

Global Market Outlook

For Solar Power / 2020 - 2024



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FOREWORD

Welcome to the Global Market Outlook for Solar Power 2020–2024,

The return of the global solar market to two-digit growth rates in 2019 signaled a positive trajectory for the sector. But in 2020, the solar world looks very different: the COVID-19 pandemic has not spared the solar power sector. This year, new solar grid connections are expected to drop the first time in many years. Now it is of utmost importance that governments do not disregard renewables and solar power when developing economic stimulus packages. If the world is serious about meeting the Paris Agreement climate targets, solar deployments not only need to get back on their recent growth track, but the installation rate of solar, the lowest-cost and most versatile power generation technology, must increase much faster, in the short- and mid-term.

This year's Global Market Outlook presents the first results of a worldwide survey conducted in April by the Global Solar Council on the impacts of COVID-19 on solar – over 71% of polled solar businesses reported a decline in orders, of which 6 in 10 said that orders were down by up to 50%, and 3 in 10 experienced a decline of 50–90% (see, p. 63). The effect of the pandemic on installation rates varies in different countries and segments, largely depending on how badly the countries suffered from COVID-19, and the response of governments.

We estimate in our Medium Scenario that new global installed capacities will decrease by 4% to 112 GW in 2020. Compared to our forecasting in last year's Global Market Outlook, when we projected as much as 144 GW of new solar, this represents a loss of 32 GW.

In comparison, 2019 was a successful year for solar. Demand grew by 13% to 116.9 GW, and it would have increased further if the world's largest market, China, had not continued restructuring efforts, resulting in an even stronger drop in demand than the year before, and India, the world's third largest PV market, also declined for multiple reasons. One key takeaway from the study: solar demand continues its diversification process. As the number of countries that strongly embrace solar increases, it reduces the risk that market contractions in major solar countries depresses the entire sector.

To provide better insights into the world's most-promising markets, we have again invited leading national solar associations of GW-scale solar markets – 16 in 2019, up from 11 in 2018 (see p. 69) – and received support from GET.invest for a chapter on Sub-Saharan Africa, our first time focusing on an emerging on-grid solar region (see p. 35). We would like to warmly thank all of our contributors.

Another important lesson learned: the cost competitiveness of solar continues to improve rapidly. While solar has been outcompeting most other power generation technologies for years, depending on the region, it is now entering a new frontier. Many awarded solar tariffs in tenders in 2019 were in the 2 US cent/kWh range, however, there were also auctions with winners in the 1 US cent/kWh range on three continents. As our technology overview on p. 55 shows, there are a broad variety of solar innovations to further improve solar power generation devices.

The industry has been working hard to make solar the lowest-cost power generation technology, and it is now on policymakers to provide the appropriate frameworks so that all of society can benefit from flexible and clean solar. While the virus has taken its toll on solar's development, the recovery packages are a big chance to enable this sustainable technology to return even stronger.

Enjoy reading our Global Market Outlook,



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

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

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EXECUTIVE SUMMARY

In 2019, the global solar power sector returned to a two-digit growth path, increasing by 13% to 116.9 GW, marking a new annual installation record.

This growth helped solar to expand its annual share among all other power generation technologies to 48% – in other words, almost half of the global net power plant capacity installed in 2019 was based on solar PV technology. While solar's combined electricity output reached a mere 2.6%, this highlights the immense growth potential, which is increasingly in reach.

Analysis from various sources substantiates the fact that utility-scale solar is often the lowest cost power generation technology, with costs continuing to go down. While solar can compete with combined cycle gas turbines (CCGT), the rapidly decreasing cost for batteries enables solar + storage to outcompete gas peakers, depending on region and framework conditions.

Only one year after several tenders saw solar-winning bids enter the 2 US cent /kWh level, the next frontier was reached in 2019, when solar tariffs in the 1 US cent range were reported from four different regions: Latin America, North America, Europe, Middle East.

Cost leadership alone is insufficient to expand the solar market if the policy framework is not fit for solar. This was again experienced in several of the major markets. The most prominent example is the world's largest market China, which decreased by 32% to 30.1 GW, as the country's administration was still struggling in 2019 (and still is) with its energy transformation – from a former uncapped and generous feed-in tariff system, to a market-based scheme including auctions and IPP systems. India, the world's third largest market, suffered from multiple problems and installed 11% less solar in 2019 than the year before. The good news is that a trend continued and gained momentum that could already be observed last year. The low cost of solar and its unique, versatile nature have been attracting many new markets to embrace the technology, while several emerging markets strongly committed to solar power generation. In 2019, 16 countries added over 1 GW, in comparison to 11 in 2018, and 9 in 2017, showing how the diversification of the solar sector is beginning to unfold into markets with notable volumes, which together are able to absorb the slumps of leading markets.

Notable growth regions in 2019 included Europe, which added 22.9 GW – more than twice the capacity of the previous year – and the Middle East and Africa, where primarily tenders helped several countries turn into viable on-grid solar markets. In the case of Sub-Saharan Africa, these tenders were frequently and successfully facilitated by developing finance institutions, which is why we included a chapter in cooperation with GET.invest, which provides a detailed background on grid-connected solar in that region.

Due to the effects of COVID-19, 2020 can be considered for the solar sector a year, where demand is expected to shrink by 4% to 112 GW in our Medium Scenario. The good news is that we expect the following four years, covered in our Global Market Outlook, to add even more solar than we anticipated last year. Although the actual growth level will depend, among other things, to the extent that solar will receive support from various economic stimulus programs.

The report and all figures can be downloaded at:

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1

GLOBAL SOLAR MARKET

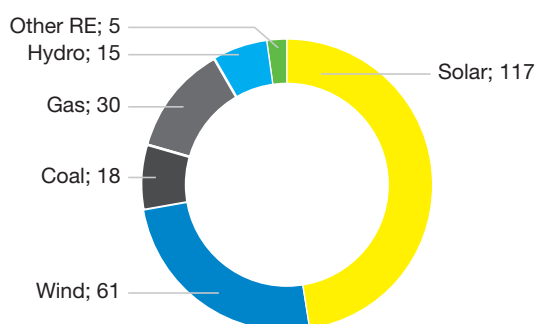
UPDATE 2000 - 2019

75 MW, Kalkbult, South Africa. © Scatec Solar

Overall, 2019 was a decent growth year for the global solar sector, improving with a low two-digit rate after it basically paused the year before. Looking beyond the newly-installed worldwide solar capacity, solar developments look much brighter. Despite China's dramatic demand decrease last year, global installations grew by two digits, showing that the world's desire for solar power is diversifying, with an increasing number of countries turning towards the sun.

In any case, solar maintained its title as the most attractive power generation source installed in 2019. As in the years before, not only was more solar PV added than all fossil fuel and nuclear power generation capacities combined, it also saw nearly twice as much power installed as wind, and more than all renewables together. On top of these impressive achievements, solar's power generation share increased to 48%, compared to 42% in 2018 (see Fig. 1). However, these positive developments showing solar dominating annual global power generation capacity additions need to be taken into perspective. When looking at solar's cumulative share it is still very small, adding up to only 8.5% by the end of 2019. Regarding actual output, all solar PV systems united generated a mere 2.6% of the global power output. This is also true in comparison to renewables as a whole, which owned about one third of total generation capacities, and 23% in the world's power output in 2019 (see Fig. 2). The good news is that the market potential for solar is immense, and its constantly improving cost-competitiveness will enable the technology to reach an increasingly larger share.

FIGURE 1 NET POWER GENERATING CAPACITY ADDED IN 2019 BY MAIN TECHNOLOGY



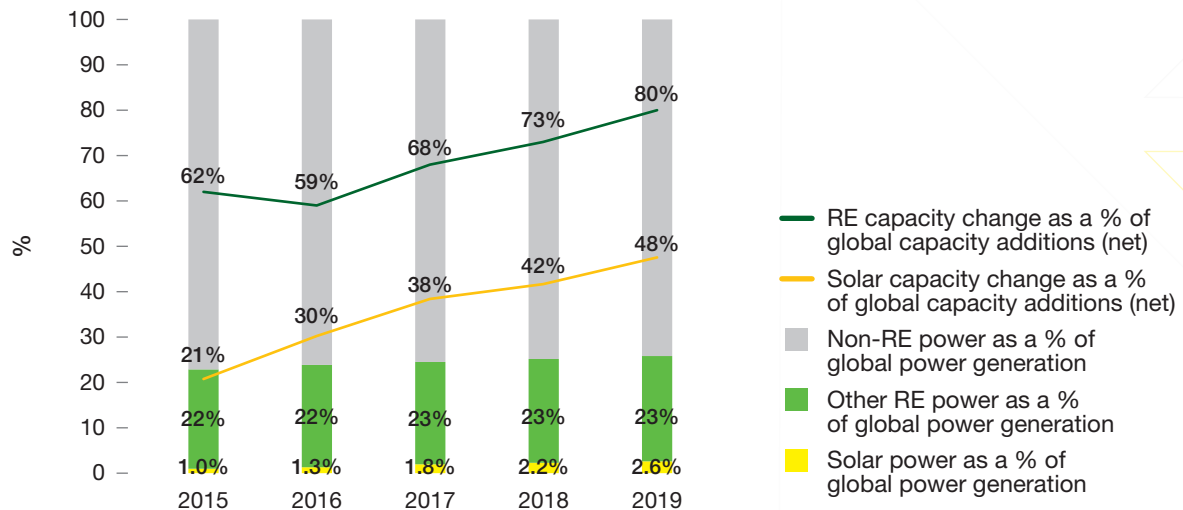
Source: Frankfurt School-UNEP Centre/BNEF (2020).

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1 GLOBAL SOLAR MARKET

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FIGURE 2 SOLAR AND RENEWABLE POWER AS A SHARE OF GLOBAL POWER 2015-2019



Source: Frankfurt School-UNEP Centre/BNEF (2020); IRENA (2020); SPE estimates.
Note: RE capacity includes large hydro.

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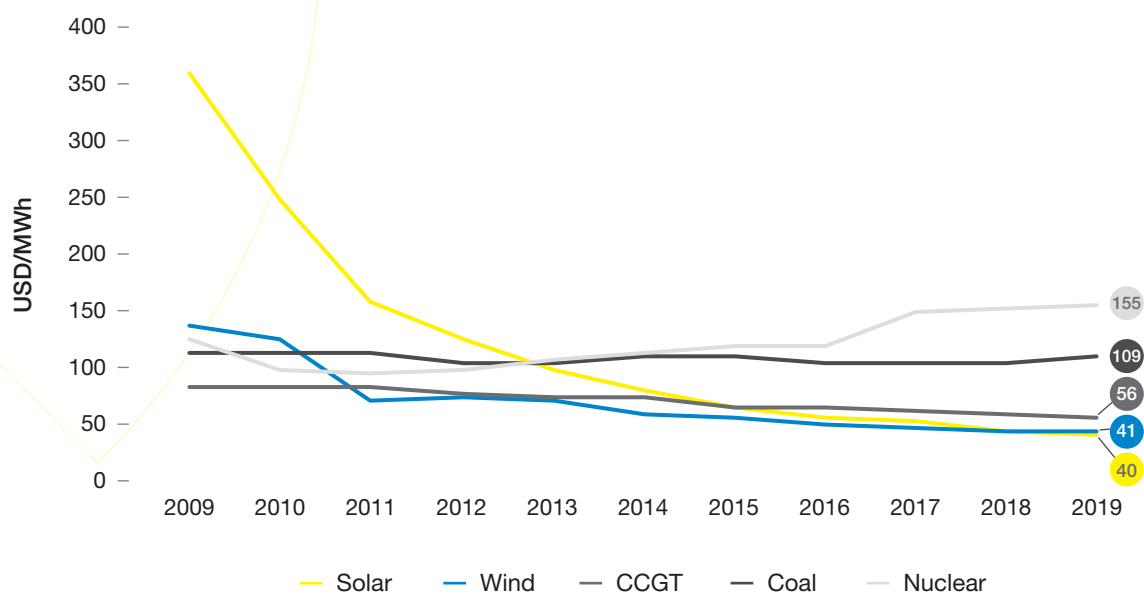


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Solar's success story over other technologies has a variety of reasons, but a key factor is its rapid cost reduction over the last decade, which has finally led solar to become the cost leader (see Fig. 3). While the

cost of solar PV power generation has been lower than unsubsidised fossil fuels and nuclear for several years, they are now often also less costly than gas and even wind in many regions of the world.

FIGURE 3 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH OTHER POWER SOURCES 2009-2019



Source: Lazard (2019). Historical mean unsubsidised LCOE values (nominal terms, post-tax).

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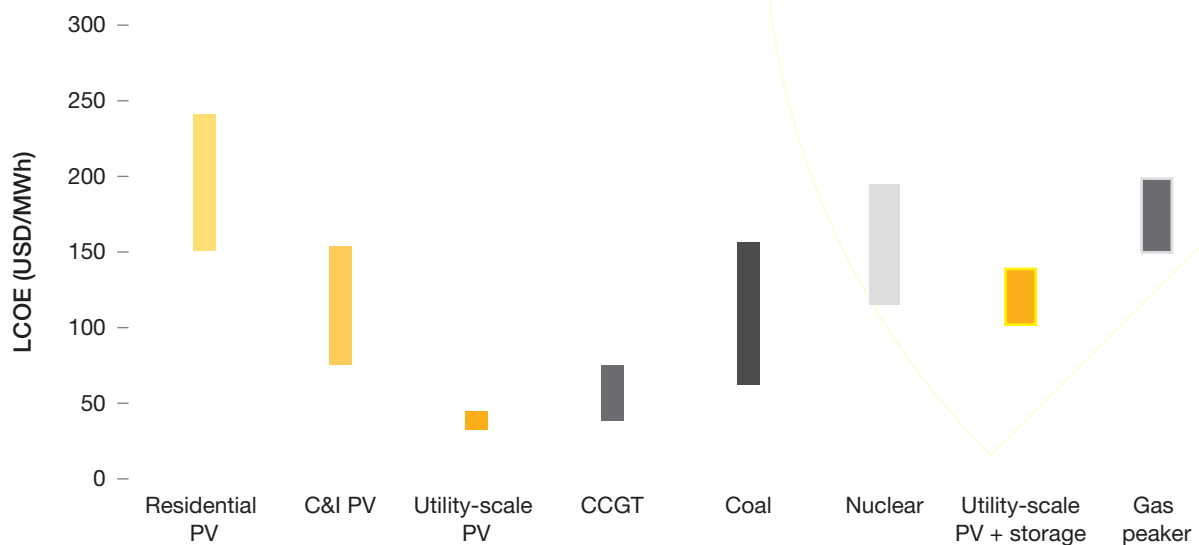
1 GLOBAL SOLAR MARKET

UPDATE 2000 - 2019 / CONTINUED

The latest Levelised Cost of Energy (LCOE) analysis, version 13.0, released in November 2019 by US investment bank Lazard, shows utility-scale solar's cost improving over the previous version by 7%. Utility-scale solar is again cheaper than new conventional power generation sources nuclear and coal, as well as combined cycle gas turbines (CCGT) (see Fig. 4). However, solar has started to compete with another fossil fuel segment: gas turbines used to meet peak demand. With the rapidly decreasing cost for batteries, solar + storage can outcompete gas peakers, depending on region and framework conditions. Last year in Arizona, for instance, a utility ordered a 100 MW/4 hour battery storage system to provide peaking capacity of its solar power generation fleet.

Solar's constantly increasing competitiveness around the world can be well observed in power tender results. In 2019, tenders and auctions led to a new low for solar bids, awards, and contracts. While the 2 US cents/kWh level could be seen in several instances in 2018, a year later, the 1 US cent level has been touched multiple times and in different continents (see Fig. 5). The world's lowest solar power contract at the time was awarded in Portugal's first solar energy auction in August 2019 at 1.47 EUR cents/kWh (1.65 US cents) for a 150 MW system, to French PV company Akuo, beating the lowest solar bid of 1.69 US cents/kWh achieved in Brazil's A-4 New Energy Auction only a month earlier. A third 1 cent range deal was claimed in November, at 1.7 US cents for a 900 MW part of Dubai's Rashid al Maktoum Solar Park, which is targeted to reach 5 GW by 2030. In addition, a solar PPA signed in California made it to the sub-two cent level, at 1.997 US cents/kWh, although it benefits from the US Investment Tax Credit scheme.

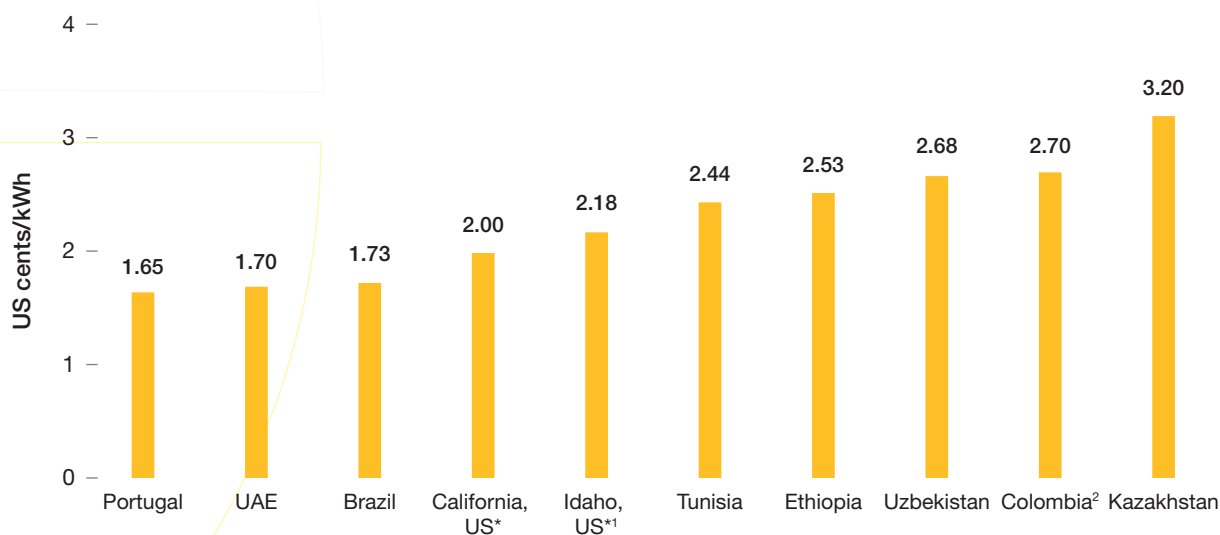
FIGURE 4 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH CONVENTIONAL POWER SOURCES 2019



Source: Lazard (2019). Nominal terms, post-tax.

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FIGURE 5 SELECTION OF LOWEST SOLAR AUCTION BIDS AROUND THE WORLD IN 2019



*: PPA with Investment Tax Credit, 1: With 1.5% annual escalation, 2: Average winning bid.

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The general rule is that solar power prices are considerably lower in economies with stable policy frameworks and high credit ratings compared to developing countries. But in recent years there have been an increasing number of examples showing impressively low PPAs in developing countries as well. With support from international lenders, primarily development financing institutions (DFI), the risk for solar projects can be substantially reduced in these regions. In 2019, several tenders were won in the 2 US cent range in developing and emerging countries. One such example is a 2.5 US cents/kWh bid from ACWA Power in Ethiopia, a new world record low for a solar power tariff at the time in Africa, which secured the company the rights to develop two solar power plants

with a combined capacity of 250 MW. The tender was part of the Scaling Solar Programme of the World Bank Group, which is probably the largest solar scheme of this kind. Scaling Solar has been primarily supporting solar deployment in African countries such as Ethiopia, Madagascar, Senegal, and Zambia, but recently expanded to Afghanistan and Uzbekistan. In Uzbekistan, the first Scaling Solar tender resulted in a 2.68 US cent winning tariff for a 100 MW project, which is the first of a total of 1 GW planned as part of the programme in the Asian country. But even without the help of DFIs, solar tenders are now starting to attract low bids, like in Tunisia, which was another example for a 2 US cent range winning tariff of a 360 MW portion in a 500 MW tender.

1 GLOBAL SOLAR MARKET

UPDATE 2000 - 2019 / CONTINUED

New record installed capacity in 2019

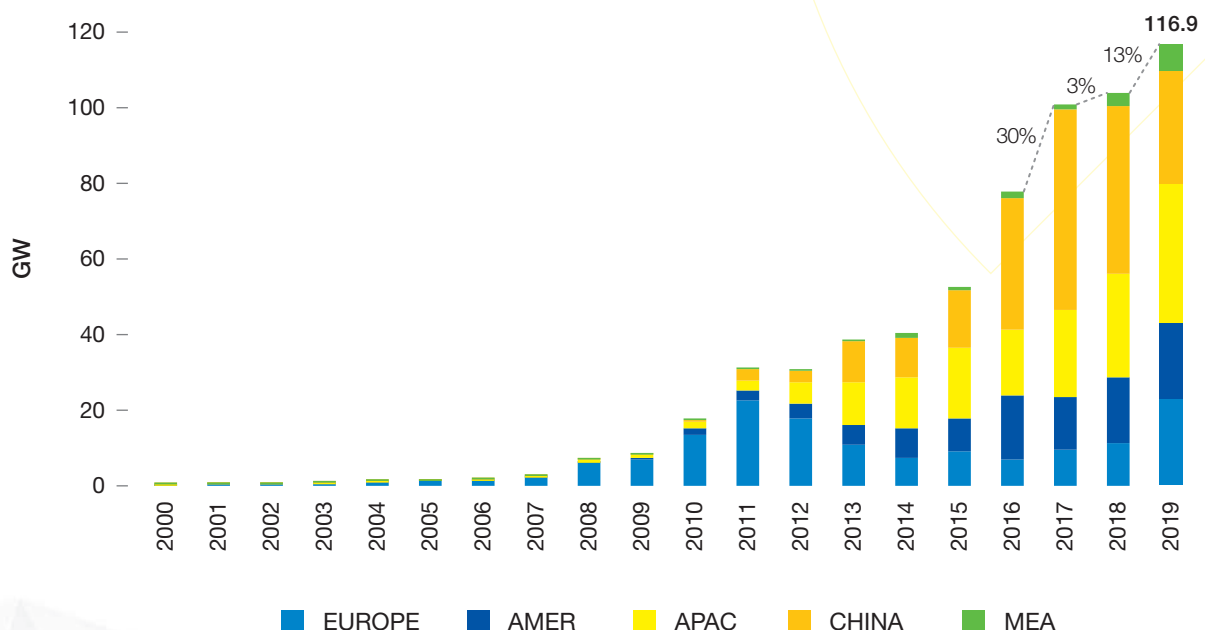
In 2019, a total of 116.9 GW solar was installed globally, representing a 13% growth over the 103.7 GW additions the year before and marking a new solar record (see Fig. 6). Originally, we expected that demand would rise to 128 GW, but the world market leader China's solar programme restructuring not only continued but fully unfolded in 2019, reducing newly installed capacities by 14 GW year-on-year. While we were almost spot on with our global installation forecast for 2018, after underestimating the growth of the solar sector for years, this time, it is the other way around – we have overestimated annual market growth by about 9% in our 2019 medium scenario. This is because we were off by a large margin on China, which we estimated to install 43 GW in our medium scenario 2019 (the Chinese PV Industry Association was a bit more conservative forecasting 40 GW), based on the expectation of a strong market response after its administration released its updated incentive guidelines in the spring of 2019. While the importance of China's solar market has decreased in the global context (see p. 16), understanding the development of the country is key as it will remain the world's largest off-taker for solar power systems.

Top 5 Global Markets

China's market decline for the second year in a row led to 'only' 30.1 GW of newly-installed capacity in 2019. This represents a 32% decrease from the 44.4 GW installed in 2018, and a 43% decrease from its all-time record of 52.8 GW in 2017; it was even 13% less than the 34.5 GW China added in 2016. Still, China remains the world's largest market by far, adding over twice as much solar power capacity than the second-largest market, and as much as the top three markets combined.

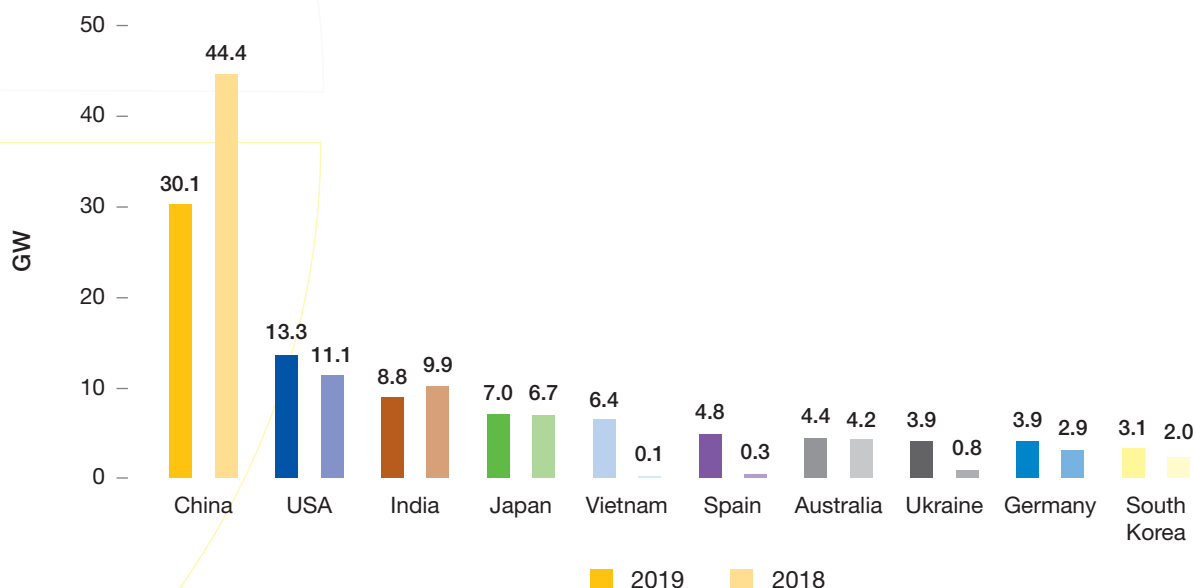
This downward trend is due to a restructuring plan of the country's administration announced in May 2018, which strives to transform the former incentive scheme based on uncapped and attractive feed-in tariffs into a framework based on auctions and, finally, subsidy free systems to better control cost and growth. After China slashed further approvals for ground-mounted solar power plants at the time, it also implemented another round of feed-in tariff cuts. Delays of over a year in providing new incentive guidelines resulted in severe investor uncertainties, exacerbated by continuing deferrals of feed-in tariff payments, grid-connection, and curtailment issues, among others. A new combined

FIGURE 6 ANNUAL SOLAR PV INSTALLED CAPACITY 2000-2019



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FIGURE 7 TOP 10 SOLAR PV MARKETS IN 2018-2019



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FiT/bidding scheme resulted in nearly 40 GW of FiT and subsidy-free system approvals in the July 2019 auction, but only about a third of this was built.

The **United States** saw an almost 20% market uptick to 13.3 GW, from 11.1 GW the year before, providing enough cushion to comfortably maintain its rank as the world's second largest solar market. The main growth driver was the looming decrease of the federal solar investment tax credit (ITC), which dropped from 30% in 2019 to 26% in 2020, and was complemented by several state renewable portfolio standards. The bulk of new capacity came from utility-scale solar, which is traditionally the largest PV segment and was responsible for 63% of newly installed capacity. While residential solar grew by 15% to a new installation high of 2.8 GW, another very positive solar development took place in the corporate sourcing segment. From around 9.6 GW of solar PPAs signed in 2019, around 8.6 GW were inked in the US, according to BloombergNEF. With over 30 GW of new large-scale projects announced in 2019, a pipeline that has added up a total to 48 GW, solar's future looks bright in the US.

The world's third largest PV market, **India**, decreased in 2019. India added 8.8 GW, down 11% from 9.9 GW in 2018, which was already significantly less than the record 11.5 GW installed in 2017. There are multiple reasons for the decrease of solar demand in India: beyond the earlier issues with the goods and services tax (GST), safeguard duties, land problems, access to financing and grid quality, or even missing transmission lines, a new state government in Andhra Pradesh started to renegotiate PPAs for multiple GWs with local solar power producers. In fact, due to liquidity constraints there have been several instances in India's largest solar market in 2019, Karnataka, and Uttar Pradesh, where state power distribution companies attempted to renegotiate or cancel signed PPAs with solar and wind power developers. The rooftop market, which represented only around 15% of 2019 installed capacity, also decreased, adding only 2.8 GW. Nevertheless, around 35 GW of tenders were announced. While this is an 8% decline compared to the year before, according to Mercom, the auctioned capacity increased by 2%.

1 GLOBAL SOLAR MARKET

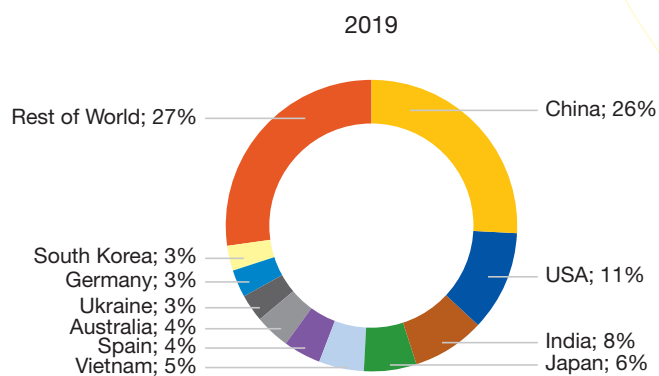
UPDATE 2000 - 2019 / CONTINUED

Unlike in the previous three years, **Japan** added a little more solar than the year before, installing 7.0 GW in 2019, up 4% from the 6.7 GW connected in 2018. This uptick comes mainly from time pressure on approved large-scale FiT projects that needed to be installed by the end of the fiscal year (end of March 2020). The general market sentiment, however, remains negative, coming from continuous FiT reductions for non-residential systems and grid constraints, limited land availability and cost competitiveness, as both construction and soft costs for installing solar systems are generally higher in Japan than in other markets, according to the analysis of the Japan Photovoltaic Energy Association (JPEA). A little bit like China today and the European Union in the past, Japan's solar market is struggling in its transition phase from its FiT scheme to auctions and self-consumption. As there was still a considerable project pipeline with high FiTs in 2019, also the two solar auctions (round 4 and 5) for systems above 500 kW in 2019 were undersubscribed, like the previous editions, and resulted in the selection of around 226 MW from over 700 MW tendered. The latest, fifth auction alone launched in late 2019, awarded beginning of 2020 only 40 MW of the 416 MW on offer. The lowest bid was awarded in the fourth tender in September 2019 at 10.50 JPY (9.9 US cents) per kWh, which is significantly higher than in auctions of

other countries. Japan is the world's country where a considerable 2 GW volume of residential rooftop systems saw their 10-year FiT contracts finish by the end of 2019, challenging the market to create solutions to use and remunerate this zero marginal electricity from written off power plants. However, JPEA now believes the country's solar downturn to continue into the mid-2020s, when they expect that restructuring will be accomplished, enabling the next growth phase for rooftop, and for MW-scale systems as well (see JPEA's market assessment, p. 78)

A new entry in the global top 5 is a country that was probably not on many people's radars: **Vietnam** added 6.5 GW in 2019, up 6,400% from 97 MW in 2018. The surge is due to a very attractive and uncapped feed-in tariff scheme, offering 20-year FiT contracts for 9.35 US cents/kWh. Announced in April 2017 with a deadline for this incentive level set for end of June 2019, the bulk of the systems was grid connected in the first half of 2019. In addition, Vietnam created a net-metering scheme to support distributed generation, with buying and selling prices determined on an annual basis depending on the VND/USD exchange rate that resulted in 270 MW rooftop installations last year. While the expiration of the first FiT scheme in June 2019 opened a 10-month legislative vacuum that created high uncertainty around the future of solar, as of April 2020, the FiT programme continues at somewhat lower though still very generous tariffs.

FIGURE 8 TOP 10 SOLAR PV MARKETS 2019



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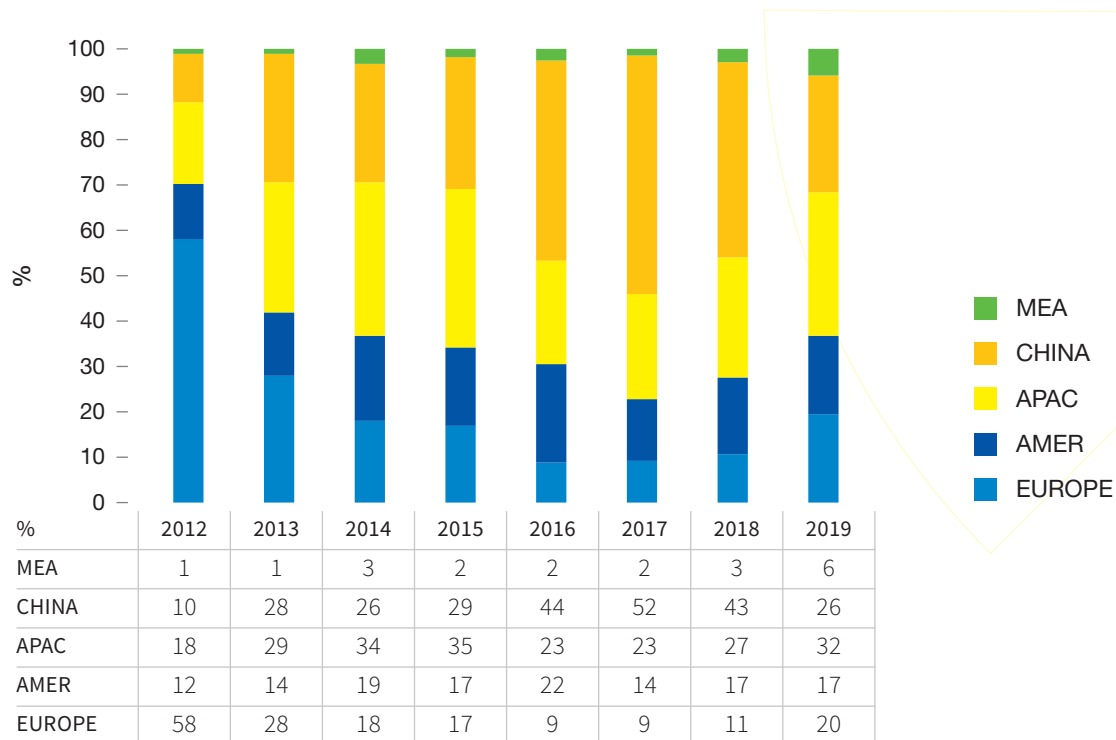
UPDATE 2000 - 2019 / CONTINUED

Regional update 2019

The weak performance of **Asia-Pacific's** top markets China and India pushed demand further down in the region - dropping by 7% to 67.1 GW, after it already shrank by 6% in 2018 (Fig. 9; note that due to its large size, China is listed separately from the Asia-Pacific region). Still, Asia-Pacific remained the largest global solar hub in 2019 with a total share of 57%, 6 spots among the top 10 solar markets, and 7 countries that added GW-scale capacities, more than any other continent. Without China, the rest of Asia-Pacific actually grew considerably, by nearly 10 GW to 37.1 GW, a 35% increase over last year. The biggest solar jump in Asia last year came from Vietnam, which bets on low-cost solar to meet its quickly increasing power demand. Another market showing positive developments was South

Korea, which grew by 54% to 3.1 GW, exceeding the 3 GW level 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 exceeding 500 MW generation capacity 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 installed under this program. Taiwan added for the first time a GW-scale volume – 1.4 GW in 2019, after falling slightly short to reach that level the year before. The island nation, that is fully dependent on energy imports, has an ambitious target to reach 20 GW by 2025, and a generous feed-in tariff scheme as a key tool to accomplish that goal. Several other Asian markets have started to look seriously into solar as well, like Uzbekistan, which built its first 100 MW PV Power plant last year.

FIGURE 9 ANNUAL SOLAR PV INSTALLED CAPACITY SHARES 2000-2019



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Australia continued its positive solar streak in 2019. It added 4.4 GW, which means a slight growth over the 4.2 GW from 2018, when demand nearly tripled. Australia saw equal installations for rooftop and ground-mount systems. The strong continued uptake of rooftop PV has resulted in over 2.3 million homes by end of 2019, translating into ratio of around 1 in 4 of all homes using onsite solar. One reason for the strong demand for residential solar in 2019 were the recent bushfires, according to Australia's Smart Energy Council (see SEC market assessment, p. 85). The wish for energy security also boosted the battery market, adding around 22,000 home storage devices in combination with solar last year. At the same time demand for utility-scale projects also boomed as developers have been attempting to beat the 2020 deadline, when the national Renewable Energy Target (RET), a carbon price certificate model mechanism based on offsetting emissions in the grid through solar output, ends utility scale support for new entrants.

The new growth phase that started 2017 in **Europe** has gained huge momentum in 2019 – both for the entire continent and the European Union. After increasing demand in the low two-digit range, at 21% to 11.2 GW in 2018, solar additions in Europe more than doubled to 22.9 GW in 2019, which has made the region the second largest solar market in the world last year. The EU-28 alone added 16.7 GW, translating into an even larger growth of 106%. Europe's solar boom is carried on many shoulders – four countries added over 1 GW (Spain, Germany, Ukraine, Netherlands), with a few others getting very close to that level (Turkey, France, Poland). As expected, Spain turned out to be Europe's largest solar market, installing 4.8 GW, of which the bulk stemmed from the 2017 auctions with a grid-connection deadline end of 2019. This means the market catapulted by 17 times from 262 MW in 2018. Spain's installation number also included 459 MW_{AC}, equal to around 550 MW_{DC}, of self-consumption systems, a capacity that had become quickly popular after the so-called Sun Tax, that basically prohibited that segment, was discarded end of 2018. There were also a number of subsidy-free PPA power plants installed, but grid constraints prevented larger volumes of the 100 GW system pipeline to be turned into reality.

Though the solar history of the Ukraine is much shorter than for Spain, the eastern European country showed a similar dynamic as the southern European nation last year. Annual installed capacity was catapulted to 3.9

GW, from 803 MW the year before, excited by very lucrative feed-in tariffs. Europe's 2018 solar market leader Germany increased newly installed capacity by 34% to 3.9 GW, but that was only enough to secure rank 3 last year. Backed by larger annual tender volumes, strong interest in self-consumption/feed-in premium systems in the commercial and residential sector, feed-in ground mount systems below 750 kW and the first subsidy free systems, Germany's solar sector stood very strong also in 2019. The Netherlands experienced further strong solar growth as well, adding 2.4 GW compared to 1.5 GW the year before. Dutch solar investors continued to profit from a solid net-metering scheme for residential rooftop systems, and a regular tendering programme for commercial and ground-mounted PV plants. However, Holland's 59% growth rate was not enough to secure again a global Top 10 rank, which would have required new installed capacities of more than 3.1 GW. Overall, the interest in solar had again increased in 2019 in Europe. From the European Union's 28 EU member states, 18 exhibited higher installation numbers than the year before.

The **Americas** is clearly dominated by the US, which added much more capacity than all other countries on the Continent combined, owing a 66% share of that solar market. In 2019, the Americas installed 20.1 GW of solar, the first time it reached such a level that is 15% higher than the 17.5 GW deployed the year before. The Continent's other two GW-scale markets – Mexico and Brazil, went different paths last year. The Latin American 2018 shooting star Mexico reduced its newly annual installed capacity nearly by half to 1.4 GW in 2019. In the past long-term auctions had a paramount role in solar PV deployment in Mexico, which is predominantly composed by large-scale installations. But a new government changed the course of the country's energy policy, taking decisions that has put the solar sector in a limbo. In February 2019, it cancelled the fourth renewable energy auction without giving a new date, after it had been temporarily suspended in late 2018. Moreover, Mexico's energy regulator CFE announced to review existing PPAs awarded in the first three renewable energy auctions. On the other hand, no negative effects on solar developments could be seen in 2019 in Brazil, where a new conservative government took office at the beginning of that year. Installations grew to a record 2.1 GW, with the major part, around 1.5 GW, stemming from distributed generation below 5 MW

1 GLOBAL SOLAR MARKET

UPDATE 2000 - 2019 / CONTINUED

that profit from a net-metering programme, and 657 MW newly installed centralised generation, awarded through energy auctions held by the government but also from direct PPAs in the free electricity market.

The general picture for solar in the Americas looked rather positive in 2019, with many of the countries growing its installation volumes, and increasingly with the use of solar tenders. Notable examples were Colombia, where a first 86 MW system was installed; Jamaica, which commissioned the Caribbean's largest PV system at 51 MW; or Panama, which had over 500 MW of solar capacity under development and partly in construction last year.

The **Middle East and African (MEA)** region absorbed 6.8 GW of new solar power capacity in 2019, that's over twice as much as the 3.1 GW the year before.

News about the Middle East were again dominated from a tender with record-breaking low solar tariffs in the United Arab Emirates. But in addition to the 1.69 cent/kWh award for the 900 MW part of Dubai's Rashid al Maktoum Solar Park, there was another significant achievement in 2019 in another emirate – Abu Dhabi. After 2 years of construction time, one of the world's largest PV systems, the 1.17 GW Sweihan project entered commercial operations middle of last year, turning the UAE for the first time into a GW-scale PV market.

There was vibrant solar activity in many other Middle Eastern countries last year, and although many countries issued new tenders, selected bidders and increased their installed capacities, none of them other than the UAE reached the GW-level. The second biggest market was Israel, which saw its market grow significantly to 628 MW, followed by Saudi Arabia, where the 300 MW Sakaka system led to 459 MW of newly installed capacity, and Jordan with 392 MW, slightly up from 382 MW the year before. One of the notable tenders took place in Iraq, which invited bids for 750 MW capacity that is planned to be installed in several systems ranging from 30 to 300 MW.

What Sweihan means for the Arabian Peninsula, Benban is for Africa. In late 2019, Egypt's Benban Solar Complex with almost 1.5 GW was fully commissioned, now providing power to over 1 million people and lifting Egypt into the group of annual GW-level markets as well.

Though one magnitude smaller, there were only two other markets that installed over 100 MW on-grid PV on the Sub-Saharan Africa region last year – South Africa, which installed around 507 MW, up from 373 MW in 2018, and Namibia, with 130 MW. But looking only at these two will be misleading. Africa has been seeing a number of countries entering the on-grid solar segment and quickly progressing. Backed by the World Bank's Scaling Solar, GET.Invest and other development financing institutions, Africa saw several new tender projects announcements, while a few systems from earlier DFi-supported tenders were installed, like in Mozambique and Zambia. In addition, there was news about first utility-scale installations in other countries, like Kenya or Uganda. However, the reasons for installing on-grid solar in Africa are manifold – in addition to tenders, there are still feed-in and net metering schemes, as well as plenty of international support instruments, but weak grids and/or regulatory frameworks for IPPs in many Sub-Saharan African countries, in combination with the steep reduction in storage prices have been leading to an uptake of C&I projects as well. In 2019, on-grid PV in Africa increased by 92% to 2.5 GW, of which 52% was added in the Sub-Saharan Africa part, which alone grew by 116% to 1.3 GW. A chapter on p. 35 focussing on Sub-Saharan Africa provides in-depth background on the latest developments in those countries.

To sum up, 2019 was characterized by another growth year for the solar sector that would have been even better if two of the world's Top 3 markets, China and India had not severely struggled again – one on its growth path to transitioning away from traditional feed-in tariff incentive schemes to auctions and other market-based schemes, the other for a multitude of problems, including complex taxation schemes, programme management, financing and grid issues. Despite these growing pains, solar continued on its rapid cost reduction path, attracting even more countries to start looking more seriously into this unique and versatile true clean power technology.

In 2019, 16 countries added over 1 GW, in comparison to 11 in 2018, and 9 in 2017, showing how diversification of the solar sector starts to unfold into markets with notable volumes. Details on these 16 GW-markets can be found in Chapter 4, where national associations active in the solar sector provide background and analysis on their markets (see p. 69).

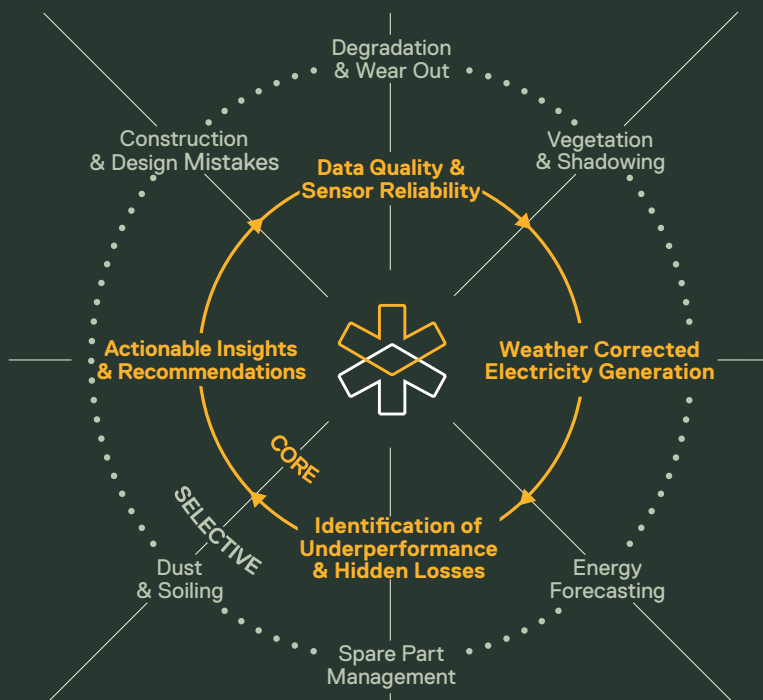
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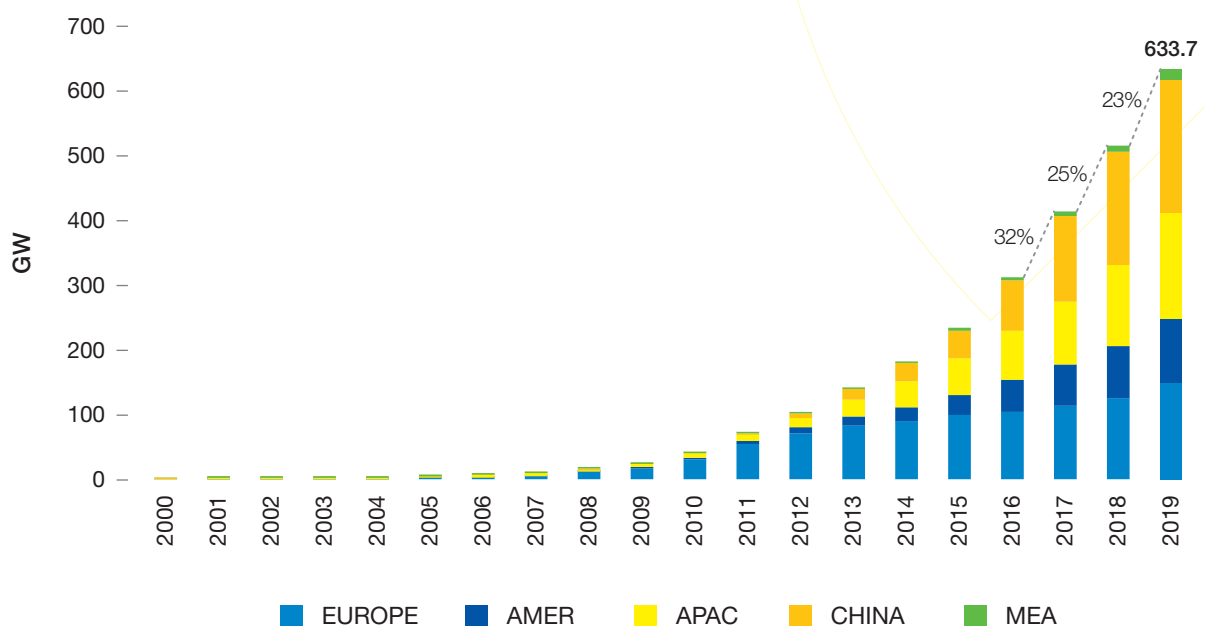
Cumulative Solar Installations until 2019

Cumulative installed solar PV power capacity increased by 23% to 633.7 GW by the end of 2019, up from 516.8 GW in 2018 (Fig. 10). That means total solar power has grown by nearly 400 times since the start of the century, when the grid-connected solar era basically began with the launch of Germany's feed-in tariff law. Looking back only 10 years, the world's total installed PV capacity augmented by over 1,500% – from 41.4 GW in 2010.

Over **630 GW**
Solar capacity installed
globally today

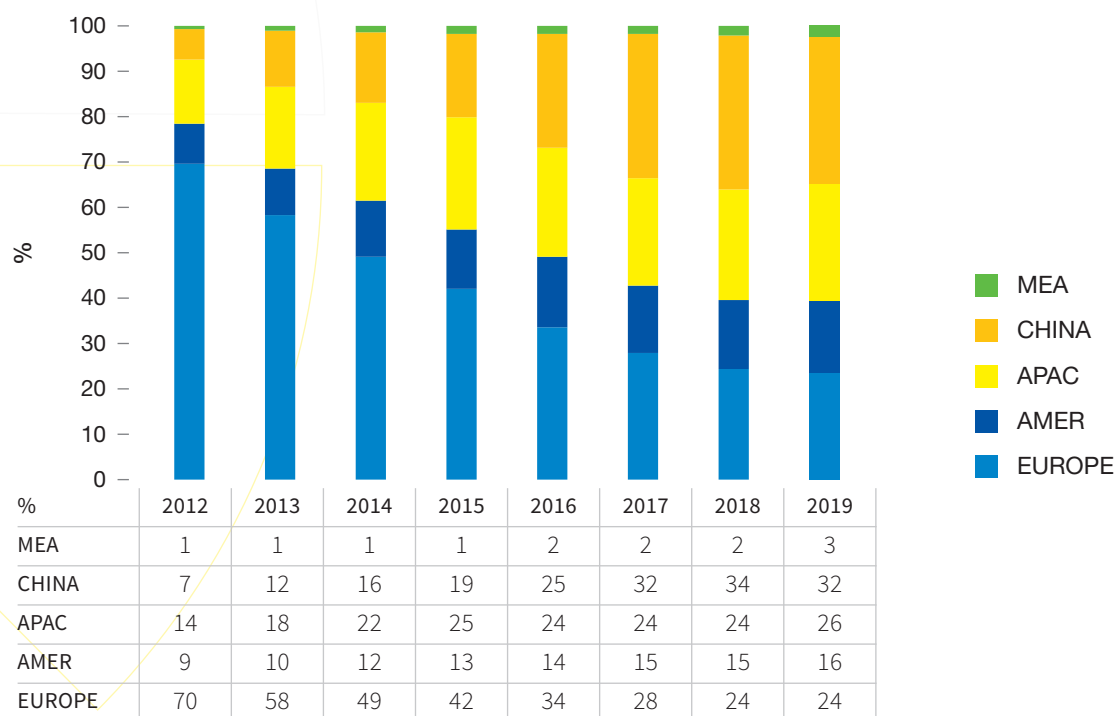
Dramatically slower growth in Asia's leading market, China, and a somewhat smaller contraction in the region's No.2, India, have stopped the further rise of the Asia-Pacific region. While Asia Pacific maintain its strong solar leadership in 2019, representing 58% of the global solar power generation capacities, this is exactly the same percentage as the year before. Additions of 67.1 GW in 2019 resulted in 368.3 GW of total installed capacity (see Fig. 11). The strong growth year of the European solar pioneers, on the other hand, had not effects on market shares either - the continent finally stopped its several yearlong market losses, but the 2019 shares stayed at the level of the year before, at 24%. With additions of 22.9 GW, Europe kept its second position based on a cumulative PV capacity of 149.1 GW. The Americas was again the world's third largest solar region in 2019 – with a cumulative installed capacity of 99.3 GW and a 16% stake, which means 1% point year-on-year growth. The strong activity in the Middle East and Africa (MEA) had a little impact on the region's solar development last year. With a total solar capacity of 17.0 GW, its world market share moved up 2.7% in 2019, from 2.0% the year before.

FIGURE 10 TOTAL SOLAR PV INSTALLED CAPACITY 2000-2019



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FIGURE 11 TOTAL SOLAR PV INSTALLED CAPACITY SHARES 2012-2019

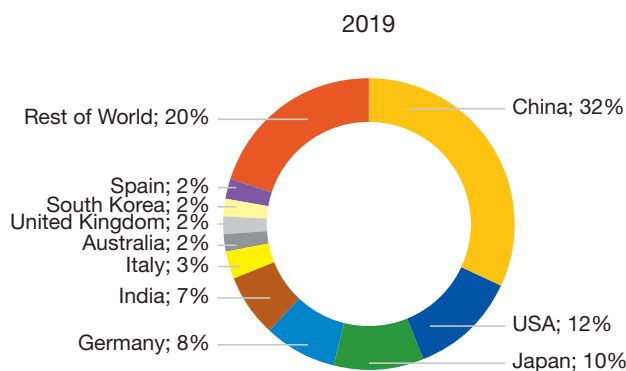


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When looking at individual countries, it shows that China's dramatic 32% market contraction in 2019 has not affected its strong solar dominance. Its operational solar power generation capacity reached 32%; this is 2% points lower than in 2018, when China's share was at 34%, but still equals close to one-third of global power generation capacities (see Fig. 12). The sequence of closest followers hasn't changed – China was trailed by the United States, Japan and Germany. While the US

kept its 12% share, the other two each lost 1% point market share in 2019. The US' cumulative installed PV capacity reached 76.1 GW, Japan's 63.0 GW meant a 10% share, and Germany's 49.7 GW resulted in a 8% share. While India again did have anything but a great solar year in 2019, its 1.1 GW market decline is not mirrored in the total global power rankings – its 42.0 GW of total installed solar capacity was good enough to easily defend its fifth place and even up its share to 7% from 5% in 2018.

FIGURE 12 TOP 10 TOTAL SOLAR PV INSTALLED SHARES 2019



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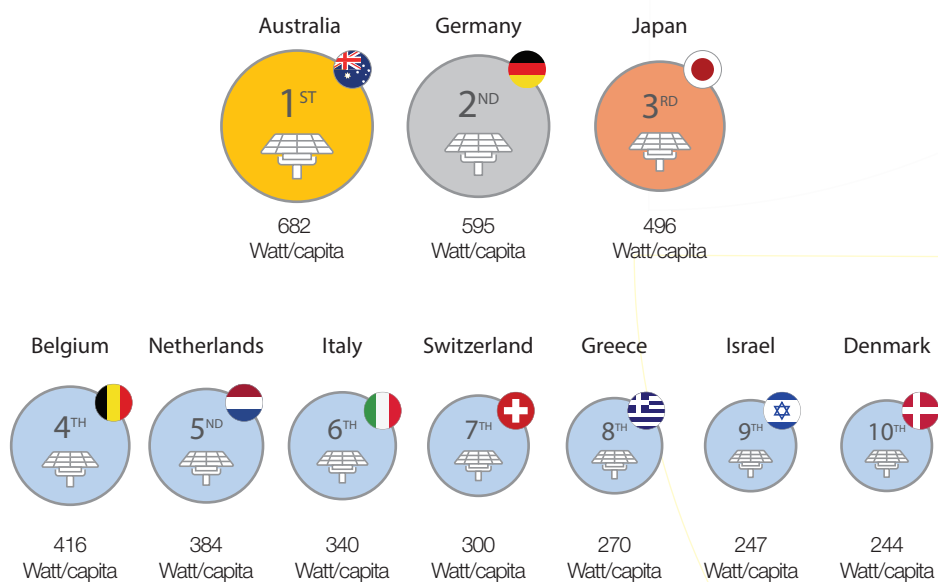
1 GLOBAL SOLAR MARKET

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All other solar markets considerably lag behind the top 5. In that group, there are only two noteworthy changes: following Italy at 20.6 GW, Australia at 16.0 GW and UK at 13.2 GW, South Korea now turned into a +10 GW solar power generation capacity market of 10.9 GW by the end of 2019. Moreover, Spain, on grounds of its massive growth streak adding 4.8 GW, that led to a total installed solar capacity of 10.6 GW, re-entered this top 10 list, replacing France.

However, when putting the microscope on the installed PV capacity per capita of a country, the global picture looks very different. None of the global top 3 markets China, USA and India is anywhere to be seen on the W/capita top 10 list (see Fig. 13). While the countries with the highest installed system capacities per inhabitant – Australia, Germany and Japan – also belong the 10 world's biggest solar markets, all the others are not, and most of them are pretty small nations with 10 million or less citizens.

FIGURE 13 TOP 10 COUNTRIES SOLAR CAPACITY PER CAPITA 2019



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1 GLOBAL SOLAR MARKET

PROSPECTS 2020 – 2024

Forecast 2020

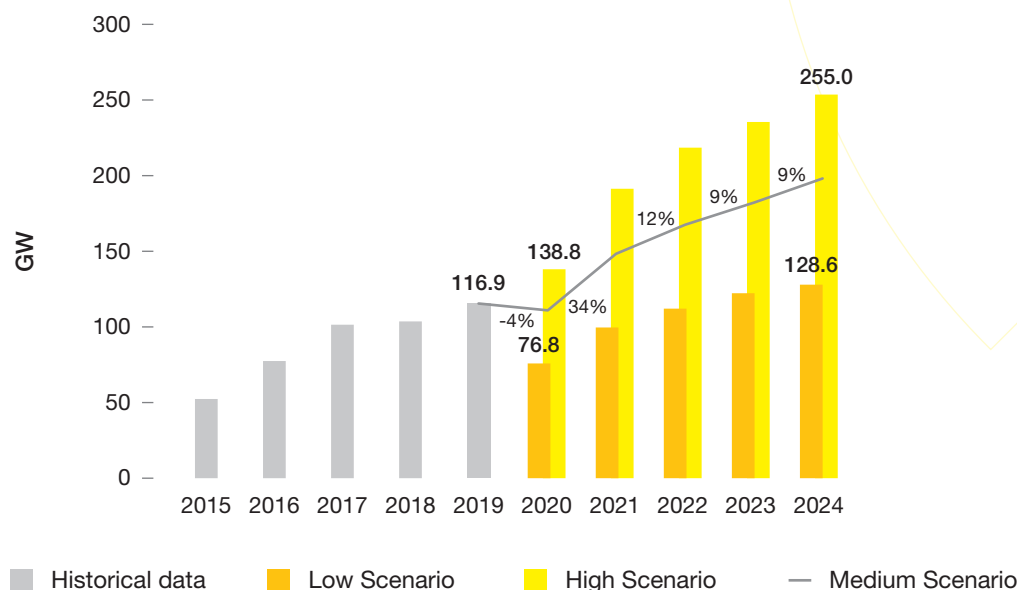
All leading solar market analysts have significantly decreased their 2020 forecast during the first 5 months of this year, some even twice, to account for the impact of COVID-19 on their market models. The largest short-term corrections came from IHS Markit, which reduced its 2020 forecast by 26%, or 32 GW, to 109 GW in April, from 142 GW in December 2019. By the end of May, the estimates in the analysts' medium scenarios ranged between 106 GW (Wood Mackenzie) and 111 GW (Bloomberg NEF), with one conservative outlier from the International Energy Agency (IEA), which anticipates only 90 GW new solar this year, caused by supply chain disruptions, lockdown measures, and emerging financing challenges.

Our market analysis in the time of COVID-19 resulted in a Medium Scenario anticipating about 112 GW of newly installed PV capacity in 2020, making it the most optimistic global solar forecast, even though only by a slim margin. Compared to 2019, this would translate into a 4% market shrinkage over the 116.9 GW added in 2019 (see Fig. 14).

For now, the effects of the virus seem to be under control in many countries, where lockdown measures are lifting and economies are being boosted with significant recovery packages; others appear to still be very much in the midst of the crisis. However, the Global Solar Council has conducted a survey on the impacts of COVID-19 on the solar sector, outlining that despite disruptions, the industry has the chance to come back even stronger with the support of recovery packages.

Our Low Scenario estimates a demand drop to 76.8 GW. This outcome is extremely unlikely based on observations of overall solar activities in the first months of the year. However, if another wave of the pandemic hit major economies severely in the second half of the year, demand for solar might indeed collapse. Our High Scenario forecasts up to 138.8 GW of solar additions in 2019, which 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.

FIGURE 14 ANNUAL SOLAR PV MARKET SCENARIOS 2020-2024



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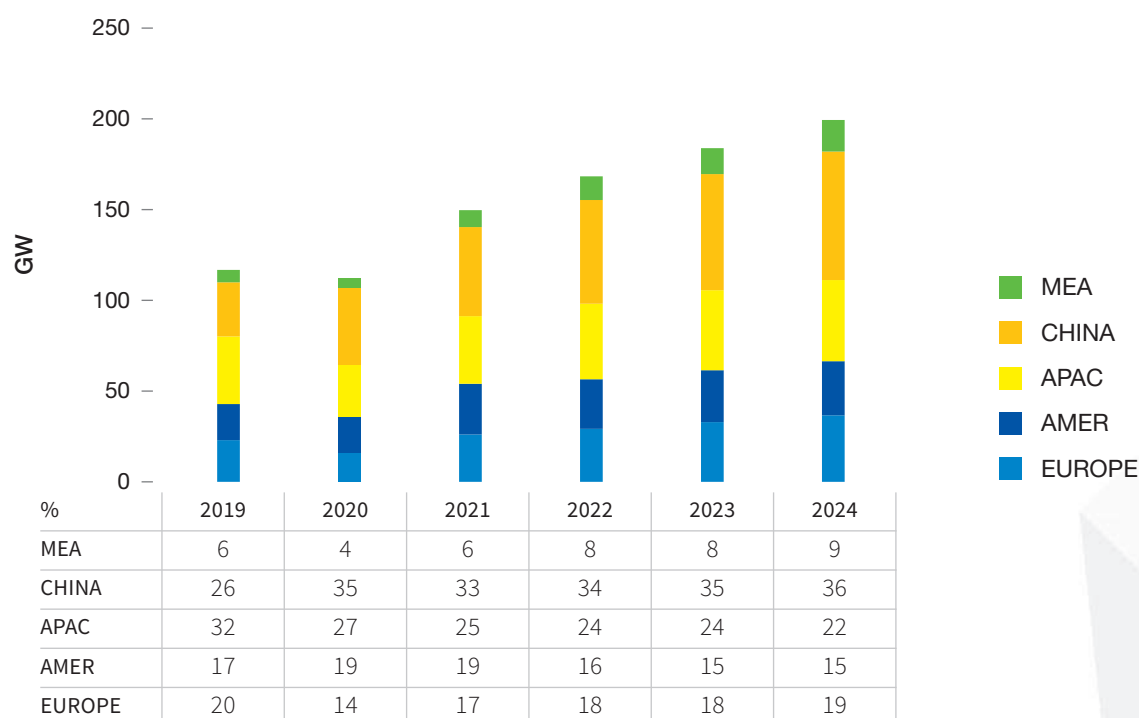
Regional market developments 2020

Retrospectively, looking into a crystal ball to forecast the future of solar installed capacities has never been easy for industry experts – the solar market is too dynamic and still hinges on a few countries, in particular China, that can influence the course of the entire industry. However, our Medium Scenario forecast clearly shows that China and the rest of Asia-Pacific will continue to dominate global demand (see Fig. 15). Once the Chinese solar market programme restructuring is completed, scheduled for next year, the country is also expected to develop more smoothly. In 2021, Europe is expected to grow its shares slightly, while the American Continent is estimated to slightly lose shares.

After the recent Asian solar market slump induced by China's and India's severe demand drops last year, all solar analysts' eyes are on the two solar heavyweights in 2020. Theoretically, **China** should grow rapidly this year, as it has overcome COVID-19 first and needs to protect installers and feed its domestic manufacturers, which have been seeing less demand from abroad where the lockdowns were taking place later. This was

the rationale for IHS Markit to increase its forecast for PV installations in China to 45 GW at the end of March. After only 3.95 GW was installed in the first quarter, a strong decline from 5.2 GW a year earlier, there should be plenty of demand for the remainder of the year, in particular as quite some capacity from the July 2019 auction was not built by the end of that year, and an installation deadline end of June were supposed to trigger demand in Q2. With the national auction scheduled for March shelved and expected to occur later in the year, this is another event that might trigger installation activities in 2020. However, the China PV Industry Association (CPIA) reduced the lower end of its 2020 forecast in early June from a 35–45 GW range to 32–45 GW, while GlobalData lowered its forecast from 40 GW to 33.4 GW because of the economic slowdown and lack of capital. With 2020 anticipated to be the last year the national government offers subsidies before the “subsidy free” era of the 14th 5-year programme starts next year, our Medium Scenario forecast shows some modest optimism, anticipating China to install 39.3 GW this year, which would mean a 31% market growth over the 2019 additions of 30.1 GW.

FIGURE 15 EVOLUTION OF GLOBAL ANNUAL SOLAR PV MARKET SHARES UNTIL 2024



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PROSPECTS 2020 – 2024 / CONTINUED

We are also upbeat about the **United States'** solar market developments, where we expect newly installed capacity to increase by 21% to 16.1 GW, from 13.3 GW in 2019. This is not as optimistic as the US Solar Industries Association (SEIA), which argues in their market analysis that utility-scale solar will propel the US solar industry to a record 18 GW due to a project pipeline of 51 GW, despite massive job losses in the sector due to a decline in residential demand (see p. 73). But our view is a bit more cautious, as COVID-19 was not over in the US in early June, and the safe-harbor provision offered companies to delay project completions.

Unlike for the top two global markets, our Medium Scenario for **India** is very negative for this year. In Q1/2020, only 1.1 GW was installed – a 43% decline compared to Q4/2019 and the lowest volume in over three years. In addition to the multiple problems that caused India's market to shrink in 2019, this year is adversely impacted by COVID-19, which has resulted in logistical issues for material supply and labour. We estimate that India will install only 6.1 GW, a 31% decrease over last year's 8.8 GW additions, and another step away from a two-digit market volume it installed only once in 2017, after which annual additions went down.

Looking at the bigger picture, **Asia-Pacific** is expected to see demand increasing by 4% to 70.1 GW, whereas the **Americas** is anticipated to grow by 5% to 21.1 GW.

With many countries in **Europe** hit very hard by the virus, the continent is expected to see a deep dive in demand this year, putting a clear break on the very positive momentum seen in the last two years. When looking just at the European Union, 11 of the 27 members, including some of the largest markets, are expected to install less solar than the year before. There are a few exceptions in countries that were less affected and did not implement hard lockdowns, like Germany. As the EU's second-largest market in 2019, Germany installed more solar in April, during the climax of the crisis, than in the same month last year. Altogether, during the first four months of 2020, Germany added a total of 1.48 GW, which is close to the capacity of the 1.55 GW deployed during the same period in 2019. Still, our Medium Scenario anticipates Europe's solar additions to fall by 29% to 16.1 GW, from 22.9 GW in 2019.

Middle East and Africa has not been affected by COVID-19 as severely as Europe so far, although this may change in the future. Nevertheless, many countries in

these regions have taken measures which restricted life and work; this is why we expect in our Medium Scenario a 31% demand reduction to 4.7 GW in 2020.

Global Solar Market Developments, 2021 to 2024

We do not expect the virus to pose a big risk in the medium-term for utility-scale solar, while C&I and residential sectors might see negative impacts for some time as businesses and consumers will not necessarily invest in solar if they are struggling from a longer economic downturn. Here, the economic stimulus package will have a very important role, indirectly to boost national economies to enable a healthy business environment, but also directly, offering financial incentives for solar investments, which some countries and regions have already announced (for more details on the effects of COVID-19 on solar, check p. 63).

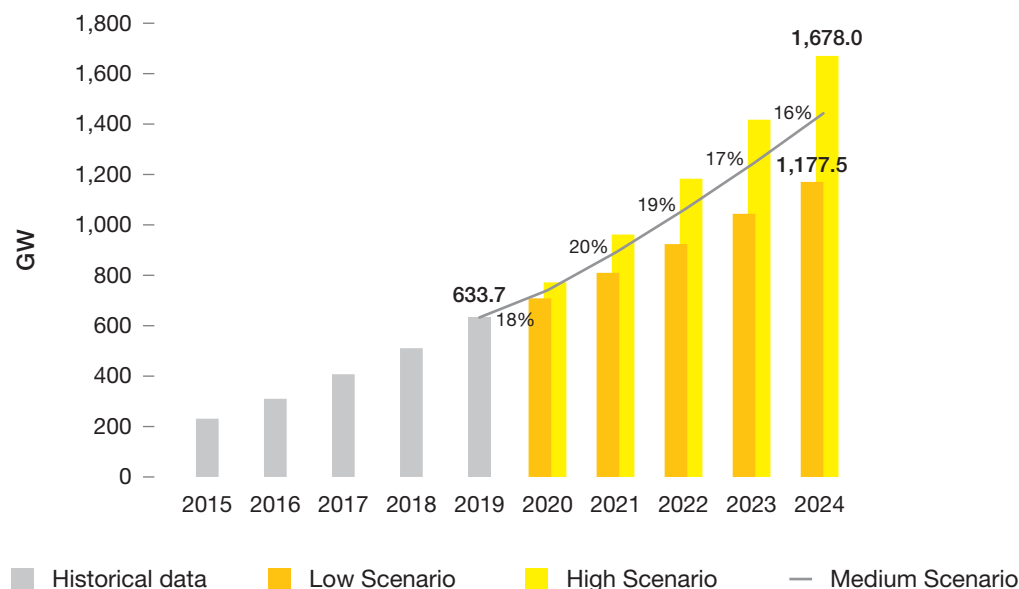
In any case, solar's striking value proposition will bring it back on its growth path, but 2020 will be a lost year due to COVID-19 – the fewer additions added this year will be missed in the cumulative capacities, even if we expect that annual additions as of 2023 will be already larger than anticipated last year.

Solar's return to growth in the coming years will be backed by all major markets for various reasons. In **China**, as of 2021 the new post-FIT area will begin based on auctions and wholesale systems. Until then, the Chinese administration will get its act together and call for an end to its solar programme restructuring. In our Medium Scenario, we estimate Chinese solar demand will reach around 39.3 GW in 2020, 49 GW in 2021, 57.5 GW in 2022 and 64 GW in 2023 and 71 GW in 2024, which is in the range of the China Photovoltaic Industry Association's (CPIA) forecast, though leaning a bit towards the upper end of its estimates (see p.71). Post-COVID, solar in **India** is expected to grow strongly in the coming years, as the government will do its utmost to meet its 100 GW target by 2022. We do not expect this to happen – so far only 4 GW of the 40 GW rooftop systems is installed, and there is also a huge pile of administrative, financial, and logistical issues for large-scale solar in the way. Still, at least 15 GW is likely to be installed annually as of 2021. In the **United States**, 2021 is supposed to be the year when the maximum ITC capacity will be installed, probably over 22 GW. While this will likely be the peak for the next few

years, the 20 GW level might be the new normal in the US. Europe is expected to return as of 2021 back on its growth path. The European Commission's Green Deal calling for carbon neutrality by 2050 and a much more ambitious reduction target for CO₂ emissions of 50-55% instead of today's 40% by 2030, will have to make use of low-cost and versatile solar to succeed. As the Green Deal will be core to the EU's COVID-19 economic stimulus package, solar is expected to access funds from a number of incentive tools, such as InvestEU, which will support renovation of buildings. In the COVID context, Japan for example, has as part of its economic stimulus package, allocated 1 billion USD to support corporate renewable power purchase agreements. There will be more such opportunities for solar in recovery packages, as in Malaysia, where a 1 GW tender programme for solar was announced.

While we assume in our Medium Scenario a notable 34% growth rate to 149.9 GW in 2021, which does anticipate significant levels of governmental recovery support, this capacity would be still 6% short of last year's 2021 forecast. It would take until 2022 to get almost back on track, reaching 168.5 GW. Only in 2024 are the virus impacts expected to be fully left behind (see Fig. 14). If our High Scenario assumptions could occur, this would result in an annual market size of up to 255 GW in 2024. But that would require decision-makers in politics and business to quickly act upon the understanding that solar is already today often the lowest-cost power generation source and also the most versatile technology to produce electricity. In combination with other renewables and storage, solar is extremely flexible, providing a 24/7 supply source. Following the high-scenario path would also require solar to be included as a benefactor in all leading solar markets national COVID-19 economic recovery packages.

FIGURE 16 TOTAL SOLAR PV MARKET SCENARIOS 2020-2024



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PROSPECTS 2020 – 2024 / CONTINUED

When looking at total installed global solar power capacities, our Global Market Outlook 2020 shows that COVID-19 resulted in a little lower growth than in last year's GMO. In 2020, we project a cumulative installed capacity of 746 GW for the Medium Scenario, which is about 5% lower than in last year's GMO (see Fig. 16). The final year 2023 of the 5-year forecast in last year's GMO 2019 ranged between 1,044 and 1,592 GW, with the most likely Medium Scenario resulting in 1,289 GW of total operating solar power in 2023. **For this GMO 2020, we forecast between 1,049 and 1,423 GW, with 1,248 GW for the Medium Scenario in 2023 – this is about 3% lower.**

Our new 5-year Global Market Outlook anticipates for our most-likely Medium Scenario that global solar power generation plant capacities will reach 1,448 GW in 2024. But under optimal conditions, the world could operate a solar power fleet as large as 1,678 GW by the end of 2024. The most likely scenario for entering the solar terawatt age is 2022; only four years after the 0.5 TW level was reached in 2018.

In our Medium Scenario, we now expect that total global installed PV generation capacity will pass the following milestones over the next 5 years: 700 GW in 2020, and 1.0 TW in 2022, and 1.2 TW in 2023.

Over **1.2 TW**
Solar power by 2022

Among the 20 markets with the highest 5-year installation potentials (in the order of Medium Scenario assumptions; see Fig. 17) little has changed from last year. The top 3 are the same – China, US, and India, although the US has overtaken India. The anticipated installation volumes for both high and low scenarios over the next five years are again higher for most markets, with a few exceptions such as Japan. Newcomers on this year's top 20 list are Israel, UAE, and Vietnam, with the latter being an unexpected success, jumping directly to eighth place. The pattern of the markets on this list also remains similar: few countries will install the bulk of all solar system capacity, though diversity is growing. This time, we expect for the High Scenarios three countries (last year it was 2) to install over 100 GW – China (328 GW), the US (115 GW) and

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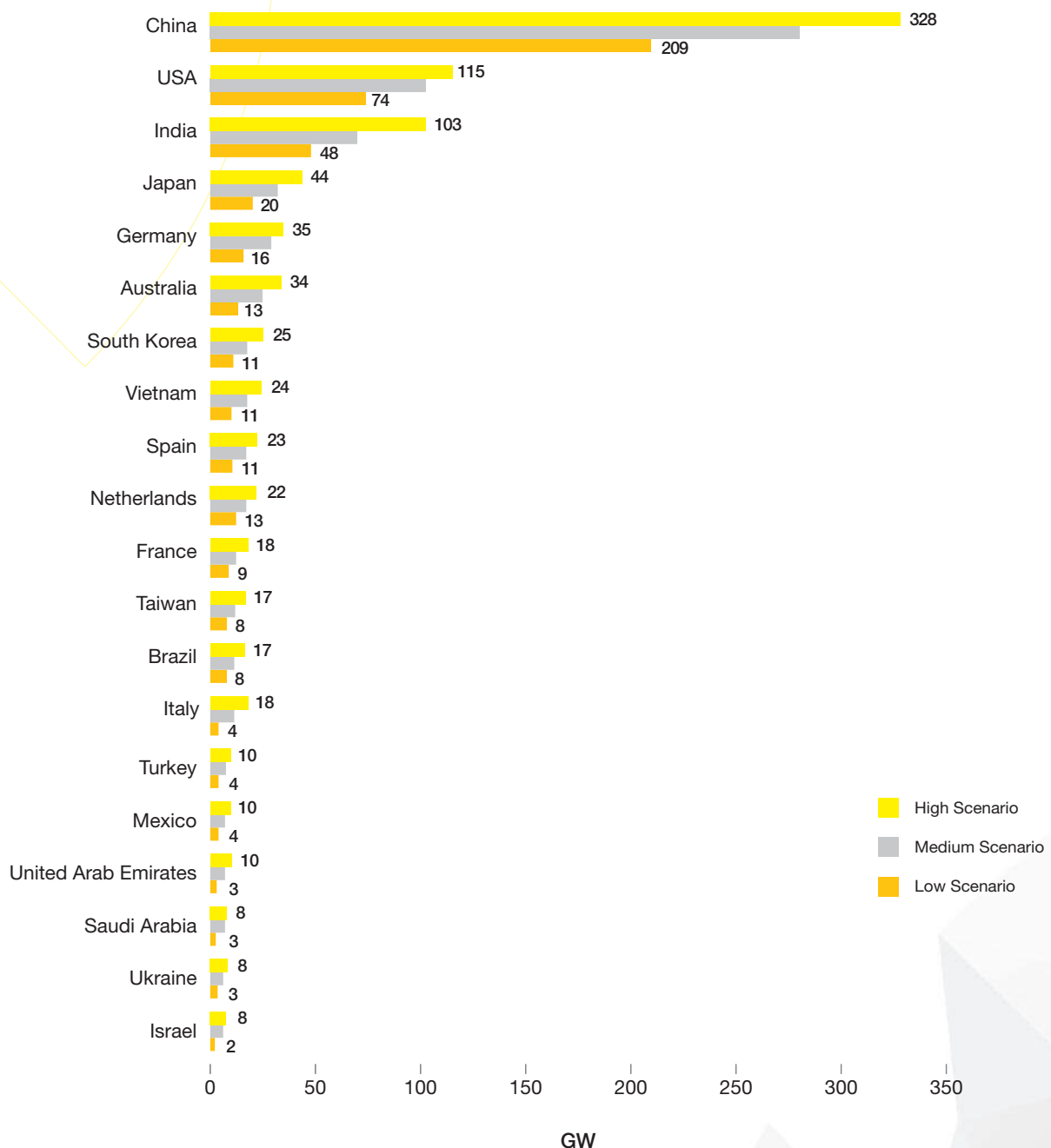
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India (103 GW) – and 10 countries to add around 20 GW or more – China, USA, India, Japan, Germany, Australia, South Korea, Vietnam, Spain and the Netherlands. The world's top 5 markets combined are anticipated to install 625 GW until 2024 in the High Scenario and 368 GW in the Low Scenario, covering a share of around

60% and 68% of total additions in that period (last year it was 61% and 68%). In comparison, the top 20 are estimated to add 876 GW over the next five years until 2024 in the High Scenario and 473 GW in the Low Scenario – this is 36 GW less and 9 GW more than our GMO 2019 5-year assumptions, due to the COVID-19 effect.

FIGURE 17 TOP 20 MARKETS SOLAR PV ADDITIONS 2020-2024



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Despite the enormous burden of COVID-19 on the global economy, **the top global PV markets' prospects for solar** continue to look very good for the next five years (see Fig. 18). Nearly three quarters of the top 20 markets are expected to install at least 10 GW each between 2020 and 2024, according to our Medium Scenario, with new capacity additions anticipated to range from 281 GW for

the first, China, to 5.9 GW for Israel, the last on this list. All 20 markets combined are estimated to add a total of 693 GW until 2024. This is even more optimistic than in our previous GMO, when we had projected that two thirds of the top 20 markets would be in the 10 GW+ group and a minimum of 4.4 GW capacity additions needed to be listed for the period for the coming 5 years.

FIGURE 18 TOP GLOBAL SOLAR PV MARKETS' PROSPECTS

	2019 TOTAL CAPACITY (MW)	2024 TOTAL CAPACITY MEDIUM SCENARIO BY 2024 (MW)	2020 - 2024 NEW CAPACITY (MW)	2020 - 2024 COMPOUND ANNUAL GROWTH RATE (%)	POLITICAL SUPPORT PROSPECTS
China	205 187	485 987	280 800	19%	☀️
United States	76 119	178 869	102 750	19%	☀️
India	42 031	111 881	69 850	22%	☀️
Japan	62 951	95 076	32 125	9%	☀️☁️
Germany	49 729	78 643	28 914	10%	☀️
Australia	15 977	40 168	24 191	20%	☀️☁️
South Korea	10 872	28 456	17 584	21%	☀️
Vietnam	6 458	23 720	17 262	30%	☀️
Spain	10 641	27 734	17 093	21%	☀️
Netherlands	6 559	23 495	16 936	29%	☀️
France	9 874	22 033	12 159	17%	☀️
Taiwan	4 151	15 977	11 826	31%	☀️
Brazil	4 460	15 935	11 475	29%	☀️
Italy	20 600	31 904	11 304	9%	☀️☁️
Turkey	5 994	13 139	7 145	17%	☁️🌧️
Mexico	4 940	11 863	6 923	19%	☁️🌧️
United Arab Emirates	2 009	8 789	6 780	34%	☀️
Saudi Arabia	478	7 185	6 707	72%	☀️
Ukraine	5 937	12 058	6 121	15%	☀️
Israel	2 104	7 999	5 895	31%	☀️

1 GLOBAL SOLAR MARKET

PROSPECTS 2020 – 2024 / CONTINUED

For the period up to 2024, we see sunny political support prospects for three quarters of the top 20 countries, all of them expected to show two-digit annual growth rates. Our weather forecast is cloudy for 3 countries, of which two are expected to grow only with one-digit growth rates. In Japan, the government has done little to reverse the general downward trend for new solar – the restructuring of the energy market restructuring has taken too long and solar installations are still too expensive. Instead of utilising the low-cost potential of solar, the government has tried for years to revive nuclear against the will of the population, and has recently even begun to turn towards coal at a time when most countries are leaving behind this CO₂-intensive fuel. Another country with cloudy prospects is Italy. For years, the market has hovered at a very low installation level, while attempts to harvest the country's abundance of sun has failed – the latest example is the failure of technology neutral renewables auctions, where solar

was awarded only very small volumes. The third in this group, Australia, is different: it is the country with the world's largest solar home density (2.3 million) and has been on a growth streak for years. But its main growth driver, the national Renewable Energy Target (RET), a carbon price certificate model mechanism based on the offsetting of emissions in the grid by PV output will end in 2020 for utility-scale support. The current federal government has no intention of extending the program, leaving a huge pipeline of utility-scale solar in limbo. The two markets with a rainy outlook are Turkey and Mexico. While Turkey has again suffered another year of decline after the climate for solar changed two years ago due to a financial crisis and dwindling political support, more or less abandoning the formerly successful feed-in tariff scheme, in Mexico a change in government led to a new path in energy politics, with a full focus on centralised fossil fuel power plants, while challenging the policy frameworks for solar installations.

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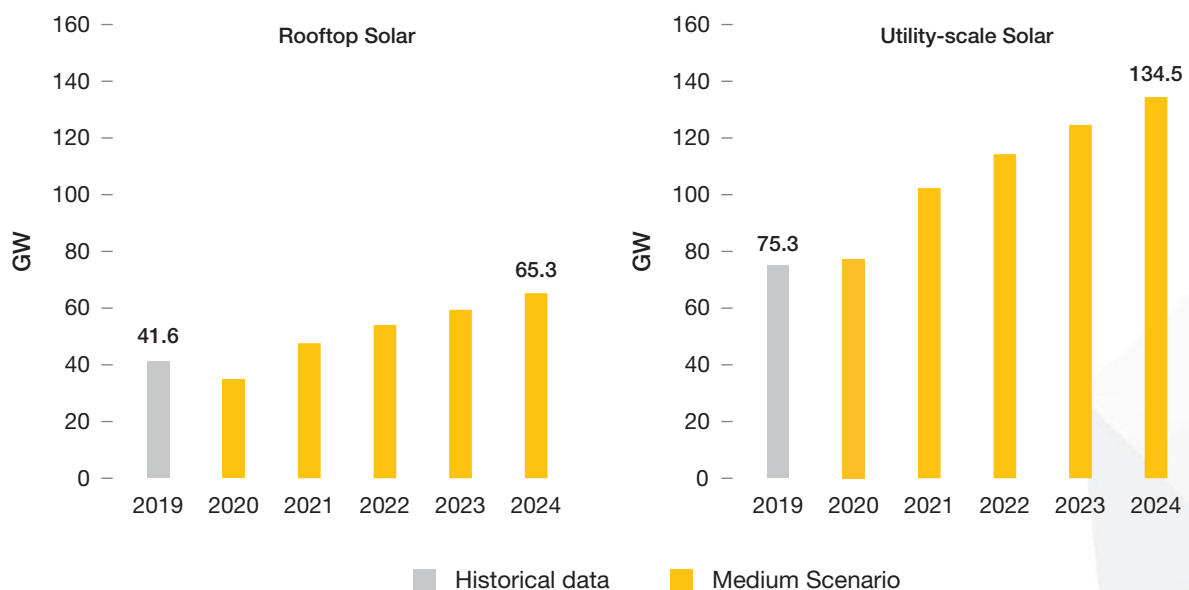
SEGMENTS 2020 – 2024 / CONTINUED

Ground-mounted utility scale solar PV power systems continued to clearly dominate the solar space in 2019 – and this won't change until 2024. The segment had a share of around 64% last year, which is anticipated to hike to 69% in 2021, and then remain flat at around 68% for the coming years.

The slight 'weakness' of utility-scale solar in 2019 is in direct relation to the market developments in China and India. Both world leading markets have been strongholds of ground-mounted PV power plants. While the termination of the feed-in tariffs for large-scale power plants in May 2018 in China resulted in immediate market contraction, it also directly had a positive impact on rooftop PV. This development continued in 2019 when solar demand in China fell even steeper. Still, close to 60% of the solar capacity added in China last year were utility-scale power plants. The other leading market that disappointed last year was India, where the bulk of the total installed capacity are ground-mounted power plants. Less PV demand in India meant less utility-scale power plants for the world. On the other hand, the United States, as the world's No. 2 PV market, saw increasing demand in 2019, mostly driven by a year-end deadline for the 30% ITC, which primarily triggered investments in utility-scale PV capacities.

However, deploying large volumes of utility-scale solar is much simpler to deploy 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 why emerging markets usually begin their solar chapter with tenders for utility-scale solar and frequently struggle to set up the distributed rooftop segment, even if politicians generally prefer PV on roofs which they consider the natural place for the technology as it avoids any potential conflicts on land use. A good example for such a development is India, which targets 100 GW of solar by 2022, with 40 GW coming from rooftop solar. But of the 35.7 GWAC total of solar power capacity installed by the end of 2019, only 4.4 GW_{AC} were rooftop systems—the vast majority (88%) was utility-scale PV power plants. The Indian Government had approved 1.7 billion USD under its Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) programme in 2018 to accelerate the installation of rooftop solar. Instead, an economic slowdown had pulled that rooftop solar down, resulting in the first decline for the small segment in five years in India.

FIGURE 19 SOLAR PV ROOFTOP AND UTILITY-SCALE SEGMENTS SCENARIOS 2020-2024



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SEGMENTS 2020 – 2024 / CONTINUED

Two relatively recent solar feed-in tariff hot-spots and new GW-scale markets, Vietnam and Ukraine, have been also focusing on utility-scale solar, whereas the European country's net metering programme has been nurturing a small rooftop market as well. However, even the most advanced solar rooftop market, Australia, with more than 2.3 million solar homes, has recently been leaning towards utility-scale solar. Though less than the year before, half of the 4.4 GW were solar farms.

Even in long-established solar markets like Europe a recent renaissance of ground-mount systems can be witnessed. The trend to tenders has been providing the grounds 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. Europe's very sunny and spacious countries Spain and Portugal have multi-gigawatt pipelines for such PV power plants. But even

in Germany, a first merchant solar system with a size of 50 MW was recently completed, a record size plant of 175 MW is under construction, and several are in the development stage.

At the same time, 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 history-making decision to make it mandatory to have solar as part of newly built homes as of 2020 will motivate many others to follow – the latest was Germany's smallest federal state of Bremen, which passed in June 2020 legislation to require solar on new homes and public buildings, a post-COVID measure to support local, sustainable jobs. While the share of the rooftop market segment is not expected to increase by 2024, according to our Medium Scenario it will rather slightly decrease to 33% from 36% in 2019, there will be absolute increase to 65 GW from 42 GW today.

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FOCUS: THE SUB-SAHARAN AFRICAN SOLAR MARKET

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Chapter supported by GET.invest

Market analysis

Ensuring steady access to affordable, reliable, sustainable, and modern energy (UN Sustainable Development Goal 7) is a key milestone for emerging markets when laying the foundations for sustainable development. Sub-Saharan Africa is the region with the lowest rates of access to electricity in the world – in 2018, only 48% of the population had access to electricity. In fact, the electrification rate is increasing – between 2010 and 2018, it grew by 14%, from 34% to 48%, and five out of 46 Sub-Saharan countries have reached electrification rates above 90% (Seychelles, Mauritius, Cabo Verde, Gabon and South Africa). But these numbers show there is still a long way to go to power all people. Low-cost and versatile solar energy is a particularly appropriate solution to speed up that process. **The solar potential in Africa is immense** thanks to high irradiation (ranging between 1,500 to over 2,000 kWh/kWp per year) and strong demand. Yet the continent's installed capacity today (3.8 GW) represents **less than 1% of the world's solar capacity**, and less than 3% of Africa's power generation capacity.

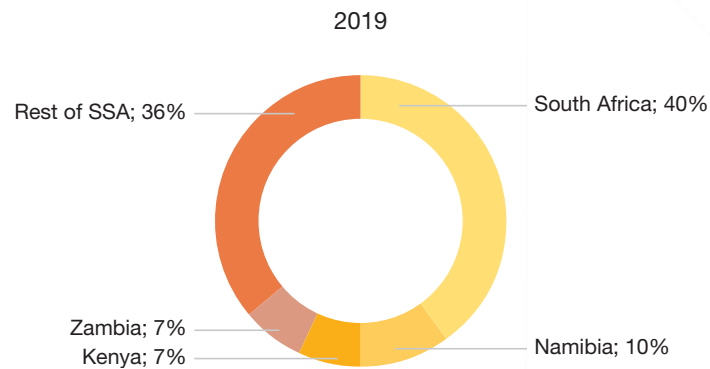
While off-grid solar is a large and very important business segment in Sub-Saharan Africa, the Global Market Outlook focuses only on grid-connected PV applications. That's why this chapter looks into on-grid IPP projects (large- and small-scale) and the commercial and industrial (C&I) solar segment. These are also projects that represent the lion's share of the capacity installed and under development, and which are the most interesting business opportunities for international investors.

By 2019, Sub-Saharan Africa reached a **total installed solar capacity of 3.8 GW**, with South Africa responsible for 2.4 GW. Apart from South Africa, the only countries with more than 100 MW installed capacity in 2019 were Namibia, Kenya, and Senegal. In terms of annual market size **in 2019, the Sub-Saharan African solar market more than doubled, adding nearly 1.3 GW of installations and thus reaching gigawatt-scale for the first time**. South Africa also dominated 2019, accounting for roughly 40% of all installations in Sub-Saharan Africa (see Fig. 20). Aside from South Africa, the other three largest markets in 2019 were Namibia, Kenya and Zambia with around 100 MW each.

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FIGURE 20 SUB-SAHARAN AFRICA SOLAR PV MARKET SHARES 2019



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The market growth in recent years was enabled by maturing national as well as international support instruments. Policies and regulations for off-grid solutions have improved faster than those for grid electrification. For rural and isolated communities, off-grid solutions such as mini-grids, solar home systems, and solar lamps have received a considerable level of attention as they allow for basic access to electricity even where there is no grid available. This was also the case many years ago, but what has changed on the commercial side includes the cost of solar equipment, and the business models that are now often based on ‘solar as a service’ or ‘Pay-As-You-Go’ (PAYG) solutions, which have made solar power affordable to a much larger group of people.

While grid stability and availability in Sub-Saharan Africa remain major challenges for larger-scale power generation projects, national grids will stay crucial, for instance, to cover electrification of very poor areas: utilities with a stable urban customer base may be able to finance connections for rural poor households by subsidising rural connections with urban revenues. Additionally, grid-connected larger-scale solar PV projects placed near points of high demand are also more feasible and economical due to economies of scale, the possibility of future expansions of capacity, and a lower risk of under-utilisation.

According to BloombergNEF’s Sub-Saharan Africa Market Outlook 2020, the biggest source of new electricity connections since 2000 has been on-grid. Centralised energy access is the lowest-cost option for 40% of people currently lacking energy access, and it is likely to remain the most favourable option particularly for households in more densely populated areas. Therefore, reinforcing national grids remains a priority for many Sub-Saharan African countries, which backs the development of very large-scale solar as well.

Utility-scale IPP projects in Sub-Saharan Africa are often developed through individually negotiated contracts or tenders. **Individually negotiated projects** are usually completed in the absence of an appropriate regulatory framework such as a tender scheme directly between a developer and the public utility or the government. Even though several utility-scale projects in the tens of MW have been developed on an individually negotiated basis, there is a trend towards **competitive tenders**, which can reduce transaction costs significantly. Successful examples of tenders include South Africa’s Renewable Energy Independent Power Producer Programme (REIPPP) launched in 2011, Uganda’s 2014 GET FiT solar facility auction supported by KfW and Zambia’s 2015 Scaling Solar auction implemented in cooperation with the World Bank Group. Some African countries have also adopted **feed-in tariff systems** and there are even examples of **net-metering schemes**.



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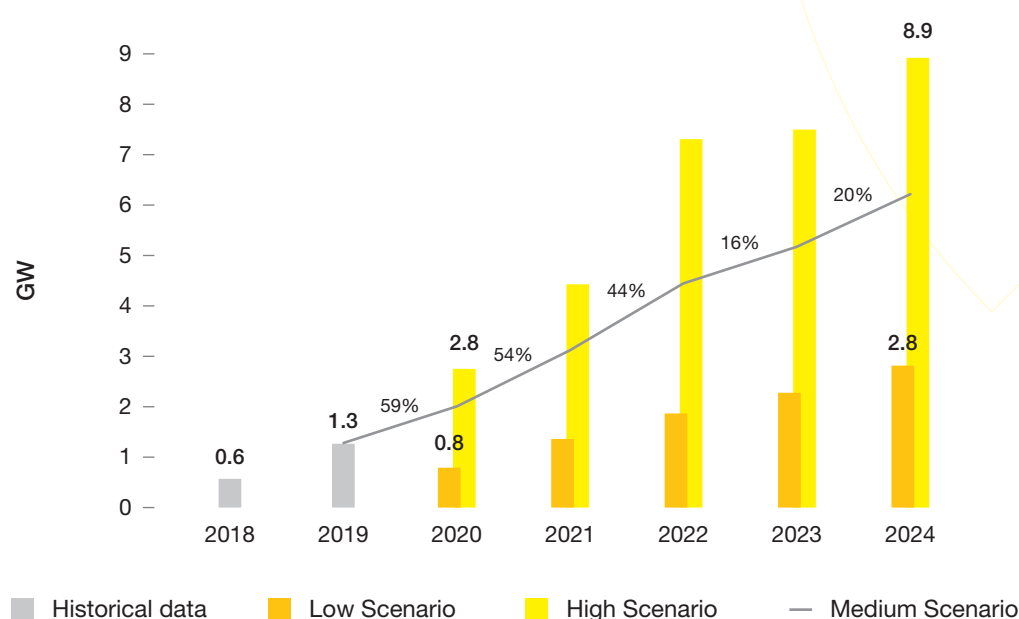
Weak grids and regulatory frameworks for larger-scale IPPs in many Sub-Saharan African countries, together with the drastic reduction of storage prices are leading to an uptake of **C&I projects** in the region. C&I projects are spreading both in the on-grid and the off-grid domain, with national grids often becoming a back-up component. In addition to the different regulatory schemes for solar project development, many African governments apply financial and fiscal incentives in the form of tax reductions, grants and guarantees to support projects development. There is also a multitude of **international support instruments** aimed at supporting renewable energy projects in Africa (see Box 1, p. 39).

The upcoming years are expected to significantly benefit from the technology price reductions for solar and storage and increased efforts to reach complete energy access. Moreover, financial support instruments and tender schemes will mature, while innovative business models will continue to emerge. Between 2020–2024, the Sub-Saharan Africa solar market will see a significant increase in installed capacity (see Fig. 21). According to SolarPower Europe's medium scenario, **the region will add 21 GW of solar between 2020–2024**. Keeping up its good track on the solar market development, South

Africa is expected to remain the largest market in the near future. However, recent political commitments to renewables and attractive regulatory frameworks are expected to catapult a number of smaller markets to become leaders with annual additions in the hundreds of MW. Examples of this are countries like Zambia, Ethiopia, Zimbabwe and Nigeria. Forecasted improvements for 2020 are particularly positive, as a lot of momentum has been building up in some Sub-Saharan countries, however, the ongoing pandemic can potentially become a limiting factor; SolarPower Europe's Low Scenario, which is a worst-case assumption, foresees only additions of 9 GW until 2024, compared to 31 GW under the best-case High scenario.

Although quantifying the **impact of COVID-19** on the solar sector in Sub-Saharan Africa is difficult, there are indications that the pandemic will have some negative effects on solar market growth. Smaller IPPs are suffering from severe disruptions, being affected differently depending on the projects' stage; while projects at pre-closing stage have been affected due to mobility restrictions, plants already under construction or operational are suffering with significant drops in electricity demand (25-40%). Some utilities have sent

FIGURE 21 SUB-SAHARAN AFRICA ANNUAL SOLAR PV MARKET SCENARIOS 2020-2024



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BOX 1

EUROPEAN SUPPORT INSTRUMENTS AND INITIATIVES FOR SOLAR PROJECT DEVELOPMENT IN AFRICA

The difference between the low, medium, and high scenarios for solar capacity additions between 2020–2024 in Africa (see Fig. 21) demonstrates the importance of robust policies and successful international cooperation. Besides successful national schemes such as South Africa's REIPPP, international support instruments such as the EU External Investment Plan (EIP), KfW's GET FiT programme and the World Bank Group's Scaling Solar (which is supported by the Netherlands) have significantly contributed to the development of solar in Africa and will remain essential when ambitioning for results resembling the medium scenario, let alone the high scenario. Therefore, it is crucial that the international community continues to support African countries in their energy transition efforts.

European support instruments

Solar investors in Africa face various economic, financial, institutional, and technical challenges such as limited political will and institutional capacity, political and economic instability, lack of transparency, ineffective regulatory framework, and poor grid capacities. These challenges increase business risk for potential investors; however, they can be mitigated by well-designed instruments. International support instruments have been used to help governments and industry to tackle these challenges and to scale up both on-grid and off-grid solar development in Africa. There exist various types of support instruments that are being used to support African governments to improve conditions for solar deployment and help investors to de-risk solar investments.

The main categories of support instruments are:

- financial assistance (loans, grants, guarantees, insurance),
- technical assistance (such as grid integration studies),
- capacity building measures (such as trainings to reinforce human and institutional capacities to manage processes) and

- standardised documents (tendering procedures, bankable template contracts).

The landscape of available financing and other support instruments of solar project development in Africa is very diverse, and most support instruments are limited in terms of geographical coverage, eligible technologies, project sizes and project phases covered, and types of assistance provided. However, some instruments such as the EU External Investment Plan and Scaling Solar have a broader scope including various types of measures including financial and technical support, as well as capacity building and standardised documents. Along these lines, the industry-backed renewAfrica initiative proposes the creation of a comprehensive approach to facilitate renewable energy investments in Africa.

European Africa initiatives

Recent international developments that can have an impact on the growth of solar and solar business opportunities in Africa in years to come include the European Green Deal, the proposed new EU Strategy with Africa, and the COVID-19 crisis. Through the Green Deal, the European Commission ambitions to establish the European Union as the first climate neutral region by 2050. The external dimension of the Green Deal, the **Green Deal Diplomacy** focuses “on convincing and supporting others to take on their share of promoting more sustainable development [utilising] trade policy, development support and other external policies [through] all diplomatic channels.” This is in line with the objectives of the new Strategy with Africa outlined by the European Commission in March 2020. The proposed **new Strategy with Africa** suggests building a strong partnership on sustainable energy with Africa through a Green Energy Initiative, building on the recommendations of the successful public-private dialogue that took place in the context of the Africa-EU High Level Platform for Sustainable Energy Investments in 2018-2019. It is expected that the above objectives will also be reflected in the European Commission's 2018 proposal for a so-called “Neighbourhood, Development and International Cooperation Instrument” (NDICI). A 90 billion EUR instrument over the period 2021-2027, the NDICI is intended as a fundamental reform of the way in which development cooperation of the EU is financed. It is meant to further streamline existing financing instruments by merging a

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dozen regulations. Although the above strategies were published before COVID-19, they offer an opportunity for the EU to lead the **green recovery** in Africa and globally. Renewable energy technologies, and solar in particular, offer solutions not only on the long term, but also on the short term, during the current crisis.

SolarPower Europe's Emerging Markets Workstream, chaired by Eni, works closely with the European Commission and other partners to implement the Green Deal Diplomacy, the EU Strategy with Africa and to support the global green recovery.

SELECTED SUPPORT INSTRUMENTS FOR SOLAR PROJECT DEVELOPMENT IN AFRICA:

NAME & WEBSITE	DESCRIPTION
GET.invest www.get-invest.eu	<p>A European programme which supports investments in decentralised renewable energy in sub-Saharan Africa and the Caribbean region. The programme works with private sector businesses and project developers, financiers and regulators to build sustainable energy markets. Services include project and business development support (via the Finance Catalyst and the Funding Database), market information as well as business-to-business matchmaking. They are delivered across different market segments including small IPPs (<50MW), C&I, microgrids etc.</p> <p>To support business impacted negatively by COVID-19, GET.invest also launched a COVID-19 window, which provides business advisory for acute and critical finance-related problems. A COVID-19 business continuity checklist and a scenario modelling tool are freely available on the GET.invest website. In collaboration with PFAN, GET.invest has created the COVID-19 Support Database which lists business advisory and financial support options offered by associations, impacts funds, international associations and programmes across the sector.</p> <p>GET.invest is supported by the European Union, Germany, Sweden, the Netherlands, and Austria, and works closely with initiatives and industry associations such as SolarPower Europe.</p>
Electrification Financing Initiative (Electrifi) www.electrifi.eu	<p>An EU-funded impact investment facility, financing in early stage private companies and projects, focusing on new/improved electricity connections as well as on generation capacity from sustainable energy sources in emerging markets. Implemented by EDFIMC and funded by the European Union, the USA's Power Africa Initiative and Sweden.</p>
The Private Financing Advisory Network (PFAN) www.pfan.net	<p>The Private Financing Advisory Network (PFAN) is a multilateral public private partnership which provides targeted financing advice and investment facilitation services to small and medium clean energy and climate adaptation projects and businesses to help prepare and position them for investment. These services are provided through a global network of climate and clean energy financing experts and bridge the gap between entrepreneurs and investors to help meet the objectives of the Paris Agreement and the Sustainable Development Goals. PFAN is hosted by UNIDO and REEEP and funded by the Governments of Australia, Austria, Japan, Norway, Sweden and the US as well as by the Kigali Cooling Efficiency Programme; PFAN operates in Sub-Saharan Africa, Asia and the Pacific, Eastern Europe & Central Asia as well as Central America and the Caribbean.</p>
The Renewable Energy Performance Platform (REPP) www.repp.energy	<p>REPP is an innovative funding platform created by the European Investment Bank and the UNEP, and funded by the UK Department of Business, Energy and Industrial Strategy. REPP provides early-stage funding, advisory services, and results-based finance for the development and construction of small and medium-scale renewable energy projects in sub-Saharan Africa.</p>
Climate Investor One (CIO) www.climateinvestorone.com	<p>An investment fund that provides support to energy projects from beginning to end, attempting to address current market failures and inefficiencies at every step of the project. By improving the quality of projects, CIO aims to entice private investors and attract financing for low and lower-middle income countries, especially in Africa. Implemented by FMO and supported by the European Union, the Green Climate Fund, USAID via PowerAfrica, the Nordic Development Fund and the Netherlands.</p>

SELECTED SUPPORT INSTRUMENTS FOR SOLAR PROJECT DEVELOPMENT IN AFRICA (CONTINUED):

NAME & WEBSITE	DESCRIPTION
Africa Renewable Energy Scale-Up Facility (ARESUF) www.proparco.fr/en/are-scale	A facility consisting of a technical assistance component to strengthen regulatory frameworks and to prepare financing of private or public sector RE projects; and a guarantee facility to support investment in off-grid, mini-grid and decentralised power industry players. Funded by the EU and implemented by the Agence Française de Développement (AFD).
Transferability and Convertibility Facility (T&C) www.edfi.eu/facility/tc-guarantee	The Transferability and Convertibility Facility (T&C) is an EU-funded guarantee product managed by EDFIMC, in sub-delegation structure with Proparco, and funded by the European Union. T&C provides protection against losses arising from an investor's inability to legally convert local currency into hard currency and/or to transfer hard currency outside the host country where such a situation results from a government action or failure to act.
EU External Investment Plan (EIP) https://ec.europa.eu/commission/eu-external-investment-plan_en	The External Investment Plan, launched in 2017, aims boost investment in multiple sectors including sustainable energy by allocating EUR 4.6 billion in public funds to de-risk investments and leverage EUR 47 billion in public and private investment in Africa and the EU Neighbourhood. The EIP operates through three pillars: (1) the European Fund for Sustainable Development (EFSD), which (a) provides guarantees (such as the European Guarantee for Renewable Energy EGRE or Africa GreenCo) to reduce risks and increase private financing and (b) supports existing investment facilities (such as the Climate Investor One or ElectriFI) via so-called "blending"; (2) providing technical assistance to entrepreneurs to be able to develop financially attractive projects and (3) improving the investment climate in partner countries via structured dialogues and policy advice.
Scaling Solar www.scalingsolar.org	A "one stop shop" program supporting large-scale on-grid solar projects, including technical advice, tendering procedures and standardised contractual documentation, financing and insurance and risk management and credit enhancement. While Scaling Solar started and still focuses mostly on African countries, it has recently expanded to Afghanistan and Uzbekistan. The programme is supported by the Private Infrastructure Development Group, the UK, the USA, The Netherlands and Denmark, and implemented by the World Bank Group.
GET FIT www.getfit-uganda.org www.getfit-zambia.org www.getfit-moz.org	The German development bank KfW along with other stakeholders has developed the Global Energy Transfer Feed in Tariff ("GET FIT") Programme. The GET FIT Programme aims to fast-track the development of smaller renewable energy generation projects through a comprehensive set of tools, including tariff viability gap funding, targeted technical assistance, risk mitigation against off-taker risk, and renewable grid integration support. It currently operates in Uganda, Zambia and Mozambique.
Sunfunder www.sunfunder.com	SunFunder provides debt financing for businesses working in off-grid, residential, productive use, mini-grid and commercial and industrial solar in Africa. Debt fund investor partners of SunFunder include the FMO, Deutsche Bank and others.
Acumen Fund www.acumen.org	Acumen raises charitable donations to invest in companies, leaders, and ideas who tackle poverty in developing countries. The fund operates like a venture capital fund for the poor, supported by a global community of philanthropists willing to take a bet on a new approach. Donors are called "Partners" and treated like investors. The fund invests in companies leading innovations in hand-held solar power, cook stoves, off-grid generation, home systems, bio-gasification systems, and others.

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force majeure notices to reduce payments to IPPs, indicating that this market segment is expected to endure negative long-term effect, together with weakening credit ratings and state budgets. The C&I sector is suffering as well, due to revenue decrease resulting in capital shortage, as well as from workforce limitations, as employees often cannot work from home due to lack of internet connectivity. The decrease of electricity demand may also affect the C&I projects in the mid-term, where electricity sellers compete with local distributors and utilities. This analysis is valid for all of the region's hottest solar markets listed below.

Sub-Saharan Africa's hottest solar markets

South Africa has the best structured solar market in Sub-Saharan Africa, with scheduled tender processes through its Renewable Energy Independent Power Procurement Programme (REIPPP). The REIPPP auction system program with state guarantees for 20 years of production has succeeded at attracting not only international IPPs but also local participants. Renewable energy in South Africa is mainly developed through the REIPPP, however, the country is also home to Sub-Saharan Africa's largest C&I market. After years of political uncertainty, which involved significant delays in the signing of PPAs for winning projects in the last (fourth) round of the REIPPP, there is now revived political support for renewables in South Africa. The new Integrated Resource Plan (IRP 2019-2030) announced in autumn 2019, foresees a leading role for solar and wind, under which 6 GW of new solar PV projects are planned to be commissioned between 2022 and 2030. While there were already discussions to launch the fifth REIPPP round in 2018, it now seems that this could happen soon. In addition to renewed large-scale tenders, the government has also simplified permissions for smaller projects below 1 MW, which are dominating the C&I market. Moreover, PPA projects of up to 10 MW have recently received permission by the government to be issued with generation licenses. An upcoming regulation may open up the possibility for municipalities in South Africa to source their own renewable energy.

Zambia was the first country to launch the World Bank Group's Scaling Solar programme back in 2015. It resulted in an initial 54 MW PV power plant from First Solar and its partner that went online in March 2019, and was followed by a 34 MW project from Enel Green Power – two of the first competitively tendered large-scale projects on the continent outside of South Africa.

GET FiT Zambia, a tender programme supported by the German development bank KfW, was started in 2017, resulting in awards of 120 MW of solar projects in April 2020. Following these first large-scale solar success stories, Zambia is implementing an ambitious plan to go renewable and develop hundreds of MW of utility-scale solar in the coming years. For the second round of Scaling Solar in Zambia, the aim is to have 500 MW of solar power capacity in the form of 2–4 projects. The latest announcement is from Zambia's state-owned utility ZESCO, which, at the end of May, awarded Power China a contract for 600 MW solar capacity, broken down in three 200 MW grid-connected PV power plants in various regions of the country. In late 2019, a Spanish–Japanese renewable energy business group announced plans to invest in two solar power projects, which will add 200 MW to the country's national grid in 2020. Despite the ambitious targets, the country may face challenges in expanding its utility-scale solar market due to its limited grid capacity and low electrification rate (28%) – something Zambia is trying to address by opening up the possibility of international wheeling.

Kenya is often viewed as an attractive destination for renewables. In the past, this was particularly the case for solar home system start-ups and C&I projects, however, less so for IPPs. The country has the goal of universal access to electricity to all Kenyans by 2022, outlined in its Kenya National Electrification Strategy (KNES) that was developed in partnership with the World Bank – and off-grid solar and mini-grids are identified as a low-cost options to help achieve the aim. Regarding on-grid solar, in 2019, Kenya added around 100 MW, a significant share of which being C&I projects. Given the C&I project pipeline activity there is space for similar annual installation levels in the next 5 years. In terms of larger-scale projects, Kenya Power announced in January 2019 that it would put the signing of new PPAs on hold, due to excess capacity and financial issues. This froze the process of more than 2 GW of generation capacity that was under development based on the country's feed-in tariff. While the signed PPAs are being renegotiated, the country is currently working on an auction scheme. However, in December 2019, a 50 MW PV plant was inaugurated after several years of development work. Further PV plants are being planned, backed by international financing agencies. In September 2019, a company raised over 106 million USD in financing from the European Investment Bank (EIB) and Dutch development bank FMO for its 80 MW solar portfolio.

The **East African Power Pool (EAPP)**'s connection with the **Southern African Power Pool (SAPP)** through the Zambia-Tanzania-Kenya (ZTK) interconnection, which is currently under construction could prove to be a game-changer for larger scale projects not only in Kenya, but also regionally. It is also noteworthy that Kenya is considering the introduction of a net-metering legislation.

Uganda was the first African country to completely unbundle its state utility, which resulted in increased collection rate, lower transaction losses, and a bankable off-taker (the Uganda Electricity Transmission Co.), attracting renewable energy investment. The Ugandan energy sector's transition has succeeded in attracting several smaller IPP investments, including 20 MW of solar projects solicited under the German development bank KfW's GET FiT programme. Moreover, there have been reports in early 2020 about a Chinese state-owned energy conglomerate reportedly having secured an EPC contract to build 500 MW of solar generation capacity in Uganda. A challenge facing the Ugandan electricity sector is linked to the fact that the ambitious government plans for grid-based generation (mainly hydro), introduced after a power crisis in 2005, might result in a significant power generation oversupply by 2023. Because supply must be paid for, regardless of it being used, the potential oversupply can increase electricity prices. To address these challenges, the government has started strengthening transmission and distribution grids and encouraging decentralised generation such as solar.

Namibia was most likely not on many people's on-grid solar radar until news spread last year that the country together with Botswana was looking into building a 5 GW solar mega project over the next 20 years. However, putting that aside, Namibia's PV on-grid market has steadily emerged into a decent size over the years, making it one of Sub-Saharan Africa's largest. In 2016, the country adopted an ambitious national renewable energy target of 70% of the energy mix by 2030. To achieve this goal, the country is promoting renewable projects via competitive tenders (for systems over 5 MW), a feed-in tariff scheme called REFIT (for systems below 5 MW) and even a net-metering scheme (for self-consumption systems up to 500 kW). Thanks to these measures, the country's total installed capacity exceeded 200 MW in 2019. The bidding deadline for the latest tender was in January 2020 for a 20 MW, which was originally planned to go online this year. Namibia's

solar growth is expected to continue in the years to come, backed by tenders, feed-in tariffs, and the Namibian C&I segment being one of the most dynamic on the continent.

Zimbabwe strives to reach 1,575 MW of solar capacity by 2030, from around 50 MW at end of 2019. The country just launched its National Renewable Energy Policy (NREP) in March 2020 to back this ambition. The NREP aims to streamline procedures and timelines for project development below 5 MW. The country has also recently published regulations allowing net-metering, where customers can feed excess electricity back into the national grid. Moreover, Zimbabwe removed import duties on solar panels and accessories. However, if only some of the solar projects that were recently announced came online, the country would install much more solar power than envisioned in its NREP. While Zimbabwe added an estimated 35 MW of solar PV capacity in 2019, the country's utility Zimbabwe Electricity Distribution Company (ZETDC) announced in May 2020 a tender for a total of 500 MW of solar projects of varying sizes at different locations. In December 2019, the heads of Zimbabwe and the United Arab Emirates reportedly agreed on 2 GW of solar capacity to be built in the country within the next 18 months. All of this comes on top of 39 solar PV projects with 1.15 GW total capacity Zimbabwe's Energy Regulatory Authority (ZERA) had received by September 2019.

Other notable markets in Sub-Saharan Africa:

Ghana's grid electricity tariffs are among the highest in Sub-Saharan Africa, which, combined with a relatively high electrification rate of 84%, puts the C&I market in the spotlight. In February 2020, a 704 kW and 30-year solar corporate power purchase agreement was signed in Ghana, one of the first of its kind in Africa. **Nigeria** is the region's country with the largest population, representing nearly 20% of SSA's 1.1 billion inhabitants. Nigeria's vast power demand offers huge potential for C&I solar, in particular as no licence is required for projects up to 1 MW. But a combination of weak grids and a lack of political support has led to disappointing developments for large-scale solar in the country so far. While PPAs for 1.4 GW of large-scale projects have been signed since 2016, none of the systems have been completed as of today. **Senegal** has seen steady progress in its solar sector. Following the country's National Action Plan for Renewable Energies (PANER) launched in 2015, solar power saw considerable

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development, with four grid-connected IPP PV projects ranging from 20 to 30 MW each commissioned between 2016 and 2018, including a total of 60 MW realised through the World Bank Group's Scaling Solar programme. Due to saturation of its power grid, Senegal is currently focusing on microgrids developments; no utility-scale solar PV tenders are expected for the next 2–3 years. In **Mozambique**, the first large scale solar power plant with a capacity of 40 MW started commercial operation in 2019, and another 41 MW project reached construction phase, scheduled to be completed by the end of 2020. In addition, there are a number of utility-scale solar tenders in the pipeline supported by AFD (PROLER) and KfW (GET FiT). One of SSA's most promising utility-scale solar markets is **Ethiopia**, which has officially 1 GW of utility-scale solar capacity in the pipeline. While a first round was launched in early 2019 and a little later in the year extended to 750 MW in 2019, the 2017 launched first round with 250 MW was finally awarded at a African record low tariff of 2.5 US cents/kWh in September 2019. However, the Scaling Solar process has now been delayed in Ethiopia.

Interesting market segments for international investors

The most interesting market segments for international solar investors in Sub-Saharan Africa are (1) utility-scale IPP projects and (2) commercial and industrial (C&I) rooftop projects.

1. IPP projects

IPP policy frameworks have been implemented as part of wider reforms to the power sector for quite some time in most of Sub-Saharan Africa's markets. But it wasn't until larger-scale PV entered the market that the potential could be tapped, as those system sizes are bringing down costs, leading to an increasing speed of deployment and attracting foreign investment. Initially, the market focus was on very large plants over 50 MW mostly due to high market entry costs in the early stage. However, the focus in several countries now seems to gradually shift towards smaller system sizes in the 5-25 MW range, as well as towards rural utility and mini-grid projects in the 0.5-5 MW range. Offering easier integration opportunities to existing power grids, smaller IPP projects involve a larger market potential; moreover, they are much more accessible to local developers.

The most prevalent **IPP business model** in Sub-Saharan Africa remains the electricity sales agreement with a single buyer, usually the national utility. Structured programmes offering financial toolboxes, including risk insurance, liquidity guarantees, or extended reserve accounts have paved the way to cheaper finance and ultimately cheaper electricity. Attempts have been made by policymakers to attract more private sector participants into under-served regions through mini-grid programmes, however, little progress has been made.

Developing a smaller IPP project in the range of a few MW requires similar efforts by developers and financiers as large projects in the hundreds of MW. The developer needs to set up a project team, understand the legal framework, obtain licenses, and have onsite due diligence conducted by the financier. While it is still comparably difficult to get commercial banks or development banks interested in project finance for projects below 20 MW, some new actors – including impact funds (or new facilities within institutional investors) – are seizing this opportunity. For example, the European programme GET.invest works with a host of financiers supporting smaller-scale IPPs, mini-grid and off-grid companies in the range of 0.5-5 million EUR, many of which are listed in GET.invest's Funding Database.

In terms of **financial structuring**, developers are focusing on obtaining the best concessional rates for their senior debt, as well as mitigating the off-taker's risk through guarantees and often expensive insurance products. Although important, these offer little competitive advantage within tender-based programmes, as they are generally available to all successful bidders. Other levers to improve bids and differentiate from the market can be on the equity side, where customised mezzanine tranches can increase equity returns, which allows for more competitive tariffs.

The following case studies present selected IPP projects, realised or in development, from a variety of Sub-Saharan African countries.

CASE STUDY

300 MW SOLAR PV PROJECT CLUSTER IN SOUTH AFRICA



ABO Wind is developing a 300 MW solar PV project cluster in South Africa, consisting of three 100 MW sites with 132 kV grid connection and single-axis tracker technology.

South Africa is a very attractive market for solar energy projects. The selected sites have a very good solar resource at 2,200 kWh per m² per year. The country's electricity demand is growing rapidly, and the government has ambitious renewable energy targets. The country has a successful history in renewable energy tenders and project realisation, as well as an established renewable energy industry. The availability of land also favours the development of large-scale projects.

Challenges faced by ABO Wind in South Africa were related to strong competition, grid availability in resource rich areas, strict tender conditions, and vast project areas and distances. As an internationally strong project developer with local presence, ABO Wind was well-positioned to tackle these challenges. A fine-tuned site selection process done jointly between ABO Wind's local team and international experts based in the HQ lead the developer to a relatively uncomplicated site in a privileged area in the North-West of the country. In South Africa, it is key to have local experience and resources in order to obtain permits and other authorisations within reasonable timeframes. The development of the three sites of the cluster will be done by shared infrastructure in order to optimise CAPEX.

The approach taken by ABO Wind in South Africa is to develop a large pipeline of projects over 2 GW and aim to participate with the 300 MW cluster, which is the most advanced project currently, in the next tender. Depending on the timing of tenders, it is expected that the other projects of the 2 GW pipeline will eventually mature and participate in tenders as well. When participating in tenders, ABO Wind may join forces with a suitable partner.

Typically, utility scale renewable energy projects in South Africa are financed using project finance with a debt/equity ratio of up to 80%, which is enabled by a comparatively strong financial sector experienced in renewable energy project finance. Currency risk is an important risk, which is addressed by a smart combination of financing in local currency and EUR or USD, and also by a consortium of local and European banks. The project will also comply with "Black Economic Empowerment", a form of affirmative action introduced by the South African government to support groups previously disadvantaged by the Apartheid.



One of ABO Wind's solar sites of the South Africa cluster.

© ABO Wind.

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CASE STUDY

MALI'S FIRST LARGE-SCALE SOLAR POWER PLANT



The 50 MW Kita solar power plant is Akuo Energy's first project in Africa. Akuo is the first renewable energy player in Mali and the Kita solar power plant the first utility-scale solar IPP in operation in the country. The project, which was commissioned in March 2020, will meet the vital energy needs of a region that regularly suffers from electricity shortages and will help the country begin the move towards energy independence that is vital to its development. The Kita project will also generate numerous social benefits, creating sustainable jobs and enhancing local competences.

The target market is attractive as Mali benefits from a very good solar resource, with an annual global irradiation of 2,139 kWh/m². There is a strong need for electricity production capacity increase in Mali, with the public off-taker being ready to turn to IPPs.

Akuo faced several challenges when developing the project. First of all, Mali did not have a dedicated legal framework for such projects. Second, security issues had to be considered, with Mali being a potential conflict zone. Akuo therefore put in place a very strong security scheme to protect local teams and sub-contractors. Finally, Akuo being in charge of project EPC in-house, they had to adapt the power plant design to Mali's hot and dry environment.

For this project, Akuo registered a Malian project company (SPV), which signed a 28-year PPA with the Malian public utility (EDM). The business model is that all renewable energy produced by the plant is injected into EDM's grid, and EDM pays a tariff per kWh to the SPV in exchange. This tariff covers the project capital expenditures, operational expenditures during the 28 years, the financing charges, the taxes and the financial return for the shareholders of the SPV.

In order to finance the project, the SPV raised equity (~20% of financing needs) and mezzanine (~10%) through its shareholders (Akuo and its co-investor on the project PASH Global Ltd), as well as long-term debt (~70%) through a pool of banks (EAIF, BOAD, BNDA and FMO), under a non-recourse project finance scheme, which allows the SPV to repay the lenders only from the profits generated by the project, and not by any other asset from the shareholders of the SPV. Long-term loans are very important for the competitiveness of such projects, considering the long maturity of PPAs.

On the site adjacent to the plant, Akuo sponsored a project supporting soy production, market gardening, poultry and jatropha for women thanks to solar power.



Kita, with a capacity of 50 MW the largest solar power plant in West Africa.

© Akuo Energy.

CASE STUDY

HYBRIDISING HEAVY FUEL OIL PLANTS WITH SOLAR IN MADAGASCAR



Financial advisor:



Malile is a portfolio of three PV projects totaling 42MW that will hybridise existing heavy fuel oil (HFO) plants to grant cheaper and cleaner access to electricity, as part of the strategy of the government of Madagascar. Lidera Green Power PCC is a holding located in Mauritius and owner of the Malile portfolio. The project is supported by Finergreen as financial advisor.

Due to its geographical and economic features, the electricity network of Madagascar is spread across 3 regional grids and several isolated grids powering some major cities. These isolated grids are powered by expensive IPP HFO plants.

One of the biggest challenges is the complex contractual structure. Each of the three project companies (SPV) registered in Madagascar has signed a 20-year concession agreement with the Government of Madagascar, and an energy supply contract with the IPP which owns the HFO plants to be hybridised. The IPP has in turn a PPA with the national off-taker.

Financing will be done at holding company level rather than at SPV level in order to pool the three projects into one financing facility. An additional advantage of this is that the holding is located in Mauritius, a jurisdiction that is better understood by investors.

In order to meet the expectations of Malagasy authorities which consider these projects emergency projects, a pilot phase is currently under construction on each site combining 5.65 MW that will be commissioned in the coming months. For this, Lidera has already spent over USD 2 million on the 3 projects and now seeks to leverage them with USD 6 million debt. A long-term debt will be raised in the first half of 2021 to build the remaining 36.3 MW. The bridge debt financing will be repaid or converted into a subordinated loan.



Lidera power plant site in Madagascar.

© Lidera.

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CASE STUDY

POWERING AGRICULTURE IN SUDAN WITH SOLAR AND INNOVATIVE GRAVITATIONAL STORAGE



Supported by:



The project is an innovative private/captive renewable power transaction in advanced stage of development for supplying power for irrigation purposes to the GLB farm in Sudan, located about 100 km north of Khartoum, an expanding agribusiness project, in Sudan a high-risk least developed country. The sponsors of the project are: the Haggar Group - one of the most prominent companies with a long standing presence in Sudan since 1904 with interests in the energy, agriculture and ICT sectors - and Managing Partner of the GLB farm, and its technical partners Photon Energy, a global solar power solutions and service company, and Energy Vault, the creator of an innovative gravity and kinetic energy based, long-duration energy storage solution.

GLB farm currently spreads over a productive area of 3,150 hectares mainly used to grow alfalfa crop. The farm is in the process of doubling the developed productive area by adding a further 4,350 hectares. Efficient and cost competitive irrigation is critical for the results of the farm in terms of return, export of food crop production to the Middle East, and employment for a large work force in a rural area.

The planned solar power plant will be a fixed ground-mounted installation with capacity of 19 MW, including 2 MW to pump water from the Nile river. It will be equipped with Energy Vault's gravitational storage with 60 MWh capacity, which will allow the replacement of a 9 MW diesel generator, even though the existing diesel generators will remain in place as emergency back-up. The gravitational storage system consists of two 130 m high towers (each with storage capacity of 30 MWh) with 5,000 concrete blocks (2t each) that be hoisted up during the day with the PV power, and released at night to generate power. The Energy Vault storage system and related IT technology allow power generated during the day to be stored around the clock and power the farm pivots according to the scheduled irrigation plans.

The investment will be structured under a multi-investor blended finance project company (SPV). The Green Climate Fund (GCF) is considering a minority equity investment and the African Development Bank (AfDB), which is the selected lead investment advisor, is considering a senior loan support. The financing will be done, according to international project finance principles, including customary off-take, project completion and performance warranties, with governance principles for allowing arm's length operations from the farm. The total investment in the project is about USD 34 million, with a 35% equity/65% senior debt ratio. Power costs to the farm is expected to be around USc 14/kWh.

The foreign exchange risk will be mitigated through the substantial export income from alfalfa sales to neighbouring Saudi Arabia. Financial close is expected in Q1/2021.



Illustration of a solar power plant and Energy Vault gravitational storage in Sudan.

CASE STUDY

40 MW PROJECT DEVELOPED UNDER KENYA'S FEED-IN TARIFF



Kopere Solar Park is a solar PV plant of 40 MW in Kenya. The project is in the Nandi County, 5 km from the centre of Kopere, alongside the Kopere-Kimwani Road, on a total area of approximately 100 ha.

This is one of the best areas of the country in terms of solar irradiation, with more than 2000 hours of sun per annum. The project is in the highlands (1,300 m above sea level), where average monthly temperatures over the year are between 20°C and 25°C, which avoids overheating and decrease in efficiency.

The development process of Kopere Solar Park started in 2013. Kopere Solar Park applied to the Kenyan feed-in tariff program and signed a 20-year PPA with the public utility (Kenya Power LC) in May 2018.

Kopere Solar Park was designed only with single-axis trackers for intra-day production optimisation. To increase the production in the first moments of the morning and the last of the afternoon, having it closer to the maximum power a longer period, the PV plant was designed to furnish a peak power of 50 MW_{dc} being transformed in 40 MW_{ac} (nominal power) at the injection point. The result on the daily power curve will be closer to a rectangular shape instead of a parabolic one.

Discussions are still underway for project financing and other key points of the development procedure are in progress. Votalia invested significant time and efforts in securing a loan from the African Development Bank (AfDB) and has appointed a co-lender of international reputation for the provision of a long-term senior debt financing package.

2. C&I projects

The C&I solar sector in Sub-Saharan Africa is one of the most active and promising segments for solar energy, offering the possibility for commercial and industrial players to become independent from (often unreliable) national grids. Such installations, also called “captive power projects”, sell solar directly to commercial or industrial electricity consumers, with or without the option to sell excess power to the grid. As the sale of excess power, e.g. through net-metering schemes, in most Sub-Saharan African countries the power has to be either consumed or stored locally. This makes the C&I business model viable only where the self-generation cost is significantly (at least 10-30%) lower than grid electricity (e.g. Ghana, Senegal, Rwanda, Uganda, Kenya), or where other drivers like power reliability (Nigeria) or corporate environmental targets come into play.

C&I projects are usually being financed through direct sales of the system, or, in the case of systems larger than 1 MW, PPAs or leasing contracts. External financing has been largely absent, only some smaller projects have been supported by crowdfunding. The advantage of leasing is that leasing rates can be variable, reflecting electricity costs as if there was a PPA, but still offering

the advantage of system ownership. This can also be an option in markets where electricity sales licenses are difficult to obtain.

The largest hurdle for the C&I sector to gain more traction is the absence of debt finance at accessible rates. Individual projects are usually too small to attract financiers. While some developers/installers have tried a portfolio approach by bundling several projects in order to reach economies of scale with banks and suppliers, these often turned out difficult in practice. Therefore, it is likely that the focus will remain on large C&I consumers and private equity finance for some time to come. A notable exception is Kenya, where AFD's SUNREF programme is channelling both loans and donor finance through local commercial banks for C&I projects.

For developers or project owners with little track record but high-quality projects, partnering with a more experienced international developer may help to get financing for their projects. Alternatively, developers may seek equity finance at international financiers.

The following case studies present selected C&I projects, realised or in development, from a variety of Sub-Saharan African countries:



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CASE STUDY

KENYA'S LARGEST ROOFTOP SOLAR C&I PROJECT



Supported by:



Founded in Nakuru, Kenya in 1988, Menengai Oil Refineries Limited is a leading manufacturer of cooking oils, soaps, shoe polish, industrial detergents and baking powder for the East and Central African markets. Committed to lowering both its energy spend and environmental footprint, Menengai Oil hired Premier Solar Group to assess the feasibility of installing a rooftop solar PV system at its facility. The project was found to be highly feasible and Phase 1 of the system (850 kW) was commissioned in March 2019. The client was very happy with the results and a further 1,050 kW is currently being implemented as Phase 2. Once completed, this will be the largest rooftop solar PV project in Kenya.

High irradiation levels and a pickup in industrialisation, coupled with unreliable and expensive grid power, provide an attractive backdrop for the growth in demand for distributed solar PV systems in Kenya. However, high import duties and other levies, a lack of clear regulations, difficulty in accessing finance and the absence of net metering are some of the challenges currently facing the industry and keeping a cap on its growth.

Given the lack of net metering, correct sizing of the system was crucial, and several rounds of load logging were performed by Premier Solar before arriving at the 850 kW Phase 1 sizing. After the addition of new production lines, the Phase 2 system sizing of 1,050 kW was similarly determined. Multiple buildings of varying heights, jack roofs and other obstacles were taken into consideration during the analysis stage to ensure limited losses due to shadows. Given the large area of the facility, two separate interconnections were made to minimise cable losses. A PLC ensures no excess generation is fed back into the grid or standby diesel generators. Walkways and a lifeline system were installed to ensure O&M can be carried out in a safe manner and a cleaning system was installed to ensure modules are easily kept clean to minimise soiling losses. JinkoSolar monocrystalline modules and Sungrow string inverters with multiple MPPTs were used to ensure the highest possible generation from the rooftop space available. Full and detailed remote monitoring capabilities were installed to ensure the systems functionality can be observed constantly.

Premier Solar's team in Nairobi provides O&M services to ensure optimal generation and system life are preserved. To date, over 1.5 GWh has been generated by the system, offsetting nearly 1,000 tonnes of CO₂ and allowing the client to remain on track to achieve its targeted return on investment of under 3 years.

Premier Solar Group offers end to end distributed solar PV solutions to the C&I sectors in India, Sri Lanka, Dubai and East Africa. It provided design, engineering, supply, installation, testing, commissioning and O&M services to Menengai Oil and arranged the financing of the system via its financing partner in Kenya, Solarise Africa. Solarise is a pan-African solar finance company which offers PPAs, Operating Leases and Asset Finance options to clients in Kenya who use Premier Solar's services.



Aerial view of the 850 kW rooftop system.

© Premier Solar Group.

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CASE STUDY

PARTNERING WITH AN INTERNATIONALLY WELL-ESTABLISHED PLAYER IN A C&I PROJECT FOR A TEA FACTORY IN KENYA



Solarcentury East Africa was founded in 2013, in response to the burgeoning C&I solar market in Kenya and its surrounding countries. Since its inception, it has installed solar power plants on several sites around Kenya, developing a healthy pipeline of projects in the C&I space. The Unilever Tea Kenya Limited (JAMJI) project was an opportunity to further this pipeline, but also to join forces with a local subsidiary of a global firm, developing a model that might open the door to collaboration in other markets.

The project had been initiated and developed by CrossBoundary Energy, which signed a Power Purchase Agreement (PPA) with Unilever Tea Kenya to supply power from the solar PV facility at a discount to their existing cost of power.

The JAMJI project consists of 618 kW of single axis tracker PV connected with local hydro, grid and diesel gensets to the Unilever Tea substation, making it very much a hybrid project and the first tracker project for Solarcentury in Africa.

The biggest challenges faced by Solarcentury with the project were related to international logistics. With framework parts coming from three different countries, (Brazil, Spain and China) and various delays caused due to trucker strikes and customs clearance and processes, the project was delayed by many months, and this led to increased costs on importation (demurrage and detention costs) and project management (extended ex-pat project management time), which severely decreased the project margin. These issues were dealt with during the project by becoming more informed about the new importation processes involved and by rearranging the project schedule, but ultimately, the lessons learnt would only be applicable to follow on projects.

CrossBoundary Energy contracted Solarcentury to provide EPC services for the project. Solarcentury funded the project off its own balance sheet until the completion of construction, whereafter CrossBoundary Energy purchased the operational asset and now own and operate the plant. This was mutually beneficial structure which allowed Solarcentury a good price for the project whilst mitigating the construction risk of the project for CrossBoundary, the ultimate system owner.



JAMJI solar power plant, Kericho, Kenya, with trackers in stow position.

© Solarcentury.

BOX 2

RECOMMENDATIONS FOR SUSTAINABLE GROWTH OF THE SUB-SAHARAN AFRICAN SOLAR SECTOR

A message by the African Solar Industry Association (AFSIA)

1. Thanks to the rapidly decreasing cost of storage technologies, **solar & storage has become a very attractive option** for bringing reliable electricity to Africa for both on-grid and off-grid customers. This solution offers great benefits not only where the grid is unreliable (solar & storage beats diesel) but also where the grid is reliable but expensive (a growing number of countries are gradually removing subsidies and applying cost-reflective grid prices). The impact of this evolution can particularly be felt in the rapidly increasing C&I segment.
2. However, Africa has been plagued with sub-quality products and projects in the past, and this has affected the trust of consumers. National and regional **technical standards must be put in place** to ensure delivery quality and to build back confidence.
3. It is key that **more pre-financed offers** (also called Pay-As-You-Go or PAYG) be proposed to customers as this is the key enabler for wide and fast market adoption. Local SMEs must develop greater financial skills and literacy so they can better engage with the international financing industry and be more successful in securing adequate financing to fund their PAYG efforts.
4. Several niche segments will attract specific interest in the near future thanks to the latest **technological innovations, including solar for agriculture (Agri-PV), solar street lighting, and solar for e-mobility services.**

Authors: *Máté Heisz & Beatriz Ildefonso, SolarPower Europe; Jean-Jacques Ngono, Finergreen; Karsten Schlageter, ABO Wind; John van Zuylen, African Solar Industry Association (AFSIA).*

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TRENDS

WHAT'S HOT IN SOLAR TECHNOLOGY

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With solar having reached the point where it consistently outperforms all other power generation technologies, in terms of cost and efficiency, some might wonder if and where there is still reduction potential. First of all, there is still plenty of cost-reduction potential, which can be tapped on all fronts of the technology. As the solar module and its process materials are the largest contributors to system cost, they are the prime focus for cost-reduction efforts. Researchers and developers are hard at work to improve solar's competitiveness even further. SolarPower Europe has examined the latest solar technology developments that can reduce overall system cost.

WAFERS

Mono – towards full dominance: While some analysts already saw monocrystalline silicon taking over from multicrystalline silicon (also referred to as polycrystalline) in 2018, there is now consensus that as of 2019, mono has taken over as the leader. In any case, the scale will swing further towards mono this year and beyond, as all silicon ingot crystallisation capacity expansions are focusing on the mono variant, which has fewer defects than multi, enabling production of higher cell efficiencies. Multi is expected to have a share of only 20% or less and will basically vanish over the next few years. In April 2020, the world's largest wafer manufacturer LONGi Group, which exclusively produces mono products, announced that it will expand its mono ingot/wafer capacity from 42 GW at the end of 2019, to 75 GW by the end of 2020, accelerating and boosting its earlier plans that called for 65 GW by the end of 2021. Cost improvements in mono wafering/crystallisation technology pushed the development from multi to mono, while a pull has been coming from higher-efficiency solar cell technologies.

Larger and larger wafers: While solar cell manufacturers were using more or less one mainstream wafer size for many years, so called M0 wafers (6 inch or 156 x 156 mm side length), as of 2017 a new format took over: the M2 wafer size (156.75 mm side length in pseudo square format), which is already expected to fade away from this year on. Why? Increasing wafer size has become a strong trend in the industry as it is the simplest way to increase module power without changing the cell technology. For comparison, the M6 wafers that were introduced in 2019 have about a 12% higher surface area compared to the M2 format. Since module power is a function of area, moving from M2 to M6 wafer formats correspondingly increases the module power by 12%. However, G1 (158.75 mm full square) is the new wafer size to go mainstream starting this year. On the other hand, 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. For this reason, M6 is supposed to take over the lead from G1 in the coming years. Where is the end and what size will dominate over the next decade? This is not yet clear. Inspired by the interest in larger formats, wafer manufacturers recently introduced even bigger sizes, including M4 (161.75 mm), M8 (18x mm), and M12 (210 mm).



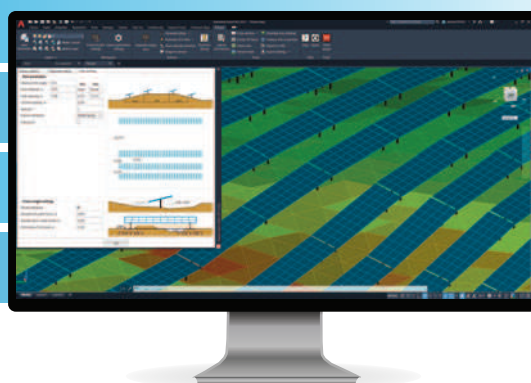
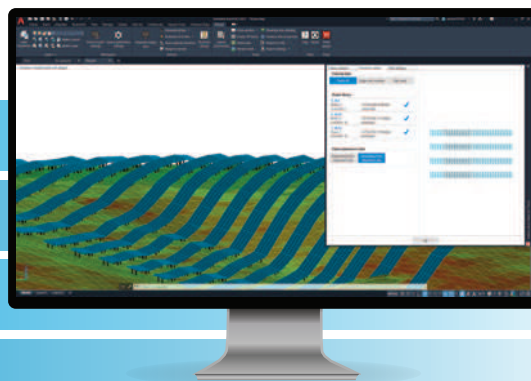
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CELLS

PERC – the new cell standard: What mono now means for wafers, PERC does for cells – it has become the new standard technology. As Passivated Emitter Rear Contact (PERC) solar cell technology has brought 0.5-1% points efficiency improvements over the earlier cell generation, with little more cost for additional production equipment, the bulk of crystalline silicon cell equipment investment has been spent on PERC tools in recent years. A considerable drop in capex for the PERC production equipment also paved the way for multi-GW scale expansion with PERC in China. PERC has also been progressing at a rapid pace in terms of efficiency improvement of greater than 0.5% absolute per year. Another interesting development that is relevant for PERC is the gallium doping technology. The ingots for today's monocrystalline wafers are produced with a Czochalski (CZ) process and the wafers are historically mostly positively-doped (p-type) with boron, which is the root cause for light induced degradation (LID). Negatively-doped wafers (n-type) do not suffer from this issue. Employing gallium instead of boron liberates p-type for this inherent disadvantage, which has recently started to be used more frequently. However, many in the industry strongly believe that p-type PERC technology will soon reach its threshold in terms of industrial production efficiency at about 23%. Although there are record PERC cell efficiencies attained at 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 PERC upgrade: The next evolutionary step in solar cell technology following PERC is likely to be Passivated Contact cells, often referred to as 'TOPCon', where a sophisticated passivation scheme is adapted to advance cell architectures with the promise of higher efficiencies of around 1% point. While there are several possibilities to design a TOPCon cell, today's industrial practice is to adapt the structure on the rear side of the n-type cell. In May 2019, Trina announced a 24.58% world record efficiency TOPCon cell based on n-type monocrystalline silicon substrate, overtaking JinkoSolar, which had reached 24.2% in January 2019. TOPCon is the way forward for those that had formerly bet on n-PERT cells to keep up the efficiency advantage over PERC. China's Jolywood is one of the early adaptors of this approach

and is currently the largest manufacturer of TOPCon products with average cell efficiencies at 23.5%. However, only few companies are producing commercial quantities of TOPCon cells today, although there is a lot of interest as PERC production lines can be upgraded to manufacture TOPCon cells with minor investment. While the potential and opportunities for TOPCon are huge, there are still some hurdles to overcome, such as limited availability of the optimal production equipment, double-side silver and low bifaciality compared to other n-type variants.

Heterojunction – high efficiency promise: The highest crystalline silicon cell efficiency potential is offered by Heterojunction technology (HJT), which holds the overall cell record for silicon solar cells at 26.3%. One of the most efficient modules in the market today, a 21.7% panel introduced by REC last year, is based on HJT. While Sanyo/Panasonic have been producing HJT modules exclusively for many years, the expiry of key patents has given others access to the technology that combines the best of silicon wafers and thin film. Led by Meyer Burger, a number of equipment providers now offer HJT processing tools, and the first new commercial cell/module lines have started commercial production; for example, ENEL Green Power, Ecosolifer in Europe, Norway's REC in Singapore, and others. Some large Chinese solar players have announced massive investments in HJT production capacity as well. While 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, it requires investment in a completely new line and the capex is significantly higher than for baseline PERC. However, with several Asian tool vendors venturing into the development of deposition equipment for HJT, the capex is expected to come down in the coming years.

Tandem Cells – the next frontier: If cell technology development continues at the current pace – improving 0.5 to 0.6%/year – single junction crystalline cell efficiencies will hit their practical efficiency limits very soon. Considering that today's HJT best commercial cells are produced at 24%, the practical limit of about 26% would be reached in few years. By then, 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.

TRENDS WHAT'S COOL IN SOLAR / CONTINUED

There are many different options for choosing materials and combinations. But today the most promising candidate seems to be a c-Si/Perovskite tandem cell structure, with which Oxford PV demonstrated a world-record 28% certified efficiency in 2018, and offers a practical efficiency potential of around 35%. The company is currently setting up its first commercial 125 MW manufacturing unit for the production of tandem cells in Germany, featuring Meyer Burger's HJT technology cell topped with perovskites.

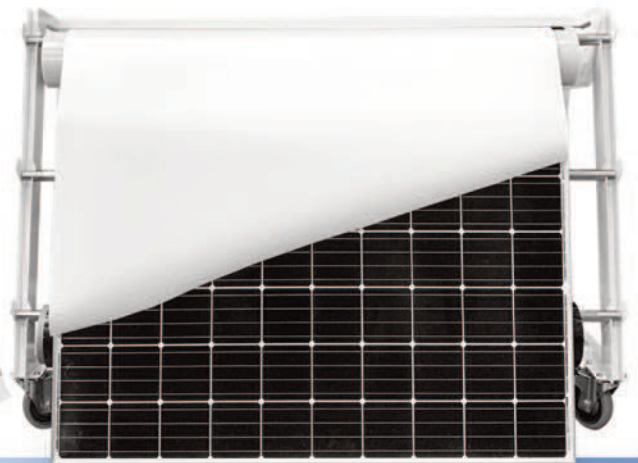
MODULES

Bifacial – power production on the back and front: Bifacial solar modules, which generate power on the front and also back, is the technology that will help 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. In fact, today's new high-efficiency cell generations (HJT, TOPCon) are all 'naturally' bifacial. 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 adding up around the world, real-time data showing the benefits of bifacial systems is becoming available, which is improving the bankability of the technology. Researchers around the world are developing simulation programs to predict bifacial gains more precisely. Overall, the knowledge pool for bifacial is growing larger. All of these developments are supposed to enable the technology to gain in market share – from around 15% in 2019, to 30% in 2022, and eventually a 70% market by 2030, according to the International Roadmap for Photovoltaic 2020 (ITRPV).



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Half cells – easy power gain: Though it sounds counter intuitive, slicing a fully-processed solar cell into two pieces has its benefits. The half-cell design that reduces the resistance losses is a simple but effective means to increase 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 half, with interconnection tools and laser scribes becoming very cheap, module makers are beginning to add this pair of additional equipment to make modules based on half-cut cells. Basically, every module manufacturer now has half-cell products in its portfolio, and will only increase shares in the years to come. Few module makers have completely converted their module production to half-cell layout. With larger wafer sizes, the half-cell design would transform into 1/3 cells, meaning that cells are sliced into three pieces.

Multi-busbars – reducing cell resistance: One of the easiest ways to reduce resistance losses of solar cells is to add more busbars. The current state of the art is to employ a 5-BB design, which has evolved from 3-BB before 2015. 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, which are so close to each other that the finger width can be reduced significantly. On top of this, MBB enables the elimination of busbars from the cell layout. This helps in saving silver paste consumption by up to 80% on the cell level. The top module products usually come with MBB technology (or SmartWire, as it is called by Meyer Burger). The shift towards MBB will be more apparent as the industry increasingly moves towards larger wafer formats. In fact, MBB is part of the expansion plans of most module producers.

Shingled/Tiling ribbon – optimising module efficiencies: Shingling is one approach that eliminates the spacing between the cells in a solar module, thus 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 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.

The 500 W+ module: It looks like module manufacturers are in a race to increase module output power. While last year’s benchmark was 400 W, the current target is 500 W. The key ingredient of this power boost is usually a larger wafer. This approach complements other efforts, such as improvements at the cell level and other advanced module designs, such as multi-busbars, half cells, shingles, all of which can be generally combined. This combo pack is helping to raise the power rating bar of a crystalline solar module above the 500 W level for a panel with 72 cells (or 144 half-cells). Some module producers are also using atypical configurations such as a 76-cell layout to reach higher output powers. The number of cells can also be reduced when opting for even larger wafers such as 210 mm, with 50 cells. Higher power ratings mean fewer modules and a lower space requirement for solar plants of all sizes, which reduces installation, system material, and land costs. However, the different wafer sizes and configurations are resulting in very large module sizes.

Double-glass or glass-backsheet? Glass-glass is a key enabler for bifacial and vice versa. There are several benefits of the glass-glass configuration. Double glass modules provide a heavy-duty solution for harsh environments with high temperatures, high humidity, or high UV conditions and improves mechanical stability of the modules. Due to lower estimated degradation of glass-glass modules, they typically boast a 30-year power performance warranty, which is five years longer than the typical warranty for a glass-backsheet module. All of this did not help gain market shares in the past, but the fact that the technology was around for several years earned the trust of early adapters of bifacial technology who were looking for a reliable transparent rear cover. A highly transparent glass cover indeed seems to be the natural fit, and module manufacturers have been mostly using glass as a rear cover for their bifacial products thus far. According to ITRPV, glass as a

rear cover had a market share of 10% in 2019 and will double to 20% in 2022 then slow down its growth until it captures a share of 35% in next 10 years. However, glass is losing its exclusivity in bifacial applications. Since last year, a number of backsheet suppliers came out with new transparent products, and the first top-tier module manufacturers have started offering bifacial glass-transparent backsheet solar panels, with 30-year power warranties as well. Glass-backsheet module technology is now ready for the bifacial era, too.

Thin and large: Thin-film technology has made a strong leap with the introduction of First Solar's Series 6 CdTe technology. The Series 6 modules come with a large form factor of 430W+, 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.

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 real brains of solar systems. They cope with all types of storage systems, are a key tool for efficient solar power plant operation & management, also regarding grid services, and 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 higher power solutions as well, with the largest reaching up to 250 MW to compete in the field of large-scale power plants. There is also the popular concept of commercial-size inverters with power optimisers to more efficiently operate a solar system, 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.

MOUNTING SYSTEMS

Following the sun: Today's large utility-scale solar power plants are all using tracking systems that have basically become a standard for utility-scale PV plants in southern regions. They operate reliably and the investment over fixed mounting systems is more than compensated by lower LCOEs. The latest product updates address the needs of bifacial modules to have open access to the grounds, in order to be able to generate power 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 sum of the individual benefits.



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SOLAR SYSTEMS AND INNOVATIVE APPLICATIONS

Floating Solar: An interesting new and rapidly growing application for PV is to make use of water as an installation site instead of land. The approach is called floating PV – the system setup is somewhat similar to 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. After reaching a cumulative installed capacity of 1.5 GW at the end of 2019, floating solar PV installations are expected to grow by 143% annually from 2019, to reach over 900 MW in 2020, according to IHS.

Agri-PV: Any strategy to utilise the space required for a solar installation more efficiently is always welcomed by the sector. Agrophotovoltaics, 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.

Solar & Storage – a dream team: 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, Europe's largest solar storage market, 65,000 residential storage systems equal to around 260 MW were installed in 2019, up 44% from 45,000 in 2018; while in the US, the behind-the-meter battery storage market experienced a 66% growth to 272 MW last year, according to EuPD Research. In certain regions, more than every second solar system is already sold with a storage system.

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HIGHLIGHT:

COVID-19 IMPACTS ON SOLAR

Solar panel on the roof of a hospital, Thailand. © Shutterstock

The global solar market, although impacted by the COVID-19 crisis, can come back stronger and more sustainable.

The COVID-19 pandemic has reshaped our world in 2020: from the dynamics of the globalised economy to the dynamics of our daily working routines. Beyond the devastating impact on health, one of the most visible result of lockdowns around the world has been the emergence of clear blue skies.

It is not just smog that has disappeared from our cities and industrial districts: global carbon emissions have plummeted with the kind of rapidity that needs to become standard, year after year, if we are to achieve the ambitious climate goals outlined in the Paris agreement of 2015 and reach net-zero emissions by 2050.

A group of world-leading economists and environmental experts – including Nicholas Stern from LSE, and Joseph Stiglitz from Columbia University – has been investigating what kind of policy response is best suited to ensuring 2020 marks a turning point in climate action. The group came together to ask whether the fiscal recovery packages being put in place would entrench or partly displace the current fossil fuel-intensive economic system, a key pillar of the request to “build back better”.¹ The academics noted:

“Opinion polls in many countries show that people are noticing the clean air, uncongested roads, the return of birdsong and wildlife, and are asking whether ‘normal’ was good enough; could we not ‘build back better’? The shape of COVID-19 fiscal recovery packages put in place in the coming months, once lockdowns are eased, will have a significant impact on whether globally agreed climate goals are met.”

The COVID-19 crisis presents an opportunity to adopt smart, green policies that favour solar investments and job creation.

¹ Hepburn, C., O’Callaghan, B., Stern, N., Stiglitz, J., and Zenghelis, D. (2020), ‘Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?’, Smith School Working Paper 20-02.

These are important questions for the global solar industry, which not only faces short-term challenges from lockdowns and similar restrictions on personal movement and economic activity but is also looking to benefit from an acceleration in the energy transition away from fossil fuels and towards clean energy technologies.

The Global Solar Council has been active in analysing the impact that the COVID-19 pandemic has had on the PV industry worldwide, and gathering input on how solar businesses could best be supported at a policy level. There are immediate actions to help companies weather the short-term shock. Beyond this, however, many are looking to governments to seize the opportunity to promote clean energy and climate friendly investments that will accelerate solar projects.

That's why, as members of the IRENA Coalition for Action, SolarPower Europe and the Global Solar Council were among 100 leading renewable energy organisations to actively support its joint call for action, putting forward concrete recommendations on how governments can ensure a rapid and sustained economic recovery that aligns with climate and sustainability objectives. Among recommendations for stimulus packages, we called on governments to:

- Prioritise renewable energy and commit to phasing out support for fossil fuels;
- Provide public financial support to safeguard the industry and mobilise private investment in renewable energy;
- Enhance the role of renewable energy in industrial policies;
- Revise labour and education policies to foster a just transition and help workers make the shift into renewable energy jobs and
- Strengthen international co-operation and action to accelerate renewable energy deployment in line with global climate and sustainability objectives.

Global Solar Council survey in midst of lockdowns

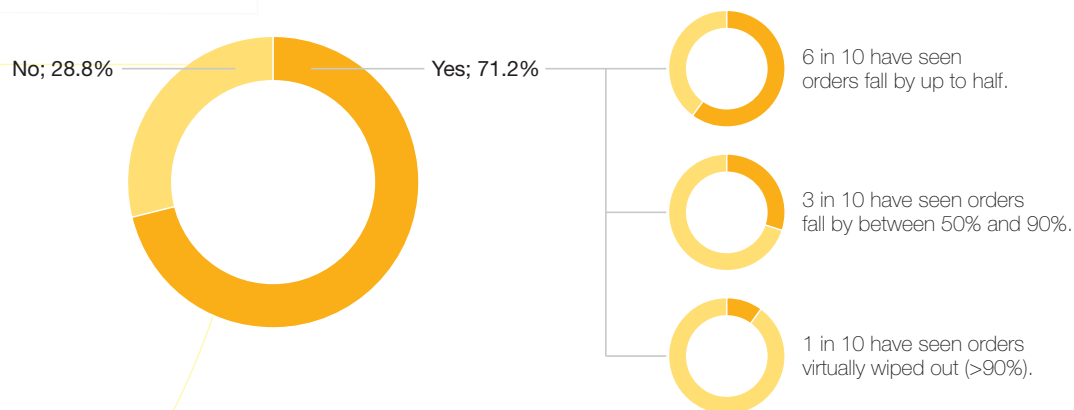
In April, as the global economic disruption caused by the COVID-19 pandemic was in full swing, the Global Solar Council surveyed about 500 businesses in over 60 countries worldwide to get real-time information from companies on the ground about how they were being impacted and get their input on how governments and institutions could respond and support the PV sector. We received responses from all over the world: 71% of responses came from Europe, Middle East and Africa, 20% from Asia Pacific, and 9% from the Americas.

The Global Solar Council initiative captured the serious repercussions the pandemic was having on the solar industry at a global level, driven above all by lockdowns and restrictions on work and travel, which hampered day-to-day operations. It was a dramatic contrast to the growth story that had been common in recent years.

The survey found that **72.1% of respondents reported a decline in orders compared to the pre-emergency period** with 6 in 10 of these saying orders were down by up to 50%, 3 in 10 reporting a decline of 50%-90% and **1 in 10 stating that orders had been virtually wiped out**. Looking ahead to the coming four months, **79.5% of all respondents expected orders to decline compared with a pre-COVID situation, with half of these preparing for a decline of 40% or more**.

In terms of the impact on daily operations, more than half of respondents (57%) cited **lockdowns and related restrictions on work and movement as the main disruption to their activities**. Just over a third (37%) said they had problems getting orders, suffering from lower client demand, and struggled to finalise contracts. About a fifth of businesses say they have troubles with their supply chain and logistical issues.

GSC SURVEY QUESTION 1 IN TERMS OF SALES TO THE SOLAR PV MARKET, HAVE YOU EXPERIENCED A DECLINE IN ORDERS AS A RESULT OF THE HEALTH EMERGENCY SINCE THE BEGINNING OF THE CRISIS IN YOUR COUNTRY?



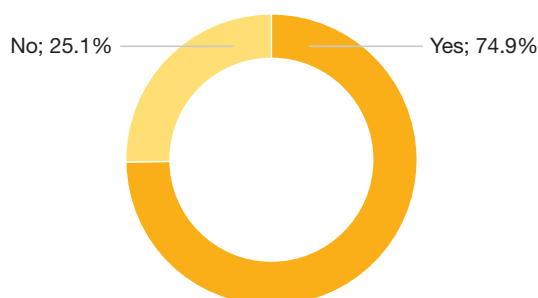
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Supply chain issues add to the pain

The disruption to supply chains came both because of the closure of component manufacturers and other suppliers – in China for example – and because increased logistic issues. When asked in the survey about the purchase of goods and services, **74.9% of respondents said they had already experienced difficulties in their supplies** and 71.4% expecting problems in the coming four months.

In Asia, India is an example of how the regional interdependency of solar markets and supply chains has amplified the local crisis, as the country's industry is heavily dependent on Chinese PV module imports, which account for 80% of the total volume. According to Wood Mackenzie, first quarter solar installations were projected to crash 60% from a year earlier. The consultancy was bearish about PV installations in the rest of the year too, as supply and logistics bottlenecks linger, and forecast solar installations to fall 24.8% to 8.9 GW in 2020 as a whole.

GSC SURVEY QUESTION 2 HAVE YOU EXPERIENCED DIFFICULTIES IN SUPPLYING GOODS AND SERVICES COMPARED TO THE PERIOD BEFORE THE START OF THE COVID-19 CRISIS AND GOVERNMENT DECISIONS RELATED TO THE HEALTH EMERGENCY?



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COVID-19 IMPACTS ON SOLAR / CONTINUED

The situation was equally dire in Italy, one of the first European countries to be heavily hit by the pandemic. According to the Italia Solare association, one in five solar companies said they risked being pushed out of business by the prolonged disruption, with more than a quarter saying they were preparing to cut more than 25% of their workforce. That prompted Italia Solare to write to the prime minister and call for a “zero-cost” green stimulus package capable of creating 100,000 jobs.

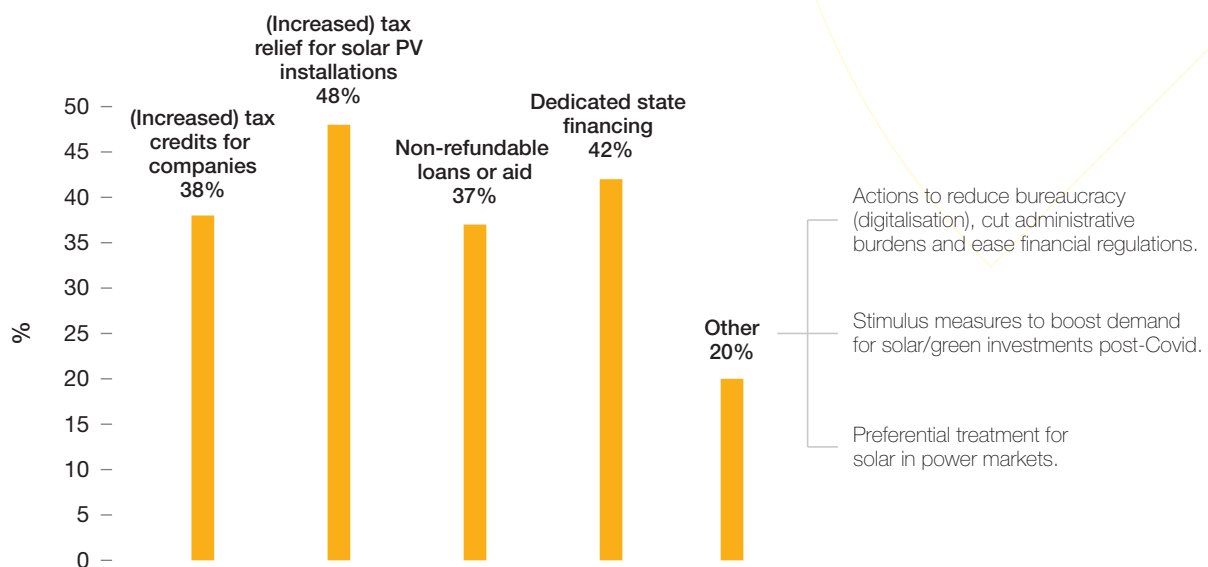
The role of governments and institutions in this difficult context is critical and solar PV businesses are eager to see a range of policy responses to help them get back to work first of all and resume operational activities and installations as quickly and smoothly as possible but also in the longer term to **sustain the solar sector with a view to boosting the shift to renewables and the decarbonisation of economies**. Respondents in the GSC survey were particularly in favour of tax relief – or increased tax relief – for solar PV installations but also dedicated state financing, non-refundable loans and tax credits for companies, and many respondents called for reduced bureaucracy and administrative burdens to speed investments.

This kind of positive, long-term message has been coming not only from those working in solar on the ground but also from many national and regional associations that are members of the Global Solar Council.

The Asian Photovoltaic Industry Association (APVIA), a member of the GSC, retains an optimistic position and encouraged companies to take the opportunity to improve their competitive position for an inevitable rebound. Economy-driven demand contraction will hurt new solar installations in the short run but will be followed by a significant catch-up over the next few years, it said in a Global Solar Council webinar. APVIA had two key recommendations for solar businesses at this time: to “tough out” this difficult time by focusing on maintaining healthy cash flow and to step up efforts on technology innovations and organizational management which could greatly benefit the industry when activities pick up.

SolarPower Europe is also positive about the sector weathering the current storm, with projects and sales returning to normal in 2021 or 2022 depending on the strength of the wider economic recovery and stimulus

GSC SURVEY QUESTION 3 WHAT SUPPORT INITIATIVES AND/OR TAX RELIEF MECHANISMS SHOULD BE PROVIDED BY GOVERNMENT/INSTITUTIONS TO HELP YOU MITIGATE THE EFFECTS OF THE COVID-19 PANDEMIC?



packages. Ahead of the package presented by the European Commission, the association was proposing stimulus measures including:

- Supporting access to finance for solar industries in the crisis period
- Ensuring a favourable ecosystem for new solar projects
- Boosting the deployment of large-scale solar projects
- Unlocking the job-creation potential of renewables in Europe by boosting demand for small-scale PV.

Solar is key in protecting jobs, promoting health

In the US, where the solar industry employed 250,000 people pre-COVID, and was on track to add nearly 50,000 more workers this year, the focus has been on protecting solar jobs and stimulating the economy. “As one of the fastest-growing industries in America, the solar industry is poised to lead the U.S. out of the massive economic recession caused by COVID-19,” stated the Solar Energy Industries Association (SEIA). “With the right policies in place, solar can be a crucial part of the solution to rebuild America’s economy and put people back to work.”

This emphasis on solar jobs is at the core of the Global Solar Council mission, which makes our work all the more relevant today. The Global Solar Council, in fact, has set a target of 10 million solar jobs by 2030. How will COVID-19 impact that ambition?

A paper by the Oxford Smith School of Enterprise and the Environment offers encouraging indications for policymakers and suggests that central bank officials, finance ministry officials, and other economic experts are aware of the potential for green economic stimulus measures to favour not only a climate-friendly shift to renewables but also associated benefits of building back better in terms of employment and social equality.

Studies have suggested that renewable energy investments generate more jobs, especially in the short run – important when jobs are scarce in the middle of a recession. One model suggests that every 1 million USD invested in clean energy infrastructure generates 7.49 full-time jobs in renewables, 7.72 in energy efficiency and only 2.65 in fossil fuels.

Governments around the world understand the value of solar with regards to jobs, and to advance the energy transition, when putting together stimulus packages. Malaysia, for example, wants to use investments in solar PV to stimulate the economy. This spring, the government announced a new tender for 1 GW_{AC} utility-scale solar capacity to be set up in Peninsular Malaysia as part of its recovery measures. The Swiss government has given the green light to support the expansion of solar PV systems this year with 46 million CHF (48.5 million USD) in view of the coronavirus situation. And at the end of May, the European Commission proposed a two-year 750 billion EUR (846 billion USD) COVID-19 recovery instrument, ‘Next Generation EU’. The European Green Deal will be at the core of the EU’s recovery strategy, rolling out solar energy projects across member states and launching a massive renovation of the EU’s building stock and infrastructure, which will benefit solar as well.

Beyond jobs, there are non-economic, non-environmental benefits that can add to the positive impact. One case in point, just to return to the context of the pandemic, is health. Beyond reduced air pollution in dense urban areas, clean energy solutions can be deployed rapidly in regions where the electricity grid is unreliable or even non-existent. That means health centres can work around the clock, instead of relying on candles or flashlights. The Solar for Health programme, funded by the UN Development Programme among others, showcases a green model that improves health services while saving lives, the environment, and money.

Initiatives like this highlight the wide range of benefits that flow from investment in solar energy; benefits that extend to environmental protection, public health, and resilient communities. It is key, therefore, to look beyond the immediate crisis and seize the opportunity for a better, solar future.

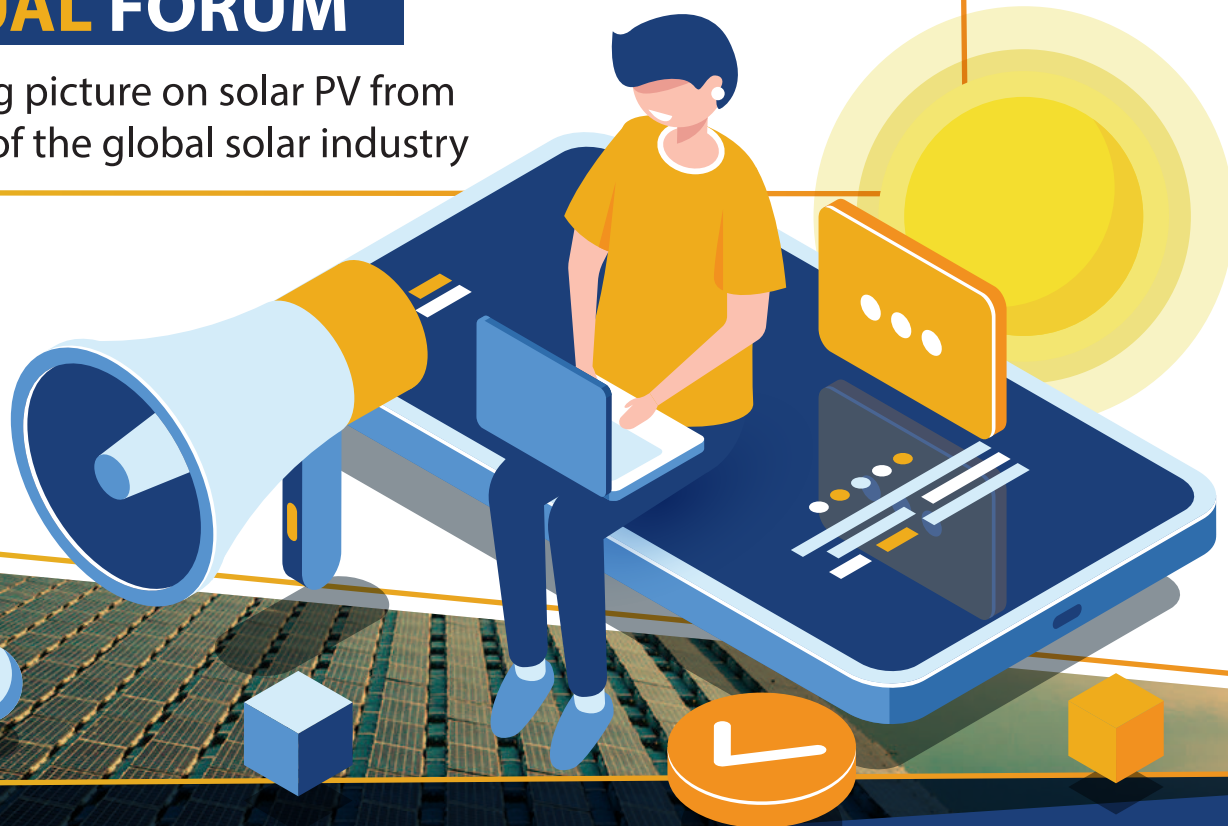
Authors: James Osborne & Cecilia Bergamasco, Communication Officers, & Gianni Chianetta, President, Global Solar Council (GSC).



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SAVE THE DATE - 27 October 2020

OUR TOPICS

- Enabling sustainable societies: solar's key role in achieving the UN SDGs and powering ambitious climate goals
- Solar jobs in the new policy scenario: rebuilding employment opportunities post-pandemic
- Technology & innovation: the latest developments and the brightest opportunities for 2021 and beyond
- Emerging solar markets: unlocking new potential in Africa, south-east Asia and Latin America



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3

GW-SCALE SOLAR POWER MARKETS IN 2019

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In 2019, 16 countries installed more than 1 GW of solar; a 45% growth rate compared to the 11 GW-scale solar markets in 2018 (see Fig. 22). While we anticipate the number will slightly decrease to 14 this year due to negative impacts from COVID-19 on solar demand, we expect growth to continue reaching 19 GW-scale markets in 2021, and at least 21 GW-scale markets in 2022.

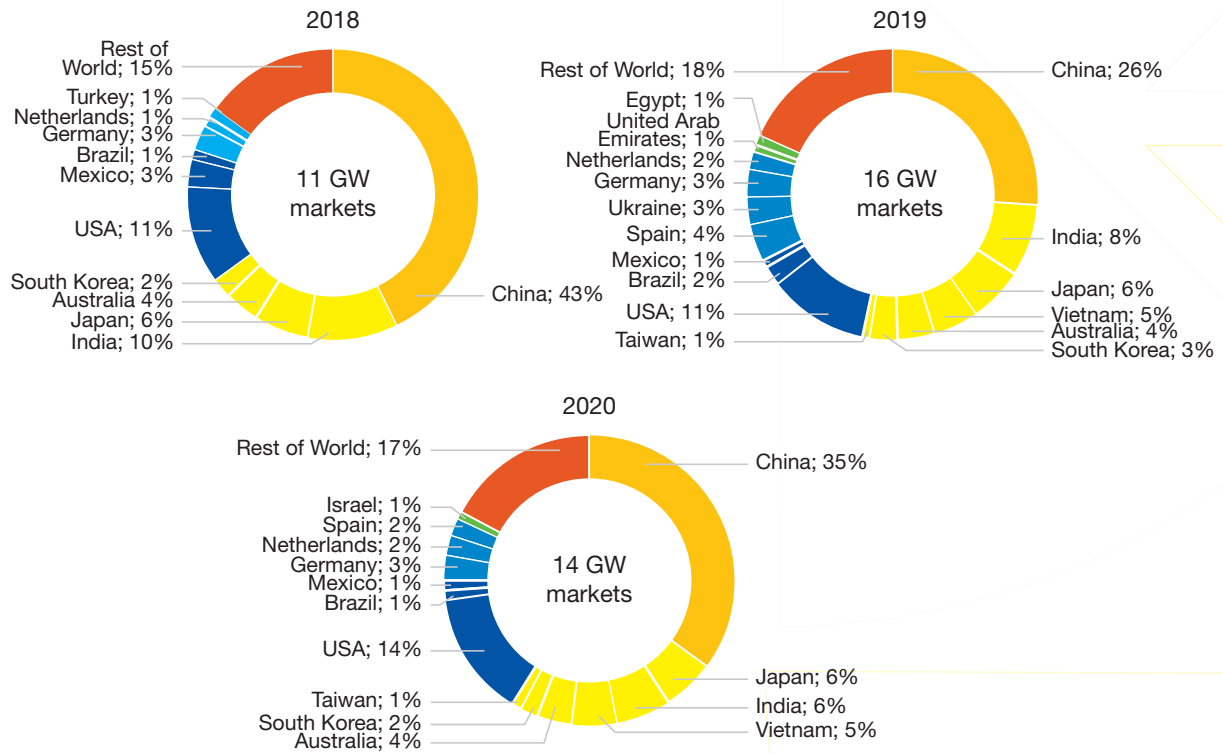
Like in the previous Global Market Outlooks, national solar associations from markets that have added more than 1 GW in the previous year (GW-scale market) have been invited to present their local expert views on their ‘home’ markets (which sometimes differ from our estimates that are based on several sources). Many of these associations, like our organization, 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, Taiwan, Vietnam), we have written the overviews based on our SolarPower Europe research.

1	China	China Photovoltaic Industry Association (CPIA)
2	United States	US Solar Industries Association (SEIA)
3	India	National Solar Energy Federation of India (NSEFI)
4	Japan	Japan Photovoltaic Energy Association (JPEA)
5	Vietnam	SolarPower Europe
6	Spain	Spanish Solar Energy Association (UNEF)
7	Australia	Smart Energy Council
8	Ukraine	Solar Energy Association of Ukraine (ASEU)
9	Germany	German Association of Market Innovators (BNE)
10	South Korea	Korea Photovoltaic Society (KPVs)
11	The Netherlands	Holland Solar
12	Brazil	Brazilian Photovoltaic Solar Energy Association (ABSOLAR)
13	Taiwan	SolarPower Europe
14	Mexico	Mexican Solar Energy Association (ASOLMEX)
15	UAE*	Middle East Solar Energy Association (MESIA)
16	Egypt	African Solar Industry Association (AFSIA)

*United Arab Emirates.

3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

FIGURE 22 WORLD GW-SCALE SOLAR MARKETS 2018 - 2020



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1. CHINA

Overview of PV developments

In 2019, total PV installation in China was 30.1 GW, which was 32% less than installation in 2018. By the end of 2019, the cumulative installed capacity reached 204.3 GW, representing 17.1% year-over-year growth. Although newly installed capacity has declined, China remains the largest PV market in the world, and its production value chain continues to undergo rapid growth. In 2019, the polysilicon output in China was approximately 342,000 tons, equal to 32% year-over-year growth; the production of silicon wafers, cells, and modules reached 134.7 GW, 110.3 GW, 98.6 GW respectively – this is a growth rate of 25.8%, 29.8%, and 17%, respectively.

Solar targets

Over the course of 2019 and 2020, China's PV industry management policies underwent major changes. The overall goal of these policies was to reduce dependence on subsidies, and eventually begin a subsidy-free era due to start on 1 January 2021. This development laid the foundation for the forthcoming 14th Five-Year-Plan (2021-2025).

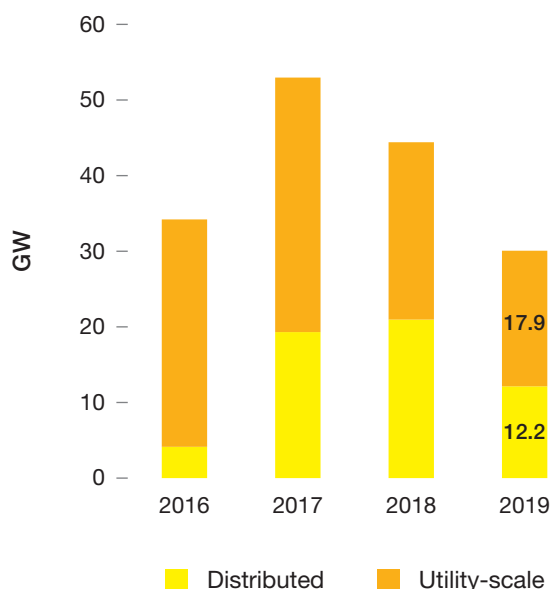
Drivers for solar growth

The year ahead is crucial for China's PV industry. PV power generation projects will still adopt the management mode of giving priority to parity projects and implementing bidding for projects requiring state subsidies. Because 2020 is the last year with state subsidies, except residential PV projects, the enthusiasm for enterprise on project construction will increase significantly.

Utility-scale vs. distributed and rooftop solar development

In 2019, China's PV power generation adopted priority support for parity projects which did not require state subsidies, and adopted a competitive allocation method to determine market size for projects that required state subsidies. After the auction, 22.7 GW capacity was finally determined in projects list, but due to the late policy introduction and the shortage of enough project construction time, many projects could

FIGURE GW 1.1 CHINA ANNUAL SOLAR PV MARKET 2016-2019, BY CPIA



Source: CPIA.

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not finish construction were not connected to the grid before the end of the year. The actual grid-connected volume of bidding projects is only one-third of the projects list size.

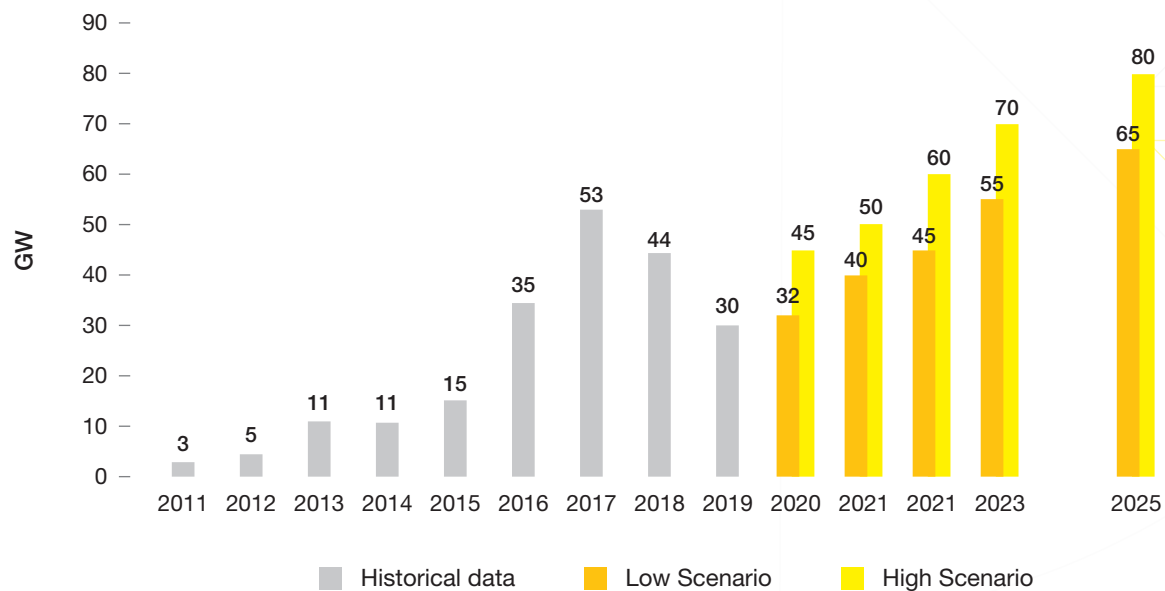
In terms of market segmentation, 17.91 GW of utility-scale projects were installed, a 23.1% year-on-year decrease, of which 10.18 GW was newly installed in the fourth quarter. The distributed plants contributed 12.19 GW, a year-on-year decrease of 41.8%. The development of the residential PV market exceeded expectations with a newly installed capacity of 4.18 GW, supporting the distributed plants.

Challenges

In 2020, the COVID-19 epidemic has impacted the global PV market. In China, uncompleted bidding projects could not be finalised. As the government's policy on the extension of unfinished bidding projects has yet to be released, some PV project developers have not resumed project construction, and some of these projects may eventually face the risk of being abandoned. This adds further uncertainty to China's PV market in 2020.

3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

FIGURE GW 1.2 CHINA ANNUAL SOLAR PV MARKET SCENARIOS 2020-2025, BY CPIA



Source: CPIA.

© SOLARPOWER EUROPE 2020

Outlook

The coming year is a crucial one for China's PV power generation to enter the era of parity. The management mode is similar to 2019, meanwhile with developments in technology, and the decline of initial investment, unfinished bidding projects will be completed in 2020. It is expected that China's PV market will recover completely by the end of the year. The Chinese PV industry will continue to strengthen its technological innovation and further accelerate the pace of upgrading, reducing costs, and increasing efficiency.

Author: China Photovoltaic Industry Association (CPIA).

2. UNITED STATES

U.S. Solar Industry Poised to Lead Economic Recovery Efforts

The world has changed dramatically since last year's Global Market Outlook in small ways, as many of us adapt to teleworking and socially-distant living, and in profound ways, as this public health crisis deepens and US unemployment reaches its worst level in generations. And more recently, our country, with notable activism around the world, is confronting racial injustice.

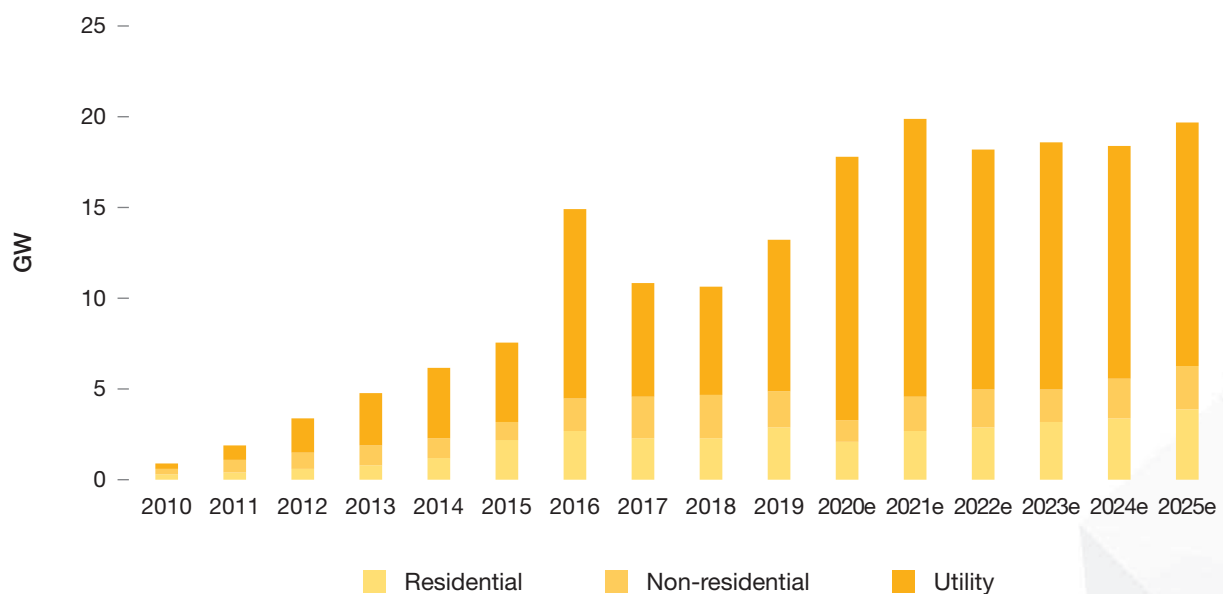
Like so many American business sectors, the solar industry has been hit hard by COVID-19. At the same time, we have proven ourselves to be a resilient industry. The impacts on the market, at least according to our most recent quarterly Solar Market Insight report, which was released June 11, tell a tale of two industries. Projections show that distributed markets will see a combined 32% reduction in the amount of solar installed in 2020 compared to pre-COVID forecasts, while utility-scale solar will propel the US solar industry to a

record 18 gigawatts (GW) of electric generating capacity due to a record project pipeline. While we will still see growth at the end of the year, there is now a 9% reduction to the previous market outlook, where nearly 20 GW of solar was forecast for 2020.

The industry is still grappling with financing challenges and a significant drop in residential customer demand, resulting in job losses and furloughs across the industry. Instead of adding more than 50,000 jobs during the first of half of this year as we projected, the industry has lost more than 72,000 workers. Tens of thousands of solar jobs have been cancelled or postponed, putting billions of dollars of investment on indefinite hold.

Through our industry survey, we have heard from many U.S. companies about the hardships and challenges they are facing, from companies folding to recent startups that are unsure whether their new business will survive the pandemic. However, we believe that there is pent up demand for distributed solar and that both sectors can surge in 2021 with the right policies in place.

FIGURE GW 2 UNITED STATES ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



© SOLARPOWER EUROPE 2020

3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

What's Next

Last year, we unveiled a bold vision for the future — for solar to reach 20% of electricity generation by 2030 during what we are calling The Solar+ Decade, an era of radical market transformation for energy in the United States. I firmly believe that those goals are more relevant than ever. By advocating for the solar industry during this crisis, we are fighting on behalf of American industrial progress, American innovation, and American jobs. This is no Green New Deal, and it is not a handout from Uncle Sam. We are setting a comprehensive policy vision that creates hundreds of thousands of well-paying jobs — with a commitment to ensure our workforce reflects the diversity of our nation — as we build a resilient electricity infrastructure to bring clean, reliable, low-cost power to millions of Americans.

The COVID-19 pandemic, the ensuing economic crisis and the fight for racial justice have highlighted many vulnerabilities and areas in need of reform across our economy and society. But it also provides an opportunity to build the future we need. As we look for ways to put Americans back to work, the solar industry stands ready to come back stronger than before and help lead this nation's economic and social recovery for all Americans.

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

3. INDIA

Overview of PV developments

The average solar radiation in India is approximately 4-7 kWh/day for about 300 days each year. In order to utilise this potential, the Union Government of India has identified solar as a key pillar for its power supply strategy and committed to one of the world's largest solar energy capacity expansion programs. Over the past five years, India installed around 30 GW of solar, with an annual capacity addition of solar in fiscal year (FY) 2018-2019 standing at 6.5 GW.

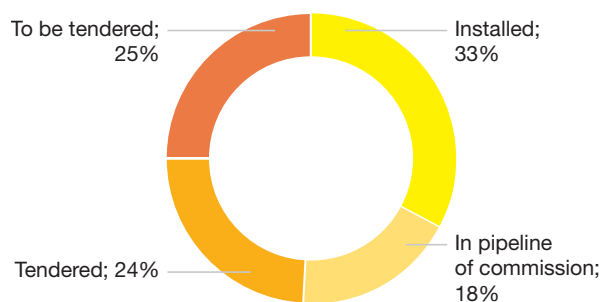
In 2019, the Indian government launched two flagship schemes to accelerate solar deployment: SRISTI and KUSUM. The Phase-II rooftop solar program, 'Sustainable Rooftop Implementation for Solar Transfiguration of India' (SRISTI), aims to push India's rooftop installations towards its target of 40 GW, while the Prime Minister Kisan Urja Suraksha evam Uthaan Mahabhiyaam (PM KUSUM) scheme targets around 25,000 MW of distributed solar installations, through solar pumps both on-grid and off-grid, along with 500 kW – 2 MW solar plants on uninhabited land near to substations. India still remains an attractive destination for solar energy investments, with an annual average investment of 6-8 billion USD in the sector over the past two years.

Solar/RE target

By the end of 2022, India's government targets 100 GW of solar installations, of which 60 GW will be from utility and 40 GW will be from rooftops. This ambitious goal has triggered a high intensity of solar energy deployment in the country. India's overall target by end of 2022 is to install 175 GW of RE. While solar will provide the largest share, wind power is targeted to contribute 60 GW, bio energy is planned to provide 10 GW, and small hydro power is foreseen to contribute 5 GW. It is envisioned that by 2030, 40% of India's power needs – projected to reach 15,280 TWh – will be covered by renewable energy, up from 21.4% in 2019.

The Green Corridor initiative by India's Union government, which is expected to be finalised in 2020, allows for the large-scale transmission of renewable energy from eight 'renewables rich' states – Tamil Nadu, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Himachal Pradesh and Madhya Pradesh – to states with lower renewable energy capacities. Once finalised, the project will include approximately 9,400 km of transmission lines and substations with a total capacity of around 1,900 MVA.

FIGURE GW 3.1 INDIA CURRENT STATUS OF UTILITY-SCALE PROJECTS, BY NSEFI



Source: Ministry of New and Renewable Energy.

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Drivers for Solar Growth

While large-scale solar power generation projects are being installed to achieve the ambitious target of 100 GW of solar power generation by 2022, India simultaneously plans to develop decentralised solar energy. The government recently published guidelines for the implementation of the KUSUM scheme for the installation of solar pumps and grid-connected solar power plants by farmers. Under this scheme, which was approved in July 2019, the government aims to develop decentralised solar energy and other renewable energy generation plants with capacities up to 2 MW.

Under SRISTI, the government recently approved a total funding of 1.7 billion USD for Phase 2 of the grid-connected rooftop solar program to accelerate the installation of rooftop solar. This funding is aimed at improving the proliferation of rooftop solar, which at the end of 2019, had a capacity of only 4 GW, leaving 36 GW to go to reach the 2022 target.

India's National Action Plan on Climate Change (NAPCC, 2008) includes the objective of intensifying solar energy deployment as well as advising RPO's to be set at 5% of total grid purchase and to increase by 1% each year for 10 years. The plan also includes Renewable Energy Certificates (RECs), which were introduced in 2011 and enhance renewable energy capacity by levelling interstate divergences of renewable energy generation and the requirement of obliged entities to meet their RPOs with differentiated prices for solar and non-solar.

3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

In March 2019, India's central government also approved INR 85.8 Billion (around USD 1.2 billion) for the second phase of the Central Public Sector Undertaking (CPSU) scheme, which aims at setting up 12,000 MW of grid-connected solar PV power projects by government producers with Viability Gap Funding support for self-use or use by government entities, either directly or through distribution companies

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

For now, India's solar market is driven by large-scale ground mounted projects. As of September 2019, 82.3% of India's installed solar capacity came from utility-scale plants. The country's energy system is composed of an installed capacity of around 28.9 GW ground-mounted and 4 GW of rooftop solar electricity (MNRE 2019b; SPE 2019). With many utility-scale projects in the pipeline, this trend is likely to continue. Ground-mounted solar projects, which predominantly operate under the Solar Parks and Ultra Mega Solar Power Projects scheme, are tendered by the government through a reverse bidding process.

Rooftop solar is yet to pick up in India. Commercial and industrial clients contribute the major chunk of rooftop solar installations. While the National Solar Energy Federation of India believes there is a good chance that

India will manage to achieve its ground-mounted solar target of 60 GW by 2022, as envisioned by the National Solar Mission (and may even exceed it), meeting its rooftop solar target of 40 GW remains a big challenge.

Challenges

There are at least three major challenges that India's solar industry currently faces:

1. **GST:** While EPC businesses only had to pay 5% tax under the old value-added tax (VAT) regime, the current GST regime bifurcated taxation to 5% for balance of systems/BoS (equivalent to 70% of the plant's cost) and 18% for services (equivalent to 30% of the plant's cost). This effectively brings the total tax to 8.9%, which is far higher than 5%. The logical bifurcation, however, would have been 90-10, wherein at least 90% of the plant's cost is incurred for BoS. Another ambiguity is GST applied on BoS when module supply is not in the scope of the EPC contractor – the figure could be 18%, 8.9% or 5%, or as per HSN 84, 85 and 94 an effective of 13.5%. For the solar market to continue grow, it is fundamental that GST guidelines are clear and transparent.
2. **Manufacturing:** With more than 90% of modules being imported from China, India's government imposed a 25% tariff on Chinese solar modules. This move was accompanied with the recent



200 MW, Bhadla, Rajasthan.

© ACME Solar.

announcement of a dedicated domestic module procurement scheme for CPSUs in India. The government believes a comprehensive manufacturing policy is necessary to strengthen domestic manufacturing and position India as a quality producer of PV modules. Amidst the aftermath of COVID-19 the government has declared solar manufacturing as one of the champion sectors where special incentives will be given to this sector for making India self-reliant. A recent tender, where an Indian company has won a contract to develop 8 GW of solar projects and establish 2 GW of additional solar cell and module manufacturing capacity at a cost of 6 billion USD, is an example of Indian government's seriousness about solar manufacturing.

3. **PPA renegotiations:** DISCOMs are the largest power off-takers in the Indian renewable energy sector, engaged to purchase power under long-term power purchase agreements (PPAs) at pre-decided tariffs. However, due to liquidity constraints there have been instances in which the DISCOMs of Andhra Pradesh, Karnataka, and Uttar Pradesh attempted to renegotiate or cancel signed PPAs with solar and wind power developers. Mitigating this risk by public

decisionmakers requires long-term structural fixes aimed at solving the systematic failures of the utilities sector through coordinated efforts by DISCOMs and the central and state governments.

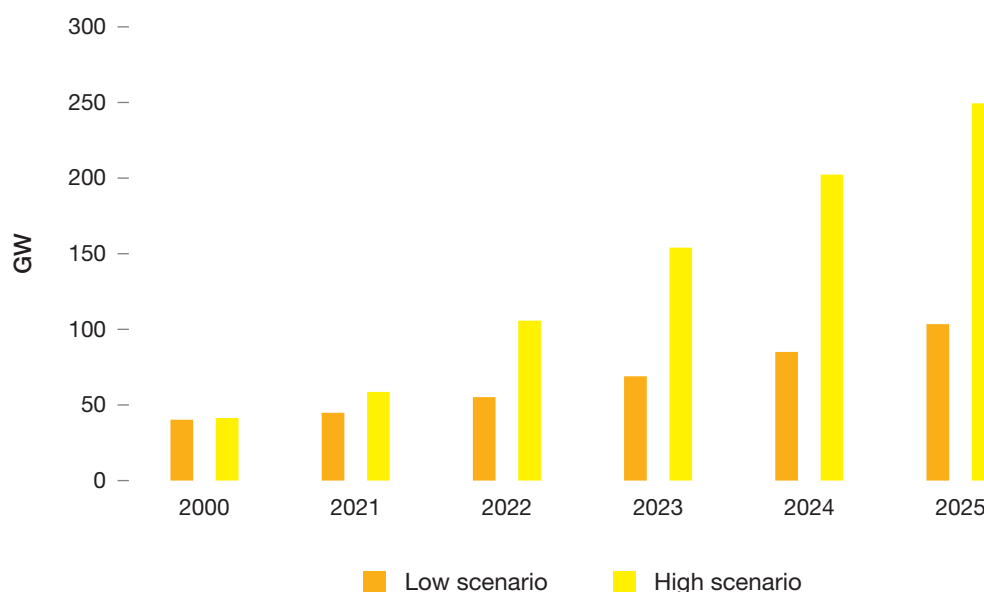
Outlook

Despite a number of challenges, strongly exacerbated by COVID-19 in 2020, the Indian solar sector to a large extent remains unaffected. There have been two reverse auctions successfully completed in the last two months despite the imposition of lockdown in India. While one of the auctions received a lowest tariff of 2.55 Rs./kWh (3.35 US cents/kWh), the other auction was of India's first tender to provide round-the-clock (RTC) solar power through storage which received a tariff of 2.9 Rs per unit (3.8 US cents/kWh) for the complete capacity of 400 MW.

Although there will be a slight decrease in the capacity installed this year, the outlook looks very positive with double digit growth for the next three years starting from 2021.

Author: Subrahmanyam Pulipaka, CEO, National Solar Energy Federation of India (NSEFI).

FIGURE GW 3.2 INDIA TOTAL SOLAR PV SCENARIOS 2020-2025, BY NSEFI



Source: NSEFI.

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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

4. JAPAN

Overview of PV Developments

The Japan Photovoltaic Energy Association (JPEA) estimates that approximately 7.0 GW_{DC} (5.2 GW_{AC}) was installed in 2019, resulting in a cumulative installed PV capacity of 63.1 GW_{DC} at the end of 2019. 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. This trend is likely to continue up until the mid-2020s, largely due to reduced FIT support for solar PV in Japan. With that said, JPEA expects that solar PV capacity will increase again in the late 2020s, due to the improving cost competitiveness and innovation of business models (e.g. from FIT/FIP based models to Corporate PPA type ones).

JPEA has released its new 'PV OUTLOOK 2050', which notes that a total of 420 GW_{DC} (300 GW_{AC}) will need to be operational by 2050 in order to achieve the Japanese government's target of an 80% GHG reduction.

Japanese Solar/RE Targets

- **The government target for 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

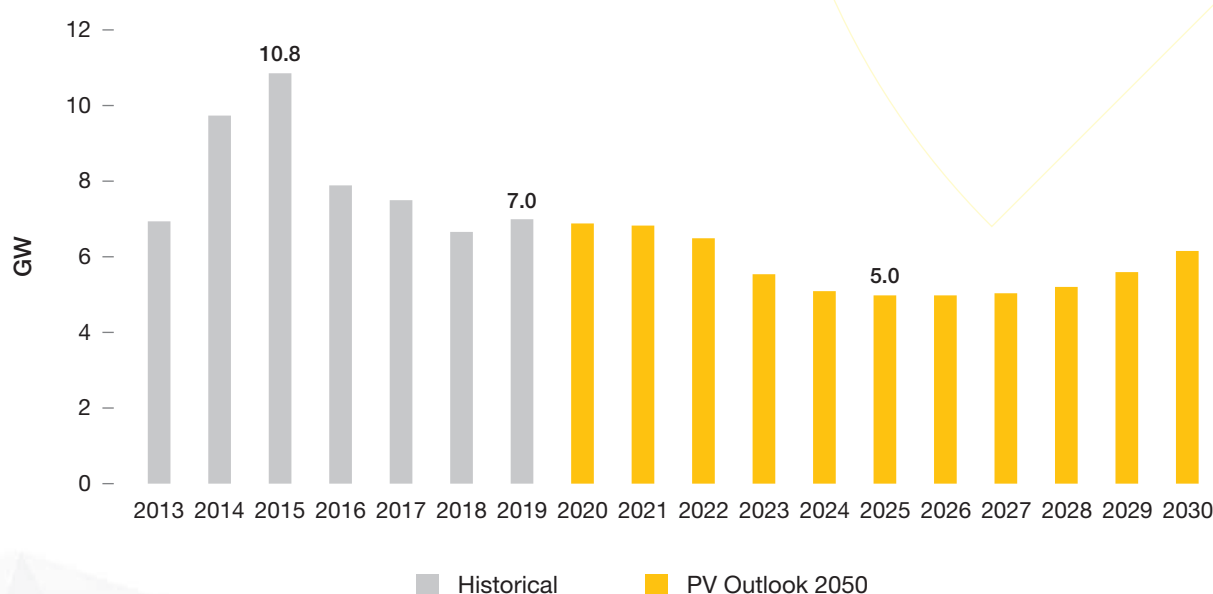
cumulative installed PV capacity in 2030 will be 64 GW_{AC} (75 GW_{DC}). This target will come up for review by METI in 2021.

- **JPEA's vision (PV OUTLOOK 2050):** In our PV OUTLOOK 2050, the cumulative installed PV capacity is expected to be around 100 GW_{AC} (120 GW_{DC}) in 2030, and 200 GW_{AC} (250 GW_{DC}) in 2050, for the base scenario that is unchanged from our previous vision released in 2017. However, the new vision has revealed that 300 GW_{AC} (420 GW_{DC}) of solar PV will be needed for the 2050 target to reduce Japan's GHG emission by 80%. In this 300 GW_{AC} scenario, solar PV will be providing 31% of Japan's power mix, aided by sector coupling in a highly electrified energy system; 300 GW_{AC} by 2050 will require tremendous efforts and innovative developments by the industry. JPEA sees this 300GW_{AC} scenario as a technically and economically viable option for a sustainable future.

Drivers for Solar Growth in Japan

- **The FIT schem** has been, and continues to be, the strongest support for solar PV growth in Japan. However, the role of FIT will gradually become smaller with the growth of other drivers, such as on-site self-consumption business models.

FIGURE GW 4.1 JAPAN ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2030, BY JPEA



Source: JPEA.

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- 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 retail electricity variable prices for commercial and industrial users, on-site self-consumption PV systems are becoming an attractive option for corporate users.
- **Non-fossil fuel share target** in the power mix will be one of the post-FIT drivers for solar PV. In Japan, power retail suppliers are obliged to increase the share of their non-fossil fuel (RE and nuclear) percentage, to reach at least 44% by 2030. The actual share was 23% in 2018, and this 2030 target of 44% is challenging for Japan. From 2020 onwards, the government will set an interim target each year for all power retailer, towards the 2030 target.
- **Distributed solar PV, from 10 - 999 kW**, mostly ground-mounted, is on a downward trend since 2016, largely due to reduced FIT support. This segment requires business transformation, such as from simple ground-mounted to self-consumption systems integrated with RE users' and/or local community's energy demand. JPEA expects that with this transformation, the downtrend will be reversed in the mid-2020s.
- **Mega-watt scale solar PV, 1 MW and above**, including utility scale, is also on a downward trend. In addition to the FIT reduction, this trend is due to constraints concerning power grid and land availability. In JPEA's vision, these constraints will be overcome, and due to improved cost competitiveness, this segment is likely to start growing again in the late-2020s.

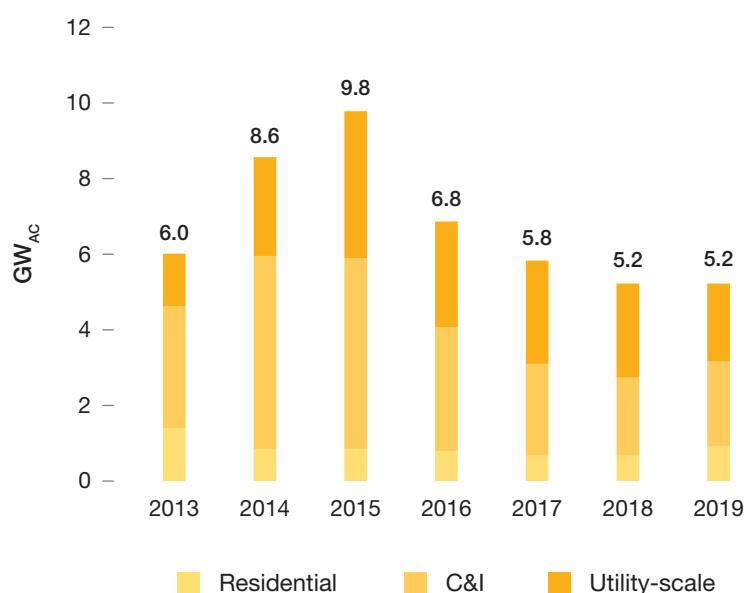
Utility-scale vs. Distributed & Rooftop Solar Development

- **Solar PV below 10 kW**, mostly **residential rooftop**, installed 0.9 GW_{AC} in 2019. JPEA expects this segment will grow in this decade under the FIT scheme and thanks to the subsidies for net-zero energy houses (ZEH) and for battery systems with solar PV. This segment is seemingly going through the transition from early adaptors to early majority users.

Challenges

- **FIT reform for large-scale PV**: The current FIT scheme is undergoing a fundamental revision by the government. According to the amendment bill, a feed-in premium (FIP) will be introduced for large-scale solar PV. One of the biggest challenges for the industry and policymakers is the smooth transition from FIT to the more market-oriented FIP incentive.

FIGURE GW 4.2 JAPAN ANNUAL SOLAR PV MARKET 2013-2019, BASED ON METI DATA



Source: METI data. Values are expressed in GW_{AC}.

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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

- **For small to middle-scale solar PV**, the FIT scheme will be maintained for the time being. However, the qualification as “locally utilized RE” (defined by METI) is required to obtain FIT support from 2020. For 10–50 kW PV, a minimum 30% self-consumption (out of total generated kWh) is one of the qualification conditions for “locally utilized RE”. The current business model, mostly simple ground-mounted PV, needs to be transformed to on-site self-consumption models from this year.
- **The FIT/FIP scheme** has been, and will be, the most important growth driver for solar PV. However, the role of FIT/FIP will gradually get smaller with time in the coming years. With the emergence of corporate PPA business models, JPEA sees this decade as the transition period towards growth without FIT/FIP.
- **Grid constraints:** Limited grid capacity and curtailment risks are the primary causes of the downward market trend in Japan. METI is taking several mitigation measures, such as the “connect and manage” program, for the transmission grid level to maximise grid capacity with existing assets. Unbundling of vertically-integrated power utility companies has been exercised from this April as part of Japan’s electricity system reform. It is expected that this system reform will accelerate the integration of variable RE into Japan’s electricity system by overcoming the difficult grid constraints.
- **Land availability:** New business models without dedicated land space (e.g. on-site self-consumption models), and utilisation of unused/abandoned farmland presents a solution for 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. If Japan’s unused/abandoned farmland is fully utilised for solar PV, JPEA estimates that several hundred GW of solar can be installed.
- **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 the challenges for the industry. The FIT for non-residential PV (50 kW–250 kW) was set in the fiscal year 2020 at 12 JPY/kWh (0.11 USD/kWh). The average electricity wholesale spot market price in 2019 was approximately 8 JPY/kWh (7.5 US cents/kWh). JPEA expects that grid parity will be achieved by 2030. The government targets a PV LCOE of 7 JPY/kWh (6.5 US cents/kWh) between 2025 and 2027.
- **The COVID-19 crisis** is not reflected in JPEA’s vision PV OUTLOOK 2050. Although the full extent of the impact is yet to be known, JPEA believes that the solar PV industry will overcome the crisis for our sustainable future by leading the RE deployment in Japan.

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



235 MW, Setouchi, Okayama.

© Setouchi Future Creations LLC

5. VIETNAM

Overview of Solar PV Developments

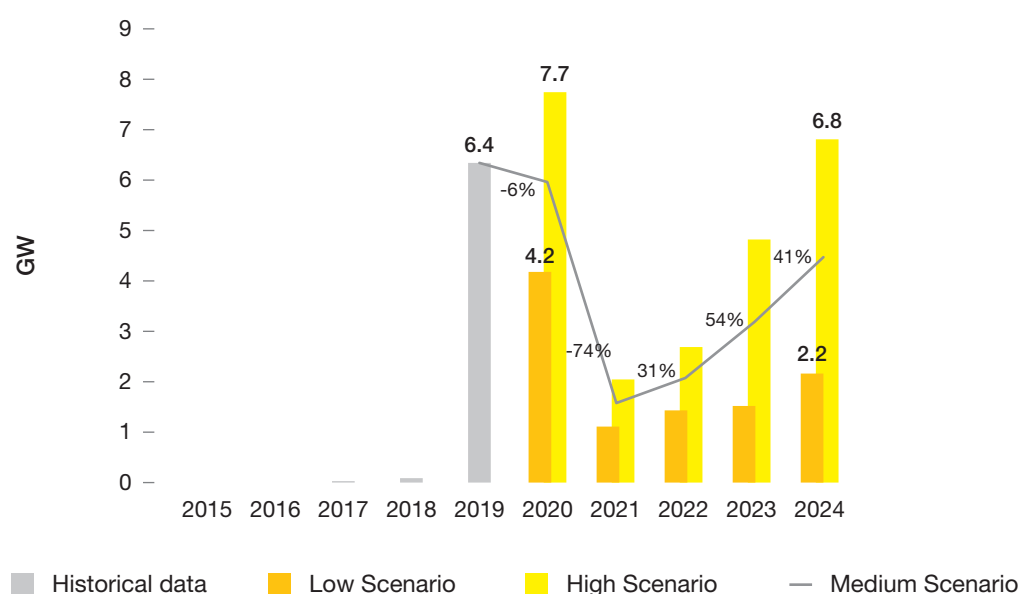
Solar development in Vietnam was at its infancy when, in April 2017, the government introduced its first feed-in tariff (FiT) scheme. Under this support scheme, utility-scale solar projects that began operations before the end of June 2019 have been granted a generous 20-year tariff at 9.35 US cents/kWh. In parallel, a net-metering scheme has been set up to support distributed generation, with buying and selling prices determined on an annual basis, depending on the VND/USD exchange rate.

Under this highly remunerative legislative framework, the Vietnamese solar market experienced a boom in new capacity in 2019, with 6.4 GW installed year-on-year. The great majority of these projects were grid-connected towards the end of June, just before the deadline to be awarded the remuneration rate. This record level of annually installed capacity was a surprise to many, and catapulted the country in the GW solar club for the first time ever. The bulk of 2019 installations were ground-mounted projects, complemented by approximately 270 MW of rooftop systems.

The expiration of the first FiT scheme in June 2019 opened a 10-month legislative vacuum that created high uncertainty around the future of solar. This period was concluded with the “Decision 13” announcement, in April 2020, of a new set of solar feed-in tariff rates. Under the new regime, which entered into force on 22 May, utility-scale projects and floating solar projects are granted a 7.09 and 7.69 US cents/kWh tariff, respectively. In addition, small rooftop systems under 100 kW in size are eligible for an 8.38 US cents/kWh tariff. The new tariffs are valid for projects starting operations by the end of 2020; afterwards, the support level will be determined through competitive bidding processes. This is in line with the plan to transition from the current FiT regime to a more cost-effective auction mechanism, as announced in late 2019. However, this new tight deadline appears challenging and will trigger a new rush for project completion by the end of the year.

While the COVID-19 crisis has surely affected the Vietnamese solar market, its impact so far has not been as pronounced as in other countries. The lockdown measures were enforced mainly during the legislative gap period when no FiT was available, and to date have been almost entirely lifted. Some limitations affecting

FIGURE GW 5 VIETNAM ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

international travel remain, but any delay caused by the health crisis is likely to be more than counterbalanced by the urgency of completing installations by the end of the year.

Decision 13 also sets out a legislative PPA framework for rooftop installations below 1 MW. The PPA terms and format are directly negotiable between the electricity provider and the corporate offtaker without interference by the state utility EVN. Even though the provisions do not address explicitly the framework for utility-scale PPAs making use of the national grid, in principle these are also possible under the new legislation.

Solar PV targets

Thanks to the capacity boom that took place in 2019, the solar target that had been set out for 2025 was reached six years in advance and thus had to be revised. Currently, as outlined in its latest power development Master Plan, the government expects 14.5 GW of solar by 2025, and 20 GW by 2035. The strongest driver for PV deployment in Vietnam relates to the projected surge in the country's electricity consumption. With an annual growth rate in the range of 10%, about 4 GW of new generating capacity needs to be installed every year to cope with such an increase in demand. As the cheapest and most versatile power generation source, solar will have an essential role to play in this capacity expansion. Delays in the construction and the start of operation of coal power plants has exacerbated this trend, giving further pressure to the government to push for the rapid capacity deployment that solar can ensure.

Challenges and perspectives for Solar PV growth

All investments that were finalised before 23 November 2019 were able to qualify for the new FiT scheme unveiled in April 2020, as long as the projects are grid-connected by the end of 2020. Despite the tight deadline, it is not unlikely that most of these projects will be completed on time, as it happened last year.

While the solar market is expected to remain strong in 2020, a new legislative vacuum will open as of January 2021. There is still considerable uncertainty regarding the timing of the shift to the auction system. An auctioning pilot has been envisaged for 2021, but the overall transition process is unclear as it has not been decided at the political level. The slow transition to auctions and uncertainty deriving from the upcoming general elections in May 2021 are likely to cause a market contraction, while solar developers wait for news on the policy front.

At the current stage, post-2020 large-scale solar in the absence of feed-in tariffs and auctions will rely on corporate PPAs. A pilot program for PPA projects starting by the end of the year and the new legislation for rooftop PPAs indicates that the policy framework around corporate PPAs is becoming more and more encouraging; although their attractiveness vis-à-vis the future remuneration scheme is still to be verified.

Grid issues constitute a key challenge to solar deployment, at least in the short term. The electricity network must be reinforced, especially on the southern coast, where most of the capacity has been installed. As these rural areas need to be properly connected to the regions where the consumption takes place, a rapid expansion of transmission lines is urgently needed. While the utility is taking action to strengthen the network, grid congestion still causes high levels of curtailment to renewable generation. In reaction to grid congestion, the government announced in December 2019 a halt in licensing to new large-scale projects. It is unclear whether this decision will be lifted with the new remuneration system, or when the grid issues will be addressed.

Curtailment risk and the absence of international arbitrage rules have been a barrier to the involvement of international banks in solar projects. However, given the sheer amount of installed capacity despite the aforementioned bankability issues, the government has little interest in changing the current state of play.

Author: *Raffaele Rossi, SolarPower Europe.*

6. SPAIN

Overview of PV Developments

With 4,201 MW installed on the ground, plus 459 MW of self-consumption installations, 2019 was Spain's best year ever for solar PV. In addition to the installed capacity of solar PV, there is a portfolio of projects currently in progress, which amount to approximately 100 GW.

There were two main drivers that account for this success. First, the auctions organised by the previous government (whose term ended on 31 December 2019) were responsible for ground-mounted project. Second, the success of self-consumption projects is due to the new Law of October 2018, which eliminated artificial barriers and the famous "sun tax" thus establishing a free market system.

The triumph of solar PV auctions must be further highlighted. Of the 3,909 MW that was approved, 3,728 MW of installations were connected on time; this means that solar PV experienced a 95.5% success rate, compared to the 42.9% success rate of wind energy installations. This further demonstrates the competitive advantage and reliability of solar compared to other renewables energy technologies.

Solar/RE targets.

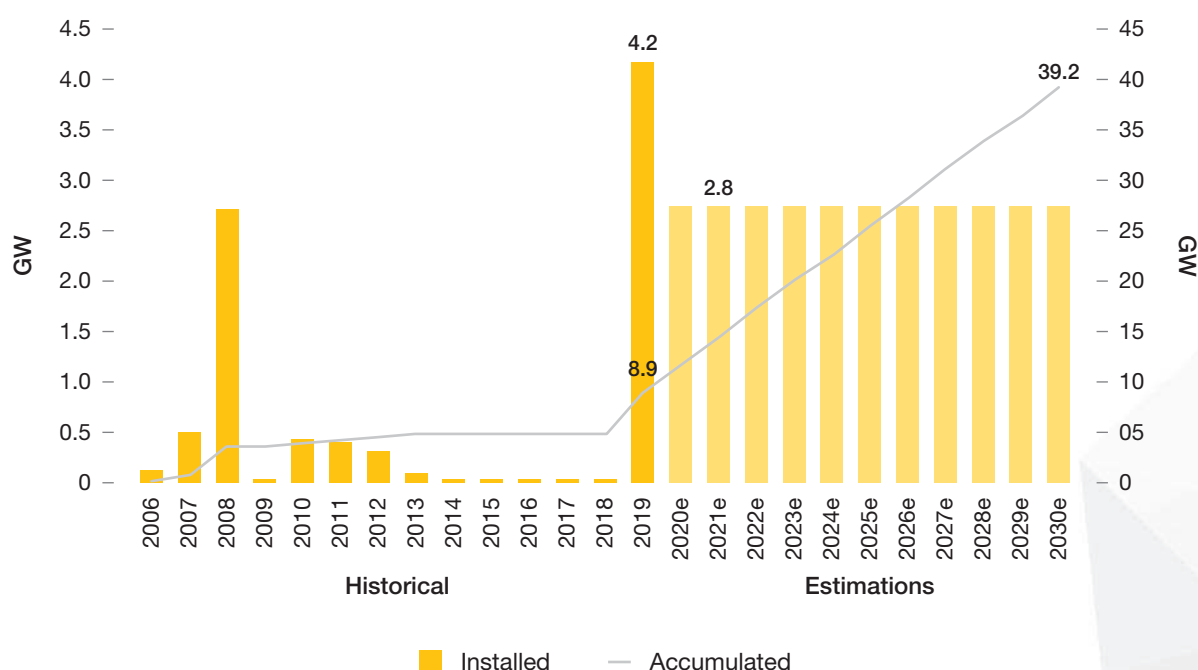
Spain's "National Energy and Climate Plan" sets a 2030 target of 42% of final energy consumption from renewables, and 74% from renewable electricity. These percentages represent 60 new GW of installed renewable power, more than half for solar PV, which will result in an annual market of between 3–4 GW. Moreover, in November 2018 the country published a new climate plan that targets a 100% renewable energy electricity system by 2050.

Drivers for Solar Growth

Due to solar's cost-competitiveness, combined with available land in Spain, new government auctions are no longer the single driver of the sector. PPAs have emerged as a strong driver for solar growth; in a single year, the market for PPAs went from being virtually non-existent to signing more than 4 GW.

In the self-consumption sector, the main drivers thus far have been the desire of SMEs and the tertiary sector to reduce their energy costs, as it is in these sectors where 90% of solar PV has been installed. The domestic sector

FIGURE GW 6 SPAIN UTILITY-SCALE SOLAR PV MARKET SCENARIO 2020-2030, BY UNEF



Source: UNEF.

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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

is driven by an increasing awareness of home-owners of the environmental benefits of solar, as well as tax incentives in particular municipalities. The Spanish government intends to continue to promote collective self-consumption projects.

Challenges

In the short term, the main challenges that face Spain's solar PV market stem from the COVID-19 crisis. The **self-consumption** market has been particularly impacted, with projects being delayed and some cancelled, including the termination of already signed contracts. The sector that works with the SMEs has been affected, as these companies are now focusing their debt capacity on their core business. In terms of ground floor installations, expectations for 2020 **were for continuity**, with a broad portfolio of development projects. The estimates of new capacity from UNEF were in the order of 2–3 GW for plants on the ground, and 600 MW for self-consumption.

Plants under **development** are suffering delays due to logistical problems (especially due to the importing of components) as well as problems related to **administrative procedures**. This, together with the absence of an auctioned power reference as in 2019, makes it difficult to predict the capacity that will be connected to the grid by the end of 2020.

The most significant impact has been identified in

projects in lower stages of development. In this regard, the halt in development is related to the effect that COVID-19 is having on **electricity market prices**. The drop in these prices is resulting in a tightening of financial conditions for merchant project loans and a considerable decrease in the PPA market. Another pending challenge is a new “Access and Connection Regulation”, which streamlines procedures, eliminates positions of dominant abuse, and clears connection points for projects of dubious completion.

Outlook

The forecast for achieving the objectives of the PNIEC remains unchanged. However, the driver is likely to be more auctions rather than merchant projects. Our estimate that the market closes at 2–3 GW by the end of 2019 remains unchanged. Of these projects, those that fail to connect this year will do so in the first months of 2021.

The self-consumption market will suffer a drop in expectations, but as the Spanish economy recovers, it will as well. To mitigate the impact of COVID-19, we are requesting a series of measures, such as speeding up the call for auctions, streamlining administrative procedures for large plants, tax relief, administrative streamlining, reduction of the fixed component of the electric bill, and promotional campaigns.

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



Alarcos Solar Park, 50 MW, Ciudad Real, Castilla-La Mancha.

© X-Elío

7. AUSTRALIA

Overview of Solar PV in Australia

“The best of times, the worst of times!” In the GMO 2019 Report we said the Australian market “had taken off after delays caused by political actions of a conservative national government”. We now know that 2018 was a record year for large scale that was not persistent. The utility scale slowdown we forecast as likely for 2020, already appeared in 2019. The last year saw a total of 4.4 GW solar power capacity installed. As of 31 December 2019, Australia had added new installed capacity of just over 2.2 GW of rooftop PV, but just 2.2 GW of utility scale PV (systems larger than 1 MW) for the year. The uptake of PV installations by residential homeowners is approaching 3 million Australian homes, 1 in 4 of all homes. Commercial & Industrial (C&I) installations with systems sizes from 30 kW to 1 MW increased in 2019, while utility scale orders and commissioning fell. The total installed base at end of January 2020 was ~13.1 GW producing just over 7% of total generation (wind ~8%, hydro 7%).

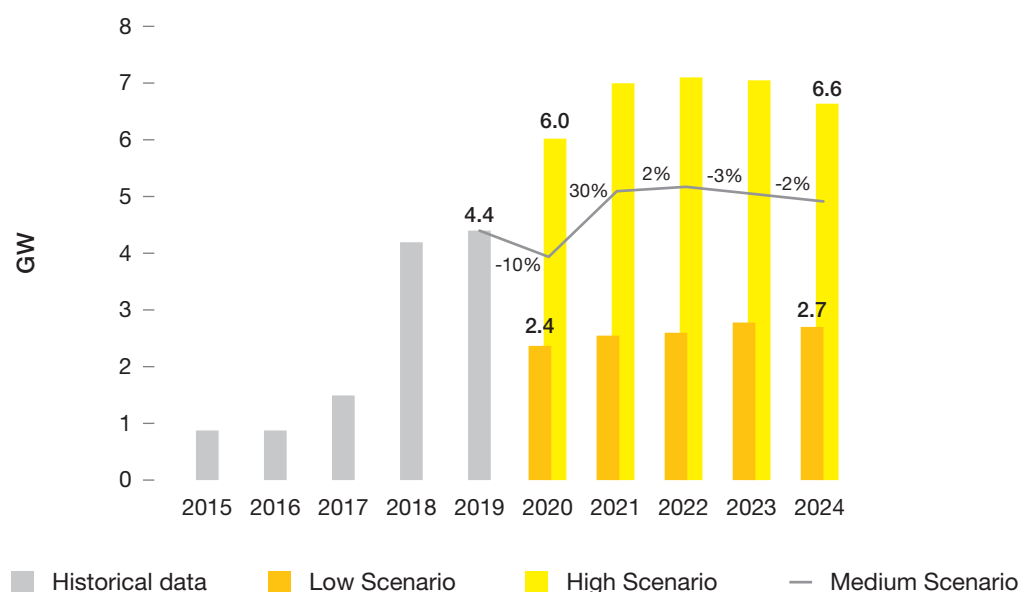
The national Renewable Energy Target (RET), a carbon price certificate model mechanism based on the offsetting of emissions in the grid by the PV output, ends in 2020 for utility scale support. For small scale systems (Small Scale Renewable Energy Scheme – SRES) a deemed 15-year upfront payment is available and for large scale systems (Large Scale Renewable Trading – LRET) Large Scale Generation Certificates (LGCs) are issued based on generated output into the grid. During 2020 the RET target of 23.5% of total generation (33 TWh) was met - all by renewables.

Australian PV Solar/RE targets

Self-consumption offsetting retail power prices remains the primary driver for PV uptake depending on location. Network constraints continue to see imposition of limits on new installations, sometimes at zero. This continues to encourage the self-consumption model in the market for residential and C&I PV.

The PV rooftop market remains highly competitive and systems are being installed from 0.65 AUD/W

FIGURE GW 7 AUSTRALIA ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

(0.45 USD/W) to 1.65 AUD/W (1.13 USD/W) with a median price of 0.97 AUD/W (0.67 USD/W) even with significant currency fluctuations and drop of AUD versus USD. The average system size is now over 7 kW and battery storage systems for new installations are increasing. System management and monitoring software as an option to manage costs & performance is seeing considerable growth.

The small-scale systems, up to 100 kW, continue to have access to an upfront payment from the SRES via Small Scale Trading Certificates (STCs), under the RET. This is declining annually from 2017 out to 2030, but in 2019-20 still offers a capital reduction on purchase of just under 25%.

Potential for Growth & Risks in Australia

The uncertainties identified last year have if anything worsened with the narrow return of a conservative national government in the election of May 2019. As mentioned, utility scale PV support from the RET (LRET) ends for new entrants in 2020. Large Scale Generation Certificate (LGCs) moved to values close to zero in 2019 in anticipation of the target being met early. There remains no national replacement policy that would support large scale PV, or other renewable energy

deployment beyond 2020. The good news is that every State & Territory government (5 states & 2 territories), from both sides of politics, have established strong renewable energy targets and are taking action to increase adoption of solar PV and other renewables. That is creating a more positive business climate for the solar industry, but is sub-optimal as is not a clear national transition path to move from a 75% coal & gas based electricity system to renewables. Even more concerning is that following the impacts of COVID-19 a body established by the Australian government has recommended massive increase in methane (“natural” gas) infrastructure as a post-Covid stimulus package. That continued antagonism towards solar PV (and wind) remains a threat to the large-scale solar industry in Australia complicating proposals already in the pipeline and any future opportunities.

The national government as well as State & Territory governments have increased their commitments to the development of H2 production and its downstream opportunities which should be a stimulus for utility scale solar growth, but again politics is in play. The national government is defining fossil fuel H2 production, from coal gasification & methane (“natural” gas) steam reformation as ‘green’ on the basis of CCS (carbon capture & storage) so the expansion of renewables expected from a clean hydrogen strategy is not anticipated.



Daydream Solar Farm , 180 MW, Queensland.

© Edify Energy Pty Ltd

Outlook 2020 and beyond

The widespread bushfires that impacted Australia between September 2019 and February 2020 seem to have triggered a considerable increase in inquiries for both PV and battery systems, which might be the reason that the expected slow-down from COVID-19 has not been as large as expected.

Australia will continue as the country with the highest per capita penetration in the world for rooftop PV. In the first few months of 2020, records were being set. Forecasts indicate ~2.7 GW rooftop PV will be installed this year with ~30% being businesses (C&I). The large-scale pipeline of about 2.5-3GW in 2019 is much reduced to 1.7GW with many large-scale projects previously committed being held back.

The most recent CER report suggests about the same utility-scale PV deployment in 2020 as was seen in 2019 – a little over 2GW, but the Smart Energy Council expects it to be lower. The future for large-scale PV has higher uncertainty in and beyond 2020, but the pipeline and continuing planning and development proposals, albeit with longer deployment horizon market confidence has

not collapsed. Although the corporate PPA demand is high and growing the ability to meet that remains constrained by the grid technical and regulatory barriers. There is some movement to address these, and a recognition by regulators (see the Australian Energy Market Operator (AEMO) “Integrated System Plan”), but planning and logistics means not much can be completed by 2024. Rooftop PV systems are likely to remain at more than 2.5 GW annually for some years, with strong public support, in part as a counter to high electricity prices and competitive prices, and now as a ‘personal security’ choice to increase household resilience against natural disasters and climate change impacts.

Solar PV systems at competitive prices and a perception of high electricity prices (although retail prices have reduced from 2019, largely due to the downwards cost pressure from increased renewables generation), and an increasing understanding by businesses of PV’s value proposition, means the rooftop PV market will remain strong. Electric vehicles still have no national support policy, but as the variety of choices in the market increases the impetus for PV at home and work will grow.

Author: Steve Blume, President, Smart Energy Council.



Finley Solar Farm, 175 MW, New South Wales.

© Esco Pacific

8. UKRAINE

Overview of PV developments

Intensive development of solar energy in Ukraine began only in 2018-2019, despite the existence of a FIT renewable energy support scheme since 2010; the country saw very low installations between 2010–2016. As of 1 January 2015, only 411 MW of solar PV had been installed in Ukraine; by the end of 2015 this value had increased to 434 MW; in 2016, it increased to 548 MW; and in 2017, to 793 MW (see table below). In 2018, twice as much solar PV was installed compared to the previous

three years, reaching 1,545 MW in total. During 2019, the number of all installed capacities increased 3.5 times compared to 2018 (+3.53 GW of utility scale PV in 2019).

As of 1 January 2020, Ukraine had **5,543 MW** of installed solar PV. Of this, 553 MW is on-grid residential solar PV (more than 22,000 facilities), with a capacity of up to 30 kW (up to 50 kW only for those installed in 2019).

Among all new RES technologies in Ukraine, the most electricity is generated from solar PV (except for large hydropower plants). Solar generation of electricity in kWh is 1.5 times higher than generation from wind farms.

TABLE 3.1 INSTALLED CAPACITY OF RENEWABLE ELECTRICITY FACILITIES, MW

	2014	2015	2016	2017	2018	2019
PV (excl. residential)	411	432	531	742	1,388	4,925
Residential PV	0.1	2	17	51	157	553
Wind Power Plants (WPP)	426	426	438	465	633	1,170
BioPP	49	52	59	73	97	170

Source: State Agency on Energy Efficiency and Energy Savings of Ukraine.

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TABLE 3.2 DYNAMICS OF RESIDENTIAL PV INSTALLATION (QUANTITY, NUMBER)

	2016	2017	2018	2019
Residential PV	1,109	3,010	7,450	21,968

Source: State Agency on Energy Efficiency and Energy Savings of Ukraine

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TABLE 3.3 DYNAMICS OF RESIDENTIAL PV INSTALLATION (CAPACITY, MW)

	2016	2017	2018	2019
Residential PV	16.7	51	157	553

Source: State Agency on Energy Efficiency and Energy Savings of Ukraine

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TABLE 3.4 GENERATION FROM RES (MLN. KWH)

	2016	2017	2018	2019
PV (excl. residential)	492	711	1,092	2,783
Residential PV	18	37	112	281
Wind Power Plants (WPP)	924	970	1,181	2,038
BioPP	200	231	282	439

Solar/RE targets. Legal Framework.

There are two long- and short-term legal regulations that concern 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. According to the National Action Plan adopted in 2014, Ukraine should reach the target of 10.9 GW RES capacity (2.3 GW of which solar), and the share of generation from RES of 26,000 GWh, which is 11% in final energy consumption (2420 GWh share of PV) by the end of 2020.

The second, the **Energy Strategy of Ukraine until 2035**, which states that the share of electricity from renewable energy sources (including hydropower) by 2035 should reach 25%. Market players from the RE sphere understand that both targets are not ambitious enough for Ukraine and in 2019 initiated a revision of Energy Strategy goals for RE. In addition, in late 2019 the Ministry of Energy and Environmental Protection of Ukraine presented a draft of concept for a 'green' energy transition in Ukraine by 2050, which aims to achieve 70% of generation from RES by 2050. The Government of Ukraine has yet to approve the concept.

The laws, "On the Electricity Market" and "On Alternative Energy Sources", are the main regulatory acts for the Ukrainian renewable energy industry.

Drivers for solar growth

The main trigger for the development of solar generation in Ukraine and RES is the feed-in tariff (FIT) support scheme, which applies to all solar, wind, and bio-generation facilities, but does not apply to hydro power plants and pumped hydro storages (except small and micro hydro power plants).

For 16 years, new electricity generation capacities have **not been installed in Ukraine, except renewables**. The FIT support scheme in Ukraine was introduced in 2009 and will last from 2010 by 2030, gradually decreasing until the end of its validity. The initial rate in 2009 for ground-mounted solar stations was 0.4653 EUR/kWh (0.52 USD/kWh), for roof stations over 100 kW, 0.4459 EUR/kWh (0.5 USD/kWh), and for rooftop PV up to 100 kW, 0.4265 EUR/kWh (0.48 USD/kWh).

As of 2020, there is a FIT with a rate of 0.1125 EUR/kWh (0.13 USD/kWh) for ground PV stations and 0.12 EUR/kWh (0.14 USD/kWh) for stations installed on the roofs and/or facades of buildings, and 0.16 EUR/kWh (0.18 USD/kWh) for residential PV (only up to 30kW). The stacks of FIT in Ukraine are protected by the Laws of Ukraine, "On the Electricity Market" and "On Alternative Energy Sources", which guarantee the payback period for new solar stations for an average of 5–6 years. It has stimulated the development of solar energy in recent years with the significant reduction of equipment costs in 2018/2019.

According to the amendments to the below stated laws, which were introduced in the middle of 2019, **the auction support system** should be implemented for new RE projects instead of FIT support scheme. The "test" auction should have taken place in December 2019 and the regular auctions should start from January 2020. Nevertheless, the Ukrainian government did not announce the support quotas for 2020 auctions and have postponed the start of auctions.

At the same time, in September 2019, the government initiated negotiations with huge RE wind and solar investors regarding the reduction of the FIT for new projects and offered retroactive changes for PPAs regarding the amount of FIT annual payments. Negotiations are still ongoing with the involvement of the Energy Community Secretariat's Dispute Resolution Center.

3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

Utility-scale vs distributed & rooftop solar development and plans

As of January 2020, most of the installed capacity of PV is utility-scale stations, amounting to 4925 MW, and 22 thousand residential solar systems with a total capacity of 553 MW. It is worth noting that residential PV is the fastest-growing type of RES generation in Ukraine. In the last three years, the number of residential PV has increased more than 70 times (from 293 to 21968 facilities) due to the introduction of FIT for residential PV in 2017.

Due to uncertainty about the future of retroactive changes for PPAs and problems with auctions, the amount of

investments to new PV reduced by three times in December 2019 and twice more in January-February 2020 (even before the COVID-19). Due to that same reason, more than 7,000 employees were dismissed in the Ukrainian solar industry since December 2019.

Challenges

The key challenges that face the Ukrainian solar sector include a lack of trust from the investor's side to the government's activities in the RE sphere, huge debts for purchased electricity (only 5-11% are paid for the period of March-May 2020) and possible retrospective changes

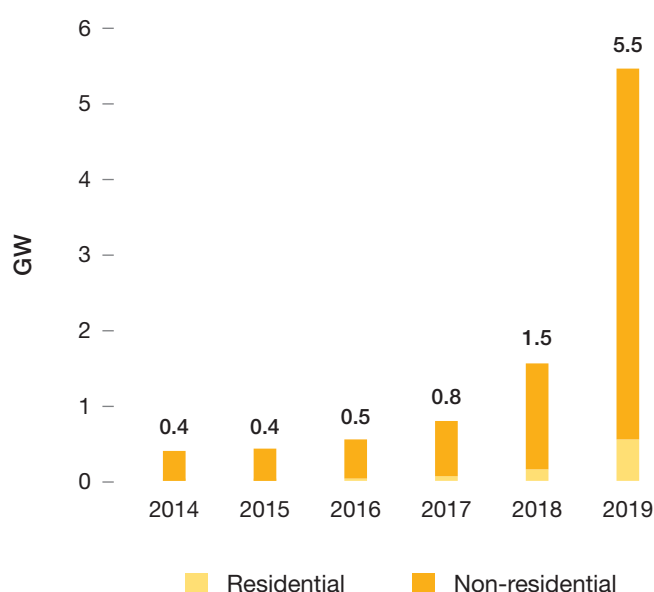
TABLE 3.5 INSTALLED CAPACITY OF SOLAR PV AND RESIDENTIAL PV, MW

	2014	2015	2016	2017	2018	2019
PV (excl. residential)	411	432	531	742	1,388	4,925
Residential PV	0.1	2	17	51	157	553

Source: State Agency on Energy Efficiency and Energy Savings of Ukraine.

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FIGURE GW 8 UKRAINE TOTAL SOLAR PV CAPACITY 2014-2019, BY ASEU



Source: ASEU.

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of the FIT for all RES facilities. Possible retrospective changes of the FIT PPAs will have a significant impact on small PV facilities (up to 20MW), as the payback period for expensive bank loans for this type of PV is the longest and is usually calculated by the end of the feed-in tariff, up to 2030. These changes will affect investments in the RES sector for the next 3-4 years.

The legislative framework for energy storage is still under development, which limits the integration of new capacity from renewables in the energy system. In addition, the Transmission System Operator has not taken any serious measures to modernise the grid over the past 5 years, which again limits the integration of renewables.

The impact of COVID-19 on Ukraine's economy, and the high cost of loans for residential PV are further obstacles for the development of solar. A final challenge is the postponement of the RE auctions implementation.

RES development 2020-2024 and conclusions

The COVID-19 outbreak and the introduction of quarantine measures in Ukraine, alongside high prices on

the electricity market, could increase the construction of industrial stations for self-consumption in 2020-2022. Foreign investors are not available to proceed in their business due to flight restrictions, which is sure to result in a decrease of foreign investments worldwide. This is why the total capacity of installed PV in 2020 in Ukraine under the support schemes will be at least 3-5 times less than the already built capacity in 2019.

In 2020-2024, the launch of RE auction support schemes in Ukraine is expected, which will significantly decrease the amount of subsidies for the solar PV industry, but will become the main driver for development in the sector. This will ultimately lead to an extension of utility-scale PV, but no earlier than 2021-2023.

The further development of BESS is necessary for the achievement of the goal of 25% RES by 2035 and further RES development. The limited growth of residential PV, due to impact of COVID-19, is expected. In the coming years, the Ukrainian solar sector will face a slowdown in the development of all new renewables (except wind PP). Yet one thing is clear: solar generation will retain its worldwide leadership among all new RES facilities due to it being cheaper, more scalable, and easier to install.

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

9. GERMANY

Overview of Solar PV Developments

The past year saw more growth in the German solar market – with nearly 4 GW installed, Germany has installed 34% more PV than the year before. When it comes to solar, Europe's largest economy seems to be back on a positive trajectory again, for now. While the market will likely stagnate in 2020 due to COVID-19, the base seems set for further strong growth in the coming years. Besides the regulated market of auctions, we see a number of projects that are outside the Renewable Energy Sources (EEG) remuneration regime. Corporate PPAs are starting to take-off, as witnessed by the first 50 MW+ connected in 2019, kick-starting a dynamic development as of 2020. For 2021, we expect total PV market demand of 6 to 7 GW.

Solar PV Targets in Germany

With the 2020 deadline fast approaching, suddenly it looks like Germany will now be able to meet its EU renewable target of 40% greenhouse gas (GHG) emission reduction due to one-time COVID-19 related effects and a mild winter at the start of the year. However, originally anticipating to achieve its targets, the German government agreed in 2019 on its Climate Action Programme 2030, which set a 65% renewable target in gross electricity consumption by 2030, in which solar's target is at 98 GW. Alongside the Climate Action Programme 2030, the first major national climate law entered into force in December 2019, enshrining into law a 55% GHG reduction by 2030 and stating that the country will pursue GHG neutrality by 2050. The decision of shutting down all nuclear plants by 2023 (at the start of 2020, only 6 were still active) also provides a significant market opportunity for solar in the short run. An exit from coal by 2038, passed by the parliament in January 2020, offers also huge business potential for solar in the mid-term. Discussions about land availability, fair sharing of regional benefits and added value in the biodiversity support the acceptance of PV in general, including in the large-scale segments.

Drivers for Solar Growth

As outlined in Germany's feed-in tariff law (EEG), support to renewable generation is provided through a feed-in tariff for systems below 100 kW, a feed-in premium for systems between 100 and 750 kW, and a tendering scheme for systems above 750 kW. In parallel, small systems below 10 kW are fully exempted from the EEG levy – the surcharge on electricity prices to finance the costs of the EEG – whereas systems between 10 and 100 kW are granted a 40% reduction on the EEG levy.

The remuneration system set out in the German FIT scheme depends on the country being on track to meet its annual installation target: FIT rates are decreased or increased based on installation levels achieving or falling short of the yearly target. Notably, the new energy law package that entered into force at the beginning of the 2019 lowered the benchmark from 2.5 GW to 1.9 GW, meaning that remuneration rates are digressing at a faster pace than before. At the start of 2020, also for small systems below 10 kW the FIT decreased below the 0.10 EUR/kWh level.

In Germany, there are three types of tenders for large-scale solar: regular tenders for projects between 750 kW to 10 MW; special tenders for projects of the same size, with the aim of installing a total capacity of 4 GW by 2021, and mixed wind and solar tenders. Regular tenders have been taking place three times per year with a volume of 2 x 150 MW, 1 x 175 MW and 2 x 500 MW each and are technology-specific. As Germany was not on track to meet its renewable energy targets, in addition to the regular solar and wind tenders, the government coalition agreed to organise extra tenders in 2019 and 2020, accounting for a total solar capacity of 4 GW. Finally, the two joint tenders for solar PV systems and onshore wind farms held in 2019 saw solar winning all the auctioned capacity. This trend continued in the first auctions scheduled for 2020. In terms of bids, after the constant price decrease experienced in the last three years, final auction prices have been stabilising around the 0.05 EUR/kWh (0.056 USD/kWh) range. Both the regular solar tenders and the extra tenders were oversubscribed in 2019. Bids submitted exceeded the quantity awarded by a factor of 1.73 to 4.3.

In addition to the existing operational incentives, a number of investment support options in the form of grants and low-interest loans are provided by German Development Bank (KfW), which also offers a special scheme for energy storage, which helped Germany to develop into Europe's largest solar market with around 65,000 residential installations in 2019, 44% up from 45,000 in 2018.

First PPA-based solar projects constitute a third pillar for solar deployment, in parallel to capacity installed through the EEG regime and self-consumption markets. A handful of 50 MW+ projects have been developed and connected; these projects are backed up with contracted PPAs with utilities and energy trading companies for 10-15 years. Even national railways operator Deutsche Bahn signed a first PPA agreement for a 42 MW project with an energy supply agreement of 30 years. Corporate PPAs have an own and somehow also uncontrolled dynamic. All parties must focus on the regional public acceptance of the generally larger system capacities, which are build outside the EEG system. In 2020, we are seeing already 100 MW+ projects outside the EEG regime which are build on older permits or on conversion land. Utilities, large investments funds and private investors are still very active in Germany looking for larger projects in PV.

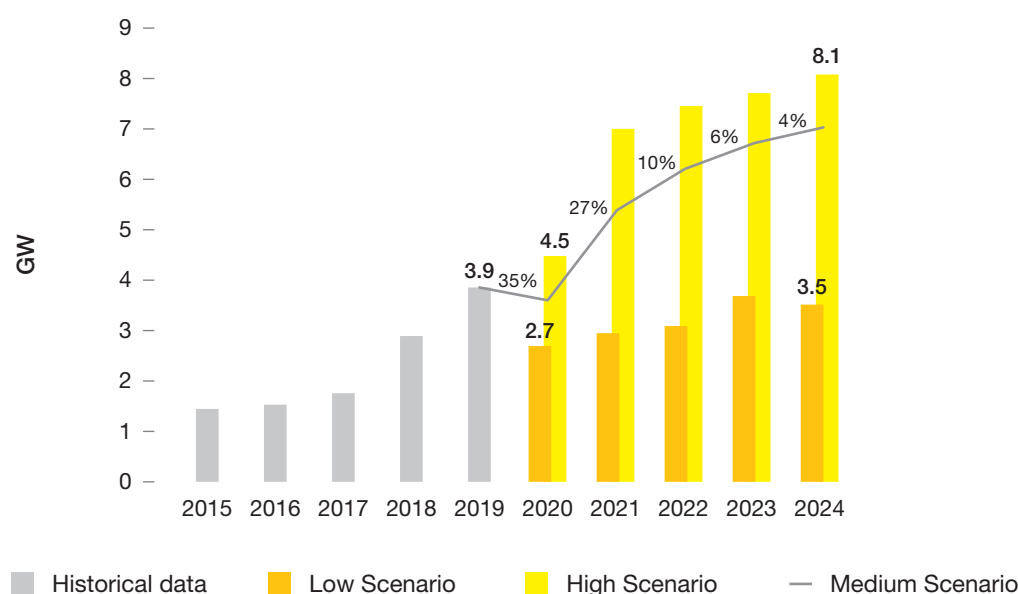
Challenges

The 52 GW cap for solar feed-in tariffs, as set out in the EEG law, seems to be deleted from the Act as the government agreed on its removal in May 2020. At the editorial deadline at the beginning of June, this was not yet in force, but was available as a draft.

Lowering the benchmark for annual capacity also represents a challenge for small-scale installations. With the annual soft target reduced to 1.9 GW, and demand now much higher, remuneration rates from the feed-in tariff system will quickly decrease which will make the economics for "FIT- only" systems very difficult in 2021; system owners will have to build their business case rather on a combination of FIP and self-consumption.

Another bigger FIT amendment is scheduled for summer 2020; it is not visible which changes will follow and whether or not it will incorporate the EU's RED II framework. As the COVID-19 crisis had a deep impact on electricity consumption and the wholesale prices, a massive rise of the EEG surcharge may occur in 2021. This puts high pressure on German policymakers to find a way to avoid this occurrence.

FIGURE GW 9 GERMANY ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

The economic drivers for solar and storage self-consumption systems are getting under pressure as the EEG surcharge may be reduced resulting in lower electricity prices and more burdensome grid responsibilities might be given to these systems. A whole new policy framework for this segment seems possible, as is it unclear how the FIT amendment will address these issues, including the RED II provisions concerning the right for self-consumption.

The Mieterstrommodell (on-site community solar) regulation introduced in 2017, enabling collective self-consumption of PV installations on apartment-buildings, continues to attract limited interest. The reasons are manifold: participants being subject to the full payment of the EEG levy, the 100 kW-size limitation, and further administrative and technical hurdles. Only 13.4 MW of systems have been installed under the Mieterstrommodell in 2019.

Despite these challenges, market developments in Germany are seen very positively and well balanced between residential, C&I, traditional large-scale projects in auctions and the new corporate PPA segment. Two main actions which can enable further growth would be carrying out deregulations speeding up the self-consumption segment in the C&I sector and highlighting the benefits of PV as a the main contributor to the Energiewende.

Author: *Bernhard Strohmayer, Head of Renewable Energies, German Association of Market Innovators (BNE).*



Hügelschart, Bavaria.

© BayWa r.e. / Eckhart Matthäus

10. SOUTH KOREA

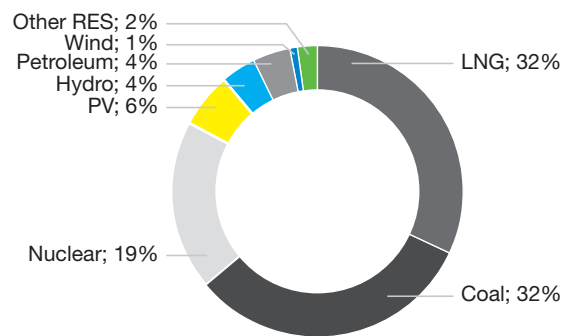
South Korea added 3,130 MW of new PV installations in 2019, up from 1,362 MW in 2017, and 2,367 MW in 2018. Thanks to the country's ambitious renewable energy target ("RE3020"), the country gained over 3 GW of PV installations for the first time ever. By the end of 2019, Korea reached a cumulative capacity of 11 GW. Since 2014, Korea has continuously ranked among the world's top 10 PV markets.

Korean Solar/RE Targets

Under the government strategy "RE 3020" set out by the Ministry of Trade, Industry and Energy (MOTIE) at the end of 2017, renewables are set to generate up to 20% of Korean electricity by 2030. The country's national energy plan from 2019 aims to provide a safe energy system and eco-friendly supply-demand energy structure through the implementation of a decentralized ecosystem with public participation. Every two years, the Korean government publishes a plan to forecast mid- to long-term electricity demand and to expand electric power facilities since 2002.

The '9th Basic Plan for Electricity Supply and Demand' announced in May 2020, predicts electric power supply and demand for the next 15 years, from 2020 to 2034.

FIGURE GW 10.1 SOUTH KOREA ELECTRICITY GENERATION CAPACITY IN 2019, BY KPVS

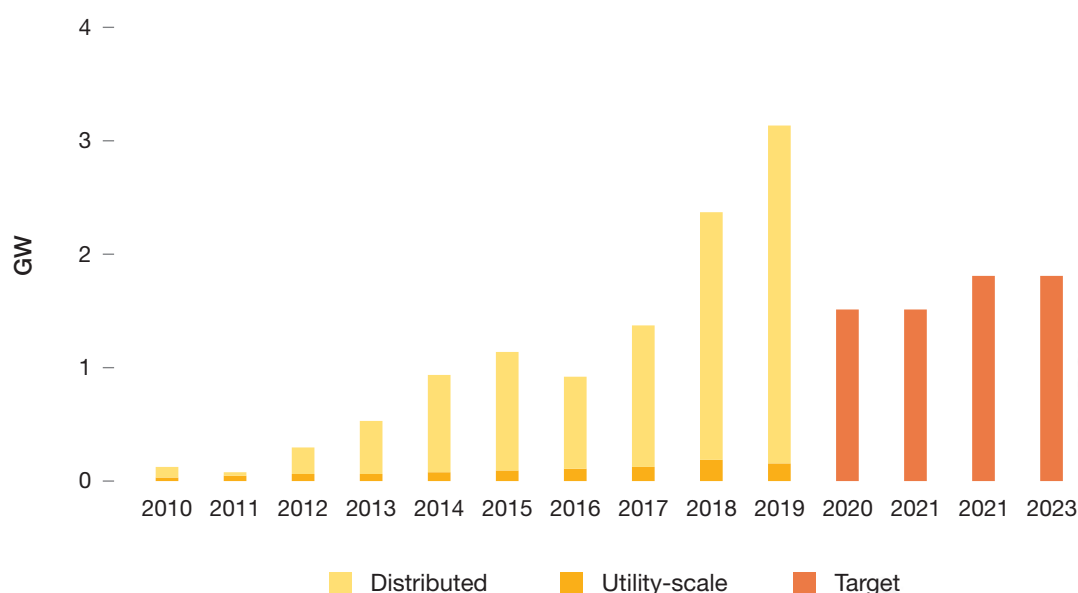


Source: KEPCO, Dec 2019.

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Generation capacity from renewables was 15.8 GW in 2019 and is expected to reach 19.3 GW capacity by 2020; renewables will reach 57.9 GW by 2030, and 78.1 GW by 2034, respectively. This would correspond to 33.1% and 40.0% (respectively) of the nation's total installed electric capacity, which is a strong leap forward from the 15.1% in 2020. Solar PV is expected to take the lion's share of renewable deployment, with over 50% of the new additions equal to 30.8 GW.

FIGURE GW 10.2 SOUTH KOREA SOLAR PV MARKET SCENARIOS 2020-2023, BY KPVS



Source: KPVS.

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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

Drivers for Solar Growth

A series of financial and non-financial incentives and programs have been set in place to support PV development in order to meet Korea's solar targets. The Renewable Portfolio Standards (RPS) scheme, launched in 2012 to replace the Korean feed-in tariff, is the major driving force for PV installations in Korea, especially small-scale systems. It mandates that utility companies exceeding 500 MW generation capacity are required to supply 6.0% and 10.0% of their electricity from new and renewable sources by 2019 and 2023 (from 2% in 2012), respectively. The bulk of PV installations in the country (91%) have been installed under this program.

Utility-scale vs. residential solar development and plans

Facing an issue with its mountainous terrain that makes it difficult to find areas for large utility-scale PV plants, the Korean government has identified distributed power production as one of the key policy goals for its energy planning. According to the national energy plan, distributed power generation should contribute to 30% of total generation by 2040 (more than 15% of total generation by 2035) compared to 12.2% in 2017. Due to its characteristics, solar PV will play a central role in the development of distributed generation. The government's commitment to developing smart grid technologies, including smart meters, energy storage systems and infrastructure for electric vehicles is another reason for the focus on distributed solar.

Korea plans to encourage more people to participate in the expansion of renewable energy, to develop in a planned manner and to support and promote large projects with deregulation. Incentives for solar PV in buildings exist under the Home Subsidy Program, the Building Subsidy Program, and the Public Building Obligation Program. The Public Building Obligation Program sets out sustainability requirements for newly constructed or expanded large public buildings with floor areas of more than 1,000 m², stating that more than 27% of their energy consumption must come from renewable sources in 2019, with the target increasing to 30% by 2020. The Zero Energy Building Obligation Program will apply for public buildings with > 1,000 m² floor area from 2020, public buildings with > 500 m² and private buildings with > 1,000 m² floor area from 2025, and all buildings from 2030.

Challenges

Korea Electric Power Corporation (KEPCO) still enjoys a monopoly over transmission, distribution and remains the sole purchaser in the power sales business. Given this structure, there are no mechanisms available for private companies to purchase renewable energy power directly from independent solar power producers. Korea has a problem due to delays with grid connection of renewable energy systems. In order to connect the renewable energy capacity to the grid, the "Long-term Transmission and Transmission Facility Plan" and "Annual Transmission and Transmission Facility Plan" have been established and the "Renewable Energy grid connection TF" is being operated with participation of KEPCO, Korea Energy Agency, and Korea Power Exchange.

Outlook

The PV market in Korea will be greatly expanded by the RE3020 policy, and it will enter into a sustainable virtuous cycle structure through strengthening acceptance, lowering the installation cost, and expanding the market. The market for ESS (energy storage systems) will also increase by the expansion of the PV market, while the electric power market is expected to change owing to the expansion of VREs (variable renewable energies), especially PV and wind.

The goal of photovoltaic power deployment has been conservatively set at the 2 GW level every year since 2020, but it recorded 1.16 GW in the first quarter of 2020, which is the first figure to exceed 1 GW in a quarter in terms of solar power deployment. If current trends continue, new PV installations could approach 4 GW in Korea in 2020. However, COVID-19 is expected to increase uncertainty after the second quarter.

Authors: *Prof. Son, Chang Sik, Vice-President, & Prof. Cho, Eun-Chel, Director, Korea Photovoltaic Society (KPVs).*

11. THE NETHERLANDS

Project pipeline doubled to 15 GW; Solar now must compete with CCS projects for new subsidy grants

With the 2020 Spring SDE+ subsidy round completed, the project pipeline with SDE+ subsidy-awarded projects has now grown to a record 15 GW. The pipeline includes both rooftop commercial and ground-mounted projects, with rooftop making up the lion's share. Approximately 1.6 GW of solar was deployed in 2019 (excluding residential) and now there is another 15 GW of projects to go. The main challenge now is 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 now officially in grid congestion, meaning no new projects can be connected to the grid in the near term.

In 2020, the Dutch solar market will grow again, expected to reach 2.5-3.5 GW, with the varying range due to market uncertainties caused by the COVID-19 crisis. Most projects are expected to progress as planned but could also face delays in implementation.

Many system-size records in 2019

In October 2019, a 103 MW solar park was completed in Hoogezand, in the province of Groningen in the north of the country, and the construction of another solar park

larger than 109 MW will soon begin in the same province. A number of floating solar projects were also completed in 2019 – the largest being a 15 MW array built on a sandpit in the area of Zwolle. Currently, the country's largest rooftop project has a capacity of 18 MW (warehouse in Venlo).

The biggest market segment in 2019 was the commercial rooftop market, with a share of around 40% (0.9 to 1.1 GW); the residential market had a share of nearly 40% (0.8 to 1 GW). Finally, the market for ground-mounted and floating solar PV accounted for more than 20% (0.4 to 0.6 GW). These estimates are based on the completion of 2018 projects and the applications for the SDE+ in 2017-2019.

The residential market saw continuous growth, and it is expected that this will stabilise at a level of at least 800 MW per year. Residential solar is an important market segment for the Netherlands; although small, it helps create awareness and support for the energy transition among citizens, leading to greater acceptance of the (spatial) consequences of introducing solar and wind energy into the energy mix.

Dutch policy/RE targets

The Netherlands will not fulfil its EU 2020 targets from national sources, which would see renewable energy account for 14% of the country's total energy mix. The European 14% renewable energy target for 2020 will not



11.7 MW, Achtkarspelen, Friesland.

© Solarfields

3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

be achieved either, at 11.4% [10%–12%]. However, there is an impressive pipeline of projects both in solar and wind (off-shore and on-shore). The Energy Agreement 16% renewable energy target for 2023 is therefore projected to be achieved, with 16.1% [14%–17%].²

A Climate Law with a CO₂ reduction target of 49% in 2030

A Climate & Energy Agreement was reached in 2019 between a broad range of stakeholders concerning the distribution of the required CO₂ reduction throughout a range of sectors, including: built environment, electricity, industry, mobility, and agriculture. The agreement entails that at least 75% of electricity in 2030 will come from renewables. The electrification of heat (industry) and mobility (personal cars) will dramatically increase the need for electricity. The Netherlands targets a 95% CO₂-reduction for 2050.

Drivers for solar growth

The residential solar market is driven by net-metering; there is no limitation or charge for net-delivery. From 2023, the right to use net-metering will gradually decrease, with 9% every year, up until 2031, when net-metering will no longer exist in the Netherlands. This

degressive path is based on a seven-year payback time for the prosumer, assuming 30% self-consumption and an optimal situation. Besides net-metering, small businesses with solar system connections up to 3*80 A are offered a fiscal advantage in their profit tax.

Up until the present, the Netherlands' commercial and utility-scale market was driven by the SDE+ tendering scheme, where solar had to compete with other renewable energy sources. In the scheme, a different maximum capacity was on offer, dependent of the technology (wind, biomass, solar), the size, and the application (ground-mounted, rooftop, floating). In 2019, there were two subsidy rounds – in the spring and autumn – with a budget of 5 billion EUR (5.64 billion USD) each. The projects had to have sizes of at least 15 kW, with no maximum size. In the spring of 2020, the last round in the current format has been held. The SDE funds are collected by a surcharge on the consumer and commercial electricity prices (ODE).

As of autumn 2020, it is agreed that the SDE scheme, which will remain in place until 2025, will be broadened in scope, including energy saving projects and CCS. The ranking in the amended scheme (now called SDE++) will be based on euros per kilo-ton CO₂ avoided. The maximum SDE++ contribution will be lowered every year. This will also depend on the reference price of



Tienbunderweg Solar Park, Hengelo.

© SolarCentury/Twence

2 Source: <https://www.pbl.nl/publications/climate-and-energy-outlook-2019>

energy based on fossil fuels. However, the expectation is that solar energy projects can be developed, in 2025 at the latest, without any incentives based on PPA contracts. Utility-scale solar is estimated to reach grid-parity in 2022-2023.

Future market development

Holland Solar, the Dutch Solar Energy Association, is positive about the market development for the next five years, as can be seen in our forecast (see graph). The market is divided into two parts: (1) the residential and small businesses market (both < 3*80A), and (2) the commercial and utility-scale market. Commercial-scale includes large rooftop projects, and utility-scale covers solar parks. Our forecast was more or less confirmed by a recent publication from Wood Mackenzie, which estimated a growth of 12.9 GW in the next five years, equal to an average newly-installed capacity of 2.58 GW per year.

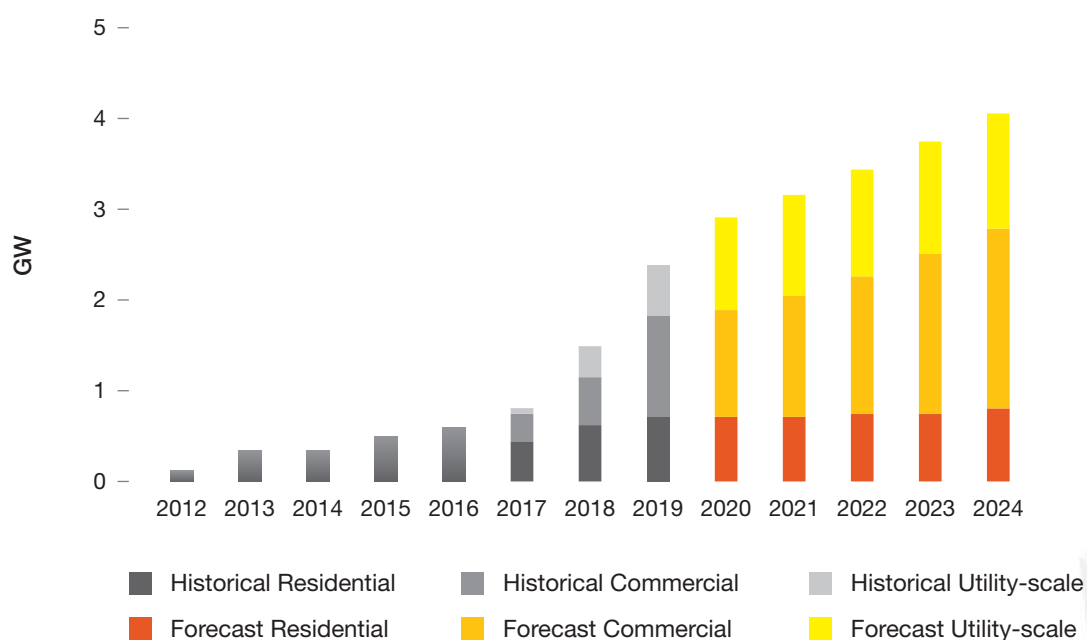
Challenges

One of the main challenges for solar in the Netherlands is securing timely grid connections. In several areas throughout the country, there is simply a lack of grid capacity. Additional reserve capacity will be put into general use by the grid operators and maximum grid capacity per installation will most likely be reduced to below 70% of installed capacity.

Another challenge the country faces is finding space, especially for utility-scale projects, as well as social acceptance when it comes to using land for solar energy projects. Government policy is to prefer rooftop over fields for solar installations. A code of conduct has been established supported by many NGO's and stakeholders on how to best integrate solar with the natural environment.

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

FIGURE GW 11 NETHERLANDS ANNUAL SOLAR PV MARKET SCENARIOS 2019-2024, BY HOLLAND SOLAR



Source: Holland Solar.

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12. BRAZIL

Overview

In 2019, Brazil continued its strong solar PV growth in the two main market segments of the country: (1) centralised generation (utility-scale projects, above 5 MW, commercialised in energy auctions held by the government and through direct PPAs in the free electricity market), and (2) distributed generation (small- and medium-sized projects, equal to or below 5 MW, via a national net-metering regulation). Installations grew to a record 2,114.4 MW – 1,458.0 MW in distributed generation, and 656.5 MW in centralised generation.

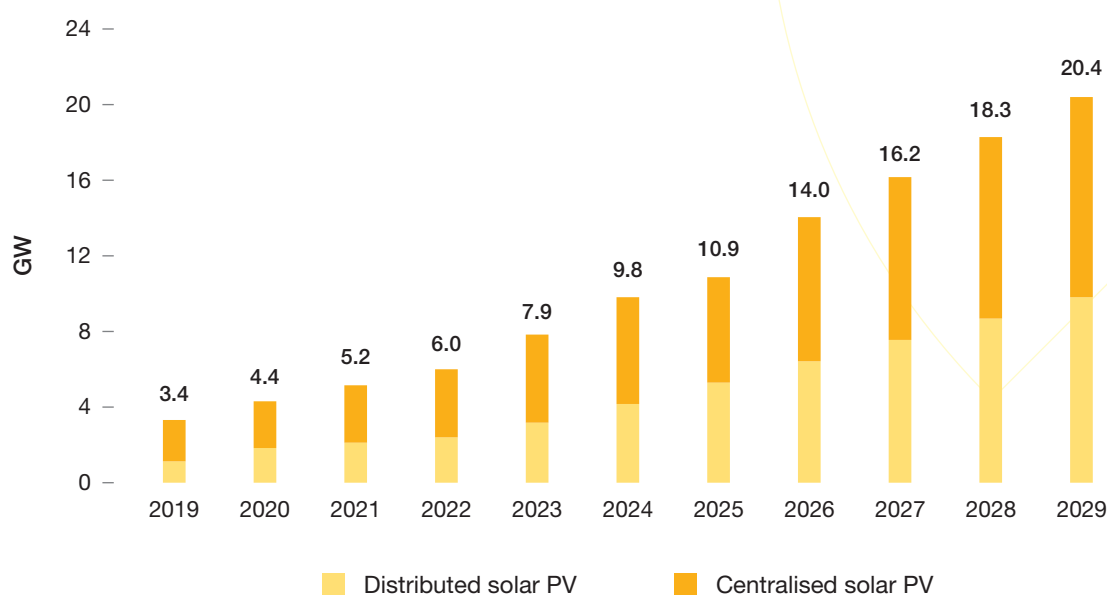
In the first quarter of 2020, the country reached the 5 GW milestone, surpassing all official governmental expectations. Before the effects of the COVID-19 pandemic, the Brazilian Solar Photovoltaic Energy Association (ABSOLAR) projected a total increase of more than 4 GW in 2020. However, the number is likely to be impacted by the effects of the pandemic on the global and national economy.

Solar PV targets

The Brazilian Energy Research Office (EPE) forecasts in its 10-Year Energy Plan (PDE 2029) that solar PV would reach 20,444 MW of cumulative installed capacity by 2029, in its reference planning scenario. For centralised generation, PDE 2029 considers energy auctions adding a yearly capacity of 1,000 MW between 2023 and 2029. For distributed generation, it projects 9,822 MW of cumulative installed capacity by 2029.

Considering both centralised and distributed generation, the PDE 2029 forecasts 1,709 MW of solar PV added capacity on average per year, between 2019 and 2029. ABSOLAR evaluates these numbers as below expectations, due to the excessively conservative premises used on the study. Based on current data on the increasing competitiveness of solar PV and, despite the effects of the COVID-19 pandemic, ABSOLAR recommends a national PV target of at least 30 GW by 2030.

FIGURE GW 12 BRAZIL TOTAL SOLAR PV CAPACITY SCENARIOS 2019-2029, BY ABSOLAR



Source: ABSOLAR, based on official data from EPE, 2020.

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Challenges

In 2019, solar PV centralised generation market growth in Brazil mainly came from projects commercialised under the federal government Reserve Energy Auctions (Leilões de Energia de Reserva – LER) of 2015. The New Energy Auctions (Leilão de Energia Nova – LEN) held in June and October 2019 (LEN A-4/2019 and LEN A-6/2019) represent a new phase for large projects in terms of competitive prices. The auction in June reached an average sale price of 17.62 USD/MWh, whereas the auction in October reached 20.33 USD/MWh – both results were lower than the average sale prices of wind, small hydroelectric, biomass, and fossil fuel power plants, highlighting solar PV as one of the most competitive energy sources in Brazil. In total, 733.7 MW of projects were contracted in 2019 and will be delivered and operational by January 2023 and 2025, respectively. In early 2019, the federal government established an agenda with two new auctions per year until 2021, however, due to the COVID-19 pandemic, the auctions planned for 2020 are now on hold.

2019 saw an increase of 650 MW brought online in centralised generation. The increased competitiveness of solar PV in the country resulted in a pipeline of more than 5.7 GW in direct PPAs being evaluated in the so-called “free electricity market” (Ambiente de Contratação Livre – ACL) by December 2019. This shows the growing interest of large corporate consumers in solar PV electricity, despite challenges related to bankability and grid connection bottlenecks, topics that ABSOLAR is tackling with the participation of the sector. In terms of distributed generation, 2019 was a record-setting year. The increasing competitiveness of solar PV under the net-metering regulation throughout the country led to an added

capacity of 1,458 MW compared to 397 MW in 2018, which represents a strong improvement for the sector.

To date, Brazil has a full national net-metering programme for projects up to 5 MW, including both local and virtual net-metering, as well as community solar mechanisms. This has allowed 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. In this regard, there was a public consultation that took place in 2019, which assessed the benefits and costs of distributed generation in the market and its impacts in electricity tariffs. It is not clear if a final decision about the topic will be made in 2020, considering the new focus of decisionmakers in actions to address COVID-19.

ABSOLAR’s recommendation from the solar PV sector to the Brazilian Electricity Regulatory Agency (ANEEL) is that with proper technical analysis, the benefits of distributed generation greatly outweighs the 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 economic recovery related to COVID-19, as it can create new investments, opportunities, and jobs at the municipal, state, and federal levels. ABSOLAR defends the Brazilian solar PV sector in this and other strategic decisions affecting the development of solar PV, with recommendations to make solar PV a decisive tool to support the 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.*



Headquarters of the Ministry of Mines and Energy, Brasília, DF.

© Samuca Mello, MME/PR



225 MW, Ituverava, BA.

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13. TAIWAN

Overview of Solar PV Developments

In 2018, the Taiwanese solar market fell short of achieving the GW milestone, but only by a few dozen MWs. In 2019, with 1,412 MW installed year-on-year, the market is now firmly in the GW solar club, and is expected to remain in the future. The GW scale has been reached despite concerns surrounding the termination of the previous feed-in tariff (FiT) regime, which offered advantageous rates for PV systems at all scales.

Under the FiT scheme announced in September 2019, the new remuneration rates, applicable from January 2020, are lower than they were in the past, with a decrease ranging from 0.34% for small residential systems below 20 kW, to 2.2% for utility-scale projects. The new tariffs, now set between 13 and 19 US cents/kWh, are nonetheless still attractive for investors. A bonus on the remuneration rate can be added if the awarded project falls under the Green Energy Roof scheme (+3%), if high-efficiency modules are used (+6%), and if the project is located in particular rural and remote areas (+15%). The new regime also sets out a local manufacturing bonus – “VPC policy” – under which projects using locally-manufactured PV modules are

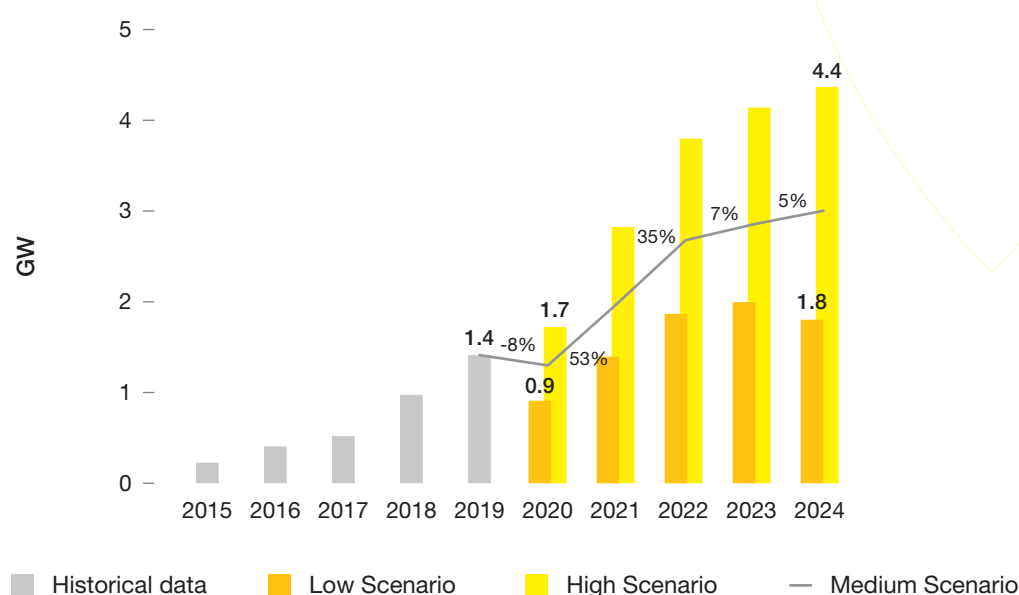
granted a 6% bonus on the FiT. This measure is meant to protect the Taiwanese solar manufacturing industry, which has been consolidating in recent years due to increasing pressure from mainland China.

Solar PV targets and drivers

The government has set ambitious targets for solar. A total of 20 GW of PV capacity is expected to be installed by 2025, broken down into 3 GW of rooftop systems and 17 GW of ground-mounted projects. That means around 16 GW must be installed in the next five years. In September 2019, Prime Minister Tseng-Chang announced plans to build 3.7 GW of new solar capacity before 2021, in order to ramp up total installed capacity to 6.5 GW by the end of the year.

The rapid uptake of solar capacity is driven by growing energy demand and the need to reduce reliance on conventional power sources such as coal and nuclear. Under the Greenhouse Gas Reduction and Management Act, carbon emissions should be reduced by 20% by 2030, and 50% by 2050 compared to 2005 levels. These goals are quite ambitious compared to many other East Asian countries. In the aftermath of the Fukushima accident in 2011, Taiwan is also phasing out nuclear

FIGURE GW 13 TAIWAN ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



capacity by no later than 2025. In addition to this, following the COVID-19 crisis, an increasing part of civic society is asking for a green recovery plan to boost the uptake of renewables. Taiwan has ambitious short-term goals, targeting an increase in its renewables share in power generation from 6% in 2019, to 20% by 2025.

Challenges for Solar PV growth

Land availability is the key challenge to solar deployment in Taiwan. As a densely-populated island, and with two-thirds of the country's land constituted by mountainous areas, solar developers are facing growing challenges to find suitable locations for their projects. In a context of limited rooftop availability and government targets mostly relying on large-scale capacity, the deployment of ground-mounted projects is hindered by hurdles in purchasing land. Often, large-scale projects span over several landowners, something that is making negotiations for land acquisition very challenging and lengthy. Resistance from the local agricultural sector is exacerbating this issue. On top of land acquisition issues, slow bureaucracy processes are causing significant delay in project approval.

Against this background, alternatives that make use of currently unused areas are looked at with growing interest. Floating solar projects are high on the agenda, although they must cope with the challenges of extreme weather events, in particular, typhoons. Similarly, aquavoltaic projects – floating solar on fish farms – is gaining a lot of attention. Aquaculture ponds have an estimated solar potential of 40 GW in the country. While covering fishponds with PV somewhat reduces the oxygen in water, under the new FiT regime the loss in aquaculture yield would be more than compensated by revenues from electricity generation.

The PV industry in Taiwan is undergoing profound changes – wafer, cell, and panel manufacturing are shrinking dramatically due to fierce international competition. It is unclear at this stage whether the VPC bonus will remain at the current levels; from their side, local manufacturers are lobbying to increase it under the condition of further efficiency gains.

From the financing point of view, the attractiveness of the FiT regime remains high, and is leading to interest from foreign investors. On a political level, the re-election of incumbent president Tsai Ing-wen in January 2020 has contributed to a perception of high stability in the support of solar deployment.

Author: *Raffaele Rossi, SolarPower Europe.*

14. MEXICO

Overview of Solar PV Developments

For the second year in a row, Mexico has joined the solar GW club, with 1,360 MW installed year-on-year in 2019. In 2018, the solar market reached the gigawatt scale for the first time with 2.8 GW installed, booming by a factor of 10 compared to the previous year. Currently, the country has over 5.5 GW of installed capacity allocated between large-scale projects and distributed generation.

Long-term auctions (SLPs) have so far played a paramount role in solar PV deployment in Mexico, which is predominantly composed by large-scale installations. After two successful renewable energy auctions in 2016, the third auction round was held in November 2017, with solar getting the largest share of renewable energy projects (55%) for a total 1.3 GW of solar capacity contracted. An average price of 20.57 USD/MWh set a world record low at the time. The three auctions together allocated 4.8 GW of solar generation capacity.

While the solar capacity awarded in the three renewable auctions has guaranteed a solid market until 2020, recent policy developments have put the local solar industry in a limbo. In February 2019, the newly installed administration, cancelled the fourth renewable energy auction, after it had been temporarily suspended in late 2018. To date, it is unclear whether a new auction round will take place.

Another shake to the future of solar in Mexico was given when state-owned electric utility CFE announced in a press release to be mulling a review of existing contracts awarded in the three past renewable energy auctions, further increasing investor uncertainty.

In the context of the COVID-19 crisis, on 29 April 2020, the government introduced new limitations to renewable projects citing the need to preserve the country's energy security. The National Energy Control Center (CENACE) put an indefinite hold on new wind and solar projects about to begin testing or to connect to the national grid. However, only a few weeks later several projects have been given permission to resume their work, following several "amparo" lawsuits that were filed against this provision.

Adding to this current context is the publication of the Agreement of The Ministry of Energy (SENER) that modifies the conditions for the electricity sector.

Solar PV targets/ drivers for solar growth

As part of the energy reform introduced in 2017, Mexico set a target of 35% renewable electricity by 2024, up from 21% in 2017. This reform restructures the entire electricity sector, starting from unbundling state-owned utility CFE, and opens up competition in the market.

In order to achieve the 35% clean energy target, a clean energy certificate (CEC) scheme was introduced in January 2018. The scheme mandates retail suppliers and large consumers to meet a share of their energy with renewables through a quota system. These actors are able to buy and sell CECs in a cap-and-trade scheme. Every year, the clean energy requirements target is raised, jumping from 5% in 2018 to 13.9% in 2022.

Relevant initiatives are taking place regarding the legislative framework for distributed generation. Asolmex has pushed to increase the capacity threshold for PV systems that are exempt from too cumbersome administrative obligations – under this proposal, the threshold would be lifted from 0.5 MW to 1.0 MW. Likewise, the Chamber of Representatives recently approved an initiative to reform the Electric Industry Law with the goal of promoting the use of solar roofs in federal administrative buildings. Finally, the Energy Regulation Commission issued a regulatory framework for the operation of community solar schemes, which will enable solar projects for small communities.

Challenges and perspectives for solar PV growth

With 80% of the market being comprised by large-scale projects coming through auctions, the key aspect determining the development of solar in Mexico is related to the restart of renewable auctions. For the time being, with national SLP auctions on hold since 2017, the utility-scale sector has turned its attention to bilateral PPAs, which have become the only option available for large-scale projects. In addition, Mexico's

first private auction for renewable power was organised in mid-2019 following the cancellation of the fourth SLP auction. However, though demand was large, the final awards planned for early 2020 were delayed due to change of public administration.

National utility CFE's plans appear to be heavily based on conventional generation expansion, as shown by the recent announcement of 13 GW new generation capacity, without referring to renewable energy. This delivers a stark contrast with national energy and climate targets.

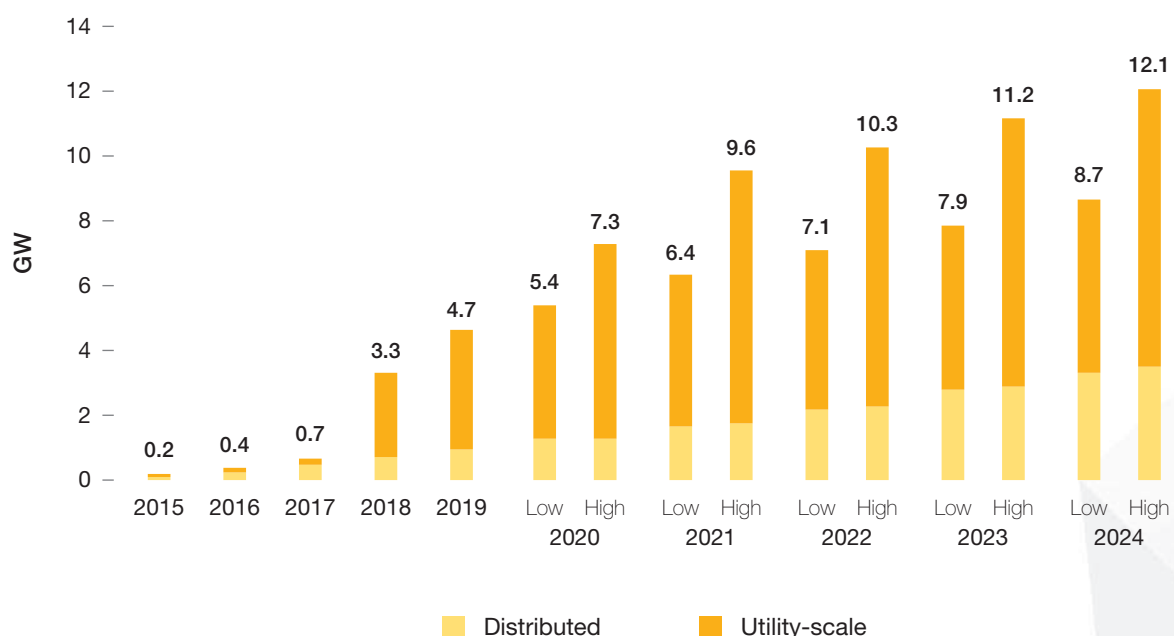
The outlook seems brighter when looking at distributed generation, which policy framework remains untouched by the current administration. While there are currently over 110,000 solar roofs in the country, with an installed capacity of 818 MW, the growth potential of the segment remains high, and it is estimated it can reach up to 25 GW by 2030. However, in response to the COVID-19 crisis, CFE is not applying high electricity consumption rates during lockdown. Under this perspective, lower electricity prices would worsen the cost-competitiveness of rooftop solar.

A key challenge for the Mexican solar sector is the currently underdeveloped power grid, which poses a threat to future solar expansion, especially large-scale plants that are developed in remote areas. To face these obstacles, grid management improvement actions should aim at strengthening the capacity of transition and distribution systems, as well as incentivising more distributed generation and demand-side response.

The Mexican wholesale electricity market is still missing an energy storage regulation, a crucial regulation for the development of this sector. On a positive note, the first utility-scale solar and storage plant in the country started operations in 2019, amid a promising outlook in terms of bankability for future solar and storage projects.

Without a doubt, solar roofs are now more than ever an important catalyst for developing the economy of the country through clean and competitive energy, that empowers the consumers while providing a necessary relief to the existing distribution networks.

FIGURE GW 14 MEXICO TOTAL SOLAR PV INSTALLATIONS FORECAST 2020-2024, BY ASOLMEX



Source: ASOLMEX.
Low scenario: with CENACE & SENER measures.
High scenario: without CENACE & SENER measures.

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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

Asolmex considers that the market will grow continuously over the next 5 years from a total of 4.66 GW end of 2019 to 8.7 GW by end of 2024, meaning installations would remain below the 1 GW level.

However, if conditions in México become stronger; by opening Distributed Generation to 1MW, the rules for the Community Solar, and others, we assume that the market would grow stronger to 12 GW.

Author: Mexican Association of Solar Energy (ASOLMEX).



Aura Solar I, 30 MWac, La Paz, BCS.

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15. UNITED ARAB EMIRATES

The solar energy market in the UAE has grown rapidly in recent years, adding for the first time in 2019 over 1 GW for the year. This positive solar development has been driven by several factors, namely the UAE governments' focus on energy diversification and the continued falling cost of solar technology. The UAE has made its mark by securing some of the lowest tariffs globally for utility-scale solar projects. For example, the Al Dhafra 2 GW solar project in Abu Dhabi, achieved a global record low tariff in the midst of the COVID-19 pandemic. There has also been significant progress made in distributed generation throughout the UAE, particularly in Dubai, via the Shams Dubai program.

Solar targets

UAE is a leader in the Middle East's energy transition, with the highest portfolio of renewables in the region. The UAE Vision 2021, Green Growth Strategy, Future Strategy, as well as the UAE Climate and Energy Plan 2050, all set high targets for renewables. The aim is to raise the share of clean energy to 50% by 2050, of which 44 % would be supplied by renewables and 6% from nuclear power.

Drivers for growth

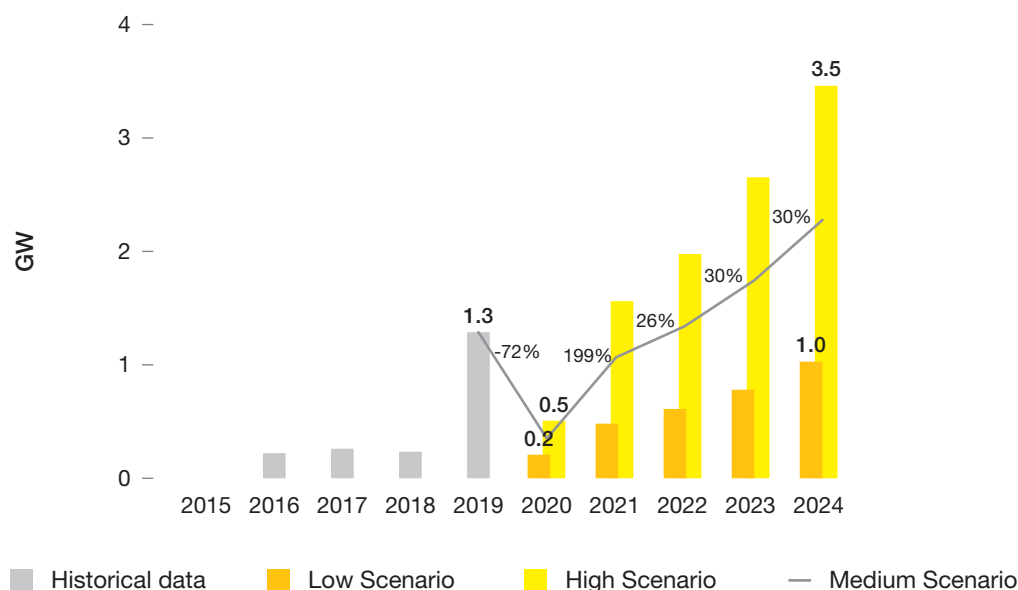
The key drivers for the growth of solar in UAE has been the clear support and targets set by the UAE government, coupled with a robust regulatory framework to support such projects. For example, in 2014, Dubai enacted net metering regulations which enabled the connection of self-consumption generators to the distribution network and netting off import and exports of power to the distribution system. This kick-started the distributed generation market in UAE. Abu Dhabi has also enacted small-scale solar PV regulations in 2017 to encourage rooftop solar installations.

The continuous improvements in technology and falling prices of products, such as modules, has also been a driver for growth. In relation to large-scale solar PV, the availability of cheap funding and the support from government in the form of robust project documents have enabled these projects to take off in the UAE.

Utility-Scale and Distributed Solar

UAE's achievements are increasing every year. Some of the key developments for solar include the following projects:

FIGURE GW 15 UAE ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



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3 GW-SCALE SOLAR POWER MARKETS IN 2019 / CONTINUED

- **Al Dhafra Solar PV project:** The world's lowest tariff of 1.35 US cents/kWh was announced for the 2 GW Al Dhafra Solar PV Plant in April 2020. The project, located in Abu Dhabi, will power 160,000 UAE homes, and is expected to be operational in the second quarter of 2022.
- **Sweihan Solar PV project:** This project, also located in Abu Dhabi, entered commercial operation in mid-2019 with 1.17 GW capacity. The 871 million USD project has more than 3.2 million panels and provides power for 90,000 people.
- **Mohammed Bin Rashid Al Maktoum Solar Park (Phases 1-5):** This is a huge solar park (up to 5 GW) being developed in Dubai. Phase 4 was a 900 MW CSP plus solar PV project, which was awarded at a record low price. It was also unique in that the project used two different CSP technologies (parabolic trough and tower) combined with bifacial PV modules. Phase 5 of the solar park of 900 MW PV capacity was awarded in October 2019 at a global record price of 1.69 US cents/kWh. The current total production capacity of the park is 713 MW.

In relation to distributed solar, the Shams Dubai program has been promising, especially in the commercial and industrial segments. By October 2019, 1,354 photovoltaic installations in Dubai were already connected with a total capacity of 125 MW. The Dubai

utility also implemented a rooftop project in Hatta, UAE, whereby 640 villas were retrofitted with solar rooftop panels and a number of installations were installed on government buildings, schools, and mosques. In addition, Dubai has announced that all buildings are to be fitted with rooftop solar installations by 2030.

Challenges

One of the key challenges for solar to provide a true alternative to fossil fuels is the intermittent nature of solar energy. Therefore, the combination of solar and storage solutions will become more important. A challenge to date has been the relatively high costs of storage solutions, but the costs of storage is falling, and we expect this trend to continue. We are starting to see more tenders being issued with solar PV and battery storage solutions and hybrid solutions such as the combination of solar PV and CSP. Hybrid projects will become more attractive as they will be able to provide dispatchable power with cheaper solar PV power during the day.

In relation to distributed generation, a key challenge is the relatively low residential tariffs and subsidies in the region. This does not provide the necessary incentives to change consumer behavior towards renewables. A related issue is the lack of regulatory framework in all jurisdictions to enable self-consumption.



869 kW, Dubai.

© BPC / Greenhouse Rooftop Project - Yellow Door Energy

Outlook

The outlook for solar energy in the UAE is very promising. Currently, solar capacity has largely been to manage peak demand. The next phase will see the roll-out of storage technology, innovation through artificial

intelligence, and increased distributed generation projects. We also expect new technologies such as bifacial modules and thin films that promise greater efficiencies for solar projects across the region. The future will be a move towards decarbonisation, digitization, and decentralization.

Authors: *Gurmeet Kaur, Marketing & Communications Director, & Dania Musallam, Research & Content Manager, Middle East Solar Industry Association (MESIA).*



Mohammed Bin Rashid Solar Park.

© Ghadir Shaar

16. EGYPT

Overview of PV developments

Last year was very successful for solar PV in Egypt, with the full commissioning of the Benban Solar Complex with a total capacity of 1,465 MW. This project alone has propelled Egypt to the second largest PV market in Africa, with a total installed capacity of 1,647 MW by the end of 2019. Next to PV, the country also bolsters 140 MWe of CSP.

Thanks to this major Benban achievement, the Egyptian government has announced in May 2020 its plan to add another 3 GW of renewable energy, including almost 1 GW of solar in the short term. Exact details are still to be shared. And this comes on top of projects that have been proposed spontaneously by developers.

But large-scale solar was not the only winner of the Egyptian solar market. Both residential and C&I solar have experienced great progress as the government has started to gradually remove subsidies on retail electricity prices. Consumers have logically started to feel the pain of cost-reflective grid electricity prices and have naturally turned increasingly to solar solutions to reduce their electricity bills. It is expected that both these segments will grow massively in the years to come.

Egyptian Solar/RE Targets

By the end of 2019, Egypt relied on 52,000 MW thermal capacity and nearly 6,000 MW of renewable capacity. The lion's share of RE capacity was composed of hydro resources with 2,832 MW, followed by PV, wind at 1,375 MW, CSP and biomass at 11.5 MW.

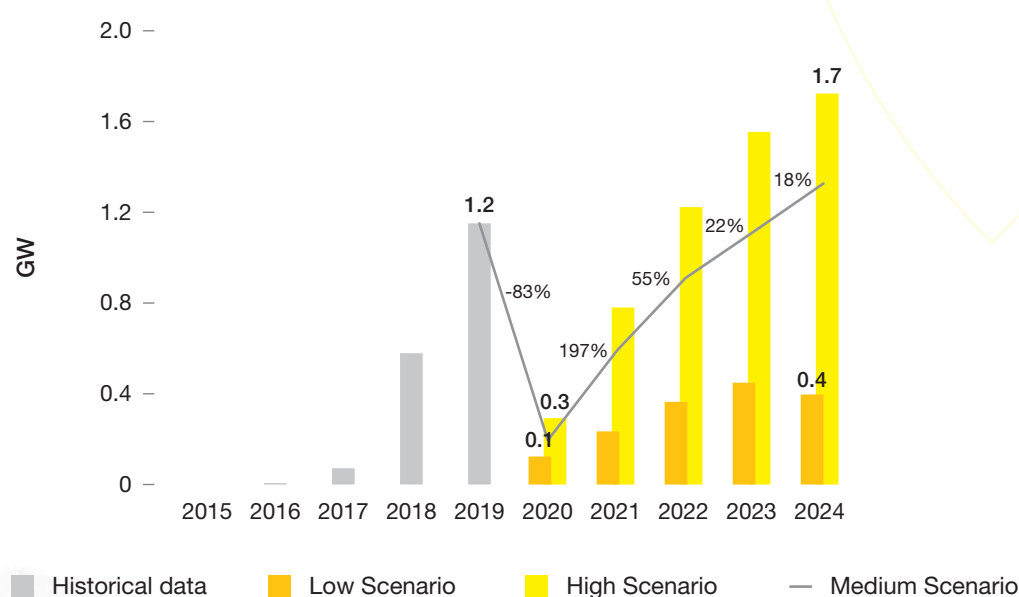
Egypt aims to reach 20% RE in its national energy mix by 2022, and 42% by 2035. In 2022, PV is expected to contribute 2% of total energy production, wind 12% and hydro 6%. The remaining 80% originating from thermal power plants.

By 2035, the share of renewables will reach 42% of total energy produced. PV will be the major contributor with 22%, followed by wind at 14%, CSP at 4% and hydro decreasing to 2%.

Drivers for Solar Growth

The success of the solar industry in Egypt has been fueled by a combination of policies and flexible mechanisms that encourage the participation of private investments in its projects. These include various tenders for EPC, BOO, and IPP schemes, as well as a feed-in-tariff policy and a net-metering scheme for projects below 20 MW.

FIGURE GW 16 EGYPT ANNUAL SOLAR PV MARKET SCENARIOS 2020 - 2024



In parallel to providing these mechanisms, the Egyptian government has also embarked on a gradual removal of subsidies for retail grid electricity price. This move has had the anticipated effect as many consumers have started to realise the “true” cost of electricity and are increasingly turning to solar to keep their electricity expenses under control. This is happening not only for the C&I segment, but also for the residential consumers.

Another supporting element comes from the activities of NREA, the New and Renewable Energy Authority. Next to coordinating large-scale projects, NREA has successfully created a supportive environment for the roll-out of smaller solar applications. To circumvent any potential quality issues, testing labs have been established under the latest international standards, to ensure the quality of a broad range of products, including solar water heaters, PV modules, as well as home-appliances such as refrigerators, dishwashers, and others to ensure energy efficiency. Moreover, a program for accrediting PV installers has also been implemented to ensure quality installations are being provided to small and medium users.

Finally, the Egypt-PV entity has been created to support the development of the small solar project segment (<500 kW). Egypt-PV is implemented by the Industrial Modernisation Center (IMC) in cooperation with the United Nations Development Program (UNDP), and funded by the Global Environment Facility (GEF). Egypt-

PV has provided technical and financial support for the development of 130 projects in various sectors, including government, industrial, residential, tourism, and commercial.

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

By the end of 2019, nearly 90% of Egypt’s installed PV capacity came from utility-scale plants. This comes as no surprise considering the massive scale of the iconic Benban project. The appetite for large-scale projects is clearly not going anywhere, and several additional GWs of PV from large-scale projects will be required to reach the 22% generation share of PV by 2035.

But this percentage should not mask the reality of a vivid market for residential and C&I installations. While still in their early days, they are expected to grow exponentially as the right market fundamentals are now in place for a flourishing development of these solar segments.

Looking at market developments in the coming years, the country has a large solar pipeline including projects under the net metering scheme, the feed-in tariff policy, government procurement (EPC) and concessionary projects (BOO). About 1,800 MW are currently under development, of which 970 MW have budget already allocated, and the remainder is at the planning phase.

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4

GLOBAL MARKET OUTLOOK

2020–2024

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When solar entered 2020, it was prepared for a solar decade. Impressive cost reductions have made solar the lowest-cost technology in many regions of the world.

The 1 US cent/kWh power price range was achieved in several tenders last year, and with the backing of developing financing institutions, the 2 US cent/kWh range was reached even in the first tenders in developing countries. Corporate solar PPAs had been increasingly finding traction in the market, and with the cost of battery storage quickly dropping as well, solar plus storage at utility-scale had been starting to become an attractive solution instead of gas peakers to utilities. In addition, residential and commercial rooftop systems, increasingly used for self-consumption after reaching socket parity and providing attractive returns, had proven to be more and more popular, reaching around 33% of total solar power installations by the end of 2019.

But then the COVID-19 pandemic basically shut down the world's markets, and disrupted solar's hot streak – China was impacted the first quarter of 2020, and the rest of the world was hit in second quarter. While the installation of large-scale power plants had been affected to a much lesser extent, the rooftop PV segment has been generally hit much harder, primarily in countries with full lockdowns, as the social distancing measures made it difficult for installers to get access to buildings. A poll conducted by the Global Solar Council showed that solar businesses around the world were heavily impacted by the lockdown. Depending on how bad the economic slump will turn out, homeowners and SMEs might delay or even cancel their solar investment plans completely. Also, the International Energy Agency (IEA) noted that the growth of renewables altogether may slow down for the first time in history, and distributed solar PV potentially taking the biggest shock. In our Medium Scenario, we estimate that new global solar PV installed capacities will drop by 4% year-on-year to 112 GW in 2020. When compared to last year's GMO's 144 GW forecast for 2020, this decrease would be much higher, at 22% or 32 GW.

Now, governments have the opportunity to accelerate the energy transition and realise the structural benefits renewables can bring regarding economic development and job creation. With the right policies they can enable low-cost solar to reach its full potential and lead the energy transition.

4 GLOBAL MARKET OUTLOOK

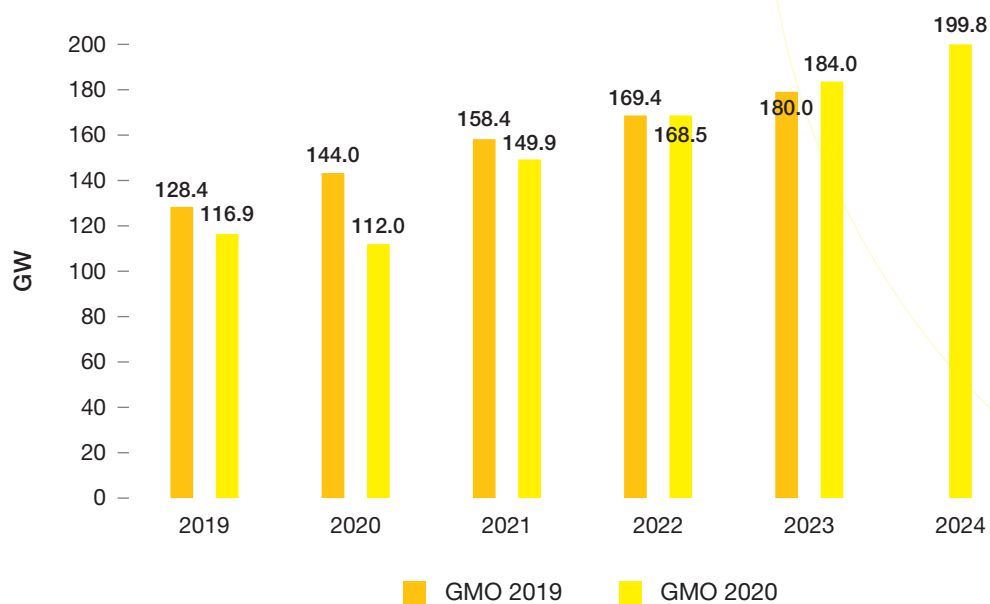
2020 – 2024 / CONTINUED

The first solar support examples as part of COVID-19 economic stimulus packages can be already seen around the world. This spring, the Malaysian government announced a new tender for 1 GW_{AC} utility-scale solar capacity as part of its recovery measures; the Swiss government has given green light to support the expansion of solar PV systems this year with 46 million CHF (48.5 million USD); Japan included an economic stimulus package of almost 1 billion USD to support corporate PPAs to facilitate the development of onsite renewables. At the end of May, the European Commission proposed a two-year 750 billion EUR COVID-19 recovery instrument, 'Next Generation EU', with the European Green Deal at the core of the recovery strategy – this is expected to roll out solar energy projects across member states and launching a massive renovation of the EU's building stock and infrastructure, which will benefit solar as well. In early June, Germany's smallest state, Bremen, made it mandatory to put solar on all new houses, including public buildings. But all this can be only a start.

While we assume in our Medium Scenario a notable 34% growth rate to 150 GW in 2021, which does anticipate significant levels of governmental recovery support, this capacity would be still 6% short of last year's 2021 forecast. It would take until 2022 to get back on track, reaching 169 GW. Only in 2024 are the virus impacts expected to be fully left behind (see Fig. 23).

But given that the right policy support measures are taken to accelerate the deployment of the lowest-cost clean power generation sources solar and wind – and enabling also the large scale production of renewable hydrogen to help decarbonise our society before 2050 –, the 2020s could indeed evolve into a solar decade, fully unleashing the power of the sun.

FIGURE 23 COMPARISON MEDIUM SCENARIO GMO 2019 VS 2020



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