SolarPower Europe

Global Market Outlook

For Solar Power

2021 - 2025

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Foreword

Welcome to the Global Market Outlook for Solar Power 2021-2025.

Nobody could have predicted a year ago that solar would manage so smoothly through a devastating global pandemic, and yet, despite the fact that COVID-19 has persisted longer than expected, global demand for solar did not shrink at all. Instead, surprising us yet again, solar reached a new annual record of 18% growth, with 138 GW installed in 2020.

The success of solar is due to many factors. A primary one is its cost leadership, which continues to improve without an end in sight. Another is its versatility: solar covers an unmatched spectrum of power applications from very small residential systems to very large utility-scale plants, individual installations to building-integrated solutions in carports, apartment houses or agricultural green houses. There are also mobile applications and off-grid systems for rural electrification. Finally, no other power plant can be planned and built as rapidly as solar PV, while at the same time involving the highest job intensity.

This solar market outlook sees much stronger growth for each of the coming years than anticipated in our previous edition. While the deployment volume is somewhat limited due to COVID-19 and the silicon raw material shortage in 2021, increasing vaccination rates in major solar markets and new silicon factories coming online will result in additions of over 200 GW per year as of 2022, two years earlier than forecasted in last year's GMO. The total solar power generation fleet will boost capacities from about three quarters of a terawatt in 2020, to over 1 TW in 2022, and nearly 1.9 TW in 2025, in our most realistic scenario. There is good reason why the International Energy Agency (IEA), in its World Energy Outlook 2020 highlights that solar is the new king of electricity markets.

While China was the main growth driver in 2020, boosting its solar grid-connections by 60% to 48 GW, bringing online about 2.5 times the capacity of the second largest market, the United States; we now have more markets that installed 1 GW per year than ever before. In 2018, only 11 countries were in the GW-club, which grew to 18 in 2020, and will reach 29 by 2023.

One of the biggest solar surprises in the last two years was Vietnam, the world's third largest solar market in 2020. Two attractive incentive schemes had the country first develop in just one year a vibrant GW-level utility scale market, followed in 2020 by the creation of a gigantic solar rooftop market, kick-starting the segment from basically nil to over 9 GW, with 6.9 GW connected to the grid in December alone. This example shows how fast the solar industry can execute under the right framework conditions.

Except for COVID-19 impacted 2020, we have seen in the past and expect in the future double-digit growth also in the off-grid solar market, a field we are covering for the first time in our Global Market Outlook. With the support of GET.invest we started a research project to address the vast market of close to 10% of the global population without access to electricity.

However, it would be a big mistake to sit back and enjoy the coming years of solar growth. A recent industry poll on COVID-19 by the Global Solar Council shows that the majority of respondents were not overly happy with the emergency stimulus offered to the solar sector during the crisis as well as the post-crisis recovery funds, even though satisfaction rates increased. Indeed, our pre-pandemic released GMO 2019 forecasted somewhat higher installation levels in 2020 than we actually saw happening. The pandemic did slow down solar growth at a time when every additional solar watt counts.

While it is certainly a cause for celebration that solar keeps surprising us with larger installation numbers, considering the fact that around 70% of global power still comes from non-renewable polluting energy and global carbon dioxide emissions are set this year for their second biggest increase in history, solar power needs more support from policymakers. Only much higher ambition and appropriate policy frameworks will enable the industry to accelerate deployment in order to tap the full potential of solar - and meet the Paris Agreement target.

We want to express sincere gratitude to all contributors and supporters of this globally-produced solar market outlook that would not have been possible without all the different helping hands.

Enjoy reading our Global Market Outlook.

WALBURGA HEMETSBERGER
CEO, SolarPower Europe

MICHAEL SCHMELA
Executive Advisor, SolarPower Europe

GIANNI CHIANETTA
CEO, Global Solar Council

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Table of contents

Project manager & lead author: Michael Schmela, SolarPower Europe.

Market intelligence: Christophe Lits, Raffaele Rossi & Michael Schmela, SolarPower Europe.

Internal co-authors: Benjamin Clark, Máté Heisz, Christophe Lits & Raffaele Rossi, SolarPower Europe.

External co-authors: : Abigail Ross Hopper, Solar Energy Industries Association (SEIA); GIZ Energy Support Program; Japan Photovoltaic Energy Association (JPEA); Steve Blume, Smart Energy Council (SEC); Tusshar Sharma & Subrahmanyam Pulipaka, National Solar Energy Federation of India (NSEFI); Rodrigo Lopes Sauaia & Ricardo Lacerda Baitelo, Brazilian Photovoltaic Solar Energy Association (ABSOLAR); Peter Molengraaf & Amelie Veenstra, Holland Solar; José Donoso & Alejandro Labanda, Unión Española Fotovoltaica (UNEF); Paulina Wojciechowska, Polskie Stowarzyszenie Fotowoltaiki (PSF); Jaime Pérez de Laborda, Mexican Association of Solar Energy (Asolmex); Artem Semenyshyn, Solar Energy Association of Ukraine (ASEU); Niveshen Govender, South African Photovoltaic Industry Association (SAPVIA); Cécile Heneffe, Fédération des énergies renouvelables (EDORA); Wannes Demarcke, & Ellen Van Mello, Organisatie Duurzame Energie (ODE); Marie Buchet, Syndicat des Energies Renouvelables (SER); Francesco Luise & James Osborne, Global Solar Council (GSC).

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Contact: info@solarpowereurope.org.

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; a separate overview of off-grid solar is provided in Chapter 2. 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.

Executive summary

Despite the severe impact of the COVID-19 pandemic across the world in 2020, the year still saw 138.2 GW of solar installed, representing an 18% growth compared to 2019, yet another global annual installation record for the solar PV sector. This brings the global cumulative solar capacity to 773.2 GW, a 22% increase, and marks a new milestone for the solar sector by exceeding three quarters of a terawatt.

This surprisingly strong growth helped solar maintain its dominance among all newly installed power generating technologies, reaching a 39% global share, which translates into the impressive fact that more than every third power plant unit installed in 2020 came from solar. At the same time, solar's total power generation share increased by 0.5 percentage points to around 3.1%, with nearly 70% still coming from fossil fuel and nuclear, highlighting the need to rapidly accelerate solar deployments.

The good news is that solar's cost competitiveness progressed further in 2020, resulting in an even wider spread to conventional generation technologies as the cost of gas, coal, and nuclear increased. Solar's cost improved across the board for all segments with utility-scale solar now superior to fossil fuels in all unsubsidised investment cases, which also applies to solar + storage used to meet peak demand compared to gas peakers, according to investment bank Lazard.

The strength of solar could be observed in many tenders in 2020, where several winning bids in different geographical regions outperformed the record low of the previous year. At 1.32 USD cents, the 2020 global record bid in the second Portuguese auction was approximately 20% lower compared to the 2019 record, which was also achieved in Portugal.

The strong performance of China, growing by 60% to 48.2 GW, easily overcompensated for India's losses in 2020, pushing up demand for solar in the Asia-Pacific region to a global share of 62%. While an exceptionally good year for solar in the United States carried the Americas to a higher share of 19%, Europe's slower growth rate than the global average meant a market share reduction to 17%. Despite China's market growth, the number of volume markets entering the GW-level has only marginally increased to 18 in 2020, up from 17 the year before.

In the first half of 2021, the solar sector was characterised by increasing costs for wafer, cell, and module manufacturers, primarily due to rising silicon prices because of a supply shortage. COVID-19 affected several major solar markets, in particular India. However, a Global Solar Council poll on the impacts of the pandemic on the solar sector showed an improving industry outlook, with 81% of respondents expecting sales to grow in 2021 compared to 72% in 2020 (see Chapter 'COVID-19 impacts on solar'). Despite the various price increases along the solar value chain and the continued negative impact of COVID-19 and its variants, solar will see another stellar growth year in 2021. Our Medium Scenario anticipates newly installed capacities to increase by 18% to 163.2 GW.

As vaccination rates reach necessary levels across the major solar markets, and with the silicon supply issue solved, the next four years are expected to be very strong for solar power around the world. For each year up to 2025, we have considerably increased our forecasts, but 2022 will stand out. In our Medium Scenario, we see the global solar market increase by 25% to 203 GW in 2022, the first time that annual PV installations will cross the 200 GW level, which we had previously expected to be accomplished only in 2024. With continued growth to annual additions of 266 GW in 2025, the operating global solar power generation portfolio will reach close to 1.9 TW, and in the most optimistic scenario even exceed the 2 TW level in four years' time.

The Global Market Outlook traditionally has focused on grid-connected solar. In order to offer a view on the much smaller but, for hundreds of millions of people around the world, existentially-important off-grid sector, we have extended our research this year to show that solar off-grid applications across all segments – small scale, C&I, and mini-grids – are a thriving GW-scale market with two-digit growth rates for the coming years.

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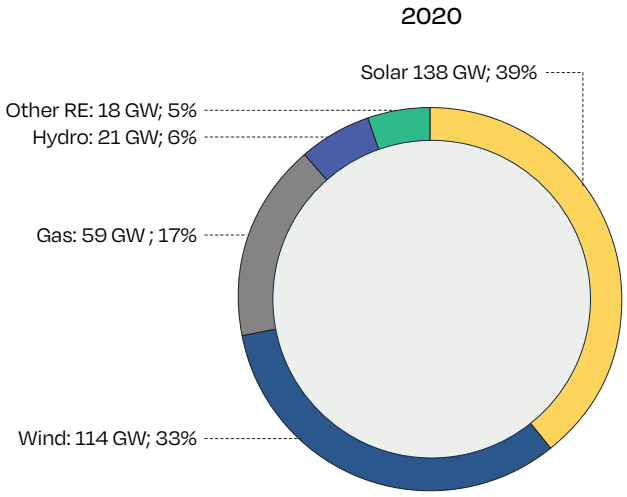
1 Global solar market

160 MW, Atacama desert, Chile. © Soltec

In 2020, a year the world suffered from a severe health and economic crisis, solar was again the power generating technology with the highest net installed capacity, with a 39% share of all new installations for the year (see Fig. 1). This is more than twice as much as all new fossil fuel capacity combined. Like nuclear, coal does not even appear on the chart anymore, as its decommissioned capacity outweighs new installations.

Despite its considerable growth rate in 2020, solar's dominance decreased compared to the year before, when it took 48% of all new energy capacity. But this is mostly due to an exceptional year for the wind energy sector, which grid-connected a hitherto unseen record level of 114 GW, based on a volume from China where the end of its FIT subsidy programme for onshore wind triggered a rush much larger than expected. When summing up all new renewable power generation capacity shares, we see a steady upward trend in recent years. In 2020, 83% of new installed capacity belonged to renewable technologies, up from 59% in 2016.

FIGURE 1 NET POWER GENERATING CAPACITY ADDED IN 2020 BY MAIN TECHNOLOGY

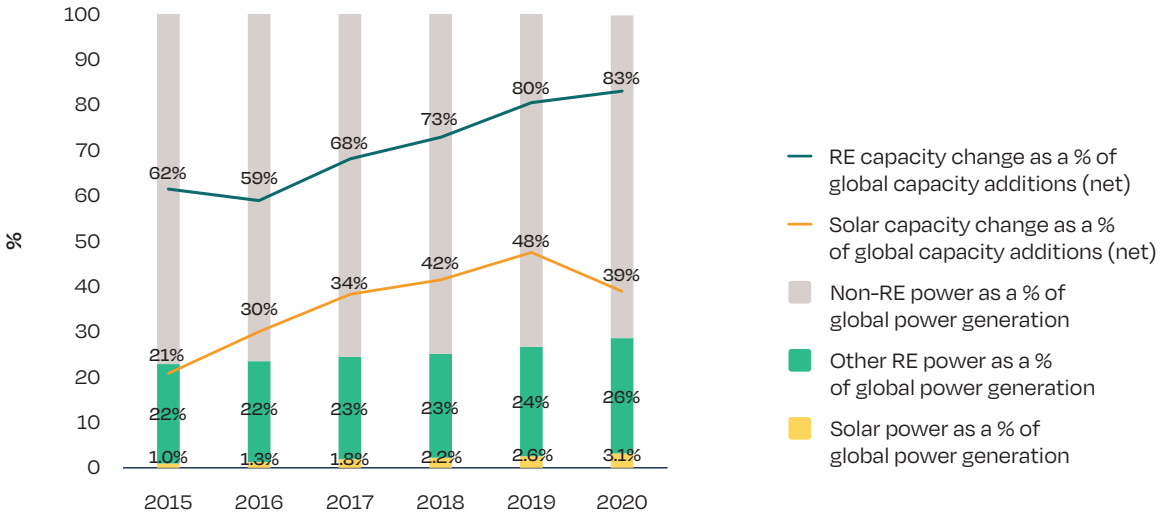


SOURCE: IEA (2021).

1 Global solar market / continued

While solar's leadership in annual global installations for the last few years is indeed a very positive development, this needs to be taken into perspective. Solar was able to increase its share among operating power generation plants by 1.5 percentage points last year, but the total capacity amounted to only 10% by the end of 2020. In terms of actual output, solar improved by 0.5 percentage points year-on-year, but cumulatively it barely generated 3.1% of last year's global power production (see Fig. 2). This is also valid for renewables as a whole, which improved by 2.3 percentage points to 39% of total generation capacities, and by 0.9 percentage points to 29% of the world's total power generation. The good news when taking a much bigger and longer perspective is that solar's share of the market is continuously increasing. And with no end for improvements in cost competitiveness in sight, the potential for solar power is only growing.

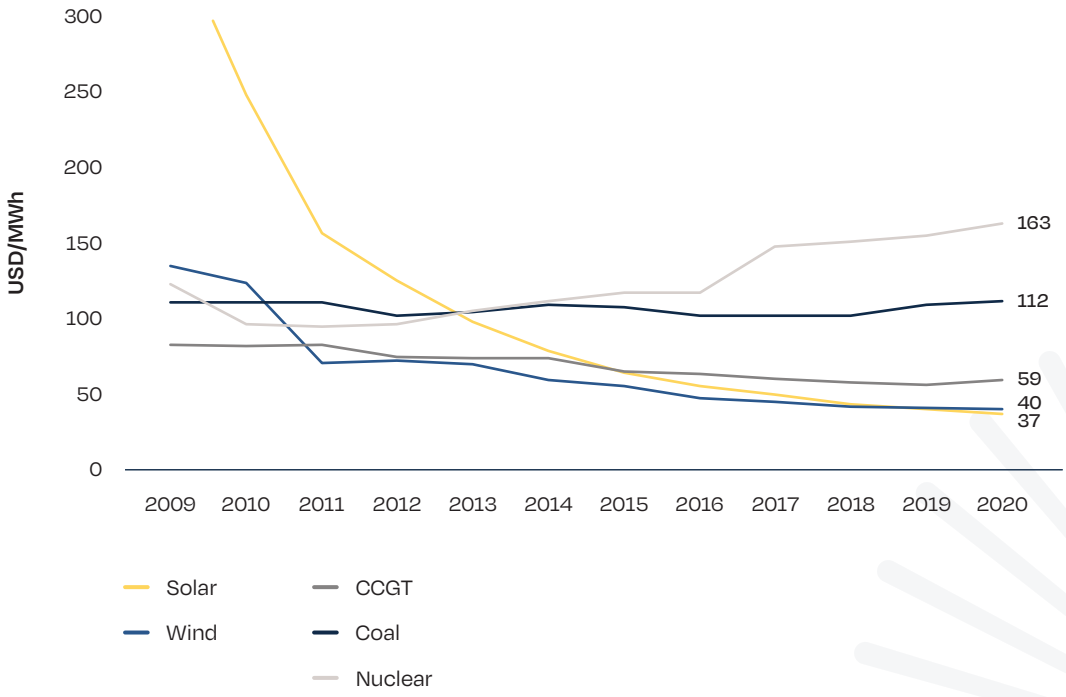
FIGURE 2 SOLAR AND RENEWABLE POWER AS A SHARE OF GLOBAL POWER 2015-2020



SOURCE: IRENA (2021); IEA (2021); SPE estimates. RE capacity includes large hydro.

There is a variety of reasons to explain solar's global success story over other power generation technologies, but a crucial factor has been its rapid cost reduction over the last decade, thanks to which solar has clearly become the cost leader around the world (see Fig. 3). While the cost of solar has been lower than fossil fuel and nuclear generation for several years, it is also now lower than wind in many regions around the world. The latest Levelised Cost of Energy (LCOE) analysis, version 14.0, published in October 2020 by US investment bank Lazard, illustrates how the downward trip of utility-scale solar cost has progressed by a further 8% compared to the previous year. The spread with conventional generation technologies is widening, considering that the cost of gas, coal and nuclear all went up.

FIGURE 3 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH OTHER POWER SOURCES 2009-2020



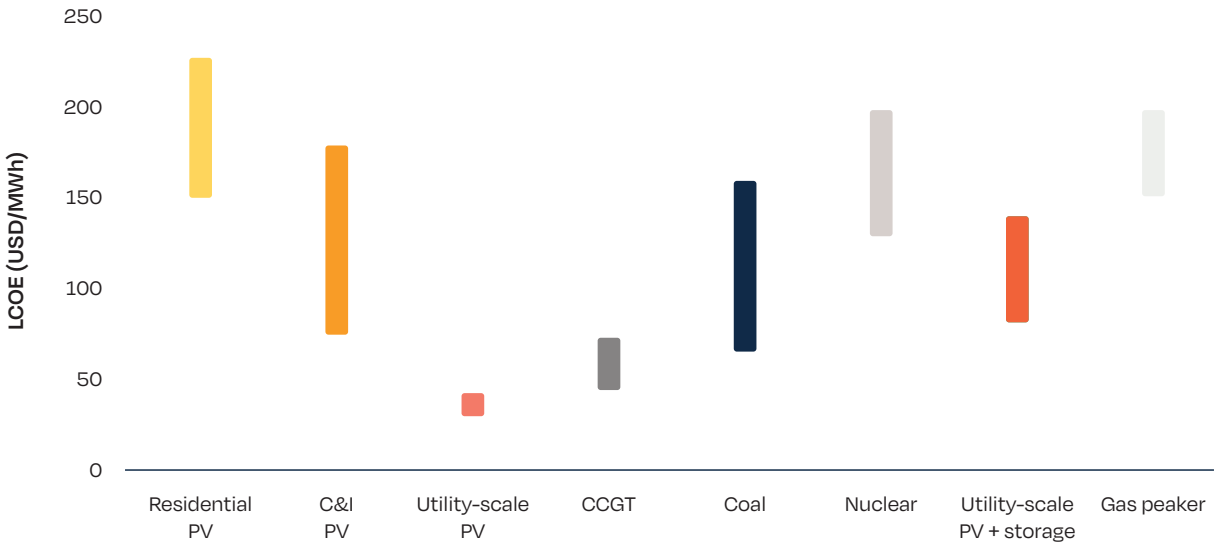
SOURCE: Lazard (2020). Historical mean unsubsidised LCOE values (nominal terms, post-tax).

A look at the different solar segments compared to new conventional power generation sources shows that utility-scale solar today is cheaper than fossil fuel and nuclear power sources in any unsubsidised case (see Fig. 4). Moreover, the cost-competitiveness of solar + storage versus gas turbines used to meet peak demand has improved further, with the lower end of the LCOE range decreasing by 21% year on year. With this as the background, many countries around the world – including Portugal, Germany, India and the United States – have launched hybrid renewable auctions, whereby the co-location of various renewable sources plus battery storage provide a flexible solution to their energy needs.

Tenders

The power tender results bear witness to the ever-growing competitiveness of solar energy. Throughout 2020, again, record-breaking bids were announced across the world, with awarded solar energy prices hitting new lows (see Fig. 5). If 2019 was the year which saw bids below the 2 USD cents level happen multiple times and in different continents, 2020 saw the downward trend continue, with two awarded bids even below 1.5 USD. Interestingly, these two tenders occurred in the same countries that had secured the best bid performance in 2019 – Portugal and the UAE.

FIGURE 4 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH CONVENTIONAL POWER SOURCES 2020



SOURCE: Lazard (2020). Nominal terms, post-tax.

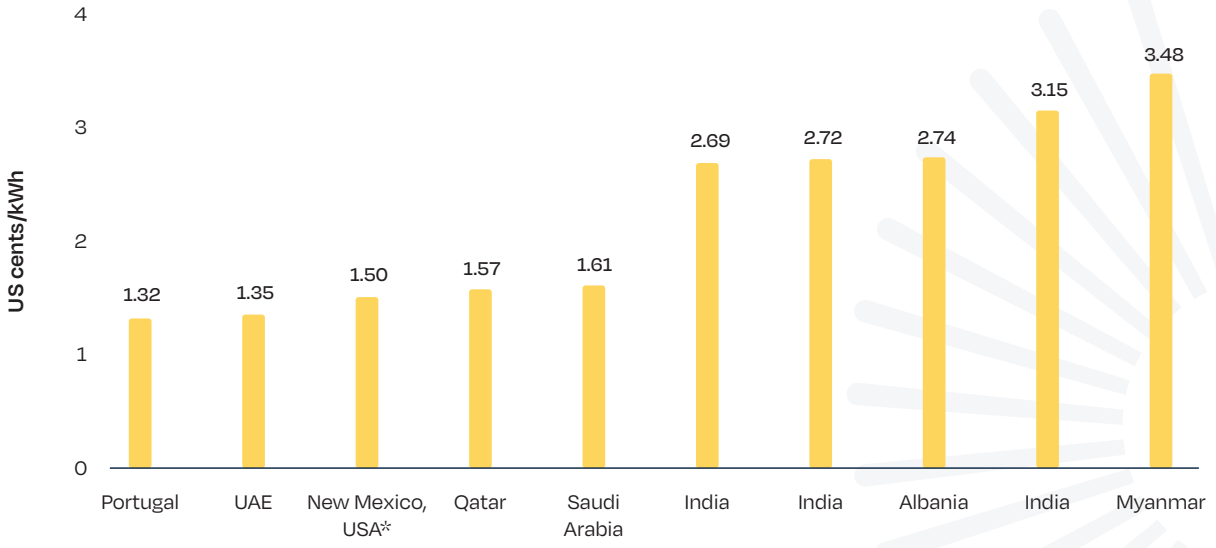
Portugal's 2nd solar energy auction brought the lowest price in 2020, at 1.32 USD cents/kWh. This is more than 0.3 cents lower than last year's record-setting winning bid of 1.65 USD cents/kWh. Such a low price can be partially explained by the tender design. First, only a part of the electricity generated by the projects will be sold through the power purchase agreement, with the rest being offered to the merchant market. Second, and crucially, developers were awarded grid connection permissions in a country characterised by high grid congestion, and that too for an indefinite period of time. Securing access to land in Portugal proved to be a driver strong enough to bring down prices so dramatically.

The other exceptional low was in April of 2020, when Abu Dhabi's 1.5 GW solar tender drew the record low bid at the time, at 1.35 USD cent/kWh, which is 0.25 cents lower than the country's Dubai record bid in 2019.

Three other tenders awarded in 2020 almost reached the 1.5 USD mark. A 100 MW solar PPA project signed in New Mexico reached 1.5 USD cents/kWh – although it benefits from the US Investment Tax Credit scheme. Other remarkable results were achieved in Qatar's 800 MW auction (1.57 USD cents/kWh, another world record at the time), and Saudi Arabia (300 MW, 1.61 USD cents).

It is no surprise that countries blessed with high solar irradiance and supported by a stable policy framework can achieve very competitive prices. However, while policy stability and high credit ratings certainly favour low solar prices, there has been an increasing number of examples in recent years showing impressively low PPAs in developing countries as well. Thanks to the support of international lenders, above all international development banks, solar projects can mitigate their financial risks. For example, Albania's 140 MW tender in 2020, assisted by the European Bank for Reconstruction and Development, saw a winning bid of 2.74 USD cents/kWh.

FIGURE 5 SELECTION OF LOWEST SOLAR AUCTION BIDS AROUND THE WORLD IN 2020



*PPA with Investment Tax Credit.

1 Global solar market - Update 2000 - 2020

UPDATE 2000 - 2020

In 2020, a total of 138.2 GW solar was installed across the world, representing an 18% growth over the 117.6 GW added the year before (see Fig. 6). In a year characterised by a global pandemic, solar demand showed strong resilience, and much stronger than anticipated in our previous GMO, published in June 2020. At the time, we were the most optimistic among the market analysts, forecasting the global solar sector to add 112 GW in our Medium Scenario, which would have meant a 4% year-on-year market decline. The actual number of 138.2 GW, however, was very close to the top end of our High Scenario, which we had forecasted at 138.8 GW with the following reasoning: "It sounds extremely optimistic and is also improbable; but the development of solar has been full of surprises in the past. Again, the biggest wildcard is China, which has a big lever to move the solar balance in any direction." Indeed, the world's largest solar market surprised with strong growth in 2020, adding 18 GW more than the previous year. Positive solar market dynamics could be observed in many other countries and most global regions as well, the US and Europe in particular, which were hit exceptionally hard by COVID-19 in 2020.

TOP 10 Global Solar Markets

The top 10 solar markets in 2020 remained mostly the same as in 2019, except for one new addition, but many positions changed due to unexpected growth dynamics (see Fig. 7). **China** remained the market leader in 2020, adding over twice as much solar power capacity than the second-largest market, and as much as the following 5 major markets combined. After 2 years of market decline, the Chinese market excelled with additions of 48.2 GW in 2020, a 60% growth rate over the 30.1 GW installed in 2019. The 2020 results are the second best ever for China, just falling short of its all-time record of 52.8 GW in 2017. Affected by the COVID-19 pandemic in H1/2020, and still working on its transformation to turn the former incentive scheme based on uncapped and attractive feed-in tariffs into a framework based on auctions and subsidy free systems, Chinese solar installation activities took place

FIGURE 6 ANNUAL SOLAR PV INSTALLED CAPACITY 2000-2020

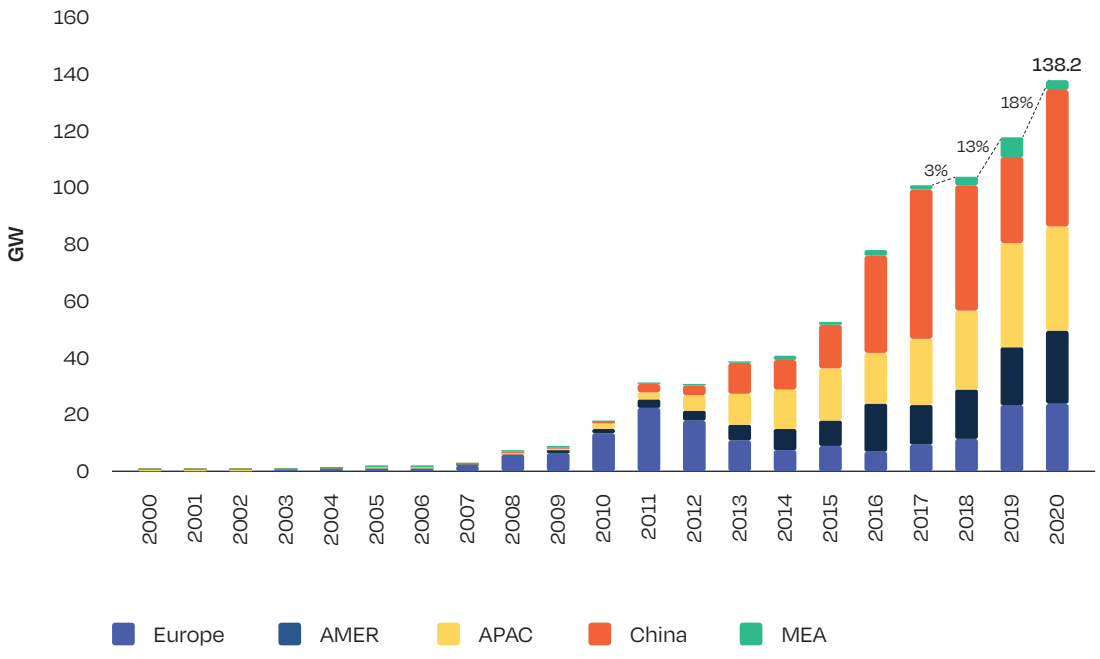
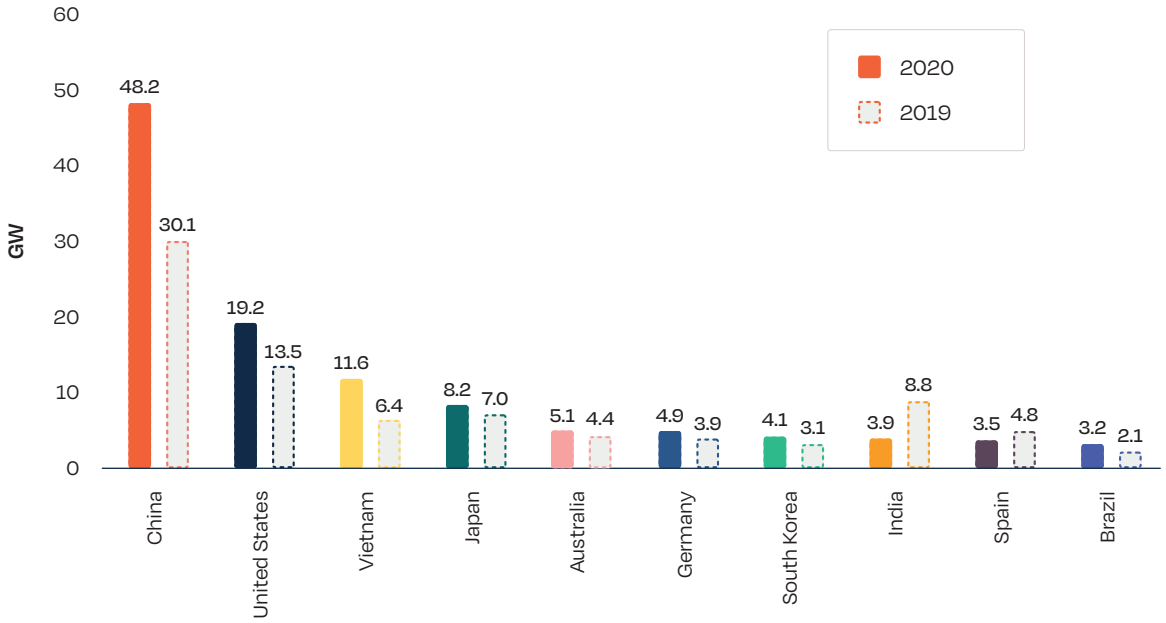


FIGURE 7 TOP 10 SOLAR PV MARKETS, 2019-2020



mostly in the latter part of the year. Of the 2020 total, 29.5 GW were grid-connected in the fourth quarter, with 23.3 GW going online only in December. The reason: hard deadlines set in the subsidy programs meant that a large volume of projects had to be installed by year-end to avoid penalties for delays. As the sanction levels were significant, developers tried to beat the deadlines despite the price increases for solar glass and other solar module components. China's solar growth continued to rely mainly on utility-scale projects, but material subsidies offered for residential systems led to around 10 GW of grid-connected PV installations on homes.

The **United States** geared up its solar ambitions in 2020, doubling its growth rate to 43% over the previous year, resulting in 19.2 GW of new installed capacities. But even if it had not grown at all, the 13.5 GW added in 2019 would have been sufficient to keep its second rank. The main growth driver was again the decreasing federal solar investment tax credit (ITC), which had dropped from 30% in 2019 to 26% in 2020, and was scheduled to drop further to 22% in 2021. An extension of the ITC passed end of December had no impact on 2020 installations; the fourth quarter, adding 8 GW, was the best solar quarter ever in the US. Traditionally, utility-scale solar has been the largest PV segment in the US, and last year it was even more dominant, accounting for almost the entire growth of its solar sector. While utility-scale was responsible for 81% of the newly installed capacity, residential grew by 'only' 11%, down from 18% in 2019, and contributions from the C&I segment even dropped by 4 %. The worse performance of the rooftop segment was mainly due to COVID-19. However, on the positive side were again the solar developments in the corporate sourcing segment. Close to 11.9 GW of the 23.7 GW of renewable PPAs signed in 2020 we inked in the US, according to BloombergNEF.

The name for the world's third largest market belongs to the bucket of biggest surprises in the solar sector in 2020. **Vietnam** installed 11.6 GW, nearly doubling from 6.4 GW in 2019 , which was already a huge surprise that placed it fifth on the list of the world's largest solar power markets. The Asian country did not even figure on the global on-grid solar map before 2019, with only a measly 97 MW installed in 2018. While the 2019 momentum stemmed from a very

attractive and uncapped first feed-in tariff scheme, offering 20-year FiT contracts for 9.35 US cents/kWh that triggered a big run against a program end in mid-2019, the 2020 boom was built on the rooftop solar segment. The second feed-in tariff programme was eligible for ground-mount solar, floating PV, rooftop systems – with the latter offered FiT levels that were slightly higher than the average retail electricity prices. Valid from May until the end of 2020, this attractive offer triggered a rush of installations, kick-starting the rooftop market from basically nil to over 9 GW, with 6.9 GW connected to the grid in December alone.

Japan maintained its fourth rank, after adding 8.2 GW in 2020, up 17% from the 7 GW connected in 2019. This is the second year that Japan's newly installed solar capacity increased, albeit only slightly. Following its installation record of 10.8 GW in 2015, Japan saw demand decline for three consecutive years. Again, the uptick came partly from time pressure on approved large-scale FiT projects that needed to be installed by the end of the fiscal year in March 2020. As the feed-in tariff era has come to an end (about 1.8 GW new FiT projects were approved in 2020), some of the new incentive tools are slowly getting traction. Auctions in 2020 continued to be undersubscribed but success rates finally went up – nearly half of the 750 MW offered in the 6th auction was awarded in December. There is a growing interest from corporates in renewable PPAs, and self-consumption systems are also starting to see demand with solar power reaching competitive levels with variable electricity prices in the C&I segment.

Australia's 2020 solar market performance trend line surprisingly showed another up tick in 2020. A 15% annual gain of 0.7 GW led to a total of 5.1 GW of newly deployed capacities – a new installation record for the

country with the largest solar power installed per capita. It also meant a better ranking among global solar markets, finding itself within the top 5 from being placed 7th in 2019. Difficult business conditions, partly caused by COVID-19, hampered work in the industrial and utility-scale segments, but very strong interest in residential rooftop systems more than compensated for the decline of the large-scale solar business. Homeowners opting for solar still profited from the national Renewable Energy Target (RET) programme's Small-scale Renewable Energy Scheme, but the drivers have already started to change – with consumers increasingly striving for high self-consumption rates. While the RET Large scale Generation Certificates Scheme (LGC) ended in 2020, utility-scale solar suffered from regulatory uncertainty and grid connection issues. However, in the absence of a missing renewable vision from the federal government, Australia's states have been increasingly taken over, introducing several support policies to speed up the country's energy transition, such as New South Wales, which published an Electricity Infrastructure Roadmap for 12 GW of new transmission capacity with the goal to trigger up to 32 billion AUD (23.4 billion USD) in private investments.

Germany performed a big jump in the solar market rankings in 2020, now placed at #6, up from #9 in 2019. All it needed was the installation of just above 1 GW over its previous annual addition. Europe's largest solar market grid connected 4.9 GW in 2020, up from 3.9 GW in 2019. Backed by a profound feed-in premium scheme and regular tenders for systems larger than 750 kW, rooftop installations remained the backbone of Germany's solar industry. Despite COVID-19, residential rooftop installations doubled their share to over a quarter in 2020 as the government kept DIY stores open and craftsmen at work. Economically very appealing in an environment of very high residential electricity retail prices, self-consumption solar systems have been increasingly attracting homeowners, who combine their solar investment now mostly directly with a battery storage system. A decrease in the feed-in premium scheme for C&I rooftop systems implemented in January 2021 had this main pillar of Germany's solar sector grow only little to 2.9 GW last year. On the other hand, an increase in the tender volume in 2019 led to more ground-mount capacity, which was also backed by PPA systems, including Germany's largest solar park, a 187 MW subsidy-free PV power plant that went partly online in 2020.

South Korea's solar market grew by 31% to 4.1 GW, breaking the 4 GW annual installation level barrier for the first time. The main driver continues to be the Korean Renewable Portfolio Standards scheme, which was launched to replace the feed-in tariff and requires utility companies with generation capacities exceeding 500 MW to supply between 6% and 10% of their electricity from new and renewable power sources by 2023. Over 90% of the PV installations in the country have been under this programme. Given the limitations to utility-scale presented by the country's mountainous terrain, South Korea focusses on the distributed solar segment, but has also been looking at alternative solutions. In 2019, it announced to build a 2.1 GW floating solar plant, which would be the world's largest.

If there was one country that was a major disappointment among the world leading solar markets, it was **India**. The sub-continent installed a mere 3.9 GW in 2020, down 56% from 8.8 GW in 2019, and even 7.6 GW less than in its record year 2017 after which demand constantly declined. While COVID-19 was the major market constraining factor last year, there continues to be the nagging issue of electricity distribution companies' (Discoms) unwillingness to sign power sale agreements. In several states, tenders were cancelled or winning PPA renegotiated. Another big challenge remains the rooftop market, which should contribute 40 GW to India's 100 GW solar goal by end of 2022. But in 2020, this segment even declined to only around 20% of the newly installed capacities, adding to a total of less than 1 GW of rooftop solar deployed.

Spain dropped 3 places to rank 9 with an estimated newly installed capacity of around 3.5 GW, down 26% from around 4.8 GW last year. Nearly 4 GW of the 4.2 GW ground-mounted power plant capacity installed in 2019 mostly stemmed from two tenders in 2017. But in 2020, there were no new volumes from additional tenders to be deployed. Instead, a large share of the 2020 installations came from PPA based systems out of a 100 GW+ pipeline under

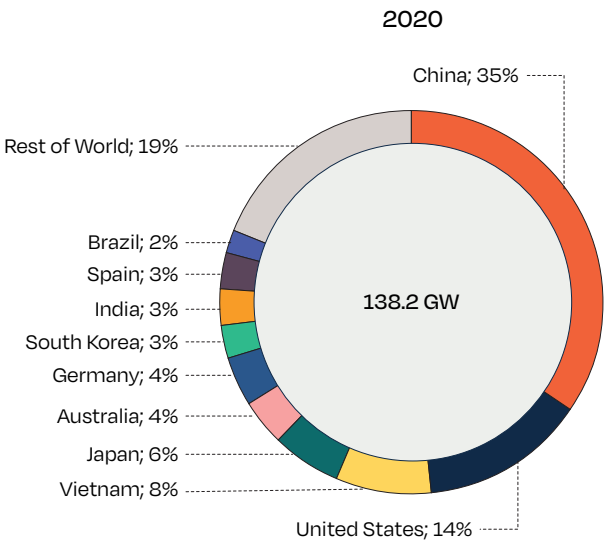
development in Spain. This makes the country probably the world's largest market for subsidy-free solar, while showing at the same time that grid constraints can dramatically slow down the installation pace for solar power plants. Spain's self-consumption rooftop market only opened in early 2020 after the abolishment of the Sun Tax, which had kept that segment economically unattractive in the past. But the new and attractive business opportunity was limited by COVID-19, which hit Spain extraordinarily hard and resulted in a dire economic situation for many SMEs. Still, C&I and residential together contributed around 715 MW to Spain's solar deployment in 2020, a 30% growth compared to the year before.

Brazil entered the top 10 ranking for the first time and is the only Latin American country in that group. The 3.2 GW grid-connected in 2020 is a new annual record and a 49% improvement over the 2.1 GW added in 2019. The 2020 number would have been likely even higher if the pandemic had not struck the country so bad. Around 2.5 GW, the bulk of last year's installations, stems from distributed solar systems up to 5 MW that can access a national net metering scheme. The other leg of the solar sector in Brazil in 2020 were centralised systems from energy auctions for large-scale power plants, mainly in 2017, and some PPA based systems.

In **summary**, 2020 was an impressive year of growth for solar, even more when taking into consideration the severe impacts of the pandemic on many countries across the globe. The growth was carried to a large extent by global market leader China (see Fig. 8). But many countries around the world showed strong resilience to COVID-19, performing much better than forecasted by solar analysts across the board.

In 2020, 18 countries added over 1 GW, compared to 16 in 2019 and 11 in 2018, showing how diversification of the solar sector begins to unfold into markets with notable volumes. Details on these 18 GW markets can be found in Chapter 3, where national and regional industry associations active in the solar sector provide their market analysis on these markets (see p. 77).

FIGURE 8 TOP 10 COUNTRIES SOLAR SHARE 2020



Regional Update

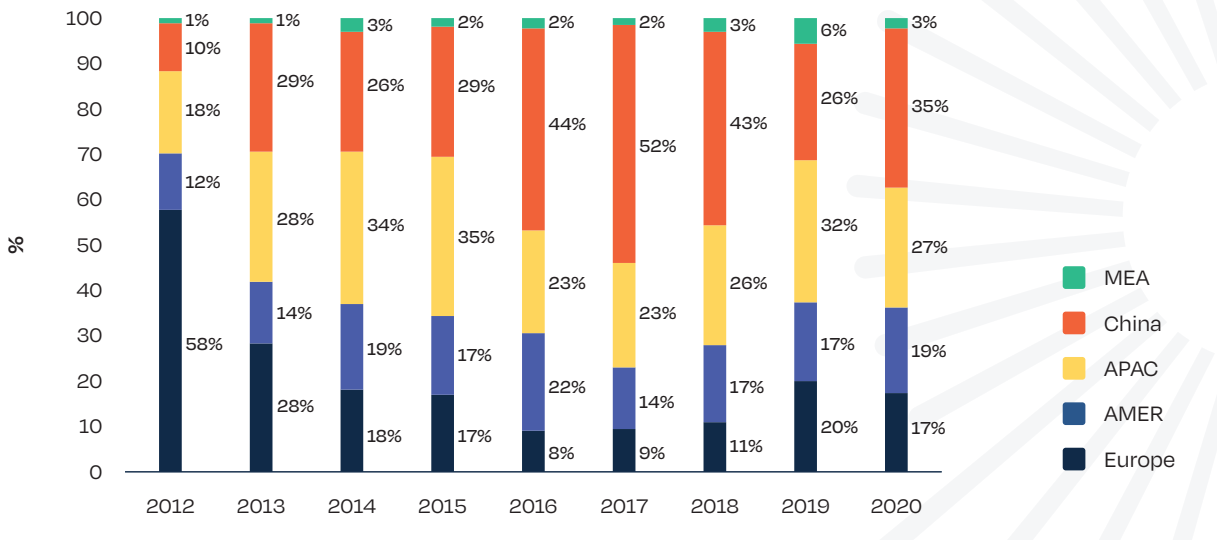
The strong performance of China in particular more than compensated for India's losses, pushing up demand for solar in the **Asia-Pacific** region (see Fig. 9). Through the addition of 84.9 GW, the world's largest solar region expanded its dominance by 4 percentage points to a global share of 62%. This means a halt on the downturn of the previous two years characterised by China's weakness that followed its record year in 2017, when three quarters of the global solar capacity was installed in Asia-Pacific, and 52% in China alone (note that due to its large size, China is listed separately from the Asia-Pacific region). In 2020, Asia-Pacific was again home to 6 of the top 10 solar markets and 7 countries that added GW-scale capacities, unmatched by any other region.

When looking at **Asia-Pacific** ex China, the region's solar market share dropped considerably by 5 percentage points to 27% in 2020, adding a little less capacity than the year before – 36.7 GW, compared to 37.1 GW in 2019. The losses – caused primarily by India failing to meet its ambitious targets and others hardly growing – were so substantial that all non-Chinese Asia-Pacific countries put together achieved a lower global share than China alone, which expanded its market share to 35%.

The US plays an even more important role in **the Americas** than China in Asia. The world's 2nd largest market was responsible for 74% of 2020 additions on the American Continent, up from 66% in 2019, after installing three times as much capacity than the others. In 2020, both the US and Brazil carried most of the Continent's growth on their shoulders, while its third GW-scale solar market, Mexico, continued its trip downhill, suffering from fossil-fuel focused government policies. Newly installed solar capacity in the Americas increased by 29% to 26.1 GW over the 20.3 GW deployed the year before. As the Americas' growth rate beat the global average, the region's global market share improved by 2% points to 19%.

On the other side of the Atlantic, **Europe** also increased its total installed capacities, but the negligible volume growth of 0.3 GW or 1 percentage point to 23.7 GW translates into a lower global share of 17%, down from 20% in 2019. This outcome is actually much better than anticipated in the Medium Scenario of the previous GMO, when we assumed that a large number of pandemic-stricken European countries would pull down installation numbers dramatically by 29% to 16.1 GW. But surprisingly, around 70%, the vast majority of the European markets, added more solar

FIGURE 9 ANNUAL SOLAR PV INSTALLED CAPACITY SHARES 2012-2020



than the year before. Next to Europe's market leader Germany, other GW-markets like the Netherlands, Poland and France also performed better than the year before. The developments are notable in particular for the Netherlands and Poland, which grew their solar demand to 3.1 GW and 2.4 GW, missing the top 10 rankings only by a small margin. Dutch solar investors continued to profit from a solid net-metering scheme for residential rooftop systems and a regular tendering programme addressing commercial and ground-mounted PV plants among other renewables. The Polish success, in contrast, is based on self-consumption systems incentivised by a favourable policy net-metering/feed-in framework for prosumers, a RES auction system, and several further support tools, including reduced VAT and income taxes, and low-interest loans. The only negative exceptions among Europe's GW markets were Spain and Ukraine, though mostly for reasons other than the pandemic, as described earlier in the top 10 section.

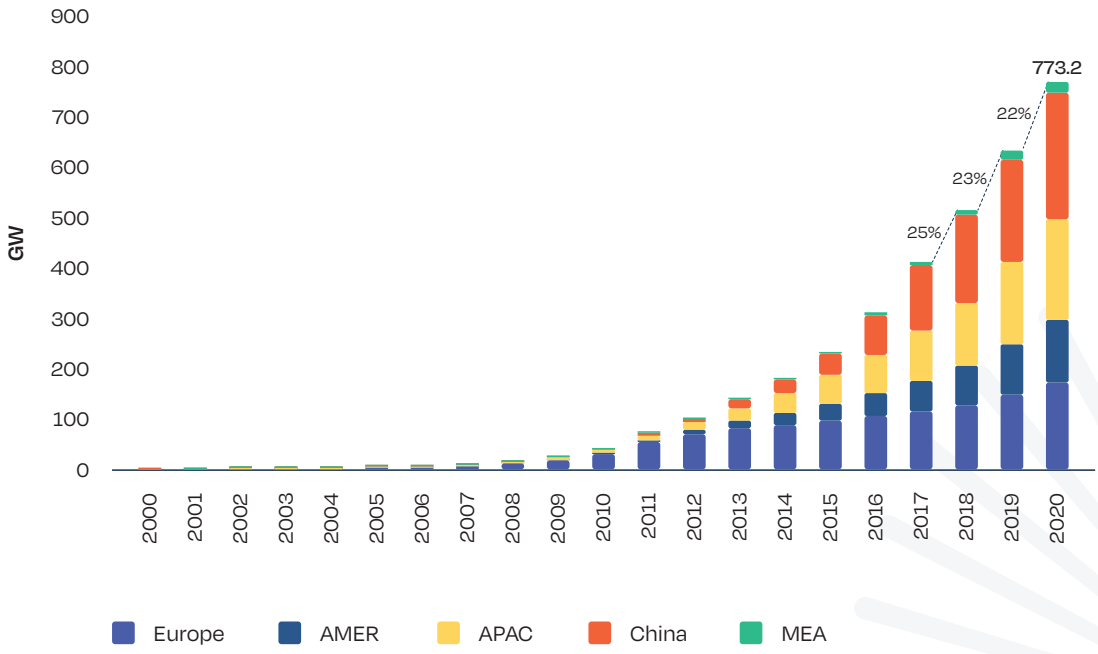
The **Middle East and African (MEA)** region absorbed 3.5 GW of new solar power capacity in 2020, about half of the 6.8 GW installations in 2019, and falling back close to the level of the 2018 market volume of 3.1 GW. Though covering over 60 countries, the analysis of MEA's negative market performance is rather simple, and its outcome has little to do with COVID-19. Both Egypt and the UAE turned into GW-scale markets in 2019, when each finished a major solar power plant project: in Egypt, the Benban Solar Complex with almost 1.5 GW was fully commissioned; in Abu Dhabi, the 1.17 GW Sweihan project entered commercial operations. While several very large-scale projects are being developed in the UAE and other countries on the Arabian Peninsula, nothing major was grid-connected in 2020. The Middle East's largest solar market was Israel despite a 20% drop in newly installed capacities to 505 MW in 2020. The African Continent was dominated by South Africa, which exceeded the GW-level deployment for the first time by installing 1.3 GW in the utility and distributed segments, a 154% improvement over the previous year. South Africa has seen the start of a solar renaissance under its current president. After solar project PPAs from the 4th round tender in 2015 were finally signed in 2018, an Integrated Resource Plan with a 6 GW by 2030 solar target was passed in 2019, and a 5th round tender launched in 2021.

Total Solar Installations until 2020

The world's total installed solar PV power capacity increased by 22% to 773.2 GW by the end of 2020, up from 635 GW in 2019 (see Fig. 10). Cumulative solar power has grown almost 500 times since the start of the millennium, when the grid-connected solar era basically began with the launch of Germany's feed-in tariff law. Comparing the decade just gone by with the one before that, the global deployed on-grid PV capacity has grown an astonishing 1,860% – from 41.5 GW in 2010.

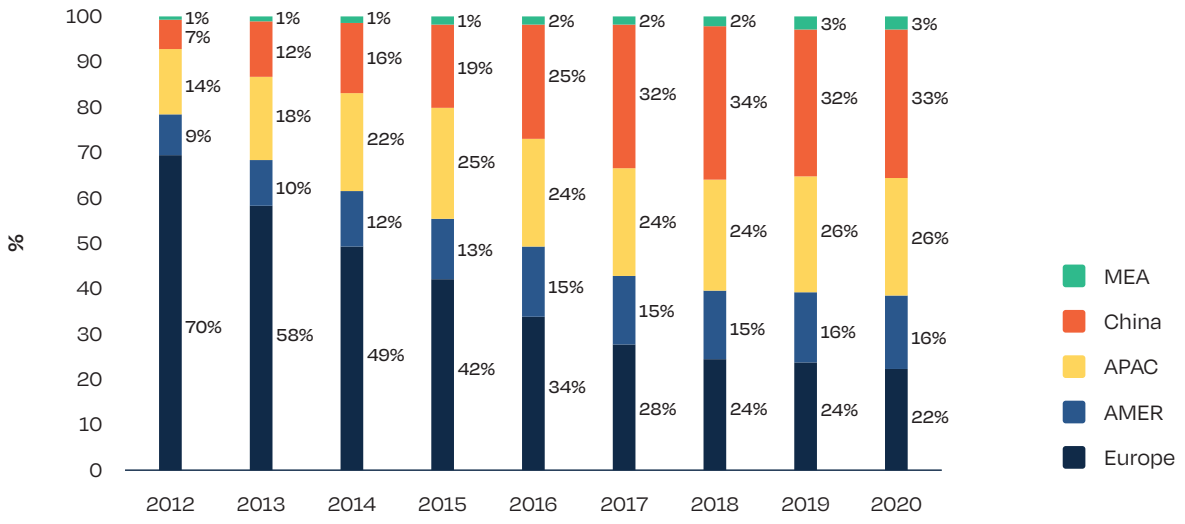
Over 770 GW
solar capacity installed today

FIGURE 10 TOTAL SOLAR PV INSTALLED CAPACITY 2000-2020



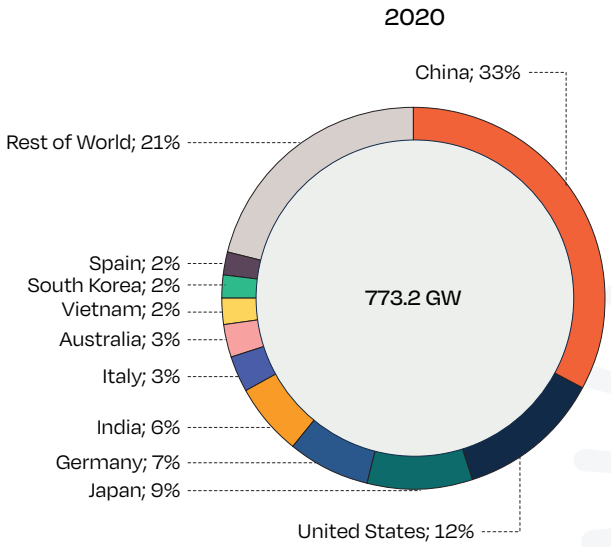
Strong growth in Asia's top markets China and Vietnam made up for big disappointments, like India, further strengthening the standing of solar in the Asia-Pacific region. The region easily maintained its leadership in 2020, representing 59% of the global solar power generation capacities, which is half a percentage point higher than the year before (see Fig. 11). Newly installed capacities of 84.9 GW in 2020 led to a total of 453.2 GW. The stagnation of the European solar pioneers resulted in a decrease of about 1 percentage point in market share, down to 22.4%, the lowest value in the last decade. But the addition of 23.7 GW was enough to defend its second position based on a cumulative PV capacity of 173.9 GW. Like in previous years, the Americas were ranked the third largest solar region in the world in 2020; total installed PV capacities of 125.6 GW translated in a 16.2% stake, a half percentage point higher than in 2019. The decrease in demand in the Middle East and Africa had no impact on the region's solar positioning last year. With a cumulative solar capacity of 20.5 GW, its world market share remained exactly at 2.7% in 2020.

FIGURE 11 TOTAL SOLAR PV INSTALLED CAPACITY SHARES 2012-2020



A comparison of individual countries shows that China's 60% market growth in 2020 had little positive effect on its outstanding solar dominance. Its operational solar power capacity increased to 32.8%, a 0.5% higher share than in 2019 – and again, that's close to one-third of global power generation capacities (see Fig. 12). The volume of globally deployed solar systems is simply too large to be impacted by one country during the course of one year, even if it is as dominant as China. For that reason, the order of the direct followers has not been altered – China was again trailed by the United States, Japan and Germany. While the US kept its 12% market share, the other two lost another percentage point each in 2020, like the year before, making the US now the only other country with a double-digit share in global solar power generation capacities. The US' cumulative installed PV capacity reached 95.5 GW, Japan's 71.2 GW resulted in a 9% share, and Germany's 54.6 GW a 7% share. Again underperforming, India's distance to Germany was even larger at the end of 2020 than the year before. Still, its 45.9 GW of total installed solar capacity was good enough to hold its fifth place with a 6% market share. The top 5 have been in a league of their own for quite a while, and it doesn't look like this is changing anytime soon. The country ranked sixth has less than half of India's solar power capacity. The bottom half of the top 10 saw only a few notable changes: Italy, at 21.2 GW, is now very closely followed by Australia at 21.1 GW; Vietnam claiming rank 7 as it entered the group with 18.1 GW, replacing the UK, which dropped out completely. While South Korea reached 15 GW of operating solar power plants, Spain's 14.2 GW helped the country hold on to 10th.

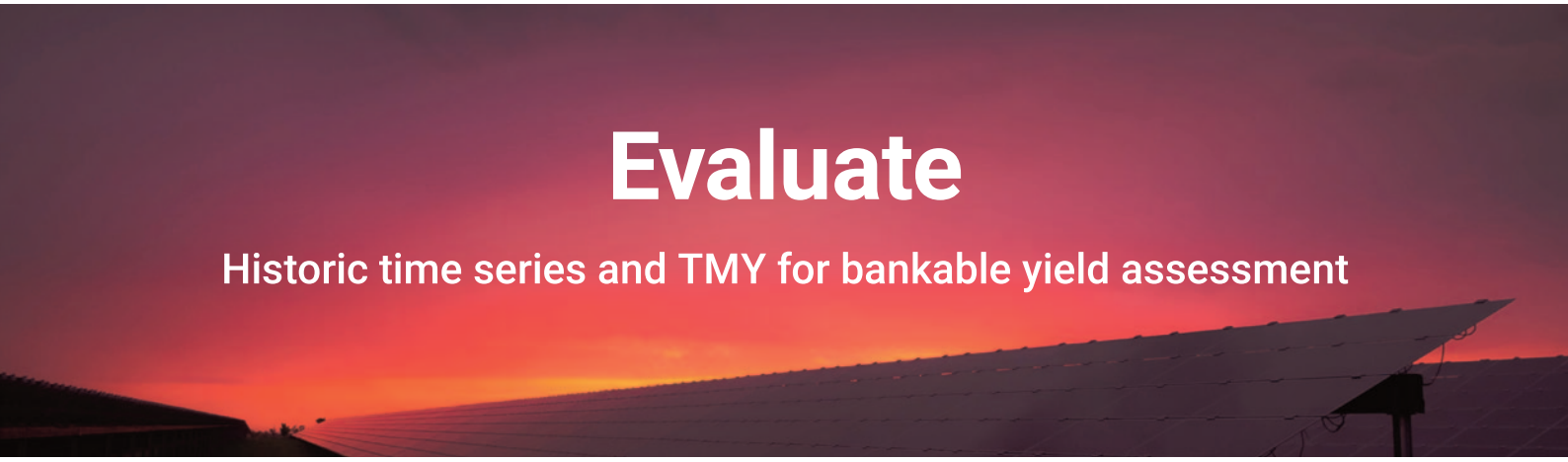
FIGURE 12 TOP 10 SOLAR PV MARKETS TOTAL INSTALLED SHARES 2020



However, examining closely the installed PV capacity from a per-capita perspective, the global solar picture looks completely different. Despite its strong dominance, none of the global top 3 markets – China, USA and India – figures on the W/capita top 10 list (see Fig. 13). While three of the four countries with the highest installed system capacities per inhabitant – Australia, Germany and Japan – also belong to the 10 world's biggest solar markets, several others do not, including the new No. 3, the Netherlands, which, if all goes as forecasted, will end the year even in the second place. The old and new per capita solar leader will again be Australia, with an impressive installation level of over 1 kW per inhabitant.

FIGURE 13 TOP 10 COUNTRIES SOLAR CAPACITY PER CAPITA 2020

SOLARGIS



Evaluate

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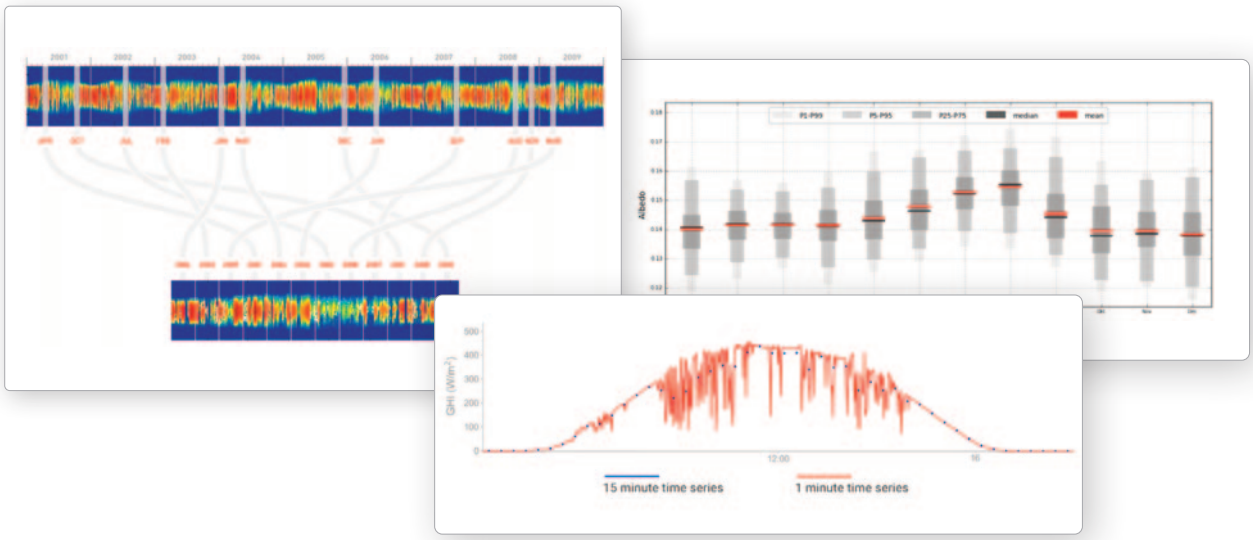

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PROSPECTS 2021 - 2025

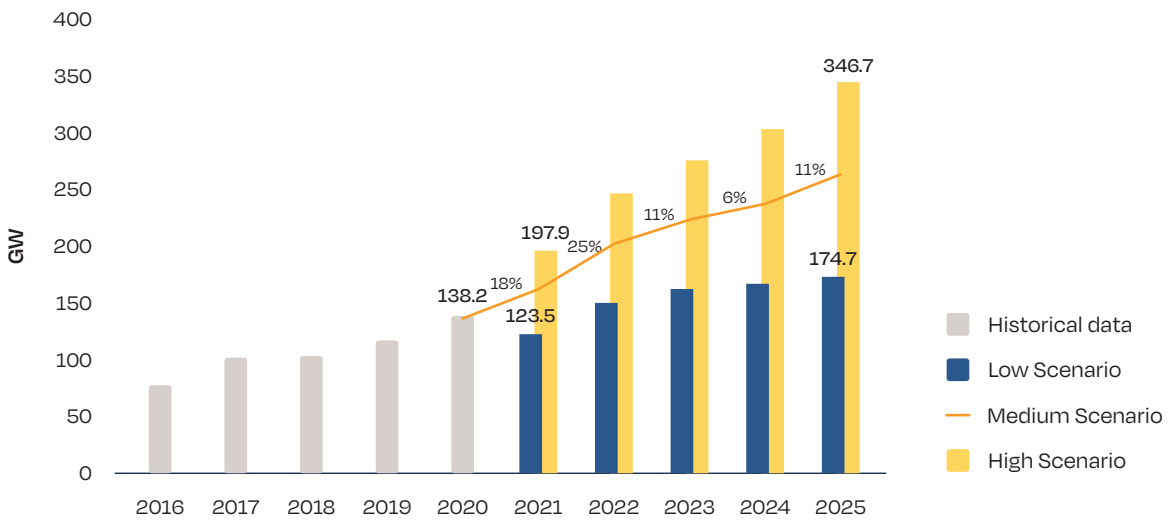
Forecast 2021

The first half of 2021 in the solar sector was characterised by increasing costs for wafer, cell and module manufacturers. Silicon prices more than doubled in the first 5 months, while aluminium appreciated by nearly one-third, encapsulation material costs grew in the low double digits. Silver, the most expensive consumable of a solar cell besides the wafer, costs over one and a half times its average over the last few years. On the system side, rising steel and copper prices – used in mounting systems or cables – drove the costs higher. However, the main cost driver has been silicon, where a severe supply shortage has caused solar's main raw material to roughly double its cost in a module, adding about 20% in production costs. The consequence: module prices changed their general direction for over a decade – they not only stopped its downwards trend but went up significantly.

Despite the various price increases and further negative impacts from the pandemic, solar will see another stellar growth year in 2021. In our Medium Scenario, we anticipate newly installed capacities to reach 163.2 GW, an 18% growth rate over the 138.2 GW installed in 2020 (see Fig. 13). This estimate is a bit more on the conservative side compared to leading solar analysts. In June, IHS Markit revised its forecast down to 171 GW, from 182 GW, after BloombergNEF had marginally lowered its forecast to 182 GW, from 184 GW end of May.

The situation with the silicon shortage is not expected to get much better this year, but it's unlikely module prices will ascend any further; otherwise too many projects would be delayed. While tenders usually have strict deadlines forcing developers to finish in time, the growing field of corporate PPAs is generally not very time-sensitive; if a solar power plant project doesn't make economic sense, it won't be built. Already in June, module factory-gate prices remained basically stable, though at record levels. How quickly things change in the solar sector can be seen with another module component shortage, solar glass – this case was resolved very rapidly in recent months. After the prices for solar glass spiked last year with rising interest in bifacial solar modules – a product commonly designed with two glass covers –, Chinese glass manufacturers reacted quickly to build new capacities. Glass prices are back to normal now, which has offered silicon prices further room to rise.

FIGURE 14 WORLD ANNUAL SOLAR PV MARKET SCENARIOS 2021 - 2025



The other major threat to growth in the global solar sector has been the COVID-19 virus, but it seems to be currently under control in most of the large solar markets as they make rapid progress in vaccinating their population. Regardless, the 2020 experience during the height of the pandemic showed that solar has proven to be very resilient. Even in most countries heavily affected, solar demand has generally remained very strong – and that hasn't changed. Like last year, the Global Solar Council conducted a survey on the impacts of COVID-19 on the solar sector, which showed an improving industry outlook – with 81% of the respondents expecting sales to grow in 2021 compared to 72% in 2020 (see Highlight at pg. 75).

Our market sensitive analysis for 2021 shows a large spread. The Low Scenario estimates a demand drop to 123.5 GW, which is extremely unlikely when looking at the positive market dynamics in the first half of the year. However, if a new global wave of the pandemic takes hold, maybe even with an aggressive mutation, the US ban on solar products from China's Xinjiang region meticulously executed and other countries following, this might have severe negative implications on market growth in 2021. There's also the possibility that more projects will be shelved than anticipated depending on further price developments. But it's much more likely that the pendulum swings somewhat in the other direction. Our High Scenario forecasts up to 197.9 GW of solar additions in 2021, which also sounds extremely optimistic and quite improbable. Modelled bottom-up, if this scenario materialised, it would mean that basically all possible silicon output will be consumed. As in previous years, the biggest wildcard remains China, which still has a lever to move the solar balance significantly in either direction even at a market of today's size.

Regional market developments 2021

As long as China's solar market dominance is as overwhelming as it has been in recent years, it's rather difficult to estimate market growth accurately – that was the case in the past, when uncapped feed-in tariffs facilitated unexpected growth records up to 53 GW in 2017, and has been getting only more complicated as the country is transitioning away from traditional incentive schemes to auctions and non-subsidised systems. After the reform was started, demand dropped to 44 GW in 2018, even further to 30 GW in 2019 and bounced back to a near record level of 48 GW in 2020. No wonder the latest mid scenarios of different analysts range widely – from 57 GW (IHS) to 60 GW (China PV Industry Association) and 65 GW (BNEF). Our Medium Scenario for China leans more to the conservative side, at 55.9 GW. While the project pipeline in China is over 50 GW, the grid-connection deadline for the bulk of these has been extended into 2022, even if conditions worsen somewhat. The final size of the Chinese market in 2021 will depend on module prices and availability in the coming months, which will be the decisive criteria if the run in the fourth quarter is similar to 2020, when 61% of the entire year's solar capacity was installed. In Q1/2021, China added 5.3 GW. Taking a year-end sprint into account, our High Scenario for China anticipates up to 71 GW in 2021.

As China is supposed to grow only 16% YoY this year, its global market share will decrease slightly by 0.6 percentage points to 34.3%. The other Asia-Pacific countries combined will also lose some share, 4.4% down to 22%. Although some of their major markets are expected to add significantly more capacities than in 2020, their average growth will be below market rates.

The region's biggest solar 'loser' will be Vietnam, even though this title might be a bit unfair as nobody had expected this shooting star would fly so high. After the solar heydays in 2020 came to an end with the deadline of the FiT 2 programme end of last year, there's no more funding scheme in place at the time of writing; every investment has to rely on self-consumption. The industry's hopes now rest on rapid development of the pilot programme for PPAs and implementation of the FiT3 draft. Still, our Medium Scenario forecasts 2 GW newly installed capacities in 2021, acknowledging a very experienced local solar industry with a large group of solar installers and a business case for self-consumption systems if solar LCOEs are attractive. This would be the country's third best solar year ever by far. With India's 100 GW Solar Mission Programme scheduled to close by end of 2022, but the target still more than half the way ahead, India's government is trying to be as supportive as possible during a time the country has been hit massively by another COVID-19 wave in the first half of 2021. Despite the challenges from the virus, aggravated by the unsolved issue of retroactive re-negotiation claims for PPAs, our Medium Scenario is very optimistic on India's solar development in 2021. After nearly 2.5 GW was installed in Q1/2021 and a large-scale project-pipeline of over 50 GW, we anticipated solar additions of

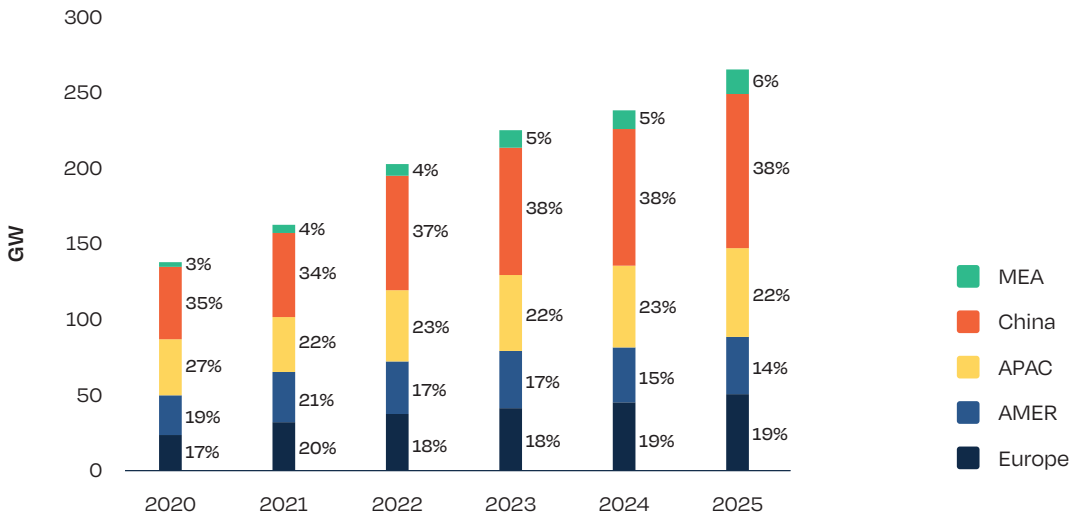
10.0 GW. With India being traditionally very sensitive on any PV product price, there is a good chance of several projects getting delayed. The Low Scenario assumes newly installed capacities of 5.6 GW. The other Asia-Pacific GW markets are expected to see quite different evolution trends – minus 15% to 6.9 GW for Japan, 37% to 6.9 GW for Australia, 1% to 4.2 GW in South Korea, and 55% to 2.6 GW in Taiwan.

However, like in the past years, despite about 5% share losses, our Medium Scenario forecast clearly shows that all Asia-Pacific countries together will continue to dominate global demand with a combined share of 56.4% in 2021 (see Fig. 15). On the light weakness of Asia-Pacific, all other regions are assumed to grow their market shares by about 1 to 2%.

In 2021, the Americas will remain the world's second largest region for solar installations with a market share of 20.5%. There is one major reason for this jump – the performance of the US. The 2-year extension of the ITC and the positive developments in the rooftop segment supported by the pro-renewables climate of the new administration will boost solar deployments to 24.1 GW, a 25% growth over 2020, which is in line with the 23.8 GW forecast of the US Solar Energy Industries Association (SEIA) and Wood Mackenzie published in their June Q2 market update. In addition, the other major American market, Brazil, is believed to continue its solar streak, though at a lower level. Backed by an established and fairly regular power tender scheme, a very attractive net metering programme up to 5 MW, and a strong system, Brazil is expected to boost newly installed solar capacities by 16% to 3.6 GW. Even the third American GW-level solar market, Mexico, which is facing a difficult political environment for renewable deployment, will see installations grow by 24% to 2.3 GW in 2021.

Following a flat market in 2020, when Europe's global market share decreased by 2.7% points to 17.2%, in 2021 the continent's share of the pie will grow again to 19.5%. With high vaccination levels reached in most countries, the health effects of the virus seem to be under control in the summer of 2021, except for Russia. The main driver for solar growth in Europe is the EU, which has ambitious Climate targets and has been working on various sophisticated legislative toolsets toward carbon neutrality by 2050 with intermediate goals for its member states in 2030. When looking just at the European Union, 23 of its 27 members, including all the largest markets, are expected to install more solar than the year before. We are most upbeat on the EU's largest market in 2020, Germany, which has already deployed 2.45 GW by May 2021, and is supposed to add 6.2 GW by year-end. Recent changes in legislation have resulted in several positive, and a few negative, changes for the solar sector in Germany. While taxes on self-consumption have been extended from

FIGURE 15 EVOLUTION OF GLOBAL ANNUAL SOLAR PV MARKET SHARES UNTIL 2025



residential to small commercial systems among other improvements, a new tendering scheme imposed on industrial rooftop systems as small as 300 kW that could previously benefit fully from the self-consumption/feed-in tariff scheme makes investments in this segment much less attractive. Next to Germany, the European Continent will likely count 7 other GW-markets, more than any other global region. That's one more than in 2020 and all of these GW-markets are expected to deploy more solar power in 2021 than the year before. Established European solar market leaders, Spain, the Netherlands and Poland, will likely each add over 3 GW, while France is anticipated to touch the 2 GW level, Denmark and Greece exceeding the GW level for the first time, and Turkey returning to that group. Ukraine will drop out of the GW league as a consequence of worsened support framework conditions; the recent retroactive FiT cuts have severely damaged the international investment confidence in this Eastern European market. Due to a revision of its regional support schemes, Belgium should also see a decrease in annual installations after surpassing the GW mark for the first time since 2011. In contrast, the positive developments in Denmark are noteworthy in particular. A northern European country with modest sunshine levels, mostly known for its leadership in wind power, is now seeing solar win shares in technology-neutral tenders in recent times: the main driver of its solar boom are corporate PPA based systems, triggered by solar's attractive value proposition in terms of cost and versatility.

Solar in the Middle East and Africa region is gaining strength in 2021. Additions of 5.8 GW mean a 64% growth rate, and almost get close to the record levels deployed in 2019. Our Medium Scenario foresees the region to grow by 1 percentage point, reaching a global market share of 3.6% on the back of UAE turning into a GW market again and South Africa anticipated to install close to that level. At the same time, the positive news on the advantages of solar is quickly spreading across the region, with many utility systems being planned in various countries.

1 Global solar market - Prospects 2021 - 2025

Global Solar Market Developments 2022 to 2025

The next four years will be a very good period for solar power around the world. For each of these years, we have considerably increased our forecasts, but next year, **2022**, will stand out on various fronts. In our Medium Scenario, we see the global solar market adding 203 GW in 2022, the first time ever that annual PV installations will crack the 200 GW level. To put that into perspective, this would be only five years after the 100 GW level was reached, and two years earlier than our GMO 2020 forecasted (where 199.8 GW was predicted for 2024). This would also mean a 25% growth rate over the 163 GW added in 2021, higher than for any other year in this 5-year market outlook. The final deployment volumes will depend on price developments in 2022 and H2/2021. If silicon, and in consequence, PV module prices do not decrease in Q3/2021, which is likely, there will not be a fourth quarter rush but more delays of projects to be finalised in 2022.

Much of the 2022 growth will be shouldered by two countries: China and India. China will execute on its fourteenth 5-year plan, which strongly backs solar and wind, demonstrating that the country wants to expand extensively and accelerate the development of these technologies. We are very bullish on solar in China next year. Taking into account the volumes postponed from 2021, we believe the Chinese market will skyrocket to nearly 76 GW in 2022, which is close to CPIA's high forecast for that year. India, on the other hand, will enter its final year of the National Solar Mission, doing its utmost to advance solar project grid-connections towards the 100 GW target, even though none of our scenarios see this installation target being met. Still, the sub-continent is anticipated to add nearly 18 GW in 2022, although it could reach up to 22 GW, according to our High Scenario, depending on module prices for India's developers, COVID-19, and the PPA grid-connection issues.

Strong demand will continue in the European Union, where recovery funds will be widely used to support solar as the region begins to look how to reach its new, higher renewable 2030 targets. Europe will add 37.4 GW of new PV capacity. The Americas' growth will flatten as its major solar market, the United States, is due to take a breath after a strong 2-year growth phase; with the country increasing just slightly to 25.5 GW, the continent's solar grid-connections for 2022 add up to 34.7 GW. In MEA, positive developments continue on a broadening scale, finally beating the 2019 installation record with additions of 7.8 GW. Based on China and India's strength, the Asia-Pacific region as a whole will grow its shares to 60.6% in 2022, while Europe is anticipated to lose some of its 2021 gains to 18.4%, the Americas will drop below 2020 levels to 17.1%, and MEA will marginally increase its share to 3.9%.

The years **2023–2025** will be characterised by somewhat more modest growth. Our Medium Scenario anticipates 11% market growth to 225 GW in 2023, 6% to 239 GW in 2024, and a return to the 2-digit level at 11% to 266 GW in 2025. After China's very strong uptick in 2020, the momentum is anticipated to level out in the world's largest market, but it will continue to add impressive volumes and perform at least level with global average growth with 11% to nearly 85 GW in 2023, and 8% to 91 GW in 2024. In 2025, China is expected to grow demand by 12% to 102 GW, marking the first time a single country adds 100 GW in one year. Our Medium Scenario assumptions are basically in line with CPIA's mid forecast for those three years.

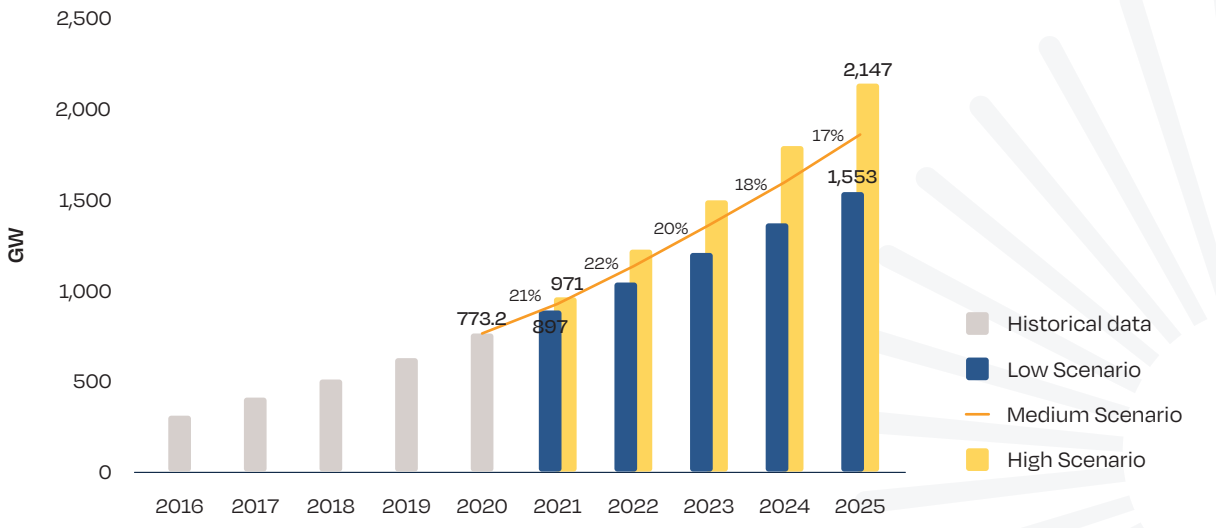
Asia's second largest market India is expected to reach its 100 GW on-grid solar capacity target during 2024, after adding over 19 GW in both 2023 and 2024. US demand will peak at 28 GW in 2023 with the expiration of the 26% solar investment tax credit, and will return to levels a little higher than the year before, between 25.5 GW and 26 GW, whereas most of Europe's countries striving to inch towards the EU's 2030 renewables target will basically expand in line with the market, resulting in the continent's solar additions to rise to 45 GW in 2024, and 51 GW in 2025. MEA outperforms average global growth – with little visibility into many countries of that large but less developed on-grid solar region, we anticipate annual installations to reach 16 GW in 2025, equal to a new record share of over 6%. But that could also be much more, as our high scenario forecasts 26 GW additions for MEA in 2025. Like MEA, Europe will also further improve its global standing to 19% between 2023 and 2025, while Asia-Pacific including China will keep its global shares at a similar level of about 60%. The only region that will lose more than 2% points is the Americas, as growth is still mostly carried by the US, which is not enough to keep up with the solar developments in the other regions.

Regarding cumulative grid-connected solar power capacities around the world, our Global Market Outlook 2021 is much more upbeat than last year, which we prepared in the midst of the first wave of COVID-19 (see Fig. 16). Although the pandemic continues to impact many people around the world, in mid-2021 increasing vaccination levels in major solar markets 2021, the experience of the solar sector's resilience in 2020, and recovery funds accessible for solar in several countries have made us more optimistic for the next few years. The Medium Scenario forecasts total installed capacities will reach 936 GW, which is about 5% higher than in last year's GMO. The final year of the 5-year forecast in the previous GMO ranged between 1,180 and 1,680 GW, with the most likely Medium Scenario resulting in 1,448 GW of total operating solar power in 2024. For this GMO 2021, we forecast between 1,380 and 1,801 GW, with 1,604 GW for the Medium Scenario in 2024 – this is about 11% higher.

This year's GMO anticipates for our most-likely Medium Scenario that the global solar power fleet will reach 1,870 GW in the final year, 2025, of this analysis. Under optimal conditions, the world could operate PV generation plant capacities as large as 2.147 GW by the end of 2025, the first time we are looking into the 2 TW level for any of our scenarios. However, the most likely scenario for entering the solar terawatt age remains 2022, but now we are also certain that this level will be reached even in our Low Scenario.

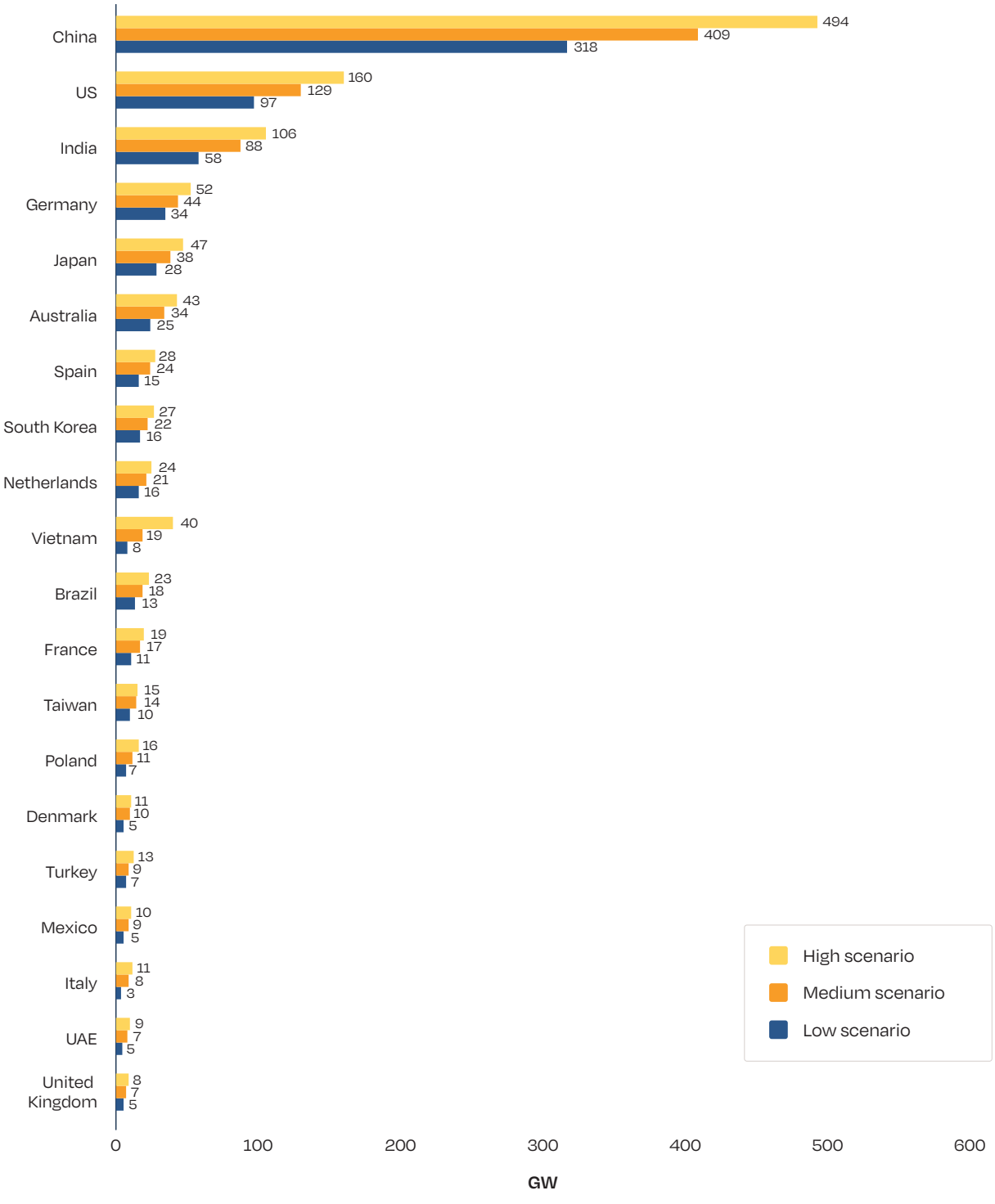
In our Medium Scenario, we now expect that total global installed PV generation capacity will pass the following milestones over the next 5 years: 900 GW in 2021, 1.1 TW in 2022, 1.3 TW in 2023, 1.6 TW in 2024, and 1.8 TW in 2025.

FIGURE 16 GLOBAL TOTAL SOLAR PV MARKET SCENARIOS 2021 - 2025



The 20 markets with the highest 5-year installation potentials (in the order of Medium Scenario assumptions; see Fig. 17) show a number of changes compared to the 2020 GMO edition. The top three markets remain the same – China, US, and India, and in the same order. The anticipated installation volumes

FIGURE 17 TOP 20 MARKETS SOLAR PV ADDITIONS 2021-2025



for both high and low scenarios over the next five years are again higher for most markets, with a few exceptions, such as India. Newcomers on this year's Top 20 list are three European markets: the United Kingdom, Denmark, and Poland. The pattern of the markets on this list remains similar with a few countries installing the bulk of all solar system capacity, though the number of mid-size markets is growing. This time again, we expect in the Medium Scenario for two countries to install over 100 GW: China (409 GW) and the United States (129 GW). But we see the number of countries adding at least 20 GW increase from six to nine, including China, United States, India, Germany, Japan, Australia, Spain, South Korea, and the Netherlands. This time, higher capacity volumes are needed to enter the Top 20 market prospects, with at least 6.8 GW compared to 5.9 GW last year.

Around three quarters of the top 20 markets are expected to install at least 10 GW each between 2021 and 2025, according to our Medium Scenario, with new capacity additions in this group showing a large spread, ranging from 409 GW for the first, China, to 6.8 GW for United Kingdom, the last on this list. All 20 markets combined are estimated to add a total of 938 GW until 2025. This is much more optimistic than in our previous GMO, when we had projected this group to install 693 GW over the coming five years in our Medium Scenario.

The sensitive analysis for the top 20 shows additions of 1.156 GW over the next five years until 2025 in the High Scenario, and 686 GW in the Low Scenario; this is respectively 280 GW and 213 GW more than our GMO 2020 5-year assumptions, due to the consequences of COVID-19. Putting the microscope only on the top 5, these markets combined are expected to grid-connect 859 GW until 2025 in the High Scenario and 535 GW in the Low Scenario, covering a share of around 74% and 77% of total additions in that period (in the GMO 2020, it was 60% and 68%).

Over the 5-year period of this GMO we once again see very positive prospects for political support behind solar, with climate change becoming an increasingly important topic for policymakers around the world, and awareness quickly spreading that solar is the most cost-effective and job-intensive energy technology with the highest variability (see Fig. 18 on the following page). Our weather forecast is sunny for three quarters of the top 20 countries, with all but one of them expected to show two-digit annual growth rates. The country with the largest 5-year growth rate expectations in this group is Denmark, with an impressive level of 47% CAGR, where the low cost of solar has enabled the technology to take away shares from wind in technology-neutral state tenders and attract several investors in large-scale subsidy-free PPA systems.

On the other side of growth expectations for this group is Japan, with a compound annual growth rate of 9%. As Japan operates the third largest solar power fleet in the world, with over 71 GW, and is the country with the world's fourth largest solar capacity installed per capita, this 9% growth translates into additions of nearly 39 GW in the Medium Scenario. Of course, much more support from Japan's government is needed, as the restructuring of the energy market has taken too long and solar installations are still too expensive in comparison to other developed PV markets. But forecasts of market decline for the past two years proved wrong, acceptance for the tender scheme is slowly growing, and next year the new self-consumption scheme will start; all of which makes us more hopeful about the prospects for Japan for the next five years than previously. Australia's federal government still has a ways to go to support solar, however, many policy initiatives on the state level will boost solar in the coming years. Further, there are announcements for gigantic green hydrogen projects in Australia, which if supported by local policymakers, could lift solar in the country to an entirely new level.

The weather forecast is cloudy for four countries, of which two are expected to see only one-digit growth rates. One is the United Kingdom, which is anticipated to grow with 8% CAGR. The country is missing major support schemes for solar, but the regulatory framework enables growth based on cost competitiveness, increasingly playing into solar's hands even in its cloudy northern climate. The other country with one-digit growth prospects is Italy, where 2020 was another year that the market hovered at consistently low installation levels. A complicated permitting environment and an unfavourable tender system for solar have kept Italy's PV market from taking off, even though there are positive signals in the residential rooftop market stemming from a COVID-19 recovery package. Although not yet back in the GW-

club in 2020, Turkey, despite its disastrous financial situation, is anticipated to re-join in 2021, mainly backed by a recently-introduced net metering scheme for small-scale installations and tenders. While last year was sunny, Vietnam is facing heavy clouds as the incredibly successful FiT2 programme has come to an end without a successor in place. It now remains to be seen when and how the FiT3 programme will come into effect and when the PPA scheme will be fully implemented.

FIGURE 18 TOP SOLAR PV MARKETS' PROSPECTS

Country	**2020** Total capacity (MW)	**By 2025** Total capacity Medium Scenario (MW)	**2021-2025** New capacity (MW)	**2021-2025** Compound annual growth rate (%)	Political support prospects
China	253,404	662,818	409,414	21%	
United States	95,519	224,991	129,472	19%	
India	45,918	133,935	88,017	24%	
Germany	54,609	98,313	43,704	12%	
Japan	71,182	109,663	38,481	9%	
Australia	21,053	55,482	34,429	21%	
Spain	14,153	37,654	23,501	22%	
South Korea	14,977	36,647	21,670	20%	
Netherlands	10,324	31,028	20,704	25%	
Vietnam	18,070	36,774	18,704	15%	
Brazil	7,613	26,029	18,416	28%	
France	10,967	27,631	16,664	20%	
Taiwan	5,818	19,535	13,717	27%	
Poland	3,901	15,119	11,218	31%	
Denmark	1,644	11,402	9,758	47%	
Turkey	6,767	15,511	8,744	18%	
Mexico	6,808	15,531	8,723	18%	
Italy	21,191	29,568	8,377	7%	
United Arab Emirates	2,404	9,861	7,457	33%	
United Kingdom	13,780	20,547	6,767	8%	

In summary, an increasingly supportive policy environment with further cost reduction and technology innovations promises a very bright investment climate for solar over the coming years. The only rainy country in our political weather forecast is Mexico, where annual installations are set to shrink due to large uncertainties over the future of the policy framework for solar. The government's decision to support fossil fuels to the detriment of renewables took its toll on the outlook for solar, with investor confidence severely affected. Still, even in a difficult political environment, Mexico is expected to have a 18% CAGR until 2025, which shows how resilient solar truly is.

SEGMENTS 2021 - 2025

The growth in annual solar installations in 2020 led to an increase in capacities in both the rooftop and the utility-scale segments. However, the market dynamics for distributed solar have been very different than for centralised solar. At 60.6 GW, rooftop additions grew by 46% compared to the previous year, when they totalled 41.6 GW. By contrast, utility-scale installations grew by just 3%, reaching 77.6 GW – although they still contribute most of the total annual capacity (56%). This was partly the impact of COVID-19 on business conditions, which hampered work on large-scale solar parks and caused delays in project completions.

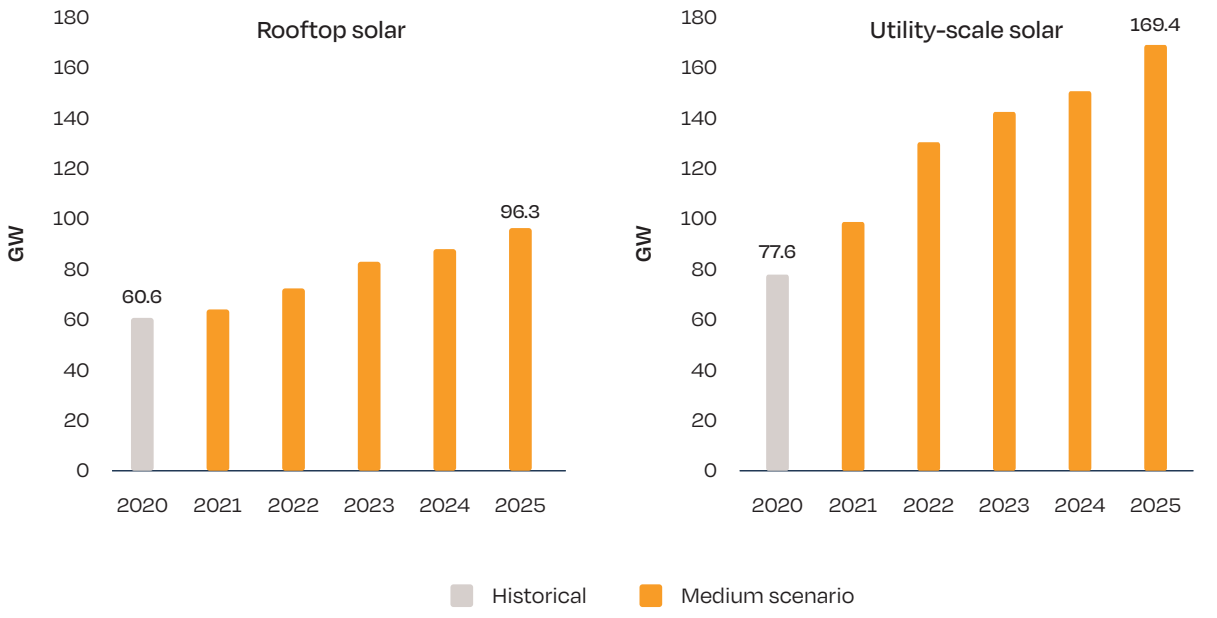
In China, the transition from the uncapped feed-in tariff system to a new regime of auctions and subsidy-free projects did not prevent the ground-mounted sector from expanding significantly. The Chinese market still largely relies on large-scale projects, which made up an even higher share in 2020 than the year before — about 70% of the annual capacity. Hard deadlines for subsidised utility-scale systems propelled gigantic demand. However, support for rooftop solar had this segment grow as well on absolute terms, by over 3 GW year-on-year.

In the United States, the 2nd largest solar market, a deadline for the ITC that was surprisingly extended end of December 2020 at the same 26% level did trigger a run on ground-mounted solar. At the same time, demand for residential rooftop systems grew less, while the C&I segment even declined. In sum, over 15 GW of utility-scale projects were installed, increasing that share to 81% in the United States last year.

While the two largest solar markets, China and the United States, saw an expansion of large-scale projects, ground-mounted installations experienced a sudden slowdown in many other geographies. A change in the incentive scheme in Vietnam, the world's 3rd largest market, shifted, to a very large extent, the newly installed capacity from centralised to distributed solar. In India, grid connection issues, tender re-negotiations and the severe impacts of the health crisis led to a dramatic contraction of the solar sector, as evidenced by a significant decrease in new large-scale projects—its fully dominant solar segment. In Ukraine, after an exceptional year for solar, the end of generous feed-in tariff schemes and retroactive FIT cuts for large-scale solar brought the market back below the GW-scale. In addition, the full commissioning in 2019 of ultra-large solar projects in the Middle East that were not followed up by new installations of similar dimensions also played a role in the reduced growth of the segment.

Deploying large volumes of utility-scale solar is much simpler than creating a distributed PV rooftop market, which requires a substantial period of time and a lot of effort to educate consumers, while setting up an effective platform with the right financing instruments and technical standards. That's a major part of why emerging markets usually begin their foray into solar

FIGURE 19 SOLAR PV ROOFTOP AND UTILITY-SCALE SEGMENTS SCENARIOS 2021-2025



with tenders for utility-scale solar and frequently struggle to set up the distributed rooftop segment, even if politicians generally prefer PV on rooftops as it avoids any potential conflicts on land use. A good example of such a development is India, which targets 100 GW of solar by 2022 with 40 GW coming from rooftop solar. However, with less than 5 GW_{AC} of rooftop systems reportedly installed at the end of 2020, reaching this target is basically impossible. Not differently from 2019, the Indian rooftop market failed to grow in concert with its solar ambitions.

While the utility-scale segment dynamics have been quite varied across the world, rooftop solar has experienced growth almost everywhere. The most notable improvement comes from Vietnam, which entirely shifted its market segmentation towards distributed solar, with over 8 GW of rooftop systems installed in 2020 alone. Vietnam is a very encouraging example, showing that the solar industry is now ready to develop even more sophisticated market segments like rooftop PV from basically zero to world record levels in a very short time – all it needs is the right policy and technical framework conditions, and a workforce with the right skillset.

The more advanced rooftop solar markets – Australia, Japan, Germany, South Korea and Brazil – all installed more distributed capacity than the year before. Outside the top 10 markets, the segment saw notable contributions from mid-sized European countries, a region in which more than half of the annually installed capacity was made up of rooftop systems.

The impressive growth in the rooftop segment notwithstanding, a renaissance of ground-mount systems can be observed even in long-established solar markets like Europe. The trend towards tenders has been providing the basis for a big wave of ground-mount PV plants, like in Spain; but even in Holland, one of Europe's most densely populated countries, there is a boom for ground-mount installations, though land issues limit growth. The cost competitiveness of solar enabling merchant/PPA solar systems also drives the growth of the ground-mount segment. Two of Europe's very sunny and spacious countries, Spain and Portugal, have multi-gigawatt pipelines for such PV power plants. But even in Germany, a record size subsidy-free solar plant of 187 MW was partially grid connected last year, and several other projects are in the development stage. With solar's competitiveness further improving across the board (once the silicon supply issue is solved), the PPA segment will become a major driver for ground mounted solar. After a 2020 with marginal growth, we expect the global utility-scale market to reach nearly 100 GW and increase its share to 61% already in 2021, which could be even higher if the high silicon/module prices had not caused delays in planned projects. For 2022, we expect the utility-scale share to further increase to 64% and reach 130 GW. For the following years until 2025, it is forecast that utility-scale installations will make up to 169 GW globally – and more or less maintain their share. What could tilt the balance even more towards large-scale ground-mounted power plants are green hydrogen related solar power generation capacities that have been announced in several locations around the world, Australia in particular. That trend, however, is probably going to become visible only towards the second half of the decade.

Nonetheless, there's also strong momentum on the rooftop side of the sector. Both residential and commercial power consumers are beginning to evolve into prosumers, solar panels will turn into building materials, and smart cities will want to employ the advantages of distributed small-scale solar in combination with storage and digital solutions. California's decision of making solar a mandatory part of new-build homes as of 2020 has been followed by several other sub-national actors. In Germany, following the states of Hamburg, Bremen and Baden-Württemberg, the city of Berlin established in June 2021 a mandate to install rooftop PV on all new and renovated buildings. Despite the positive developments and the huge potential in the rooftop market segment, its shares are expected to decrease until 2022. Utility-scale solar has proven more resilient during the pandemic, and with the silicon shortage and high-price module phase assumed to end next year – according to our Medium Scenario — rooftop solar will slightly drop to 39% in 2021 from a 44% share in 2020, and will further decrease to 36%, a level it will basically keep until 2025. Still, in absolute terms, the market for rooftop solar is supposed to expand significantly over the coming years by nearly 60% to 96 GW in 2025 from 61 GW in 2020.

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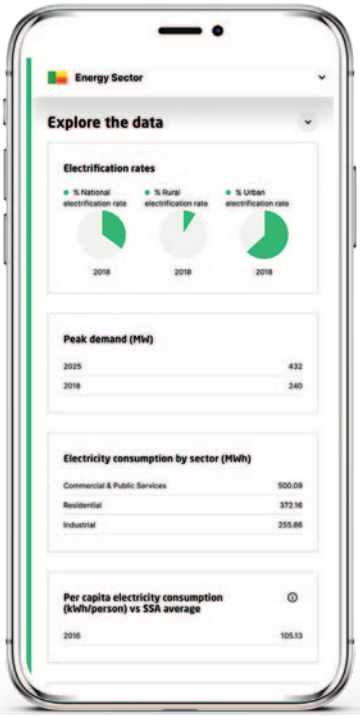

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2 Off-grid solar

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Introduction

Achieving the goal of universal access to affordable, reliable, sustainable, and modern energy by 2030 (UN Sustainable Development Goal 7) is a key target for emerging markets when laying the foundations for sustainable development. There are currently an estimated 759 million people worldwide without access to electricity and around 1 billion people with access to an unreliable grid. With progress on economic development and electrification stalling over the COVID pandemic, the World Bank forecasts roughly 100 million people in emerging markets and developing economies (EMDEs) will have fallen back into extreme poverty, increasing the importance of affordable electricity solutions. Off-grid solar installations, that are not connected to a utility grid, will be key in answering this energy demand and achieving universal energy access. While off-grid solar plays an important role in the electrification efforts of emerging economies, significant amounts of off-grid installations can also be found in the Global North. This section of the Global Market Outlook will investigate off-grid solar's role in supplying global energy needs in a sustainable and affordable way.

This chapter will be looking at three types of off-grid systems: solar home systems and small-scale applications (SHS); commercial and industrial installations (C&I); and mini grids. This is the first time that the Global Market Outlook is covering off-grid solar. Unlike for grid-connected systems that must be registered with regulators, data is not as readily available for off-grid installations, in particular C&I, somewhat larger self-consumption systems that are often installed without government support programmes. When calculating the amount of installed capacity of SHS installations, we also included installations covering small-scale applications, e.g., traffic lighting systems, to give a more complete picture of the total installed capacity in Europe and North America in particular. Given the growing attractiveness of low-cost solar in all off-grid segments, SolarPower Europe has written this chapter, with the support of GET.invest, to address this sector's contribution to global electrification efforts.

Chapter supported by GET.invest and GOGLA.

Market Analysis

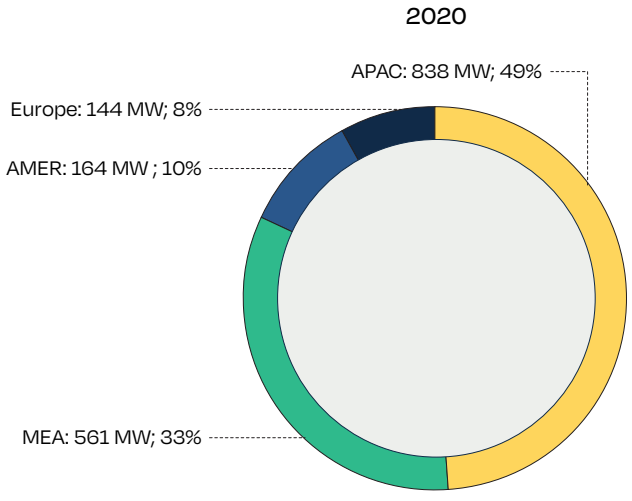
In 2020, the global installed capacity of off-grid solar continued to increase with more than 1.5 GW added. However, annual growth in new capacity only saw a 9% increase from 2019, whereas between 2017 and 2019, growth had consistently been in double digits. This slowdown can largely be ascribed to the effects of the COVID-19 pandemic, restricting the activities of businesses.

The most successful areas for the off-grid solar market are currently the Asia-Pacific and Sub-Saharan African regions, which made up over three quarters of the 2020 annual off-grid solar PV market collectively. This is largely due to the number of people and businesses that either do not have access to electricity or suffer from unreliable grid connection and the fact that off-grid solar forms a key pillar of national electrification efforts.

The total capacity of off-grid solar installations has risen rapidly from the early 2000s to nearly 10 GW in 2020. Instead of being stymied by increased efforts to bring on-grid power to people, off-grid solar is increasingly seen as the ideal partner to electrification efforts. For example, mini grids are used to provide "last mile" electrification to remote communities where grid expansion would be highly expensive and time consuming, the same applies for SHS where grid expansion is similarly impractical. Meanwhile, off-grid C&I provides a commercially viable, renewable energy alternative to expensive and unreliable on-grid power for businesses. In the effort to reach universal electrification by 2030, off-grid solutions provide a cost-effective way to electrify areas efficiently.

This growth has been supported by policy and financing instruments, at both the international and national level, that reflect a growing understanding of the sector's importance and the range of instruments required to support it. Internationally, increasing recognition of the importance of off-grid solar energy solutions, particularly in rural electrification, has led to a growing number of grants being awarded for the deployment of SHS in particular. This has allowed many off-grid companies to expand into new markets, especially within the Sub-Saharan African region. In terms of SHS, a further driver of growth is the recent shift away from low wattage lighting products to more expensive systems. This has been made possible by the reduction in cost of solar equipment for the consumer, with business models shifting towards Pay-As-You-Go (PAYGo).

FIGURE 20 ANNUAL OFF-GRID SOLAR PV MARKET SHARES 2020.



Solar investors in emerging markets face various economic, financial, institutional, and technical challenges, including limited political will and institutional capacity, political and economic instability, a lack of transparency, ineffective regulatory frameworks, and poor grid capacities. Fortunately, there are several international support bodies and instruments that exist to help overcome these obstacles. One of these instruments is GET.invest, a European programme that supports investments in decentralised renewable energy, supported by the European Union, Germany, Sweden, the Netherlands, and Austria. Services include market information, a funding database, matchmaking events and access-to-finance advisory via the GET.invest Finance Catalyst.

GET.invest works across several market segments, including mini grids, C&I, and SHS. Another example is the Electrification Financing Initiative (EDFI ElectriFI), an EU-funded impact investment facility that finances early-stage private companies and projects. EDFI ElectriFI's aim is to support investments that increase and/or improve access to modern, affordable and sustainable energy services, in particular for populations living in rural, under-served areas as well as regions affected by unreliable power supply. A further popular model for providing international support is through strategic partnerships between several organisations, such as EnDev. EnDev brings together likeminded climate change and development organisations to support social and economic development by providing access to modern, renewable energy.

On a national level, the off-grid solar industry has increasingly benefited from preferential policies. These can range from large scale support in the form of dedicated national electrification plans, to specific policies such as concessionary systems, upfront subsidies including results-based financing, and targeted tariff exemptions.

Future sector growth is likely to go hand-in-hand with technological advances in the off-grid sector. In the SHS sector, the trend of improving quality standards, leading to more expensive SHS being sold via affordable PAYGo models, is likely to continue. Increasingly, solar PV is being used for commercial ends. Water pumps used for agriculture, and refrigerators used by small businesses are both examples of products that can be powered by solar PV, and fall under the productive use, or PULSE (Productive Use Leveraging Solar Energy), category. Expansion is expected in the PULSE and appliance sectors as solar systems increasingly require less energy to operate, resulting in a decrease in costs. As more investors realise the potential of this sector, it is likely that these advancements will be backed by increasing levels of dedicated financing, including risk-based financing to de-risk early development of these segments, higher availability of convertible debt, and more early-stage equity. Alongside these, the presence of local currency financing is due to increase as local lenders and investors gain a better understanding of the off-grid sector. This is vital as it makes debts more serviceable for companies and keeps the price of off-grid power solutions low.

It is expected that existing business models will continue to evolve from micro-utility models, whereby off-grid solar products are rented, to lease-to-own models. Whereas now the market is dominated by larger, vertically integrated players, an increasingly diverse range of business models will create the potential for SMEs to specialise, allowing for growth at scale. However, larger, already vertically integrated companies are likely to receive increasing interest from strategic investors like ENGIE – providing impact funding to energy access companies, with stakes in mini grids in Tanzania, Zambia, Myanmar, and Somalia. In a bid to improve proximity to end users, more and more players are expected to specialise in "last-mile distribution" in tandem with strategic partnerships in the value chain (suppliers, PAYGo platforms, financial institutions). This will have the added benefits of decreasing customer acquisition costs and improving the quality of PAYGo sales portfolios.

As the market continues to grow, policymakers will become more aware of the significant contribution that off-grid solar can make towards universal energy access. This will see the sector's role in future energy planning increase. With positive examples of the benefits of off-grid solar across the SHS, mini grids and C&I segments, it is anticipated that policymakers will look to simplify regulatory frameworks to create an enabling environment for the sector. Effectively modernising rural electrification policies will also require a significant amount of support from donors in terms of technical assistance and capacity building for staff in public institutions, especially in Sub-Saharan Africa.

Outlook

While the impacts of the COVID-19 pandemic are yet to be fully known, there are some things that we can ascertain thus far about how the pandemic has affected the off-grid sector. Typically, SHS and mini grid users tend to come from lower income households, holding precarious employment in informal labour sectors. These sectors have been disproportionately affected by the restrictions imposed by national governments to combat the spread of COVID-19 and, as a result, the World Bank estimates that around 100 million people have fallen back into extreme poverty. This would have had a knock-on effect on customers' ability to afford SHS, even on a PAYGo basis. In general, though, every sector saw setbacks after consistent growth since 2010, when IFC released its first off-grid lighting report. However, resulting from the pandemic has been a desire to build back better and greener that has accelerated the development of programs, incentives, and international financing for off-grid solar, particularly in the SHS and mini grid segments. According to SolarPower Europe's medium growth scenario, cumulative global capacity will maintain double digit growth through to 2025, highlighting the sector's resilience and importance in universal electrification efforts.

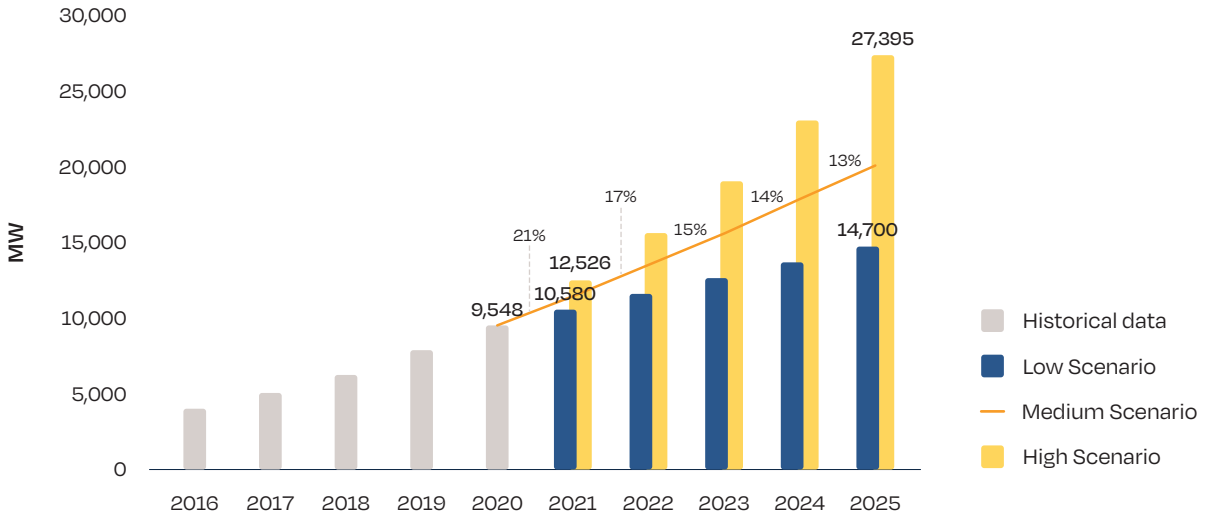
Hottest off-grid solar markets

Sub-Saharan Africa

Off-grid solar is particularly important in Sub-Saharan Africa, given that with 46% in 2019, the region has the lowest energy access rate in the world. This proportion is likely to grow as the economic effects of the COVID-19 pandemic manifest themselves. There are several more established off-grid markets in the region, such as Kenya, South Africa, and Tanzania. More recently, newer markets have also seen significant growth as the cost of off-grid solar has dropped. This has also led to the integration of off-grid solar into several national electrification strategies.

Kenya is one of the more established markets in Sub-Saharan Africa. Its SHS market is also one of the largest in the world, helped by strong government backing of off-grid electrification. The Energy Act of 2019 promotes the use of renewable energy and removes the requirement for a license for self-consumption systems under 1 MW. Similarly, the Kenya Electricity Sector Investment Prospectus 2018-2022 presents clear investment and financing opportunities for off-grid electrification. The Kenyan government also helped to mitigate some of the potential effects of the national lockdown during the

FIGURE 21 GLOBAL CUMULATIVE CAPACITY OF OFF-GRID SOLAR 2016-2025



COVID-19 pandemic by designating power generation (including off-grid solar) as an essential service. This allowed SHS companies to continue their work as normal, albeit facing increased supply chain difficulties due to the lockdown. In line with their pro-SHS stance, the government also abolished charges on making mobile microtransactions under 1000 KSH (10 USD). However, the initial economic repercussions of the COVID-19 pandemic have led Kenya to announce a new 14% VAT rate on off-grid products, rising to 16% in 2021.

The country is home to a well-developed mini grid sector. Its initial growth is largely thanks to the widespread use of MPesa, a mobile money platform making payments more secure and reliable. Kenya was also one of the earliest countries to introduce supportive policies for mini grid development, initially consisting of allowing small projects to operate with minimal oversight. However, this has transformed into dedicated programmes such as the Kenya Off-Grid Solar Project, which aims to provide electricity to 27,000 households in the least developed parts of the country by working in partnership with private companies. While the Kenyan government will own the assets, private companies will build and operate them. Other projects include the Renewable Energy Performance Platform (REPP) providing 3 million USD of results-based financing to a project that looks to build 100 mini grids in Kenya, adding a total of 1 MW of generating capacity.

A relatively nascent market segment, developments in off-grid C&I are less documented than in SHS or mini grid segments. To date, Kenya boasts one of the largest C&I markets in Sub-Saharan Africa. While data on the exact proportion of on-grid to off-grid C&I in the country is scarce, the country's relatively high grid electricity tariffs, combined with a tax supported programme, have incentivised growth thus far. Project developers expect future demand for C&I installations to come from the manufacturing, agricultural and horticultural sectors.

South Africa is another large market in Sub-Saharan Africa. However, given its comparatively advanced on-grid system, the SHS segment of the market is much smaller proportionally than in other countries. According to the country's 2019 Integrated Resource Plan, there are still 3 million households without access to grid-based electricity. The government plans to electrify these areas with a combination of SHS and mini grid technologies. Currently, the government is quantifying the off-grid opportunity so that they can design policies and frameworks to accelerate rural electrification and use of off-grid technologies. It is worth noting that off-grid electrification is seen as a temporary measure, until it becomes possible to establish grid connections economically. There is a well-established concession scheme in South Africa that has been running since 2001. Under this system, six concessionaires have been tendered to provide electricity in the KwaZulu Natal, Limpopo and Eastern Cape regions. The concession regime gives the concessionaire exclusive rights to supply energy services for five years, with a total service contract length of 20 years. Customers are expected to pay for connections and a monthly service fee for the operation and maintenance of the system. To speed up electrification and improve energy access, the Department of Energy allows municipalities to apply for off-grid electrification services in their areas. In further support to off-grid electrification, the Department of Energy subsidises the entire cost of SHS. South Africa also has the largest C&I segment in Sub-Saharan Africa thanks to the simplification of permissions by the government for projects below 1 MW.

Nigeria's off-grid market has experienced rapid growth recently. The SHS segment seems destined to grow further with the Nigeria Renewable Energy Master Plan aiming to deploy 4 million solar home systems by 2025. SE4All's Agenda for Nigeria foresees a combination of mini grids and SHS creating 8 GW of additional capacity by 2030 (almost 20% of total capacity). The worst effects of the COVID-19 pandemic were mitigated by the off-grid sector being declared an essential service, thus avoiding the restrictions placed on other sectors. The mini grid sector benefits from a largely supportive policy environment. The development of a multi-year tariff calculator has provided developers with more certainty around the economic viability of projects. Similarly, the 2017 Mini Grid Regulation allows for smaller projects of less than 1 MW to apply for a permit that allows for protection against grid encroachment. Nigeria has dedicated funding instruments to support its strategy for rural electrification. The government has earmarked 150 million USD for two phases of mini grid projects: a minimum subsidy tender, ongoing since 2018, that

targets the electrification of rural areas with a high growth potential; and a results-based grant that rewards the development of mini grids, through developers' own initiatives, with 350 USD per connection. C&I is also popular in Nigeria given the large corporate sector in the country and problems with frequent and extended power cuts. The off-grid C&I segment is boosted by licences not being required for projects up to 1 MW. In terms of future developments, in its SE4All Action Agenda, the Nigerian government plans to have 5,000 MW of C&I installed by 2030, although the proportion of on-grid to off-grid installations is not clear.

Senegal was one of the earliest countries in Sub-Saharan Africa to develop supportive policies for off-grid solar. The SHS market in Senegal is growing quickly and while cash sales still dominate, PAYGo sales have managed to penetrate the market successfully. Government policies from the late 1990s developed a reliable framework for private development of SHS, which attracted a lot of investment to the sector. During the COVID-19 pandemic, the Senegalese government also designated off-grid solar companies as an essential service, largely exempting them from the restrictions imposed during national lockdowns. Senegal provides fertile ground for mini grids, not least because of its typically dense rural communities. Mini grid development is organised through a concession system. The Senegalese concessionary system has been operational since 1998 but cumbersome bureaucratic processes meant it took five years to award the initial concession and a further five to connect the first household. Similarly, developers claimed that Senegal's ten concession regions were too large to effectively carry out electrification projects. In 2018, the Senegalese Regulatory Commission for the Electricity Sector (CRSE) was tasked by the government to conduct an audit of the concession system in an attempt to better understand the obstacles facing concessionaires. The Senegalese government is currently considering reforms to the system based on the audit results. Those areas not covered by the concession system fall into the remit of the Local Rural Electrification Initiative (ERIL) programme that encourages village level, community led projects for electrification. The off-grid C&I segment in Senegal is not well documented. However, given problems around persistent power outages, it is likely that off-grid C&I installations are particularly attractive to SMEs in the country. A key policy in support self-generation is that excess electricity can be sold to the national utility SENELEC. More recently, in March 2019 it became possible to sell excess power to actors with a consumption of 1 MW or over.

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Tanzania, along with Kenya, is responsible for the initial growth of the Sub-Saharan African off-grid sector and, as such, has a reasonably developed market. Its SHS sector was known for its volatility but stabilised and experienced steady growth from 2017 – 2019. It is still uncertain how the market will respond to the COVID-19 pandemic but there are already encouraging signs suggesting that it may be able to bounce back. The SHS sector is only loosely regulated, with a requirement for companies to inform the national regulator of their activities. There is also a requirement for products to meet the Lighting Global standards for small renewable energy and hybrid systems for rural electrification. While Tanzania's policy framework had previously been supportive of mini grid development, recent, ongoing regulatory changes will have an impact on the previously agreed tariffs, potentially affecting the financial viability of projects. However, the mini grid market still continues to innovate and 2019 saw the launch of the first project financing facility for mini grids with an initial funding commitment of roughly 16.5 million USD. Moreover, a special purpose vehicle (SPV) has been set up to purchase existing and future mini grids from PowerGen Renewable Energy, helping to source long term financing for sites and enable the developer to break new ground. Tanzania has a favourable policy environment for C&I with generators able to sell excess energy to the grid and balance their use through net metering. On top of this, smaller generators are exempt from more burdensome licensing requirements, while the operational cost savings are attractive for larger generators. While available data does not clearly distinguish between off-grid and on-grid solar, given the relatively low electrification level in Tanzania (38%) it is reasonable to assume that these trends stand for off-grid C&I in general.

Uganda places a high strategic importance on providing access to modern energy services through renewable energy. As such, the domestic SHS market is thriving, with uptake increasing. This has also been supported by policies such as a removal of VAT on solar products in 2005, with the aim of reducing prices. Mini grids are another key pillar of Uganda's Rural Electrification Strategy and Plan (RESP) which targets 8500 connections from mini grids by 2022. Currently a mini grid specific regulation and tariff calculation methodology are under development. The country's Rural Electrification Agency (REA) supports developers by providing the distribution infrastructure for mini grids (including network installation and establishing connections) free of charge, providing they fall within an REA area of interest. This significantly reduces the CAPEX of projects. Uganda's C&I market is also worth noting, given the extent of its development – there are roughly 30 installers and suppliers active in the country. Most C&I installations focus on farming and office blocks.

There are several other notable players in the Sub-Saharan African region. **Zambia** has a particularly vibrant SHS market, where both demand and uptake had been growing steadily before the COVID pandemic. This growth was helped by reasonably light regulatory requirements and licensing processes. **Côte d'Ivoire** also has a steadily growing SHS market. The government is currently developing an off-grid strategy. However, it is prioritising rural electrification through grid extension in the country. It is worth noting that the criteria for being included in grid extensions would leave a population of roughly 5 million people without grid connection. **Ethiopia's** SHS market is one of the largest in Sub-Saharan Africa. While the government aims to have practically the entire population grid-connected by 2030, the effects of the pandemic may mean that SHS will need to bridge the gap in the interim until grid extensions can be completed. It is expected that around 35% of houses in Ethiopia will be powered by off-grid systems until grid connections can be achieved, with 16% of those houses being powered by mini grids. Thanks to the development of a tariff calculator for mini grids and the establishment of the Universal Energy Access Programme, which makes provision for IPPs, private sector participation in the mini grid sector is becoming increasingly possible and easy. A recent call for proposals was released for 25 sites, as the first tranche of a plan to develop roughly 300 mini grids. With some of the highest electricity tariffs in Sub-Saharan Africa, it is no surprise that **Ghana** has a particularly active C&I market. However, the growth of this market is somewhat limited by domestic content rules and interest rates of around 30% for Cedi (local currency) loans. **Namibia** also has a highly dynamic C&I market, driven by the need for a reliable energy supply. Namibia's national grid is powered by the South African public utility Eskom and outages have become more frequent in recent years. The bulk of C&I installations are centred on commercial, tourism, manufacturing, and extractive industry sectors, with shopping centres becoming an increasingly important sub-segment for the C&I market.

Asia Pacific

The Asia Pacific market is a more developed market than the Sub-Saharan African one and has been in existence since the early 2000s. Despite concerted efforts on the part of national governments to improve on-grid electrification, in India and Bangladesh in particular, technical limitations mean that off-grid solar is considered as a complementary technology to grid extensions. Meanwhile, the Pacific Islands have long been dependent on importing expensive fossil fuels to meet their energy demand. However, many are now transitioning to a renewable energy-dominated energy mix.

The **Pacific Islands** represent a high growth potential for off-grid solar, with many island nations looking to reduce their dependency on imported fossil fuels. There are several programmes run by the Asian Development Bank (ADB), that look to promote the uptake of renewables. For example, the Pacific Renewable Energy Investment Facility streamlines ADB and other DFI investments in the 11 small Pacific Island nations. Combined, the facility deploys around 700 million USD for small-value renewable energy projects. Alongside this, the facility also oversees energy sector reforms, promotes private sector engagement and investment opportunities, prepares further investment channels, and disseminates best practices and lessons learned. The ADB also provides capacity building and advises on energy sector reform with a view to increasing investment. They also seek to encourage private sector investment through the Pacific Renewable Energy Programme. Here, the ADB uses donor funds to underwrite the payment obligations of power utilities. This is designed to mitigate any short-term capital risk and encourage long-term investment through a partial risk guarantee.

In terms of specific Pacific Islands projects, **Tonga's** Outer Island Renewable Energy Project is seeking to convert four community-owned diesel mini grids on the outer Ha'apai islands into solar-diesel hybrids. The mini grids range in size from 70 kW to 150 kW. The project also seeks to expand the existing SHS capacity in Niuafo'ou and Niuatoputapu with an additional 180 kW of systems. In **Micronesia**, a hybrid solar-diesel mini grid is being updated in Walung with an additional 60 kW of solar PV generation, 30 kW of diesel generation and 30 kW, or 160 kWh, of battery storage.

Papua New Guinea has benefited from the *Pawarim Komuniti* programme, launched by the Australian Department for Foreign Affairs and International Trade. This scheme offers grant funding to off-grid projects in remote areas of Papua New Guinea. The programme is a part of the wider PNG Electrification Partnership programme that has the goal of delivering energy access to 70% of the country by 2030.

Bangladesh is a traditionally strong market in the region, with a well-established, national level SHS programme targeted at rural populations not yet served by grid connections. This programme started in 2003 and ended in 2018. Over this timespan, over 4.1 million SHS were sold, bringing energy access to around 20 million people or 14% of Bangladeshis. In total, 1,095 million USD was invested over the project's lifetime. Several development partners provided foreign currency grants and loans on soft terms to the government of Bangladesh, which then converted this into local currency funding to provide loans on soft terms to the implementing organisation, the Infrastructure Development Company Ltd (IDCOL), to, in turn, provide loans to partner organisations that marketed, sold, installed, and maintained SHS to rural households in Bangladesh. These loans reduced the burden of the total cost paid by the consumer. Bangladesh's 2016 Power System Master Plan foresaw total electrification in Bangladesh by 2021. However, currently, electrification stands at 85%, suggesting that there is still room for investment in off-grid solar solutions. Given recent advancements in grid extension, the need for an off-grid C&I segment is lower. However, the government does provide for power purchasing from C&I installations, but the tariffs are anchored at same level as the Bangladesh Power Development Board.

India has several programmes in place to support the uptake of off-grid energy, mainly through solar PV. In 2015, the *Deen Dayal Upadhaya Gram Jyoti Yojana* (DDUGJY) programme was launched. DDUGJY supports the off-grid electrification of rural India. This particular scheme is mainly aimed at mini grid development. India's National Solar Mission has a target of installing 2,000 MW of off-grid solar for areas where grid extension is not economically viable. In 2017, the Ministry of New and Renewable Energy launched the Off-Grid and Decentralised Solar PV Programme to support this aim. The programme delivers SHS, solar streetlights, solar pumps, and lanterns to rural areas. In

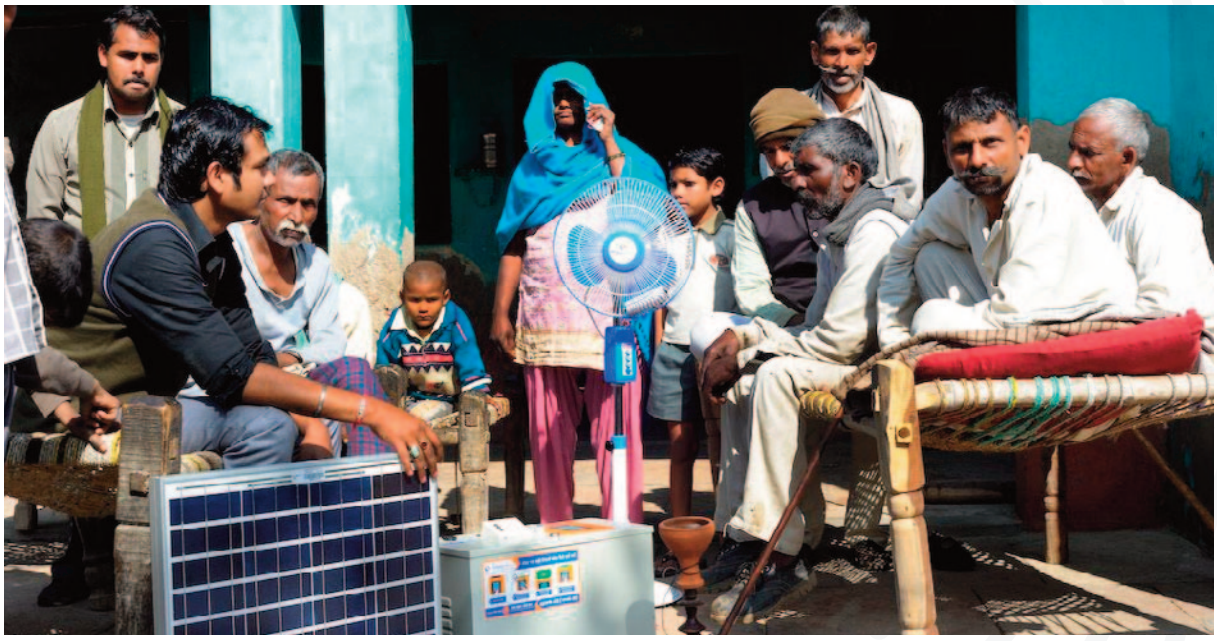
December 2018, the second phase of the *Atal Jyoti Yojana* (AJAY) programme was launched to provide financing and installation of over 3 million solar streetlights around the country. In 2019, the Indian government launched the PM-KUSUM scheme. The programme has three components, one of which includes supporting farmers without grid connections to replace 1.75 million old diesel-powered pumps with off-grid solar pumps. While the off-grid C&I sector is not widely reported on, EDFI ElectriFI recently invested 2.68 million EUR in an Indian C&I rooftop firm, called Candi, which provides installation and O&M services for off- and on-grid clients. Candi offers substantial savings to SMEs compared to grid power. However, the C&I market in India is suffering from a lack of suitable financial solutions like longer tenor debt financing for assets.

Pakistan's off-grid solar market is still nascent. However, this is likely to change in the coming years, thanks to the 2019 Alternative & Renewable Energy Policy. The policy identifies several regulatory barriers for off-grid solar, such as SHS, mini grids and off-grid C&I having to use the same licensing regime as utility-scale solar. The policy calls for the National Electric Power Regulatory Authority to design a more streamlined and bespoke licensing procedure for off-grid renewables. Projects in the country include the Sindh Solar Energy Project that was financed by the World Bank. This initiative provided 200,000 SHS to people in districts with low energy access. The main funding source for off-grid projects in Pakistan are micro-finance institutions. These were particularly affected by the COVID-19 pandemic, the implications of which threatened to derail the off-grid market. However, the German development bank KfW released the first tranche of 17 million USD loan to the Pakistan Microfinance Investment Company and this should stem cash flow issues in the short term.

There are several other interesting off-grid markets in the APAC region. **Vietnam** suffers from relatively high electricity tariffs and there is a burgeoning interest in off-grid C&I power solutions. **Thailand** has the most mature off-grid C&I sector in the Asia-Pacific region due to high electricity tariffs and relaxed regulations around private PPAs, making this segment particularly popular and wide-spread.

Other regions

While this chapter has focused predominantly on off-grid solar in the Asia-Pacific and Sub-Saharan African regions, this is not to say that there are no developments in other regions. In 2020, the **Middle East and North Africa (MENA)** region installed 192 MW of off-grid solar and the rate of growth of off-grid solar PV is expected to increase until 2023. In **Saudi Arabia**, the



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Mutajadedah project, designed by the Saudi Industrial Development Fund, offers 12 years of funding for off-grid C&I installations with a three-year grace period and low interest rates. The country is also due to open a new battery production facility that will produce storage systems for telecom towers, mining sites, remote cities and off-grid locations. **Central & North America** saw over 100 MW of off-grid solar installed in 2020. However, this growth rate is likely to remain sluggish in the future. Countries with high potential for off-grid solar in the region are **El Salvador, Guatemala, Honduras, Nicaragua, and Panama**, because of the relatively low levels of electrification and the high price of diesel generation in comparison to the rest of the region. A similar story can be told for **South America**, where installation growth has fluctuated around 30 MW per year since 2015. Interestingly, this rate of growth is expected to increase markedly between 2023-2025, posting double digit figures of over 20% according to SolarPower Europe's medium scenario. Notably, **Colombia and Peru** have large rural populations and high diesel generation prices compared to the rest of the region, making them attractive potential markets for off-grid solar. **Uruguay**, despite its 98% electrification rate, has the highest diesel prices in the region, making it a potential market for the off-grid C&I sector. In **Europe**, over 100 MW of off-grid solar was installed in 2020. The most popular applications include off-grid C&I for companies looking to improve their sustainability and reduce the cost of their energy bill and residential off-grid solar projects in the **Scandinavian** countries in particular.

Market segments

Solar Home Systems

While the SHS sector has been around for over 20 years, it has evolved rapidly very recently, growing from 1 billion USD annual turnover in 2018 to 1.75 billion USD in 2019. With 759 million people globally without access to electricity and 1 billion people with an unreliable connection, there is a ready-made market of 1.8 billion people for whom SHS could provide better quality power solutions. Despite rapid electrification progress around the world, SHS play an even more important role in the national and rural electrification strategies of several governments. This is because SHS are increasingly being seen as the ideal partner to electrification efforts. For example, SHS can play a vital role in electrifying remote communities where grid expansion would be expensive and time consuming. In the early 2000s, SHS products comprised simple, low wattage lanterns (0–3 W). However, thanks to technological improvements and the lower cost of solar

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technology, the range of products now includes more sophisticated and efficient SHS of over 100 W, capable of lighting a home and powering several appliances.

From cash sales to PAYGo

The longest standing SHS business model is a cash payment upfront and, given the relatively inexpensive systems at the lower wattage end of the SHS scale, this remains the predominant business model in this segment. However, a more recent driver of growth has been a shift away from these lower cost items in favour of more expensive products based on a pay-as-you-go (PAYGo) basis, improving the financial sustainability of the sector. At their base, PAYGo systems offer credit to customers, removing the initial financial barrier of purchasing an SHS and instead paying the cost in more manageable instalments. There are three main categories of PAYGo companies: **distributed energy service companies (DESCO)** that provide a stipulated level of energy service in exchange for payments; **rent-to-own companies** who retain a certain level of ownership of an SHS that transfers to the customer once they have paid for the system in full; and **B2B companies** that supply software and hardware support across the SHS value chain (installation, maintenance, last-mile energy service and payment logistics).

SHS financing

There are three main sources of financing for the SHS segment: **international grant funding**; **debt funding**; and **equity funding**. The sector witnessed a record level of grant financing in 2020 (29 million USD) according to GOGLA. This was designed to help existing companies enter new markets and try new business models and products. It was also used to fund early-stage companies. Some of the grant funding increase can be attributed to the electrification of rural health centres as vital frontline services during the COVID-19 pandemic. In comparison, the share of equity financing in the overall blend plummeted by nearly half. This fall can be directly linked to the effects of the pandemic – the difficulties of completing equity transactions was increased during the pandemic as the ability to undertake due diligence on the ground during corporate acquisitions was severely hampered. Debt financing absorbed this loss, increasing its share in the finance blend from around 54% in 2019 to 65% in 2020. GOGLA attributes the majority of debt investments to impact investors, DFIs, and crowdfunding platforms, suggesting a growing importance of the social impacts of off-grid electrification in the minds of debt providers.

While the full economic effects of the pandemic are yet to be felt, the relative stability of capital flows during this period is a reassuring sign of investors' confidence in the off-grid industry's business model and ability to deliver impact. Finally, local currency financing is expected to play a bigger role in the future, as off-grid solar gains importance in national electrification efforts and expertise develops among local finance institutions.

CASE STUDY 1: AMPED INNOVATION PBC

Supported by:

150 W off-grid SHS powering 50,000 households across Sub-Saharan Africa and Southeast Asia

Amped Innovation's products are targeted at lower income areas that do not have grid connection. They fill an affordability gap that exists between solar lanterns and having access to significant levels of power that would provide a basis for earning additional income. Their focus is on a bottom of the pyramid market that is significant in size and where the opportunity for impact is huge.

Initially, Amped Innovation struggled with the assumption of several other off-grid market players that solar powered appliances would not gain customer traction or generate enough revenue to make their business sustainable. Furthermore, initially a lot of companies in the off-grid sector were vertically integrated which made finding distribution partners hard for Amped Innovation. However, through specialising in design and production, they were able to reduce their need for financing and provide the blueprint for a model that could easily be scaled if they found willing investors.

Amped is a venture-backed B2B social enterprise that sells Solar TV, Lighting, and Business Kits through dedicated distributors in over 20 low-income countries. They produce these solar appliances and use a network of last-mile, PAYGo enabled distributors to get their products to the areas where they are needed. They also use this network to get intelligence on demand for new products and use this in future designs.

Amped receives equity funding from FINCA adventures, which it considers a particularly good match as FINCA specialises in investing in early-stage companies with business models where social impact and revenues grow together. As an unbundled company, it also makes sense for Amped to get specialist equity investors on board who can apply their expertise when needed.

Compared to other tech industries, the energy access sector has generally suffered from a lack of fundamental innovation. This is not surprising given that many companies are reluctant to invest R&D into a customer segment that earns less than 4 USD per day. Meanwhile, Amped has doubled down on designing appliances from the ground up exactly with these users in mind, with the belief that building a brand that stands for performance, quality, and affordability will unlock a massive user base that is worth the investment.

Amped televisions are built with custom, high-efficiency LED strips, custom LED control circuitry with smart energy control, built-in PAYGO, and motherboard firmware that limits excess power draws. The Amped solar generator has no fragile parts, and it is heat and dust proof. Unlike other solar inverters, Amped claims it can run daily and productive use appliances, including large fridges with compressors, grinders, and belt sanders. The Amped solar generator is affordable due to its minimalist design (one-tenth the components of competing systems) and comes with built-in payment plans, meaning the cost is recouped within a year.

Amped does not see electricity as an end in itself but as something that can be used to power things that improve productivity and quality of life. Their product line is expanding to include inexpensive productive use appliances like solar-powered icemakers, water pumps and maize grinders, allowing clients to generate income. The hope is then that this can contribute to people moving out of poverty.

A customer in Uganda uses their newly installed Amped Innovation SHS to charge their phone. © Finca.

CASE STUDY 2: NAMENE SOLAR

Carbon offsetting with solar lights

Just over 53% of Namibia's total population have access to electricity. In Zambia, that number is less than 40%. Without reliable power, many families light their homes with toxic and expensive carbon-polluting kerosene lamps. These customers represent a huge market opportunity, to simultaneously give millions of people first-time access to modern energy, and cut carbon emissions.

Namene Solar's Gold Standard-certified carbon offsetting projects in Namibia and Zambia are financed by the sale of carbon credits. These are generated by the carbon savings of the solar lights, with every solar light certified to reduce CO_2 emissions by 92 kg per year. But the impact of each light goes far beyond cutting emissions.

The solar lights are designed to be easily and rapidly deployed at scale, through community hubs that simplify distribution to rural and peri-urban areas. They are pocket-size and lightweight, while also being versatile and durable. They are designed for use both indoors and outdoors with two brightness settings - 34 lumens for 5 hours of use, or 13 lumens for 16 hours of use, and charge via an inbuilt PV panel.

Through carbon financing, the lights can be subsidised which makes them truly affordable, without the need for a debt burden, for low-income customers in off-grid and rural areas. Customers that purchase a light immediately benefit from a renewable source of light that eliminates the cost of fuel for fossil-fuel lighting. They also cut the risk of respiratory disease from indoor pollution and no longer live with the fire risk of open flame lighting, like candles. The lights also give children in off-grid homes a chance to study safely after sundown, without the danger of fire from candles or the irritation to their eyes from the toxic, low-quality light given off by kerosene lamps.

A significant challenge in the development of the project is the lengthy process to certify each project on a country-by-country basis. As a team, Namene Solar were required to submit several rounds of consultation, evaluation and data monitoring to adhere to the highest standards in the voluntary carbon market.

But commitment to the project's outcomes and perseverance through the process is the key to the success of the projects. The first carbon certificates are expected to be issued in Q4 2021 from the 1.3 million solar lights currently being distributed across Namibia and Zambia, and yet more projects are being developed across Africa. This network of carbon offsetting solar light projects is just one of the ways that Namene Solar is bringing affordable, reliable solar to off-grid homes.

Namene Solar lights save 92kg CO2 each year by replacing fossil fuel-based kerosene lamps. © Namene Solar.

Mini grids

The mini grid market is also not a particularly new one, given that, at some point, all power generation was decentralised. Today, evolution has reached what is commonly known as the third generation of mini grids that are either run exclusively (or partially, as is sometimes the case with hybrid systems) on renewable energy, compared to the second generation, built predominantly in 1980s–90s and powered either by fossil fuels or by hydro power, and the first generation, built in 19th and 20th centuries in industrial economies and later converted into centralised grids. While SHS are particularly useful in remote areas with low population density, mini grids provide an effective way to power areas that are too expensive for the main grid to reach, but that have a large enough population and demand for power supply. Mini grids are significantly more expensive than individual SHS systems, with cabling for each connection constituting an additional issue that affects overall cost. Therefore, demand for energy must be sufficiently high to make a mini grid-based solution viable. Given that energy demand is greatest at night, solar PV mini grids rely on battery storage to supply consumption. Battery storage is a key component of any mini grid system.

There are several possible business models for mini grids that highlight the adaptiveness of the market in different contexts. Perhaps the most common category of business model is the utility operator model, whereby a national utility owns and operates mini grid systems, charging customers for the supply of electricity. These charges can be equivalent to electricity payments for grid-connected electricity supply, but, given the nature of communities that mini grids serve, they are sometimes subsidised by charges paid by on-grid customers. Public-private partnerships are also common in the mini grid market. In this model, mini grids are owned and financed by a public sector entity but are operated by a private company. Where the government has no role in the ownership of a mini grid, they often provide incentives and subsidies to developers to construct, own and operate the mini grid. These can come in the forms of preferential loans or grants or as results-based financing that provides a lump sum when project milestones are reached. In very limited cases, ownership of the mini grid lies with the local community it serves.

There are three key types of finance in the mini grid segment: debt; equity; and grants. Within these, there are multiple financing structures available. Grants tend to come in one of two forms, either as results-based financing or an upfront payment, paid by the host government and supplied through development finance institutions (DFIs) and other donors. The advantage of grant funding is that it provides a quick way to recoup the CAPEX of a project and any repayment terms are likely to be more favourable to the developer than standard commercial loans. At the same time, applying for grant funding is highly competitive and often the proportion of CAPEX recouped is not particularly high. This, in turn, is why most mini grid projects are funded through a mixture of grants and equity finance.

Equity finance can be raised through various avenues, including capital that belongs directly to the developer, or through private equity. Most equity investors in the mini grid sector are early-stage impact investors that put an emphasis on the social transformation achieved by projects. Raising equity financing can be easier than competing for grants, but investors expect a return on investments and will be less likely to fund developers who do not have a more extensive track record.

Far less common in the mini grid market is debt funding. The main sources of debt are still preferential loans provided through DFIs and national governments. While these usually have lower interest rates and a longer repayment period, they tend to be provided in USD and can be hard to repay when the exchange rates of local currencies, in which the developers are paid by customers, fluctuate. While still uncommon, specialist debt providers are increasingly investing in projects. Given that mini grids tend not to be very large scale, developers will often bundle a series of individual projects together in a portfolio to improve investment attractiveness.

CASE STUDY 3: HAVENHILL SYNERGY LIMITED

Supported by:

Delivering last mile electricity connections to 10,000 people in Nigeria

Over 90 million Nigerians currently live without electricity. The majority of these people live in off-grid communities across the country. Nigeria's currently unstable grid extension plan and the inefficiencies in the power sector present an immense opportunity for private businesses, like Havenhill, to deploy solutions to fulfil electricity demand.

To improve energy access, Havenhill Synergy Limited, is designing and deploying smart solar mini grids in growth-ready communities. The first step in the process involves the identification of communities, where the potential for economic development is high, from the Rural Electrification Agency of Nigeria's dataset of over 10,000 communities. Havenhill identifies these communities using GIS tools, local government sources, and on-site inspections.

Once eligible communities have been identified, the company then conducts a thorough energy assessment to make a final selection. This process then leads to the design of the energy system to be deployed in each community.

So far, Havenhill has four mini grids in operations which currently serves the energy needs of over 10,000 people. The Kigbe solar mini grid combines 20 kW of solar PV generation with lead acid battery storage. The mini grid in Kwaku is slightly larger at 30 kW and runs on a solar and 90 kW storage model. Yebu's is larger still at 40 kW with 144 kW of storage. The largest is the Budo-Are mini grid which is 100 kW in size and is a solar-diesel hybrid generator.

Passionate about its mission to "end blackout" in Nigeria, the company has recently commenced its commercial scale-up phase with plans to scale its mini grid solution to a minimum of 100 communities in Nigeria. In March 2021, Havenhill closed a debt funding of 4.6 million USD from the Chapel Hill Denham managed Nigeria Infrastructure Debt Fund. With the funding structured through an asset HoldCo, the company aims to deploy its system to 22 communities.

Havenhill operates a utility model across host communities. The users pay for the electricity they consume. Each customer's premises is equipped with a smart meter which helps the company with billing and effective customer service.

Though Havenhill has big ambitions for its energy access projects, the business model is not without challenges. First, project development activities cost a lot of money. So, during its early days, the company had challenges with funding this huge cost. The grant from the United States Trade and Development Agency helped ease this challenge. Another major challenge faced by the company is the lack of appropriate own funding for these types of projects to complement external debt funding. Energy access is relatively new in Nigeria, so commercial lenders have not really invested much in the sector. This makes it difficult to achieve financial close for projects.

Havenhill now aims to deliver over 100,000 new electricity connections over the next three years. Beyond electrons, these mini grids have so far catalyzed economic activities in host communities, serve healthcare facilities, and overall deliver a transformative multiplier effect. All this means Havenhill generates both profit and impact for its stakeholders.

Havenhill's scale up plan is currently supported by several industry and financial partners including the GET.invest Finance Catalyst, United States Trade and Development Agency (USTDA), and others.

Budo Aare solar mini grid in Nigeria powered by a 100 kW PV-diesel hybrid system

CASE STUDY 4: EARTHSPARK INTERNATIONAL

Supported by:

Electrifying two rural communities in Haiti using innovative smart solar PV-diesel hybrid mini grids

EarthSpark International has built and operationalised two smart solar-diesel hybrid microgrids, with storage, in Haiti. Haiti's electrification rate was 25% when the first mini grid was inaugurated in Les Anglais, in 2015, and there is still a large, unserved market in the country. This need for electrification and EarthSpark International's social enterprise model makes Haiti the ideal place for EarthSpark International's work to have the most impact.

Given the low electrification rate in Haiti, EarthSpark International has worked with communities to understand their energy needs and show how solar PV can be a reliable, inexpensive, and sustainable way to support that. They had to innovate to be able to prove that solar PV mini grids could allow the same flexibility as buying kerosene, they did this by developing smart metres that allowed customers to track their energy consumption. To accompany this, EarthSpark also created a pre-pay system for customers to purchase more electricity as they went. Ultimately the popularity of this flexible system led to EarthSpark International created a spin-off company called SparkMeter. The success of their initial pilot project, which supplied electricity to 54 customers by using the excess capacity from a nearby telecom tower they were able to secure funding from USAID to expand the mini grid to 430 households and businesses and install 90 kW of PV capacity and 400 kW of battery capacity.

This model provided the blueprint for EarthSpark International's second mini grid project in Tiburon, a 95 kW solar-diesel hybrid mini grid that serves 500 homes and businesses, and was switched on in 2019. The project received grant funding from the OPEC Fund for International Development, USAID, the Pan-American Development foundation, and the Organisation of American States. The project also received nearly 20,000 EUR of crowdfunding.

Currently EarthSpark International and its spin-off Haitian social enterprise Enèji Pwòp operate both grids, providing clean, reliable and inexpensive electricity to around 8000 people. Building on this, EarthSpark is now working towards an additional 22 microgrids over the next five years. Anchored by a 9.9 million USD commitment from the Green Climate Fund, EarthSpark is pulling together grant, debt, and equity from foundations, social impact and institutional investors alongside connection subsidies from the Government of Haiti's new microgrid program backed by the World Bank. This private sector project company led by a non-profit organisation allows for long-term low-cost capital to catalyse microgrid deployment while also explicitly supporting workstreams that enhance the impact of the grids.

Overall, the microgrids will provide life-changing energy access to over 16,700 households and small businesses (>83,000 people) and enable other critical productive uses of energy including agricultural processing, telecommunications, and even electric cooking solutions. Multi-solving for energy poverty and other aspects of sustainable development both boosts the microgrid business model and enables robust, transformative change for communities in Haiti, and beyond.

EarthSpark International's 95 kW solar array in Tiburon, Haiti basks in Caribbean sunshine.

CASE STUDY 5: SUN MOKSHA

Innovative 30 kW Smart Nanogrid in rural Odisha, India

Sun Moksha piloted their innovative Smart Nanogrid solution for rural electrification in Chhotkei village in Angul, Odisha, India. The company invested years to closely understand the challenges of energy access and has developed a holistic solution with a 'systems' approach to address these challenges. Innovative business models, access to finance, close partnerships with grassroots organizations and continuous skill development for scalable and sustainable operations and socio-economic development are key social interventions. The business model creates micro-enterprises in the villages in an MEZ (micro-enterprise zone) to not only make them self-sufficient, but also to create local economic growth and move the villagers up the economic value chain. The village has been supplied with a 30 kW solar-powered Smart Nanogrid to meet the energy demands of 140 households, 20 streetlights, a temple, and three community centres consuming about 20 kW. The rest 10 kW has been set aside for daytime use by irrigation pumps and microenterprises, such as stitching, rice-puff machines, provision stores, poultry, refrigerators, oil mill, welding, cold-rooms, etc., to improve agricultural output, enable value-addition to agriculture, and generate employment.

30 kW solar-powered Smart Nanogrid in Chhotkei, Angul, Odisha, India. © Sun Moksha.

CASE STUDY 6: SUSTAINSOLAR

Supported by:

Innovative Asset Finance for Scalable Turnkey Mini Grids

In response to the global economic slow-down caused by the COVID-19 pandemic, SustainSolar, supported by GET.invest, has launched innovative asset leasing and construction finance tools providing catalytic capital to mini grid developers. The goal is to be a "force multiplier" through these asset finance solutions, enabling faster scalability of mini grid portfolios at lower "all-in" cost. A pilot phase to deploy these catalytic tools with select mini grid developers is currently underway, with initial results due in late 2021.

Encountering mini grid finance and procurement challenges, SustainSolar has structured scalable finance models for short and long-term contracts to match developer needs. The model for these has been adapted from similar asset-based financing models used in mature industries such as construction and mining, SustainSolar's new finance tools have been designed to address some of the biggest hurdles faced by mini grid developers, such as: high upfront capex, oversized idle capacity, expensive cost of finance, and slow funding deployment.

Under these finance models, qualified mini grid companies can now contract SustainSolar generation units over extended payment terms, with minimal upfront deposit, enabling faster site construction and revenue growth. SustainSolar's asset finance approach is aimed at helping mini grid companies improve bankability by strengthening project returns, scalability, and energy services for rural communities across Sub-Saharan Africa.

The short-term construction finance model, or "grant bridge," provides SustainSolar generation units for a low upfront deposit, at competitive interest rates over 6–18-month tenors. It is aimed at supporting projects that are guaranteed to receive post-construction funding awards, as in the case of results-based financing. Under this model, mini grid companies can easily procure, and commission quality power systems required for performance-based funding.

The long-term tool is the asset leasing model, providing extended payment terms on SustainSolar generation units over 10-year contracts. This model significantly reduces debt and equity needs, lowering upfront generation CAPEX cost by 70% after deposit. Offering scalable power systems and financing, this approach enables mini grid "right-sizing" with modular expandability, giving flexibility to grow alongside customer demand.

Commercial & Industrial

The commercial and industrial (C&I) off-grid market is a relatively young one and, unlike SHS and mini grid systems, does not serve bottom-of-the-pyramid customers in rural areas. Instead, C&I projects aim to provide power to corporates such as hotels, industry, shopping centres, small and medium sized cold storage facilities, telecoms towers, mining companies and larger SMEs with the capital available to pay for the installation or with strong balance sheets to access financing for these projects. However, the segment also extends to public buildings such as universities, schools, and hospitals. Particularly in Sub-Saharan Africa, many of these entities suffer from expensive and unreliable grid connections, leading them to install and rely upon expensive diesel generation to answer their power needs. As private and public entities seek to improve their emissions profile and bring down costs, the C&I segment of the off-grid market is expected to boom.

C&I rooftop projects offer competitively priced energy services and represent very bankable investments. There are two predominant business models for this segment: **lease-to-own** or a **perpetual fee-for-service** agreement. Under the lease-to-own arrangement, companies gradually pay off the cost of the C&I installation through the savings they make on their energy bills after switching from a grid connection or diesel generation. Once the cost of the installation has been fully paid, the institution owns it outright. In a perpetual fee-for-service model, the cost of the energy service provided is amortised with the savings on energy bills as in the lease-to-own model. However, ownership of the asset never changes hands. The advantage of these models is that the total cost of assets does not appear on a company's balance sheet immediately, keeping their debt-to-equity ratios low while they benefit from a less expensive service.

With the off-grid C&I segment still being very young, understanding of the sector is not widespread. This means that bespoke financing methods are still in the early stages of development. Currently, the bulk of financing comes from specialist investors and DFIs that are willing to accept the risks of these projects. However, as the sector grows, it is expected that longer tenor loans and debt finance, with lower interest rates, could be offered, particularly after the bankability of off-grid C&I projects has been established. Given the smaller size of off-grid C&I projects (usually between 100 kW – 5 MW), it is likely that they will be bundled, with financing being dedicated to portfolios rather than individual projects.

CASE STUDY 7: OFGEN LIMITED

Powering UAP Old Mutual's Equatoria Towers office, Juba, South Sudan with 338 kW solar PV system and a 715 kW Tesla Storage solution.

OFGEN commissioned a 338 kW solar PV system with a 715 kW Tesla storage solution for UAP Old Mutual's Equatoria Towers office in South Sudan, home to international NGOs, South Sudanese government agencies, commercial enterprises and restaurants. The country has one of the lowest rates of electrification and energy consumption in the world and lacks a national grid. Despite being an oil producing country, South Sudan lacks refining capacity and must import all its refined fuel and petroleum products. The larger cities have diesel or heavy-fuel powered grids or mini-grids, in varying degrees of operation. Located on the White Nile, South Sudan has considerable hydropower potential, but conflict has prevented the construction of any of the planned hydro projects over the last decade. This lack of electrification represents a major barrier to economic growth as households and enterprises remain constrained by the lack of access to reliable, affordable energy. This off-grid C&I installation represented a way for UAP Old Mutual to benefit from energy savings, generated by switching away from expensive diesel power, while boosting their environmental sustainability.

The main challenges facing the project included a lengthy construction period because of delays in delivery of equipment to site, harsh weather conditions on site and COVID restrictions. The other challenge was attracting appropriate project financing due to the political and economic instability in South Sudan. OFGEN's regional expertise and reputation as a trustworthy and effective company played in their favor in overcoming these challenges.

OFGEN invested in the power plant, which provides electricity at a lower tariff rate compared to the existing diesel generator power. The electricity is sold under a power purchase agreement with UAP Old Mutual paying only for what they use, ensuring immediate savings. Currently, the PPA is run on a fee for service model. However, UAP Old Mutual can exercise the right buy out the system, should they choose.

The project was financed primarily through OFGEN's own equity reserves and funding contributed by their shareholders. It was difficult to attract other sources of funding because of the perceived political instability in South Sudan. OFGEN are currently seeking to refinance the project to improve project returns and free up their funds to finance future projects of a similar nature.

South Sudan holds enormous solar power potential, and off-grid solar can play a major role in addressing unmet energy demand. The project was implemented over parking bays to maximise use of space and provide shading to vehicles while generating clean, affordable, and reliable power for the UAP Old Mutual Equatoria Tower.

The project has boosted the local economy, improved public services, and preserved scarce natural resources, while contributing to efforts to address the chronic poverty and unemployment that fuels armed group recruitment. It also supports more sustainable national development and reduces global emissions.

The new carport off-grid system for UAP Old Mutual Equatoria Towers, Juba, Sudan. © OFGEN

1 According to World Bank (2017) data, South Sudanese average over 44 kWh of electricity per capita per year, the second lowest figure after Haiti.

CASE STUDY 8: GENIUS WATTER

30 kW Solar PV C&I smart management system for a hydroponic greenhouse

The Africa Hydroponics Market is greatly expanding. Also, hydroponic systems can successfully meet African agriculture challenges. The main advantages of hydroponic systems over traditional growing methods include: a more efficient use of water and fertilizers and minimal land use. Furthermore, Hydroponics reduces incidences of pests and diseases that are common with conventional soil farming.

Such methods need a constant flow of water and energy to produce it. Genius Watter aims to make these projects energy self-sufficient, environmentally sustainable and economically competitive.

For this project Genius Watter was asked to provide an autonomous and sustainable energy system that would guarantee 24/7 electrical power, with "smart" load management for a reverse osmosis unit and pumps.

Genius Watter provided an off grid solar photovoltaic system with a peak power of 30 kW. The automated energy management system enables the generator to run only in case of prolonged bad weather conditions, thus guaranteeing the required solar energy and water to the hydroponic greenhouse. In this way, the energy costs are reduced by over 95 %.

Before Genius Watter's intervention, the staff had to manually operate the entire (already existing) plant, made of 25 pumps and an osmosis unit, on site. Thanks to the Genius Watter system, it is possible to automatically manage all the electric and hydraulic loads through real-time monitoring of more than 50 parameters to obtain perfect synchrony between solar PV plant, pumps, osmosis and other loads.

In addition, to cope with the humid, saline and dusty environment, Genius Water provided an automatic panel cleaning system, dust proof structures and protections to preserve all the electrotechnical components from corrosive agents.

Generally, GW has two business models for this kind of plant:

1 Plant sale + long-term O&M.

2. Energy and water as a service (GW builds the plant, without any upfront investment by the client who purchases water and energy via a monthly fee under a long-term agreement) + long-term O&M.

For this specific project, the client has opted for the direct purchase of the solar photovoltaic plant, the energy management system and long-term O&M service.

For the future expansion of the project, a co-investment is planned through a special-purpose vehicle in which Genius Watter and other investors participate. This innovative management solution for energy and water supply plants is mainly financed through private capital. It is particularly attractive to the client and the investors as the risks and investment are very low and Genius Watter's direct involvement is seen as a guarantee of reliability, long-term efficiency, ensuring savings.

Our technology ensures that hydroponic agricultural cultivation in semi-desert areas has a constant supply of energy and water at minimal cost in an automated and remotely controllable way, thus making the entire project resilient.

Genius Watter has trained and engaged local technicians both for the construction of the plant and its maintenance. The planned expansion of the project will create additional sustainable jobs and technical expertise, bringing prosperity to local populations as well as quality agricultural products.

Hydroponic Farm in Cape Verde, powered and managed through a 30 kW solar C&I installation. © Genius Watter

GET.invest – mobilising renewable energy investments

GET.invest is a European programme which supports investments in decentralised renewable energy, supported by the European Union, Germany, Sweden, the Netherlands, and Austria. The programme works with private sector businesses and project developers, financiers and regulators to build sustainable energy markets in developing countries. Services include market information, a funding database, matchmaking events and access-to-finance advisory via the GET.invest Finance Catalyst.

More information about GET.invest is available on the new website, including many useful resources for navigating the complex landscape of funding sources, insights into different market segments and the opportunity to apply for advisory services from the GET.invest Finance Catalyst.

Key features of the new website include:

- **An up-to-date funding database featuring 100+ financing instruments** for decentralised renewable energy projects and businesses in sub-Saharan Africa, covering grants, loans and equity providers.
- **15 new country briefs,** providing succinct, business-oriented data and insights to help guide initial market entry research.
- **A resource center** collecting publications, podcasts and other materials produced with GET.invest's partners, including SolarPower Europe, providing access to a wealth of industry knowledge.
- **Results and stories** from supporting 180+ projects and companies with access-to-finance advisory.

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What's cool in solar

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Solar as a technology is full of surprises. When a particular solar component or application is thought to have reached its technical limitations, often some new approach leads to increased optimisation.

With that said, once-successful solar technologies do fade away as they can no longer keep on lowering costs or supporting improvements in the performance of a PV device. This is also true for many promising product revolutions – for some, it has simply taken too long to develop, and once market ready, incumbent technology has developed beyond the need for that approach.

Although solar is already the lowest cost power generation technology in many applications and locations, there is still much room for further developments in order to continue cutting costs to make the technology even more competitive and open to new frontiers. For instance, combing solar with battery storage on massive scales or producing the only true sustainable hydrogen solution, green hydrogen, are two of many opportunities for further innovation.

SolarPower Europe has examined the latest solar technology developments that can reduce overall system cost and thus lead to increased deployment.

Wafers

Mono – close to monopoly

With the solar industry focusing on improving the performance of PV devices, monocrystalline silicon has become the material of choice for wafers over its casted variant multicrystalline silicon (also referred to as polycrystalline). Monocrystalline silicon, which has fewer defects than multicrystalline thus enabling production of higher cell efficiencies, is dominating the solar market with an estimated market share of 80% today. Once the dominant variant, multicrystalline now represents only 20% of the market and is expected to completely fade away in the coming years.

In any case, the scale will swing further towards mono this year, as all new silicon ingot crystallisation capacity expansions for ingot and wafering fabs have been focusing on the mono variant. For example, the world's largest integrated solar module manufacturer LONGi Group, which is also the largest wafer maker today and has been the primary advocate of monocrystalline wafers, has been quickly executing on its ambitious wafer capacity expansion plans. After reaching 85 GW installed capacity by end of 2020, LONGi Group alone now targets 105 GW by the end of 2021, over 76% of last year's newly installed solar capacity.

The PV industry's increased focus on high efficiency crystalline silicon cell technologies has led to yet another monocrystalline wafer variant: the 'n-type', or negatively doped products. These wafers are oppositely doped than today's standard p-type substrates and are the preferred choice for high efficiency crystalline cell technologies, such as interdigitated back contact cells (IBC), heterojunction (HJT) and passivated contacts, often referred as 'TOPCon'. With a few companies now in volume production of these advanced cell architectures, n-type wafers gained less than 10% market share in 2020, but is expected to increase strongly in the coming years – to around 50% in a decade, according to ITRPV.

Larger and larger wafers

Employing larger wafers has been a low hanging fruit in augmenting module power, without changing to a whole new cell technology. Since module power is a function of size, adapting larger silicon substrates boosts modules power accordingly. At the same time – unlike for designing larger modules with a higher number of cells – the key benefit for larger wafer-based modules is that power improvement does not require increasing the voltage, thereby lowering the balance of system (BOS) costs in a solar system; in other words, building high power modules using larger wafers is an effective to reduce the PV system costs. The benefits have been so compelling that the entire solar process, manufacturing and supply chain, has been adapted to facilitate the deployment of very large wafer-based PV products.

While solar cell manufacturers were using more or less one mainstream wafer size for many years, 'M0 wafers' (6 inch or 156 x 156 mm side length), as of 2017 a new format took over: M2 (156.75 x 156.75 mm). In 2018, the first companies introduced G1, a full square 158.75 mm format. The same ingot used for producing G1 can also be used for making M6 wafers with a larger area and side length of 166 mm, but in a pseudo-square format, resulting in a better cost-performance ratio. Starting in 2019, and for a short period of time, it appeared that M6 was the largest wafer size and would remain so. But over a timespan of merely a few months, a full square format with 210 mm side length called G12 was introduced, which is today's largest commercially available wafer size. Modules based on the 210 mm wafer formats started appearing at the end of 2019. As an alternative, M10 was introduced, 182 mm side length and pseudo-square format that was introduced in 2020. In consequence, last year's market was flooded with multiple wafer sizes. However, as large new cell capacities have been built and brought online very recently, most of the new factories were designed to handle these larger substrates.

While basically all large cell manufacturers have started using the two largest wafer formats – and both together are expected to take a major market share already in 2022 - it remains to be seen which will be the more successful format, M10 or G12. While the largest vertically integrated companies are promoting M10 as the non-plus ultra-format (also for the reason that their older wafer capacities could not produce larger sizes), the top cell and module producers without any wafer capacities are mostly favouring the G12 path.

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Cells

PERC – the workhorse

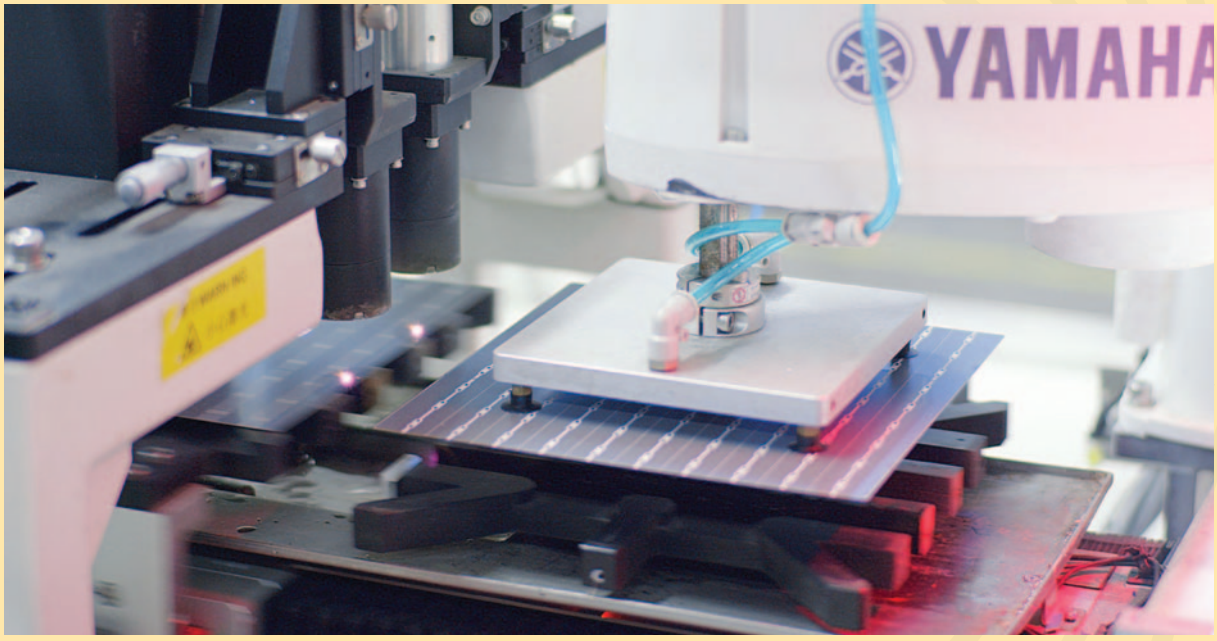
With basically all the recent gigantic solar cell manufacturing capacities based on Passivated Emitter Rear Contact (PERC), this cell architecture has become the state-of-the-art cell technology. A considerable price drop for PERC production equipment paved the way for multi-GW scale expansion in China. PERC has progressed at a rapid pace in terms of efficiency improvement of greater than 0.5% absolute per year. While the pace has slowed down, several manufactures have already exceeded 23% efficiency in commercial production of PERC cells. With PERC technology being flexible towards production using larger wafers, it has further strengthened its position. Another bonus is its bifaciality, as it is very simple to tweak PERC into a cell that produces power on both sides without any additional costs. With that said, the bifaciality of this technology is on the lower side of crystalline solar cell varieties.

Another interesting development that is relevant for PERC is gallium doping technology. Ingots for monocrystalline wafers are historically mostly positively doped (p-type) with boron, which is the root cause for a degradation mechanism, light induced degradation (LID). Negatively doped wafers (n-type) do not suffer from this issue. Employing gallium instead of boron liberates p-type from this inherent disadvantage, which has started to be used more frequently.

Today PERC has everything: a well-established supply chain, high throughput, efficient production equipment, and compatible process consumables. The technology is at its peak in terms of process optimisation, providing the best cost performance ratio today. But PERC is expected to hit its limits; there is no clear pathway to improve the efficiency beyond the current level of a little over 23% in industrial production environment. While record PERC cell efficiencies reach around 24%, these production practices are not cost effective for mass production; at least not yet. Now the big question is: What comes next to bring cell efficiencies to a higher level?

Passivated Contacts – a prominent upgrade

The next evolutionary step in solar cell technology following PERC is likely to be Passivated Contact cells, often referred to as TOPCon (a passivated contacts technology developed at Germany's Fraunhofer ISE), where a sophisticated passivation scheme is adapted to advance cell architectures with an aim to reduce recombination in the electrical contact region. Implementing TOPCon requires only a few additional processing tools over PERC. Theoretically speaking, TOPCon shows the highest ultimate efficiency potential of all c-Si cells at 28.75%. But in practice research institute ISFH has attained a record level performance of 26.1% by combining its proprietary



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POLO structure with a back contact architecture on a p-type base wafer in lab scale. In the industrial environment, there has been a tight race for record efficiencies in recent times. In June 2021, JinkoSolar announced a 25.25% world record efficiency for commercial-size cells. When it comes to industrial implementation, the technology has only a handful of followers so far, as there were issues with certain production equipment. Now, not only workarounds and new tools have been developed to overcome those limitations, the machines are also capable of processing larger wafers. With these developments in place, TOPCon is seeing new traction. At the world's largest solar trade fair SNEC 2021, several leading cell and module makers unveiled TOPCon products. The pioneer in this field, Jolywood, has recently developed a second generation of TOPCon technology that has reached an average cell efficiency of 24.09% in its pilot lines.

Heterojunction – High in Efficiency

Heterojunction technology (HJT) has demonstrated the highest crystalline silicon cell efficiency so far – it holds the overall cell record for silicon solar cells at 26.3%, based on a combination of HJT and IBC. When it comes to the pure HJT structure, the highest efficiencies for commercial sizes were reported this June/July by China's LONGi and Huasun, both at 25.3%. There has been significant interest expressed to venture into HJT, totalling to about 50 GW globally during 2020, but the actual production capacities are much lower, with output at the single-digit scale. Probably the most important recent development in the context of HJT commercialization is former PV equipment manufacturer Meyer Burger's decision to become a cell and module manufacturer itself and stop selling its HJT technology. In May 2021, it started production of cells and modules in Germany, each with 400 MW capacity, and has already announced expansion to 1.4 GW in 2022 and 7 GW by 2027. This comes after it sold its technology to REC, which was the first company after Panasonic that successfully commercialized HJT cell/modules in volume manufacturing in Singapore, as well as to ENEL Green Power in Italy and Ecosolifer in Hungary. Another European pure HJT player is Hevel Solar from Russia, which operates a 340 MW cell/module factory based on its own cell technology, while a few Chinese companies are working on HJT as well.

HJT has several advantages over traditional crystalline solar cells, showing a leading low temperature coefficient, the highest bifaciality of all cell technologies and much less production steps, but it requires investment in a completely new line and the capex is considerably higher than for baseline PERC. However, with several Asian tool vendors venturing into the development of deposition equipment for HJT, the capex has already been coming down.

Tandem – generation next

The way improvements in cell efficiencies are progressing, not only PERC but single junction crystalline cell efficiencies as a whole will reach their practical efficiency limits soon. Considering that HJT's best commercial cells are produced at 24.5% today, the practical limit of around 26% will be reached in a few years. At that time, the industry must be ready with next generation multi-junction technology, where different materials are stacked to harvest a larger part of the light spectrum. There are many different options for choosing materials and combinations. As it looks today, the most promising candidate seems to be a c-Si/Perovskite tandem cell structure, for which Oxford PV demonstrated the latest efficiency world-record efficiency of 29.52% at the end of 2020, anticipating a practical efficiency potential of around 35%. Oxford PV is currently setting up its first commercial 125 MW manufacturing unit for c-Si/perovskite tandem cells in Germany, targeting first sales in 2022.

Modules

Bifacial – power production on both sides

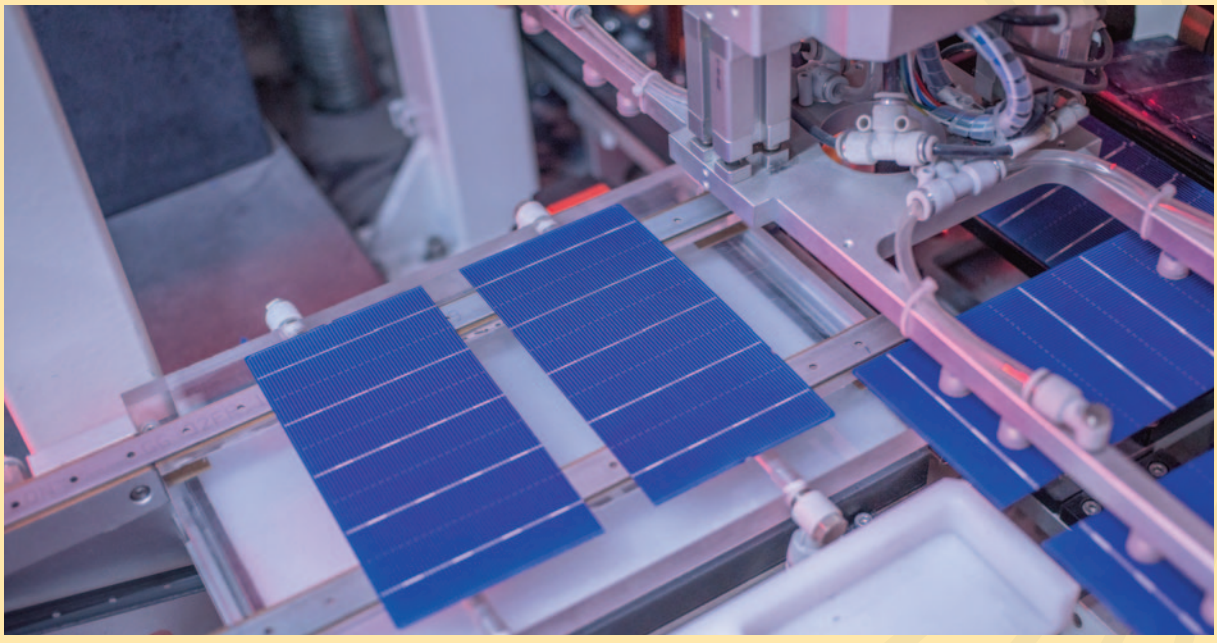
Bifacial solar modules, which generate power on the front and back, is the technology that helps bring down LCOEs of solar power plants the most in the short-run. This results in power gains between 5% and up to 30%, depending on the solar cell technology used, location, and system design. Transforming PERC into bifacial does not cost anything extra. Indeed, today's new high-efficiency cell technologies HJT and TOPCon are both 'naturally' bifacial. Bifacial technology comes with yet another advantage of extended power warranty of 30 years. The supply chain to support the changes required at module level is fully evolved – regarding the change of

encapsulation, transparent rear cover, or optimised junction box designs. With more and more bifacial installations popping up around the world, real-time data showing the benefits of bifacial systems is available, and the technology is now fully bankable. Researchers around the world have been working on developing simulation programs to predict bifacial efficiency. Traditionally, bifacial products suffered from a lack of standards for measuring IV measurement of the PV devices and respective ratings. With IEC TS 60904-1-2:2019 coming into effect in 2019, this ambiguity has been successfully addressed. The current standard allows for testing a bifacial substrate from a single side as well as with double-side illumination with clear guidelines to specify the bifacial gains. Cell testers and sun simulators from leading suppliers are also now available to test bifacial PV cells and modules. All of these recent developments have enabled the technology to quickly gain in market share – from close to 15% in 2019 to 20% in 2020 – and continue on this path. The International Roadmap for Photovoltaic 2021 (ITRPV), expects bifacial modules to reach a market share of 30% already this year and 55% by 2031.

Slicing cells – increasingly inevitable

It sounds counter intuitive but slicing a fully-processed solar cell into two pieces (in the case of half-cells) has huge benefits. A half-cell design reduces resistance losses and is thus a simple but very effective means of increasing module power. A power boost of about 5–6 W on the module level can be gained from a half-cell design. Although the half-cell approach reduces the throughput of stringing tools by 50% and requires additional laser cutting tools, with interconnection tools and laser scribers becoming very cheap, half-cell has emerged as a standard in state-of-the-art module fabs.

Several module makers have completely converted their module production to a half-cell layout and others are expected to follow suit. With the trend to very large wafer sizes, a solar cell's current is rising accordingly, thereby augmenting its losses. If such losses want to be avoided, slicing of cells will become inevitable. An industry-wide practice to slice cells generally starts from M6 format and is applied to all larger formats. A few module suppliers offering products based on G12 cell sizes even offer 1/3 cells, which means the cell is sliced into 3 pieces. The half-cell term might just become a figurative term as PV producers are evaluating slicing a cell into 4 pieces.



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Multi-busbars, multiple benefits

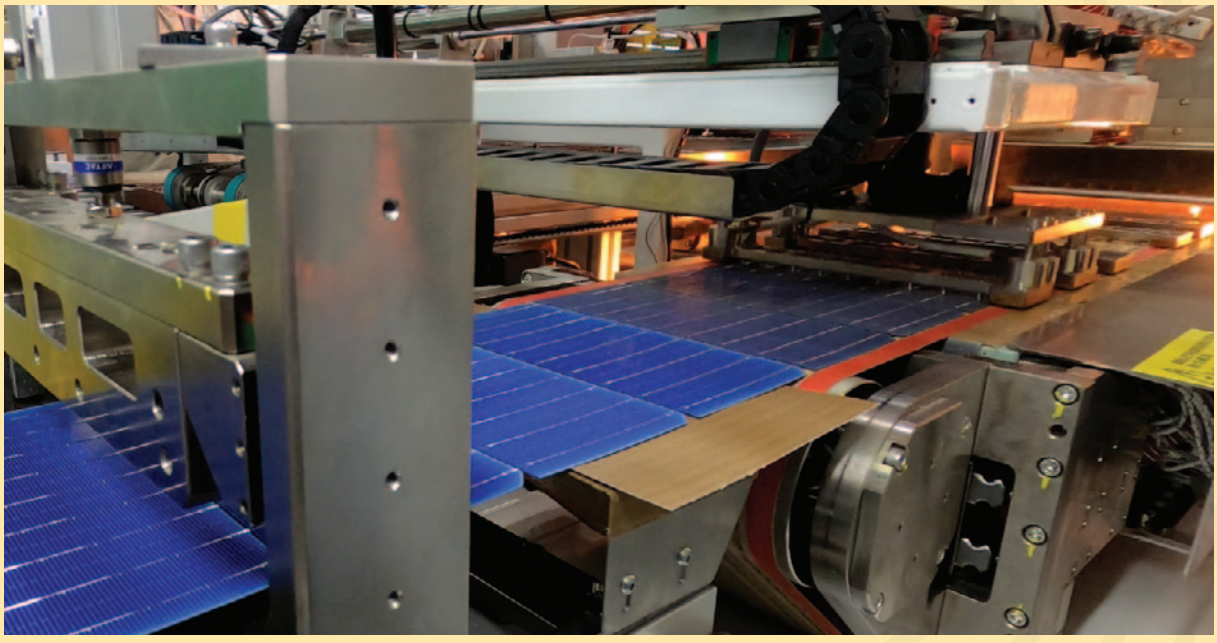
The multi busbar (MBB) approach in principle is an extrapolation of the 'more busbars' concept. Here, a higher number of wires (currently from 9 to 12) is used instead of flat solar ribbons to electrically connect the solar cells in a module. The advantages are many: reducing resistance losses, lowering current density carried by each busbar, better optical properties enabled by the round shape of the interconnection, and higher tolerance to cracks in cells. Employing MBB makes busbars so close to each other that the finger width can be reduced significantly, thereby reducing the silver paste consumption. While the current practice is to use still busbars, MBB in principle also enables replacing the busbars with small soldering pads, which paves the road to further reduction in silver paste consumption. The shift towards MBB has become much more apparent with the industry's move towards larger wafer formats.

Reflective ribbons – gaining from reflection

While using circular copper wires is helpful in reducing the optical shading footprint of the interconnect, employing reflective interconnects may even add to optical gain. The fundamental principle is simple. Making the interconnect surface reflective reflects the light back on to the active module area. While some European ribbons manufacturers, including Ulbrich (light capturing ribbon) and Schlenk (light harvesting string) have commercialized such ribbons in the past, LONGi recently started employing its proprietary triangular segmented ribbon in its latest module range using M10 wafers.

Narrow or no gap – eliminating dead areas

Increased wafer and module size calls for better utilization of the module area. Packing solar cells as densely as possible makes sense to reduce the module area to the maximum possible extent, and thus positively impact module efficiency. Shingling is one approach that eliminates the spacing between the cells in a solar module completely, providing the module with a stunning optical appearance. In addition to aesthetics, the approach also enhances the module power. Shingling is nothing but slicing the fully processed cell into 5 or 6 strips that are interconnected by overlapping at the edges, like roof tiles. However, the technology is mostly protected by patents owned by SunPower and Solaria. This is why



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companies started looking for workarounds. Tiling Ribbon (TR) is one such approach commercialised by JinkoSolar. In this alternate approach, a round ribbon, similar to the one used in the MBB approach, is pressed flat exactly where it would bend in order to connect the top of the next cell. Instead of placing the cells side-by-side, the cells slightly overlap. The technology is very similar to shingling as far as overlapping is concerned, but it uses an interconnection media and at the same time avoids laser stripping of cells into several pieces, even though JinkoSolar uses half-cells.

If not eliminating the inter-cell spacing completely, the majority of the module makers are trying to reduce it. The approach closely follows on the footprints of Tiling Ribbon technology up to the level of interconnects that are pressed flat between the cells. However, instead of overlapping the cells, the gap is just narrowed considerably. While the traditional cell layout maintains a cell gap of 2 mm, the latest module products of several leading module companies reduce this gap to between 0.5–0.7 mm.

Power going higher and higher

One of the most important trends in today's PV world is realising higher module power using larger wafers. While building modules with 500 W was an important trend about a year ago, today several leading PV manufacturers have started mass producing close to or already 600 W+ panels on a multi-GW scale. At the SNEC show in Shanghai in June, a few companies even showcased modules with 700 W power ratings. In addition to employing larger wafers, module makers are also implementing a blend of advanced technologies in a single product to increase output, such as bifacial design, cut cells, MBB and narrowed cell gaps, or no gaps. At the same time, module companies are increasingly including in their product portfolios the new breed of modules in down sized versions for rooftop applications. While also employing very large and half or third cut cells, the cell number in these products is reduced to enable production of smaller panel formats that have still high power ratings of around 400 W but can be lifted by craftsmen, like the earlier rooftop module generation. With the advent of larger wafers, the variety in module configurations with different cell counts has increased to 78, 72, 66, 60, 54 and even 40, or to be precise, the equivalent (if a 72-cell configuration is cut in half, the module has 144 cells, for example).

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Glass-glass modules

The rapid expansion of bifacial modules was the main cause for a shortage of solar glass for modules in 2020. As bifacial modules need two transparent covers – and the product of choice is mostly glass, demand for solar glass from module manufacturers increased significantly last year. According to ITRPV 2021, modules with glass covering both the front and rear had a market share of around 18% in 2020 and are expected to constantly expand over the years to reach a 55% market share in 2031.

Thin and large

Thin-film technology in solar is mostly represented by CdTe technology, produced primarily by US company First Solar at a total production capacity of around 7.9 GW. The company introduced its latest Series 6 in 2019 – a product with a large form factor and up to 460 W, a superior temperature coefficient, better spectral response, a true tracking advantage as shading has less impact on thin-film modules, and reduced soiling, which results in high energy yields and low LCOEs. In June 2021, First Solar announced its plan to increase its production capacity by 3.3 GW via a third factory in the US.

Inverters

Big, small, and very small

The importance of the inverter's role in PV systems has only been increasing with the arrival of digitalisation in the solar sector. Primarily used in the past as a means of converting DC into AC power, today, inverters are the true brains of solar systems. They cope with all varieties of storage systems, are a key tool for efficient solar power plant operation & management, also regarding grid services, and are a partner of intelligent energy management systems in homes or the solar mobility world. Regarding size, on the one hand, inverters are getting bigger, with **central inverters** now available over 5 MW to address the needs of ultra-large utility-scale plants.

At the same time, producers of **string inverters** are offering increasingly higher power solutions as well. While the maximum power rating was around 250 MW a year ago, the largest products are now reaching up to 325 MW to compete in the field of large-scale power plants. An important development for string inverters is its compatibility with the new module generation featuring very large cells, which have different needs regarding current and voltage. The typical increase in current with larger wafers such as M6, M10 and G12 is 9%, 28% 75%, respectively, compared to the earlier 156 mm wafer 'standard'. The earlier generation of inverters with a limit for the maximum current at 13 A were only compatible up to M10 modules, but not very well with G12 modules. Now nearly every leading inverter supplier has a high current variant that can manage different configurations of G12 modules.

There is also the popular concept of commercial-size **inverters with power optimisers** to operate a solar system more efficiently, which has found new proponents; while module-integrated **micro-inverters** are also seeing increased traction as bifacial modules and a growing rooftop market with a focus on safety provide the grounds for a stronger growth of module-level power electronics. Probably the most visible trend in the residential rooftop segment is the **hybrid inverter** for solar & storage systems, which basically every inverter manufacturer has added to its product portfolio.

Mounting systems

Always facing the sun

Today's large utility-scale solar power plants have become a standard for utility-scale PV plants in southern regions but are increasingly used in less sunnier areas. They operate reliably and, depending on the location, the investment over fixed mounting systems is more than compensated by lower LCOEs. The second latest tracker generation was designed to be able to include bifacial modules, so that they have open access to the grounds, in order to be able to generate power unhindered on their back-side. In fact, the marriage of bifacial with trackers results in a synergistic effect: the benefit of combining both the technologies is more than the sum of the individual benefits. The latest product updates address the needs of the new high-power module types with power ratings of 600 W+. These very large module formats require much sturdier tracking systems to resist stronger wind loads.

Solar systems and innovative applications

Floating Solar

A rapidly growing application for PV is to make use of water as an installation site instead of land. This approach is called floating PV (FPV) – the system setup is somewhat like ground mounts, except for the fact that all panels, and often the inverter, are fixed on a floating platform with an anchoring system. The approach costs somewhat more to build but has several advantages: it saves on land for PV installation, and is especially beneficial for locations where land is scarce. The benefits are even more apparent when combined on commercially-used water sites for drinking water, fishing, hydropower generation sites – the floating systems help to reduce water evaporation and improve water quality, and in the case of hydropower plants, can even use the transmission infrastructure. The setup also promises higher power yields compared to ground-mounted systems due to the cooling effect from the water underneath. According to a 2018 report from the World Bank, even under conservative assumptions, floating PV can grow up to 400 GW if only 1% of the potential area is used. Indeed, FPV systems are beginning to sprout across the globe, with the most impressive being a gigantic 2.1 GW project in South Korea.

The World Bank has also published a Floating Solar Handbook for Practitioners, to set up best practices in FPV deployment and offer practical guidelines. Building on this, technical advisory DNV, which expects a FPV pipeline of over 10 GW by 2025, has released, together with an industry consortium, detailed practical recommendations for FPV project development, focusing on 5 key topics, namely site conditions assessment, energy yield forecast, mooring and anchoring systems, floating structures, permitting, and environmental impact.

Solar & battery storage – a perfect match

Stationary battery storage is quickly gaining in popularity in an increasing number of solar markets; in particular, in established residential PV rooftop markets, where the technology already supports the dissemination of solar self-consumption systems, and soon will be crucial to bring solar penetration to the next level. In Germany, around 106,000 residential storage systems were installed in 2020, which is an increase of 63% as compared to the 65,000 residential storage systems installed in 2019. In sum, the amount of systems installed in 2020 equal around 740 MW, which makes Germany by far the largest storage market in Europe. Within the residential

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segment between 7 and 10 kW, three out of four new PV systems in Germany were installed in combination with a storage solution in 2020. For 2021 EUPD Research forecasts 150,000 new residential storage systems to be installed in the German market.

Sustainable solar for farmers

Any strategy to utilise the space required for a solar installation more efficiently is always welcomed by the sector. Agro-photovoltaics, or Agri-PV, is a fairly new mounting technology and method, which enables the use of agricultural land for both food production and solar power generation at the same time. Like Floating PV, Agri-PV costs more in the beginning, as the mounting structures are much more sophisticated, but offers many benefits. In addition to increasing the resource efficiency thanks to dual-land use, Agri-PV also enables farmers to diversify their income, thus helping to work against the rural population exodus. For farmers, it actually means a triple-win, as the shading of the PV system enables higher crop yields, lower water use, and clean energy generation.

Green Hydrogen – made with renewables, the only acceptable solution

Regions, countries and a quickly growing number of companies around the world have discovered hydrogen as the next very big thing for the energy transition. But due to its comparatively low efficiency it makes sense to prioritize direct & lowest cost electrification whenever possible, e.g., replacing ICE cars by electric vehicles. Yet, hydrogen for decarbonisation of the so-called 'hard-to-abate' sectors heavy industry (cement, steel, chemical), heavy-duty transport (shipping, aviation) is the appropriate solution - if generated with renewable energy. Multiple GW of renewable hydrogen facilities have been announced in recent months, in particular in Australia, MEA, and the European Union, which has set an ambitious green hydrogen target of at least 40 GW by 2030. Probably a good example for today's hydrogen hype is a June 2021 announcement about plans for a 30 GW hydrogen facility based on 45 GW solar & wind in Kazakhstan, a country with a little more than 1 GW of solar installed so far.

HIGHLIGHT

COVID-19 impacts on solar

Prospects for solar power shine brighter as industry's expansion accelerates even during the COVID-19 pandemic. Resilience and historically-low costs make solar PV the new "new king" of electricity markets but there is ample scope to improve policy support.

The solar sector was impacted hard in 2020 due to the COVID-19 pandemic, with companies experiencing severe disruption in their day-to-day operations and supply chains, yet it demonstrated impressive resilience nonetheless, emerging at the end as one of the few bright spots in the global economy. One year later, as vaccines and stimulus packages are phased in globally, the prospects for the global solar PV industry have grown brighter as industry sentiment improves and policymakers in various regions endorse investments and concrete measures to support dramatic growth in renewable energy.

The upbeat outlook emerged clearly in a survey in Q2/2021 carried out by the Global Solar Council which heard from its members – comprised of national and regional solar associations – as well as solar business leaders around the world. The engagement initiative was aimed at producing a snapshot of the sector's current health and gathering insights into possible post-pandemic scenarios for the solar market to ultimately understand the opportunities and barriers to solar development at this very important stage for the energy transition.

The survey showed an improving outlook for solar business, with 81% of respondents expecting growth in sales in 2021 compared to 72% who reported a positive expansion in 2020. The improving picture was underscored by respondents' assessment of how governments are supporting solar PV in terms of post-pandemic plans and green recovery policies compared to the support provided in the midst of the health emergency in 2020. The overall judgement is not overwhelming because those with a negative opinion of government support and green recovery prevailed – but sentiment is certainly improving, which is important. The proportion of respondents giving a positive or very positive rating to government action is higher in terms of the post-pandemic scenario, meaning the net perception (positives minus negatives) drops to minus 2.3% (see Fig. GSC SURVEY QUESTION 1).

GSC SURVEY QUESTION 1 RATING OF HOW GOVERNMENT HAS RESPONDED TO THE NEW SCENARIO

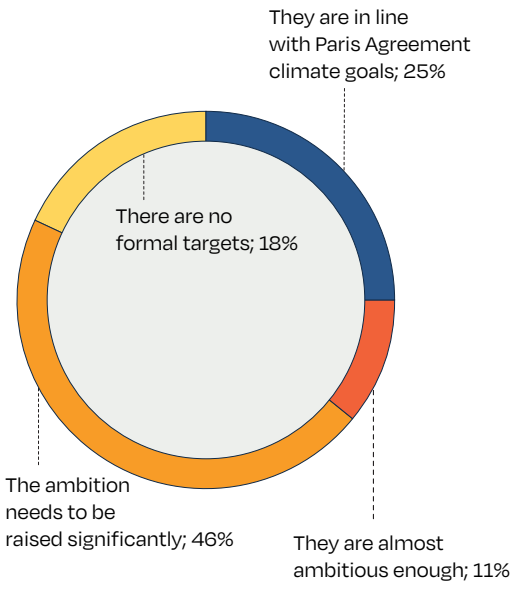
SOURCE: Global Solar Council (2021).

How to accelerate solar growth

What kind of support are industry participants expecting from governments? To be sure, there is a big focus on better permitting and simplification of authorisation procedures, improved power market access rules, better financing conditions and mechanisms, tax reductions and incentives for PV investment and self-production.

Overall, there is certainly an expectation that the policy ambition needs to be raised in many countries, with a majority of respondents saying renewable energy and PV targets were not high enough. Indeed, 18% said their government had no specific target and another 46% stated there needed to be a "significant" raising of ambitions (see. GSC SURVEY QUESTION 2).

GSC SURVEY QUESTION 2 HOW DO YOU VIEW YOUR GOVERNMENT'S OFFICIAL TARGETS FOR RENEWABLE ENERGY AND PV INSTALLATIONS? (% OF RESPONSES)



SOURCE: Global Solar Council (2021).

Global Solar Council Covid-19 Survey Takeaways for Policy Makers

At a practical level, five specific actions for policymakers emerged from the survey in order to improve solar businesses' performance:

1. Support self-sufficiency for all buildings employing renewables packages integrating PV, energy storage, electric vehicles, and energy management systems to stimulate decentralised self-generation and tackle the decarbonisation challenge as a whole;
2. Increase the transparency of grid connection processes for large-scale PV projects;
3. Standardise the rules for environmental licensing procedures for large-scale PV projects;
4. Reduce the discrepancy of financing conditions between regulated and free market PPAs for large-scale solar PV projects;
5. Improve the regulations on Energy Communities, allowing industries to share the benefits of the self-consumption of the energy and boosting the development of distributed generation.

Business continues despite restrictions

The picture that emerges from our survey respondents is supported by evidence from different countries and regions. In fact, following the widespread and near simultaneous lockdowns that put the global economy on ice in the first half of 2020, the spread of the pandemic has been more uneven, with successive waves affecting different regions at different times and restrictions being less severe. This has underpinned the resilience of PV supply chains and allowed companies to find business continuity strategies, supported by strong underlying demand growth. In any case, the pandemic has forced everyone to find innovative ways to keep activity going.

One recent example comes from the devastating third wave that struck India in early 2021: the Indian government shifted from having a sweeping national approach to COVID-19 restrictions to state-based decisions. That meant some states like Gujarat only applied a partial lockdown, allowing business activity and logistics there to continue. Still, India as a whole has been affected heavily by the pandemic, which can be held responsible at least for part of its dramatic downturn in 2020.

The COVID-19 pandemic has brought unexpected shifts in behaviours and choices, from the consumer perspective, in business as well as from a policy standpoint. The residential solar sector has been sustained by the fact that being forced to stay at home for large amounts of time has given people more reasons to pay attention to their energy bills and provided time to pursue home improvements, including solar installations. By the summer of 2020, capacity of sub-10 kW solar systems installed in **Germany** had exceeded the figure for the whole of 2019, according to the country's energy regulator Bundesnetzagentur. In **Australia**, where one in four households already has solar, data from the Clean Energy Regulator analysed by CSIRO showed that in 2020 a record 362,000 rooftop solar PV installations were issued with small-scale renewable energy scheme certificates (STCs), an increase of 28% from 2019. The majority of installations under the scheme were residential, with a smaller number for commercial and industrial properties.

In the **United States**, the country with the highest confirmed fatality number due to COVID-19 so far, households have been also turning to rooftop solar for energy savings and resiliency. That meant that city permit offices were sitting on large backlogs of rooftop solar permits as normal operations resumed in the second half of 2020.

Indeed, 2020 was a banner year for the U.S. renewable sector with over 19 GW of new solar energy capacity installed. This came despite the pandemic and four years of unhelpful federal policies and thanks to increased cost-effectiveness, strong consumer demand, and aggressive state renewable energy targets. But the main driver was a year-end deadline for the 26% US solar investment tax credit (ITC), triggering a record also on the investment side, with 36 billion USD going into solar, mostly utility scale PV plants. In fact, renewable energy was America's largest source of private sector infrastructure investment in 2020. However, end of December 2020, the solar ITC, instrumental for U.S. solar growth for over a decade, has been extended by two years as part of 2.3 trillion USD federal spending and corona relief packages.

COVID-19 has also changed attitudes to the environment and brought heightened awareness of the need to act to prevent global risks, from pandemics to extreme weather events. Driven in part by a rapid shift in consumer and employee expectations and the need to raise their sustainability performance, an increasing number of corporations have started to turn to renewable power purchase agreements (PPAs). The trend has been most evident in the U.S., where BloombergNEF reported 11.9 GW of corporate PPA announcements in 2020 alone. In the same year, the European RE-Source platform reported a record-breaking year with nearly 4 GW of PPAs signed across 12 countries.

The **European Union** has responded to the pandemic crisis with its 750 million EUR Next Generation EU (NGEU) programme to help repair the immediate economic damages, which also foresees investments and reforms accelerating the ecological and digital transition as well as improving social conditions. Member states who want to tap these funds need to invest about 30% into projects that contribute to the fight against climate change.

Thanks to a first-ever EU common debt issue, the programme allocates more than 200 billion EUR to Italy, the disbursement of which is tied to a package of investments and reforms: the EU Recovery and Resilience Plan, the centrepiece of the NGEU. As the biggest recipient of EU funds, Italy is a useful case for how post-COVID recovery plans have sought to take a green turn, directly impacting the solar sector.

As reported by Italia Solare, the plan – though not yet implemented – targets solar PV in several ways. Investments of 1.5 billion EUR are planned for the installation of solar PV on the roofs of buildings for productive use in the agricultural, livestock and agro-industrial sectors, with an installed capacity of approximately 430 MW. An additional 1.1 billion EUR is foreseen for the development of agrivoltaics, with an installed capacity of approximately 1.04 GW of medium and large scale PV plants. Solar PV is also set to benefit from part of 2.2 billion EUR allocated to the promotion of RES for energy communities and self-consumption, as well as from 680 million EUR assigned to the promotion of innovative plants (including off-shore).

With its National Energy and Climate Plan (NECP), Italy targets about 30 GW new solar PV by 2030, but this number needs to rise to meet the new ambitious EU emissions reduction goals. Despite the pandemic, Italy installed 625 MW of new solar PV in 2020 and 174 MW in Q1 2021, raising the cumulative installed capacity to 21.8 GW. This trend is too low compared with the current plan and is far from what Italia Solare expects will be that of the revised NECP. Hence the need to simplify regulatory and authorisation processes and to clarify the development of solar PV on agricultural areas.

Here again, small scale installations may come to the rescue thanks to measures which have not yet expressed their full potential like the Superbonus, a residential solar and storage 110% tax credit created to boost post-pandemic recovery while improving the energy efficiency in the residential sector, as well as energy communities and collective self-consumption, which are expected to generate up to additional 20 GW.

The pandemic, therefore, was not the economic disaster for the solar PV industry that it might have seemed back in early 2020, thanks to the resilience of supply chains, strong underlying demand at both the residential and industrial sectors and a favourable turn in policy. This positive solar outlook has been reinforced by several industry experts and institutions on the international stage, with full agreement about solar PV being key for a complete economic recovery and essential for achieving the more ambitious decarbonisation targets of many countries around the world. With solar PV now being the cheapest source of electricity in most countries, according to the International Energy Agency (IEA), it is set to triple before 2030 under current and proposed policies, with the potential for an even faster growth. No wonder the IEA said during the launch of the World Energy Outlook 2020 last October that it 'sees solar becoming the new king of the world's electricity markets.'

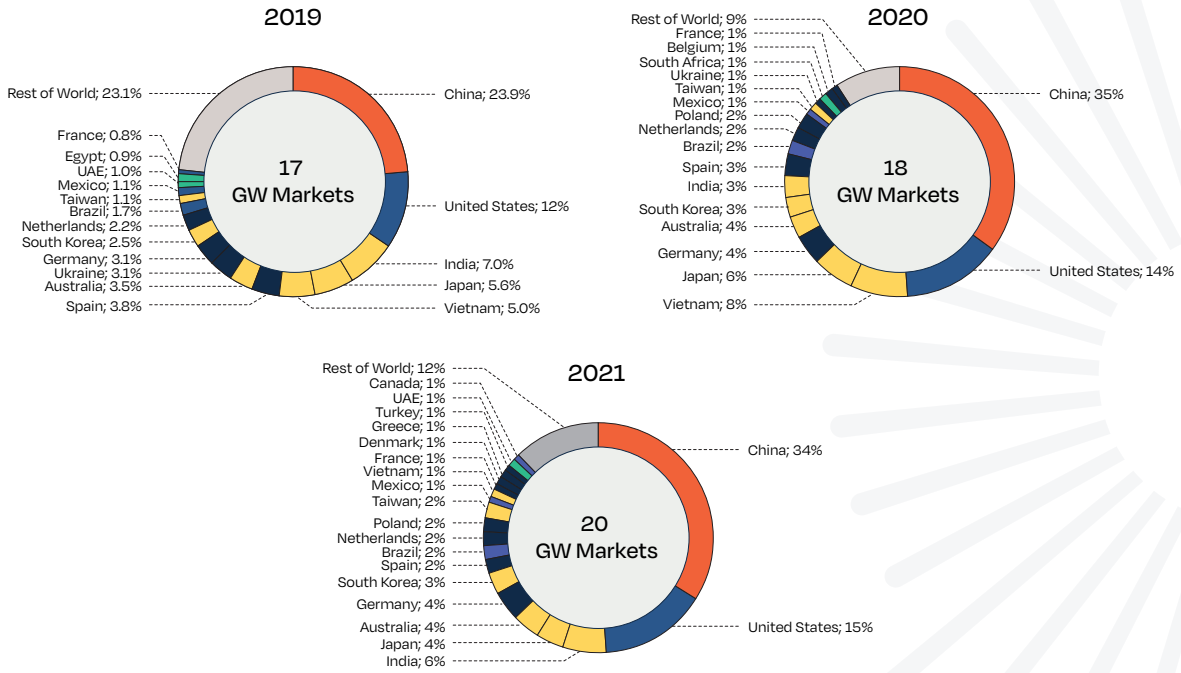
Authors: *Francesco Luise & James Osborne*, Global Solar Council

4 GW-scale markets

300 MW, Cáceres, Extremadura, Spain. © Statkraft

In 2020, 18 countries installed more than 1 GW of solar; one more compared to the 17 GW-scale solar markets in 2019 (see Fig. 19). The negative impacts from COVID-19 on solar demand were not as bad as we forecasted last year, when we expected the number of GW-scale markets to decrease. Based on this more positive outlook, we also expect growth to continue reaching 20 GW-scale markets in 2021, 23 GW-scale markets in 2022 and at least 29 GW-scale markets in 2023.

FIGURE 22 GW-SCALE SOLAR PV MARKETS 2019-2021



4 GW-scale markets / continued

Like in the 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 our organisation, are members of the Global Solar Council (GSC), which is a long-time supporter of the Global Market Outlook. For the GW-scale countries for which we did not receive contributions from local associations (this time, China, Germany, South Korea, Taiwan), we have written the overviews based on our SolarPower Europe research.

1.	**CHINA** SolarPower Europe
2.	**UNITED STATES** Solar Energy Industries Association (SEIA)
3.	**VIETNAM** GIZ Energy Support Program
4.	**JAPAN** Japan Photovoltaic Energy Association (JPEA)
5.	**AUSTRALIA** Smart Energy Council
6.	**GERMANY** SolarPower Europe
7.	**INDIA** National Solar Energy Federation of India (NSEFI)
8.	**SOUTH KOREA** SolarPower Europe
9.	**BRAZIL** Brazilian Photovoltaic Solar Energy Association (ABSOLAR)
10.	**THE NETHERLANDS** Holland Solar
11.	**SPAIN** Unión Española Fotovoltaica (UNEF)
12.	**POLAND** Polskie Stowarzyszenie Fotowoltaiki (PSF)
13.	**TAIWAN** SolarPower Europe
14.	**MEXICO** Mexican Association of Solar Energy (ASOLMEX)
15.	**UKRAINE** Solar Energy Association of Ukraine (ASEU)
16.	**SOUTH AFRICA** South African Photovoltaic Industry Association (SAPVIA)
17.	**BELGIUM** Fédération des Énergies Renouvelables (EDORA) & Organisatie Duurzame Energie (ODE)
18.	**FRANCE** Syndicat des Énergies Renouvelables (SER)

1. China

Overview of PV developments

China installed 48.2 GW in 2020, representing a 60% increase from the 30.1 GW installed in 2019. Affected by the COVID-19 pandemic, most of the installations were completed in the second half of the year, with a monthly record of 29.5 GW installed in December alone. Approximately 68% of the annual added capacity concerned large-scale ground-based power stations, while distributed power stations accounted for about 32%.

Regarding cumulative capacity, China reached 253 GW at the end of 2020, accounting for almost one-third of the global PV installed capacity. This translates to a 23% increase from 2019. From the 253 GW, utility-scale PV represents 174 GW and distributed PV accounts for 78 GW. With these numbers, the market almost returned to the record-level it experienced in 2017, ending two years of slower growth. China remains the world's Number 1 in terms of both annual installed solar PV capacity and total operating solar PV capacity.

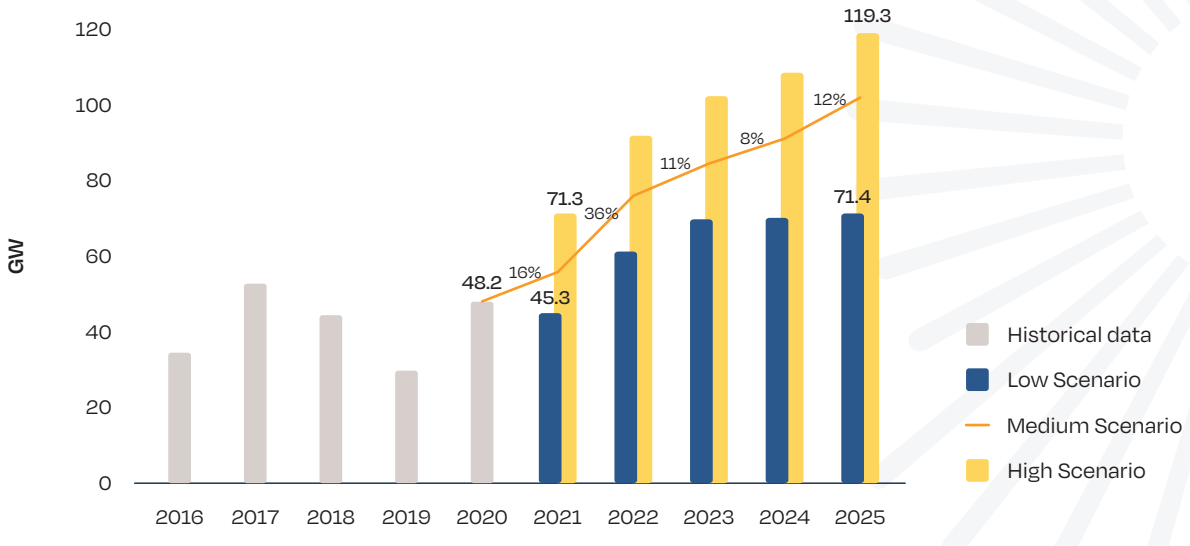
China's PV manufacturing industry, the global work bench for solar products, continues its expansion across the entire value chain. The national output of polysilicon reached 392,000 tons at the end of 2020, a year-over-year increase of 14.6%, according to the latest roadmap of the China PV Industry Association. The production is expected to reach 450,000 tons in 2021. At the same time, wafer production of 161 GW is believed to reach 181 GW; silicon cell production will increase from 135 GW in 2020 to 152 GW, and module output is forecasted to expand from 125 to 145 GW.

Solar/RE targets

In September 2020, China, today the world's largest GHG emitter, surprisingly announced a carbon neutrality goal. China's President Xi Jinping announced during the UN General Assembly that the country strives to become carbon neutral before 2050. In December 2020, he revealed new targets also for 2030: carbon emission per unit of GDP will be reduced by 65% from 2005 levels. To achieve this, the country aims for at least 1,200 GW of combined solar and wind power generation capacity – solar taking the greater share of the two.

In its 14th Five-Year Plan (14FYP), adopted in March 2021, China aims to increase its share of non-fossil energy to around 20% by 2025, up from 15.8% in 2020. This is part of a larger goal aiming to achieve a 25% share of non-fossil fuels in primary energy consumption by 2030. In the last 10 years, the share of non-fossil fuels increased by 3-4% every five years and stood at roughly 15% at the end of 2020. The 14FYP also set the binding goal to reduce carbon intensity per unit of GDP by 18% by 2025.

FIGURE GW1.1 CHINA ANNUAL SOLAR PV MARKET SCENARIOS 2021 - 2025



Driver for solar Growth

In China, solar and wind are already cost-competitive with fossil fuel generated power and will soon be cheaper than coal – with or without CCS – even with the most conservative assumptions on annual full load hours. Projections by the National Development and Reform Commission (NDRC) illustrate a steadily decreasing levelised cost of electricity (LCOE) for solar and wind, with solar being the cheapest option. The two renewable generation sources are considered as key pillars of the future energy system, as demonstrated by China's National Energy Administration (NEA) target of installing at least 90 GW wind and solar in 2021.

Starting in August 2021, China will enter a subsidy-free era, meaning that the government will no longer grant subsidies to large-scale solar parks and large rooftop systems. As the coming end of subsidies was known by industrial players in advance, this may also explain the high growth observed in 2020; the industry concluded many projects in 2020 in order to benefit from the final subsidy offers.

Challenges

While the most significant challenge for the Chinese solar market in 2020 was certainly the COVID-19 outbreak, in 2021 this issue has already been left behind. What has largely affected the market so far this year has instead been the effect of high raw material prices on projects under development. Several players are delaying their projects in the hope that a decrease in prices will occur, while other projects are simply being cancelled. This has resulted in an underwhelming level of installations in the first part of the year: only about 10 GW have been installed in the first five months of 2021.

Outlook

In the current year, the solar industry is experiencing high PV prices, something that threatens to make a significant number of projects unviable. In response to this, NEA announced in June 2021 that projects approved in 2019–2020 that do not meet the December 2021 deadline will not be revoked and can be included in the 2022 quota. For this reason, we expect only a slight increase of 14% in the Chinese market in 2021, at 54.9 GW, followed by a surge of installations in 2022 which would bring the annual market to 86 GW (+57%). We forecast that the 100 GW mark can be reached as early as 2025.

Seeing that several biddings, flat prices and ultra-high voltage (UHV) delivery projects were announced in 2020, the proportion of large ground-mounted solar is expected to further grow in 2021 and beyond.

Authors: *Raffaele Rossi & Michael Schmela,* SolarPower Europe.

400 MW, Nangong, HeBei Province, China.

2. United States

As our day-to-day lives continue to change, the U.S. solar industry has remained resilient in the face of the pandemic.

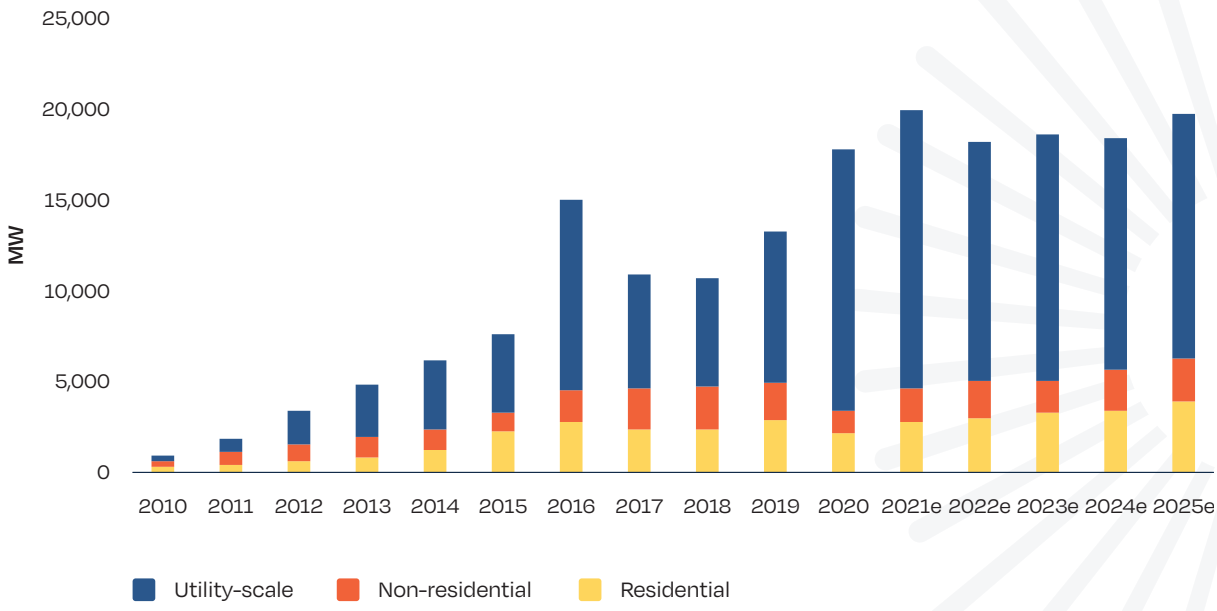
Despite many challenges over the past year, the U.S. solar industry kept tens of thousands of workers on the payroll and now employs more than 231,000 Americans, according to the National Solar Jobs Census 2020. While that was a 6.7% decline from 2019, the U.S. solar industry still experienced growth in a number of important areas when it comes to our workforce.

Representation among women and minority demographic groups has improved significantly since 2015, including a 39% increase for women, 92% increase for Hispanic or Latino workers, 18% increase for Asian American and Pacific Islander workers, and a 73% increase for Black or African American workers. Even despite the slight loss in jobs in 2020, about 5,000 more women are working in the solar industry than in 2019. The solar industry also continues to outpace the rest of the economy in its employment of veterans, which represent 8.7% of the solar workforce, compared to 5.7% in the overall workforce.

The U.S. solar industry continues to advocate for strong policies that support hard-working Americans and companies. With the right support, we can unleash the full power of solar energy, creating billions of dollars in investment and hundreds of thousands of new jobs, all while tackling the climate crisis.

And we know what policies work. At the end of 2020, the industry was able to secure a 2-year extension of the investment tax credit (ITC) that led to a 17% increase in solar deployment in the 2021-2025 forecast. According to forecasts from Wood Mackenzie, the ITC will continue to be highly influential and will drive record growth and investment over the next three years. The ITC is a proven job creator, and a long-term extension and direct pay option will help the industry continue to grow during this critical time in our history.

FIGURE GW2.1 UNITED STATES ANNUAL SOLAR PV MARKET SCENARIOS 2020-2025, BY SEIA



SOURCE: SEIA

The U.S. solar industry eclipsed 100 GW of solar capacity during the first quarter of 2021. Consumer demand for residential solar remains strong and is forecasted to grow 19% year-over-year, resulting in more than 3.8 GW of installed capacity in 2021. Utility-scale solar continues to lead the way and just set a record for first quarter installations, hitting 3.6 GW. The pipeline for contracted utility-scale solar continues to remain strong and has grown to nearly 77 GW.

Looking ahead, forecasts from Wood Mackenzie show that the solar industry will install 160 GW of solar capacity between 2021 and 2026, bringing total installed photovoltaic solar capacity to more than 250 GW by the end of 2026. Wood Mackenzie also released its first long-term forecast for the U.S. Solar Market Insight report series that shows that solar capacity will quadruple by 2030.

While the industry is on track to grow four times its size and employ more than 400,000 workers by the end of the decade, it's not enough to meet President Biden's ambitious clean electricity goals. Achieving the president's targets will require U.S. solar capacity to grow to 1.2 TW and for the workforce to grow to more than 900,000 workers by 2035.

Coupled with rising costs in the solar industry, business as usual will not suffice if we want to reach these goals. Without policy action, the gap to 100% clean electricity is becoming harder to close. Congress and the Biden Administration need to act now to decarbonise the grid and create millions of American jobs.

The American Jobs Plan is a great start for our industry, but it's time for Congress to put this plan into action. The solar industry is ready to work collaboratively to build back better in the post-COVID era. Together we can create new jobs, expand economic opportunities for Americans, and overcome one of the greatest challenges of our time.

Author: *Abigail Ross Hopper*, president and CEO, Solar Energy Industries Association (SEIA).

150 MWAC, California, USA.

3. Vietnam

Success story of the solar uptake in Vietnam and its drivers

Overview

In 2020, Vietnam experienced internationally unprecedented market growth in solar energy and jumped into the global top 3 solar markets after installing 11.1 GW. Consequently, solar PV accounted for 23.9% of the power capacity mix, equivalent to 16,640 MW, by Dec. 31, 2020. The installed capacity is comprised of 146 ground-mounted and floating solar utility-scale projects, with an accumulated capacity of 8,852 MW, and more than 100,000 grid connected rooftop solar systems (RTS) with 9,583 MW. The latter has been installed within 2 years. With this development, Vietnam has kickstarted its domestic solar market successfully

Policy framework

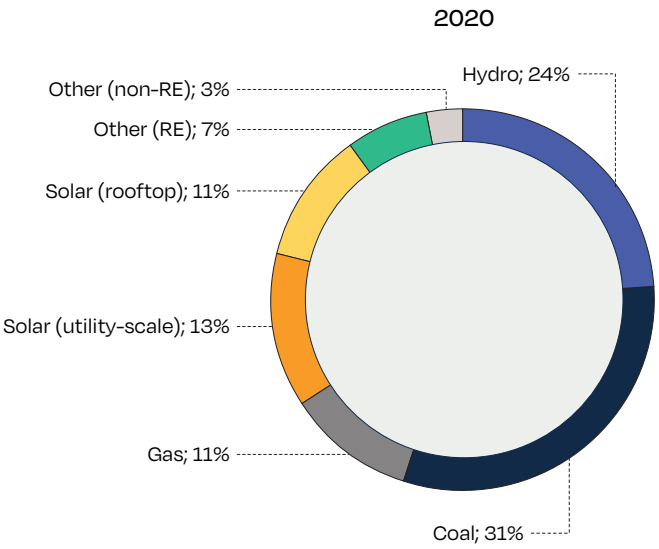
The major drivers behind this impressive story are attractive fiscal and economic incentives. Particularly, in 2020, the Feed-in-tariff 2 (FIT2)[1] was set at 8.38, 7.69 and 7.09 US cent/kWh for RTS, floating, and ground-mounted solar, respectively. Notably, the FIT2 rate for RTS was higher than the average retail electricity tariff, which was 8.35 cent/kWh from 2019 to 2020, while the FIT for utility-scale plants also enabled financially viable projects to be attractive for investors. The feed-in contracts signed under the FIT regulation have a duration of 20 years with the annual payment being determined based on the actual VND/USD exchange rate.

The FIT2 was valid from May 22, 2020 to Dec. 31, 2020 and created a rush to develop as many projects as possible before the deadline. Installed solar capacities continued to grow steadily in the third quarter, before experiencing an incredible jump in the last quarter, especially in December where a capacity of 6,855 MW newly installed RTS was recorded.

Drivers

Firstly, there is **political desire as well as social acceptance**, which are both vital drivers for solar uptake. National Determined Contributions (NDCs) of Vietnam and Politburo's Resolution on the Orientation of Vietnam's National Energy Development Strategy to 2030 and

FIGURE GW3.1 VIETNAM POWER GENERATING CAPACITY INSTALLED IN 2020 BY SOURCE



NOTE: The utility-scale solar capacity accounts for 14% in 2020. Adding the distributed grid connected rooftop solar systems (RTS) capacity, the actual share of the installed solar capacity rises to a remarkable 23.9% in Vietnam's power generation portfolio.
SOURCE: Annual report of Vietnam Electricity (EVN), 2020.

1 Decision 13/2020/QD-TTg on mechanisms to promote the development of solar power projects in Vietnam dated 6 April 2020.

outlook to 2045 (Resolution 55) affirms significant contribution of renewable energy including solar PV as a prioritised measure to reduce GHG emissions.

Secondly, **national energy security** is another important driver. Due to the delay of various strategic fossil fuel power plant developments, a national power shortage has been expected for the period from 2020 to 2023. Vietnam is motivated to ensure energy security via renewable energy, especially solar PV, which has a short project realisation time.

Lastly, the previously mentioned **attractive FIT2 and the expiration of the mechanism at the end of 2020, paired with a sharply decreasing technology price** has triggered this rapid solar uptake.

Solar outlook

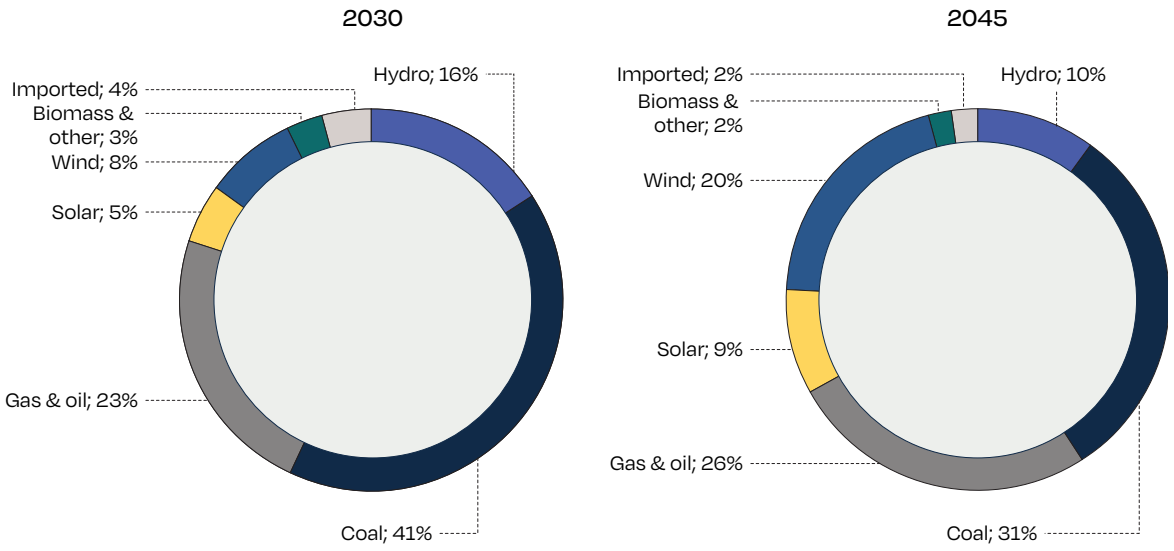
According to the Resolution 55, the share of renewable energy (including solar) of the total primary energy consumption is targeted to be 15-20% in 2030, and 25-30% in 2045 . Additionally, the draft of the National Power Development Plan (PDP) VIII states that the installed capacity of solar PV is expected to be 17,240 MW in 2025 and 18,640 MW in 2030.

However, considering the current installed capacity of more than 16 GW solar PV as of December 2020, only less than 2 GW newly installed capacity would be targeted for the next 10 years according to the PDP VIII draft. This raises questions about the low ambition of the government in terms of RE development in the future. Additionally, there are no clearly defined targets specifically for ground-mounted, floating, and RTS categories. These concerns have been raised by various parties and the government has been asked to adjust the solar target in the PDP VIII.

Nevertheless, there are additional regulatory developments that may impact the utility-scale solar and RTS developments in the next years, or maybe even already in 2021:

- **Utility-scale solar (ground-mounted and floating):** FIT2 expired at the end of 2020 and there is no immediate follow-up regulation. A direct PPA mechanism is under development.
- **Rooftop solar:** In the first half of 2021, a draft FIT3 rate has been developed but is not yet published. The current version of the draft promotes a shift towards self-consumption. An annual adjustment of the FIT (instead of having to publish a new regulation each year) is being discussed as well. Whether there is

FIGURE GW3.2 VIETNAM ENERGY CAPACITY MIX 2030 AND 2045 ACCORDING TO THE DRAFT PDP VIII



NOTE: Power capacity mix according to the Draft PDP VIII. Notably, the installed solar capacity at the end of 2020 has almost reached the target for 2030.
SOURCE: Draft report of PDP VIII for public consultation on 22/02/2021.

notable newly installed capacity of significantly more than 1 GW in 2021 will depend on how quickly the draft is published. If the draft is not published this year, the installed systems will only be 100% self-consumption systems (self-owned or private PPA).

In brief, the installed solar capacity (both utility-scale and RTS) is expected to be low in 2021 but could experience another uptake, if well-designed mechanisms that promote a sustainable long-term market are developed and announced in time.

Challenges

Among various challenges that young solar markets such as the Vietnamese one face, two key barriers affecting the current development are notable.

Very short-term policy that lacks clarity is a major challenge. The short duration of FIT2 with a validity of only 7 months led to a pressing demand in products, services, delivery, and grid connection. In December 2020, the high demand resulted in a 30% increase of the solar PV system price. Since the expiration of FIT2 on Dec. 31, 2020, no new policy has been announced. In the worst case, this gap in policy might cause a medium to long-term market distortion in the coming years or even in the best-case scenario, a temporary short-term market collapse.

Asynchronous developments of solar PV and grid projects lead to PV power curtailment. Indeed, the development of solar PV projects outpaced the transmission grid projects, which are defined to be financed, operated and managed exclusively by Vietnam Electricity (EVN) National Transmission Corporation.

Conclusion

Despite the unexpected impacts to the investment as well as on grid operation due to the short-term policy, still the Vietnam solar market remains quite promising in the middle-term.

Indeed, due to the fact that many big coal-fired power plant and gas-turbine plants will come late due to lengthy negotiation process and limited financial access, to ensure the national energy security and energy independency, opportunity for further development of solar PV is still acknowledged, especially decentralised rooftop solar. The pilot direct PPA mechanism shall facilitate the new fly of the market even without any feed-in tariff.

Author: GIZ ESP Viet Nam

50 MW, Ha Do Ninh Phuoc, Ninh Thuan, Vietnam.

4. Japan

Overview of PV developments

The Japan Photovoltaic Energy Association (JPEA) estimates that around 8.2 GW_{DC} (6.6 GW_{AC}) was installed in 2020, resulting in a cumulative installed PV capacity of 71.4 GW_{DC} end of 2020.

After reaching the record capacity addition of 10.8 GW_{DC} (equal to 9.8 GW_{AC}) in 2015, the Japanese PV market has been trending downwards following the reduced FIT support for Solar PV. Although the installed capacity went up in 2020, the general downwards trend is unchanged. The approved new FIT projects dropped to some 1.5 GW_{AC} in 2020, indicating further market contractions are likely in coming years. However, we expect the PV market will return to a state of growth again from 2022 onwards.

Japan's new emissions reduction target of 46–50% by 2030, doubling the previous target of 26%, will require a large increase of renewable energy shares in Japan, in particular for solar PV.

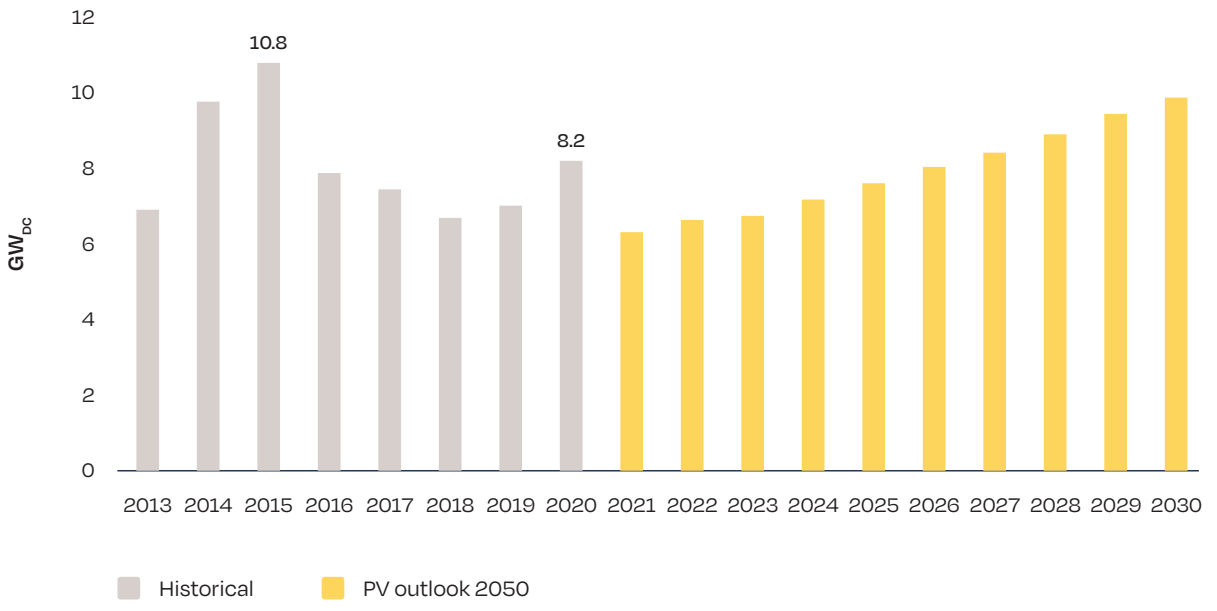
Japanese Solar and Renewable Energy Targets

- **The government target of Solar PV:** 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 is 64 GWAC. This 'old' target is under review by METI to meet the new ambitious carbon reduction target of 46–50% by 2030.
- **JPEA's vision (PV OUTLOOK 2050):** In our PV OUTLOOK 2050 released in May 2020, the cumulative installed PV capacity was expected to be around 100 GWAC in 2030. However, in accordance with the new national GHG reduction target, JPEA has revised this 100 GW_{AC} target upwards to 125 GWAC (150 GW_{DC}) by 2030. This new, much more ambitious target means, on average, some 8 GW_{DC} solar PV will have to be installed every year until 2030.

Drivers for Solar Growth in Japan

- **The FIT** scheme has been the strongest supporter for the growth of solar PV in Japan. However, the FIT's role is gradually getting smaller, and a more

FIGURE GW4.1 JAPAN ANNUAL SOLAR PV MARKET SCENARIOS 2021-2030, BY JPEA



SOURCE: JPEA.

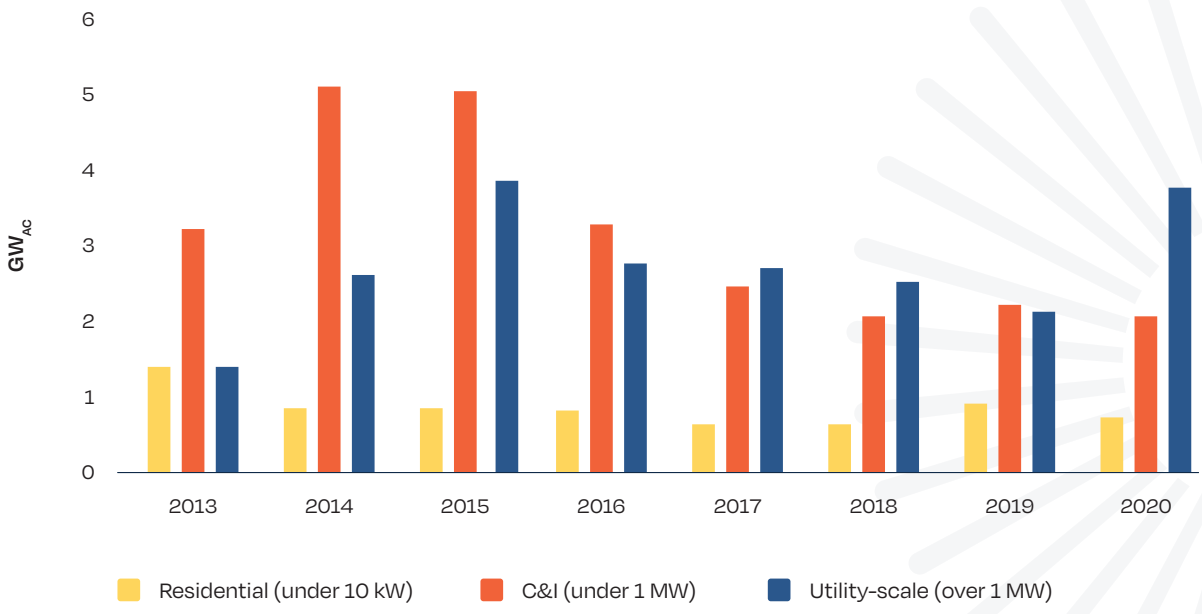
market-oriented **FIP (Feed-in Premium)** will be introduced in 2022, which is expected to be a new driver for solar demand.

- **The new national carbon reduction target 46–50% by 2030** is a game changer for the government's energy policy, and solar PV's accelerated deployment is the key success factor to meet this target. The expected government support will be a strong driver.
- **The "self-consumption business model"** for commercial and industrial users is expected to grow in Japan in the coming years. As the LCOE of solar PV is already comparable to variable retail electricity prices for commercial and industrial users, on-site self-consumption PV systems are becoming attractive to corporate users.

Utility-scale vs. Distributed & Rooftop Solar Development

- **Solar PV below 10 kW,** mostly **residential rooftop,** installed in 2019 was 0.7 GW_{AC}. JPEA expects this segment will grow strongly during this decade up to a 2 GW level supported by FIT and various subsidies for net-zero energy houses (ZEH), battery systems, and other drivers.
- **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 RE users' and/or local community's' energy demand. JPEA expects that with this transformation the segment will grow again.
- **Mega-watt scale solar PV systems of 1 MW and above** including utility scale are also trending downwards. In addition to the FIT reduction, reduction in demand is due to power grid constraints and land availability. JPEA expects these constraints to be overcome and with improved cost competitiveness, this segment is likely to start growing again in the late 2020s.

FIGURE GW4.2 JAPAN ANNUAL SOLAR PV DEVELOPMENT 2013-2020, BASED ON METI DATA



SOURCE: METI.

Challenges

- **Smooth transition from FIT to FIP:** In 2022, FIPs will be introduced as mandatory incentive mechanism for large scale solar PV (1 MW and above) and optional for distributed solar PV (50 kW – 1 MW). 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 FIT/FIP scheme has been and will be the most important growth deriver for solar PV. However, the role of FIT/FIP will gradually shrink in the coming years. With the emergence of corporate PPA type business models, JPEA sees this decade as the transition period towards the growth without FIT/FIP.
- **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" program for transmission and local grid levels. Moreover, METI has started planning the long-term grid expansion program 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 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 higher compared to average international levels, mainly due to expensive construction and soft costs. Reduced capex (mostly construction costs) and longer life (e.g. from 20-year life to over 30 years) are key challenges for the industry. The FIT for non-residential PV (50 kW to 250 kW) was set in fiscal year 2021 at 11 JPY/kWh (10 US cents/kWh). The average electricity wholesale spot market price in 2019 was approximately 8 JPY/kWh (7.3 US cents/kWh). JPEA expects that grid parity will be achieved by 2030. The government targets a PV LCOE of 7 JPY/kWh (6.4 US cents/kWh) between 2025 and 2027.

Author: Japan Photovoltaic Energy Association (JPEA)

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5. Australia

Overview of PV developments

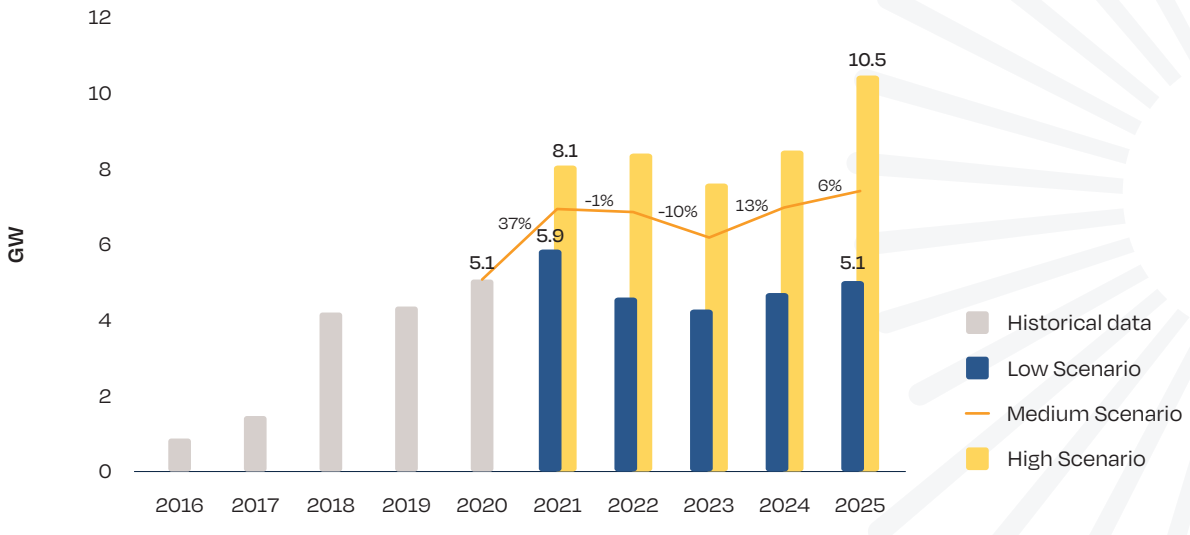
Our report on the Australian market last year was drafted in the wake of devastating natural disasters and as COVID-19 was causing significant local and international disruptions. The primary support scheme, the national Renewable Energy Target (RET), had commenced its wind down to 2032 for small scale certificates (STCs, for under 100 kW systems) and the large-scale certificate scheme (LGCs) was to end in 2020. Our outlook was for a modest increase in rooftop (residential and C&I) over the course of 2020 from 2.3 GW to around 2.7 GW and for an anticipated reduction in large scale installations from 2.3 GW to around 1.7 GW. We were very wrong for rooftop solar!

The rooftop sector has been booming in 2020 although there were significant variations across states and territories in Australia. In particular, it was a difficult year in Victoria, which has a solar PV and battery support scheme in place, where the Solar Homes Scheme[1] caused delays and slow sales in the market. Across the country, rooftop solar increased by 3 GW in 2020, while large-scale and mid-scale solar capacity (100 kW to 30 MW) decreased 29%, due to difficult business conditions during COVID-19. Total rooftop solar is now over 13 GW. Large-scale solar came in at just under 900 MW in 2020 where a range of connection issues and increasing regulatory uncertainty caused delays and reduced the pipeline. However, by the end of 2020, there were 49 large-scale solar farms under construction of around 3 GW which indicates a rebound. With additions of around 260 MW in C&I, a total of 5.1 GW was installed in 2020, just 5% up from 2019. This was an increase of approximately 23% in rooftop solar and a slight decrease in utility scale; with around 278,000 rooftop systems, the average new installed system size is now >8 kW!

Solar/RE targets

The residential rooftop market remains the strongest driver with the RET still offering value for money. The installations in 2020 were 40% up year-on-year, and in 2021 we have seen records broken each month. The states and territories continue to lead with VIC, ACT and SA offering means-tested low or no-interest loans for solar PV and batteries. The large-scale Renewable Energy Target of 33,000 GWh was met at the end of January 2021 with eligible generation from 1 February 2020 to 31 January 2021, reaching an estimated 33,100 GWh.

FIGURE GW7.1 AUSTRALIA ANNUAL SOLAR PV MARKET SCENARIOS 2021 - 2025



1 https://www.solar.vic.gov.au

Drivers for solar growth

The market has changed dramatically with consumers focusing on self-consumption rather than export prices as the wholesale market is seeing regular low and negative prices. The demand remains strong. For both mid- and large-scale we are seeing increased interest in PPAs from a range of businesses with that demand pulling investors otherwise hesitant on market conditions. COVID-19 seems to have had a relatively modest impact on PPA demand and many of the organisations have increased profitability. Domestic and internationally-owned companies have ESG/sustainability targets and/or policy goals, and new corporate regulator accounting guidelines mandate climate change risk in reporting.

The highly competitive costs of renewable generation in Australia means corporates are seeing PPAs as a hedge against volatile electricity prices. This has also seen rooftop solar installations on commercial building assets in addition to PPAs. For example, IKEA, Woolworths (groceries and liquor retailer), WesFarmers, parent of national leading businesses such as Bunnings (big-box hardware), Coles (groceries and liquor retailer), and Myer/ KMart (department stores) are rolling out rooftop PV on all premises and have PPAs too. Surveys suggest a PPA demand pipeline of around 600-800 MW for solar in the coming two years – noting the lead times are around a year. In 2020 the investment was around 2.4 billion USD and 1 GW of RE, for both solar and wind.

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

The split will remain skewed towards rooftop solar for a few years, but there are now several mega-scale projects in the pipeline and well down the development path. These include the Asia Renewable Energy Hub of 26 GW with about 12 GW of solar and the Sun Cable Project of 10 GW of solar and a 50 GW hub to be built in SW Western Australia.

Challenges

The primary challenges remain political with a federal government actively promoting fossil fuels, even to the extent of funding new gas plants with a capacity factor of 2%. The inability of regulatory structures to keep up with the rapid transition to a distributed energy resources (DER) model and the lack of policies on ordered closures of existing and aging coal plants is a barrier to investment. On the plus side are the highly supportive positions of the State & Territories

10 MW Greenough River Solar Farm, Western Australia.

which have all agreed to targets of net zero by 2050 and have strong roadmaps to get there including interim targets and policies to meet them. There have been price increases for modules and systems in 2020 and 2021 due to global shortages of silicon. The USA versus China geopolitical posturing is also having some impacts.

Outlook

Quarter 1 of 2021 saw continued growth in rooftop solar with an estimated 792 MW installed, up 28% on Q1 2020 pointing to 3.6-4 GW of rooftop solar capacity to be added in 2021. If the C&I >100 kW continues to improve another 300MW could be added. Large-scale solar is likely to be again at around 2.2 to 2.5 GW in 2021. The next two to three years will see the construction stages of the mega-scale plants already announced and others of large volumes, but smaller configurations to better fit in distributed Renewable Energy Zones (REZ) announced by the Victorian and NSW governments. That will possibly see unprecedented rollouts of > 120 GW in the coming years, just with known proposals. The two largest totalling 86 GW will be hybrid plants, primarily for green hydrogen production, and focused on ammonia for fertilisers and shipping fuel.

Author: *Steve Blume*, President, Smart Energy Council (SEC)

100 MW, Yarranlea Solar Farm, Queensland, Australia.

6. Germany

Overview of PV developments

After a successful year for solar in 2019 with 3.9 GW installed, Germany's solar market grew further in 2020. Over the course of the year, 4.9 GW was installed, a 26% growth compared to 2019. Germany has regained its role as the leading EU solar market: not only did the country claim the largest market in Europe, it also had the largest operating PV fleet in the EU (54.6 GW), and the highest ratio of solar capacity per capita, 0.65 kW per inhabitant. The outlook for solar in Germany looks very promising, with 6.2 GW additions expected for 2021, and 7 GW year-on-year growth in 2022. We anticipate that by 2024 the market will exceed 10 GW for the first time.

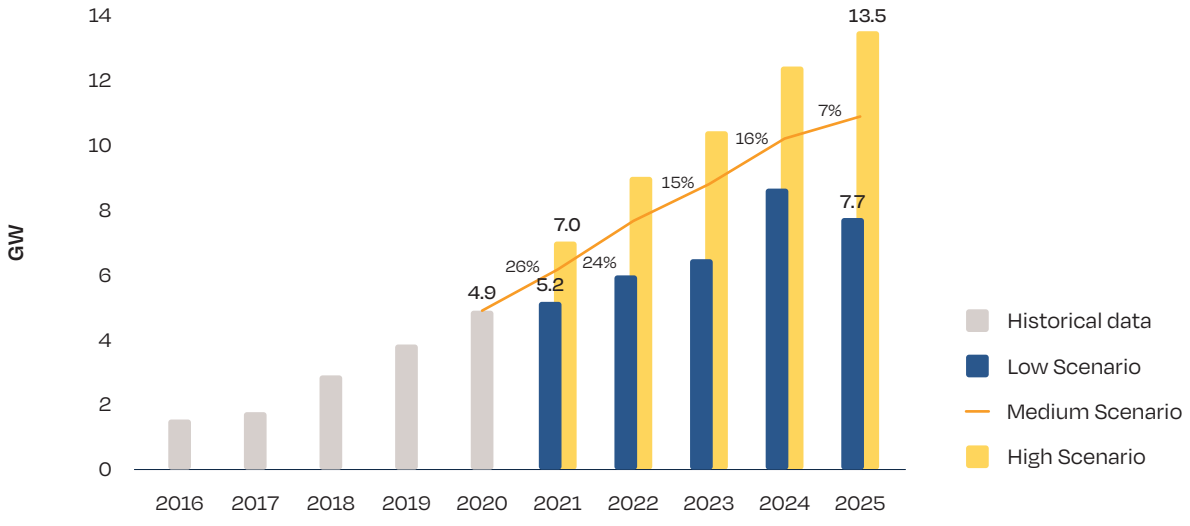
Solar PV Targets in Germany

Despite the trends suggested that Germany would not be able to meet its EU renewable target of 40% greenhouse gas (GHG) emission reduction by 2020, ultimately and surprisingly the target was reached on time. Due to the effects of the COVID-19 crisis, carbon emissions in the transport and energy decreased significantly in 2020. However, considering the progressive reduction of the COVID-19 measures, this could be interpreted as only a temporary achievement.

Solar will play a key role in the energy transition and the phase-out from nuclear and coal, scheduled for 2023 and 2038 respectively, to a renewable-based energy system. Germany's new Renewable Energy Act 2021 (EEG 2021), passed at the end of 2020, set a carbon neutrality target by 2050 and a 100 GW solar capacity target by 2030. In June 2021, the new Climate Protection Act set a binding path to climate neutrality and moved the year of achievement to 2045 instead of 2050. The interim GHG emission reduction target for 2030 is also raised to 65%.

Conversely, the adjustment of the crucial 2030 RES share target in electricity consumption has been postponed to 2021 after the parliament elections take place. A national Emission Trading System (ETS) for heating and transport fuels has also been introduced in January 2021. This scheme complements the EU-wide ETS, which currently does not cover the fuels used in the heating and transport sectors. A transition phase has started with a fixed and rather low CO_2 price of 25 EUR, increasing each year up to 55 EUR in 2025, and will be followed by an auction system with minimum and maximum prices starting in 2026.

FIGURE GW5.1 GERMANY ANNUAL SOLAR PV MARKET SCENARIOS 2021 - 2025



Drivers for Solar Growth

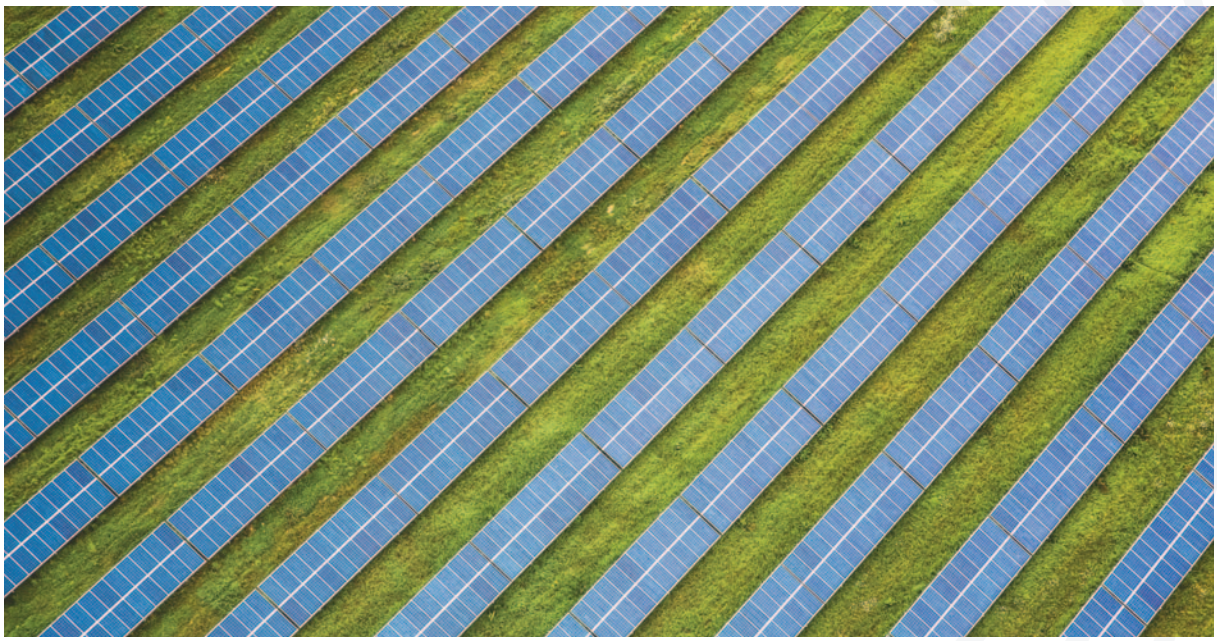
Within the context of **large-scale auctions**, three types of tenders that involved solar occurred: regular solar tenders for projects between 750 kW to 10 MW, **special tenders** for projects of the same size, and **mixed wind and solar tenders**. Regular tenders took place three times a year with a volume of 2 x 150 MW, 1 x 175 MW, and 2 x 500 MW. These tenders were technology specific. To support the achievement of its renewable energy targets, in 2018 the government coalition agreed to organise extra tenders over 3 years, accounting for a total solar capacity of 4 GW (2019: 1 GW; 2020: 1.4 GW; 2021: 1.6 GW), in addition to the regular tenders. Moreover, the technology-neutral tenders awarded in 2020 repeated the pattern of the previous year, with solar winning all of the auctioned capacity. On top of these three tender types, in March 2021 the second technology-neutral **innovation tender** took place, where solar & storage projects were awarded all the 258 MW tendered capacity. In the previous round in September 2020, nearly all the 650 MW capacity was awarded to solar projects, with more than half of this capacity including battery storage.

With the Climate Protection Act, the governing coalition agreed to give a short-term boost to renewable deployment through higher tender volumes for 2022. Auctioned solar PV capacity will grow from 1.9 GW to 6 GW, with the extra capacity equally divided between utility-scale and rooftop systems. Additionally, 50 MW of capacity will be allocated to an innovation tender specifically for special solar systems like solar carports, agrivoltaics, and floating solar.

The **self-consumption** regime underwent profound changes with the approval of the new EEG law in January 2021. On the negative side, as of this year, only PV systems with a capacity below 300 kW will fully benefit from the self-consumption scheme. Installations between 300–750 kW can only sell up to 50% to the grid for a feed-in market premium. Alternatively, operators of this system range can now participate in tenders.

On the positive side, operators of small commercial systems from 10–30 kW do not have to pay the FIT surcharge for their self-consumed solar power anymore. The new EEG law raised from 10 kW and 10 MWh/year to 30 kW and 30 MWh/year the threshold for which rooftop systems are fully exempted from the EEG levy for self-consumption. This will induce the deployment of small commercial systems of larger size.

In 2020, the C&I segment in total grew only marginally, with 2.9 GW installed year-on-year due to a decrease in feed-in premiums. With the planned tendered capacity for the 300–750 kW to be significantly lower than the current installation levels of this segment,



Bavaria, Germany.

this will result in an annual gap of 75%. Due to these changes, a decrease in this segment is anticipated. Residential solar experienced strong growth in 2020, with 1.1 GW installed. The segment doubled its yearly installed capacity compared to the previous year.

The EEG revision also brought positive changes for community solar systems, a segment that has been lagging behind expectations for years. Among others, operators do not have to supply power directly to the tenant, but also via third parties, like utilities, which is expected to make the scheme more useful.

Following Hamburg, Bremen, and Baden-Württemberg, the city of Berlin established in June 2021 a mandate to install rooftop PV on all new and renovated buildings with a usable area of at least 50 square meters. Introducing such a measure at the nation-wide level has been proposed by the Federal Ministry of Environment, but this has been met with resistance from the Federal Ministry of Economics.

The high economic appeal of residential solar in Germany has led to another promising trend: the emergence of a rapidly growing market for battery storage. As described in SolarPower Europe's *European Market Outlook for Residential Battery Storage 2020–2024*, Germany is driving the EU market for home batteries, with 70,000 units expected for 2020, which is equivalent to a storage capacity of over 500 MWh. In this context, the latest amendment of the Energy Industry Act in June 2021 removed double charges and levies to battery systems, which will be therefore enabled to better use their flexibility potential in the energy system.

Next to capacity installed through the self-consumption regime and auctions, **PPA-based projects** are the third pillar of solar development. Large-scale merchant solar is an emerging trend in the German market. For example, EnBW's 187 MW subsidy-free solar park is the largest PV plant in the country and began operations in late 2020, while several other similar projects connected to the grid over the course of the year. As utilities, large investment funds and private investors are very active in this segment, we anticipate the PPA market to grow strongly in the coming years.

Challenges

The auction scheme for systems between 300–750 kW introduced in March 2021 appears unsuitable to the country's energy transition needs. Mid-sized rooftop systems, which have been a major contributor to solar deployment in Germany in recent years, are expected to be severely affected by the new rules.

The 100 GW target for 2030 appears unambitious compared to the market dynamics and the urge to transition the energy sector. German PV association BSW-Solar asked to raise the target to 200 GW to ensure a timely replacement of nuclear and coal capacity with renewable sources; the German Association of Energy and Water Industries BDEW asked for 150 GW.

Major policy changes are unlikely to occur until the end of the year, as the current legislative term is coming to a close due to upcoming elections in September 2021. Against this background, the new government will be tasked with rapidly addressing the issue of increasing the installation rate of renewable energy and setting a new RES target for 2030.

A major market barrier is represented by the digression rates under the current FIT scheme. The remuneration digression mechanism has already given tangible negative results on the attractiveness of solar PV. Further, the postponement of the discussion around the new RES target exacerbates the issue and delays the much-needed rapid expansion of renewable capacity in the country.

Authors: *Raffaele Rossi & Michael Schmela*, SolarPower Europe.

7. India

Overview of PV developments

With an installed capacity of 41 GW*(source: MNRE), India is now the 5th largest country in terms of installed solar capacity, globally. With almost 300 sunny days, India is blessed with an abundance of solar energy. In-line with the resource availability, the Indian government set up a target of 20 GW by 2022 in 2012, which was revised in 2014 to 100 GW of solar capacity by 2022. In 2019, Indian Prime Minister Narendra Modi announced at the United Nations that India intends to procure around 450 GW of its electricity from renewables by 2030, with 300 GW coming from solar. The Indian government's resolve for ambitious targets has already started paying dividends. India's installed solar capacity soared from 3 GW to 40 GW in less than a decade. However, in order to meet its 100 GW target, nearly 60 GW need to be installed by 2022.

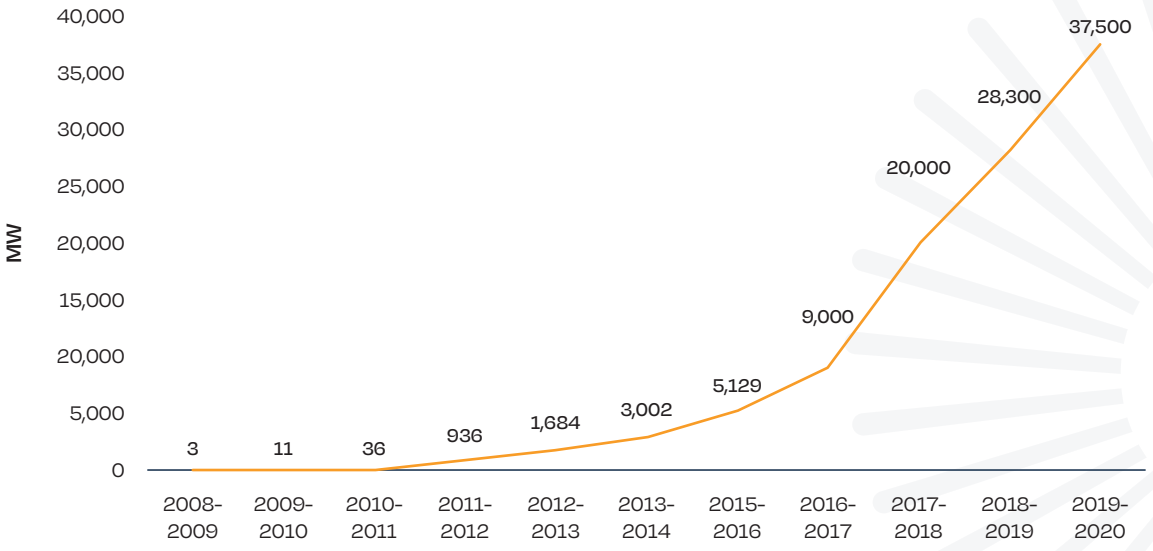
COVID-19 impact on Indian Solar Market in 2020

In 2020, the country observed, nation-wide lockdowns starting March'20 amid the COVID-19 pandemic, which caused labour migration, resulting in a scarcity of workforces on sites, and putting project constructions on hold. In March 2020, India's government declared green energy as an essential service, to ensure that renewable energy projects didn't come to halt, and also to ensure that power generation from such plants is absorbed.

But supply chain disruptions and reduced manpower due to work restrictions resulted in delayed commissioning of projects. Normally, delayed solar projects face penalties under India's strict commissioning timelines. A blanket extension of 5 months was provided, because the lockdown was considered a 'Force Majeure' condition.

Even with COVID-19 lockdowns across the country and reduced demand, RE generation increased by 41.29% in October 2020 in comparison to October 2019.

FIGURE GW6.1 INDIA TOTAL SOLAR PV CAPACITY 2009-2020, BY NSEFI



SOURCE: NSEFI.

* All installed capacity data in this article on India are AC capacities

Solar/RE targets

India's ambitious 300 GW by 2030 goal has triggered a high intensity of solar energy deployment in the country. To achieve this ambitious target India needs to install 25-30 GW of solar per year for the next 10 years.

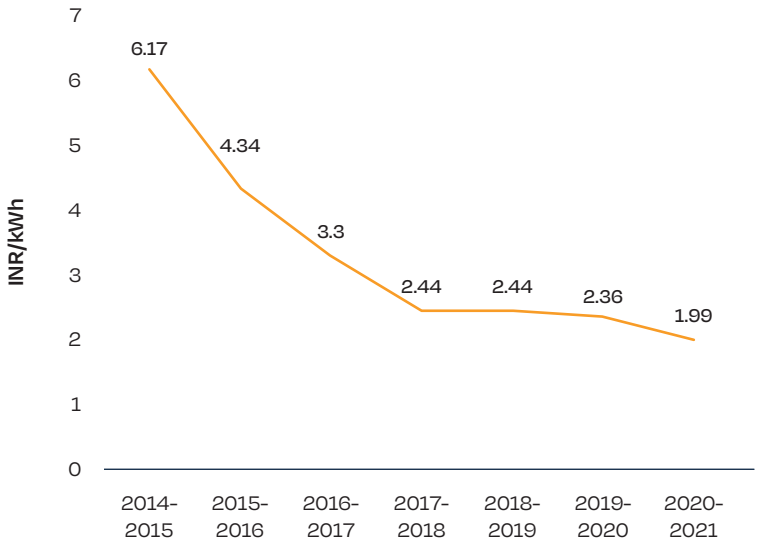
Currently, a large number of projects equal to a capacity of almost 40 GW are in the commissioning phase or auctioned and are awaiting the signing of Power Purchase Agreements (PPA). In order to resolve the offtake challenge of state DISCOMs suffering from low credit ratings most of the projects are tendered/ allotted with state owned companies (Central PSU) as the main intermediaries. While Central PSUs are responsible for tendering about 72%, state governments are responsible for only 24%.

Drivers for solar growth

Increased Tender Activity: With less than 2 years to achieve the 100 GW target, India has accelerated its tendering activity despite COVID-19. These tenders not only received an overwhelming response but also contributed to record-making tariffs. In February, India's first 'round-the-clock' (or so called peak power) tender for a contracted capacity of 1.2 GW was largely oversubscribed for. It received highly competitive bids and resulted in the world's lowest ever renewable + battery quoted peak tariff of Rs. 6.85/kWh.

Decreasing PV Tariffs: In fact, all tenders during the lockdown phase achieved equally historic milestones. Awarded prices kept decreasing throughout the year and reached a new low in December 2020 with a tariff of Rs. 1.99 for a 500 MW tender in Gujarat. An overview of the price trend can be seen in figure GW6.2.

FIGURE GW6.2 INDIA TREND IN SOLAR PV TARIFFS DISCOVERED 2014-2021, BY NSEFI



SOURCE: NSEFI.

As the Union government aims to promote domestic manufacturing of solar products, a Performance Linked Incentive (PLI) has been introduced that is linked to new manufacturing capacity. The Indian government has approved a total amount of 4,500 crores (~600 Million USD) for incentivising manufacturers setting up their manufacturing unit in India. This PLI is expected to be disbursed over a period of 5 years and will significantly depend on the percentage of local value addition.

Green Day Ahead Markets: In 2021, the Union Government of India declared its intent to move towards a centralised dispatch model with a market coupling mechanism. This model will be instrumental in mapping the success of RE in the country by resolving multiple issues of curtailment and delayed payments. For large-scale integration of RE power, in order to increase its share in the energy mix, the Green Term Ahead Market (G-TAM) was launched in India. Additionally, a Day Ahead Market solely for green energy trading will be soon launched. Such new measures will ensure that green power is sold in the market, thereby increase market liquidity.

Free Transmission: In June 2021, the Ministry of Power in India exempted solar and wind power assets in the country from paying Inter-State Transmission System (ISTS) charges for projects commissioned till June 30, 2025. It will replace the previous deadline of June 30, 2023. The extended ISTS waiver will also cover pumped hydro or battery storage if 70% of the energy storage is met via solar or wind. The ISTS waiver will be also applicable for trading electricity over the power exchange (G-TAM, G-DAM).

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

In 2021, India is expected to add around 6-8 GW of solar PV power capacity largely driven by auctions held in the years 2018-19. In 2022, another 10-12 GW of additional solar PV power capacity is expected.

For now, India's solar market is majorly driven by large-scale ground mounted projects. In March 2021, around 70% of India's installed solar capacity came from utility-scale plants. In the last 5 years, a 226% increase has been achieved by the country. The country's installed solar capacity is composed of around 35.65 GW ground-mounted and 4.44 GW of rooftop solar while around 2.5 GW solar (out of 11.5 GW in total) has been added in off-grid areas.

With many utility-scale projects in the pipeline, the trend towards large solar power plants is likely to continue. Ground-mounted solar projects, which predominantly operate under the Solar Parks and Ultra Mega Solar Power Projects schemes, are tendered by the government through a reverse bidding process. The State of Maharashtra has recently allowed 100% RE procurement by corporates wishing to offset their energy needs, which is another welcome step to accelerate the dissemination of solar. While Open Access is allowed for subsidy-free projects beyond 1 MW capacity across all states, it is just in the starting phase. But with more ease in availing Open Access for corporate power sourcing, the solar industry will become the main source due to its cost advantages.

Rooftop solar is yet to pick up in India. Commercial and industrial entities are the largest investors in rooftop solar. But with less than 5 GW rooftop solar installed by end of 2020, meeting the National Solar Mission's rooftop solar target of 40 GW by end of 2022 remains a gigantic challenge. For the proliferation of rooftop solar in the coming years, the government has taken several new progressive steps. The Central Financial Assistance (CFA) is one such tool, which is poised to provide subsidies for the installation of rooftop solar plants in the residential sector. Many states have also introduced new policy instruments such as Virtual Net Metering (VNM), which is offered in different variants, like Group VNM, Community VNM and bulk VNM.

Challenges

The Indian market remains one of the world's largest markets, but as it was hit hard in 2020 by COVID-19, it is facing several challenges that stand in the way of tapping its enormous solar potential:

1. **Sanctity of Contracts:** Sticking to power contracts is a major roadblock hindering growth of renewables in India. There has been an increasing trend in states towards cancellation or re-negotiation of awarded tender bids (e.g. Andhra Pradesh - PPA renegotiation, Punjab - tariff discount negotiation, Gujarat - Dholera tender cancellation, UP - solar auction cancellation), making it difficult for companies to execute projects in India. This issue, if left unaddressed, can negatively affect the industry at large.

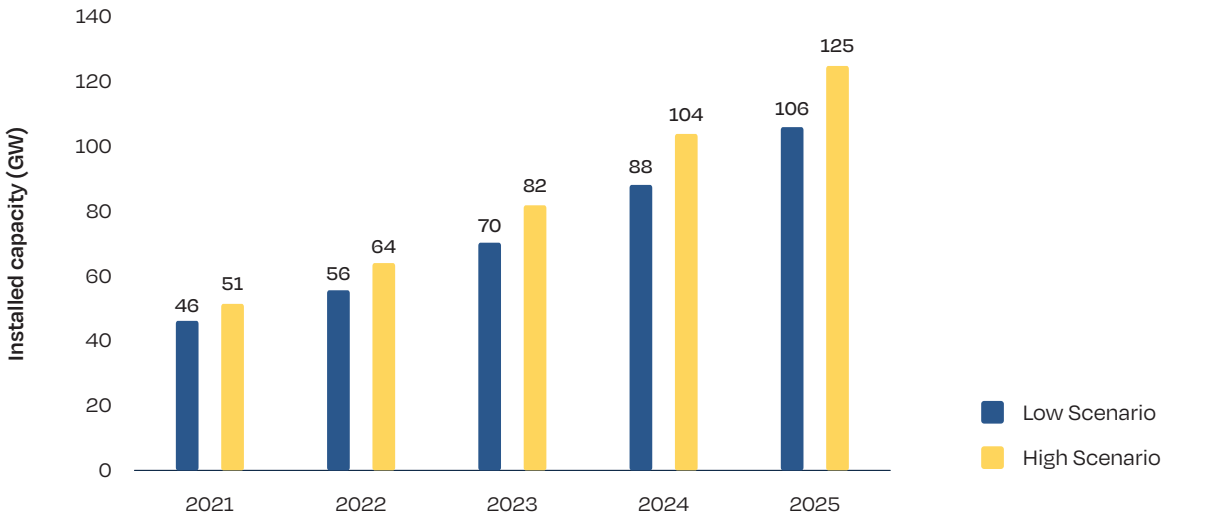
2. **Manufacturing:** India needs to have a reliable domestic module and cell supply chain that can help the country meet its demand and ambitious targets. The PLI scheme comes at an important juncture in India's solar journey and will go a long way into creating an ecosystem for domestic solar manufacturing. However, aspects like interest subventions, subsidized land and electricity rates will also be game changers for promoting manufacturing in India.
3. **Distributed Solar:** Distributed solar is yet to take off in the country despite multiple measures. However, the sector also faces several challenges, such as: little consumer awareness, lack of innovative government policies or attention and limited support from utilities.

Outlook

Given the impact of COVID-19 on the solar market, we anticipate India to move on the fast track as of 2022, when the country will add 2-digit GW levels per year for the coming years and reach the 100 GW mark in 2024, when over 20 GW are expected to be installed.

Authors: *Tusshar Sharma*, Senior Associate, & *Subrahmanyam Pulipaka*, Chief Executive Officer, National Solar Energy Federation of India (NSEFI)

FIGURE GW6.3 INDIAN SOLAR MARKET OUTLOOK



SOURCE: NSEFI.

8. South Korea

Overview of PV developments

South Korea continued its solar market growth in 2020, when it connected 4.1 GW of new PV system capacity to the grid, which constitutes a new installation record for the country. This compares to 2.0 GW added in 2018 and 3.1 GW in 2019 and translates into a year-on-year growth of 31%, but a slowdown compared to the 54% growth in 2019. In total, South Korea installed 15 GW of solar power by the end of December. In the first quarter of 2021, the country deployed 1,017 MW worth of new PV systems, which is in line with the growth rate shown in Q1/2020.

Renewables targets

Under its 2017 past government plan "RE 3020", South Korea is aiming for 20% of its electricity to come from renewables by 2030. Every two to four years, Korea publishes an energy plan that acts as a roadmap for the country's power industry. At the end of December 2020, the 9th edition of its Basic Plan for Long-term Electricity Supply and Demand was released, with details for the power sector for 15 years between 2020 and 2034. According to the Basic Plan, the generation capacity from renewables is anticipated to grow to 34%, from around 15% at the end of 2020. This is a much higher target than the 22% outlined in the 2017 released 8th edition.

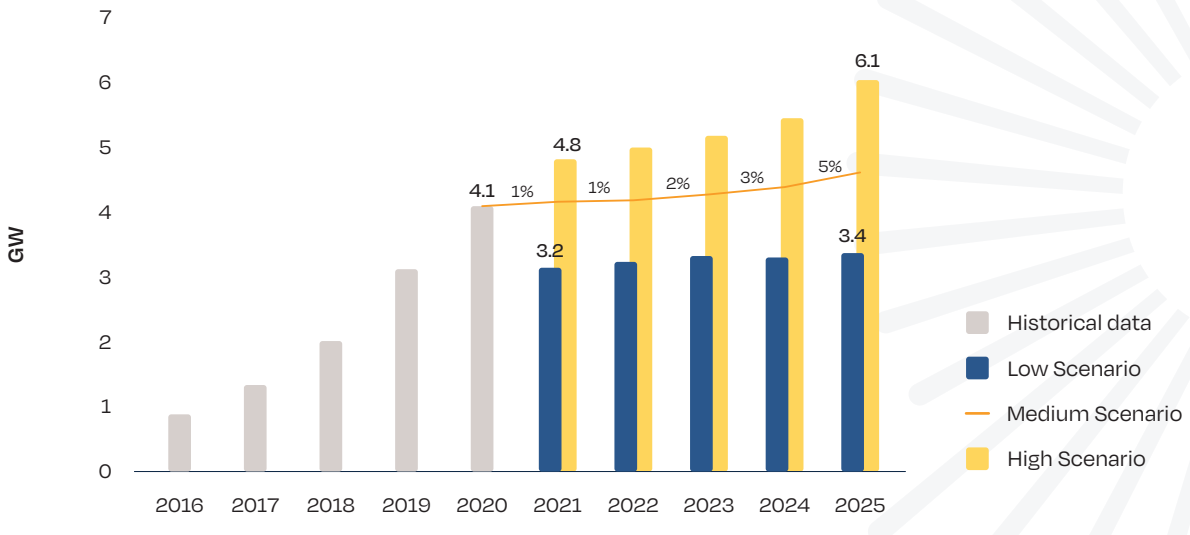
The 9th Basic Plan builds primarily on solar and secondly on wind. By 2030, it strives to reach 34 GW of solar capacity and 18 GW of wind capacity, which would represent 90% of the 57.9 GW renewables target. It is very likely that these numbers will be revised upward again. In October 2020, South Korea's president Moon made a commitment to the national assembly to reach carbon neutrality by 2050, shortly after its biggest local economic rivals China and Japan had announced net zero carbon goals – first China by 2060, then Japan by 2050.

Drivers and Challenges: today and tomorrow

The main driver for over 90% of solar demand in Korea remains the Renewable Portfolio Standards (RPS) scheme, which requires utilities with generation capacities larger than 500 MW generation capacity to supply certain shares of their power from new and renewable power sources: 6% by 2019 and 10% by 2023.

South Korea's strongly regulated market has been an obstacle for low cost solar in recent years, with the country's Korea Electric Power Corporation (KEPCO)

FIGURE GW8.1 SOUTH KOREA ANNUAL SOLAR PV MARKET SCENARIOS 2021 - 2025



enjoying a monopoly for transmission, distribution and purchase of power. But as of January 2021, domestic consumers are allowed to buy electricity from renewable energy producers through power purchase agreements (PPAs). With South Korea being home to many internationally active corporate heavy weights that increasingly need to take care about their ESG ratings, there is gigantic potential for PPA-based solar systems. KEPCO informed in July 2021 that it removed a price clause in standardized contracts that prohibited renewable deals to be signed below average industrial prices. But it still too early to quantify any impacts on solar development as high T&D costs are still a barrier for companies. It is also not yet clear how PPAs will be applied in the allocation process of Koran Emission Trading System.

South Korea has its own Green New Deal program, with the government having committed USD 38 billion to boost renewables. In his October speech at the parliament, President Moon said he was looking to commit an additional USD 7 billion to support green initiatives. This includes financial incentives for local renewable energy businesses, for projects and to accelerate R&D for the new generation of solar cells, such as high-efficiency tandem silicon-perovskite cells. South Korea's Hanwha Q Cells was the largest non-Chinese solar module manufacturer on 6th place of the global ranking in 2020. The initiatives also encompass support for building EV charging infrastructure.

The Korea Photovoltaic Society (KPVS) has highlighted the issue that the country's "mountainous terrain makes it difficult to find areas for large utility-scale PV plants". For that reason South Korea's government focuses on distributed solar, which is aimed at providing 30% of total power by 2040, up from 12% in 2017, and an interim target of 15% by 2035. That's why there is also a focus on smart meters and EV infrastructure investments, KPVS said. At the same time, the government is looking at circumventing the issues of land scarcity by looking into alternatives, primarily floating solar and offshore wind. Korea is currently developing the world's largest floating PV plant with 2.1 GW capacity and announced in March that it will build another 2.1 GW of floating PV capacity by 2030.

As part of its focus on distributed energy, South Korea has been offering incentives and has set sustainability requirements in several programs, such as its Home Subsidy Program, its Building Subsidy Program, and its Public Building Obligation Program. The city of Seoul, for example, has a goal to install 1 GW of solar on 1 million homes and all public buildings by 2022.

As South Korea has been facing delays with grid connection of renewable energy systems due to missing adequate transmission infrastructure, several government agencies have been tasked to solve these issues.

South Chungcheong, South Korea.

While South Korea's coal and nuclear power will further expand in the short term, peaking in 2024, the country's plan is to rely on imported gas as a transition and balancing fuel. Battery storage, a strong driver for solar, only plays a negligible role in the government's plan. It foresees only less than 1% of total storage capacity by 2034, despite the fact that Korea-headquartered LG is a global leader in that field. However, KPVS believes that energy storage will play an important role in expanding the Korean PV market in the future.

Outlook

With COVID-19 having comparatively little impact on the public life in South Korea, the solar market continued its growth path, though at a lower rate than the year before. Originally, the government was looking at a 2 GW level deployment per year in its 2030 policy plan. But that was already proven way too conservative, like the 20% renewables target set for 2030. If South Korea's government is serious about its 2050 carbon neutrality goal, it will have to increase its renewables targets again in the 10th Basic Plan, in particular as it strives to phase out not only coal but also nuclear, and if it does not want to get highly dependent on gas imports in the interim. The Korea Advanced Institute of Science & Technology recommended in May 2021 that the 20% RES by 2030 target should be raised to 40%.

However, South Korea's solar market is also likely to continue its growth path in the short term, due to various government initiatives, and because two tenders for 4 GW of solar are scheduled for 2021. However, one factor might be different, as the Korean Ministry of Trade, Industry and Energy (MOTIE) recently introduced a carbon footprint requirement for solar modules. It will be interesting to be seen how this will affect the sales shares of module suppliers.

Authors: *Christophe Lits & Michael Schmela*, SolarPower Europe

9. Brazil

Overview

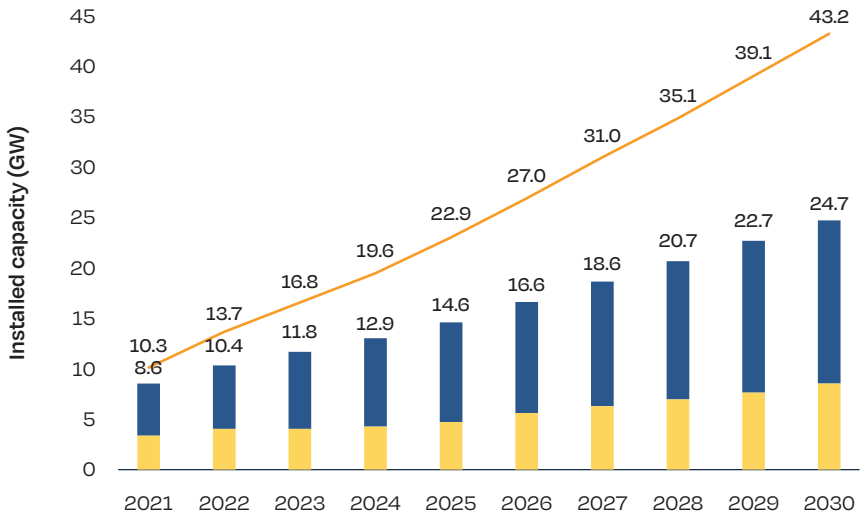
In 2020, Brazil surpassed three new milestones of 5, 6, and 7 GW of total cumulative installed solar capacity, reaching 7,747.2 MW in solar PV systems in operation. Before the effects of the COVID-19 pandemic, the Brazilian Solar Photovoltaic Energy Association (ABSOLAR) projected a total increase of more than 4 GW in 2020. This level was not fully reached, as the solar segment was also impacted by the effects of the pandemic on the global and national economy. Still, Brazil installed more solar in 2020 than ever before.

Despite COVID-19, Brazil continued to grow at a strong pace during 2020 in terms of added solar PV installed capacity in the two main market segments of the country: centralised generation (large-scale projects, above 5 MW, commercialised in energy auctions held by the government and through direct PPAs in the free electricity market) and distributed generation (small and medium-sized projects, equal to or below 5 MW, via a national net-metering regulation). Installations grew to a record 3,153 MW, of which 2,535 MW was in distributed generation and 618 MW was in centralised generation.

Solar PV Targets

The Brazilian Energy Research Office (EPE) forecasts in its 10-Year Energy Plan (PDE 2030, published in 2021) that solar PV could reach between 24.7 GW (Pessimistic Scenario) and 43.2 GW (Optimistic Scenario) of cumulative installed capacity by 2030. For centralised generation, PDE 2030 considers energy auctions adding an average yearly capacity of 559.4 MW between 2021 and 2030. For distributed generation, it projects between 16.3 GW and 34.7 GW of cumulative installed capacity by 2030.

FIGURE GW9 BRAZIL TOTAL SOLAR PV CAPACITY SCENARIOS 2021-2030, BY ABSOLAR



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Distributed PV - Scenario 1	5.2	6.4	7.5	8.6	9.8	11.1	12.4	13.7	15.0	16.3
Centralised PV	3.4	4.0	4.4	4.3	4.8	5.5	6.2	7.0	7.7	8.4
Total = DG + CG - Scenario 1	8.6	10.4	11.8	12.9	14.6	16.6	18.6	20.7	22.7	24.7
Distributed PV - Scenario 2	6.9	9.7	12.5	15.3	18.1	21.5	24.8	28.1	31.4	34.7
Total = DG + CG - Scenario 2	10.3	13.7	16.8	19.6	22.9	27.0	31.0	35.1	39.1	43.2

SOURCE: ABSOLAR, 2021 based on official data from EPE, 2021.

Considering both centralised and distributed generation, the PDE 2030 forecasts between 1.8 GW and 3.7 GW of solar PV added capacity on average per year, between 2021 and 2030. ABSOLAR evaluates these numbers as below expectations, due to the conservative economic premises used by the study for both centralised and distributed solar PV.

Solar PV Targets

In 2020, the market growth of centralised solar PV generation was mainly based on the delivery of projects commercialised under the federal government's New Energy Auction (Leilão de Energia Nova) held in 2017, as well as direct PPAs contracted in the Free Energy Market (Ambiente de Contratação Livre). As a result of the uncertainties due to the COVID-19 pandemic, energy auctions for large-scale power plants scheduled to take place in 2020 were postponed by the Federal Government. Nevertheless, new tenders remain scheduled for the years 2021, 2022, and 2023, including for solar PV projects.

2020 saw an increase of 618 MW in centralised generation. The increased competitiveness of solar PV resulted in a pipeline of more than 17.9 GW of granted projects in the country. Not all of these projects have already signed contracts, therefore, a part of this is considered prospective pipeline. This shows a growing interest by market players in solar PV electricity, despite challenges related to bankability and grid connection bottlenecks, topics that ABSOLAR is addressing with the participation of the sector.

In distributed generation, 2020 was a record-setting year. The increasing competitiveness of solar PV under the net-metering regulation throughout the country led to capacity additions of 2,535 MW, compared to 1,528 MW in the previous year, which signals a strong improvement for the sector.

To date, Brazil has a full national net-metering program for projects up to 5 MW, including both local and virtual net-metering, as well as community solar mechanisms. This allowed for the development of several innovative business models for solar PV distributed generation, such as direct sales, solar communities, cooperatives, leasing, third-party ownership, and solar as a service.

Santa Cruz do Sul (RS), Brazil.

In this regard, a public consultation assessing the benefits and costs of distributed generation in the market and its impacts in electricity tariffs took place in 2019. The subject is now being debated by the National Congress, which plans to establish a comprehensive legal framework for distributed generation from renewable energy sources in Brazil. However, in 2020, this debate was postponed as the National Congress turned its focus to immediate decisions about the pandemic. Nevertheless, a new legal framework for distributed generation is under development and expected to become law over the course of 2021.

ABSOLAR's recommendation to the National Congress is that the benefits of distributed generation greatly outweigh and compensate for any impacts or costs. Potential changes to the net-metering regulation are an important aspect to follow closely in this market segment, especially when taking into consideration the role of distributed generation in contributing to Brazil's economic recovery after the pandemic, creating new investment opportunities and jobs throughout the country.

ABSOLAR will continue to defend Brazil's solar PV sector, developing recommendations to make solar PV a decisive tool to support the sustainable economic recovery of the country, during and after the pandemic.

Authors: *Dr. Rodrigo Lopes Sauaia,* CEO; *Dr. Ricardo Lacerda Baitelo,* Technical and Regulatory Specialist; ABSOLAR.

São Gonçalo solar park, Brazil. © Enel Green Power

10. Netherlands

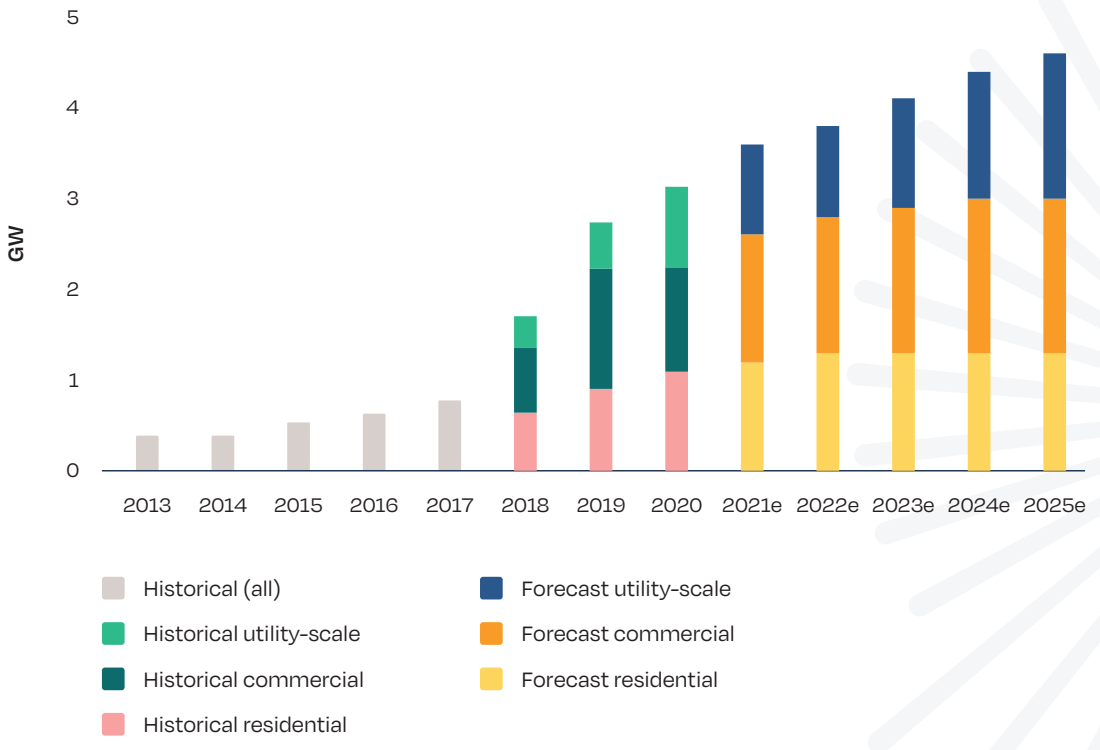
Large 13.3 GW project pipeline, strong increase of grid congestion

With an added capacity of more than 3 GW in 2020 and a project pipeline with SDE+ subsidy-awarded projects of 13.3 GW, the Dutch market looks very sunny despite the COVID-19 crisis. The pipeline includes both rooftop commercial and ground-mounted projects, with rooftop making up the lion's share. The main challenge is now to ensure the completion of all projects. In general, approximately 70% of the projects reach closure, including timely grid connections. Many favourable project development areas in the Netherlands are experiencing grid congestion, which means no new projects can be connected to the grid in the near future in that area. We are now even more upbeat on the Dutch solar market compared to our last year's forecast. In 2021, the Dutch solar market will grow again and is now expected to reach a volume of 3.8 GW, and 4.6 GW in 2025 (see Fig. GW10). After 2025 the chances of solar will strongly depend on electricity demand developments. Electrification efforts in industry, built environment and mobility sectors are not yet in place. The precent negotiations for a new government will be decisive on this point, in relation to new European Climate Targets and Recovery Plans.

Future market development

The Dutch Solar Energy Association Holland Solar is positive about the market development for the next four years, as can be seen in our forecast (Fig. GW10). The market is divided into two parts: Firstly, the residential and small businesses market (both < 3*80 A), and secondly, the commercial and utility-scale market. Commercial-scale includes large rooftop projects, while utility-scale covers solar parks.

FIGURE GW10 NETHERLANDS SOLAR PV MARKET SCENARIOS 2021-2025, BY HOLLAND SOLAR



SOURCE: Holland Solar.

New system-size records in 2020

Large solar PV parks across the country have started exceeding the 100 MW size. In September 2020, a 110 MW solar park was completed in Vlagtwedde, in the province of Groningen in the north of the country. The construction of a larger solar park of 147 MW has begun in the province Flevoland. An increasing number of floating solar projects were also completed in 2020, mostly situated on sandpits and water deposits. There is increased interest in multifunctional use of space, like solar carports. Soon the construction of a 35 MW solar panel carport will be finished on a festival site in Dronten. Currently, the country's largest rooftop project, installed on a warehouse in Venlo, has a capacity of 18 MW. However, a new record roof is under construction with a 140 000 solar panels currently being installed at Verbrugge Terminals in Terneuzen.

Market segments in 2020 were all equally successful in contributing to the total annual added volume: residential (35% share), commercial rooftop (36% share) and utility size (29% share). These estimates are calculated based on data for the completion of 2020 projects as far as figures were available.

Despite the expectation that the residential sector would stabilise at a level of 800 MW per year, there was a surprising increase of added value in this market segment to 1,100 MW in 2020. Due to the COVID-19 pandemic consumers showed more interest in investing in solar. And due to extra national campaigns and local policies, we can expect the yearly added residential volume to stay on this level for the coming years. Residential solar will remain an important market segment for the Netherlands.

Dutch policy and renewable energy targets

The Netherlands has not met its EU 2020 targets from national sources, which would have required 14% of the country's total energy mix to come from renewables. Instead, renewables account for 11%. The gap is compensated for by a statistical transfer of Danish wind. Nevertheless, there is an impressive pipeline of projects both in solar and wind, both offshore and onshore. The Energy Agreement's 16% renewable energy target for 2023 is therefore projected to be achieved, with at least 16.6%.

7.5 MW Transberg landfill, Dordrecht, Netherlands. © TPSolar

Regional Energy Strategies

As agreed in the Climate Agreement, clusters of municipalities published their concept Regional Energy Strategies with plans for wind and solar capacity. Local spatial planning and permitting procedures will be based on these Regional Energy Strategies. The second stage of this process requires local governments to specify dedicated areas of interest for the development of renewable energy on land. These dedicated areas include a possible designation for solar or wind energy as well as extra planned grid capacity. From these strategies it becomes apparent that rooftop solar systems are strongly favoured over ground-mounted solar and onshore wind turbines. The expected ground-mounted capacity will largely be developed around infrastructural hubs such as highways and railroads. The ground-mounted projects have to be developed with over-all 50% local ownership. The expectation is that these local policies become more prevalent in the Dutch solar sector and that rooftop solar will have extra incentives. This also means that access to land will be more restricted.

In order to meet local requirements, a code of conduct on how to best integrate solar with the natural and social environment is in force with the support of many NGOs and stakeholders, such as Holland Solar.

Drivers for solar growth

The residential solar market has continued to be driven by net-metering. There is no limitation or charge for net-delivery. However, this will change. A new law has been proposed by the previous government, which stipulates that as of 2023, the right to use net-metering will gradually decrease by 9% every year, up until 2031 at which point net-metering will no longer exist in the Netherlands. That being said, most political parties of influence are against this proposal, as they fear this might impede the development of residential solar energy. This could lead to amendments to the proposed law, and most likely implementation being deferred beyond 2023.

As of autumn 2020, it was agreed that the SDE+ scheme, which will remain in place until 2025, will expand its scope. Its scope now includes other CO_2 reduction projects such as CCS. The ranking in the amended scheme (now called SDE++) is now based on euros per kT CO_2 avoided. The maximum SDE++ contribution per produced kWh has gradually decreased over the past few years, including the SDE++ round in the autumn of 2021. A change in the reference energy prices has led to solar being considered more 'subsidy intensive' as compared to reaching the same amount of CO_2 reduction by another technology. This creates a risk for solar as CCS

35 MW solar Carport, Dronten, Netherlands.

© SolarFields

and CCU projects will primarily receive subsidies and only the remains of the funds will be distributed among the solar projects that have requested SDE++ subsidy. However, total budget per round allows new successes for solar. And indeed, according to the June 2021 published preliminary results of the first SDE++ round, solar PV was the largest winner with 3,426 projects representing 3.54GW of the total awarded number of 3,486 projects and 4.41 GW.

The expectation is that solar energy projects can be developed without any incentives based on PPA contracts by 2025 at the latest. A guarantee from the government could be implemented after 2025, protecting market parties against strong variations in electricity price. However, this will depend on the outcome a new government agreement.

Challenges

One of the main challenges for solar in the Netherlands hasn't changed – it's about securing timely grid connections and getting enough transport. In a growing number of areas there is simply a lack of grid capacity. However, the reserve capacity in the Dutch grids will be put into general use by the grid operators this year. This will add a significant amount of extra capacity. Cable pooling which combines solar and wind project was recently legally accepted, which allows projects to utilise a shared connection to the grid. Moreover, the market agreed upon a maximum of connection capacity of 70% of installed panel capacity. This helps the efficient use of grid capacity and planning. Also, there is an initiative to include battery projects in addition to existing solar projects, to be eligible for SDE++, hopefully from 2022 onwards.

Yet all these measures will not solve all congestion issues. The expectation is that getting grid connection and transport will be more difficult in the near future. The new Energy Law, planned to be in force in 2022, will provide new rules for market parties and grid operators. Access to the grid will be subject to more explicit terms and conditions under the new law.

Another challenge the country faces is the availability of land, especially for utility-scale projects, as well the challenge of gaining social acceptance when it comes to using agricultural land for solar energy projects. Government policy is to prefer rooftops over fields for solar installations. Political preferences have clearly shifted since the parliamentary elections in March 2021, and future possibilities for new ground-mounted solar parks may be at risk in the coming years.

Finally, the sector has put significant effort into developing a code of conduct for the development of commercial and utility scale rooftop projects. Several fire incidents have caused insurance companies to increase their fees or to refuse insuring buildings. With a newly developed code of conduct the sector as a whole shows its continued commitment to safe, green renewable energy.

Authors: *Peter Molengraaf*, President;
Amelie Veenstra, Policy Director, Holland Solar.

11. Spain

This time, Spain is here to stay

Overview of PV developments

Despite the ups and downs of the past, solar energy has entered a new era in Spain. After too many years with low installation figures, in 2019 Spain saw 4.7 GW of new capacity introduced, positioning the country as the sixth largest solar market in the world and the European leader. In 2020, around 3.5 GW was added, which meant a spot close to the global top 10 and ranked second in Europe, behind only Germany, confirming the strength of the previous year's growth. In national terms, 2019 and 2020 were, respectively, the best and second-best year for solar PV in the history of Spain.

Solar PV targets

These GW-scale figures are consistent with the target scenario set out in the Spanish National Energy and Climate Plan (NECP), which foresees solar PV capacity as high as 39.2 GW by 2030, a significant rise from around 12.5 GW today. This projection is what the Spanish Government considers necessary to meet its RES targets of the recent **Spanish Climate Change Act**, approved in May 2021. The law fixed a dual target for renewables by 2030: 42% share in final energy consumption, and 74% share in electricity generation. It also includes a clause to review (only upwards) the targets in 2023.

But the Spanish solar sector is not only driven by ambitious energy policy targets. Installed plants in the last two years show that **there is a business sector able to deploy large figures of new capacity**, such as those required to meet the objectives of the NECP.

Utility-scale vs rooftop solar development and plans

In **ground-mounted plants**, the economic competitiveness of solar PV, the terrain availability, the good resources, and the know-how of Spanish developers are attracting the interest of many. The liquidity of the capital markets and the limited investment options explain why so many actors see solar energy in Spain as an optimal investment opportunity.

According to IHS Markit, Spain is the fifth most interesting market in the world to invest in renewables, and ground-mounted solar plays a big role here. In fact, ground-mounted **solar was the technology with the largest installation share in 2020** thanks to 2.8 GW of new capacity. It should be noted that all of these solar plants were installed without any type of public aid or regulatory incentive scheme, making Spain **the leading PPA market in Europe**, according to RE-Source.

50 MW, Solanilla, Trujillo, Spain.

In terms of **solar PV rooftops**, the situation is a bit different. The existing regulatory framework (that eliminated the Sun tax as the main barrier for this segment in the past) was completed only in early 2020, which explains why self-consumption in Spain is still far below the level of its neighboring countries with huge untapped potential. However, installed power of solar rooftops increased by 715 MW in 2020, a 30% increase compared to the previous year, also showing the resilience of this segment to the impact of COVID-19.

Challenges

Regarding the challenges of the market, it is clear that the interest of many players in developing solar plants in Spain comes at a price. So far, around 100 GW of network access permits have been already granted to multiple solar plant developers that rush to advance with their permitting and get to a ready-to-build status to outperform their competitors.

This high interest and competence among developers has resulted in a massive volume of projects advancing their permitting (nearly three times the NECP targets), putting pressure on the administration, which is struggling to process all the authorisations.

The rush also seems to trigger a **NIMBY** (Not In My Backyard) effect with administrations on the local level in recent months.

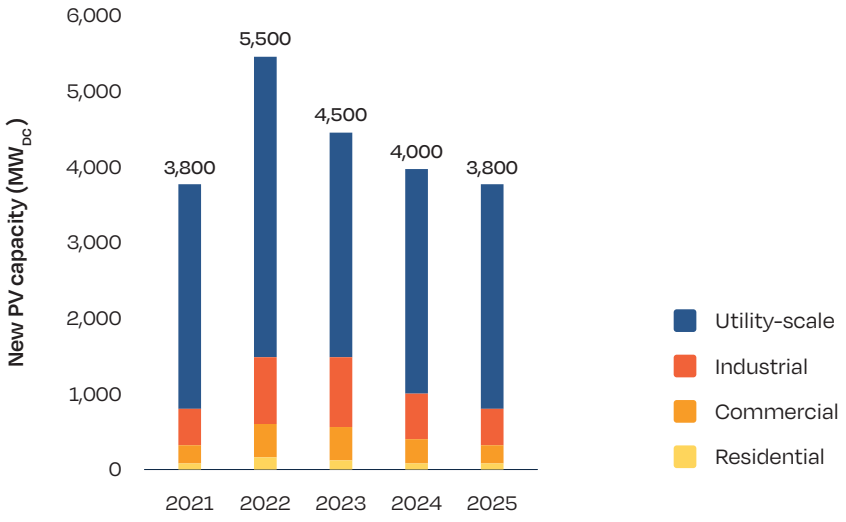
For the solar PV rooftop segment, the main challenge is the long and non-homogeneous authorisation processes at the local level as many municipalities still require construction work licenses to build the PV systems.

Outlook

UNEF expects that growth will continue in 2021. In the ground-mounted segment up to May 2021, installed capacity is already above 700 MW, a figure that will reach around 3 GW by the end of the year, according to our estimates. The January 2021 held renewable auctions awarded 2 GW to solar (to be commissioned before February 2023), and new auctions will be held every year with at least 1.8 GW reserved for solar. On top of the auction-driven capacity, the PPA segment will continue to perform well in 2021.

In terms of rooftop solar, positive growth is also expected, with 2021 likely to exceed 2020's record-breaking figures. For the coming years, growth will accelerate due to the incentive program for self-consumption included in the **national recovery plan** that could be able to deploy 3 GW of new facilities.

FIGURE GW11.1 SPAIN ANNUAL SOLAR PV MARKET SCENARIO 2021-2025, BY UNEF



SOURCE: UNEF.

In conclusion, unlike for the first solar boom a decade ago, this time **Spain is here to stay.** The figures of new installed capacity will remain at this level for the upcoming years. The competitiveness of the ground-mounted segment and the boom of rooftop solar will continue to keep the Spanish solar sector in the world's top 10.

To ensure this development is not hindered by NIMBY opposition, it is key that solar developers apply the best available ESG methods for **social and environmental integration of utility-scale PV plants.** Fortunately, many companies are already building solar plants in Spain with a focus on improving the socioeconomic conditions of local communities and the biodiversity of the terrain in which they are installed and beyond; one of them, the 300 MW Talayuela plant from Statkraft was among the three finalists of SolarPower Europe's 1st Sustainability Award 2021.

Authors: *José Donoso*, *Alejandro Labanda*, Unión Española Fotovoltaica (UNEF).

12. Poland

Overview of PV developments

Solar PV is the fastest growing energy sector in Poland, and 2020 was a record year for solar in the country. According to the data of the Polish transmission system operator (Polskie Sieci Elektroenergetyczne), installed PV capacity at the end of 2020 was 3,936 MW, which means an increase by 2,463 MW year-on-year, amounting to 200% growth compared to 2019.

We also see very high social acceptance for PV technology and no major controversy that sometimes accompanies other sources. The research conducted in 2020 by the Marketing Research Centre *Indicator*, commissioned by the Polish Photovoltaic Association, shows that 90% of respondents would accept the construction of a PV farm in their neighborhood.

Solar/RE targets

According to the Polish government's plans, in 2040 more than half of the installed capacity will be from zero-emission sources. In terms of solar PV capacity, there will be an increase in installed capacity to approximately 5–7 GW in 2030, and between 10–16 GW in 2040. These figures will most likely be achieved much sooner.

Drivers for solar growth

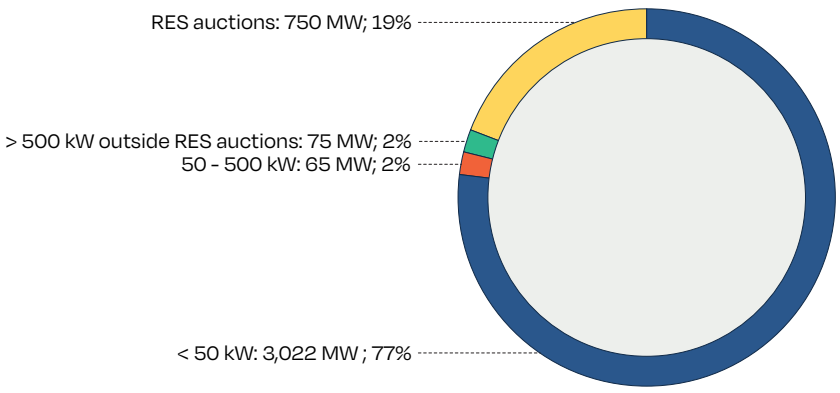
In Poland there is significant talk about the need to develop solar energy in the context of high summer peaks in the energy system, which are the result of two factors: more frequent heat waves, which results in increased energy consumption due to air conditioning. Recurring droughts reduce energy production in conventional power plants. Only solar energy can prevent the risk of blackouts during summer load peaks. Solar PV produces most energy in the moments of the highest sun exposure when air conditioning consumes most electricity.

In the micro-installation sector, co-financing programs and preferential settlement methods constitute the main drivers for growth. However, this situation will be valid only until the end of 2021, when the legislative framework for small-scale systems will change. More and more medium-sized PV installations are being built next to factories, and on the roofs of office buildings or warehouses, without any support; the costs of producing energy from such installations are already lower than the costs of purchasing electricity from the grid.

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

The Polish Institute of Renewable Energy provides an overview of PV installations in the country at the end of 2020. Total capacity of micro-installations

FIGURE GW12.1 POLAND TOTAL SOLAR PV CAPACITY SEGMENTS 2020, BY PSF



SOURCE: PSF, based on Institute of Renewable Energy.

(installations with a total installed capacity less than 50 kW) was by far the largest, amounting to 3,022 MW. Small installations, with a capacity of between 50 kW and 500 kW, had a minor share of the cake, with a total capacity of 65 MW. Solar PV installations with a capacity above 500 kW, created under the system of certificates of origin or outside the auction support scheme, contributed with 75 MW. Finally, large-scale systems built under the RES auction had a total installed capacity of 750 MW.

By the end of 2021, we expect a sharp increase in capacity in terms of micro-installations, with prosumers hurrying to install by 2022 when, in accordance with the amendment to the Energy Law, the support system will become less favorable for owners of micro-installations. The discount system, which has contributed to the growth of home investments in PV systems, will disappear from 2022 onwards, when it will only be possible to sell surplus energy. Prosumers who install before this date will remain under the old system for another 15 years.

As it stands now, the prosumer gives off surplus energy during the day, and in the evening (when the installation no longer produces energy) has the possibility to receive 80% of the previously given energy. The new system changes this, where surpluses will be sold by the prosumer during the day and bought in the evening.

64.6 MW, Witnica, Poland. © Fotowatio Renewable Ventures

Since selling online is twice as cheap as buying, prosumers may feel the changes to be a disadvantage.

Challenges

The most pressing challenge for solar energy and the entire renewable energy industry is the lack of notification of regulations on the extension of the auction support system for RES technologies after 2021. The government has presented its proposal to extend the support, but it requires the notification of the European Commission.

Industry organisations have also been sounding the alarm for many years about the need to modernise and expand the grids. Without these improvements, further development of renewable energy sources in Poland will be threatened, which will negatively impact the energy security of the country, especially at the local level.

Outlook

The change of the prosumer billing model to a less favorable one, motivated by the government with restrictions on the distribution network, will most likely result in a noticeable slowdown in the growth of new capacities in the solar PV segment. The current pace of development of solar in Poland could be sustained by new investments in the segment of small- and medium-sized enterprises. The condition is the liberalisation of the regulations on the construction of energy networks and enabling the construction of direct lines connecting PV installation with the end user. Currently, the construction of such direct lines is practically impossible due to the lack of appropriate regulations. It is necessary to adapt the Polish law to the possibility of the direct sale of electricity (via PPAs), including using a direct line. However, with nearly 4 GW installed by the end of 2020, the current 5-7 GW by 2030 target of the government will be met in any case. But that target will have to be changed upwards anyway to meet the upcoming more ambitious 2030 targets of the European Commission.

Author: *Paulina Wojciechowska,* Communication Officer, Polskie Stowarzyszenie Fotowoltaiki (PSF)

13. Taiwan

Overview of PV developments

Taiwan reached the GW-level for the first time in 2019, adding 1.41 GW, which is equal to an annual growth of 45% and results in a total cumulative capacity above 4 GW. 2020 was expected to follow a similar development. The Bureau of Energy, Ministry of Economic Affairs (MOEA) was targeting 2.2 GW of new solar deployment, targeting a total of 6.5 GW. But COVID-19 took its toll. In the first five months of 2020, only 410 MW of solar capacity was added. While market demand in the second half of the year was much better, it was not enough to catch up and meet the government's 2020 annual target. At 1.67 GW, these were missed by 24%. When looking at the cumulative capacity target, the miss was a little lower. 5.8 GW of PV capacity deployed in Taiwan at the end of 2020 meant a 10% miss.

On the one hand, Taiwan tried to support its PV industry by extending PV project completion deadlines in response to the pandemic. On the other hand, the Council of Agriculture implemented restrictions on land-use, which made the job much more difficult for PV project developers. As of July 2020, the new regime specifies that solar projects covering 2-30 hectares of agricultural land must be approved by the council rather than the local government. Moreover, PV projects cannot be built on agricultural and hillside land smaller than 2 ha.

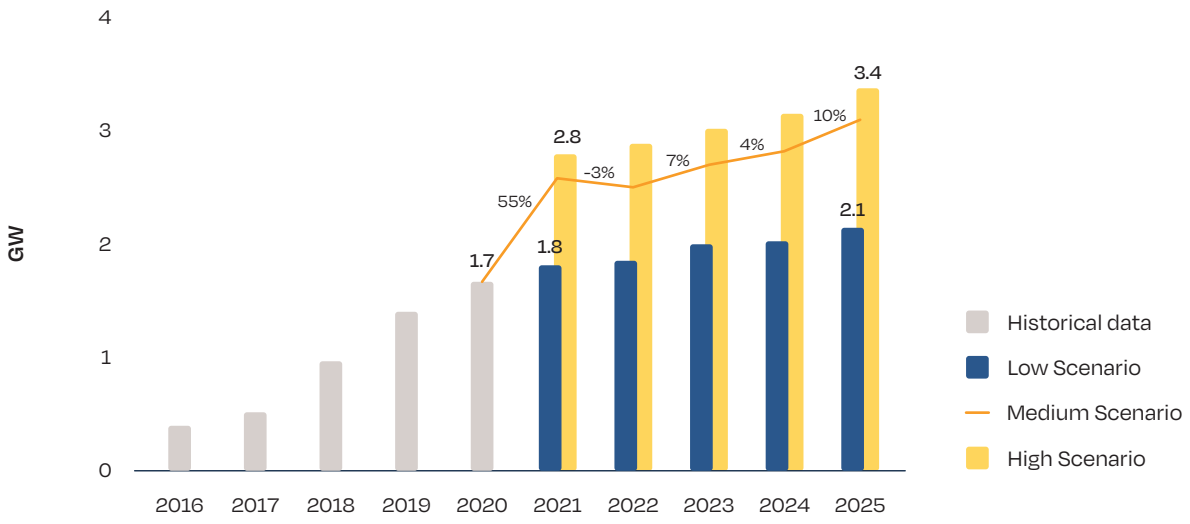
In 2021, several decisions were made to help the solar sector. In June, the Taiwanese Ministry of Economic Affairs decided to leave the feed-in-tariffs for PV installations unchanged. They were initially planned to be lowered from 13.6-20.4 USD cents to 13.4-20.3 USD cents. The decision was taken to help the solar sector recover from the delays caused by COVID-19. The ministry is also granting a three-month grace period for the completion of projects under development.

Solar PV targets and drivers

The government stated in January 2021 that its previous 6.5 GW target would be reached in the first quarter of 2021. At the same time, MOEA has also set an 8.75 GW installed PV goal for 2021, translating into new installations equal to 2.2 GW by the end of this year.

Despite the COVID-19 blip, the government maintains its 20 GW solar target by 2025, with 3 GW of rooftop and 17 GW of ground-mounted capacity. If the 8.75 GW are installed as planned by the end of the year, Taiwan will have to deploy 2.8 GW on average for the coming 4 years.

FIGURE GW13.1 TAIWAN ANNUAL SOLAR PV MARKET SCENARIOS 2021 - 2025



Challenges and perspectives for solar growth

Land availability remains the primary limiting factor to solar deployment in Taiwan. It is one of the most densely populated countries in the world and with two thirds of the island's land constituted by mountainous areas. Therefore, solar developers are facing growing challenges to find suitable locations for their projects. Moreover, the deployment of ground-mounted projects is hindered by hurdles in purchasing land. Often, large-scale projects span over several landowners, which makes negotiations for land acquisition very challenging and lengthy. There is also some resistance in the agricultural sector.

The new rules introduced in July 2020 by the Council of Agriculture are stricter than in the past. This limits land availability further and risks slowing down the deployment of solar PV. The situation is worsened by the November 2020 decision of the Ministry of Finance to stop giving permits for solar system development in ecologically sensitive areas in the County of Chiayi and the city of Tainan. Previous authorisations for PV projects granted in those areas will be revoked.

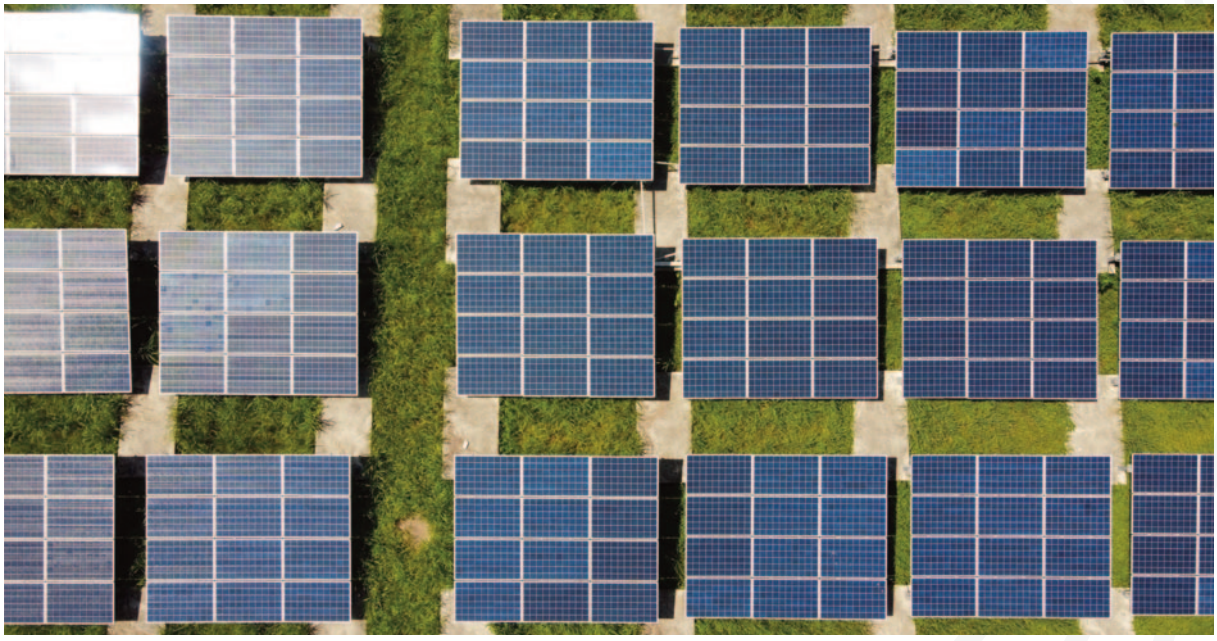
Nevertheless, project developers in Taiwan have taken interest in setting up large scale ground mounted solar power plants. The local solar cell and module player URE has secured two big deals in the country, one for a 193 MW project in 2019 and another for 120 MW of bifacial capacity in 2020.

To tackle the space issues several agencies are looking into ways and technologies to address the land issues, for example through innovative PV installations such as facilities' roof, aquavoltaics, using heavily polluted lands, etc.

Rooftop solar is now one focus of Taiwan's government. The 2021 edition of the Renewable Energy Law requires large power users to source some shared of their power from renewables. This legislation is anticipated to result in many corporates starting to opt either for onsite solar systems or off site solar PPAs.

In any case, Taiwan will have to find solutions for adding much more solar in the long run. Under pressure from announcements in the European Union, United States and its close neighbour China to turn climate neutral, its president reportedly emphasised during Earth Day that the country cannot fall behind the international trend. The government has started to discuss potential strategies towards net-zero emissions by 2050. So far, the country, which relied on coal for 45% of its power production in 2020, has been targeting to halve emissions from 2005 to 2050.

Authors: *Christophe Lits, Raffaele Rossi, & Michael Schmela,* SolarPower Europe



2 MW, Taipei Energy Hill, Taiwan.

14. Mexico

Overview of PV developments

In 2020, installed solar PV capacity in Mexico increased by 1.87 GW, exceeding the solar GW mark for the third year in a row. While this is a 10% decrease compared to the 2.1 GW added in 2019, it constitutes a 40% growth in terms of cumulative installations. Total capacity reached 6.5 GW. This is about 10 times more than the installed capacity in 2017. Out of the total installed capacity, utility-scale PV represents 79% (5.15 GW) and distributed solar PV 21% (1.39 GW).

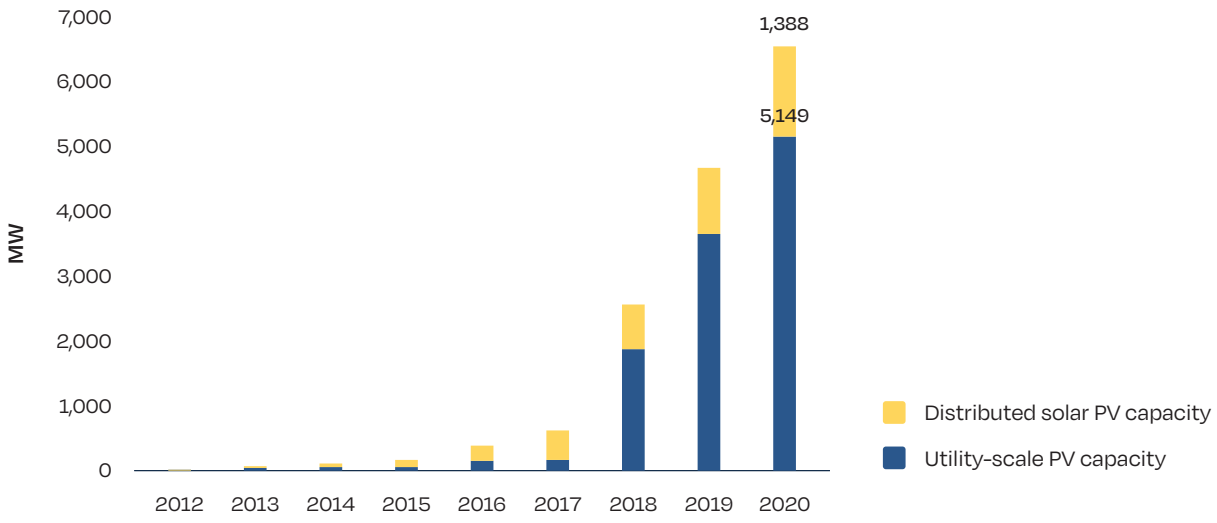
Utility-scale PV added 1.5 GW of capacity in 2020, slightly less than 2019 and 2018 (1.77 and 1.71 GW respectively). In contrast, distributed solar PV saw an increase of 365 MW, a higher value than 2019 and 2018 (335 and 236 MW respectively). Looking at the whole electricity system, utility-scale PV capacity represents 6.2% of total installed capacity (83.1 GW), while 65% corresponds to fossil-fuel-based technologies. In terms of power generation, fossil-fuel-based technologies provided 75% and solar PV 5.7% of the total electricity generation in 2020. A slight decrease in overall electricity consumption occurred in 2020 due to the COVID-19 pandemic.

RE targets

In 2015, clean energy targets were established in the Energy Transition Act (LTE) and Transition Strategies as follows: clean electricity generation minimum share was set for 25% by 2018, 30% by 2021, 35% by 2024, and indicative targets of 40% by 2035, and 50% by 2050 were established. Clean energy sources were defined as wind, solar, geothermal, hydroelectric, and other forms of renewable energy, plus nuclear, certain biofuels, and efficient cogeneration. In order to reach these goals, the power sector reform created the Clean Energy Certificates (CEC), which are permanent titles that certify a given source of power generation as being a clean source. The purpose of CEC was to encourage the installation of new clean energy generation projects. It is well known that recent changes in energy policy might result in non-compliance with Mexico's committed clean energy goals.

The Ministry of Energy has considered distributed solar PV the key component to reach the clean energy goals of Mexico. According to the Development Program for the National Electric System (PRODESEN), installed capacity in distributed solar PV could reach nearly 6 GW in 2025. In contrast, the Ministry of Energy estimates that the 2021-2025 increase in utility-scale PV capacity will be around 4.76 GW.

FIGURE GW14.1 MEXICO TOTAL SOLAR PV CAPACITY 2012-2020, BY ASOLMEX



SOURCE: ASOLMEX.

Challenges

Before 2013, electricity supply in Mexico was carried out under a vertically integrated monopoly scheme, operated and owned by the State through the Federal Electricity Commission (CFE). After the energy reform of 2013, which included the unbundling and restructuring of CFE, a competitive electricity market was introduced for generation and supply. Open access to transmission and distribution grids by market participants was a key component of this reform.

Private investments in generation were mainly promoted by means of long-term energy auctions held annually by the Independent System Operator. CFE Basic Supply could only acquire electricity through these auctions in order to guarantee the lowest possible prices. Long-term energy auctions were part of the government efforts not only to increase the generation but to accelerate the clean energy transition. From 2015 to 2017, three long-term auctions secured 4.65 GW of new utility-scale PV capacity. Approximately 80% of those projects started commercial operation before the end of 2020.

Since December 2018, President Lopez Obrador has drastically changed the direction of policy for Mexico's electricity sector, promoting a vertical integration of the state-owned company CFE, and seeking to erode key aspects of the market-oriented energy reform. Different regulatory changes have been implemented. These provisions aim to eliminate the economic dispatch of electricity by giving priority to CFE plants, aim to reduce open access to the grid, aim to eliminate long-term auctions and aim to allow the Energy Regulatory Commission (CRE) to deny permits based on discretionary reliability criteria. Many of the regulatory and policy changes have been challenged in court by market participants and environmental NGOs. However, regardless of the legal outcome, regulatory changes have eroded the investment environment in Mexico for renewable energy.

An additional challenge for renewable deployment in Mexico is constituted by the electricity grid. Between 2017 and 2020, the wind and solar electricity generation share jumped from just 3.6% to 10.6%. Utility-scale PV generation alone increased from 0.35 TWh to 13.53 TWh. This change in Mexico's electricity generation mix has shown the urgent need for significant investments to upgrade and expand the transmission and distribution networks in order to increase the flexibility and reliability of the system. It might take years for new investments in the grid to be carried out. Therefore, new technologies such as electricity storage could play a key role in increasing flexibility in the energy sector in the near future.

754 MW, Villanueva, Mexico.

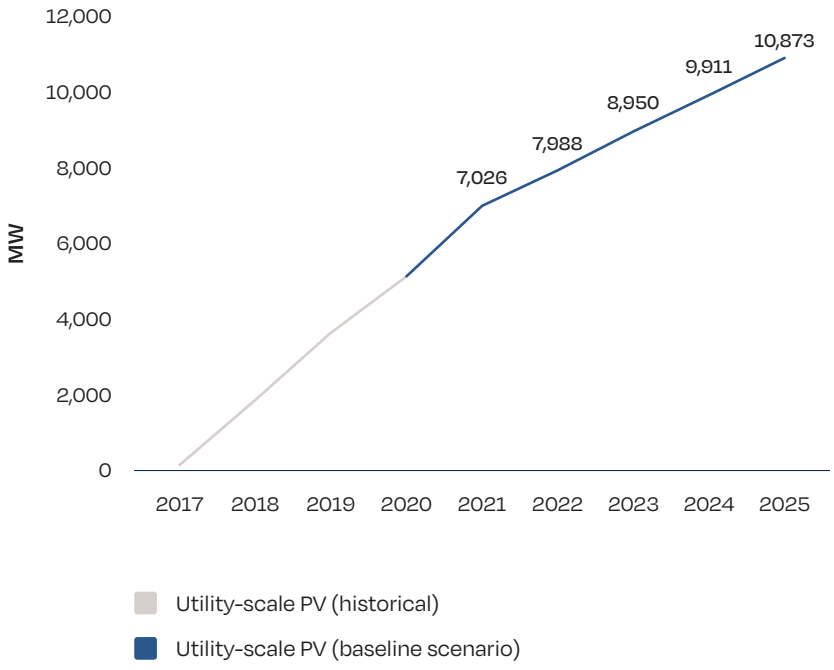
Outlook

Regulatory changes have affected the investment environment for utility-scale PV in Mexico, backtracking on the last decade of progress in the energy transition and reversing 2013's landmark energy market liberalisation. Under the current policy and market conditions, annual installed capacity from the large-scale segment is expected to stay below 1 GW in the period 2022-2025.

By contrast, investors in distributed solar PV can be more optimistic, since government's policy changes have not modified its legal framework and installed capacity has been growing at a double-digit rate over the last decade. However, this segment still needs increasing funding mechanisms and developing a national certification system for installers. Between 2021 and 2025, we forecast 2.2-3.6 GW of rooftop solar, depending on the sector's success in overcoming these challenges.

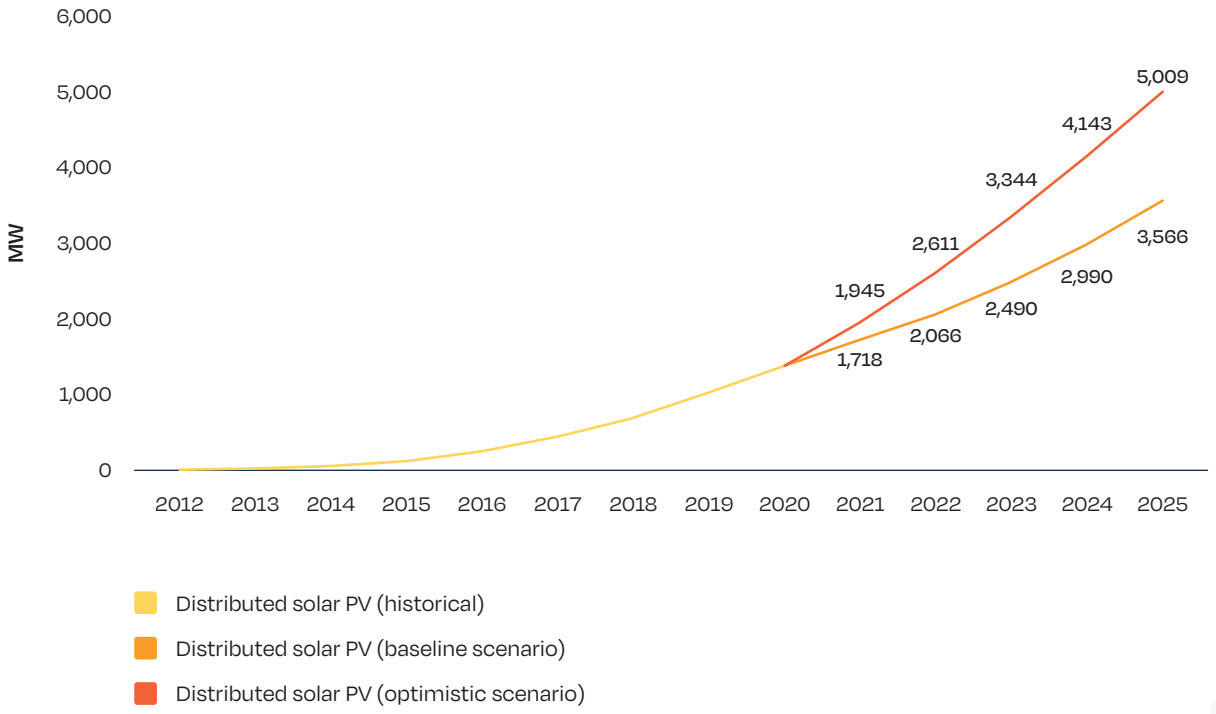
Author: *Jaime Pérez de Laborda*, President of the Mexican Association of Solar Energy (Asolmex).

FIGURE GW14.2 MEXICO UTILITY-SCALE SOLAR PV CAPACITY SCENARIOS 2021-2025, BY ASOLMEX



SOURCE: ASOLMEX.

FIGURE GW14.3 MEXICO DISTRIBUTED SOLAR PV CAPACITY SCENARIO 2021-2025, BY ASOLMEX



SOURCE: ASOLMEX.

15. Ukraine

Overview of PV developments

Intensive solar energy development in Ukraine began only recently, in 2018-2019, despite the fact that a feed-in tariff (FIT) for renewable energy support schemes was in place since 2010. Very few solar systems were installed in the country by the end of 2016, with a cumulative capacity of 548 MW.

In 2018, solar PV capacity reached 1,545 MW in total. The largest growth took place in 2019, when the total installed capacity increased 3.5 times compared to 2018. Utility-scale PV made up the lion's share of this deployment, with 3.53 GW installed year-on-year.

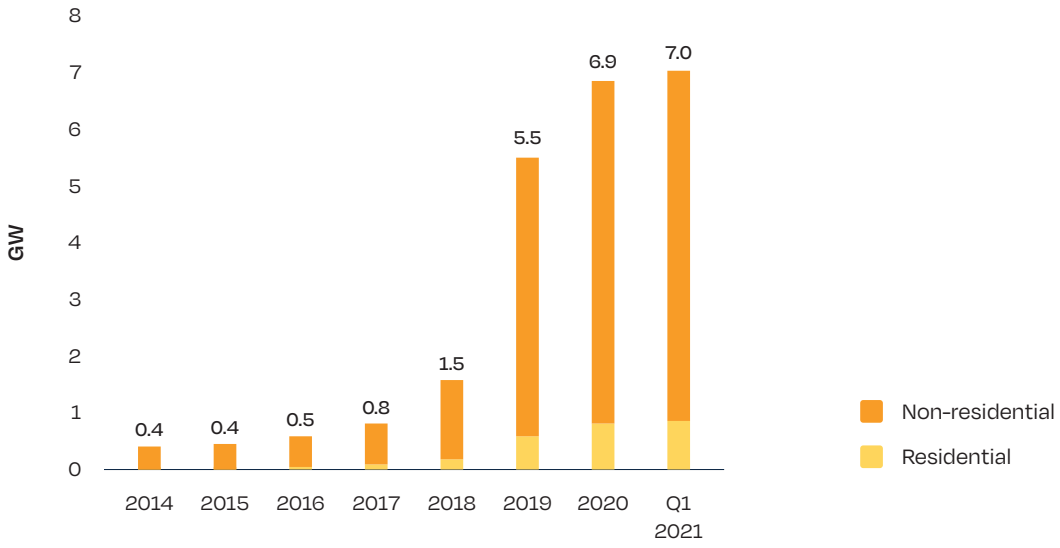
In mid-2020, the government implemented retroactive obligatory FIT cuts for all existing solar power plants. Moreover, system owners experienced unstable payback under the FIT scheme. Currently, 35% are still not paid for 2020, and the debt for 2021 is around 15%. As a result, the development of new RE capacities decreased significantly in 2020 and 2021.

Last year, the Ukrainian solar sector added 1,169 MW of non-residential solar PV capacity and 226 MW of residential PV, for a total of 1,395 MW newly installed solar in 2020 (see Fig. GW15.1). That's a year-on-year decrease of 60%. The first quarter of 2021 showed only additions of 105 MW of larger PV systems. In cumulative terms, 6,873 MW of solar was installed in Ukraine by January 1, 2021, with 779 MW or 11% of this capacity consisting of residential PV (no larger than 30 kW in size)[1].

Residential PV installations continued their growth path in 2020, but additions of about 0.2 GW are only about half of the capacity installed the previous year. The Ukrainian government estimates that 30,000 residential systems were installed in the country by the end of 2020 (see Fig. GW15.2).

Across all new RES technologies in Ukraine, except for large hydropower plants, the most electricity is generated from solar PV. Between January 2021 and June 2021, solar PV systems generated 926.8 GWh of green electricity.

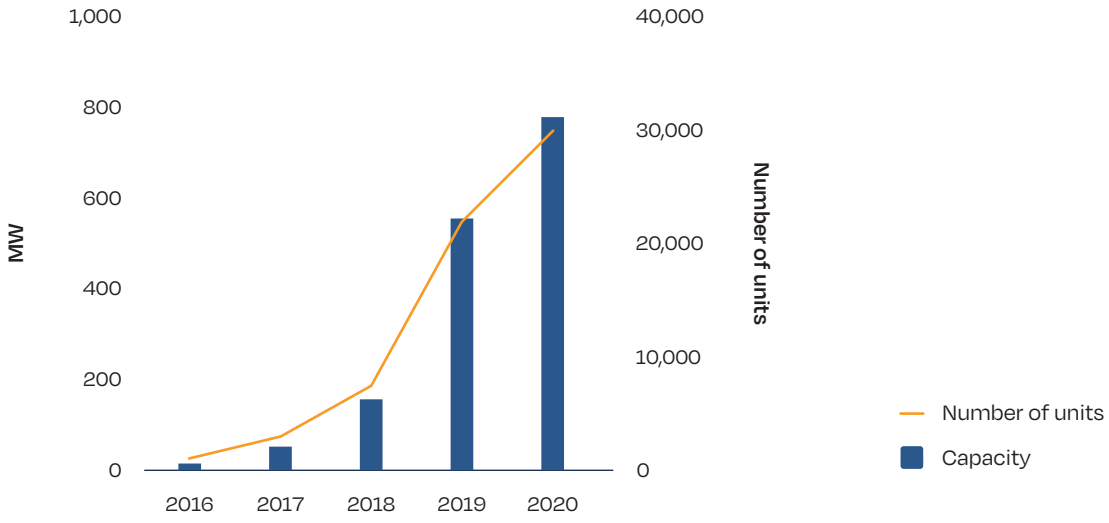
FIGURE GW15.1 UKRAINE TOTAL SOLAR PV CAPACITY 2014-2020, BY ASEU



SOURCE: ASEU.

1 Up to 50 kW only for the systems installed in 2019.

FIGURE GW15.2 UKRAINE DYNAMICS OF RESIDENTIAL PV INSTALLATIONS 2016-2020, BY ASEU



SOURCE: ASEU, based on State Agency on Energy Efficiency and Energy Savings of Ukraine.

Solar/RE targets. Legal Framework

There are two long- and short-term legal regulations on the renewable energy sector in Ukraine, which provide targets for development of RES by 2020 and by 2035.

First, the **National Action Plan on RES by 2020** has the goal of 11% of generation from renewable energy sources, including big hydro power plants, by 2020. Having passed this deadline – with the actual share reaching 11% of the electricity mix, the development of a new NAP for energy and climate for 2021-2025 is now under consideration.

The second, the **Energy Strategy of Ukraine by 2035**, states that the share of electricity from renewable energy sources, including hydropower, should reach 25% by 2035; that is up from 11% by the end of 2020. Renewable energy market players consider both these targets as not ambitious enough for Ukraine.

Drivers for solar growth

The main trigger for the development of solar generation in Ukraine and RES is the FIT support scheme, which applies to all solar, wind and biogeneration facilities, but does not apply to hydropower plants and pumped hydro storage (except small and micro hydro power plants). The FIT support scheme in Ukraine was introduced in 2009 and is planned to last until 2030, gradually decreasing until the end of its validity. The initial rate in 2009 for ground-mounted solar systems was EUR 0.4653/kWh. Rooftop systems over 100 kW receive EUR 0.4459/kWh, and for rooftop systems below 100 kW the FIT was EUR 0.4265/kWh. As of 2021, there is a FIT with much lower rates of EUR 0.04/kWh for new ground-mounted PV systems, EUR 0.10/kWh for systems installed on roofs and/or facades of buildings, and EUR 0.16/kWh for residential systems below 30 kW. The FIT tariffs in Ukraine are protected by the laws "On the Electricity Market" and "On Alternative Energy Sources" that guarantee an average payback period of 5,5-7 years for new solar systems. The FIT has stimulated the development of solar energy in recent years and led to the significant reduction of equipment costs in 2018/2019.

According to law amendments introduced in the middle of 2019, **the auction support system** should have already been implemented for new RE projects, substituting the FIT support scheme. The "pilot" auction should have taken place in December 2019 and the regular auctions should have started from January 2020. But the government has not yet announced the support quotas for 2020/2021 auctions and for the future, and has postponed the start of auctions.

Challenges

The key challenges that the Ukrainian solar sector faces include a lack of trust from the investor's side in the government's activities in the RE sphere, huge debts for purchased electricity, the ongoing international arbitrages around retroactive FIT cuts and the possible implementation of an additional excise duty for renewable energy in late 2021.

Moreover, the impact of COVID-19 to the economic context in Ukraine and the high costs of loans for residential PV are significant new obstacles for the development of the industry, as well as the decreasing investment climate.

Due to the uncertainty about the future of retroactive changes for PPAs and problems with auctions, investments in new PV reduced significantly in 2020 compared to 2019. This also caused significant job losses for the local solar industry – more than 5,000 employees left the industry.

RES development 2021-2025 and conclusions

The COVID-19 outbreak and the introduction of quarantine measures in March 2020, alongside high prices on the electricity market, could lead to an increase of self-consumption PV systems in 2021-2023.

The government's hard stance on renewable energy added to the prolonged difficulties foreign investors had in carrying out their business due to travel restrictions. All this will lower foreign investments considerably. As a result, total PV installed capacity in 2021 in Ukraine incentivised by the support schemes will be at least 2 times less than the volume built in 2020 and 5 times below the 2019 installations.

Once the RE auction support scheme is launched, it will dramatically lower subsidies for the PV industry and it will become the main driver for the development of the sector alongside corporate PPAs. It will lead to a next growth phase for the utility-scale PV segment, but not earlier than in 2022-2025.

ASEU believes that further development of BESS is necessary even for achieving the unambitious 25% RES goal by 2035, and for further renewable development. An appropriate law to solve this issue is still under consideration at the Parliament energy committee since 2019.

In the coming years, a slowdown is set to take place in the development of all new renewables in Ukraine, unless the government improves the framework conditions for new investments in the PV sector.

Author: *Artem Semenyshyn*, Executive Director, Solar Energy Association of Ukraine (ASEU).

148 MW, Progressovka plant, Mykolayiv, Ukraine. © Scatec Solar

16. South Africa

The South African solar PV market continues to grow, rapidly, with positive market indicators coming out of various national government policy objectives. Annually installed PV capacity in 2020 totalled 1,313 MW, broken down into 813 MW of utility-scale systems and 500 MW of distributed generation. Cumulative capacity reached 4,172 MW, of which 2,372 MW is provided by utility-scale solar. It is estimated that 20% of this distributed generation capacity consists of residential systems, with the C&I segment contributing the largest bulk of rooftop capacity.

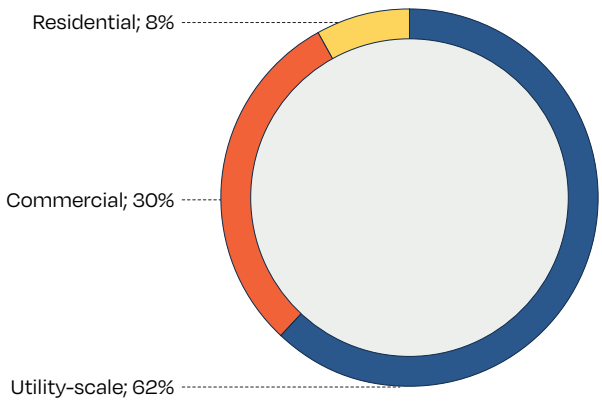
The Integrated Resource Plan (IRP2019) outlined a new additional capacity of 6 GW utility-scale solar PV and 6 GW distributed generation, the majority of which is expected to come from solar, to be installed by 2030. The IRP electricity infrastructure development plan is based on least-cost electricity supply and demand balance, considering security of supply and the environment, and will result in a 400%+ increase of solar PV by 2030. This will increase the PV installed capacity from 3% of the current total electricity supply to 11% by 2030.

The policy landscape continues to change as government and industry work to meet the increasing energy needs of the country while also striving to drive a post-covid economic recovery. The commitment of President Cyril Ramaphosa to amend Schedule 2 of the Electricity Regulation Act (ERA) and to raise the licensing exemption threshold for distributed generation facilities from 1 MW to 100 MW, should cause a rapid increase in the development of larger scale distributed generation projects.

This work on updating the regulations that will allow municipalities to develop and procure their own power generation projects shows that the government is working hard to create the right policy environment to let the industry fully realise the IRP2019 targets.

SAPVIA's growth reflects that of the industry itself. From just six members in 2010, we now represent 544 members across the solar PV value chain. Our members reflect the diversification of the sector, as we have moved from the initial focus on the utility scale market through government procurement to an open, distributed market.

FIGURE GW16.1 SOUTH AFRICA SOLAR PV MARKET SEGMENTS, BY SAPVIA



SOURCE: SAPVIA.

Challenges

There are still challenges ahead for the solar PV market in South Africa. As a priority the IRP should be reviewed and updated to better enable government policy planning.

Progress has been hampered by a lack of consistency in the procurement of solar PV projects. However, it must be noted that over the last 12 months the government has responded with pace and urgency. For the industry to fully realise the opportunities of RE and solar PV specifically, we need long-term commitments from the government to procure on a more consistent basis. If the industry is confident of a future procurement pipeline, they will then invest with confidence in local manufacturing, which could then develop and thrive, offering more local opportunities for employment and upskilling.

As a matter of urgency, we must address the capacity challenges at energy distributor level, implementing the right and most appropriate bureaucratic processes to allow policy to be implemented. We also need regulations and enforcements that ensure that the highest safety and quality standards are rolled out and maintained across all distributed generation projects.

As confidence in the market continues to grow, we have seen the introduction of more innovative solutions that allow renewables to compete with traditional energy sources. We also need more innovative funding models that allow for more participation from non-traditional investors.

Outlook

Looking forward, the growing solar PV industry must not lose focus on the just energy transition that solar PV and renewables in general can deliver for South Africa. We need to ensure that as the sector grows, we include, uplift, and upskill South Africans, not just through access to cheap, sustainable electricity but by focussing attention and resources on helping communities adapt and benefit from our transition to renewable energy.

The just transition must draw commitments from players across the sector as well from the government, and strive to elevate and empower through skills development. We have an opportunity to create an optimal workforce that delivers a best-in-class, sustainable energy infrastructure for South Africa.

Author: *Niveshen Govender*, Chief Operations Officer, South African Photovoltaic Industry Association (SAPVIA).

75 MW, Kalkbult, South Africa.

17. Belgium

Record year for Belgium in 2020, installing more than 1 GW for the second time

In Belgium, energy policy is a regional responsibility, resulting in different support schemes and legal frameworks in Brussels, Flanders and Wallonia. We will highlight the market data and the most important developments in each region, and then address some national trends.

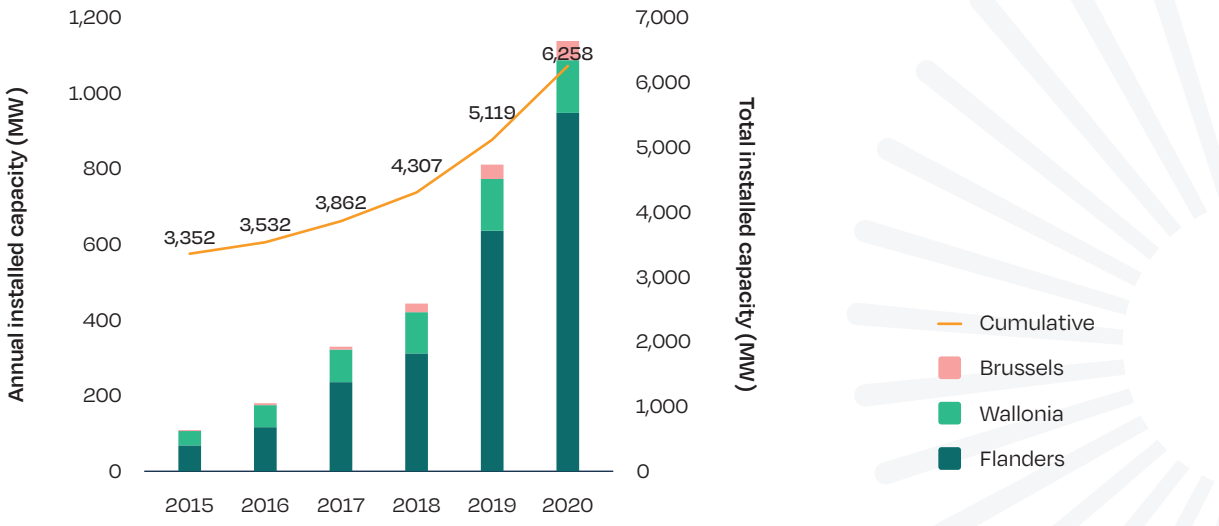
Market data

Preliminary data shows that the Belgian market reached a total of 1.14 GW installed PV capacity in 2020. The final number is expected to increase, as data is still partial. This is more than the previous peak of just above 1 GW in 2011.

In Belgium, Flanders represents about 57% of the population, Wallonia 32% and Brussels 11%. We see this reflected in the installed capacity, with Flanders being the biggest market, followed by Wallonia and Brussels. Over the last 5 years, Flanders provided more than 60% of installed capacity, with a peak of over 80% in 2020.

According to the preliminary data for 2020, the Belgian market grew 40% at the federal level compared to 2019, when annual installed capacity reached 812 MW. In Flanders demand grew by 50% year-on-year, while Brussels' yearly installed capacity increased by 32% and Wallonia by 1%. Total installed capacity reached 6.26 GW by end of 2020, of which 4.71 GW was in Flanders, 1.37 GW in Wallonia and 0.18 GW in Brussels.

FIGURE GW17.1 BELGIUM SOLAR PV INSTALLED CAPACITY 2015-2020, BY EDORA AND ODE



SOURCE: EDORA and ODE.

Flanders

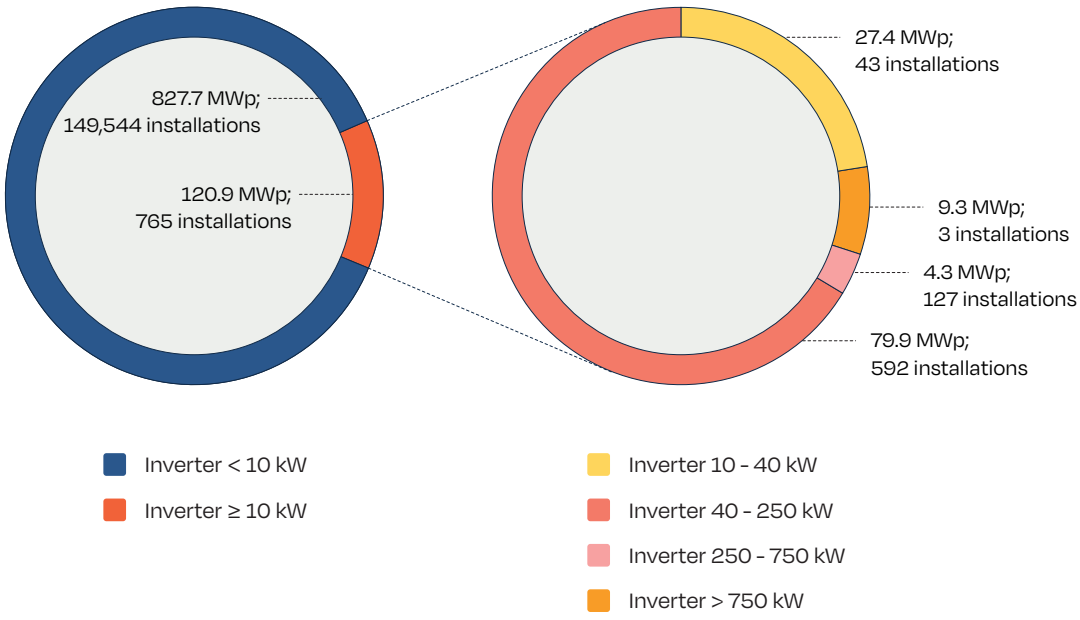
Different changes in support mechanisms were introduced in 2021. For all new residential installations (up to 10 kVA) installed as of 2021, a subsidy has replaced net-metering, which led to a substantial growth in 2019 and 2020. For larger installations (40 kW to 2 MW inverter capacity), operational support through green power certificates was phased out and replaced by a tendering mechanism ("calls"). Only the projects which request the lowest amount per estimated MWh get investment support via these calls (pay-as-bid). Project-specific operational support via green power certificates now applies for installations bigger than 2 MW (instead of 750 kW previously).

Most of the PV installations are rooftop-based. Flanders wants to maximize the use of the rooftops to reach its goals, and currently uses less than 5% of the optimal oriented rooftop space, with over 65 GW in rooftop potential remaining.

The bulk of the Flemish market consists of residential installations with an inverter of up to 10 kW. The Flemish regulator received judicial approval to end net-metering for existing installations when a digital meter is present and to replace the lump sum prosumer tax by network tariffs based on metered data. This has a negative impact on the return on investment, when self-consumption is low and/or power ratio is high and has led to a negative public perception of regulatory stability. The government introduced multiple regulatory changes to limit the financial impact on existing solar PV installations, amongst which there were two changes to increase self-consumption: an increased subsidy for battery systems and a new subsidy for energy management systems.

For installations bigger than 10 kVA, most installations had an inverter with more than 40 kW, limited to 250 kW (or 750 kW) to optimize support. Due to the introduction of the tendering system, we also expect an increase of installations with an inverter capacity of 1-2 MW to be built in coming years.

FIGURE GW17.2 FLANDERS MARKET SEGMENTS 2020, BY ODE



SOURCE: ODE (preliminary data).

Wallonia

In Wallonia, net metering remains applicable until 2023 for systems up to 10 kW, while digital meters are being introduced. Since 2020, owners of PV installations have to pay a prosumer tariff to financially contribute to their use of the grid. This resulted in a decrease of the Walloon market, due to consumers' negative response to this tariff. For installations bigger than 10 kW a support system via "green power certificates" still exists. The rate of this subsidy depends on the category (10-250 kW, 250-1,000 kW or above 1,000 kW). This support system will be revised by the end of 2021, and will result in the introduction of new subsidy rates.

PV projects continue to develop, both for rooftop and non-rooftop PV (parking lots, brownfields, agricultural land, and much more). The same applies to residential PV, partly due to the expected end of net metering.

Brussels

In Brussels, PV installations of any size can still get support via "green certificates". New categories are about to be added for various types of Building Integrated PV, which will boost the level of support for these categories. Furthermore, the discussion on collective self-consumption and energy communities is very active within this region, with a legislative initiative underway. Residential PV still benefits from operational support via green certificates and net-metering on commodity. All prosumers have a digital meter and pay grid fees based on actual consumption, creating an incentive for self-consumption.

National trends

Across all of Belgium, we see that the link between PV and EV (electric vehicles) has become more dominant, where PV on office buildings is expected to provide renewable energy for the charging points for electric company cars. A tax benefit for the installation of charging points is scheduled to be introduced in September 2021. This is a concrete example of how solar PV is more and more integrated into a broader social context.

Authors: *Cécile Heneffe,* Policy Advisor PV, EDORA; *Wannes Demarcke*, Policy Advisor PV, *& Ellen Van Mello*, Policy Advisor PV, ODE.

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18. France

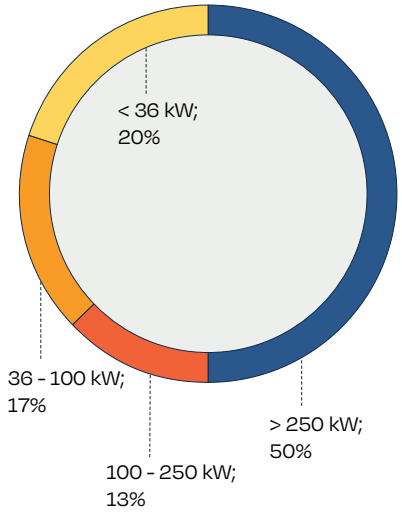
Ambitious targets, quite some way to go

Overview of solar PV developments

In 2020, France crossed the symbolic threshold of connecting 10 GW of solar power. Moreover, the 634 MW connected during the first quarter of 2021 mark a quarterly record, as this figure is larger than any other quarterly installation in the last decade. This means, the French solar fleet now amounts to 10.99 GW in total. Over the last 12 months, 1,317 MW have been connected. For the year 2020, the French operators reported that only 858 MW of PV were installed. This is attributed to a delay in market data publication for Q4/2020. However, like in 2019, it is expected that this number will be updated and slightly exceed 1 GW of capacity.

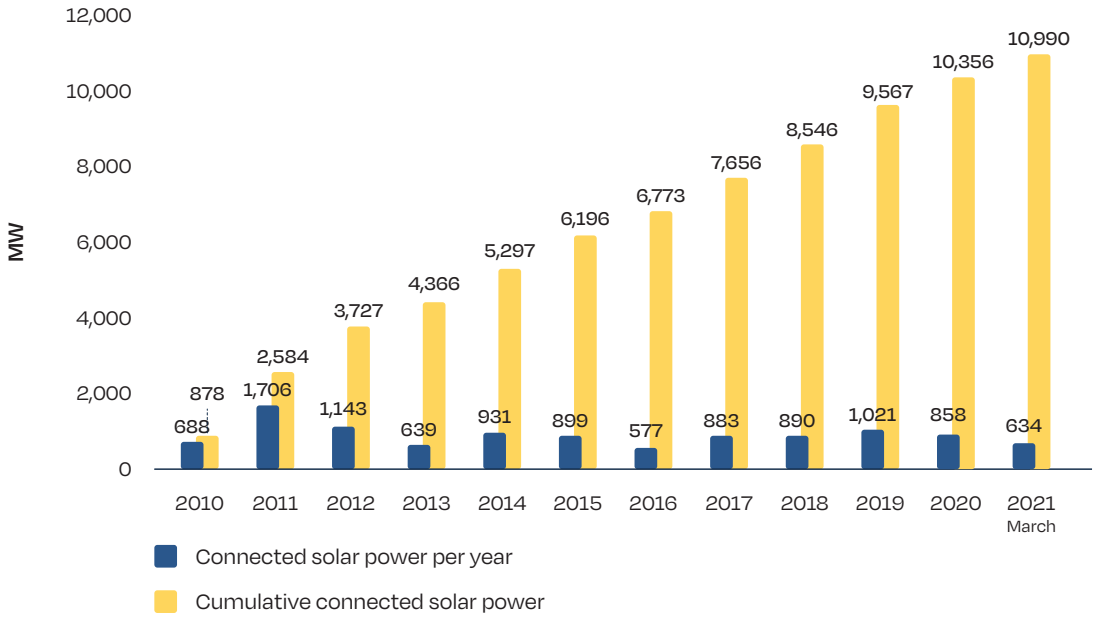
Electricity production from photovoltaic sources stood at 2.4 TWh produced during the first three months of 2021, up 13% compared to the same quarter in 2020, thanks to new connected capacities. The coverage rate for electricity consumption by solar energy thus stands at 2.8% over the last 12 months.

FIGURE GW18.2 FRANCE CUMULATIVE SOLAR PV GRID CONNECTED CAPACITY Q1 2021, BY SER



SOURCE: SER.

FIGURE GW18.1 FRANCE SOLAR PV MARKET INSTALLATIONS 2010-2021, BY SER



SOURCE: SER, based on system operators data (data for 2020 is preliminary).

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 last year. These objectives have been implemented for each technology through the Multi-Annual Energy Programme (MAEP). This defines clear trajectories and volumetric objectives for the coming 10 years. The MAEP objective for the end of 2023, which requires an operating solar fleet of 20.1 GW, has currently been reached by a little more than halfway, 53.9%.

A revised version of the first MAEP, adopted last spring, confirmed the willingness to strongly accelerate the development of the French 'solar park'. The new targets presented for 2028 lie between 35.1 GW and 44 GW in cumulative capacity. These targets suggest that the annual market needs to rise to 3.3 GW/year between now and 2023, and then to 4 GW/year between 2023 and 2028. This means between 330 and 400 km² of PV area will be installed in France for ground-mounted and between 150 and 200 km² for rooftop installations. Therefore, solar power is positioned as one of the most important contributors to the French energy transition.

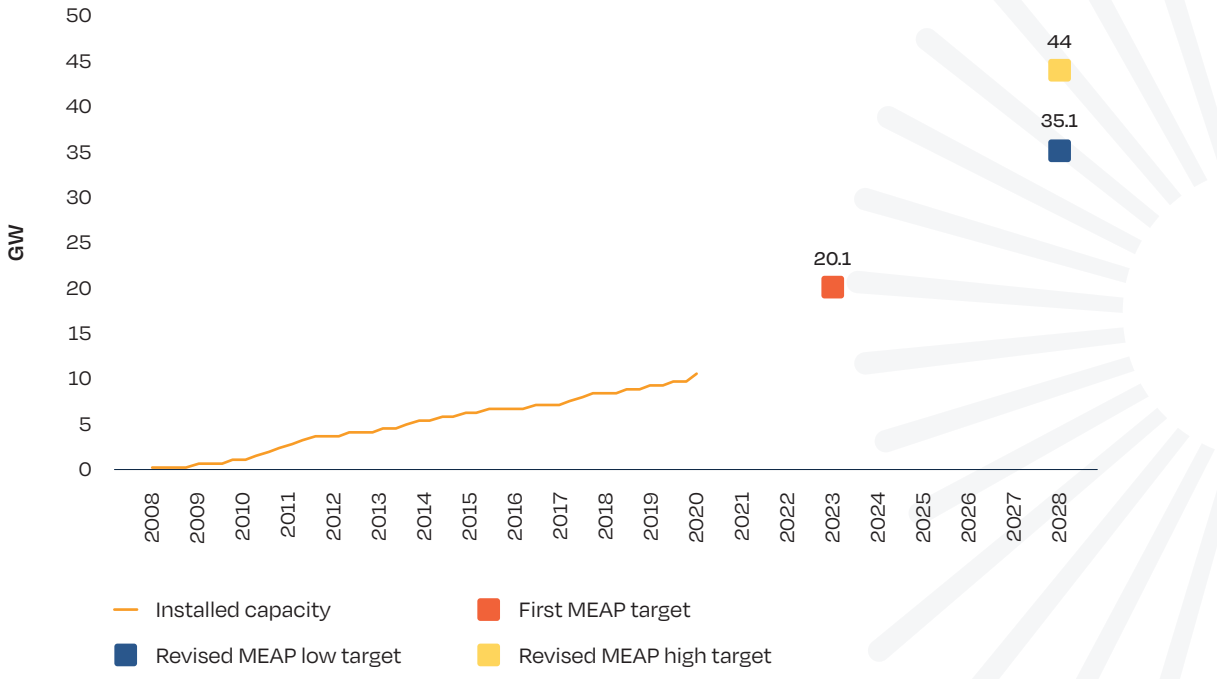
Drivers for solar growth

Calls for tenders are the main driver for achieving these targets, with 3.2 GW scheduled every year. Two-thirds of these tenders will be ground-mounted installations. The remaining third will be attributed via calls for rooftop installations.

For many years, the French renewable energy association (SER) advocated that projects for rooftop installations below 500 kW be exempt from tendering procedures and eligible to a feed in tariff (FIT), in line with the current State Aid Guidelines. After more than a year of work with the French government, the new threshold will be implemented this autumn. Raising the FIT threshold from 100 kW to 500 kW should make things easier for this market segment, where projects were previously limited by tendering procedures.

Additionally, the self-consumption market for which a dedicated framework has been put in place is growing rapidly but still represents a small installed capacity. In Q1/2021, 109,236 installations were self-consuming, representing 472.5 MW.

FIGURE GW18.3 MULTI-ANNUAL ENERGY PROGRAMME TARGETS



SOURCE: SER.

Challenges

Reaching an ambitious target of 44 GW of solar power in France by 2028, compared to the 11 GW currently installed, requires regulatory changes in order to help all market segments grow.

First and foremost, one needs to widen the perimeter of eligible land in calls for tenders for ground mounted projects. Given the 2028 MEAP target and given that the distribution of major projects remains constant, we can expect almost two thirds of solar power to be installed on the ground. Therefore, a general reflection on land use is necessary to take into account the real impact of PV projects on soils and to facilitate their development. In addition, innovative PV projects with especially low land use impacts, 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 have to be clarified and simplified. Some local services may have an ambiguous and debatable interpretation of the framework in place. This can sometime go beyond current regulatory rules, for example, regarding fire protection rules. Administrative deadlines also need to be shortened.

France promotes a low carbon footprint solar PV industry. The carbon criteria 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 the French renewable energy association (SER) advocated, the carbon criteria will be set at 500 kg CO_2e/kW in the new call for tenders' specifications, entering into force this autumn. Thanks to the work of strong R&D centers (INES, IPVF, etc.), the development of the French industry's innovation capacities and technological breakthroughs will also improve competitiveness.

Finally, as mentioned above, self-consumption is still a small market for solar PV energy. The support mechanisms for self-consumption projects need to be adapted so as to enhance the value of all electricity produced, self-consumed, and injected into the grid. This needs to occur at levels that allow the projects to be financially secured. Opening up self-consumption without penalising consumers, who are not always able to consume all of their production, is also a way forward.

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

Agri-PV greenhouses in Eyragues, France.

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INNOVATIVE SOLAR ENERGY WITH THE FLOW

The strong ambition of France, with 20.4 GWp aimed by 2023, translates into a progressive rarefaction of land easily available for the development of large photovoltaic plants, potentially inducing more conflicts of use than today. For this reason, CNR, the Rhone concessionary and the leading 100 % renewable electricity producer in France, is interested in new types of sites to promote photovoltaic field and support the development of the territories in a sustainable and innovative way all along the river Rhone.

Floating photovoltaics is an important field to be explored, given the large number of artificial lakes and waterways in the territories.

In this light, CNR has developed in 2019 La Madone, its first pilot project of floating solar plant on an irrigation lake near Lyon. Winner of a French national call of tender for innovation, the 635 panels have been installed in a constraining context: the site is still under industrial exploitation, the anchoring system must allow the platform to follow the variation of water level of 10 m due to irrigation needs, and the body of water welcomes recreational activities like fishing. This plant of 2 500 m^2 illustrates the transversal potential of this technology with new functionalities given to the lake: first, the future self-consumption of the energy by the irrigation pumps provides a solution to the risk of an upward trend in the price of electricity, which weighs heavily on the cost of irrigation and therefore on the costs borne by farmers; second, the plant boosts the development of aquatic biodiversity thanks to 16 fish sanctuaries installed under the platform, and scientific monitoring over 5 years; last, an educational path informs the site's users about the energy and agricultural issues of their region.

CNR plans to build others floating plants on an industrial scale, the next one being over 30 MWp and 35 hectares in Chateauneuf-du-Rhône.

CNR floating solar plant La Madone.

Solar innovation along rivers is not limited to water areas.

Managing almost 500 kilometers of linear sites, CNR is also interested in the development of long plants, on dikes, bike paths, roads and railways that run along them. The bifacial linear photovoltaic plant of 350 m at Sablons, under construction in 2021, is the first linear park of CNR. CNR is also working on other projects: a 2 km of linear photovoltaic shade structure on a cyclepath followed by a project of 20 km. In this configuration, the principal issue is to find the electrical architecture suitable for these linear solar plants. Therefore, CNR is especially working on DC network solutions.

CNR photomontage of linear and bifacial solar plant of Sablons.

Agrivoltaism is also under study, with a first pilot project planned for 2021 in a horticultural school.

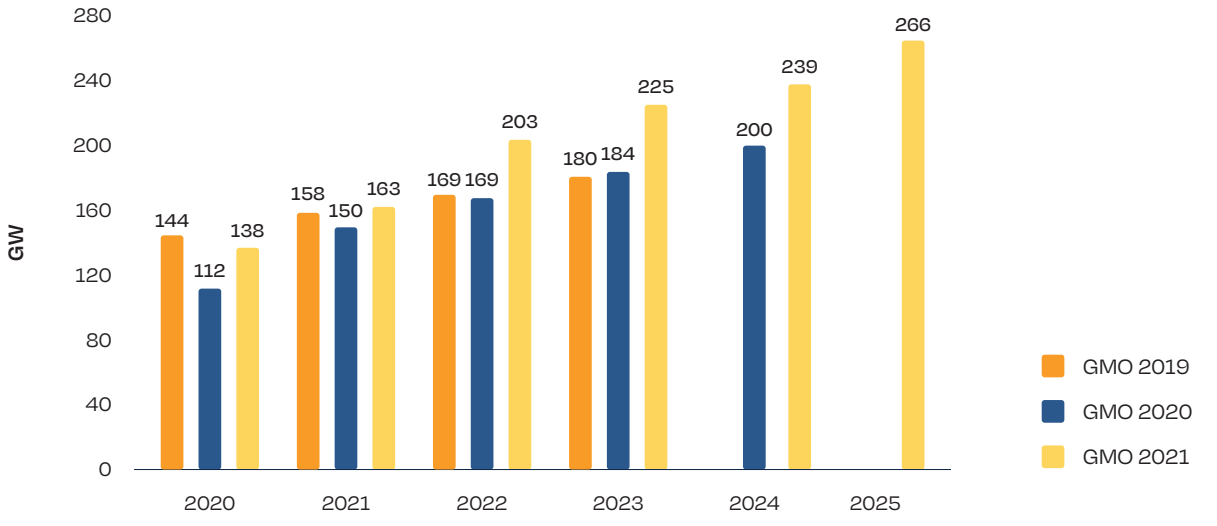
Rivers and shores, from the Rhone and elsewhere, at the crossroads of transport, industrial activities, energy and environment, are privileged vectors to promote these solar innovations to be at the heart of the energy transition.

4 Global market outlook 2021 - 2025

Solar is back and stronger than ever before. The coming years will see much more solar power plant capacity come online than anticipated in the GMO 2020, which was written in the middle of the first wave of COVID-19 last year. In this GMO 2021, we forecast larger growth for each of the coming years than last year (see Fig. 23). The deployment assumption is 'only' 9% higher for 2021, but that is because 2020 turned out to be such a surprisingly good year. Between 2022 and 2024, our growth expectation for new installations is between 20–23% higher than in last year's report. While last year we forecasted global demand to reach 200 GW in 2024, we now expect this level to be reached two years earlier, by 2022. We also expect new annual installed capacities to reach 266 GW in 2025 in our Medium Scenario; to put this into perspective, only six years ago, in 2015, this was the world's total installed solar power generation fleet.

Our increasingly positive view is based on solar's impressive resilience and recent market and technical developments. Despite all the negative implications of the pandemic, solar's unmatched characteristics have and will continue to lift the technology to new levels. No

FIGURE 23 COMPARISON MEDIUM SCENARIO GMO 2020 VS GMO 2021



other power generation source can compete with solar's versatility: from large-scale power plants to onsite commercial and residential rooftops, to building-integrated, off-grid, and mobile power solutions.

Solar's cost leadership improved again in 2020, now outcompeting fossil fuels and nuclear in any unsubsidised investment case, and it will continue its cost-reduction path for many years to come. The current silicon supply shortage and other material constraints that have led to temporary solar product price hikes, are only brief incidences that are already being resolved. Many recent product innovations across the value chain – as highlighted in our chapter on technology trends – further support solar's leading role. The latest major trend in the energy transition is 'green hydrogen', which refers to hydrogen produced from renewables, mostly solar and wind. If only a fraction of the plans recently announced, in particular in Australia, come to fruition, solar installation numbers towards the end of that 5-year forecast could be significantly larger.

However, when comparing our GMO 2021 estimates to our pre-COVID-19 report (GMO 2019) forecasts, we can see that the assumptions for 2020 at 144 GW were higher than the 138 GW that was actually installed. Also the 2021 estimate of 158 GW is close to what we assume now for that year at 163 GW, while traditionally market assumptions are adjusted upwards each year. Despite its resilience, solar has lost precious time in fighting against climate change due to the widespread effects of the pandemic.

In conclusion, we need to be more ambitious when it comes to solar deployment with more support from policymakers, in order to implement better policy frameworks that enable solar to reach its full potential; COVID-19 recovery packages are a good opportunity to take advantage of the job intensity of solar. While it is certainly impressive that solar adds larger year-on-year power generation capacities than any other technology, with 70% of global power still coming from non-renewable polluting energy sources, with solar making up just 3% of the power output, there is an urgent need to accelerate growth rates to keep the 1.5°C global warming limit within reach.

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SolarPower Europe - Leading the Energy Transition
Rond-Point Robert Schuman 2-4, 1040 Brussels, Belgium
T +32 2 709 55 20 / F +32 2 725 32 50
info@solarpowereurope.org / **www.solarpowereurope.org**

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