of new plants and repowering projects;
- Implement a mechanism which allow RES auctions bases to be adjusted according to the LCOE value;
- Facilitate the transfer of the energy produced from PV and other RES plants to consumers;
- Implement support measures for energy communities and self-consumption;
- Encourage the development of PPAs, especially long-term renewable energy purchase contracts;
- Increase support schemes for storage systems in all market segments;
- Avoid regulatory disruptions or sudden law changes which destabilise the market operators' plans; long-term planning is needed (see Ministerial Decree "FER" 1 bis, Ministerial Decree "FER 2;" tax deductions for the residential segment, tax credit for businesses);
- Ensure a correct implementation of the revenue cap that excludes PPAs, including cross-bidding zone PPAs, and that it is not retroactive;
- Finalise the legislation for the development of Agri-PV systems;
- Review the connection regulations (TICA) to speed up process timing;
- Strengthen the European PV and BESS technological supply chain for improved energy resilience and decreased dependency from non-EU countries;
- Accelerate the reform of the electricity market rules to enable a greater penetration of RES, storage, and demand-side response.

Solar market prospects 2023-2026

By 2026, Italy should install about 39 GW of new RES capacity, which for PV specifically means about 27 GW by 2026. This is equal to an average annual growth above 6.5 GW for the period 2023-2026. Considering that the market in 2023 will barely ramp up to 5 GW, a significant growth in annual additions is expected for 2024-2026. In 2023, we are expecting a notable decrease of residential installations due to the phase out of the tax rebate Superbonus 110%, while the C&I segment will probably experience a strong increase due to the high energy prices.

Author: *Michelangelo Lafronza*, Secretary, ANIE Rinnovabili; *Alessandro Scipioni* and *Edoardo Storti,* Technical Affairs, Elettricità Futura; *Federico Brucciani*, General Secretary, Italia Solare.

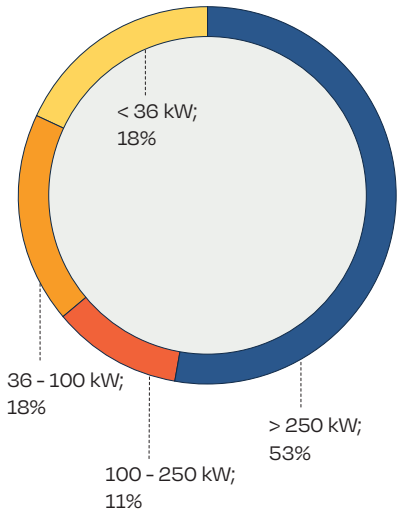
13. France

The 3 GW level within range

Overview of solar PV developments

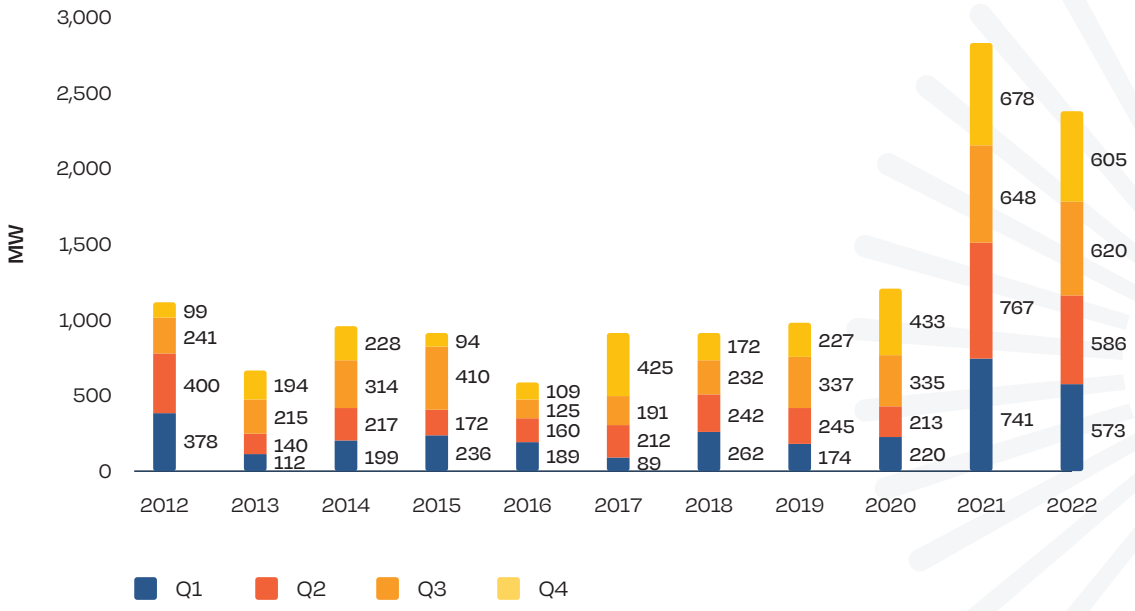
The French solar fleet is entering its acceleration phase. With an additional 2,385 MW connected in 2022, the French solar fleet passed the 16 GW milestone at the end of the year. Electricity production from solar photovoltaic sources amounted to 19.1 TWh in 2022, up 30% compared to 2021. It represented 4.2% of French electricity consumption over this period. The capacity of projects in the pipeline has grown by 46% since the beginning of 2023, reaching 16.9 GW, including 3.9 GW of projects that secured grid connection permits.

FIGURE GW13.2 FRANCE CUMULATIVE SOLAR PV GRID CONNECTED CAPACITY Q4 2022, BY SER



SOURCE: ENEDIS.

FIGURE GW13.1FRANCE SOLAR PV MARKET INSTALLATIONS PER YEAR 2012-2022, BY SER



SOURCE: MTE.

Solar PV targets in France

The 2015 Energy Transition for a Green Growth law set ambitious goals for 2030, which were also confirmed in the Climate & Energy Law adopted in 2019. These objectives have been implemented for each technology through the Multi-Annual Energy Programme (MAEP). This programme defines clear trajectories and volumetric objectives for the coming 10 years. The MAEP objective for the end of 2023 requires an operating solar PV fleet of 20.1 GW. In April 2023, the completion rate of this objective stood at 81%.

A revised version of the first MAEP, adopted in spring 2020, confirmed the willingness to accelerate the development of a French 'solar park'. The new targets presented for 2028 lie between 35.1 GW and 44 GW in cumulative capacity. This means between 330 and 400 km² of ground-mounted PV area will be installed in France, with between 150 and 200 km² of rooftop installations. These targets position solar as one of the most important contributors to the French energy transition.

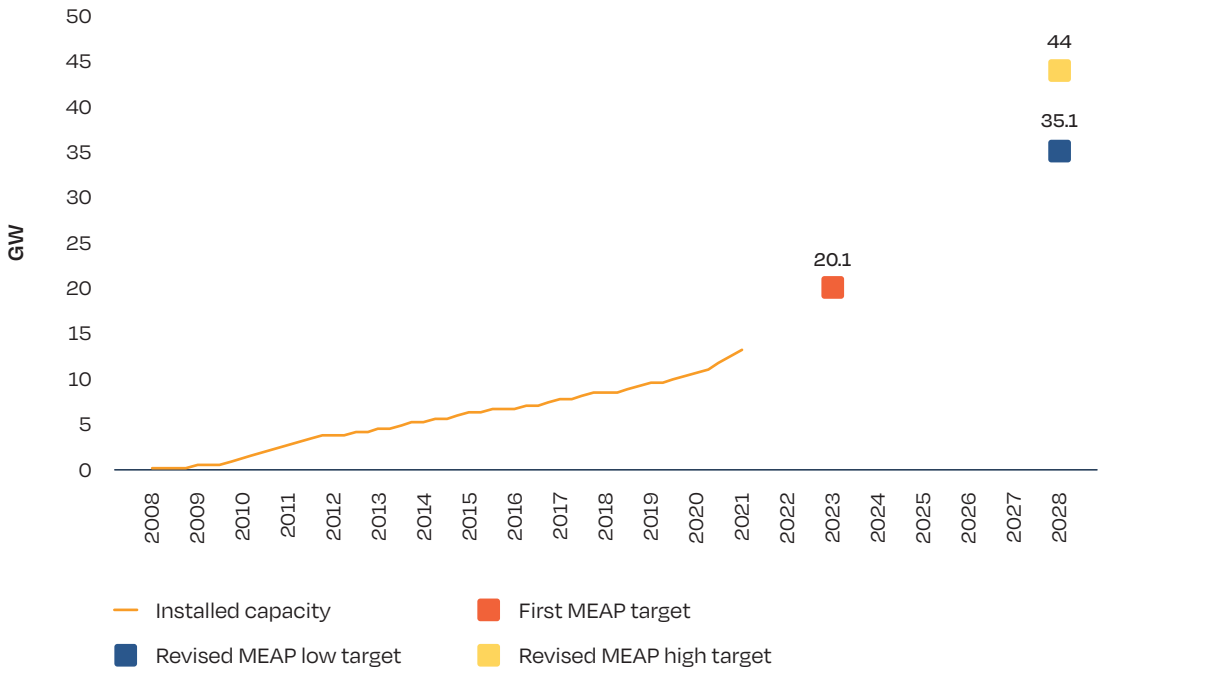
Regarding the long-term strategy, in February 2022, French President Emmanuel Macron announced an objective of 120 GW of total solar installations by 2050. However, the MAEP targets for 2033 will be revised in 2023 and will set a trajectory that could be more ambitious. It is also important to note that, in its recently published report which studied six main scenarios to reach carbon neutrality, RTE, the French transmission system operator, predicts 70 to 208 GW of solar capacity installations in 2050.

Drivers for solar growth

Calls for tenders are the main factors for achieving solar growth targets, with 3.2 GW scheduled every year. Two-thirds of these tenders will be ground-mounted installations. The remaining third will be accounted for by rooftop installations.

Since Autumn 2021, rooftop installations below 500 kW are exempted from tendering procedures and eligible for a feed-in tariff (FIT), in line with the current EU State Aid Guidelines. The FIT threshold was raised

FIGURE GW13.3 MULTI-ANNUAL ENERGY PROGRAMME TARGETS



SOURCE: SER.

from 100 kW to 500 kW at the request of the French solar PV sector. This change is making things easier for the mid-size rooftop market segment, where projects were previously limited by tendering procedures. Immediate results from this legislative change have been observed on the market, as the number of installations lower than 500 kW continues to increase.

The self-consumption market, for which a dedicated framework has been put in place, is also growing. In Q4/2022, 239,218 installations were self-consuming, representing 1,134 MW.

Many other measures allowing for a faster development of PV were recently adopted. In February 2023, a "law for the acceleration of renewable energy" was enacted to simplify procedures, and shorten the deadlines for renewables. This law includes, among other measures, the empowerment of local authorities to create preferred 'go-to' and 'no-go areas' for renewable projects. It also introduces a definition of Agrisolar in the energy and urban codes; and facilitates the use of artificial areas, or areas that do not present major environmental challenges. In particular, this can be seen through the installation of solar PV systems along major roads and highways, on coastal wastelands, and on parking lots.

An ad-hoc decree was also published at the end of 2022 to change the authorisation regime for ground-mounted PV projects. Now, only projects above 1 MW require a building permit. Smaller projects should give prior declaration, but lengthy permitting can be avoided. Additionally, a new FIT scheme should start in 2023 for ground-mounted projects under 1 MW installed on degraded land, urbanised or to be urbanised areas, and projects with trackers.

The calls for tenders have been modified in 2022 to include Agrisolar projects, either in the form of Agri-PV canopies above crops, or ground-mounted projects on agricultural land uncultivated for more than 5 years, or land that is hosting livestock.

In addition, a 'green industry' law announced at the beginning of 2023 by the French government, should be discussed over summer. One of the law's objectives will be to facilitate the installation of solar gigafactories over the next few years.

A working group was also set up in 2022 by the National Institute for Solar Energy (INES), and the producer responsibility organisation, Soren, to develop a common prevention and Ecodesign plan for the photovoltaic sector, and should lead to the definition of eco-modulation criteria for PV panels. Eco-modulation involves penalising the use of environmentally harmful materials, and rewarding the use of environmentally friendly materials.

15 MW, Curbans, France.

9 MW, Cintegabelle, France. © Akuo

Challenges

Reaching the national target of 44 GW by 2028, compared to the 16.3 GW currently installed, would require average annual additions of more than 5 GW. To achieve this, it will be necessary to implement regulatory changes that support the growth of all market segments.

Firstly, the parameters for 'eligible land' in tenders for ground-mounted projects should be wider. Given the 2028 MAEP target, and as the distribution of major projects remains stable, we can expect almost two-thirds of solar power to be installed on the ground. Assessing land use is crucial to incorporate the real impact of PV projects on soils, and to facilitate their development. In addition, innovative PV projects with especially low land use impact, such as Agri-PV and floating solar, should be encouraged.

Moreover, the development of photovoltaic projects is tightly regulated. Some administrative procedures and architectural planning issues must be clarified, and simplified for all market segments. Some local services may have an ambiguous and debatable interpretation of the framework in place. This can sometimes go beyond current regulation, such as fire safety regulations. Additionally, administrative deadlines need to be shortened.

The promotion of France's low carbon footprint within its solar PV industry should also be recognised. The carbon criterion in the call for tenders is seen as a fundamental pillar of an industrial strategy which should go hand-in-hand with the market development. In line with what SER advocated, the carbon criterion is now set at 550 kg CO_2e/kW in the new call for tenders' specifications which were published in Summer 2021. This criterion is now required to apply to the new FIT for rooftop installations. Thanks to the work of strong R&D centres (INES, IPVF, etc.), the French industry's innovation capacities and technological breakthroughs will also improve competitiveness. SER believes that manufacturers are interested in setting up solar wafer-to-module production capacities in France.

Finally, the share of self-consumption in France remains low compared to the other PV segments. The attachment rate of batteries with solar is also low – they are rarely used with PV systems. The support mechanisms for self-consumption projects must be adapted to enhance the value of all electricity produced, self-consumed, and injected into the grid. This would guarantee the financial security of projects. Another alternative is to encourage self-consumption, without penalising consumers who are not always able to consume all of their produced energy.

Author: *Marie Buchet*, Head of Solar Power & Solar Heat, Syndicat des Energies Renouvelables (SER).

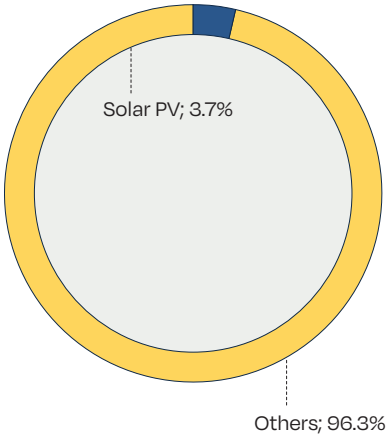
14. Taiwan

Overview of PV developments

Solar PV installations in Taiwan started increasing significantly with the adoption of a feed-in-tariff (FIT) system in 2010. Taiwan is a stable GW market; 2022 marked the year that the operating PV capacity in the country reached 9.7 GW, with annual installations of 2.03 GW. Total renewable energy capacity amounted to 14.1 GW at the end of the year. In 2022, solar energy generated 10,675 GWh, which is a contribution of 3.7% to overall power generation (Fig. GW14.1).

The Taiwanese government targets to increase solar PV capacity to 20 GW by 2025. A similar goal is set for 2030, where the aim is to have a total capacity of 31 GW (see Fig. GW14.2). Taiwan has set a broader goal to reach 20% renewable energy generation by 2025, with a specific target of 27 GW of installed renewable energy capacity. In addition to solar, Taiwan is also investing in other renewable energy sources such as wind, hydro, and geothermal.

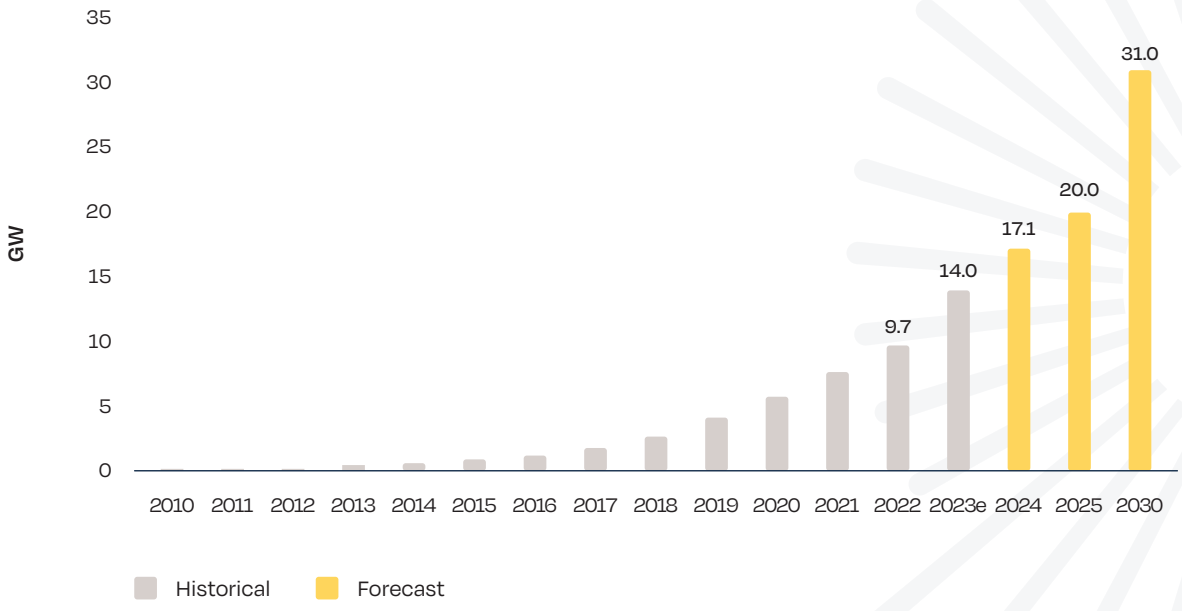
FIGURE GW14.1 TAIWAN SOLAR PV SHARE IN ELECTRICITY GENERATION 2022, BY TPVIA



SOURCE: Bureau of Energy, Ministry of Economic Affairs. © SOLARPOWER EUROPE 2023

Taiwan's government has implemented various policies and incentives to support the growth of the renewable energy sector, including the FIT scheme

FIGURE GW14.2 TAIWAN CUMULATIVE SOLAR PV INSTALLED CAPACITY AND TARGETS 2010-2030, BY TPVIA



SOURCE: Bureau of Energy, Ministry of Economic Affairs. © SOLARPOWER EUROPE 2023

and other forms of subsidies. The government also plans to invest heavily in energy storage and grid infrastructure to support the integration of renewable energy into the grid.

Besides the FIT scheme, the government has set up other policies to promote solar PV. A first priority area is the promotion of rooftop PV, with three main objectives:

- Expand the inventory of agricultural facility roofs, industrial roofs, public roofs, private roofs, etc.
- Develop a policy to mandate solar installation on new and rebuilt buildings, meeting specific conditions.
- Make adding solar to existing buildings easier by fixing the regulatory and economic obstacles faced by rooftop PV.

In this regard, the biggest regulatory obstacle is the local construction regulation and guidelines. Most PV installations are rooftop systems that are built to get FIT revenues. However, a large volume of houses are not considered eligible for solar PV because they are not registered on the government's database yet. They are classified as 'illegal' buildings. To expand rooftop PV deployment, widening the acceptance criteria is required. Some of the economic obstacles are hard to overcome as well. Landlords are asking high returns from PV energy service companies (ESCO), which is seriously jeopardising their profits.

A second priority area regards the improvement of land value in use. Central and local governments are identifying more land suitable for dual use. To help develop this, Taiwan Photovoltaic Industry Association (TPVIA) is collecting successful cases of symbiosis between fisheries and electricity production. Local governments are chiming in by promoting more possibilities for the compound use of land. Based on successful demonstrations, there are already a few cases of agricultural and electricity symbiotic applications developed.

Another key set of actions is towards the development of potential land. Revitalising unfit agricultural land, as well as public idle land, and promoting floating solar projects, are actions that can provide new opportunities to the sector.

Overall, Taiwan's renewable energy sector is showing promising growth and progress towards its renewable energy targets. However, as renewable energy technologies keep evolving and global energy markets continue to shift, it will be important to continue monitoring and updating renewable energy policies and strategies to ensure continued growth and sustainability of the sector.

PV capacity has grown rapidly in Taiwan, with currently 10 GW installed and a goal to reach 31 GW by the end of the decade. At present, solar PV projects with a focus on fishery and electricity symbiosis are receiving a lot of attention. However, ground-mounted installations are set to grow as well. The government is identifying more suitable locations for ground-mounted PV projects such as land with toxic waste, terrains with high salt concentrations, and old fish farms. Meanwhile, the electricity grid is undergoing key improvements. Additionally, the government is encouraging the combination of PV and battery energy storage systems to reduce the impact on the grid. Finally, the liberalisation of the domestic electricity market will further encourage the deployment of more substations and storage integration, which will enable more PV capacity deployment.

Authors: *ShuYu Yang*, Industry, Science and Technology International Strategy Center (ISTI) & ITRI, *Daniel Lee*, Taiwan Photovoltaic Industry Association (TPVIA).

15. Chile

Solar energy has undoubtedly experienced remarkable growth in Chile over the last ten years. In 2012, the installed capacity was only 2.9 MW, while in 2022, it reached nearly 7,000 MW, representing nearly 60% of the non-conventional renewable energy (NCRE) installed and 23% of the country's total capacity. Moreover, the Cerro Dominador hybrid Concentrated Solar Power (CSP) and PV plant with a total capacity of 210 MW began operation in 2021, becoming the first CSP plant using tower technology in Latin America. As a result, solar energy produced 14.2 TWh of electricity in 2022, accounting for 17% of the total electricity production.

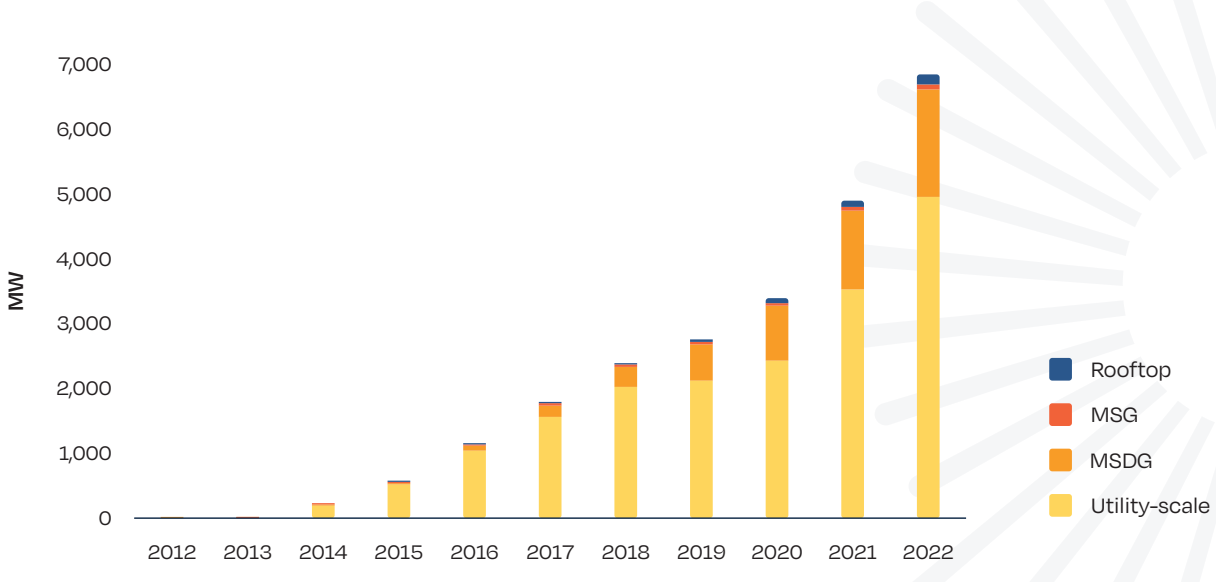
Figure GW15.1 shows the evolution of the total installed capacity of solar energy over the past decade, including both PV and CSP power plants, divided into four categories: Utility-scale, over 9 MW; Medium Size Generation (MSG) up to 9 MW connected to the transmission system; Medium Size Distributed Generation (MSDG) up to 9 MW connected to the distribution network; and rooftop solar, up to 300 kW connected to the distribution network.

It can be observed that the deployment of solar technology has primarily been led by utility-scale and MSDG. Despite significant modifications to the Net-billing Act introduced in 2018, rooftop capacity still lags behind. With only 170 MW of rooftop facilities installed in 2022, it is doubtful that the country will meet its 500 MW target by 2026 without significant changes to the regulation of the electricity distribution segment.

Chile has a general target for NCRE, so there are no specific targets for each technology. However, in 2021, the government submitted a bill to Congress to increase the NCRE national target from 20% by 2025, to 60% by 2030.

The installation of new solar capacity in Chile is driven by several factors, including the country's plan to decommission its fleet of coal-fired power plants, its commitment to achieving carbon neutrality by 2050, and the continuous reduction in solar capital expenditure (CAPEX). Additionally, public tenders for supplying energy to residential and commercial customers have become critical to the installation of new solar capacity.

FIGURE GW15.1 CHILE CUMULATIVE SOLAR CAPACITY 2012-2022 BY CATEGORY, BY ACESOL



SOURCE: ACESOL. NOTE: Data includes both PV and CSP capacity.

Figure GW15.2 illustrates the installed solar capacity by region, arranged from north to south. While most of the utility-scale projects are located in the northern part of the country, MSDGs are closer to the major cities in the central region. However, the expansion of transmission infrastructure has not been as fast as the rapid growth in solar capacity, resulting in significant increases in the amount of solar energy curtailed, and the number of episodes of price decoupling between the northern and central regions in the last two years. This will be one of the main challenges facing solar energy in Chile in the coming years.

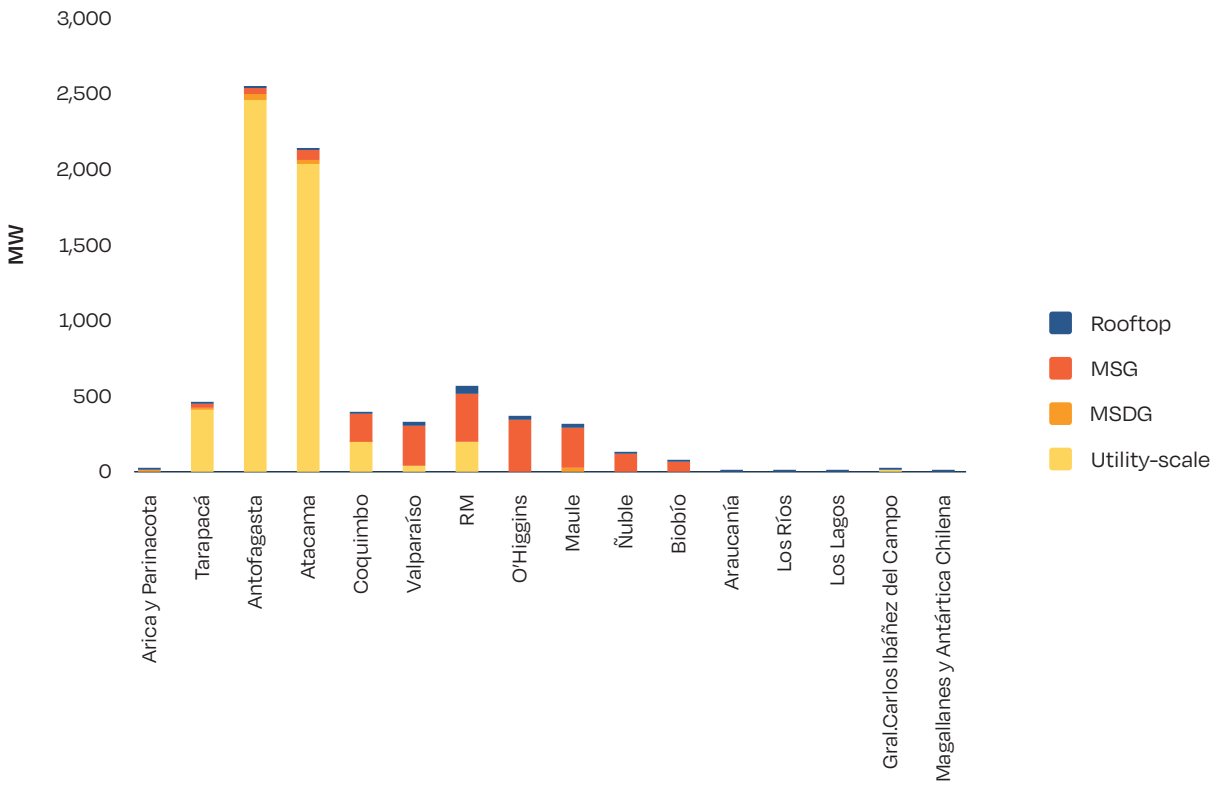
Chile is committed to reducing its dependence on fossil fuels, and transitioning to a 100% renewable energy mix as soon as possible, with solar energy expected to continue to play a vital role in this process.

However, to achieve this goal, the country must address three significant challenges: 1) undertake a major reform of the wholesale energy market to promote the efficient installation of renewable energy technologies and energy storage; 2) introduce significant reforms to the process for expanding transmission infrastructure; 3) embark on a substantial reform of the distribution sector to unlock the country's potential for decentralised power generation and rooftop installations.

Considering that about 1,300 MW of solar projects are already in the testing phase, it is assumed that Chile will be able to achieve up to 2.5-3 GW of newly installed solar capacity during 2023.

Author: *David Rau*, Vice President, Chilean Solar Association (ACESOL)

FIGURE GW15.2 GEOGRAPHIC DISTRIBUTION OF SOLAR INSTALLED CAPACITY IN CHILE, BY ACESOL



SOURCE: ACESOL

16. Denmark

Overview of PV developments

In 2022, Denmark took a big leap and entered the club of GW-scale markets. This crucial milestone has been driven by utility-scale solar, which continued a strong growth path and more than doubled the yearly installed capacity – all based on subsidy-free projects. Besides the large-scale solar segment, rooftop PV of all sizes also demonstrates significant growth with a nice potential for continued expansion in the future. The residential market peaked in 2012 and, except for a small decrease in 2013, has only regained momentum in the last three years.

By the 1st quarter of 2023, the accumulated utility-scale capacity in Denmark was 2.88 GW[12] distributed over 76 parks, including 1.56 GW installed in 2022. Also, the yearly installed capacity of all rooftop segments more than doubled in 2022 with 139 MW added, reaching a total capacity of 3.97 GW. From 2021 to 2022, the residential, commercial, and industrial market segments have experienced very high growth rates, close to 290%, 160%, and 180% respectively. This is largely because of the overall interest in supporting the green transition, and realisation of energy independence through a high degree of self-consumption.

Drivers for solar growth

Growth in the residential rooftop and commercial segment has slowed down significantly during the previous months. While the first month of 2023 still demonstrated strong growth compared to the year before, customer interest is now significantly lower, mainly due to lower electricity prices and overall constrained economic conditions.

Based on information collected from all major solar developers in Denmark, the strong growth in the utility-scale sector is expected to continue over the coming years. The total pipeline of projects is very strong, and the Danish utility-scale market benefits from well-functioning and transparent regulations, with respect to planning permission and grid connection procedures. For this reason, the experienced developers have provided estimates for each of the coming years, on the number of projects which may reach ready-to-build status.[13] According to this analysis, the Danish utility-scale market has potential to surpass the 2022 record level after two years of market contraction or stagnation.

Although the processes required to develop utility-scale projects to reach ready-to-build status is well understood and to certain extent quite predictable, it is becoming increasingly difficult to predict if these projects will pass the final investment decision. The high uncertainty comes from a change in the overall business environment in relation to realisation of such projects related to several factors:

- The new tariff scheme for grid connection of electricity production, which has now been implemented as of January 1st 2023, implies that all producers must pay a per-MW_{AC} grid connection charge between 17,600 EUR and 329,000 EUR. This fee depends on the connection voltage (from 10 kV at DSO level to 400 kV at TSO level) and geographic location of the project. If a project is to be installed in an area where the grid capacity is dominated by other existing electricity generation, the grid connection fee is higher than for consumptions dominated areas.
- The overall costs related to value loss compensation for neighbours and financial support to municipalities are quite high and may become even higher.
- The financial conditions in relation to inflation and interest rates have reduced investors' appetite for these projects.
- The lowering of the electricity price and projected cannibalisation effect will have a strong negative impact on the profitability of the projects. It is expected that the electricity prices in the future will significantly reduce the spot price of solar for many hours during the year.
- The overall increased activity in the electricity sector will also increase the cost and risk of delays in preparing for grid connection.

12 All numbers in this article are expressed in DC. An AC to DC conversion factor of 1.1 for all rooftop projects and 1.25 for utility-scale projects is assumed for Denmark.

13 To address the market uncertainty, the estimated utility-scale deployment capacity has been reduced by 10% and 20% compared to the reported value for the years 2024 and 2025-2026 respectively.

- Many of the large projects from 2025 onwards rely on the assumption that there will be a sharp increase in electricity consumption (e.g. functioning market for hydrogen and other Power-to-X technologies at the end of the decade). Political action to secure a speedy framework and the development of a hydrogen pipeline is a necessary condition.
- The optimistic outlook on medium to long term installation (from 2025) also relies on the delivery of other political promises such as the realisation of state energy parks, mandatory targets of installed capacity for municipalities, and other announced changes.

The extent to which these risk factors may negatively impact the presented optimistic deployment forecast is difficult to assess. Because of this, the outlook must be considered as an upper limit to the deployment.

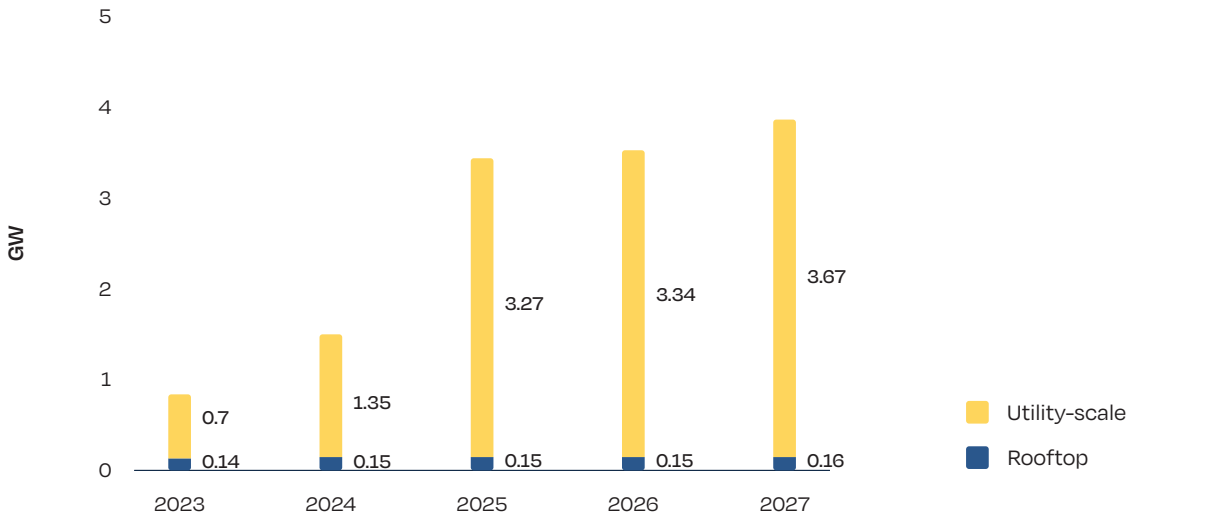
One of the key differentiators between the well-functioning utility-scale Danish market and others, is the less restrictive approach to temporary use of agricultural land for solar purposes. The requirements and formalities in general are not less demanding than in other EU solar markets, but the Danish municipalities and utility providers have a reputation for efficiency, which ensures a faster process.

Outlook

With 2022 as the first year solar reached the GW scale in Denmark, it is expected to continue during the coming years, following a strong drop in installations in 2023. The utility-scale sector is expected to be the main driver of the growth, as it is foreseen that the market will reach 1.4 GW in 2024, set a new all-time high in 2025 with 3.3 GW and increase further to 3.7 GW by 2027 (as illustrated in Fig. GW16). The annual rooftop market is expected to stay almost constant from around 141 MW in 2023, to close to 153 MW by 2027.

Authors: *Thomas Aarestrup Jepsen*, Director, VE-production, PA and Communication, Green Power Denmark; *Flemming Kristensen*, Chairman of the Board, Danish PV Association.

FIGURE GW16 DENMARK SOLAR PV MARKET 2023-2027, BY GREEN POWER DENMARK & DANISH PV ASSOCIATION



SOURCE: Green Power Denmark & Danish PV Association.

17. Türkiye

Overview of solar PV development

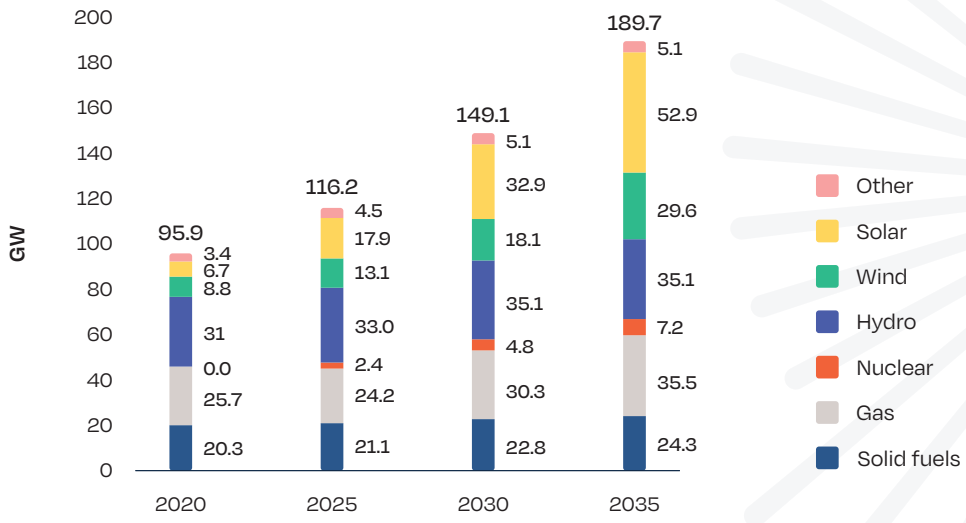
At the end of December 2022, total installed power capacity in Türkiye reached 103,809 MW, out of which PV plants accounted for 9,425 MW. The amount of solar PV projects under completion are estimated to be 1-1.5 GW. This capacity can be considered in addition to the installed capacity in 2022. Solar power installed capacity increased by 1,610 MW, compared to the end of 2021. There are 11,427 power generation plants in Türkiye and the number of unlicensed and licensed small power producers (SPPs) reached 9,353 (TEİAŞ, 2022). With solar PV installations exceeding 9 GW in less than 10 years, the PV panel production market has also expanded. There are more than 30 solar module manufacturers in Türkiye which have a total module production capacity of over 12 GW per year. New module manufacturers are expected to add 10 GW of production capacity by the second half of 2023, bringing the total annual production capacity to 22 GW per year. Likewise, production in the sub-industry for module frames, glasses, junction boxes, and cells is also gradually developing. The number of companies operating in the field of solar energy is estimated to be around 1,000, including solar module, construction, cable, and inverter manufacturers, operation and maintenance companies, smart grid, e-mobility, blockchain applications, energy management and monitoring, energy storage solutions, energy efficiency, and consultancy services, etc. There are more than 250 Engineering, Procurement, and Construction (EPC) companies actively working in Türkiye, excluding the small companies providing services locally. As a consequence of these flourishing developments, the Turkish solar energy sector currently employs over 50,000 people.

National targets for solar PV

The share of variable renewable energy sources, such as solar and wind, in total electricity generation is expected to increase. This is considering Türkiye's current flexibility opportunities, and renewable energy potential. The Ministry of Energy and Natural Resources (ETKB) released the National Energy Plan of Türkiye, which covers the period from 2020 to 2035. According to the plan, the overall installed capacity of electricity will reach 189.7 GW, with solar, wind, and nuclear power projected to rise to 52.9 GW, 29.6 GW, and 7.2 GW respectively (Figure GW17).

74.3% of this installed capacity increase should come from renewable energy sources, most notably solar and wind power. To meet the need for flexibility,

FIGURE GW17 CUMULATIVE INSTALLED SOLAR CAPACITY AND GROWTH SCENARIOS UNTIL 2035, BY GÜNDER



SOURCE: GÜNDER.

battery capacity will reach 7.5 GW, electrolyser capacity will reach 5 GW, and demand-side participation will reach 1.7 GW, according to ETKB.

Drivers for solar growth

The allocation of new capacity for land and rooftop solar systems, along with the adoption of hybrid power plants, electric vehicle charging infrastructure, and storage technologies, has enhanced the installed capacity of solar. Regardless of the amount of wind and solar power capacity that can be put into operation in the upcoming period, it will be important to be able to manage the supply-demand margin, which may be reduced when the capacity factors of wind and solar power plants are low. In this framework, factors that can provide additional flexibility to the electricity system, such as battery storage and new base/flexible capacity, will be assessed from the perspective of energy supply security, the requirements of the electricity grid, costs, the growth rate of electricity demand, status of the generation portfolio, etc, and additional measures will be taken as needed.

Utility-scale vs. distributed & rooftop solar development and plans

The number of applications in the C&I rooftop PV market exceeded 2,000 projects last year, and reached an annually installed capacity of over 1,000 MW. According to the research conducted by industry stakeholders, there is potential for at least 10 GW to be added in the coming years, specifically for unlicensed installations used for self-consumption purposes for businesses, with suitable roofs such as factories, hotels, and hospitals.

Rooftop PV project for Çimtaş Çelik (ENKA), 5.7 MW, Bursa, Türkiye. © Istrich Energy

Challenges for the market

On February 6 and 20, 2023, two major earthquakes hit Türkiye. They were unprecedented in recent history in terms of magnitude and coverage, caused major devastation in a total of 11 provinces, and claimed the lives of more than 48,000 people. Over half a million buildings were damaged, and communication and energy infrastructure were hit as well, leading to significant financial losses. There are 45 MW of licensed PV systems, 924 MW of wind power, and 224 MW of biomass and waste heat plants in the earthquake zone. A total of 3.5 TWh per year of power was generated from these power plants, corresponding to 7.5% of the total solar, wind, biomass, and waste heat power generation in Türkiye. Therefore, following the earthquake, it should be the main goal to build habitable, eco-friendly, and sustainable settlements for all, and to install water and sanitation utilities in such settlements, based on the principles of energy efficiency, and protection of water sources and biodiversity.

Outlook for the years 2023-2027

Meeting net-zero emission targets requires a major transformation in all sectors, and a system approach that is different from any previous policy agenda. As a long-term policy proposal, everyone, especially the low-income population, should have access to adequate, safe, inclusive, economically affordable, sustainable, climate-resistant, and energy-efficient housing, with basic infrastructure services. Many R&D projects are realised with support from the main funding agency, the Scientific and Technological Research Council of Türkiye (TUBITAK). METU-GÜNAM is also one of the most comprehensive national research infrastructures, combining and developing technologies in different disciplines including PV cells and modules. Additionally, the GÜNDER Vocational Qualification Centre is testing and following certification activities for employment, aimed at promoting the proper growth of the solar industry. The centre also establishes minimum standards, as well as national and international qualifications, including for installations.

Author: Turkish Solar Energy Association-GÜNDER

18. Greece

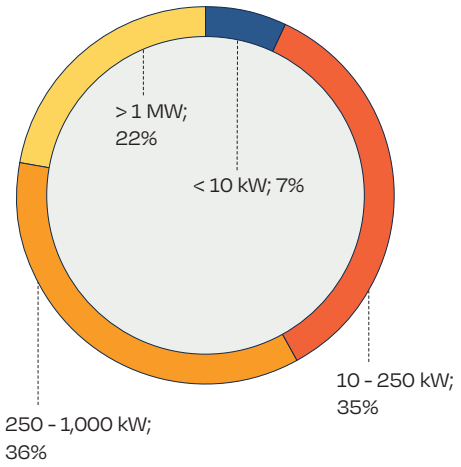
Overview of solar PV developments

The Greek solar PV market has gained tremendous momentum, which is expected to continue for the next few years. In 2022, 1.362 GW of new PV projects were connected to the grid, bringing the cumulative capacity to 5.5 GW. This was the best performance ever for the Greek solar sector. Still, it looks modest if you compare it with the expected performance of the market in 2023 which should bring online around 2 GW of solar capacity.

Once again, in 2022, the annual market was dominated by medium-size projects between 10 and 1,000 kW. However, the utility-scale and residential self-consumption segments are experiencing noteworthy growth for the first time.

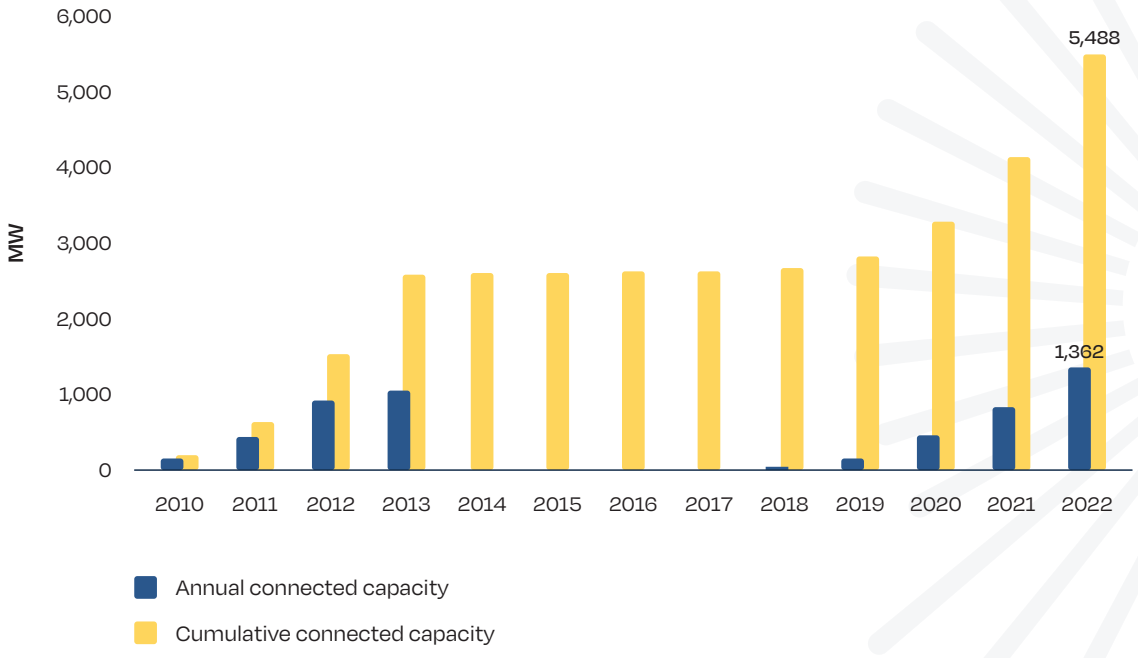
The bright weather across the country helped solar PV to contribute to some 13.5% of total Greek electricity production in 2022, breaking yet another record. This outshined the expected 10% share of solar in meeting gross electricity demand.

FIGURE GW18.2 GREEK CUMULATIVE PV MARKET SEGMENTATION 2022, BY HELAPCO



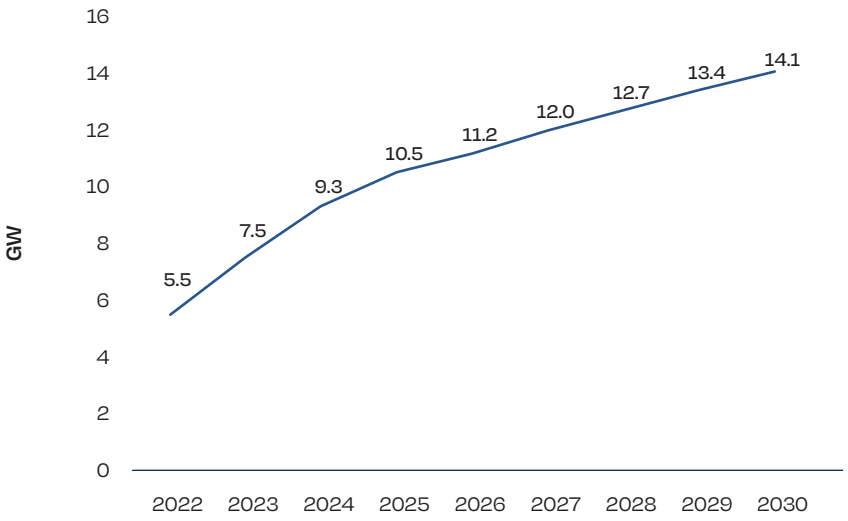
SOURCE: HELAPCO.

FIGURE GW18.1 GREECE SOLAR PV MARKET DEVELOPMENT 2010-2022, BY HELAPCO



SOURCE: HELAPCO.

FIGURE GW18.3 GREECE CUMULATIVE SOLAR PV CAPACITY OUTLOOK ACCORDING TO NEW NATIONAL TARGET



SOURCE: HELAPCO.

Considering current trends, Greece is revising its 2030 national solar target: the new draft target is 14.1 GW by the end of the decade, almost doubling the one previously set.

The major bottleneck remains the availability of grid capacity. Most of the medium-voltage grids are now congested, and soon, the same is likely to happen with the high and ultra-high voltage grids. The government

16 MW, Athens International Airport, Greece.

presented a priority list for grid connection in August 2022 and then again in January 2023, raising numerous complaints by interested investors. To address these complaints, a roadmap for grid enforcement and development for the coming years was made. However, the appetite of investors transcends this plan.

The real good news comes from the self-consumption segment. For the first time, annual installations in 2022 exceeded the 100 MW milestone (110.8 MW were connected in 2022), and 2023 is expected to be another record year for self-consumption systems, with the market expected to triple its size.

Regarding support schemes, some 4.1 GW of RES projects will be auctioned in Greece between 2023 and 2025, with PV expected to get around 3 GW. Additionally, corporate PPAs are expected to take off soon, and a Green Pool scheme to support PPA deployment has been presented by the Greek Energy Ministry for European Commission approval. An aggregator will be chosen under the Green Pool scheme to represent collectively RES producers to reduce costs arising due to differences between generation and demand profiles. It is expected that the aggregator will receive a state subsidy of up to 85% on anticipated profile costs which would normally be incurred by the offtakers.

In 2022, the Greek Parliament also passed a thorough regulatory framework for storage. Large-scale storage will be selected through a bidding process, with a total tendered power capacity of 1,000 MW and at least 2 GWh of storage capacity. The allocation of the contracts to selected projects should take place before the end of 2023, and storage facilities should be completed by the end of 2025. A support scheme for self-consumption PV systems (<10.8 kW) coupled with storage in the residential and small agricultural sectors commenced in May 2023. This programme will cover the full cost of batteries, in an effort to facilitate the development of a new market segment. Some 30,000 small batteries (<10.8 kWh) are expected to be deployed by mid-2024.

Author: *Stelios Psomas*, Policy Advisor, HELAPCO.

19. South Africa

Overview of PV developments

Renewable energy development in South Africa has been dominated by public procurement since the launch of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) in 2011. However, recent coal-fired plant performance issues at the national utility, ESKOM, coupled with changes in regulation has shifted the focus to the private sector.

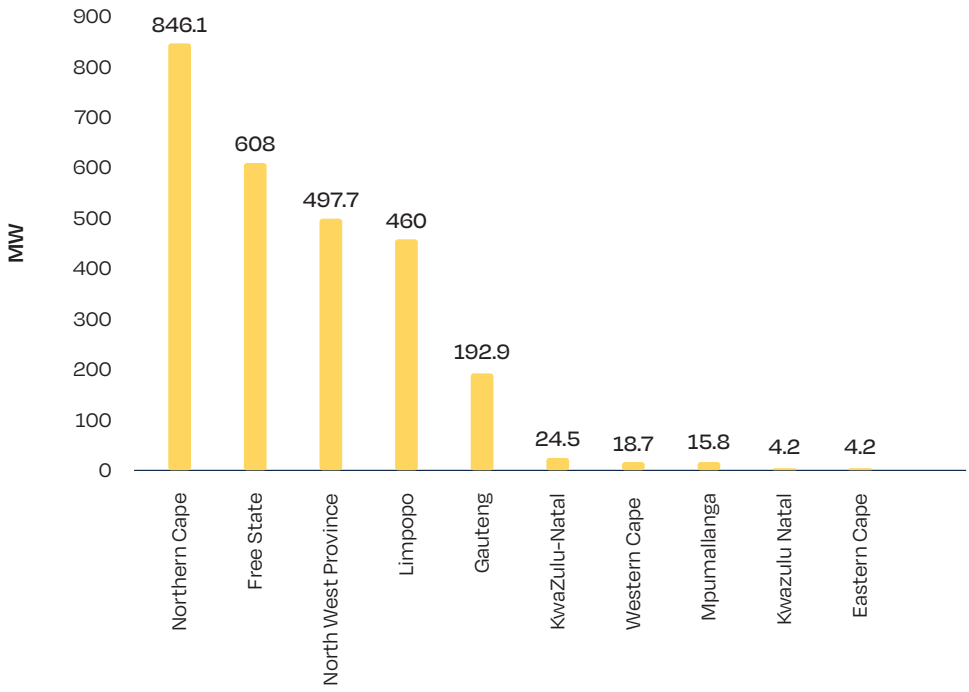
South Africa's electricity generation mix is still dominated by coal-fired generation, accounting for 80% of the national electricity generation in 2022. However, 11 GW of coal fired capacity is due for decommissioning by 2030 according to the 2019 Integrated Resource Plan (IRP). The performance of the aging coal fired power stations has deteriorated over the last 5 years, resulting in a generation supply shortfall ranging from 1,000 MW to 8,000 MW daily, and in power cuts from 2 to 12 hours per day.

Against this background, South Africa's solar sector has grown in importance and size in recent years. After reaching the GW scale for the first time in 2020, with 1.3 GW annually installed, the South African market did not cross this threshold in 2021. Last year, in 2022, the GW-scale was reached again with annual installations in the same range of the record-breaking 2020 levels. As a result, South Africa now operates a solar fleet larger than 6 GW.

National solar PV targets

South African national energy procurement is guided by the Department of Mineral Resources and energy (DMRE) through the IRP 2019. The current version of the IRP is due for review in 2023 and sets out an energy procurement roadmap until 2030 that favours a diversified approach of generation technologies. Current solar PV targets are 8,288 MW or 10.52% of total installed capacity by 2030. A total of 4,348 MW has been procured to date across 6 bidding rounds of which 2,213 MW is already operational.

FIGURE GW19 NERSA REGISTERED CAPACITY IN SOUTH AFRICA, BY SAPVIA



SOURCE: SAPVIA..

Drivers for solar growth

The electricity generation shortfall, and the ensuing power cuts, have been the primary driver for residential solar PV and storage installations as well as C&I solar PV installations over the last year. The shortfall has also necessitated a change in regulation to allow for private sector participation in utility scale generation projects. This was previously only possible through public procurement via the REIPPPP.

The demand increase from households and businesses looking to become more energy resilient is aided by the decreasing costs of solar PV installations coupled with storage solutions. Typically, costs for residential solar PV installations coupled with storage are in the range of 2,000-2,300 USD/kW (1,875-2,157 EUR/kW), while typical C&I rooftop solar installation costs range between 620-700 USD/kW (581-656 EUR/kW). The cost of solar PV through public procurement has fallen by 88% since 2011 to an average of 0.027 USD/kWh (0.025 EUR/kWh).

The uptake of solar PV systems has also been accelerated by the availability of financing for residential, C&I and utility-scale projects. Innovative financing solutions have been developed by the South African financial industry that caters to the unique requirements of residential and C&I projects. However, financing solutions are still heavily tied to individual credit scores. On the one hand, this excludes large segments of the South African market that do not have access to credit or have a low credit score. On the other hand, it has created an opportunity for companies with solar-as-a-service and rent-to-buy business models.

Private sector utility-scale growth

The sector of the market that has seen the highest growth rate in 2022 is the large C&I sector (larger than 1 MW) as well as the private utility-scale sector. In 2022 the national energy regulator of South Africa, NERSA, registered over 1.2 GW of capacity across 57 projects larger than 1 MW, the largest being 100 MW.

The growth of large-scale projects has been driven by amendments to national regulation governing the size of private sector projects that are allowed to connect to the grid. In late 2021, the upper limit was increased from 1 MW to 100 MW, and the threshold removed completely in December 2022. This has resulted in more than 1.4 GW of projects being registered in 2023 to date, with the largest being a 283 MW plant. Over 2.1 GW of projects, representing over 70% of projects larger than 10 MW, are designed for either wheeling, or for selling generated energy to an energy trader, once the market mechanisms are put in place. Wheeling is the practice of transporting energy across publicly owned transmission and distribution networks. It concerns the energy sold through a bilateral PPA with a private off-taker as well.

Challenges

The South African PV market faces challenges related to skill shortages and long equipment delays across all sectors. The exponential growth in demand for solar PV across all sectors has unfortunately not been matched by the training of individuals to design and implement the projects. This poses a limit to the growth rate of the industry. The introduction of formal vocational training programmes has been welcomed by the industry. However, new training service providers are expected to establish both formal and informal training schemes to meet the demand of the industry.

According to national import data, 345 million USD (324 million EUR) worth of solar cells, modules, and panels were imported in 2022, and 200 million USD (188 million EUR) of the same goods were already imported in the first quarter of 2023. However, the efficiency of South Africa's container ports has had a significant impact on the procurement of imported equipment, adding 3 to 6 months to lead times. The lead times have been exacerbated by the global supply chain issues post COVID-19.

The growth of the utility-scale sector is facing low available grid capacity in high yield areas, especially in the Northern Cape, Eastern Cape, and the Western Cape. The establishment of an independent TSO entity is expected to enable the deployment of new transmission infrastructure in the medium to long term. Unfortunately, utility-scale projects, both public and private, will be limited to lower solar potential areas in the Free State, Northwest, and Limpopo provinces, until new transmission infrastructure comes online.

40 MW Linde solar farm, Northern Cape Province, South Africa.

Outlook for the years 2023-2027

The energy landscape in South Africa will be dominated by the generation shortfall in the short and medium term, thus the addition of new generation capacity from various sources, acquired via public and private procurement programmes, will be the primary driver of the country's solar PV industry.

The unbundling of the state-owned, vertically-integrated, utility ESKOM into three units - namely generation, transmission, and distribution - started in 2017 and is progressing steadily. While the creation of a state-owned TSO is set to be completed in the second half of 2023, works will continue towards the establishment of a fully liberalised electricity market.

Finally, the decarbonisation of supply chains in response to Nationally Determined Contribution (NDC) targets or international trade requirements, such as the EU Carbon Border Adjustment Mechanism (CBAM), will drive further uptake of solar PV in South Africa. The potential of green hydrogen production in high solar resource areas is gaining traction amongst local and international project developers and is expected to play a significant role in the South African PV landscape in the medium to long term.

Author: *De Wet Taljaard*, Technical Specialist: Solar Energy, South African PV Industry Association (SAPVIA).

6 MW, Heineken Sedibeng brewery, Gauteng, South Africa. © SOLA

20. Austria

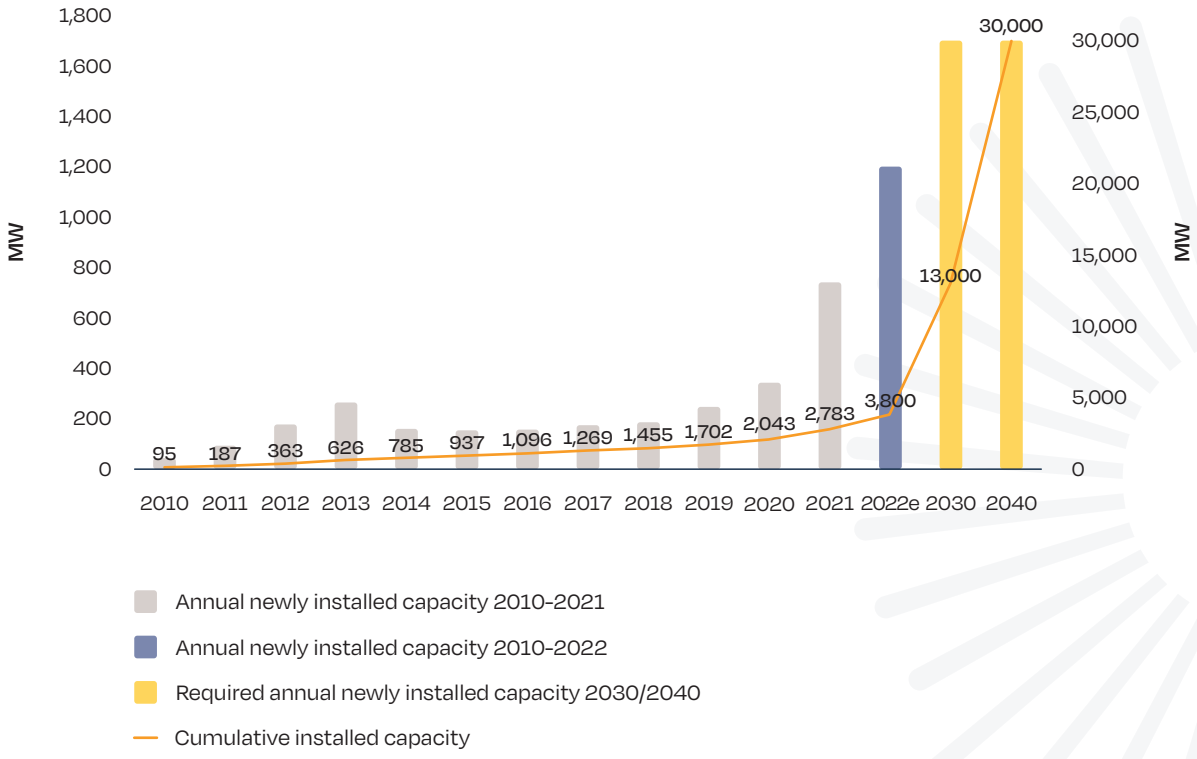
Overview of PV developments

In 2022, Austria broke the threshold of more than 1 GW newly installed PV systems for the first time. The final data will only be published in mid-2023, but preliminary forecasts assume that Austria reached about 1,000-1,200 MW of new photovoltaic capacity in 2022, which is an increase of 35-62% compared to the previous year. Already in 2021, the newly installed capacity more than doubled compared to 2020, with an increase of 117% from 341 to 740 MW. Including all recent data, a total fleet of around 3.8-4.0 GW of PV systems is now in operation. With a population of approximately 9 million people, almost 850,000 households are supplied with electricity from PV systems.

National Targets for solar PV

As a contribution to achieve the Paris Agreement's goals, and the European Union's objective to cover at least 32% of its overall energy consumption with renewable energy by 2030 – an objective now raised to 42.5% – Austria has defined binding national goals for its energy transition, through the Renewable Energy Expansion Act (EAG) in 2021. Primarily, the EAG includes Austria's plan to cover 100% of its total electricity consumption with renewables by 2030, and sets a direction to become climate-neutral by 2040. In order to achieve the 2030 target, the EAG specifically mentions that renewable electricity generation must be increased by 27 TWh by 2030, compared to 2020 levels. 11 out of 27 TWh must be generated by PV. Installing 1 million Austrian solar rooftops by 2030 will prove crucial for this expansion target.

FIGURE GW20 INSTALLED PV CAPACITY IN AUSTRIA, BY PV AUSTRIA



SOURCE: PV Austria.

Drivers for solar growth

The major driver in the past year was Russia's invasion of Ukraine, and the resulting energy crisis, which created high electricity prices and attractive feed-in tariffs. However, the PV boom in Austria actually started before 2022. Falling system prices and public subsidies for PV, combined with the growing desire of households and companies for energy autonomy, has caused a higher demand for decentralised generation systems. In particular, PV subsidies were considerably increased by the government with the publication of the EAG, rising from around 110 million EUR in 2021, to 300 million EUR in 2022, and have grown further to 600 million EUR for 2023. In addition, as part of the EAG, a market premium for PV systems (CfD scheme) has been created with the aim of deploying 700 MW per year. In summary, the combination of governmental support, Russia's invasion, and the energy crisis resulted in a rush for subsidies in 2022.

Utility-scale vs. distributed and rooftop solar developments

Unfortunately, no clear statement can be made about the distribution of utility-scale, small PV systems, or rooftop solar developments in Austria. Grid operators do not publish data regarding proportions of centralised or decentralised generation, or which categories – rooftops, ground-mounted or Agri-PV – were installed. However, the respective proportion of rooftop and ground-mounted systems that will be necessary to reach the Austrian expansion targets has been assessed. In order to achieve the PV expansion of 11 TWh by 2030 in Austria, a share of approximately 46% rooftop PV, and 54% ground-mounted PV will be required.

Challenges for the market

The greatest drawbacks for the ongoing PV boom in Austria are the slow national power grid expansion and

© PV Austria

the severe worker shortage. The continuing increase in demand for PV systems led to a demand for trained specialists in the industry. While there were around 4,500 full-time jobs in the Austrian PV industry in 2021, forecasts for 2030 estimate that 30,000 jobs will be required. Regarding the grid expansion, simpler connection procedures are needed to achieve the specified national targets, especially for smaller systems.

Significant delivery bottlenecks for important system components, resulting from the crises of the last few years, have led to a re-examination of material availability. In 2021, the share of Austrian-manufactured modules in residential PV systems was only 14%. Today, most PV system components are produced by, and delivered from Asian countries. The PV manufacturing industry must be strengthened at the European level in the coming years. Austria would also benefit from this and of course will make its contribution to the reconstruction of the PV industry in the EU.

Another domestic problem is the designation of areas for free-standing PV systems. Since Austria follows a federal structure, the competence for 'go-to areas' for PV systems, lies with the individual federal states. So far, only 3 out of 9 federal states have provided 'go-to areas.'

Outlook

By reaching the threshold of 1 GW of newly installed PV systems in 2022, Austria has already reached its target for 2025. Due to public subsidies, the EAG, and unbroken demand, the PV boom is expected to continue in 2023. Complementary to the EAG, an additional law, the Renewable Energy Expansion Acceleration Act (EABG), is scheduled to be published in 2023. This law will aim to assist the renewable expansion by simplifying administrative procedures, especially for PV systems.

Author: *Lisa Grün*, Bundesverband Photovoltaic Austria (PV Austria).

24.5 MW, Grafenwörth, Austria.

21. United Kingdom

Overview of PV developments

Solar Energy UK estimates that the UK has about 15.5 GW of deployed solar PV, where a third is installed on rooftops and the rest on the ground. Capacity will be well above 17 GW by the end of 2023. In 2022, annual deployment reached over 1 GW for the first time since subsidies were withdrawn in 2019.

According to government figures, 532 MW of solar installations below 50 kW were installed, although these figures do not include any utility-scale or large commercial rooftop projects. According to Solar Media, 481 MW of ground-mount solar assets were built in 2022, and we estimate that at least another 300 MW of large C&I rooftop projects were also installed. These figures are provisional, but we have seen even faster growth in the sub-50 kW market in 2023, where a further 228 MW had been deployed across the UK by the end of March 2023.

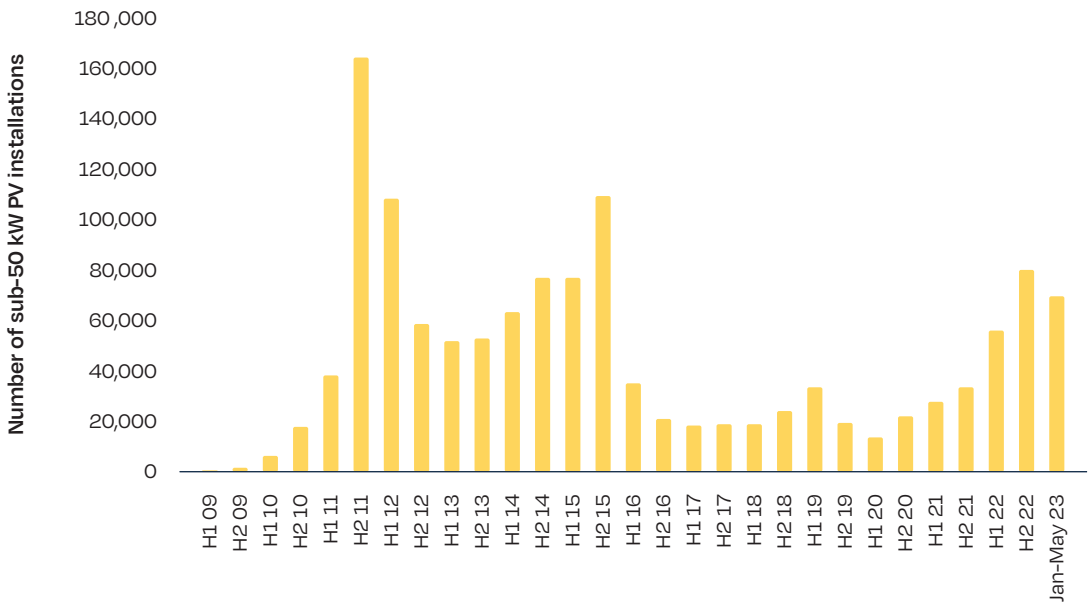
The pipeline for utility-scale projects is now substantial, with over 10 GW of solar farms having received planning permission and a connection agreement. Another 10+ GW are currently applying for permission to be built.

National targets for solar PV

The UK will have at least 70 GW of solar power in place by 2035, according to the 2022 Energy Security Strategy. This was reinforced by the Energy Security Plan in March 2023 – part of the so-called 'Green Day' – which spoke of the "huge deployment potential for solar power" in the country, and that rooftop solar "remains a key priority for the government." It confirmed plans for a government-industry taskforce to set out how the goal will be met and milestones along the way.

Perhaps more importantly, the plan put forward by Rishi Sunak's government marked a definitive departure from the opposition to solar farms expressed by Liz Truss and her short-lived Cabinet. "Ground-mounted solar is one of the cheapest forms of electricity generation and is readily deployable at scale. The government seeks large scale ground-mount solar deployment across the UK, looking for development mainly on brownfield, industrial, and low and medium-grade agricultural land," it stated.

FIGURE GW21.1 UK CERTIFIED SUB-50 KW SOLAR PV INSTALLATIONS 2009-2023



SOURCE: MCS.

The Scottish Government is also expected to set its own goal. Its Draft Energy Strategy and Just Transition Plan, released in January 2023, included a proposed 'solar vision', seeking to "maximise the contribution solar can make to a just, inclusive, transition to net zero". What the deployment ambition will be is currently unclear, though Solar Energy UK has asked for 4-6 GW by 2030, up from less than 1 GW now.

Drivers for solar growth

For rooftops, the energy price crisis, rising consumer awareness, environmental considerations and the good value of solar panels have combined to deliver an unprecedented market for solar technology.

Solar Energy UK expects that greater capacity will be delivered in the under-50 kW market in 2023 than ever before, even more than during the heights of the feed-in tariff era a decade ago. The number of such installations looks likely to reach 225,000 in 2023, up from 136,000 in 2022. There were only 36,000 in 2020, the year after the subsidy was abolished. The introduction of the Future Homes Standard in 2025 is expected to mean that nearly all new homes in England will be built with solar on the roof.

Meanwhile, the most important innovation in the ground-mount sector is the rise of very large solar farms. The largest currently under construction is at Cleve Hill in Kent, at 350 MW. Several major projects of 500 MW and above, are due for approval by the government in the coming years, the largest being the 840 MW Botley West development.

Challenges for the market

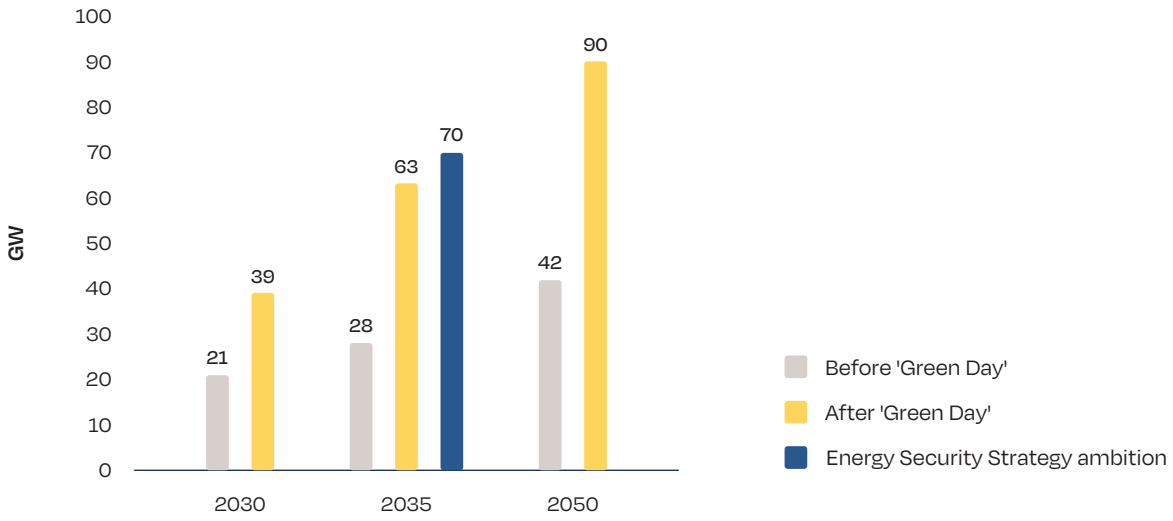
The UK was hit with supply chain difficulties in 2022, largely a consequence of COVID-19 lockdowns in China, which led to some delays in meeting contracted installations.

The main challenges now are scaling up for rising demand, finding skilled installers, and protracted waiting times for grid connections. Delays can extend well into the 2030s, presenting a serious threat to the viability of some projects. The delays can generally be attributed to chronic underinvestment in the transmission and distribution networks, and regulatory controls on investing to rectify the problem. The new taskforce will prioritise addressing these issues.

There are simply not enough trained electricians, a problem that the government, regional administrations and Solar Energy UK has recognised. The Mayor of London's 'Solar Skills London' project, now managed by standards body MCS, has been in the vanguard, reaching out to young people to join the solar industry, and organising short introductory courses. There is government interest to introduce similar projects across England.

1.9 MW, Testwood Water Supply Works solar farm, Peel Common, Hampshire, UK.

FIGURE GW21.2 UK SOLAR PV CAPACITY PROJECTIONS FOLLOWING ENERGY SECURITY PLAN, BY SEUK



SOURCE: Solar Energy UK.

Outlook for the years 2023-3027

The outlook for the coming years is very positive. Government support is guaranteed; ministers are aware that every panel installed means a securer energy system. The public are also on board, with multiple surveys demonstrating the popularity of solar power. Although there have been increasingly vocal campaigns opposing some solar farms, the vast majority are still receiving planning permission from local councils, and enjoying public and political support.

Meanwhile, the opposition Labour Party has pledged to treble capacity within its first term if it wins the next general election, due no later than January 2025. That announcement, made in October 2022, was a direct consequence of Liz Truss' brief and unsuccessful attempt to ban solar farms.

Author: *Gareth Simkins*, Senior Communications Adviser, Solar Energy UK.

Retrofitted home, Croydon, UK.

© Gareth Simkins

22. Mexico

Overview of PV developments

In 2022, the Mexican solar PV market installed 1.18 GW, a 19.7% decrease compared to the 1.47 GW added in 2021, 41.5% less than the 2.02 GW added in 2020, and 43.8% less than the 2.1 GW installed in 2019. Total capacity operating in the country reached 9.35 GW, which constitutes a 12.6% growth from 2021. This is about 15 times the installed capacity in 2017. Out of the total installed capacity, utility-scale PV represents 72% (6.72 GW), and distributed solar PV 28% (2.61 GW).

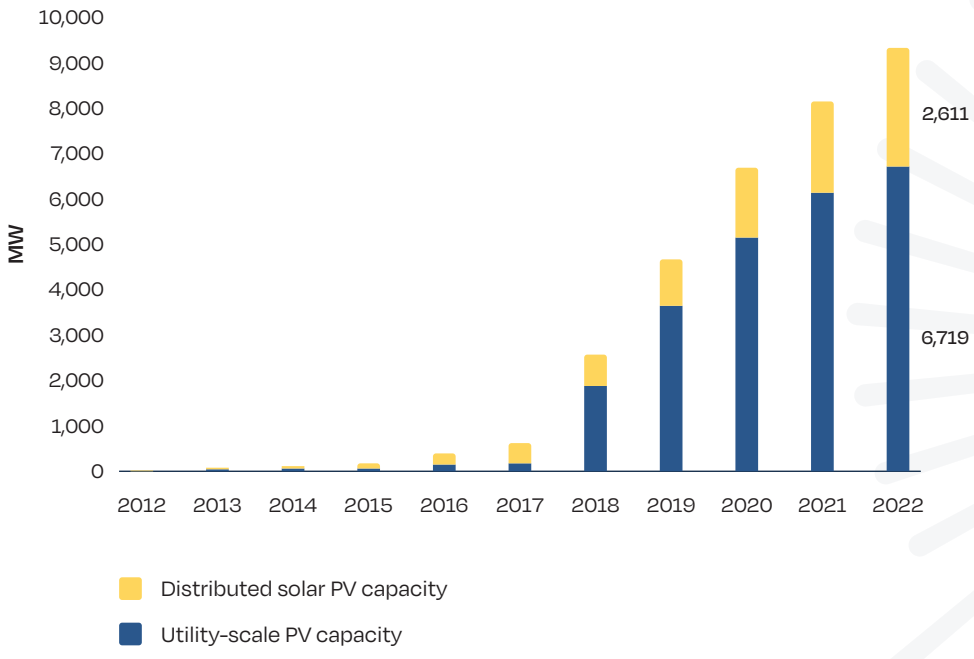
Utility-scale PV added 580 MW of capacity in 2022, significantly less than the previous 4 years (1.1 GW in 2021, 1.5 GW in 2020, 1.77 GW in 2019, and 1.71 GW in 2018). In contrast, distributed solar PV reached a new record of 596 MW, 25% more than 2021 (476 MW), 16% more than 2020 (516 MW), and notably higher than 2019 and 2018 (335 MW and 236 MW respectively). This is the first time in the last 6 years, when distributed solar additions were higher than utility-scale installations.

Looking at the whole electricity system, utility-scale PV capacity represents 7.7% of total installed capacity (87.7 GW), while 64% of installations belong to fossil-fuel based technologies. In terms of power generation, fossil-fuel based technologies provided 73.9%, an increase compared to 2021 (71.4%). Meanwhile, solar PV showed a decline for the second year in a row, contributing to 4.9% of power generation in 2022, compared to 5.3% in 2021 and 5.7% in 2020.

Renewable energy and solar PV targets

In 2015, the Energy Transition Act (LTE) established the targeted share of clean energy in electricity generation: 25% by 2018, 30% by 2021, and 35% by 2024. Based on Ministry of Energy data, Mexico did not meet its clean energy target for 2021 (reaching only 28.6% out of 30%), and due to current legal uncertainty, it is not expected to fulfil the 2024 target.

FIGURE GW22 MEXICO TOTAL SOLAR PV CAPACITY 2012-2022, BY ASOLMEX



SOURCE: ASOLMEX.

In order to promote the development of renewable energy and reach clean energy goals, a policy framework for Clean Energy Certificates (CEC) was established, as well as a system of long-term energy auctions held annually by the Independent System Operator (ISO). However, regulatory changes carried out over the last 3 years have suspended these mechanisms. At the time they were held, the long-term energy auctions secured nearly 4.66 GW of utility-scale PV capacity, from which approximately 3.42 GW (73%) started operating before the end of 2022, and the remaining 1.24 GW should be in operation before 2024.

At COP27 in November 2022, Mexico announced an updated nationally determined contribution (NDC) target, from a 22% to a 35% reduction in greenhouse gas emissions by 2030. Studies indicate that Mexico would need to add at least 30 GW of new renewable energy capacity, mainly solar PV and wind, to reach this new NDC. However, no additional plans or net-zero targets have been published since.

Challenges

After the 2013 Energy Reform, Mexico reached its maximum annual additions in utility-scale PV in 2019 (1.77 GW), mainly because of long-term energy auction contracts. In 2022, additions were 580 MW, 68% less than 2019 due to the regulatory paralysis taking place since 2020.

To reach its new NDC, Mexico would need to add at least 20.2 GW of utility-scale PV between 2023 and 2030, with an average of 2.5 GW per year. This would require clear mechanisms of public and private participation in the power sector, which guarantee sufficient investments and accelerated execution capacity.

On 20 July 2022, the United States Trade Representative announced that the United States had requested dispute settlement consultations with Mexico under the United States-Mexico-Canada Agreement. The US, as well as Canada, challenged amendments to Mexico's Electricity Industry Law introduced in 2021, that would prioritise electricity produced by state-owned company CFE. At the time of writing, the dispute settlement panel has not been requested yet.

101 MW, Laguna solar park, Matamoros, Coahuila, Mexico.

Outlook

Nearshoring offers Mexico a unique opportunity to attract investments in the manufacturing industry from the United States. This will eventually require more supply of clean energy, an essential precondition for companies with net-zero commitments.

To accelerate its decarbonisation, Mexico needs to promote transparency, accountability, and independence of the regulatory authority and the system operator, which will lead to unbiased regulation and operation. Mexico must also urgently increase public and private investments to modernise and expand the grid, and define the role of energy storage to add flexibility and reliability to the system.

Author: *Carla Medina Perezgomez*, President, Mexican Association of Solar Energy (Asolmex).

36 MW, Torreoncitos solar park, Jiménez, Chihuahua, Mexico.

23. Hungary

Even best performing years were surpassed

Overview of solar PV developments

2022 set a new record for solar PV in Hungary, with 1,102 MW of annual installed capacity, surpassing the country's already strong performance since 2019, with 700 MW to 800 MW deployed yearly. Last year, Hungary's total installed capacity exceeded 4 GW. The country's national target will reach 6.5 GW by 2030, and 12 GW by 2040. Based on past trends, it is likely that Hungary will surpass its 2030 target earlier than expected. Although government officials have mentioned increasing the 2030 target, there has been no official update on this so far.

The Hungarian market can be divided into two segments: systems below and above 50 kW. However, there is no detailed breakdown currently available to determine the size of commercial installations.

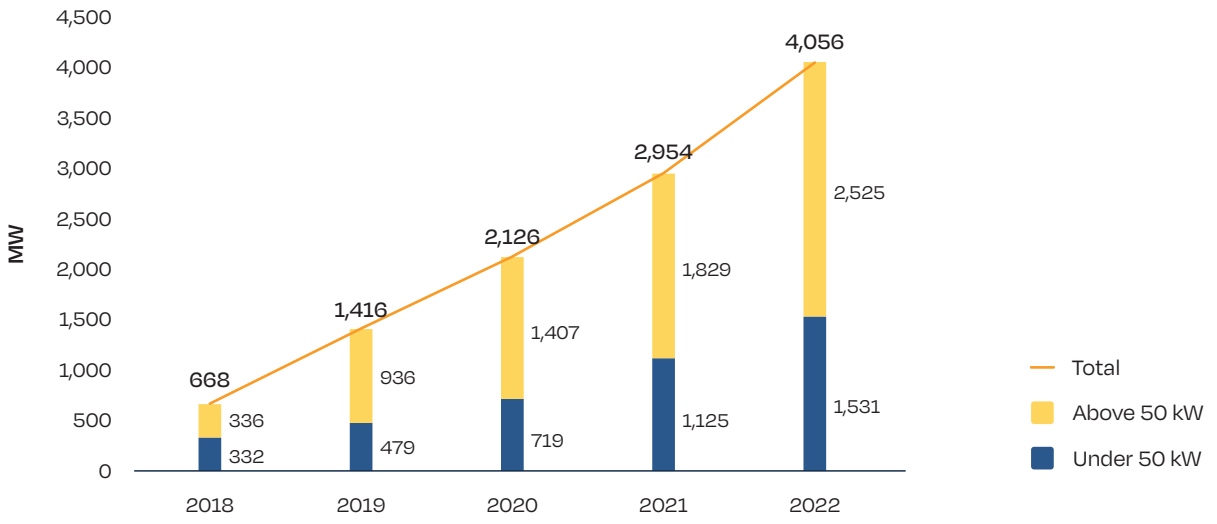
The segment below 50 kW has had a steadily growing rooftop market for years, reaching a record of 406 MW in 2021. In 2022, there was 1,531 MW of installed rooftop capacity. Hungary still has a net-metering scheme, in which produced electricity can be deducted from consumed electricity on a yearly basis. We believe this is the most favourable scheme in the EU.

Drivers for solar growth

Record 2021 installation numbers stemmed from the fear of ending net metering in that year. In 2022, two demand shocks led to similar installation levels.

Firstly, Hungary has a regulated electricity price which is artificially kept low, in spite of this, due to record-high energy prices, the price doubled for residential consumers in mid-2022. In addition, the regulated price was removed for SMEs. The impact of the regulated price changes generated a huge rush for small rooftop PV systems.

FIGURE GW23 HUNGARY CUMULATIVE SOLAR PV CAPACITY 2018-2022, BY MANAP



SOURCE: MANAP.

Secondly, in October 2022, the government announced a feed-in ban for new rooftop installations and left a 2-week deadline for applications for feed-in grid connections, which paralysed the grid operators work-flow with an overwhelming amount of requests. It also led to a huge demand for PV installers. As a result, 2023 is expected to be another strong year, although installers' salespeople are losing their jobs as order books are running out soon. Fortunately, the feed-in ban is set to be fully removed by the end of 2024, starting gradually in September 2023, which could help to provide some relief already in 2023.

Installations above 50 kW, mainly ground-mounted systems, jumped to 696 MW, setting a new record in Hungary. These systems now total 2,525 MW. The dynamics are interesting, as the largest part of these systems were still built under the old feed-in tariff system (KÁT) that ended in 2016. After KÁT, Hungary started a new auction-based Contract for Difference (CfD) support scheme, called METÁR, with 5 rounds totalling 933 MW of projects since 2019. However, by the end of 2022, only 60 MW were operating under the METÁR scheme. The main reason behind this was the record-high electricity market prices. Developers were reluctant to enter the METÁR scheme, and many also abandoned or temporarily stepped out of the old KÁT scheme to sell electricity on the Hungarian Electricity Exchange. PV power plants are also seeing good opportunities in longer-term Power Purchase Agreements (PPAs) with consumers. However, apart from a few milestone contracts, this has not yet become mainstream.

Unfortunately, small and medium commercial installations have been sidelined due to grid connection problems, despite high demand.

Challenges

Grid connection is the main challenge for PV development in Hungary. While the national target for 2030 is 6.5 GW, the operating capacity has already exceeded 4 GW, and the Hungarian grid has its limits. Since April 2021, it has not been possible to obtain a new grid connection for systems over 50 kW. The Hungarian TSO has stated that is because of connection rights already issued, and the growth of rooftop systems, for which already more than 5 GW have been reserved for the next 4 years. As the Hungarian grid load averages 6 GW and no balancing capacities were developed in the past 10 years, the grid will very soon be at its limits. A more regulated and transparent system for grid connection applications was set to begin in May 2022. Nevertheless, the original deadline of 31st July 2022 for responses by grid operators has been delayed four times; it is still not yet completed.

10 MW, Paks, Hungary.

However, as many grid capacities have already been allocated, the utility segment is expected to remain strong over the next two years, possibly surpassing 600 MW of new capacities each year. Beyond 2025, the situation is difficult to predict, and depends on grid connection possibilities. In a positive scenario, new capacities can remain above 500 MW, but in a negative scenario, they may drop back to a few hundred MW.

For rooftop systems, the 'feed-in ban', and the end of issuing new net-metering schemes by the end of 2023, may slow down progress. While 2023 is likely to be a good year for rooftop solar with 400 MW installed, everything depends on the new system entering into effect after net metering, commonly known in Hungary as "gross metering." It will definitely be less beneficial than the current scheme. Unfortunately, details about how it will operate are still unknown. In a positive scenario, new rooftop installations will not decline sharply, and they can remain at 250-300 MW levels, but in a negative scenario, they may drop back to 100-150 MW levels.

Author: *Ádám Szolnoki,* President, MANAP (Hungarian Photovoltaic Industry Association).

24. Pakistan

Overview of solar PV developments

Pakistan has made significant progress in the development of solar energy in recent years. According to the International Renewable Energy Agency (IRENA), the country's total installed solar capacity reached 1 GW by the end of 2021, up from 655 MW in 2017. Solar capacity in Pakistan has been steadily increasing over the years, and the government is now aiming to achieve even more ambitious targets. It is estimated that another GW of grid-connected solar was added in 2022, breaking all previous records and bringing the annual market to GW-scale for the first time. According to the governmental agency Alternative Energy Development Board (AEDB), an additional solar and wind capacity of 14 GW will be added in the next 10 years.

Solar has a huge potential in Pakistan, considering that roughly 25% of the country is still without grid access. With a young population of more than 230 million citizens, Pakistan is looking at solar energy as the key solution to its energy needs. The vibrant private sector can tap into this potential. Currently, installers are very active in deploying solar capacities for tube wells and villages without grid access.

139 kW, University of engineering & technology Lahore (KSK) campus, Pakistan. © PSA

Drivers for solar growth

On April 18th, 2023, AEDB CEO Shah Jahan Mirza emphasised Pakistan's immense renewable energy potential. "Pakistan has an ambitious goal of adding 14,000 MW of solar and wind energy to the grid in the next 10 years," he said. To achieve these targets, the government has launched several initiatives, including the setting up of the AEDB, and the National Energy Efficiency and Conservation Authority (NEECA).

The Pakistani government has also introduced net metering and other policy initiatives to encourage the adoption of solar energy by households and businesses. Moreover, promotion of the development of large-scale solar projects is key. One of these projects is the Quaid-e-Azam Solar Park in Bahawalpur, which is one of the largest solar parks in the world, with a capacity of 1 GW. The potential remains large in other applications as well, with almost 1 million tube wells and pumps just waiting to be 'solarised'.

Pakistan has experienced blackouts for several years, and solar energy is seen to improve energy security, and reduce dependence on fossil fuels. Solar addresses also the ongoing electrification trend, ensuring that the remaining 25% of the country gets access to regular grid power.

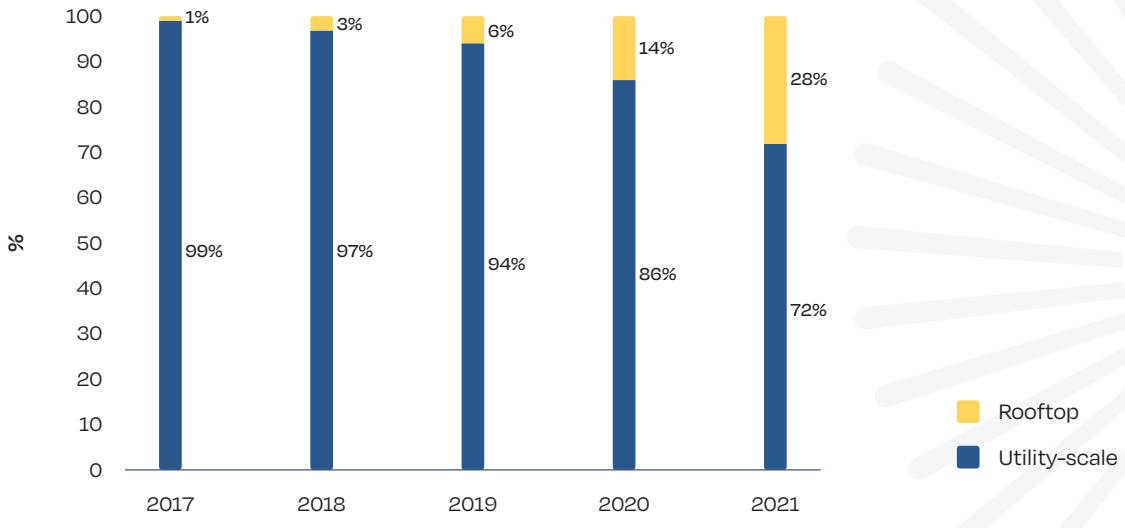
An important driver for renewable energy uptake in Pakistan stems from climate change concerns. With Pakistan being one of the most vulnerable countries to the impacts of climate change, there is a growing awareness of the need to reduce greenhouse gas emissions.

Utility scale vs. rooftop solar splits and their progress

According to IRENA and independent researchers, utility-scale installations are by far the largest segment within the installed solar capacity in Pakistan, with a 72% share in 2021 (Fig. 24). The dominance of utility-scale solar, however, has decreased compared to the past years, and is expected to be significantly further reduced in the future as consumers adopt solar to manage increasing prices of electricity on the grid.

In terms of geographical distribution, most of the utility-scale solar projects are in the provinces of Punjab and Sindh, while rooftop solar is more prevalent in the urban areas of Punjab and Khyber Pakhtunkhwa.

FIGURE GW24 PAKISTAN SOLAR PV ANNUAL SEGMENTATION 2017-2021, BY PSA



SOURCE: IRENA..

Conclusion

Pakistan has made significant progress in the adoption of solar energy in the past few years, with the country overshooting its previous installation targets. As a result, the government has set an ambitious target of installing 14 GW of solar and wind capacity in the next 10 years as of April 2023.

While there are still challenges to overcome, such as financing, land acquisition, and grid integration, the growth of solar energy in Pakistan is expected to continue in the coming years. The country has the potential to become an international leader in terms of solar energy adoption and in doing so, will reap the benefits of increased energy security, reduced emissions, and job creation.

Authors: *Faheem Ashraf, Waqas Moosa* and *Faisal Jamal*, Pakistan Solar Association (PSA).

25. Israel

Israel's PV market successfully crossed the 1 GW landmark of annual installations in 2022 (1.03 GW), allowing the country to reach its target of generating 10% of its electricity from renewable sources. Originally, the country aimed for this target for 2020. Altogether, Israel now has a total of 4,795 MW of installed renewable energy capacity. In 2021, the country updated its RES goals, to reach a 30% share of its electricity generated from renewable sources by 2030. The 2030 objective translates to about 12.5 GW of solar PV being added to the current 4.5 GW installed, alongside 10 GWh of storage.

As of 2023, solar PV is responsible for most of the RES generation in Israel, which has no hydroelectric power, limited waste-to-energy (40 MW), three wind farms (130 MW), and two concentrated solar power plants (250 MW). Furthermore, most of Israel's PV generation comes from dual-use installations, such as rooftops and water reservoirs, responsible for 60% of PV generation. The remaining 40% are ground-mounted PV plants, ranging from 3 MW to the largest Zeelim 145 MW solar park.

Historically, Israel has an impressive solar power heritage. With high solar irradiance (1,650-1,750 kWh/kWp), and with 1,900 sun hours per annum, solar water collectors cover much of Israel's rooftops (94% of households), and save some 4% on annual national electricity consumption. Israel was the first country to make solar power compulsory under bylaws in the early 1980s requiring all new multi-residential building to deploy solar water heaters. The Tabor selective surface, used in water solar collectors, was invented in Israel, and also enabled the first commercial concentrated solar power (CSP) system, by Israeli firm LUZ in California in the 1980s. The Brightsource tower technology also originated in Israel, by the same founders of LUZ, responsible for the world's 2nd largest CSP solar plant, the Ivanpah solar plant located in California.

Nevertheless, Israel has been very cautious when it comes to solar PV implementation, in allowing the market to develop quickly. The first PV scheme for rooftops below 50 kW was introduced by Israel's

electricity authority PUA in 2008, and was limited to a small cap of 50 MW, which later increased to 150 MW. While these caps targeted consumers, in 2010 a 300 MW cap enabled developers to benefit from a licensing scheme for installations of up to 5 MW. From 2011 to 2018, the PUA PV schemes were limited, ranging between 20-30 MW of annual caps for consumers, with the exception of a 180 MW CSP cap converted to utility-scale PV. These years reflect Israel's conservative approach towards solar PV and renewable energy at large, not to subsidise their electricity production. Despite its environmental benefits, and the negative effects of fossil generation, those elements that were never accounted for by PUA.

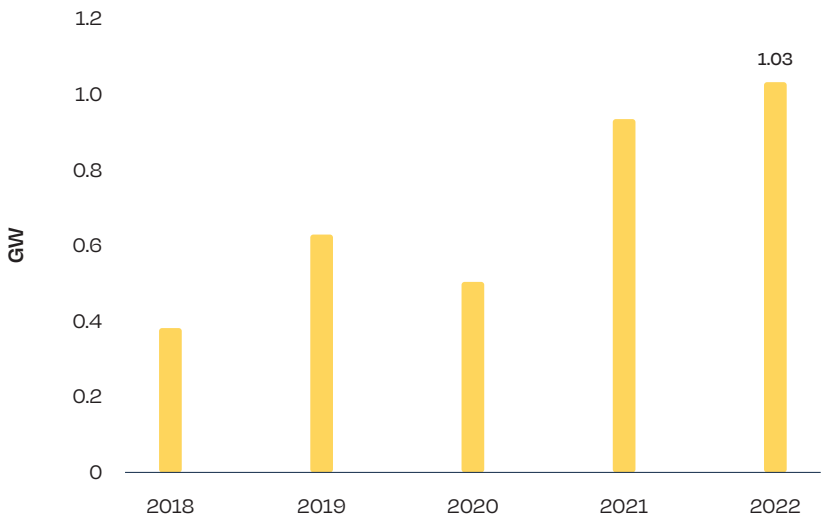
Israel was waiting for PV to become economically viable and, in 2016, the first net-metering scheme was introduced reflecting grid parity, and allowing 380 MW of solar rooftops to be installed. However, the successful scheme did not last long. The PUA, which was targeting a "free market" policy, cancelled the scheme, and launched a series of auctions for ground-mounted projects connected to the high voltage grid in 2019, aside auctions for dual-use PV systems (rooftops and water reservoirs), utility-scale ("minimal security" tariff), and PV plus storage (with 777 MW commissioned).

During this auctioning era, the government's land policy started to change. Pro-environment activist NGOs, with the support of the Ministry of Environmental Protection, managed to block many ground-mounted solar projects. As a result, in 2020, the National Zoning Committee restricted the implementation of ground-mounted projects. The current government is trying to change this decision (re-approved in 2021) but, being a small country, the use of land is expected to act as a central barrier to any future ground-mounted projects.

In terms of rooftop solar, a generous feed-in tariff (FIT) scheme was approved in 2018, and granted tariffs of 0.45 ILS/kWh (0.11 EUR/kWh) over 25 years for PV systems below 100 kW. The FIT was later enlarged to PV systems up to 200 kW. The scheme was very successful, and around 2.4 GW of applications were submitted, out of which 1.4 GW were installed. The aim was to reach the national 10% RES target by 2020, which was only achieved in 2022 as mentioned above.

The auctions and FIT scheme allowed Israel to jump from 5% RES in 2019, to 10% in 2022. However, the generous FIT scheme was replaced in 2021 by a "gradual tariff" scheme for installations up to 630 kW (low voltage limit), but with decreasing tariffs

FIGURE GW25 ISRAEL SOLAR PV MARKET 2018-2022, BY GEA-IL



SOURCE: GEA-IL.

depending on the size of the project. The Israeli solar industry has criticised this scheme for cutting down the generous tariffs of 2019.

In 2022, the PUA managed to perform its "free market" masterplan, which effectively started in January 2023, and will be open to renewable energy sources from January 2024. The masterplan introduces new electricity distributors, that can buy from RES producers and sell to allocated consumers under PPAs. The PUA is no longer setting a FIT, nor administering auctions for ground-mounted plants – the end result of a lengthy 20 year electricity market reform process, which was only made possible by reaching a historical compromise with the Israel Electric Corporation trade union. In 2018, the Israeli Parliament, the Knesset – which also owns a 450 kW solar rooftop – approved the electricity market reform, and paved the way for the liberalisation of the market with an independent TSO and other necessary market mechanisms.

In 2018, the outlook appeared positive for the Israeli solar industry. However, there is now a growing grid saturation, blocking new solar installations in several regions because of 20 years of government neglect. Until the new grid development masterplan receives ministerial approval, only residential installations up to 10 kW can get an automatic approval, which goes up to 15 kW in some cities.

On the bright side, this gigantic obstacle for solar integration is also the main driver for storage deployment. The grid development masterplan includes the 10 GWh target, reflected in the country's 2030 RES plan.

The grid saturation is also an obstacle for the commercial rooftop segment. In April 2023, a new FIT scheme was introduced targeting already installed rooftops that can now enlarge, add storage, and use the same grid connection to export stored electricity and receive an FIT. The success of this pioneering scheme is still unknown and will be tested in 2023.

The lack of land in Israel has also created a new market driver for Agri-PV, which is promoted by the government under a pilot scheme. Some 140 plots were chosen, and the first 8 MW Maale Giloba site is under construction. Israel's strength in innovation, IT, agriculture and solar technologies, is expected to play a major role in Agri-PV; this is a promising technology which could accelerate the domestic market. Moreover, financing in Israel is available through local banks and local institutional investors.

Author: *Eitan Parnass*, Director & Founder, Green Energy Association of Israel (GEA-IL).

450 kW on the Israeli Knesset, Jerusalem, Israel.

26. Switzerland

The first GW market based exclusively on rooftop projects

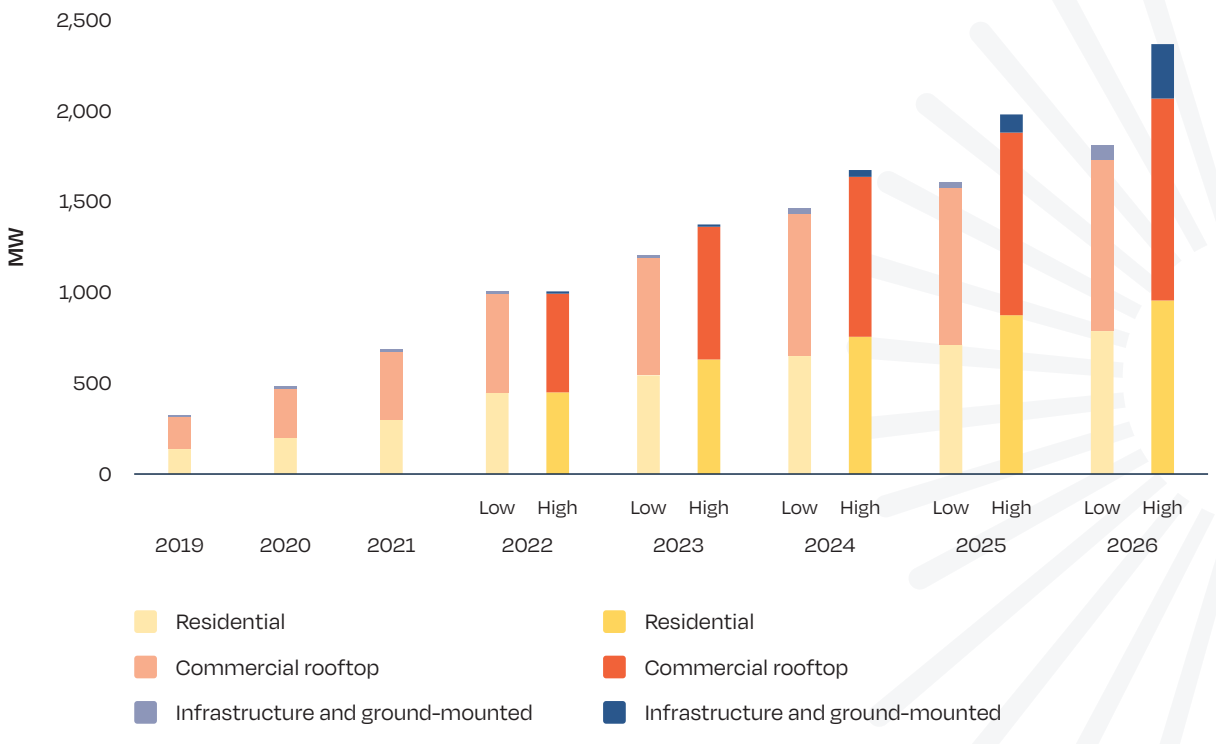
Switzerland's solar PV market is almost exclusively based on rooftop projects. These installations are standard, as ground-mounted systems outside building zones are usually not approved, and within building zones, land is too expensive. Consequently, the Swiss solar industry has specialised in installing solar on rooftops and building facades. Local research institutes and manufacturers have also contributed significantly to the development of building-integrated photovoltaic (BIPV) products.

The introduction of the cost-covering feed-in tariff in 2009 triggered the initial solar PV boom, but it came to a halt in 2014 due to the capping of available funds. In 2018, with the new Energy Act, a new support regime was introduced, replacing the feed-in tariff with a one-time remuneration covering a maximum of 30% of the investment costs. This led to annual market growth of over 40% from 2019, relatively evenly distributed across the different rooftop segments. In 2022, an additional 1 GW is likely to have been grid-connected for the first time in a single year, and an addition of at least 1.2 GW is expected for 2023. The total installed capacity at the end of 2022 was around 4.6 GW, which supplies approximately 7% of Switzerland's annual electricity demand. There was around 180,000 installations in total; the largest so far has been a warehouse rooftop with 8.3 MW capacity.

Targets

The current Energy Act sets a production target of 11.4 TWh of electricity from renewable energies (excluding hydropower) by 2035. However, the parliament is currently discussing a significant increase in this target to 35 TWh, without naming targets for individual technologies. For solar PV, this would correspond to an indicative level of about 30 TWh by 2035, around seven times more than today. This will come into force in 2025,

FIGURE GW26 ANNUAL SOLAR PV INSTALLATION AND SCENARIOS IN SWITZERLAND, 2019-2026, BY SWISSOLAR



SOURCE: Swissolar.

provided that the amendment to the law is accepted in the expected referendum that is still to be scheduled.

Drivers for solar growth

Energy costs and streamlined financing are a key driver for solar growth. As across Europe, in Switzerland, high electricity prices and the fear of supply shortages were additional market drivers in 2022. While the one-time remuneration introduced in 2018 has proved successful, it is paid without lengthy administrative procedures, and after a short period. This has generated a high level of trust in this funding instrument. Moreover, the investment can be deducted from taxes.

More widely, significant steps in electrification in heating and transport has also sparked solar demand. The rapid conversion of many fossil-fuel heating systems to heat pumps, triggered by cantonal regulations regarding heating system replacement, has increased self-consumption. The same applies to electric mobility and electric vehicles, which are experiencing a rapid uptake.

Interestingly in Switzerland, we are also seeing how frameworks for energy sharing can boost solar uptake. For multi-family houses and commercial buildings, the "self-consumption associations" (ZEV) are important. Introduced in 2018, this instrument allows the sale of solar electricity within buildings, and to other buildings as long as the public distribution grid is not used. This can significantly increase self-consumption. As part of the aforementioned revision of the Energy Act, the introduction of "local electricity associations" is planned, which are also allowed to use the distribution grid at a reduced tariff.

Market segmentation

Slightly over half of the installed capacity are PV systems on industrial, commercial, office and public buildings; and agricultural roofs. Around 45% of solar PV systems are installed on residential buildings, with three-quarters of them being single-family homes. Installations on infrastructures such as car parks and road roofs, noise barriers, or dam walls have been marginally represented so far. Although the percentage of solar facade systems is still small, it is also growing.

Challenges

The Swiss solar industry faces a major challenge in finding skilled workers. On the initiative of Swissolar, a government-endorsed vocational apprenticeship will be offered from summer 2024. In addition, further training courses are offered for specialist trainees.

Heuwinkel housing estate, Allschwil, Switzerland.

Another major obstacle is the widely varying purchase tariffs for solar electricity fed into the grid, which differs considerably among the approximately 640 distribution grid operators. The revised Energy Act aims to introduce a market-based, uniform remuneration, with a guaranteed lower limit. Many energy suppliers are also limiting solar expansion because their line capacities are insufficient. The demand for a limit on maximum feed-in is under discussion.

Outlook

Starting in 2023, several new support mechanisms have come into effect. A new regulation (Art. 71a of the Energy Act) allows for simplified approval, and up to 60% subsidies for Alpine ground-mounted systems producing more than 500 kWh/kW during the Winter, and an annual production of at least 10 GWh. This law was introduced due to concerns about Winter power supplies following the decommissioning of nuclear power plants, which cannot be replaced with new ones. However, it is uncertain how many Alpine solar projects can be realised due to insufficient connection line capacities. Increased subsidies are also being paid for systems without self-consumption through auctions for systems larger than 150 kW. The construction of agri-PV systems has been permitted, but these systems must lead to additional yields for agricultural crops, which limits their scope of application. There is also a Winter bonus for all PV systems that have a minimum 75 degrees tilt angle, creating an additional incentive for facade systems. All of these measures are expected to lead to significant market growth.

Author: *David Stickelberger*, Head Market and Politics, Swissolar.

2.2 MW alpine solar plant at Muttsee, Switzerland.

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50 MW Margariti solar farm, Greece.

Photos Kanesoulis

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