Global Market Outlook

For Solar Power / 2019 - 2023

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FOREWORD

Welcome to SolarPower Europe's Global Market Outlook 2019 – 2023.

The year 2018 was unique to us – we won the title 'Overall Best European Association' at the European Association Awards 2019 at a time when the European solar market has entered another growth phase. We expect this growth to continue beyond 2020 as the European Union has provided a legislative energy package that lives up to its name, 'Clean Energy for All Europeans'. It is now about the implementation of these directives into member states' laws – and we are looking forward to supporting our national members in their efforts to push the solar business case in their home markets – creating future high-tech jobs as we are fighting climate change.

This Global Market Outlook 2019 – 2023 is a manifesto of our successful work that has only been possible through close cooperation with our members: companies active across all parts of the solar value chain from around the world, and national solar and storage associations from many European countries. We are again very thankful to the Global Solar Council (GSC) and its members for providing deep insights into their home countries for our GW-markets chapter, which now includes overviews on the 11 leading solar markets, a number that is quickly rising. Contributions of solar associations from all continents have made this Global Market Outlook evermore a truly global collaborative effort.

2018 was also a unique year for the entire global solar industry, as we were able to exceed the magic installation mark of 100 GW per year for the first time. This led the solar power generation fleet to grow to over 500 GW or 0.5 TW. We were seeing again strong cost improvements; new applications unfolding, such as floating solar; corporate renewable Power Purchase Agreements reaching a double-digit GW-level; and a market for merchant solar starting to emerge in several markets (for more trends, please check our Solar Trends Chapter).

However, unlike in the previous two years, with 30-50% annual growth rates, solar demand rose in the single-digit range in 2018, as the world 's largest market China suddenly decided to restructure its incentives scheme to make solar fit for the next growth phase. The good news is that despite China's solar restructuring, global solar demand continued to grow last year, as new and emerging solar markets, as well as Europe, have been embracing solar's attractive business proposition – a truly clean, highly versatile and very low-cost power generation source. This market diversification means interest in solar is quickly rising around the globe, which will minimise risks to the sector if demand in any of the bigger solar markets stumbles for some reason.

Solar's short slowdown is luckily already behind us. Until 2021, we expect two-digit growth rates that will more than double the total installed solar power capacity within four years – from 0.5 TW at the end of 2018, to over 1.1 TW by the end of 2022. This sounds impressive, but when taking into consideration that global CO_2 emissions rose to a new high last year – and knowing that solar and other renewables are key to solve that overarching issue, growth needs to speed up dramatically. In any case, the solar industry is ready for much more!

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.

EXECUTIVE SUMMARY

2018 will be remembered as the year solar broke the 100 GW threshold of annual installations, and it will be recalled as the year solar in total reached a cumulative operational capacity of over 500 GW or 0.5 TW.

2018 will also likely go down in history as the year solar took a short 'break' for the next growth phase. A total of 102.4 GW went on the grid around the world last year. That's still 4% more than the 98.5 GW installed in 2017 but compares to two years with very high growth rates – around 30% in 2017 and 50% in 2016.

Despite its rather low, one-digit year-on-year growth, **solar was again the power generation technology with the largest capacity additions globally in 2018. More solar was deployed than for any other single technology.** In fact, solar additions were more than twice as high as net additions for coal and also for wind. Like the year before, solar alone installed more capacity than all fossil fuels and nuclear together in 2018, although the lead was paper-thin, less than 1%. While solar's capacity additions seem impressive in relation to its fossil fuel peers, the truth is that solar still has a very long way to go to tap its vast potential – its share in the global power output for 2018 was a very small 2%.

On the plus side, solar's power generation cost (LCOE) decreased by around 14% year-on-year in 2018, according to Lazard Capital, now enabling power prices in the 2 US cents per kWh range in many sunny places around the world.

Low generation cost alone is not enough to facilitate growth; it also needs the right policy frameworks and energy market designs. The administration in China, the world's largest solar market for years now, has pulled the break for its generous feed-in tariff incentive scheme in mid-2018 to make itself fit for the grid parity age, looking into tools to better steer growth and have generation closer to where demand is. At 44.4 GW, China's market shrunk by 16% compared to its record 52.8 GW in 2017. While other leading solar markets also stagnated (US) or shrank (India, Japan) for various reasons, many new and emerging markets more than compensated for the weakness of the tier 1 group. In 2018, 11 countries installed more than 1 GW of solar; that's two more compared to the nine GW-scale solar markets in 2017. Our Medium Scenario estimates that the number will significantly increase to 16 countries in 2019.

Europe is one of the new solar growth regions. Driven by the European Union's binding national 2020 targets, the continent added 11.3 GW in 2018, a 21% rise over the 9.3 GW installed the year before. This year, our Medium Scenario sees demand surge by over 80% to 20.4 GW, and for 2020, we see 18% growth to 24.1 GW, which would be a new installation record, beating the 22.5 GW Europe added in 2011.

While several emerging markets showed impressive growth in 2018, Australia was probably the solar shooting star of the last year. The country and continent accelerated its stellar growth pace in 2018, adding 5.3 GW, up nearly 300% from 1.3 GW in 2017 – and this high demand is supposed to continue.

In our **Medium Scenario** we anticipate around 128 GW newly installed PV capacity in 2019, which would translate into a 25% market growth over the 2018 additions. Next to many other markets, we are more upbeat on solar in the world's largest solar market China in 2019 than in last year's GMO, anticipating a newly installed capacity of 43 GW. That's because the Chinese administration seems to be getting their restructuring act together faster than anticipated. Also, for the following four years we are upbeat on global solar. Our Medium Scenario anticipates demand to rise by 12% to 144 GW in 2020, 10% to 158 GW in 2021, 7% to 169 GW in 2022, and 6% to 180 GW in 2023.

Like in previous years, the scenarios of the Global Market Outlook 2019 show higher growth than in last year's edition of the GMO. In 2019, we estimate a cumulative installed capacity of 645 GW for the Medium Scenario 2019, which is about 4% higher than in last year's GMO. Our new 5-year global market outlook anticipates for our most likely Medium Scenario, that global solar power generation plant capacities will reach 1,297 GW in 2023. Under optimal conditions, we estimate that the world could get as high as 1,610 GW by the end of 2023 and enter the terawatt production capacity level already in 2021. However, the year that will be more likely remembered for entering the solar terawatt age is 2022, which would translate into around 4% of global electricity production.

The report and all figures can be downloaded at:

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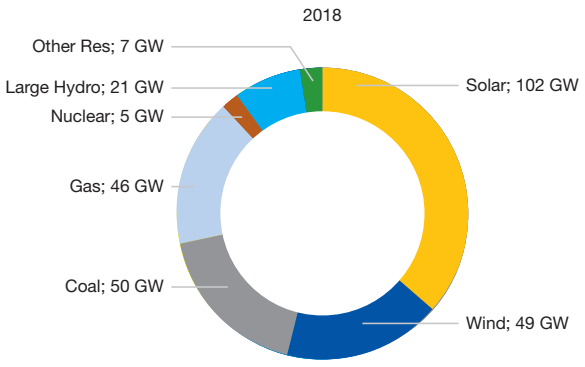
GLOBAL SOLAR MARKET

UPDATE 2000 - 2018

In 2018, solar took a little break from the enormous growth rates seen in previous years. Although the solar market grew modestly by only 4%, it was enough to again outdo any other power generation technology last year. More solar PV was deployed than all fossil fuels and nuclear together. Solar also added more capacity than all renewables combined—including large hydro—and had twice as much installed than wind power (see Fig. 1).

Relatively, solar's share reached 36% of all newly added power capacities in 2018, compared to 38% the year before. While impressive at first sight, the 'stagnation' in both solar and wind growth in 2018 meant that renewable capacities only contributed 63% to total power additions (see Fig. 2). When looking at the share of total installed power generation capacities, renewables contributed 33% in 2018, and 26% in terms of power output. All solar PV power plants together produced only 2.2% of the world's electricity output. This shows that despite solar's recent dominating role in annual power generation additions, there's huge untapped potential for both solar and its renewable peers.

FIGURE 1 NET POWER GENERATING CAPACITY ADDED IN 2018 BY MAIN TECHNOLOGY

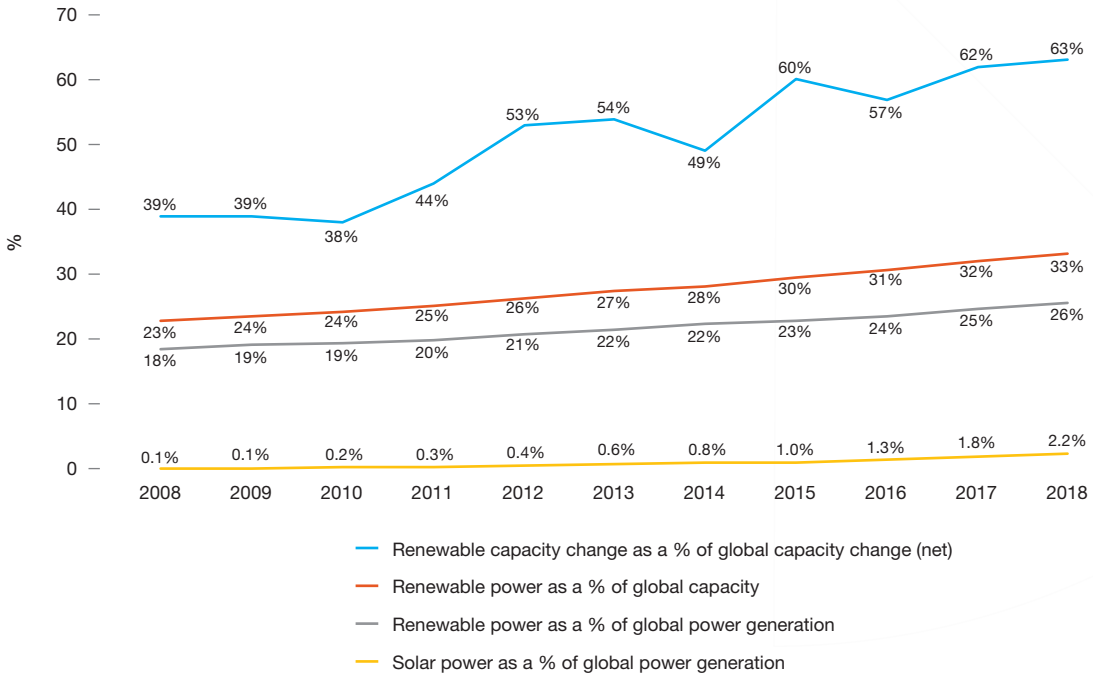


Source: Global Energy Monitor (2019); IRENA (2019); SolarPower Europe (2019).

1 GLOBAL SOLAR MARKET

UPDATE 2000 - 2018 / CONTINUED

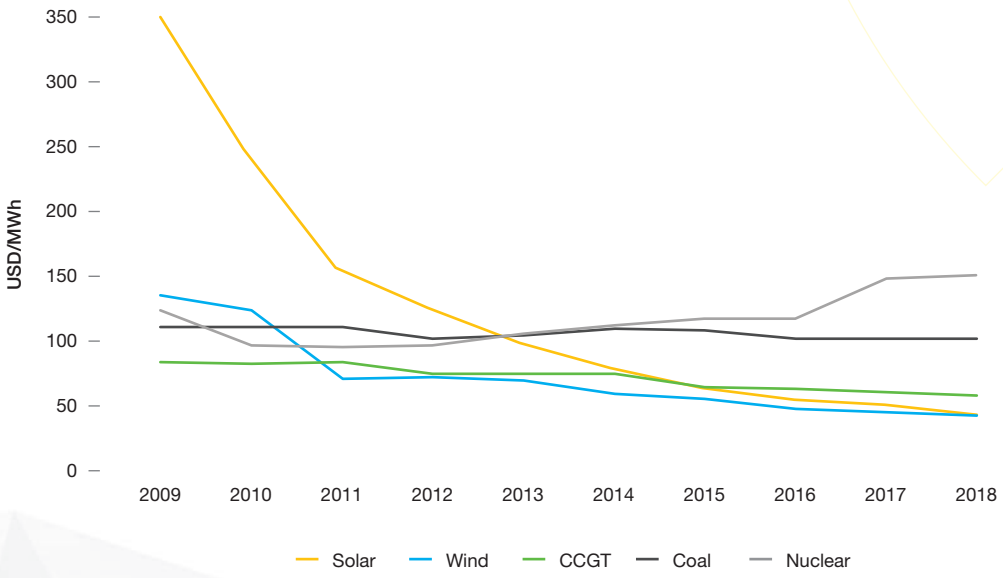
FIGURE 2 RENEWABLE POWER GENERATION AND CAPACITY AS A SHARE OF GLOBAL POWER 2008-2018



Source: IRENA (2019).

The reason for a preference for solar over other technologies has been, among other reasons, its steep cost reduction curve – which is continuing to decrease (see Fig. 3). Today, generation costs for solar power are significantly lower than for new nuclear and coal plants, but usually also below gas, and in the range of wind, depending on the region, even lower. In 2018, tenders and PPAs showed several instances of bids, awards and contracts with solar power prices in the 2 US cents/kWh range. Such price levels were reached in various

FIGURE 3 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH OTHER POWER SOURCES 2009-2018



Source: Lazard (2018). All prices In 2019 USD.

geographies around the world (see Fig. 4). The lowest solar power price bid in 2018 was recorded at 1.38 INR (1.86 US cents) per kWh in India; although this was an escalating tariff with a special business model for government rooftop buildings.

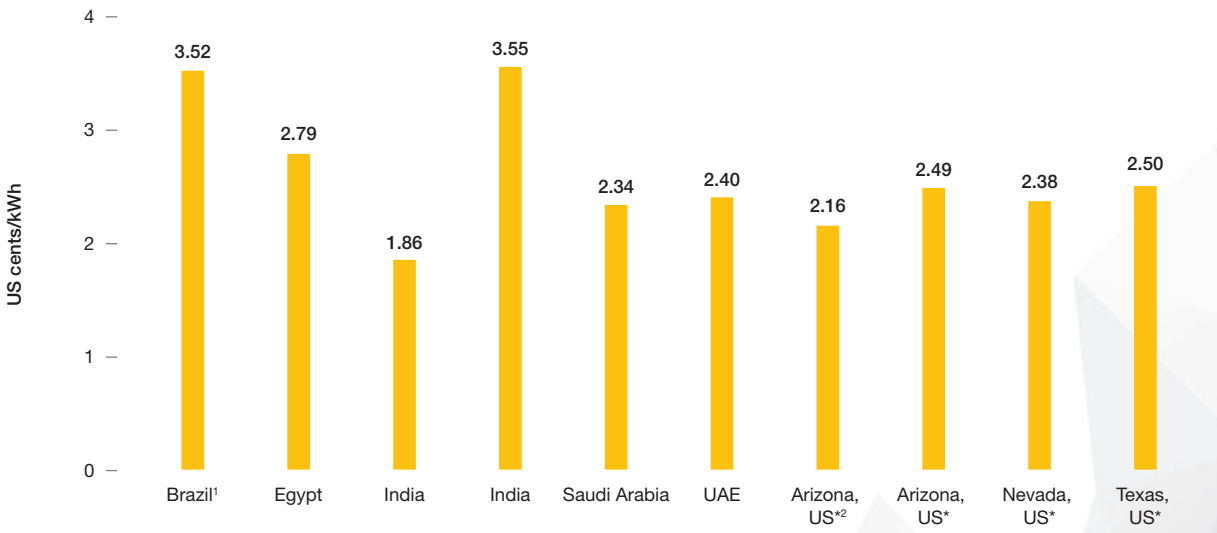
In general, prices for solar power are much higher in developing countries than in economies with stable policy conditions and high credit ratings. But with support from international lenders, such as development financing institutions, project risks can be considerably reduced in developing countries. In Egypt, for example, in 2018, a 200 MW solar tender from the Egyptian Electricity Transmission Company received the best offers from international developers in the 2 US cent range – at 2.8 US cents per kWh. This solar project is backed by the European Bank for Reconstruction and Development (EBRD). The Scaling Solar Programme of the World Bank Group, which is probably the largest solar scheme of this kind, is supporting solar deployment in African countries, Ethiopia, Madagascar, Senegal and Zambia, and in its latest tenders, has led to awards in the low 4 US cent/kWh range. In April 2019, Zambia's GET FIT programme between the country's energy ministry and the German Development Bank (KfW) awarded 120 MW of solar capacity at a price of 3.99 US cents/kWh: a new record for Sub-Saharan Africa.

While low-cost financing is key for developers to opt for solar, another important part of the cost equation are technology improvements, which continue to (see overview Technology Trends, p.49)

The latest Levelized Cost of Energy (LCOE) Analysis – Version 12.0, released in November 2018 by US investment bank Lazard, shows utility-scale solar's cost improving over the previous version by 14%. 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. 5).

A total of 102.4 GW solar was installed in 2018 (see Fig. 6), exceeding the 100 GW level in one year for the first time. While that's only a 4% year-on-year growth over the 98.5 GW installed in 2017, it is once again higher than many solar analysts had anticipated. After the world's largest solar market, China, had stopped its utility-scale solar subsidy programme in May 2018, many analysts dramatically reduced their forecasts, with Goldman Sachs being the most conservative, anticipating solar demand to drop by 24% to 75 GW in 2018. We did not change our GMO 2018 Medium Scenario over the course of last year, keeping our market growth estimate at 4% to 102.6 GW. The actual 102.4 GW installation figure deviates only 200 MW or less than 1% from our original estimate, and it's the first time in years that we have not underestimated the growth of the solar sector; in the past, actual installed capacities usually turned out be closer to the upper end of our GMO High Scenario estimate.

FIGURE 4 SELECTION OF LOWEST SOLAR AUCTION BIDS AROUND THE WORLD IN 2018



*: PPA with Production Tax Credit, **1**: Average winning bid, **2**: With 2.5% annual escalation.

1 GLOBAL SOLAR MARKET

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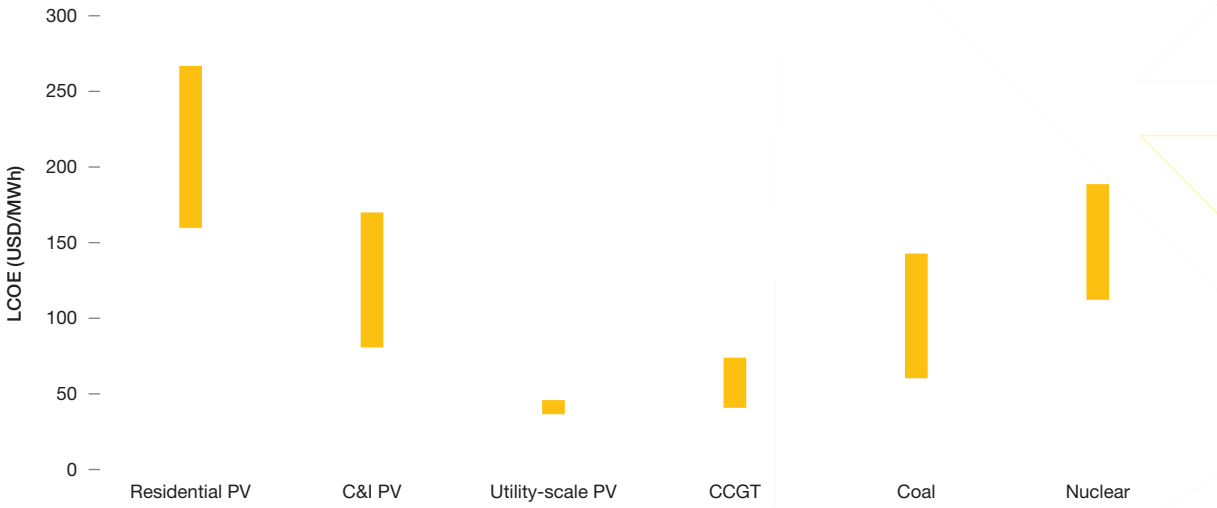
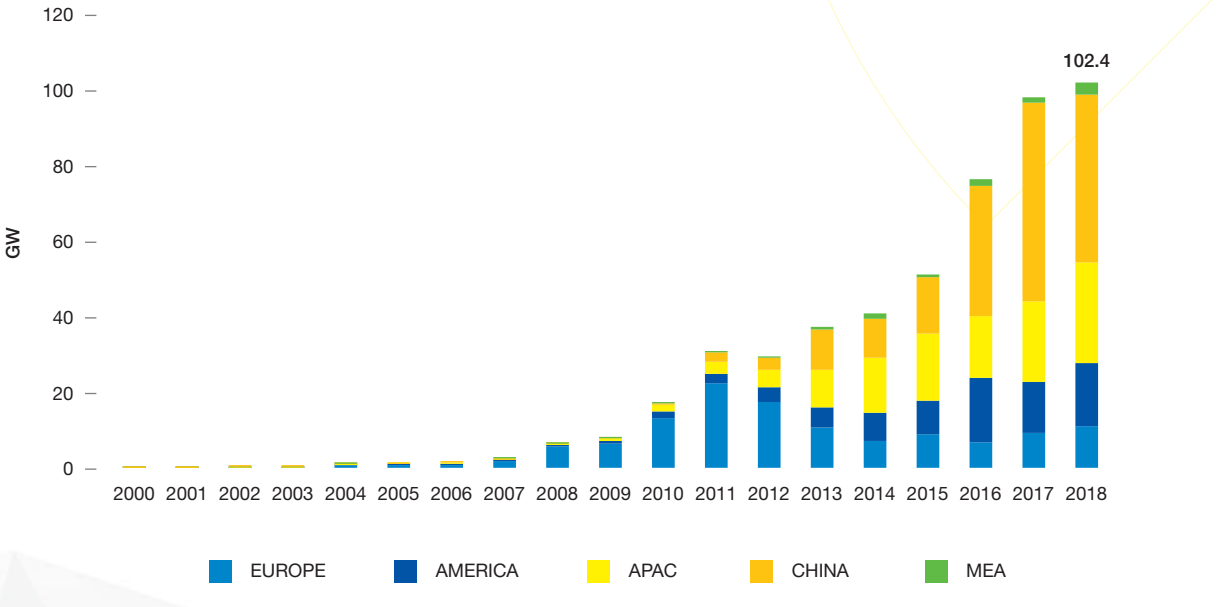
FIGURE 5 SOLAR ELECTRICITY GENERATION COST IN COMPARISON WITH CONVENTIONAL POWER SOURCES 2018



Source: Lazard (2018).

More than 100 GW installed in 2018

FIGURE 6 EVOLUTION OF GLOBAL ANNUAL SOLAR PV INSTALLED CAPACITY 2000-2018



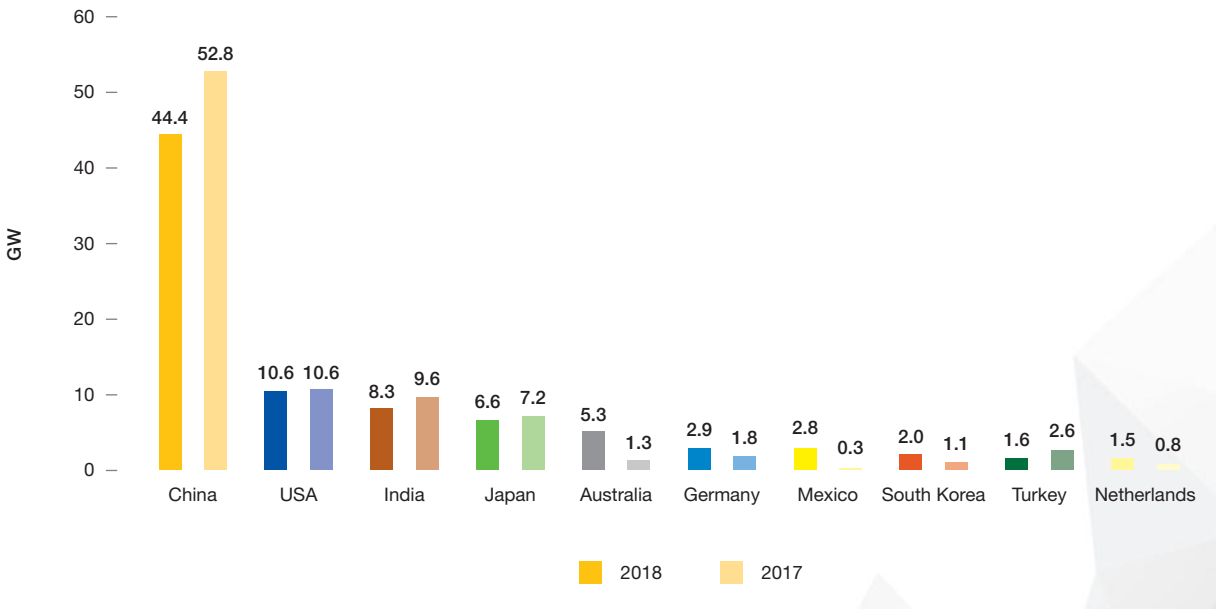
Top 5 global solar markets 2018

Although annual solar demand in **China** declined for the first time since 2014, it continued to dominate the solar world in 2018 (see Fig. 7). China installed 44.4 GW: a year-on-year decrease of 16% from the record additions of 52.8 GW and 53% growth in 2017, and installations of 34.5 GW in 2016 (128% growth). Still, this means China added over four times more solar than the second largest market in the world, and more than the remaining top 10 combined. The sudden solar restructuring programme announcement of China's administration on the 31st of May 2018 (thus tagged '531') caught the sector by surprise, but was actually overdue. After a record 9.7 GW had been installed in the first 3 months of 2018, it was apparent that the country was on course for another record year, although it was already struggling with high curtailment rates and heavy delays from payments of its feed-in tariff rates to solar power plant operators. With price offerings significantly lower in its Top Runner high-efficiency module auction programme than its regular feed-in tariff, the Chinese administration had proof that it was time for a change from its uncapped, very attractive FIT scheme that had often been higher than in many other regions of the world. China's measures to stop uncontrolled growth immediately after the 31st of May included full termination of more utility-scale plants, a hard cap for distributed generation systems, that was already met at the time, and another round of FIT cuts. As high-tech & low cost remain key to China's New Energy Administration (NEA), the Top Runner Programme continued untouched, as well as the Poverty Alleviation Programme.

The **United States'** solar market remained stable at 10.6 GW. That made the country the world's second largest solar market again in 2018. We had anticipated a slight decline in our GMO 2018 estimate (down to 10.1 GW) due to impacts on system pricing from import tariffs and the impacts of a corporate tax reform. However, utility scales solar continued to dominate US solar, being responsible for over half of new installations in 2018.

We had assumed **India** would move up to second place in 2018 after it secured rank 3 in 2017. But that did not materialise. After installing only 8.3 GW, down 16% from 9.6 GW in 2017, India maintained third place. There were multiple reasons for the market contraction – a new goods and services tax, a lengthy discussion on safeguard duties, and implementation of other protective measures, including attempts to combine multi-gigawatt power plant tenders with creation of local integrated module manufacturing facilities, and to top it off, issues with missing transmission lines.

FIGURE 7 GLOBAL TOP 10 SOLAR PV MARKETS IN 2018



Again, **Japan** installed less than the year before, adding 6.6 GW in 2018, down 8% from the 7.2 GW installed in the previous year. According to the Japan Photovoltaic Energy Association (JPEA) this was due to further FIT reductions for non-residential systems and grid constraints, leading to the first curtailment of solar in the Kyushu area on the mainland in October 2018, which has expanded to other regions as well. Japan's solar market is struggling in its transition phase from its FIT scheme to auctions and self-consumption. There is still a large project pipeline waiting for installation, while the first three solar tenders with around 1.15 GW of total capacity were all undersubscribed and resulted only in a little over 500 MW and a lowest bid of 14.25 JPY (12.85 US cents) per kWh, which is considerable higher than in auctions of other countries. JPEA anticipates the country's solar downturn to continue and bottom at 4 GW in 2024, before electricity market restructuring will be accomplished, enabling the next growth phase.

The world's fifth largest market in 2018 was **Australia**. The country and continent accelerated its stellar growth pace in 2018, adding 5.3 GW, up 295% from 1.3 GW in 2017, when it first turned into a gigawatt-scale market. While the solar base of Australia remained roof-top systems, adding over 1.8 GW to cover now more than nearly 22%, or every fifth house, the key to the new growth dimension is utility-scale systems with additions of 3.5 GW in 2018, up from less than 100 MW the previous year, and a multi-gigawatt development pipeline that is incentivised primarily though the national Renewable Energy Target (RET), a carbon price certificate model mechanism that ends in 2020.

Regional update 2018

The next growth phase seems to be taking place now both in **Europe** as a whole and the **European Union**. While Europe added 11.3 GW in 2018, a 21% increase compared to the 9.3 GW installed the year before, this is a somewhat slower growth rate than in 2017 (30% YoY). The reason: solar activities in Turkey—which is traditionally included in Europe in the GMO and was the continent's largest market in 2017—slowed dramatically due to the country's financial crisis and missing political support. Turkey added 1.6 GW in 2018, down from 2.6 GW the year before. A bright European solar spot outside the EU was Ukraine, where demand more than tripled to 803 MW, thanks to a highly attractive feed-in tariff. The European Union's solar market, on the other hand, showed significant strength after stagnation in 2017. It connected 8.2 GW to the grid; a 37% growth rate over the 6 GW installed in 2017. Last year, 22 of the 28 EU markets showed higher installation numbers than the year before. Two added over 1 GW (Germany, Netherlands), and Germany became the EU's and Europe's largest solar market again after connecting 2.9 GW to the grid, up 67% from 1.8 GW in 2017.

The PV market in **Asia-Pacific** shrank by 4% to 71.4 GW in 2018. Asia's top three – China, India and Japan – all disappointed. However, positive news came from Korea, which exceeded the 2 GW level for the first time. The main driver is 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 6% and 10% of their electricity from new and renewable power sources by 2019 and 2024. Solar in Taiwan also grew significantly—by 86% year-on-year—but fell a few megawatts short of reaching the GW level. Taiwan installed 971 MW in 2018, up from 523 MW in 2017, which led to a total of 2.7 GW. Taiwan's solar market is fuelled by a feed-in tariff as the country strives to have 20 GW of solar power capacity installed by 2025.

Latin America has a new solar star: Mexico. The Central American country not only installed over 1 GW for the first time, but it almost reached the 3 GW level, adding 2.8 GW in 2018. This is nearly a factor 10 from 285 MW added in 2017 and catapults Mexico to the number one spot in Latin America and seventh place in the top 10. The reasons for this strong growth can be found mainly in the government's three renewable energy auctions held in 2016 and 2017, and to a minor extent in a boom of distributed solar with currently more than 100,000 solar roofs on homes, industrial and commercial buildings.

As the year before, Brazil exceeded the 1 GW level in 2018, adding around 1.2 GW; a growth rate of 13%. While around two-thirds of this share was utility-scale installations stemming from tenders, nearly one-third was distributed solar capacity incentivised through a national net-metering programme. Next to the two GW-scale markets Mexico and Brazil, there is some sort of solar activity in several Latin America's countries, including a few more established PV markets, like Chile and Argentina, and more nascent solar markets, like Colombia and Peru. As managing the significant upfront cost for solar power plants is often a challenge for local developers in Latin America (as well as many other

emerging markets), a number of companies have recently issued green bonds to support their solar development plans.

The **Middle East** is mostly known in solar for its tenders that have led to several record-breaking low solar tariffs on the Arabian Peninsula. Although new tenders took place and were awarded in Kuwait, Oman, the United Arab Emirates and Saudi Arabia in 2018, in terms of grid-connections of finalised utility-scale PV power plants, there was only little news, as most of this had still been in the installation phase. The UAE was the largest market on the Arabian Peninsula with around 239 MW. Other notable markets in the Middle East region, also growing mainly through tenders, were Israel, which nearly quadrupled volumes to 383 MW, and Jordan, which added 455 MW, up from 185 MW the year before.

Africa has been seeing a number of countries entering the on-grid solar segment as of recently. There were announcements in countries including Angola, Chad, Morocco, Mozambique, Tunisia, and Senegal about new projects last year. But, when it comes to notable grid-connected capacities in 2018, these took place only in a few African countries. The largest market was located for the first time in the northern part of the continent—Egypt with 581 MW. Almost the entire 2018 PV capacity of Egypt was installed at the Benban Solar Park, which will have around 1.8 GW once fully completed in 2019. South Africa was back on the solar map last year, adding 373 MW, up from 172 MW in 2017. Its new government succeeded in getting its national utility Eskom to finally sign long-delayed PPAs for renewable energy projects worth 2.3 GW last year. In June 2018, it also announced the launch of a 1.8 GW tender in the fifth round of its Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) in November, but that has yet to happen.

2018 saw progress in the several stage tender processes for utility-scale solar power plants in Ethiopia, Madagascar, Senegal and Zambia; countries that are part of the World Bank Group's Scaling Solar Programme. A total of over 700 MW has been awarded from 2017/2018 Scaling Solar tenders in these four countries. In addition, Ethiopia issued a 500 MW tender in April 2019, the largest in this programme so far. However, no new installations from Scaling Solar were recorded in Africa in 2018; the 54 MW project in Zambia from the 2017 tender, which is the country's first, large utility-scale PV plant, went online in March 2019.

In summary, in 2018, a number of leading solar markets struggled on their growth path as they have been working on transitioning away from traditional feed-in tariff incentive schemes, in particular China and Japan. In India, protectionism and other challenges distracted the market from focussing on meeting its ambitious targets. While all this has resulted in very little growth last year, the low cost of solar has continued to attract many new countries and emerging markets to start looking even more seriously into this unique, flexible and distributed clean power technology.

In 2018, 11 countries installed over 1 GW, compared to nine in 2017, and seven in 2016. Details on the leading solar markets can be found in Chapter 2, which provides overviews on those 11 countries that installed more than 1 GW of solar in 2018 (see p.53).

1 GLOBAL SOLAR MARKET

UPDATE 2000 - 2018 / CONTINUED

The 2018 solar market not only exceeded the 100 GW level for the first time: as the year passed, it was also the first time the world had more than 0.5 TW of solar power capacity up and running. One year earlier, at the end of 2017, total global solar power capacity reached over 400 GW, after it surpassed the 300 GW level in 2016 and the 200 GW mark in 2015.

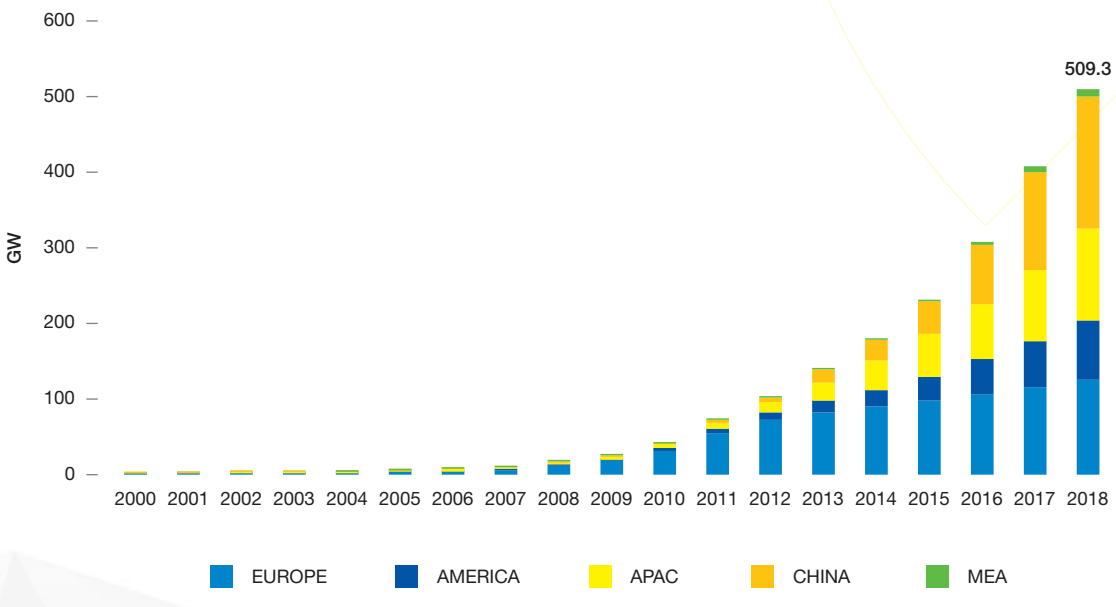
Total installed PV power capacity grew by 25% to 509.3 GW by the end of 2018, up from 407 GW in 2017 (Fig. 8). Since the beginning of the century, when the grid-connected solar era began with the launch of Germany's feed-in tariff scheme, total solar power has grown by nearly 320 times. When looking back just a decade, the world's cumulative PV capacity increased by over 3,200% – from 15.8 GW in 2008.

Although growth in the top 3 Asian markets slowed, the Asia-Pacific region further expanded its solar leadership in 2018, again representing more than half of the global power generation capacities (see Fig. 9; note that due to its large size, China is listed separately from the Asia-Pacific region). Additions of 71.3 GW in 2018 resulted in 295.7 GW of total installed capacity, equal to a 58% global market share – a 3% points year-on-year growth. The new growth phase of European solar pioneers couldn't stop the continent from losing market share, which dropped by 3% points to 25%. Still, Europe maintained its second position based on a cumulative PV capacity of 125.8 GW. The Americas was again the world's third largest solar region in 2018 – with a cumulative installed capacity of 78.2 GW and a 15% stake. Increasing activity in the Middle East and Africa (MEA) changed the region's solar development path last year. With a total solar capacity of 9.6 GW, it's world market share grew slightly in 2018, moving up to 1.9%, from 1.7% the year before.

Half a Terawatt
Solar capacity installed globally today

A look at individual countries clearly shows that China's market contraction in 2018 has not at all affected its solar dominance. Its operational solar power generation capacity reached 34.4%; this is 2% points higher than in 2017, when China's share was at 32.3% and already close to presenting one-third of global power generation capacities, which it now surpassed (see Fig. 10). Like in the previous years, China was followed by the United States, Japan and Germany. All three lost market shares

FIGURE 8 GLOBAL TOTAL SOLAR PV INSTALLED CAPACITY 2000-2018



in 2018, with Germany now down to single-digits. The US' cumulative installed PV capacity reached 62.1 GW, equal to a global share of 12.2%; Japan's 55.9 GW resulted in a 11.0% share, and Germany's 45.9 GW meant a 9.0% share, down from 10.6% in 2017. While India didn't have a good solar year in 2018, its market decline is not reflected in the total global power rankings – its 27.3 GW of total installed solar capacity was enough to stay ranked in fifth place and increase its share to 5.4%, from 4.7% in 2017.

All other solar markets significantly trail behind the top 5. In that group, there are only two notable changes to report: following Italy at 19.9 GW and UK at 13 GW, Australia now turned into a +10 GW solar power generation capacity market on grounds of its massive growth streak that led to a total installed capacity of 12.6 GW by the end of 2018. Moreover, South Korea, after reaching a total solar capacity of 7.7 GW, replaced Spain in this top 10 list.

FIGURE 9 GLOBAL TOTAL SOLAR PV INSTALLED CAPACITY SHARES 2012-2018

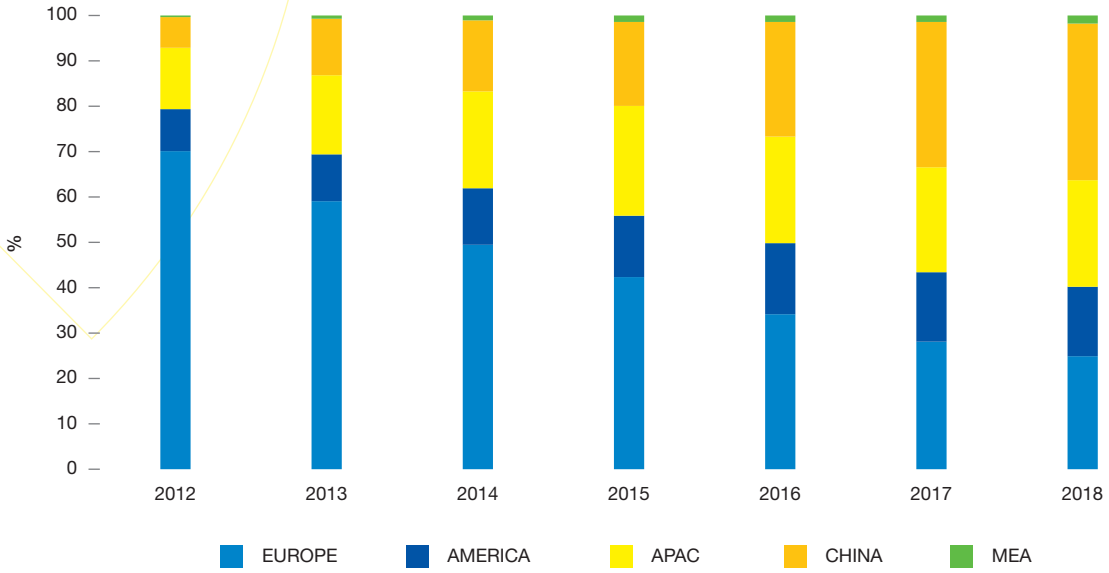
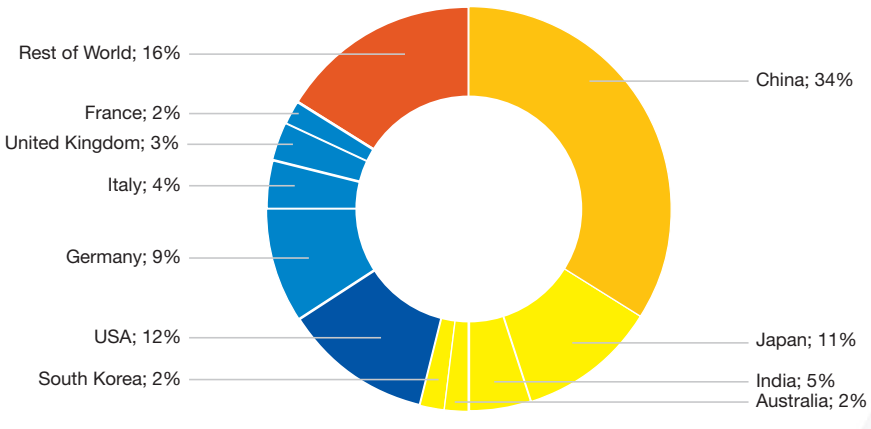


FIGURE 10 GLOBAL TOP 10 SOLAR PV MARKETS TOTAL INSTALLED SHARES BY END OF 2018



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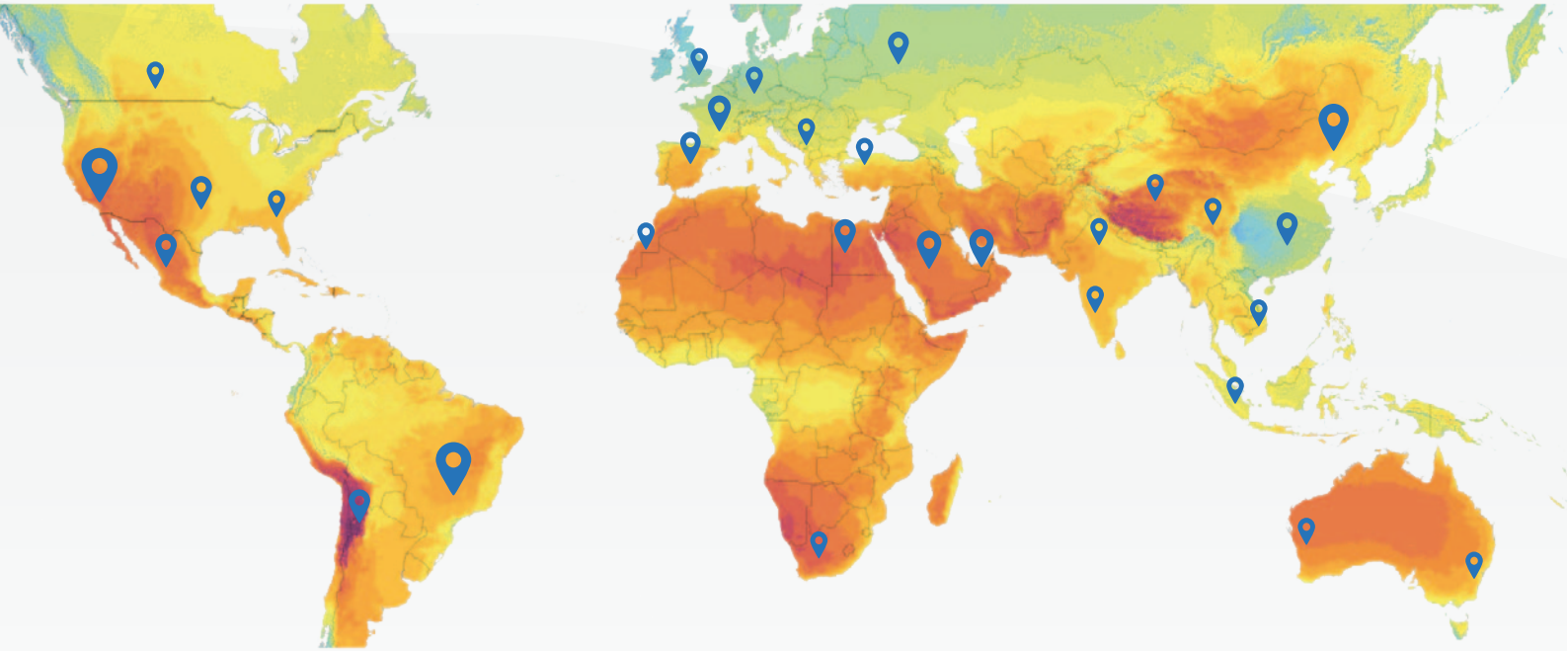

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1 GLOBAL SOLAR MARKET

PROSPECTS 2019 – 2023

In Q1/2019, most solar analysts became more upbeat about the solar market this year, expecting two-digit growth figures, although estimates for the annual volume were difficult because the outlook for China was not completely clear at that point. China's National Energy Administration had still not published its new solar support scheme to replace the feed-in tariff programme for utility-scale projects that had been abruptly shelved in May 2018. However, after several months of silence following the restructuring announcement, an internal NEA conference in November 2018 provided signals that subsidies will continue until grid-parity is reached, though at lower levels and mainly distributed through auction mechanisms. Meanwhile, a policy framework for 'subsidy-free' projects should be established. Over time, more and more details about the plans became known publicly, including a 3 billion RMB (440 million USD) budget per year. While the news in January/February led some analysts to believe demand could return to the record heights of 2017, much of this enthusiasm had disappeared, when, in early April, solar stakeholders were still waiting for the new solar incentive programme to be finally implemented. While end of April, China's National Development and Reform Commission released its '2019 On-grid FIT Price Guidance', which has provided fixed FITs for the Poverty Alleviation Programme and rooftop projects as well as upper price caps for auctions, the final new management regulation was still missing at that time.

Forecast 2019

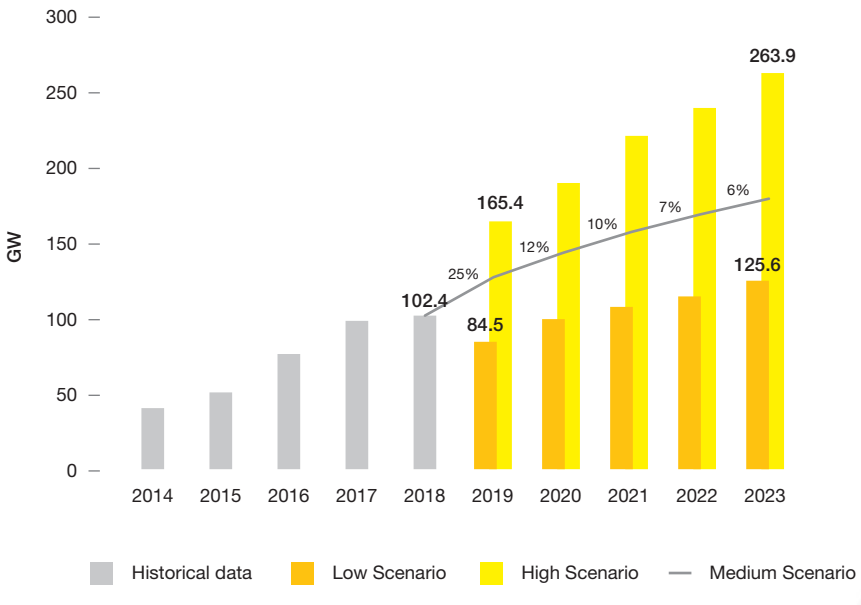
In our **Medium Scenario** we anticipate around 128.4 GW of newly installed PV capacity in 2019, which would translate into a 25% market growth over the 102.4 GW added in 2018 (see Fig. 11). Our **Low Scenario**, which models major markets to cut their solar support, estimates a strong demand drop to 84.5 GW. Obviously, this outcome is highly unlikely, when taking into account solar activities around the globe in the first months of the year. Our **High Scenario** forecasts up to 165.4 GW of solar additions in 2018, which sounds extremely optimistic and is also very improbable, but solar has rather often surprised everyone positively in the past. A lot will depend on when and how strong the world's largest market, China, will come back in the second half of the year.

Top 3 global solar markets 2019

However, we are more upbeat about solar in **China** in 2019 than in last year's GMO, anticipating newly installed capacity of 43 GW. That's because the Chinese administration seems to be getting their restructuring act together faster than anticipated. Moreover, both China's Top Runner Programme and Poverty Alleviation Programme have continued untouched.

Next to China, we expect two other markets to add over 10 GW each this year. One will be India, which we expect

FIGURE 11 WORLD ANNUAL SOLAR PV MARKET SCENARIOS 2019-2023



to become the second largest market this year, and the US, which will rank third.

After **India** missed its official fiscal year 2018-19 solar target by 59%, as it connected merely 6.5 GW of the planned 11 GW to the grid between April 2018 and March 2019, mostly due to tax, import duty and organisation issues, there is big motivation to catch up and return to growth. At the end of the calendar year 2018, India had a total installed capacity of 25.2 GW, which leaves nearly 75 GW to go to meet the 100 GW target of the National Solar Mission by 2022. However, there were high tender activities in 2018, after India's Ministry of New and Renewable Energy (MNRE) had published a roadmap to tender 20 GW in FY 2017/18 and 30 GW each in FY 2018/19 and FY 2019/20. According to the National Solar Energy Federation of India (NSEFI), the current project pipelines indicate that around 10.9 GW alone will be realised through utility-scale plants in 2019. India's government also recently approved a total of 1.7 billion USD in funding for phase 2 of its grid-connected rooftop solar programme to accelerate installations in this segment, which has a target of 40 GW by 2022, but had only around 3.5 GW installed at the end of 2018. In our Medium Scenario, we anticipate India to rise by 55% year-on-year to 12.9 GW in 2019.

Although the import tariffs on solar modules, which were the main reason for market stagnation in the **United States** last year, are still in effect, the country's solar growth story is anticipated to continue in 2019 and beyond due to the decreasing cost of solar, the investment tax credit, state requirements and incentives, strong public support and quickly increasing interest from corporates in renewable power sourcing. We estimate in our Medium Scenario that the US, again mainly through utility-scale PV installations, will add 11.8 GW, up 11% from 2018.

In both **Europe** and the EU, we anticipate very strong growth for 2019. As the EU's national binding 2020 renewables targets are rapidly getting closer, and many member states still have some way to go (according to Eurostat, 17 of the EU-28 had not reached their targets by end of 2017), low-cost and easily deployable solar is often seen as a key means to meet the finishing line in time. In non-EU Europe, the drivers are solar's low cost and attractive incentive schemes. While the financial crisis unfolding last year in Turkey and missing political support will turn Europe's number one solar market in 2018 back to a size considerably below 1 GW this year, the Ukrainian market, propelled by its attractive feed-in tariff program, is expected to cross that threshold for the first time.

Worldwide, we see the number of solar GW-level markets increasing to 16 in 2019, according to our Medium Scenario; that's five more than the 11 GW-scale markets in 2018. In fact, we had assumed that already in 2018, the number of GW markets would reach 14, but for various reasons these countries will reach that level now in 2019 (for details, see Chapter 2).

Global solar market developments 2020 to 2023

Solar's attractive value proposition will lead to 2-digit growth rates globally, not only this year but also in the next two years, and maybe beyond. After two to three transitional years, backed by different incentive schemes, we anticipate a fully restructured Chinese solar market that will absorb capacities above 50 GW as early as 2021, a year earlier than we believed in last year's GMO. Why? Because from what is known, NEA's new solar policy framework looks comprehensive and addresses the right issues to make solar fit for the next growth phase. In our Medium Scenario, we estimate Chinese solar demand will reach around 49 GW in 2020, 56 GW in 2021, 61 GW in 2022 and 64 GW in 2023, which is in line with the High Scenario of the China Photovoltaic Industry Association (CPIA) (see p.54).

China's return to growth in the coming years is needed to fuel overall solar growth, but the rest of the world will continue to play a stronger role in the solar sector, which was already shown in 2018, when demand slightly surged, although several of the leading markets decreased or stagnated.

The US Solar Industry Association believes, 'lower costs and strong public and bipartisan sentiment in favour of clean energy will lead to solar generation capacity more than doubling in the next five years' in the **United States**. In our Medium Scenario for the US, we assume two-digit growth until 2021, when the ITC expires and a new record volume of 16 GW of solar will be added, followed by two years of consolidation at the 14 GW level. The third solar leader, **India** must and will speed up to meet or get close to its ambitious 100 GW by 2022, resulting in constantly higher annual installation volumes, which according to our Medium Scenario, means a record 21 GW market in 2023. The **European Union** seems well prepared for the coming years when it comes to solar – until 2020, because the majority of the EU's 28 member states still have some way to go meet their national binding renewables targets in 2020, and increasingly opt for low-cost solar. Post-2020, the

final agreements for the 'Clean Energy for All Europeans' Legislative Package, defining the EU's energy policy until 2030, are overall very positive for solar power. The Medium Scenario expects a 23% growth rate in 2020 in the EU-28, a slower year in 2021, and again stronger 2-digit growth as of 2022.

Globally, our Medium Scenario anticipates demand to rise by 12% to 144 GW in 2020, 10% to 158 GW in 2021, 7% to 169 GW in 2022, and 6% to 180 GW in 2023. However, our High Scenario assumptions could come true, resulting in an annual market size of up to 264 GW in 2023, if decision-makers in politics and business quickly act upon fully understanding that solar is not only often the lowest-cost solution today, but also the most versatile power generation technology; in combination with storage, it is extremely flexible and with wind and other renewables it creates a 24/7 supply source. Energy market designs will be quickly adapted accordingly to enable even faster solar growth.

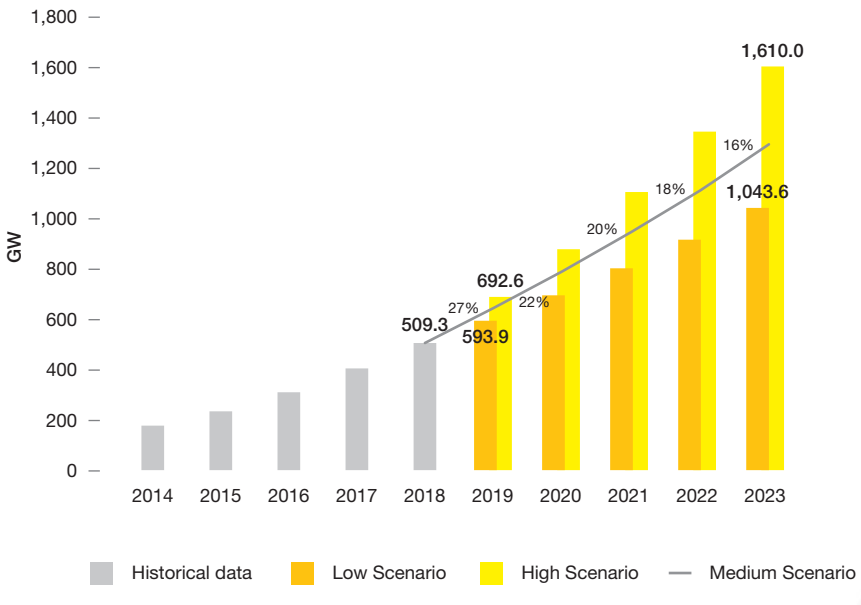
Like in previous years, the scenarios of the Global Market Outlook 2019 show higher growth than in last year's GMO edition. In 2019, we estimate a cumulative installed capacity of 645 GW for the Medium Scenario 2019, which is about 4% higher than in last year's GMO (see Fig. 12). The final year 2022 of the 5-year forecast in last year's GMO 2018 ranged between 824 and 1,290 GW, with the most likely Medium Scenario resulting in 1,041 GW of cumulative operating solar power in 2022. For this GMO 2019, we forecast between 918 and 1,346 GW, with 1,117 GW for the Medium Scenario in 2022 – that's about 7% higher.

Our new 5-year Global Market Outlook anticipates for our most likely Medium Scenario that global solar power generation plant capacities will reach 1,297 GW in 2023. Under optimal conditions, the world could get as high as 1,610 GW by the end of 2023 and enter the terawatt production capacity level already in 2021. The more 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 expect that total global installed PV generation capacity will pass the following milestones over the next 5 years: 600 GW in 2019, 900 GW in 2021 and 1.1 TW in 2022.

Over 1 TW
Solar power by 2022

FIGURE 12 WORLD TOTAL SOLAR PV MARKET SCENARIOS 2019-2023



1 GLOBAL SOLAR MARKET

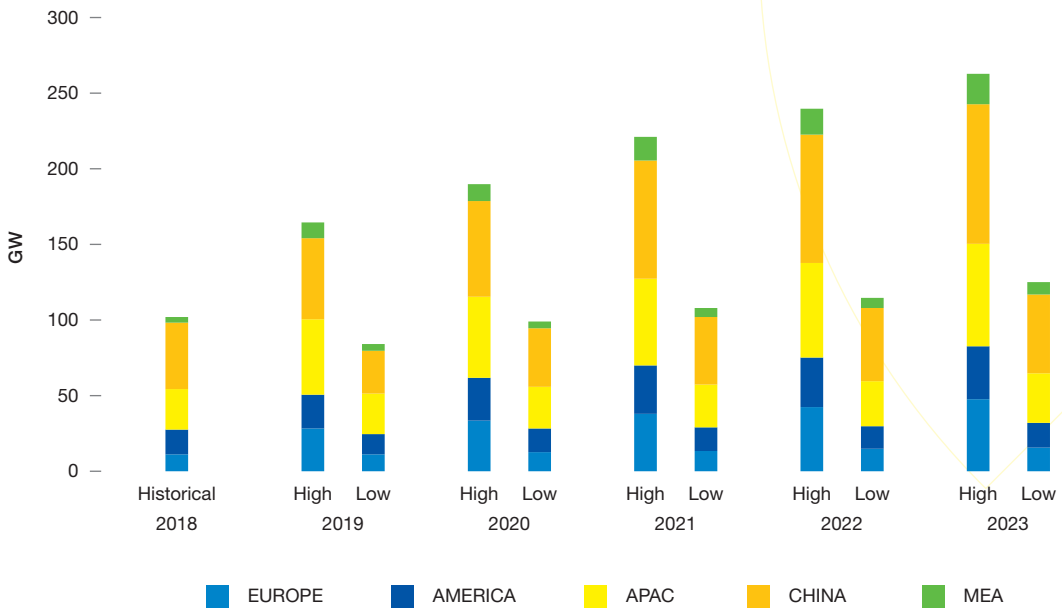
PROSPECTS 2019 – 2023 / CONTINUED

From today's perspective, solar PV seems unstoppable; there is no alternative to this low-cost and versatile clean power source that can be utilised for consumer, distributed and utility-scale applications. Still, solar is far from having a level playing field with optimal market designs to really unleash its cost and technical advantages over inflexible power plants. Many obstacles are still in solar's way – this includes fully functioning emissions trading schemes for fossil fuels or CO_2 taxes that are usually missing; investments and operation of inflexible, centralised power generation technology are often still being strongly over-subsidised, like any nuclear power plant; while self-consumed solar power is often being inappropriately highly taxed (although the new EU Market Design legislation has given the right signals in this regard).

Another big issue is solar's dependency on very few markets: In 2018, China, was responsible for 43% of the global demand; the three largest solar markets, China, the US and India, covered 61%. As China's feed-in tariff termination for large-scale solar has shown over the last 12 months – and demand decreased by only 16% in 2018 – disruptions in one of the major markets can send shock waves throughout the entire solar sector. While in this case the downstream sector and investors profited as sudden module overcapacities led to dramatic price drops, and price elasticity created more demand, this incident has been hurting many in the upstream production sector, which is very much needed to continue investing heavily in solar to enable further strong growth. Our Low Scenario until 2023 takes these and other risks into consideration, including interest rate hikes and severe financial crisis situations, like we are currently seeing in Turkey. Taking all such risks into account, our Low Scenario assumes a very unlikely development that results in an annual global market of only 126 GW in 2023, which would mean the same level as expected for 2019, and a total operating solar power generation capacity of 1,044 GW at the end of 2023.

In hindsight, forecasting details about future solar installed capacities has always been a difficult task for any industry

FIGURE 13 EVOLUTION OF GLOBAL ANNUAL SOLAR PV MARKET SHARES FOR HIGH AND LOW SCENARIOS UNTIL 2023

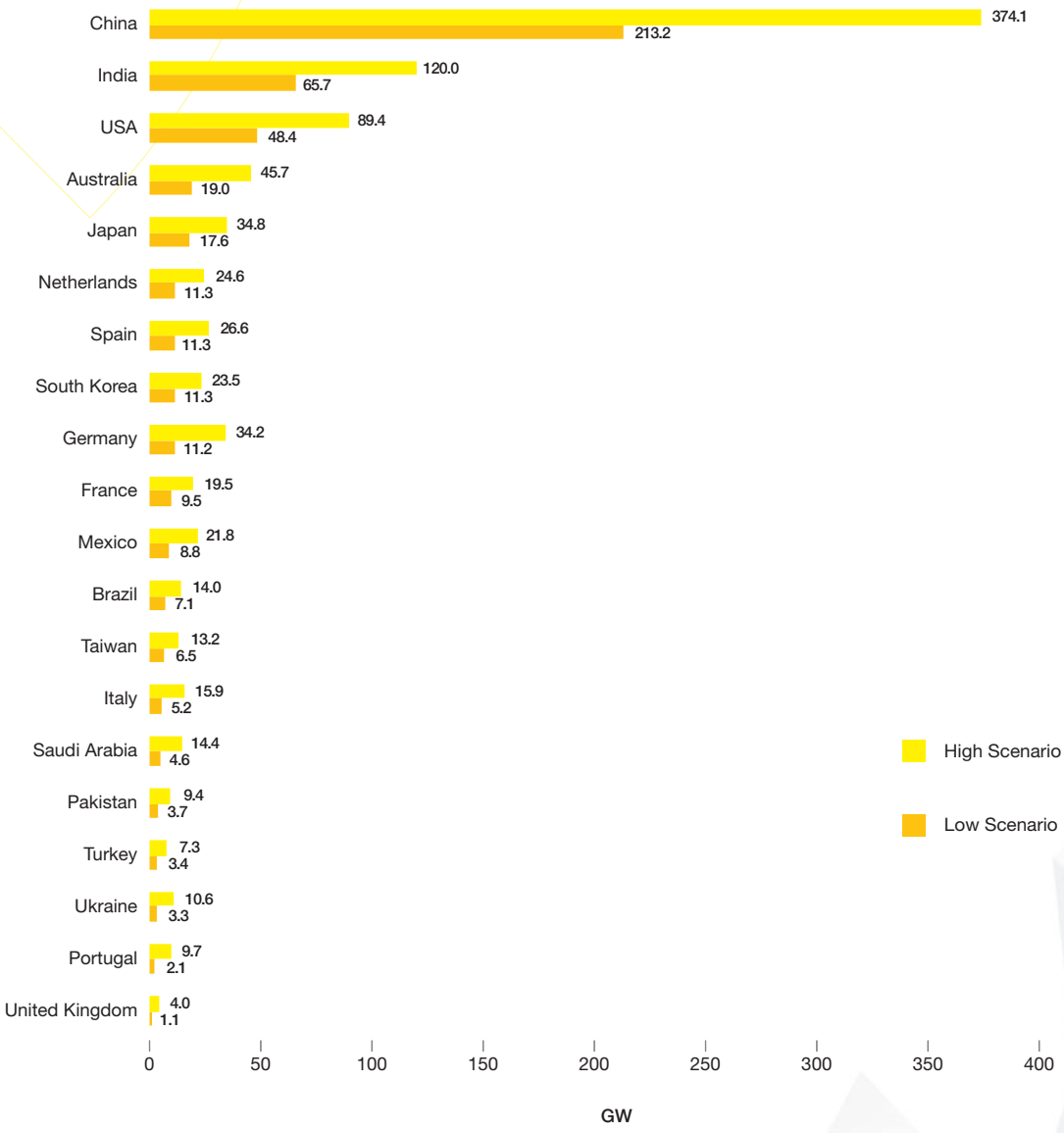


%	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023
	Historical	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**
Europe	11.01	17.18	13.71	17.88	13.17	17.27	12.64	17.94	12.95	18.19	12.94
America	16.24	13.93	15.74	14.78	15.32	14.30	14.74	13.64	13.20	13.30	12.60
APAC	26.35	29.82	32.06	28.27	27.74	26.20	25.78	25.82	25.700	25.75	26.51
China	43.36	32.49	33.06	33.44	39.20	35.28	41.30	35.47	42.21	35.16	41.77
MEA	3.05	6.58	5.43	5.63	4.56	6.95	5.54	7.13	5.94	7.60	6.19

expert, however, it is very obvious that Asia will continue to dominate global solar demand, and this will be independent from the sector developing more towards our high or low scenarios (see Fig. 13). Again, we anticipate higher solar shares for Asia-Pacific in the future than in our previous GMO. For 2018, the Asia-Pacific region is assumed to absorb nearly 70% of total installations – and range between 60 and 68% until 2023. However, when looking at China alone, the country will continue to lose market shares from 54% in 2017, to 43% in 2018, and depending on the scenario further down, hover mostly in the 30% range between 2019 and 2023.

In the group of the **20 markets with the highest 5-year installation potentials** (in the order of Low Scenario assumptions; see Fig. 14) little has changed from last year. The top 3 are the same – China, India, the US. The anticipated installation volumes for both high and low scenarios over the next five years are again higher for most markets, with few exceptions like Japan. Newcomers on this year's top 20 list are Pakistan, Ukraine and Portugal, while the biggest shooting stars are Australia (ranking fourth, up from sixth place), and the Netherlands (ranking sixth, up from eleventh place). The pattern of the markets on this list also remains similar:

FIGURE 14 TOP 20 MARKETS' SOLAR PV ADDITIONS FOR HIGH AND LOW SCENARIOS 2019-2023



1 GLOBAL SOLAR MARKET

PROSPECTS 2019 – 2023 / CONTINUED

few countries will install the bulk of all solar system capacity, though diversity is growing. This year, we expect for the High Scenarios again the same two countries to install over 100 GW – China (374 GW) and India (120 GW) – and 10 countries to add around 20 GW or more – China, India, the US, Japan, the Netherlands, Spain, South Korea, Germany and France (last year it was eight).

When looking only at the world's top 5 markets, we anticipate them to absorb 664 GW altogether until 2023 in the High Scenario and 364 GW in the Low Scenario, covering a share of around 61% and 68% of total additions in that period. If compared with the top 20, these are estimated to add 912 GW over the next five years until 2023 in the High Scenario and 464 GW in the Low Scenario – that's 183 GW and 114 GW more than in our 5-year assumptions of the GMO 2018.

The **top global PV markets' prospects** are looking very good for the coming years and that is also true for solar heavy weight China (see Fig. 15). Two-thirds of the top 20 markets are expected to install at least 10 GW each between 2019 and 2023, according to our Medium Scenario, with new capacity additions anticipated to differ from 273 GW for the first, China, to 4.4 GW for Egypt, the last on this list.

FIGURE 15 TOP GLOBAL SOLAR PV MARKETS' PROSPECTS

	2018 **Total Capacity** (MW)	2023 **Total Capacity Medium Scenario by 2023** (MW)	2019 - 2023 **New Capacity** (MW)	2019 - 2023 **Compound Annual Growth Rate** (%)	**Political support prospects**
China	175 131	448 131	273 000	21%	
India	27 347	116 106	88 759	34%	
United States	62 127	132 426	70 299	16%	
Australia	12 560	45 236	32 676	29%	
Germany	45 920	72 611	26 692	10%	
Japan	55 851	82 351	26 500	8%	
Spain	5 915	25 367	19 452	34%	
South Korea	7 742	24 768	17 026	26%	
Netherlands	4 181	20 059	15 878	37%	
Mexico	3 580	19 010	15 430	40%	
France	8 920	22 259	13 339	20%	
Saudi Arabia	19	11 412	11 393	260%	
Brazil	2 346	12 505	10 159	40%	
Italy	19 877	29 498	9 621	8%	
Taiwan	2 739	12 074	9 335	35%	
Pakistan	1 720	8 381	6 660	37%	
Ukraine	2 004	7 963	5 959	32%	
Turkey	5 062	10 562	5 500	16%	
United Arab Emirates	720	6 132	5 412	53%	
Egypt	661	5 023	4 362	50%	

Even though China had not not published the final management guideline for the new solar policy framework at the editorial deadline of this report at the end of April, it is certain that the world's solar powerhouse will continue to heavily back solar. China was the first country that fully understood the strategic importance of owning the full production value chain for its industry and its energy security, in addition to solar being the source of the lowest-cost and most flexible clean power generation. Its solar programme restructuring is an overdue transition effort from too generous feed-in tariffs to more cost-efficient incentive schemes. In our Medium Scenario, we anticipate **China** to add as much as the following six on this top 20 list together until 2023, resulting in a total installed PV capacity of 448 GW. **India** is another solar market where the government has identified solar as a key pillar for its power supply strategy. Despite the recent growing pains resulting in a market contraction last year, India remains on its growth path and is expected to be the second largest PV market over the next five years, with close to 90 GW of newly installed capacity between 2019 and 2023. The **US** is one example where the head of government, known to be a climate change sceptic and fossil fuel supporter, has not changed the country's solar course. An attractive investment tax credit (ITC), which was extended in 2015 and is eligible for residential and commercial systems that start construction by 2021, state incentives and obligations, as well as increasing corporate renewable power sourcing activities will result in 70 GW of new solar power additions, enough to keep the US in the top 3 over the next five years. The US solar sector association SEIA is so upbeat about solar in the 2020s that it has tagged this period the 'Solar Decade.' Although we expect **Japan** to add 26.5 GW by 2023, this is not enough to keep last year's rank in fourth place. Unlike for any other country on this list, annual demand is likely to decrease constantly as the country continues to work on fixing its costly solar feed-in tariff incentive scheme and infrastructure. On the other hand, solar shooting star **Australia** is supposed to install 6 GW more than Japan in the same period (although that outlook might change depending on the outcome of upcoming elections in mid-May). While Japan's transformation process is known for years, and the market still installs notable amounts of solar, even if decreasing year by year, we rate the political support prospects 'cloudy.' Our only 'rainy' forecast is for Turkey, where the climate for solar changed completely due to the financial crisis and dwindling political support.

1 GLOBAL SOLAR MARKET

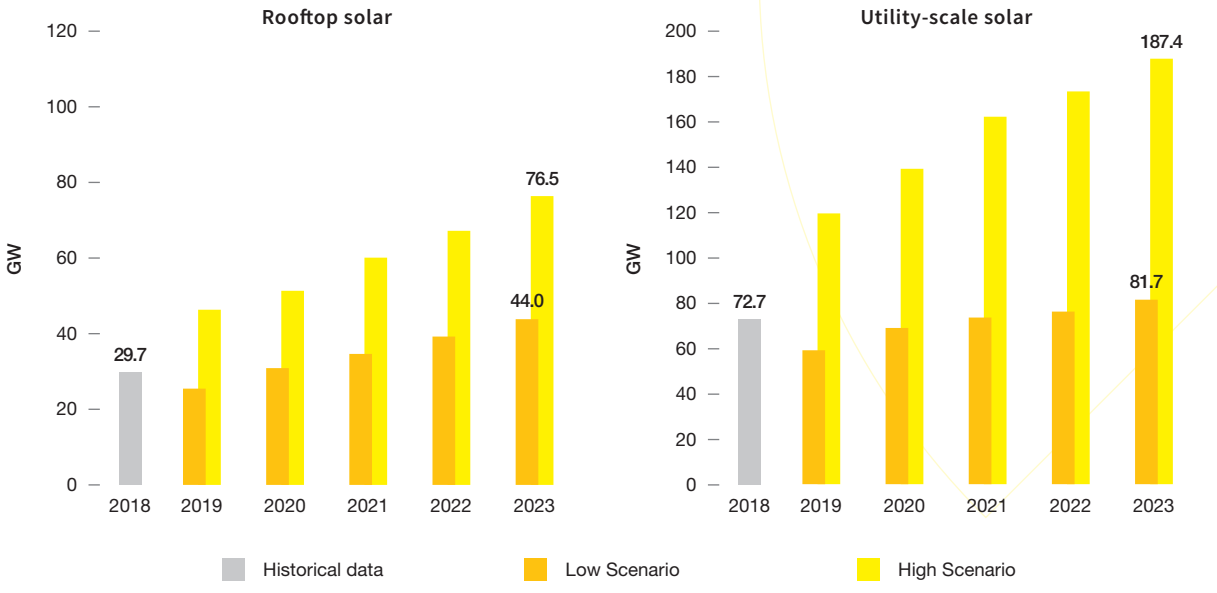
PROSPECTS 2019 – 2023 / SEGEMENTS

In 2018, the ground-mounted segment had a global share of newly installed capacity between 70 to 72%, as the major solar markets primarily rely on this type of PV application (see Fig. 16). There is no doubt that ground-mounted utility-scale PV will remain the dominant application for solar power over the 5-year span of this report. But with electric vehicles and smart cities making stronger inroads after 2020, there is a lot of potential for rooftop solar in the mid- to long-term.

The world's largest solar market, China, had always been a stronghold for ground-mounted power plants. When China's administration terminated the feed-in tariffs for large-scale power plants in May 2018, this had a positive impact on rooftop PV. Still, around three quarters of the solar capacity installed that year were utility-scale power plants. Utility-scale will continue to be a market leader in China under the new policy framework, although rooftop will gain shares.

However, installing large quantities of utility-scale solar is much easier than establishing a distributed PV rooftop market, which takes a substantial period of time and a lot of effort to educate consumers, while setting up an effective platform with the right financing mechanisms and technical standards. For this reason emerging markets usually begin their solar chapter with tenders for utility-scale solar and usually struggle to set up the distributed rooftop segment, even if politicians generally prefer PV on roofs—which they consider to be the natural place for the technology as it avoids any potential conflicts on land use. The best 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 27 GW installed by the end of 2018, only 3.5 GW were rooftop systems—the bulk was utility-scale PV power plants. The Indian Government recently approved 1.7 billion USD under its Sustainable Rooftop Implementation for Solar Transfiguration of India

FIGURE 16 SCENARIOS FOR GLOBAL SOLAR PV ROOFTOP AND UTILITY SCALE SEGMENTS DEVELOPMENT 2019-2023



(SRISTI) programme to accelerate the installation of rooftop solar. While new markets like Vietnam focus fully on utility-scale solar, even the world's most advanced solar rooftop market, Australia, is now leaning heavily towards big solar farms. At 3.5 GW, Australia installed almost twice as much utility-scale solar capacity as rooftop systems, at 1.8 GW in 2018.

The trend towards ground-mounted installations can even be seen in developed solar markets in Europe, where the recent trend to tenders has been providing the grounds for a big wave of ground-mount PV power plants, like in Spain. The low cost of solar enabling merchant/PPA solar systems also pushes the ground-mount segment. Spain and Portugal have multi-gigawatt pipelines for such PV power plants, but even in Germany, a first merchant solar system with a record size of 175 MW is under development.

At the same time, residential and commercial power consumers will quickly 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. In addition, more cities, states or even countries might follow the example of California to make it mandatory to have solar as part of newly built homes – though all this is likely to happen after 2020. In 2023, we expect the rooftop market segment to reach a share between 29% and 35%, up from 28% to 30%, depending on the growth scenario.

(20+5)

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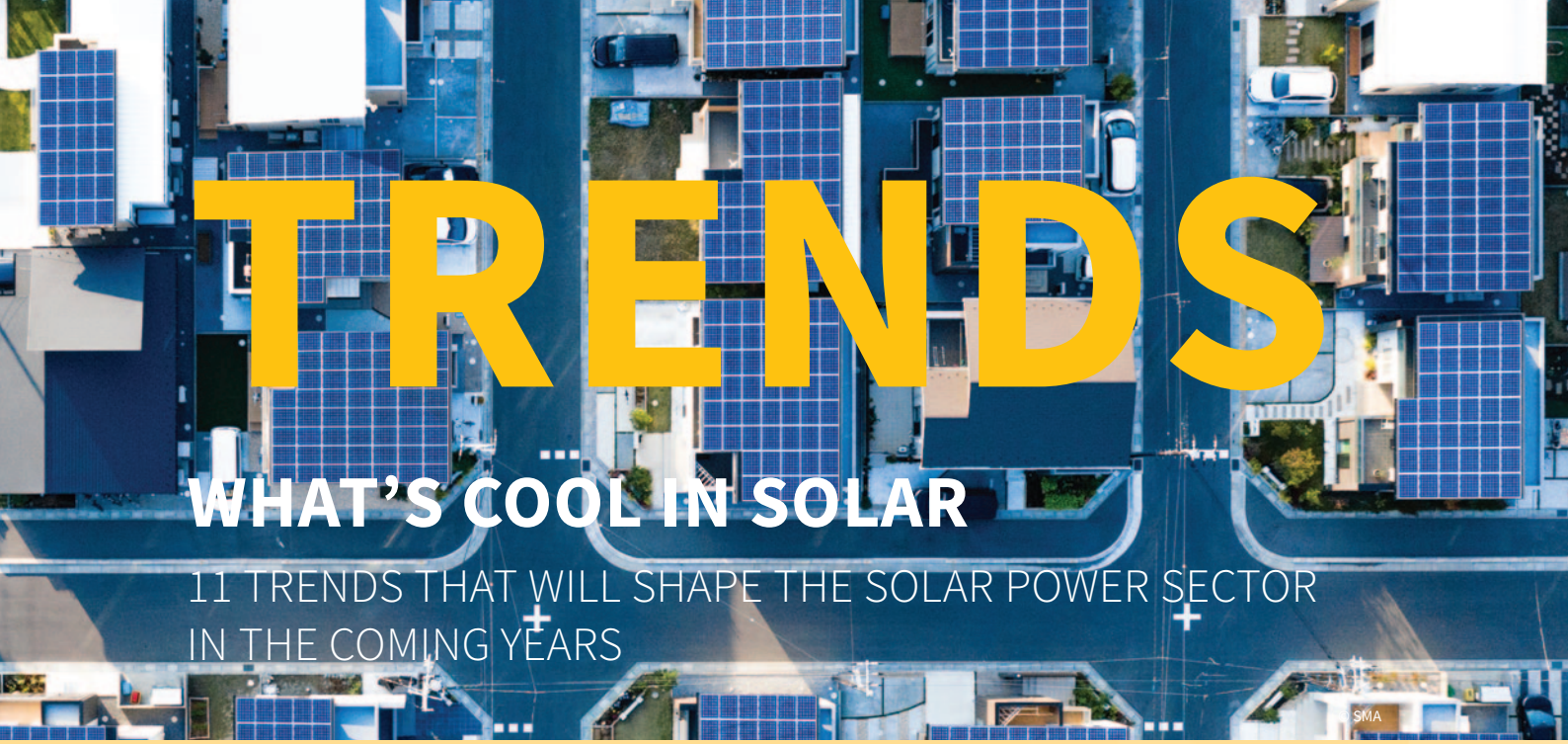

TRENDS

WHAT'S COOL IN SOLAR

11 TRENDS THAT WILL SHAPE THE SOLAR POWER SECTOR IN THE COMING YEARS

You can't say it too often – solar is the lowest cost power solution in many countries today and is continuing rapidly on its cost reduction path. At the same time, no other power generation technology is as clean, versatile, or as flexibly applicable. Despite that, solar's global power generation share was less than 3% at the end of 2018. That means there are uncounted business opportunities for solar power in all three energy segments – power, heat and transport.

Like every year, SolarPower Europe has looked at the key topics and trends that support the dissemination of solar power. This chapter is to a large extent based on the work of SolarPower Europe's Task Forces, where we cooperate closely with our members to keep track on the latest business models and develop policy recommendations in the various fields that are highly relevant for solar. Our Taskforces strive to make solar the core of a connected, sustainable and modern global economy.

1 **Digital Solar & Storage I – What solar prosumers really need**

2 **Digital Solar & Storage II – Unleashing large-scale solar & storage through grid intelligent solar**

3 **BIPV – The next generation is ready for the mass market**

4 **Solar Mobility – Electrification of the transport sector will rely heavily on solar**

5 **Taking care – Sustainability in solar**

6 **Asset Management 2.0: More transparency, more digitalisation**

7 **Corporate Sourcing of renewables – Why corporates increasingly strive to go 100% RE**

8 **Tenders – Towards intelligent tenders**

9 **Emerging Markets – Joint efforts to mitigate risks and scaling solar**

10 **Solar + hydrogen – The perfect match for a Paris-compatible hydrogen strategy?**

11 **Technology update: How to cut cost even further**

1. DIGITAL SOLAR & STORAGE I – WHAT SOLAR PROSUMERS REALLY NEED

New digital technologies such as big data analytics, internet of things, artificial intelligence, robotics and blockchain, in combination with the rapidly falling costs of residential storage, are creating the grounds for "smart" prosumers' (also called active consumers) business models. If the right policy framework is implemented, all types of electricity consumers will be able to generate and consume solar power—including tenants and industrial consumers. Digital solar & storage can also unlock flexibility potential from prosumers to operate solar power systems in a grid- and consumer-friendly manner.

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Increased self-consumption rates for smart solar & storage prosumers

The rapidly falling prices of battery storage[1] are constantly improving competitiveness of stationary battery storage systems that are now available from producers in the Americas, Asia-Pacific and Europe. Next to stationary storage, the emergence of electro-mobility is giving more and more consumers access to their own mobile battery storage.

The key to smart buildings for solar prosumers is energy management systems. These game changing software products allow monitoring and operating all actors in a prosumer household – the different building loads including heat pumps, the battery or the electric vehicle battery charging process.

Digital solar & storage are the base for any smart self-consumption model. While typical on-site solar systems can achieve a physical self-consumption rate of around 20 to 35%, smart solar & storage prosumers can even reach a 60 to 90% ratio.[2] For commercial and industrial buildings that only need power during the daytime, a 100% self-consumption ratio can usually be very easily met.

A smart solar & storage prosumer doesn't need power from the grid most of the time, which leads to reducing grid losses and helps shave peak demand, which is at risk of increasing with the electrification of economic activities, notably transport.

TRENDS FIGURE 1 PROSUMER BUSINESS MODELS

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Optimising self-consumption rates without using the public grid

- Individual self-consumption optimised with storage and energy managment systems (EMS)
- Collective self-consumption optimised with storage & EMS in a building
- Microgrid with Solar, storage and EMS

Optimising local self-consumption rates using the public grid

- Collective self-consumption with solar and EMS at neighbourhood level
- Peer to Peer trading

Providing flexibility services at system level

- Aggregated solar & storage self-consumers (Virtual Power Plants)

1 See Trends Figure 2.

The development of collective self-consumption

Thanks to innovative regulatory schemes and smart metering, the prosumer model is no longer reserved to single-house residential consumers or single-building companies. The development of collective self-consumption models allows sharing self-generated electricity among different consumers in the same premises or in a close neighbourhood. The 'Mieterstrom' (on-site community solar) framework in Germany, for example, enables collective self-consumption of tenants within a building, and smart metering systems make it possible to manage energy flows among participants. In France, the Autoconsommation (self-consumption) collective framework allows energy sharing among prosumers within a single low-voltage branch.

While a number of countries have implemented policy frameworks for collective self-consumption, these schemes are only starting to develop. However, in the European Union, the Clean Energy Package legislation, passed in 2018/2019, recognises collective self-consumption for the first time and guarantees rights to participants, which will set the stage for member states to implement such models and offer the opportunity to tenants, local public authorities or office buildings to access on-site generated solar for self-consumption.

Aggregated solar & storage prosumers

Beyond clean and low-cost energy security at home or in the commercial space, smart solar & storage prosumers can provide much needed flexibility services to the grid. Unlike coal or nuclear power plants, energy storage batteries can react very fast to a network constraint and provide a very short-term balancing service.

The aggregation of prosumers' loads and batteries can solve two challenges of consumers' engagement and the access to balancing markets, which are usually designed for much larger power providers. Aggregators can easily enter flexibility markets and they can monitor the flexibility of a group of prosumers.

Many projects have been demonstrating the possibility to rely on residential battery systems. In December 2018, after two years of demonstration, the sonnen community, a business model of energy storage provider sonnen, which is aggregating solar prosumers' batteries in Germany, qualified to provide primary balancing power to transmission grid operator TenneT.

A major obstacle to the development of prosumer business models is the availability of adequate smart metering systems and network tariff designs. Often energy storage facilities are charged twice when providing upward and downward flexibility services. In the EU, the new Clean Energy Package obliges member states to roll-out smart meters (on the basis of a cost-benefit analysis) and removes the double charges on prosumers' storage used for flexibility.

Solar & storage microgrids

Microgrids are defined as a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. Now that solar is so cheap, local grids are becoming increasingly interesting, in particular for industrial sites and local municipalities, allowing them to source their own self-generated solar electricity to reduce energy costs and provide back-up or uninterruptible power supply.

While one might think that micro-grids are mainly developed to support renewables-based electrification in rural areas of the developing world or islands, indeed microgrids are often also increasingly used in grid-connected areas where they operators are able to run them in islanding mode if market conditions are not favourable, in case of grid issues, or as mentioned above, because corporates prefer to have their own secure and low-cost power supply

All about policy frameworks

While digital solar & storage technologies to enable solar prosumers are available at an affordable cost today – and are constantly and quickly becoming more sophisticated – they need the right policy frameworks to tap into the full potential of solar prosumers. For that reason, SolarPower Europe's Digitalisation & Solar Task Force has published a report that looks specifically at how policymakers and regulators from across Europe can and are encouraging innovative digital business models in the solar PV ecosystem.[3]

Author: Naomi Chevillard; SolarPower Europe

2 Lightsource, Foresight, Good Energy, KPMG (2015): The Decentralised Energy Transition.

3 Solar Power Europe (2018): When solar policy went digital.

2. DIGITAL SOLAR & STORAGE II – UNLEASHING LARGE-SCALE SOLAR & STORAGE THROUGH GRID INTELLIGENT SOLAR

As a highly versatile and low-cost power generation source, solar is expanding rapidly across the world, and has already reached notable penetration shares in the most advanced energy markets. But in order for solar to become the backbone of the future energy system, it is necessary to move one step forward and exploit its great synergy with energy storage. Solar & storage make the perfect match, as storage allows to fully reap the benefits of solar and has a wide range of applications and technologies to meet different needs and functions.

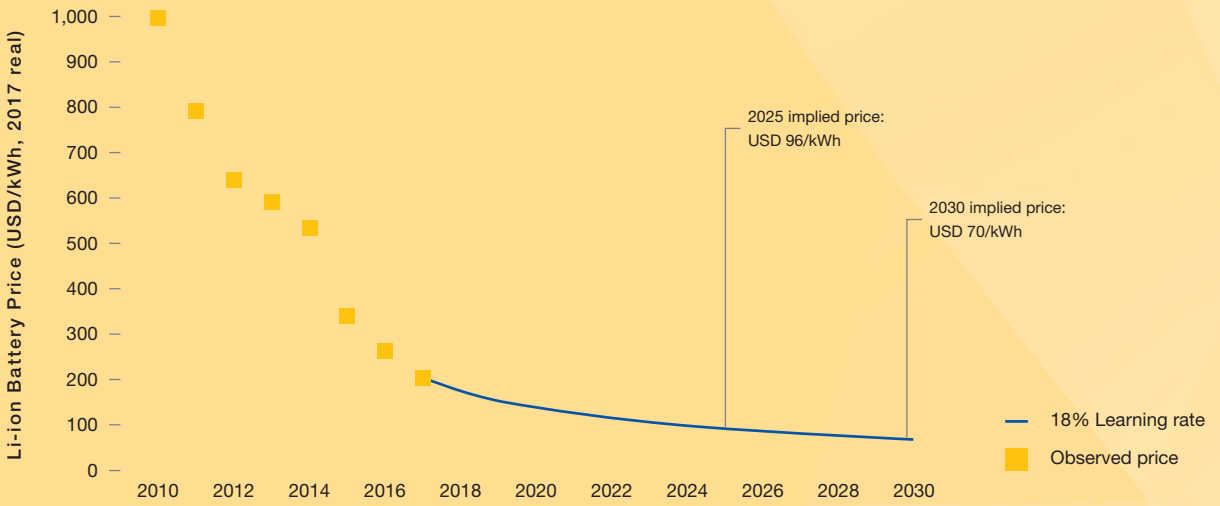
The costs of storage have decreased dramatically in the last decade. Lithium-ion batteries, which are the most diffused type of storage batteries, decreased from 1,000 USD/kWh in 2010 to 200 USD/kWh in 2017. Remarkably, the potential for further cost reduction is substantial – by 2030, prices could fall by more than 60% compared to current levels (see Trends Fig. 2). At the same time, the existence of many different storage technologies able to match different performance requirements suggests that there will be strong competition on performance and costs.

Energy systems everywhere are characterised by quickly increasing shares of variable renewables. In the future, whenever high renewable penetration rates are reached, electricity providers will switch from meeting demand needs to meeting **net** demand needs – the residual demand after accounting for variable renewable generation. In light of this change, storage is supposed to play the key role of both: providing supply during periods of high net demand and avoiding curtailment during periods of negative net demand.

Thanks to smart controls, utility-scale solar plants can already provide flexibility services to the grid, allowing system operators to quickly adapt to changing conditions. With the addition of storage, the potential of solar is fully tapped: solar energy can be dispatched at any time of the day, and has the capability to provide the same or better services and reliability than conventional power plants, because of fast and reliable regulation of active and reactive power, outlined in detail in SolarPower Europe's Grid Intelligent Solar report.[4]

The vision is to move from a **Grid 1.0 system**, in which solar has a low penetration share and is characterised by simply maximising system yields, to a **Grid 2.0 system**, where a higher share of solar corresponds to more flexible solar resources that are able to provide flexibility and grid reliability services, and eventually reaching a **Grid 3.0 system** based on high solar penetration, in which the co-location of solar and storage enables the provision of firm dispatchable capacity.

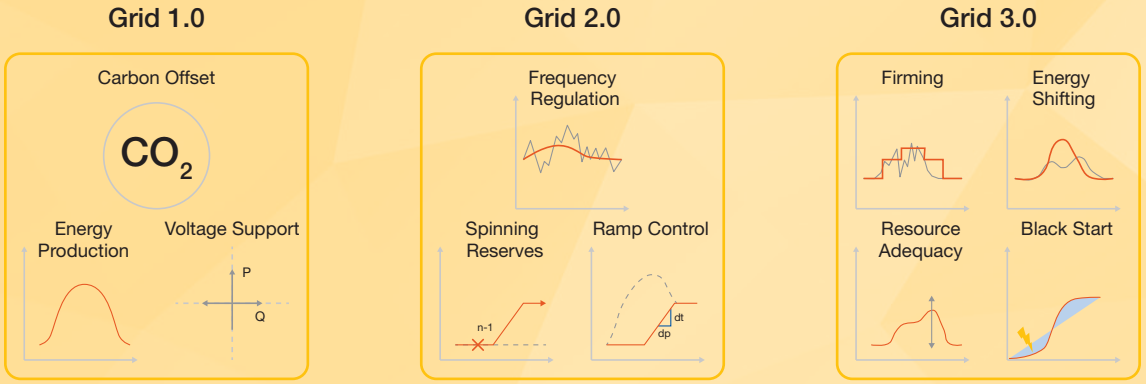
TRENDS FIGURE 2 LITHIUM-ION BATTERY PRICE, HISTORICAL AND FORECAST



Source: BNEF (2018).

4 SolarPower Europe (2019): Grid Intelligent Solar: Unleashing the full potential of utility-scale solar generation.

TRENDS FIGURE 3 THREE GRID PHASES OF SOLAR POWER PLANT EVOLUTION – BASIC SOLAR, GRID FLEXIBLE SOLAR, FIRM DISPATCHABLE SOLAR



Basic Solar
Lower solar penetration markets; maximises energy production

Grid Flexible Solar
Moderate solar penetration markets; solar controlled to provide flexibility and grid reliability services

Firm Dispatchable Solar
Higher solar penetration markets; addition of storage provides firm dispatchable capacity

Source: First Solar.

What's needed to unleash grid intelligent solar?

In order to enable this transition, it is necessary to lift administrative and legislative barriers that prevent solar & storage installations from tapping into their full potential and lower their profitability at the current stage. In particular, it is paramount to enable access to revenue streams additional to energy shifting and peak shaving, such as the provision of ancillary and grid reliability services (see Trends Table 1).

At the regulatory level, ancillary services markets should give priority to the most effective and cost-efficient service providers. Moreover, bids and scheduling of day-ahead markets should be structured in such a manner that keeps up to the availability of precise generation forecast information to better match demand and supply. Generally, the provision of different services simultaneously (e.g. self-consumption and ancillary services) should be allowed to enable income generation from additional revenue streams.

At the grid planning level, variable renewable sources should be regarded as dispatchable resources throughout system operators planning processes. Flexible dispatch capabilities and provision of system reliability services should be given appropriate value, including when designing tenders for new renewable generation.

Author: Raffaele Rossi; SolarPower Europe

TRENDS TABLE 1 THE RANGE OF SERVICES THAT CAN BE PROVIDED BY ELECTRICITY STORAGE

BULK ENERGY SERVICES	ANCILLARY SERVICES	TRANSMISSION INFRASTRUCTURE	DISTRIBUTION INFRASTRUCTURE	CUSTOMER ENERGY MANAGEMENT SERVICES	OFF-GRID	TRANSPORT SECTOR
Electric energy time-shift (arbitrage)	Regulation	Transmission upgrade deferral	Distribution upgrade referal	Power equality	Solar home systems	Electric 2/3 wheelers, buses, cars and commercial vechicles
Electric supply capacity	Spinning, non-spinning and supplemental reserves	Transmission congestion relief	Voltage support	Power reliability	Mini-grids: System stability services	
	Voltage support			Retail electric energy time-shift	Mini-grids: Facilitating high share of VRE	
	Black start			Demand charge management		
				Increased-self consumption of Solar PV		

Boxes in orange: Energy storage services directly supporting the integration of variable renewable energy. **Source**: IRENA (2017).

3. BIPV – THE NEXT GENERATION IS READY FOR THE MASS MARKET

Today, buildings are responsible for 30% of the final energy consumption worldwide.[5] In this context, increasing the rate of energy efficiency renovations of existing buildings (0.5-1% of the building stock annually) and the generation and procurement of renewable energy in buildings in general will be essential to meet the emissions reduction targets set by the Paris Agreement as well as the Sustainable Development Goals.

As CO_2 emissions from buildings have risen again in the last years, it is imperative to find alternative solutions to achieve carbon-neutrality by 2050. While the promise of building integrated PV (BIPV) has been around for decades it has so far failed to become a mass product, easily adopted by developers and architects.

Next-gen BIPV products

However, "third-generation" BIPV solutions are coming fast, offering products that efficiently support the decarbonisation of all types of buildings, and at the same time, enabling the creation of new businesses, which provide local jobs.

The next-gen BIPV products are very appealing and in line with the versatile nature of solar power technology. An increasing number of companies, including Akuo Energy and Tesla, for example, are producing a large variety of multi-functional BIPV products (tiles, windows, etc.) that offer architects and developers a wide range of possibilities to fully substitute roofs and facades while leaving space for architectural creativity. This is backed by increased activity at solar research institutes on that topic: CSEM from Switzerland has developed white solar modules for facades, ECN from the Netherlands has designed integrable large-scale modules with printed surfaces that could be also used for noise barriers or canopies, and Fraunhofer ISE just introduced colourful layers for solar modules that demonstrate high colour saturation, while maintaining an efficiency of around 93% of the original panel.

The next-gen BIPV products are based on basically any solar cell technology available. While many use dominating crystalline silicon, there are also BIPV products, such as solar roof tiles using naturally black CIGS thin-film technology. Some startups also develop lightweight and flexible organic PV solutions, anticipating "connected and integrated buildings" (with smart lighting, smart windows, canopies in parks, shading infrastructures, agriculture-related buildings) will fuel the growth of the global BIPV market.

SUNSTYLE SOLAR ROOF ON AN OFFICE BUILDING, SWITZERLAND

© Sunstyle International.

5 https://www.iea.org/tcep/buildings/

Growing investments in Net Zero Energy Buildings (NZEBs) smart homes and smart cities are driving a global market that could reach revenues of more than 6 billion euros by 2024, with a CAGR of 15% until that year.[6]

The strong decrease in regular solar module cost provides a new opportunity for BIPV. On top of this, years of research have resulted in lower costs for BIPV solutions and processes along the whole value chain. Today, higher module efficiencies, longer warranties, enhanced product performances (with warranted performances of around 25 years), make BIPV installations an attractive option for the next generation of buildings.

Some challenges to overcome

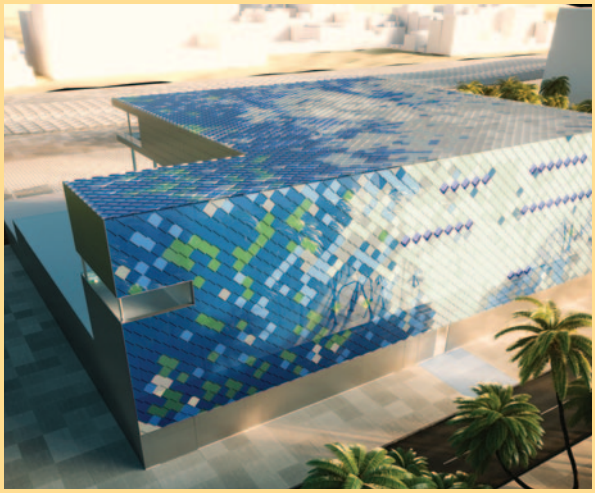
BIPV is not yet a mass-market product and still faces challenges to overcome. The current trend to reduce economic incentives (FiTs or tax incentive schemes) might make BIPV less attractive for consumers and investors. It also needs to educate the market about correlated "key product characteristics", such as long product lifetime, low maintenance costs, decommissioning and recycling. A full-fledged BIPV downstream value chain has to be established – from installation to operation, and maintenance to refurbishment – to provide certainty to the construction sector that reliable sourcing can be dealt with in a mass market.

SolarPower Europe's BIPV Task Force sees the following to-dos as necessary to bring BIPV to the next level and unlock its enormous market potential. The solar sector will have to strongly focus on comparability and access to information via standardisation and certification, allowing BIPV products to compete on equal footing with other construction materials. At the same time, building bridges with other key stakeholders such as architects, construction sector or cities, and developing innovative public/private business partnerships will be crucial to raise awareness on the benefits of this fascinating technology.

However, the next phase of BIPV might come faster than many in the solar sector think. With California making it obligatory to have solar on new builds as of 2020, there is a good chance for BIPV to find its first mass market.

Author: Mariano Guillén Paredes; SolarPower Europe

FRENCH PAVILION DUBAI EXTERIOR VIEW OF THE PHOTOVOLTAIC TILES



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FINANCE TOWER, LIÈGE, BELGIUM, BIPV BY ISSOL, SIMCO ITALIA, JASPERS EYERS ARCHITECTS

© P.Andrianopoli.

6 Arizton (2019): Building Integrated (BIPV) Market – Global Outlook and Foreast 2019-2024.

© Solar Agentur - Prix Solaire Suisse 2016.

4. SOLAR MOBILITY – ELECTRIFICATION OF THE TRANSPORT SECTOR WILL RELY HEAVILY ON SOLAR

With more than 5 million electric vehicles on roads worldwide in 2019 – and Norway as the leader in this field, seeing fully electric cars outselling fossil-fuel based cars for the first time ever in March 2019 – the electrification of transport has now reached a development stage that clearly shows it is a fast, easy, and cost-efficient solution to decarbonising transport and solving air pollution issues in cities. It is now also beginning to quickly transform the automotive sector – and at the same time, it is opening up exciting opportunities for solar.

Using solar as a fuel

Due to the scalability of low-cost solar and its matching generation curve with the common usage pattern of cars, the technology is the perfect fuel for electric mobility – and can be applied through a vast variety of models.

Solar and other renewable power supply offers – through Guarantees of Origin (GOs) or other indirect ways – have been developed for private consumers or charging station operators. Off-site solar PPAs are also being used increasingly worldwide to cover the power needs of electric transport, in particular, subways, trams or trains. Usually publicly owned entities, they are committed to using clean energy while being very sensitive to electricity prices at the same time – a perfect business case for solar. Indian Railways, for example, targets to install 1 GW of solar and 200 MW of wind by 2020.

Solar can also be installed on-site to supply electricity directly to charging stations, be they publicly available or in buildings. Solar installations can be also coupled with batteries to maximise their output. On-site solar charging is particularly interesting for daytime charging patterns in office buildings, commercial buildings or park and ride stations, as the solar generation curve fits well with users' needs, so it can be directly absorbed by the electric vehicles. This enables electricity savings for the owner of the charging stations and prevents undersizing of solar systems; moreover, it also avoids heavy usage of the grid, avoiding expensive grid connection upgrades and associated costs. On-site solar mobility solutions also provide consumers with economic benefits by pooling installation and maintenance costs.

Smart solar mobility

Smart charging is the hot topic in electric mobility, and it is also a central enabler of solar mobility. While smart charging is pivotal to enable grid integration of EVs, it offers vast potential for local and ultra-fast flexibility solutions that also support a very high density of grid integrated distributed solar capacity: many pilot projects are currently testing the ability of aggregated electric vehicles' batteries to avoid grid constraints. The development of bidirectional charging – making EV batteries capable of being discharged to offer power on the grid – and 'Vehicle-to-Home, Building or Grid' concepts will turn EVs into mobile batteries that are able to adapt the charging process to the solar generation curve and optimise self-consumption rates locally.

Solar vehicles and solar infrastructure

The idea of having true solar vehicles with car-integrated PV panels has been looked into for a long time, but in the past, small PV sun-roofs have only been offered optionally by very few companies to power. The year 2019 could be the start of a new era in this perspective as two European start-ups – Sono Motors and Lightyear – have recently launched direct solar-powered cars. Alongside cars, solar is also considered for integration with heavier vehicles, such as buses or trucks' ancillary services, and trains and boats in the urban public transportation or tourism sectors. In this context, solar boats are probably the most advanced segment, with a number of solar electric boats being used for emission-free and clean transport. Such solutions make sense for other reasons: not only do they increase the autonomy of the vehicle and decrease the dependence on larger and more expensive batteries, but they also increase the lifetime of batteries.

Last but not least, solar mobility is also about solar infrastructure. Transport infrastructure offers uncounted opportunities for utilising solar, which will simplify the transition to electric mobility, including solar carports, noise barriers and railways tunnels, among others.

What's next?

Solar offers a wide range of means to enable the electrification of transport. This includes cost savings for electric mobility and providing smart solutions for the grid integration of electric vehicles. Most importantly, versatile, low-cost distributed and central solar power systems are the key to the full and true decarbonisation of the transport sector.

It is crucial that the solar industry is now ready to propose solutions to the automotive sector. That is why SolarPower Europe has launched a Solar Mobility Task Force to put the solar industry at the front of this mobility revolution. The Task Force will map and communicate solar mobility business models. It will also engage with the automotive industry and consumers to promote solar mobility solutions, and with policymakers to ensure public support and removal of barriers.

Author: Naomi Chevillard; SolarPower Europe

TRENDS TABLE 2 THE VARIOUS MODELS OF SOLAR MOBILITY

SOLAR MOBILITY							
Solar as a fuel				Solar infrastructures		Smart solar charging	
Green electricity supply (Guarantees) of Origins)	Off-site solar supply (PPAs)	On-site solar supply	Solar charging and self-consumption	Solar vehicles: solar cars, trucks, boats and trains	Solar infrastructures: carports, roads, tunnels...	At system level: system flexibility potential	Vechicle-to-X

5. TAKING CARE – SUSTAINABILITY IN SOLAR

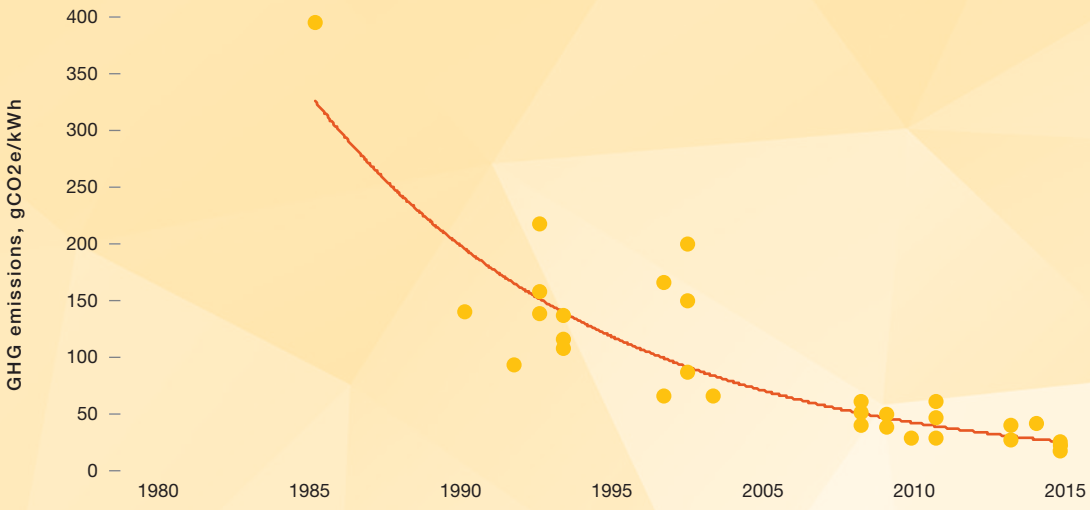
It is no doubt that climate change has been one of the strongest drivers of renewable energy deployment, in light of the need to curb greenhouse gas emissions under the limits set out in the Paris Agreement. Compared to any conventional energy generation source, solar shows clear benefits in numerous dimensions – not only in terms of cost and flexibility in fighting climate change, but also in terms of environmental footprint at large: addressing water scarcity and the use of natural resources, as well as the health impacts of air pollution, which are sustainability challenges solar often provides the answer to. Looking at the broader picture, solar delivers comprehensive benefits from a social, economic and environmental perspective – the so-called triple bottom line of sustainability.

At the socio-economic level, solar is a technology that has a strong positive effect on employment, creating more jobs per installed watt than any other power generation source, both fossil- and renewable-based. The large majority of jobs are created downstream, which means these are local jobs that contribute to socio-economic development – even in under-developed, rural areas. In parallel, at the macroeconomic scale, PV deployment is particularly valuable for net energy importing countries which can decrease their dependence on others, creating energy security at home and avoiding costly energy imports.

With the cost of solar modules having decreased by around 96% since the turn of the century, solar has become one of the cheapest power generation sources today.[7] Therefore, countries and subnational actors will increasingly rely on it as an affordable, low impact technology to meet their sustainability and climate targets. But alongside this dramatic drop in cost – which is continuing – solar is constantly improving its performance on an environmental level as well.

Across its full life cycle, solar currently generates 14 to 58 grams CO_2eq per kWh, down from 173 in 1992 – equalling a 66-92% decrease in carbon emissions.[8] This positions PV as one of the power generation sources with the lowest climate change impact. In parallel, thanks to technological improvements and increased cell efficiency, today, solar energy payback time (EPBT) is consistently below one year in sunnier regions. This means that, given a warranted life time of around 30 years, a panel throughout its service life will generate more than 30 times the electricity it needs for manufacturing.

TRENDS FIGURE 4 HISTORICAL DEVELOPMENT OF SOLAR GHG EMISSIONS



Source: Louwen et al., 2016.

7 Fraunhofer ISE (2019): Photovoltaics Report; EnergyTrends (2019): Price Trend: Market conditions at home and abroad are at odds due to thenew tax system and exchange rate changes.

8 Louwen, A., van Sark, W., Faaij, A., & Schropp, R. (2016): Re-assessment of net energy production and greenhouse gas emissions avoidance after 40 years of photovoltaics development; UNEP (2016): Green Energy Choices: The benefits, risks and trade-offs of low-carbon technologies for electricity production. Report of the International Resource Panel.

Global PV industry trends also indicate steady improvements in material and manufacturing efficiency. While the availability of commodity material needs will not pose a threat for massive deployment of solar technology, critical raw materials used in PV manufacturing, such as silver and silicon, are increasingly being replaced, reduced and recycled. Looking at the broader picture, a systematic circular approach is a necessary step to ensure long-term sustainability for solar. Applying circular principles along the whole value chain implies not only a lower dependence on critical raw materials, but also actions in terms of design for circularity, reduction of production waste, lower energy use for cell and module manufacturing, qualitative refurbishment of panels and efficient end-of-life management.

Recycling of PV modules, inverters and batteries is already an established practice in a number of markets. In some legislations, such as the EU, it is mandatory to set up take-back and treatment schemes under an extended producer responsibility (EPR) approach. While technical recycling yields of up to 90% of the weight are obtained in existing recycling plants, the low waste stream volumes being generated today pose a significant economic challenge. Due to its relatively long lifetime, the amount of PV entering the end-of-life stage is less than 1% of the total installed capacity. This situation is set to change quite considerably in the future, enabling the creation of economies of scale and improving the recycling options.

One should bear in mind that sustainability is not just an intrinsic feature of solar but can become the core of a business strategy to create competitive advantages. There are several cases of successful market positioning as producers of PV products with low environmental impact and high quality – this is the case of First Solar, which besides offering CdTe modules characterised by very low carbon emissions, also guarantees take back of every product sold on the market. In this regard, the NSF 457 Sustainability Leadership Standard for Photovoltaic Modules, launched in November 2017, is an industry-led voluntary standard that sets sustainability performance requirements for PV manufacturers.

SolarPower Europe's Sustainability Task Force has launched a Solar Sustainability Knowledge Series on Cost & Efficiency, Environmental Footprint, Materials, Employment, and Recycling at Intersolar Europe that are available to download from our website.

Author: Raffaele Rossi; SolarPower Europe

6. ASSET MANAGEMENT 2.0: MORE TRANSPARENCY, MORE DIGITALISATION

The solar industry has become a mature industry with major global investors getting seriously involved and previously unseen amounts of money flowing into solar. With the professionalisation of solar investors and the globalisation of solar investment portfolios, service quality expectations are changing and rising rapidly, which puts increasing requirements on asset managers. As opposed to operation & maintenance (O&M) service providers, who take care of the solar power plant on a technical level, asset managers deal with the commercial and financial management of a solar investment. They manage a company – or a portfolio of Special Purpose Vehicles (SPVs) – rather than a power plant, often across different geographies, with different regulatory and environmental challenges and with a variety of different business models. Asset managers cover topics such as accounting and financial reporting, cash-flow management, debt management, insurance management, Power Purchase Agreement (PPA) management, SPV representation and O&M contractor supervision.

Solutions/Answers

First, traditional asset management models employ a linear management approach, where information flows from the asset through the O&M contractor to the asset manager and ultimately to the asset owner. This linear approach means that the asset owner does not have direct access to data and information from the solar power plant. Rather, data and information from the asset are filtered before reaching the asset owner, creating mistrust and a lack of transparency between the main stakeholders. To address these inefficiencies, the asset management industry is transitioning to an asset-centric information-based management approach to address three key problems: (1) loss of generation and income; (2) loss of time; and (3) lack of transparency.

Second, asset managers are increasingly expected to continuously increase the return on investment by increasing revenues and reducing costs. This can be done via six key processes:

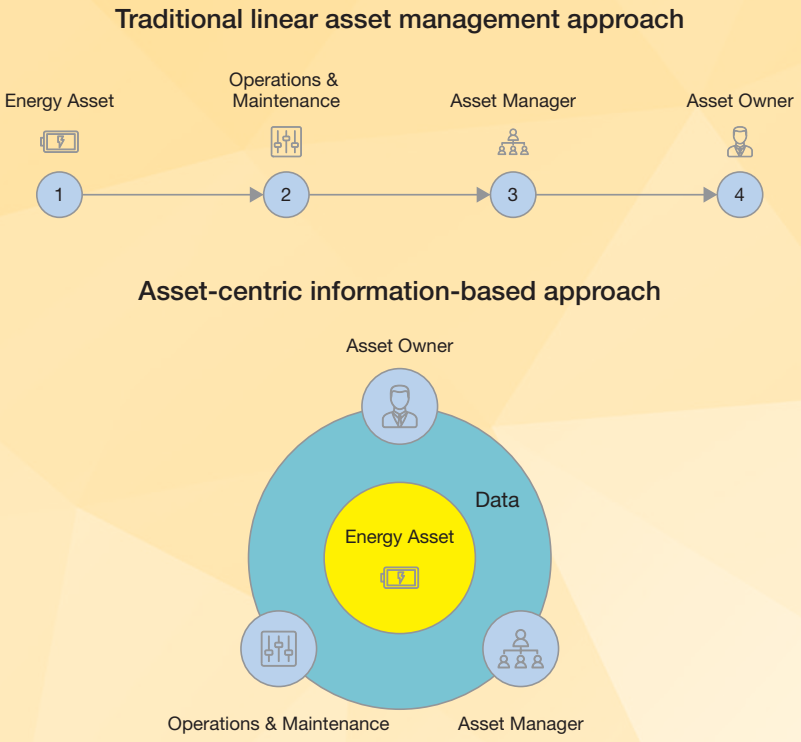
1. Plant performance
2. Operation cost reduction
3. Financial restructuring / re-engineering
4. Legal and contractual renegotiation
5. Technology adaptation and upgrades
6. People management

Third, asset managers are increasingly expected to adopt quality systems such as the ISO 55001 standard and rely on advanced digital tools integrated with other systems such as the monitoring platform, rather than spreadsheets in order to effectively and transparently manage assets. Adopting quality systems and digital tools will be key to staying competitive in solar asset management.

To address the issue of quality in solar asset management and support the growth of this segment, SolarPower Europe started a new endeavour – the development of the Solar Asset Management Best Practices Guidelines, to be launched in December 2019. The Guidelines will make the experience of leading asset management specialists available to the global solar industry, including investors looking for quality services, with the aim to increase quality and consistency in the market.

Acknowledgement for input: Ypatios Moysiadis, Greensolver
Author: Máté Heisz; SolarPower Europe

TRENDS FIGURE 5 TRADITIONAL LINEAR ASSET MANAGEMENT APPROACH AND ASSET-CENTRIC INFORMATION-BASED APPROACH WITH THE THREE MAIN STAKEHOLDERS OF ASSET MANAGEMENT



Source: Greensolver.

7. CORPORATE SOURCING OF RENEWABLES – WHY CORPORATES INCREASINGLY STRIVE TO GO 100% RE

The global corporate sourcing market has never been as active and diverse as it is today. The renewable energy procurement movement was started by trailblazing organisations that were committed to reducing their environmental footprint, and at the same time, saw an opportunity in this to reduce their electricity bill. In the meantime, green power sourcing has become a crucial part of the energy and sustainability strategy of many leading corporates – and as costs for renewables continue to decrease, the appetite for cost-competitive solar and wind power is now growing quickly.

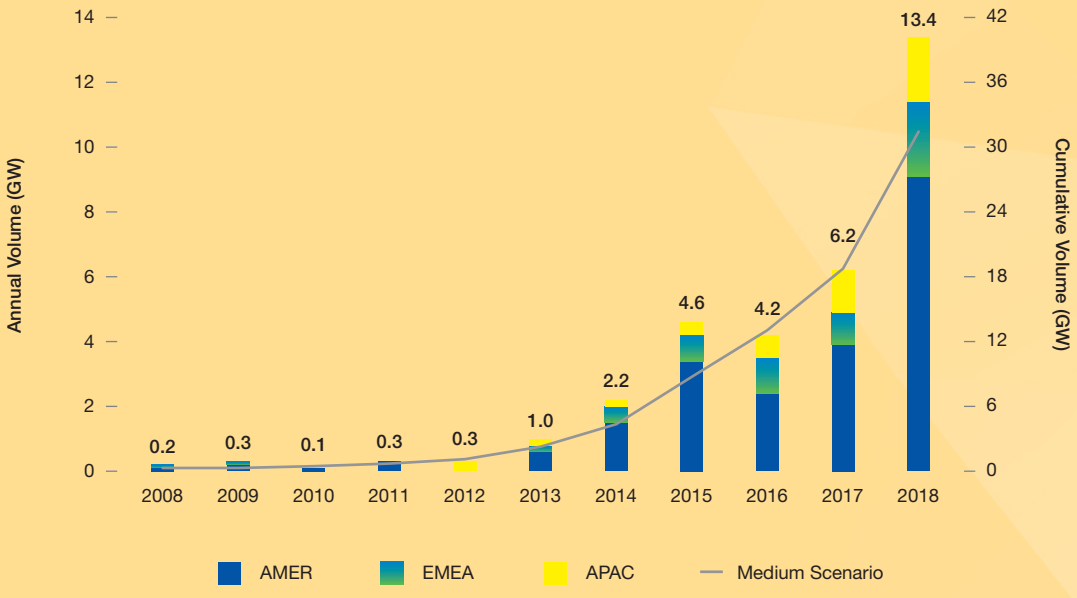
In 2018, a breathtaking 13.4 GW of corporate PPA deals were signed worldwide (see Trends Fig. 6), more than double the volume in 2017. So, what has changed in just one year to witness this incredible growth?

US continues to lead in corporate green power sourcing

The United States, the world's leading renewable energy PPA market, has seen a very strong rise in corporate sourcing of green power and the main reason is a combination of different factors. The first element was a surge in aggregation models that allowed a wave of smaller players to sign their first agreements. Secondly, a series of big deals from a few corporates were signed with utilities, benefiting from emerging Green Tariffs, which are optional programs in regulated US electricity markets offered by utilities and approved by state public utility commissions that allow larger commercial and industrial customers to buy bundled renewable electricity volumes from specific projects through special utility tariff rates. Growth in Brazil or Mexico also supported rapid development of corporate renewable PPAs in the Americas.

On a smaller scale, Europe also observed many deals for record PPA volumes that more than doubled year-

TRENDS FIGURE 6 GLOBAL CORPORATE PPAs BY REGION



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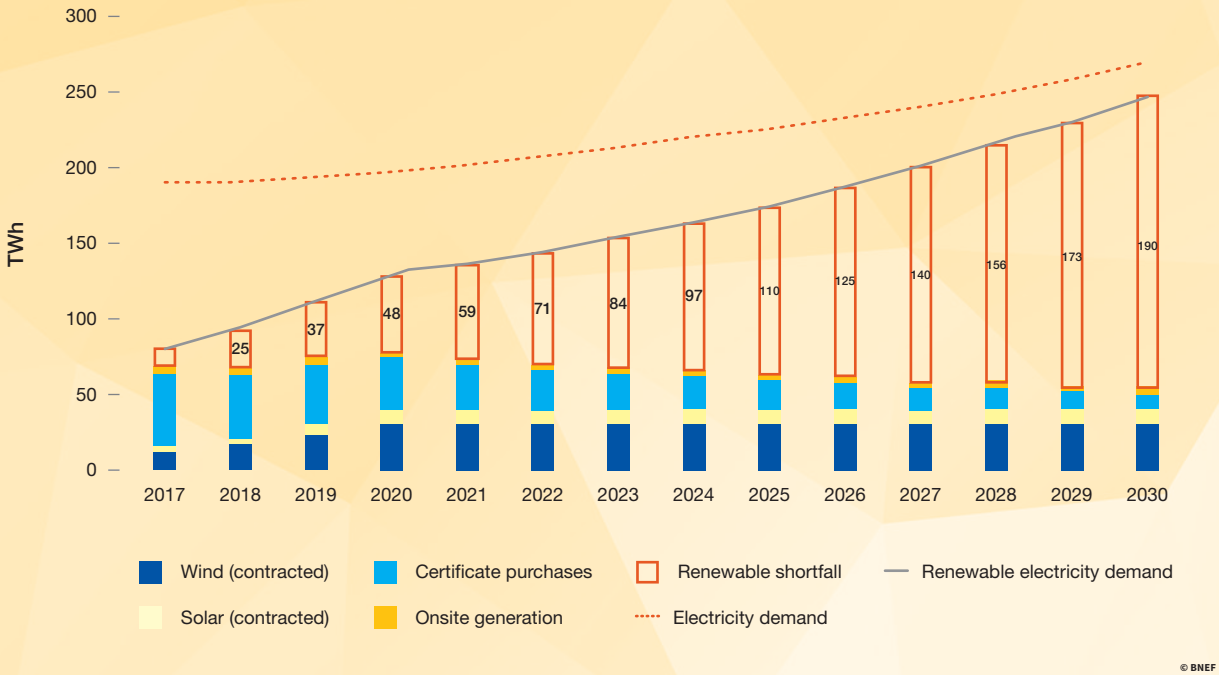
on-year to 2.3 GW in 2018. This was, in particular, thanks to the right framework conditions in Nordic countries, though mostly related to wind, and growing interest of corporates in signing deals in completely new PPA markets, such as Poland. When it comes to solar figures, more than 10 GW of rooftop solar has been installed in the past five years.

Large-scale off-site PPAs were the driver in the Asia-Pacific (APAC) region growing to 2 GW from 1.3 GW the year before. Australia and India are world leading solar markets with enormous potential that are starting to take off in corporate renewable power sourcing. Two other solar giants in that region, China and Japan, are also seeing the first corporate PPA developments, which are expected to speed up rapidly soon, as both countries currently transition away from a traditional feed-in tariff support scheme.

So far, corporates have chosen primarily wind over solar for renewable PPAs. First, it has been easy to access large, renewable power volumes from big wind farms; smaller, commercial solar has rather been directly installed on-site. With the advent of large-scale solar in Europe and corporate renewable power sourcing emerging in traditional utility-scale solar markets, such as China and India, low-cost solar is going to play a much bigger role in corporate sourcing.

Though at a very early stage, corporate sourcing of renewable energy shows the increasingly strategic role that wind and solar play in the business operation of corporations around the world. This will make it impossible for governments to neglect this vast potential much longer and force them, sooner rather than later, to implement policies that support corporate sourcing in the electricity sector and promote additional investments in renewable energy. In fact, corporate demand is already higher than the availability of appropriate projects today. According to Bloomberg NEF, today's RE100 companies, a group of leading global corporates that has committed to go 100% renewable, require an additional 190 TWh from renewable energy production by 2030 (see Trends Fig. 7).

TRENDS FIGURE 7 PROJECT RENEWABLE SHORTFALL FOR RE100 COMPANIES



Many barriers to overcome

Several organisations around the world are working to strengthen the business case and communicate the competitive advantages of corporate renewable energy sourcing (i.e. the RE-Source Platform in Europe, REBA in the US or the REI in Japan). A key event for interested parties in this field is the RE-Source Conference, which will take place in Amsterdam from the 2nd to the 3rd of October 2019. Nevertheless, regulatory constraints and legal restrictions are still in place in many markets, hindering the development of corporate renewable energy sourcing. Some of these obstacles are:

- Restrictions on third party ownership of on-site installations
- Major administrative and financial burdens
- Interconnection fees for cross-border projects
- Restrictions to multi-buyer or multi-seller schemes
- Compatibility of support schemes with corporate PPAs

These barriers, that differ from country to country, can hold back large IT companies, pharmaceuticals, food and beverage giants, and energy intensive corporates from sourcing renewable energy, but more importantly, make things particularly challenging for small and medium-sized businesses (SMEs), which also offer huge potential to be unlocked. SMEs need more flexibility and straightforward administrative and legal procedures to engage in corporate sourcing and measures that will open the door to all types of industrial and commercial consumers striving to go 100% renewables.

Author: Mariano Guillén Paredes; SolarPower Europe

8. TENDERS – TOWARDS INTELLIGENT TENDERS

The concept of tenders has many supporters among energy policymakers dealing with renewable energy market design. Tenders or auctions are considered a perfect means to control growth and reduce power purchase costs to the minimum. This is in contrary to traditional uncapped feed-in tariffs, which have been the preferred solar support scheme in the past but bear the risk of unexpected high expansion rates and high costs, if not properly designed.

There are numerous FIT examples that experienced such uncontrolled growth – from Germany to Japan, with the latest example being China, which added nearly 53 GW of solar capacity in 2017, although it was rather targeting a range between 20 and 30 GW. At that time, China was offering feed-in tariffs for utility-scale plants between 0.65 and 0.85 RMB/kWh, while its third Top Runner Programme auction round resulted in a lowest winning price of 0.31 RMB/kWh. No wonder China pulled the brake on its FITs scheme and began to restructure its solar incentives to cut on cost and make solar fit for the next growth phase, which will, in the short term, be based mostly on tenders, with the aim to enable the share of merchant solar/PPA based systems to grow quickly.

While established solar markets already have or are in the middle of transforming their large-scale PV incentive schemes towards tenders, these are also **very useful tools to help create utility-scale solar markets in developing countries**. The World Bank Group's Scaling Solar Programme has provided stable framework conditions for the first large-scale solar systems to be developed, financed and finally built in African countries Senegal, Zambia, Mozambique and Ethiopia. A total of over 700 MW had been tendered in these four countries by the end of April 2018, with the latest rounds leading to awards in the low 4 US cent/kWh range.

However, well-thought-out tender designs are needed to turn this tool into a useful instrument for growing the utility-scale segment in a sustainable manner; otherwise, tenders might even work counterproductively and distort rather than support solar markets:

- In **Japan**, the first three solar pilot auctions in 2017/2018 disappointed. The lowest awarded bids were all always significantly lower than the regular FIT level, consequently, only around 500 MW were awarded against a goal of up to 1.5 GW. As long as there are more attractive FIT schemes available, as in Japan, companies will prefer these alternatives, which offer higher returns and avoid the risk of not being awarded a PPA.
- **India's** National Solar Mission is a gigantic solar programme targeting 100 GW of solar capacity by 2022 that is mainly based on tender schemes. These tenders have led to a very competitive solar business environment and very low solar power prices in India, creating a global top 3 solar market in just a few years. But in 2018, demand contracted, partly because of issues with its tenders, such as DSOs trying to retroactively renegotiate awarded bids to profit from fallen market prices or implementation of protective measures, including attempts to combine multi-gigawatt power plant tenders with the creation of local integrated module manufacturing facilities.
- **France** is lagging behind on its solar targets – and its complicated solar tender schemes have been part of the problem. Systems as small as 100 kW are included in the tender scheme, but such small projects provide unnecessary overhead cost for bidders. For exactly that reason, solar projects under 1 MW should be exempt from tender schemes.
- In **Germany**, awarded power prices in recent tenders increased slightly rather than continuing their downward trend, unlike module prices. This indicates that project development cost went up. What's needed are larger systems (currently capped at a maximum size of 10 MW) to decrease overhead cost and less restrictions for project locations.

However, in general, tenders have been a success story for the solar sector so far. In Europe, power costs have come down so much that solar was able to win significant volumes in technology neutral renewable tenders in several countries – including Spain, France, Germany, Denmark – and in some instances even the entire volume. An issue with **'simple' technology-neutral tenders** is that they do not offer any planning visibility – neither for the solar sector, nor for regulators who actually need a clear planning horizon for the different flexible RES technologies that all have distinctive features. Regular technology-specific tenders are much better in this respect.

What's rather needed, in particular in countries with already higher shares of flexible renewables, are **intelligent technology-neutral tenders**, which permit combinations of different technologies, such as solar, wind and storage. Their job will be not only about injecting power into the grid but also providing different grid services. Germany will issue a first pilot tender in September 2019 that will award technical innovation and innovative business models regarding grid services.

Author: Michael Schmela; SolarPower Europe

9. EMERGING MARKETS – JOINT EFFORTS TO MITIGATE RISKS AND SCALING SOLAR

Introduction

While China continues to be the dominant global solar market, its shares are decreasing, and the rest of the world is picking up. New emerging markets include, in particular, developing countries that were not on the solar map until recently. Many of these markets are facing fast-growing energy demand and energy poverty, while low-cost solar has enormous potential to enable socio-economic development for communities as well as businesses. SolarPower Europe estimates that emerging markets could add 100 GW of solar until 2023 – with the highest demand expected in the Middle East and Africa (51 GW) followed by South Asia (39 GW) (see Trends Fig. 8).

However, various economic, financial, institutional and technical challenges have been major barriers in many countries to scale up on-grid solar development. To address these challenges, the international community has been deploying various initiatives to promote investment in solar. Thanks to initiatives such as the EU External Investment Plan (EIP) and Scaling Solar, as well as other development bank financing initiatives, low-cost on-grid solar is now becoming increasingly accessible in developing markets.

Challenges

Barriers facing solar investors in emerging markets include limited political will and institutional capacity, political and economic instability, lack of transparency, ineffective regulatory framework, non-bankable PPAs, and poor grid capacities. These barriers lead to high transaction costs and high business risk perceived by potential investors and need. Risks need to be mitigated by well-targeted measures in order to enable investments.

Solutions

Initiatives supporting the scale-up of solar (and renewables in general) mitigate the challenges listed above via various types of support and de-risking measures, such as financial support (loans, grants, guarantees, insurance), technical support (such as grid integration studies), capacity building measures (trainings to reinforce human and institutional capacities to manage processes) and standardised documents (tendering procedures, bankable standard contracts).

According to a recent study published by RES4Med&Africa,[9] there are more than 100 European financing instruments conceived to facilitate the development of renewable energies in Africa (and elsewhere). Apart from financing instruments, there are also a multitude of technical assistance facilities aimed at human and institutional capacity building. The landscape of financing instruments is very diverse in terms of geographical coverage, types of technologies, project sizes, project phases covered or types of assistance measures provided. Instruments such as Energising Development (EnDev) and the EU Electrification Financing Initiative (ElectriFI) are aimed at smaller-scale projects, whereas programmes such as the International Financial Corporation's (IFC) Scaling Solar target large-scale projects. Some instruments provide only capacity building (e.g.: trainings and workshops organised by institutions, such as the European Commission or IRENA) or only technical assistance (e.g.: the feasibility study financing programme of DEG). Some financing instruments cover several or all types of support measures, for example IFC's Scaling Solar, the EU External Investment Plan (EIP) or KfW's Global Energy Transfer Feed in Tariff (GET FiT), which provide financial and technical support as well as capacity building measures.

The Open Solar Contracts are an upcoming, open-source suite of bankable standard contracts for solar projects developed by the International Renewable Energy Agency (IRENA) and the Terrawatt Initiative together with more than 30 international law firms and associations, including SolarPower Europe. The Open Solar Contracts are set to be launched in the second half of 2019.

9 RES4Med&Africa (2019): White Paper: A new instrument to foster large-scale renewable energy development and private investment in Africa.

TRENDS TABLE 3 17 SELECTED EUROPEAN INSTRUMENTS FOR LARGE-SCALE RE IN AFRICA

NAME	FINANCIAL INSTRUMENT	FUND DATA	TECH. COVERAGE	PROVISION OF SUPPORT SERVICES			
				FINANCIAL	TECHNICAL	CAPACITY BUILDING	STANDARDIZED DOCUMENT
EU External Investment Plan (EIP)	Debt, equity, guarantee, grant	Fund size: € 4.1 Billion	All	X	X	X	
Scaling Solar (SS)	Debt, equity, guarantee, insurance, grant	Not specified	Solar	X	X	X	X
Public - Private Infrastructure Advisory Facility (PPIAF)	Grant	Not specified	All		X	X	
NEPA Infrastructure Project Preparation Facility (IPPF)	Grant	Not specified	Wind, solar, hydro		X	X	
FMO Infrastructure Development Fund/ Direct Investment (FMO-IDF)	Debt, equity, grants	Fund size: € 326 Million Investment size: € 5-50 Million	Wind, solar, hydro, geothermal, biomass	X	X	X	
ACP -EU Energy Facility (ACP - EU)	Grant	Fund size: € 200 Million	Wind, solar, hydro, biomass		X	X	
EU - Africa Intrastructure Trust Fund (ITF)	Debt, equity, guarantee, insurance, grant	Fund size: € 812 Million	All	X	X	X	
Southern African Development Community (SADC - PPDF)	Grant	Not specified	Solar, hydro		X	X	X
Clean Technology Fund (CTF)	Debt, guarantee, grant	Fund size: € 5.4 Billion	All	X	X	X	
Climate Investor One (CIO)	Equity, grant	Fund size: € 535 Million Investment size: € 80-100 Million	Wind, solar, hydro	X	X		
Danish Climate Investment Fund (DCIF)	Debt, equity, grant	Fund size: € 180 Million Investment size: € 2-50 Million	All	X	X	X	
Africa Energy Guarantee Facility (AEGF)	Insurance, guarantee, grant	Fund size: € 1.4 Billion	Wind, solar, hydro, biomass, geothermal		X		
West Africa Clean Energy Corridor Program (WACEC)	Grant	Not specified	Wind, solar		X	X	X
Energy Sector Management Assistance Program (ESMAP)	Grant	Not specified	Wind, solar, geothermal		X	X	
The NEFCO Carbon Fund (NeCF)	Debt, equity, guarantee, grants	Fund size: € 165 Million Investment size: € 4-5 Million	Wind, solar, hydro, biomass, geothermal	X	X		
FISEA Invest and Support Fund for Businesses in Africa (FISEA)	Equity, grant	Fund size: € 250 Million Investment size: € 1-10 Million	Wind, solar, hydro, biomass, geothermal	X	X	X	
Terawatt Initiative (TWI)	Equity, guarantee, insurance, grant	Not specified	Solar	X	X	X	X

Source: RES4Med&Africa (2019).

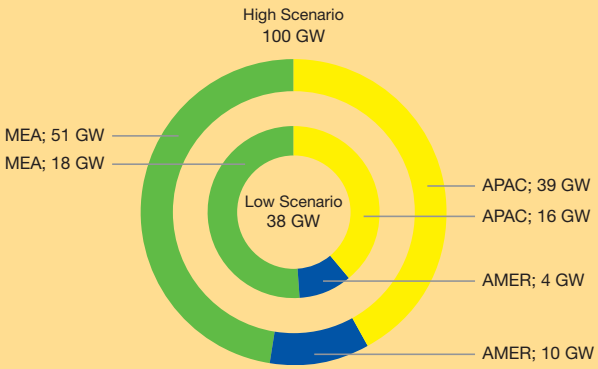
Conclusion

Ambitious initiatives such as Scaling Solar, GET FiT, ElectriFI, the EIP or the Global Solar Contracts are contributing to scaling up solar in emerging markets. For example, Scaling Solar is enabling more than 570 MW of solar power projects in Zambia, with an additional 700 MW in the pipeline in Ethiopia, Madagascar and Senegal. Such initiatives can pave the way to establish solar and enable local players to build on the experience built for the next solar investment phase.

SolarPower Europe, via its Emerging Markets Task Force chaired by Eni, is cooperating closely with international institutions such as the European Commission, IRENA and IFC and to generate synergies, identify and tackle investment barriers, and streamline and raise awareness about existing financing instruments. For example, as one of the 12 focus markets of the Emerging Markets Task Force is Mozambique, SolarPower Europe is coordinating activities and planning joint actions locally with the European Commission and IRENA, as well as the local renewable energy association AMER, with the aim to jointly engage local stakeholders, identify and create business opportunities and promote the energy transition in general. Additional focus countries of the Emerging Markets Task Force include India, Ivory Coast, Jordan, Kazakhstan, Mexico, Morocco, Mozambique, Myanmar, Tanzania and Tunisia.

Author: Máté Heisz; SolarPower Europe

TRENDS FIGURE 8 SOLAR POTENTIAL IN EMERGING MARKETS 2019 - 2023



10. SOLAR + HYDROGEN – THE PERFECT MATCH FOR A PARIS-COMPATIBLE HYDROGEN STRATEGY?

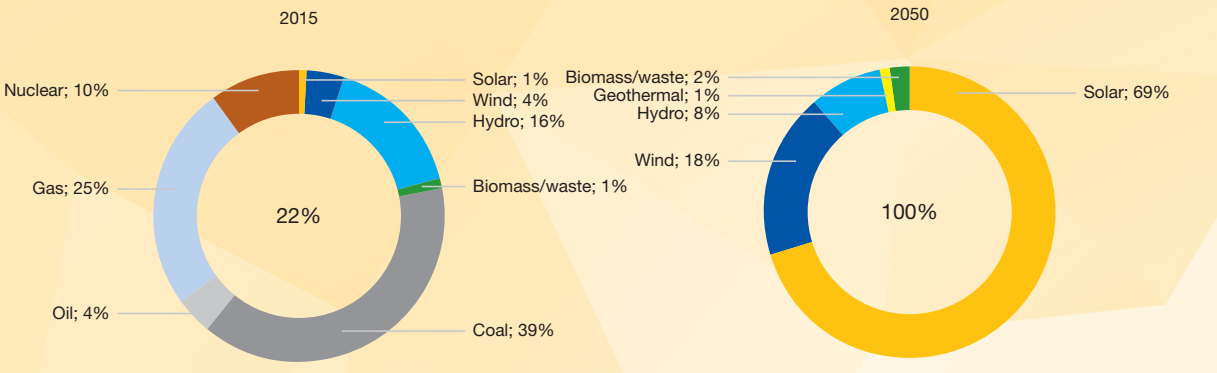
Reaching a global carbon neutral economy will require a significant level of renewable penetration – up to 85% in the world's future electricity mix. Most political and scientific scenarios acknowledge that renewable electricity will have to be complemented by power-to gas (PTG) technologies to provide carbon-neutral, seasonal storage to the energy system and achieve complete decarbonisation of global economies with a focus on electro-intensive sectors, transport and industry. In 2019, PTG is entering the selective club of "2050 clean energy technologies", which is the portfolio of clean technologies needed for a carbon neutral economy and to keep the world below the 1.5°C global warming milestone. This has not gone unnoticed by energy companies. In February 2019, the first large-scale solar-to-hydrogen facility was inaugurated by Siemens and Dubai Electricity and Water Authority (DEWA) at the outdoor testing facilities of the R&D Centre of Mohammed bin Rashid Al Maktoum Solar Park in Dubai, which – once its 5 GW capacity is completed by 2030 – will be the largest solar plant in the world.

Challenges

The rising debate about a "hydrogen economy", however, needs to be addressed with infinite precaution. Not all "hydrogen" varieties are in line with the Paris Agreement: synthetic gases produced from conventional oil and gas technologies are still a significant factor of CO_2 emissions; its potential 'green' color will rely heavily on the maturity of carbon capture and storage (CCS) which has not yet reached market parity and still has to prove its competitiveness, unlike renewable energy solutions. However, even if the world's future energy mix snapshot won't be 100% electric, it could still be 100% renewable – with solar energy being the key to any contributing technology, and this includes hydrogen.

The cost-efficient production of renewable-based hydrogen will require significant volumes of cheap electricity – which is a win-win combination for economies with high penetration of solar energy. With solar energy quickly becoming the cheapest source of power generation, with huge, untapped global potential, the technology will grow very quickly from 1% in 2015, and could cover up to 69% of the worlds electricity mix by 2050 in a 100% renewable-based energy system, according to the Finnish University, Lappeeranta University of Technology (LUT).

TRENDS FIGURE 9 ENERGY DEVELOPMENT 2015-2050



Source: Lappeenranta University of Technology and Energy Watch Group (2019).

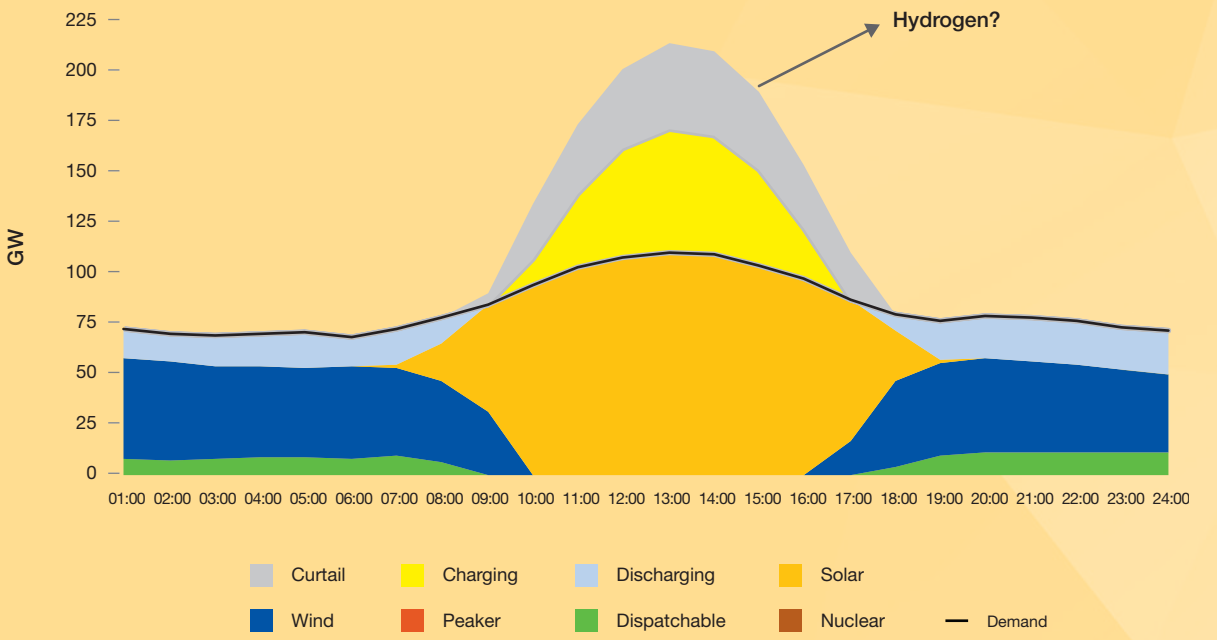
The load curve of solar generation is a "perfect match" for efficient renewable hydrogen generation. Significant volumes of battery storage will be plugged into the energy system in the next decades, driven by a massive increase in electrical vehicles and stationary home storage products. Battery storage will be key to providing flexibility to the future energy system; charging taking place during the day, with the solar surplus balancing the energy system in morning and evening periods. Despite this intraday optimisation, most future energy mix scenarios anticipate the availability of so much solar power that high volumes will need to be curtailed during midday hours, like in the German scenario from Bloomberg NEF (see Trends Fig. 10). This surplus of solar electricity is a unique opportunity to produce cheap and yet 100% renewable hydrogen in Europe, while contributing to the stabilisation of the energy system and avoiding costly balancing adjustments by electricity network operators.

With extremely competitive costs and a high scalability potential, solar electricity is the ideal solution for converting electrons in molecules. Boosting the generation of solar-based hydrogen will help accelerate the decarbonisation of energy-intensive sectors across the world, such as mobility, heavy industry and heating, that are all more complex to fully decarbonise through direct electrification. In markets with high shares of solar penetration, **solar-based hydrogen could be the culminating point of an "Industrial Green New Deal"**, merging growth and industrialisation with sustainability.

In summary, a global 'solar-to-hydrogen' revolution is possible and could unlock significant benefits for society. **All you need is much more solar energy plugged into the world's energy system**, and the right business models to emerge for the solar industry. In July 2018, SolarPower Europe organised a highly successful workshop on the opportunities for solar-to-hydrogen together with Hydrogen Europe. In March 2019, SolarPower Europe's Board of Directors decided to develop a forward-looking strategy for the solar sector.

Author: Aurélie Beauvais; SolarPower Europe

TRENDS FIGURE 10 GERMANY INTRADAY GENERATION: TYPICAL SPRING DAY 2050



Source: BNEF (2018).

11. TECHNOLOGY UPDATE: HOW TO CUT COST EVEN FURTHER

Now that solar has become the lowest cost power technology in many regions, there have been few voices asking if there's still further reduction potential. The answer is a clear yes! Solar still has a lot of leeway to cut cost – and there are many ways to tap into this potential. Naturally, the solar module and its process materials as the biggest contributor to system cost are the prime focus for cost reduction efforts. At the same time, all other parties involved in production of hardware and generation of power are working hard on solar's competitiveness to improve even further. SolarPower Europe has looked at the latest developments on different technologies to reduce solar system cost and at intelligent applications that offer synergies between solar and other applications.

WAFERS

Mono – further growth insight: Depending on the source, monocrystalline silicon was at parity or had already taken over the leadership position from multicrystalline silicon in 2018. In any case, the scale will swing further towards mono this year and beyond, as all silicon ingot crystallisation capacity expansions are focussing on the mono variant, which has less defects than multi, enabling production of higher cell efficiencies. In April, LONGi Group announced that it will expand its mono ingot/wafer output from 28 GW in 2018 to 65 GW by 2023 (that's nearly two-thirds of global installations in 2018). Cost improvements in mono wafering/crystallisation technology had pushed the development from multi to mono, while a pull has been coming from higher efficient mono PERC cell technology.

CELLS

PERC – for everyone: 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 brings 0.5-1% points efficiency improvements with little more cost for additional production equipment, the bulk of crystalline silicon cell equipment investment is mostly being spent on PERC tools these days. Now the big question is: what comes next?

Beyond PERC - Passivated Contacts or HJT? The next evolutionary step in solar cell technology following PERC are likely **Passivated Contact** cells, often called **TOPCon**, where a sophisticated passivation scheme is adapted to advance cell architectures with the promise of even higher efficiencies. In January 2019, JinkoSolar announced a 24.2% world record efficiency TOPCon cell based on n-type monocrystalline silicon substrate. So far, only very few companies are producing commercial quantities of TOPCon cells, but there is a lot of interest.

An even higher efficiency potential is offered by **Heterojunction technology (HJT)**, which holds the overall cell record for silicon solar cells at 26%. 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 the silicon wafer and thin-film worlds. A number of equipment providers now offer HJT processing tools, and the first new commercial cell/module lines have been in pilot production and/or ramp-up by ENEL Green Power and a few others. 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.

MODULES

Bifacial – back & front: The technology that will help bring down LCOEs of solar power plants the most in the short run are bifacial solar modules that generate power not only on the front side but also on the back side. This results in power gains between 5 and 30%, depending on solar cell technology used, location and system design. With today's new high-efficiency cell generations all being 'naturally' bifacial and issues with standardisation or bankability mostly solved, the technology is rapidly gaining market share – from 10% in 2018, to 30% in 2021, according to the International Roadmap for Photovoltaic 2019 (ITRPV).

Half cells – easy power gain: When most people think about a solar cell, they see a blue square slice of silicon. In the future that might be different. Using half cells is a simple but very effective means to increase module power. By cutting a fully processed cell into two parts, resistance losses can be reduced, providing a power boost of about 5 to 6 W on the module level. Basically, every module manufacturer now has half-cell products in its portfolio – and will raise shares as clients get used to the new solar look.

Multi-busbars: One of the easiest ways to reduce resistance losses of solar cells is to add more busbars. While using 3-busbar cells was the standard in module assembly only a few years ago, the industry successfully shifted to 4-BB cells in 2017. Today, basically everyone has upgraded its latest standard product range to 5-BB design. The next step is so-called multi-busbars (MBB). Here, over a dozen wires are used, that are so close to each other that the finger width can be reduced significantly. On top, MBB enables eliminating the busbars from the cell layout. This helps in saving silver paste consumption by up to 80% on the cell level.

The 400 W+ module: Improvements in cell technology and module design – such us multi-busbars, half cells, shingles, all of which can be generally combined – and the use of somewhat larger wafers can help raise the power rating bar of a crystalline solar module above the 400 W level for a panel with 72 cells (or 144 half-cells). Higher power ratings mean fewer modules and less space requirements for solar plants of any size, which reduces installation, system material and land costs.

Double glass or glass-backsheet: Glass-glass modules have been around for many years, but until recently, their share was, for a number of reasons such as heavy weight, negligibly small compared to glass-backsheet modules. Even 30-power performance warranties, that are five years longer than the typical warranty for a glass-backsheet module, didn't help too much. This has changed with the advent of bifacial modules, which need transparent back covers to generate power on the rear side. A highly transparent glass cover seems to be the natural fit, and module manufacturers have been using almost exclusively glass-glass for their bifacial products so far. However, in the last few months, a number of backsheet suppliers came out with new transparent products, and the first module manufacturers have started offering bifacial glass-backsheet solar panels with 30-year power warranties as well. Glass-backsheet module technology is now ready for the bifacial era as well.

Thin & 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 much larger form factor of 420W+, 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 solar. Primarily used in the past as a means to convert 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. On the other hand, there is 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 the 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 little higher 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 to be able to generate power on their back side.

SOLAR SYSTEMS AND INNOVATIVE APPLICATIONS

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, 45,000 residential storage systems were installed in 2018, up 20% from 37,500 in 2017, according to EuPD Research. In certain regions, more than every second solar system is already sold with a storage system.

Floating Solar – sun and sea: Water bodies can be great locations for solar power plants. The water keeps the PV modules cool, which has a positive effect on power yields, while in return, the solar panels can protect the surface of drinking water reservoirs from air pollutants or evaporation. In addition, this solar application often avoids competition on space usage. While still very small, there is huge interest in floating PV, in particular in Asia. At the end of 2014, only 10 MW was installed, increasing to 1.1 GW by September 2018. Just recently, a new floating system with 150 MW was installed, which is now the world's largest. According to the World Bank, if only 1% of all available area were used, the world could install over 400 GW of floating solar systems.[10]

Agri PV – Sun farming and more: Solar can be a great fit with agriculture – a sector often considered a competitor on available space. It doesn't have to be that way. You can install solar in such a way that agriculture and animal farming is not negatively impacted. In fact, highly innovative **Agri PV** business models support the sustainable electrification of agricultural processes and deliver symbiotic business models to bring farming to another level. Agri PV can help in solving the political dilemma of appropriate land use; it can also help in improving the production yield for both power and crops. Moreover, it provides local farmers with additional income. The potential of Agri PV is huge because of its ability to adapt to any geography: for example, in very dry areas, Agri PV can help retain humidity for crops and create micro-ecosystems supporting food supply in the world's most arid regions.

Solar meets coal – PV for coal regions in transition: Solar is now increasingly used to support the restructuring of depressed regions, such as former coal regions. After a coal mine stops working, a key question is what to do with this brownfield area. One possibility is to transform, former coal mines into solar farms,[11] a trend that is expected to grow as the world progressively transitions to a fossil-free energy system. A recent study from the EU Joint Research Centre[12] found solar to be particularly suitable for employing former coal workers and to help drive regional development.

Author: Author: Michael Schmela; Aurelie Beauvais; SolarPower Europe

10 World Bank (2018): Where Sun Meets Water.

11 PV Europe (2018): Transfer former coal mines into solar farms.

12 JRC (2018): EU coal regions: opportunities and challenges ahead.

RE-Source 2019

European platform for corporate renewable energy sourcing

2-3 October
Amsterdam

Connecting renewable energy buyers and sellers

TOPICS INCLUDE:

- Corporate sourcing strategies and business models
- Markets and regulation
- Demand growth and diversification: How to turn 100 corporates into 100,000?
- Innovation
- Simplification and risk mitigation
- Guarantees of origin
- Cities and local authorities

resource-event.eu

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RE100 | °C | CDP

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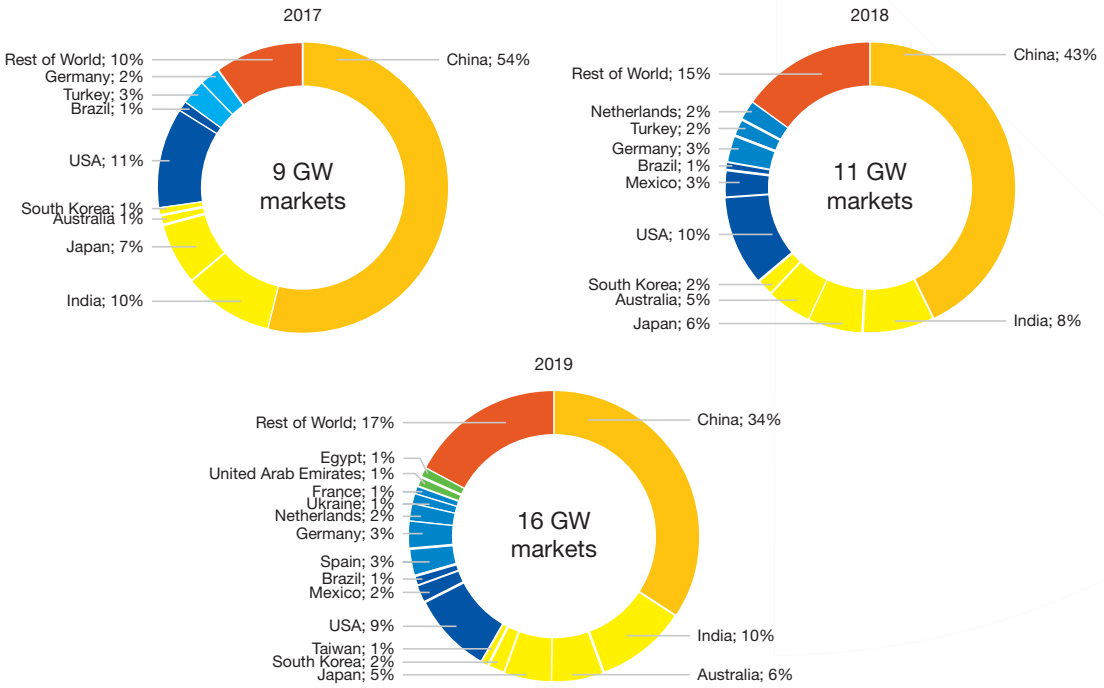
2 GW-SCALE SOLAR POWER MARKETS IN 2018

In 2018, 11 countries installed more than 1 GW of solar; a 22% growth rate compared to the nine GW-scale solar markets in 2017. Our Medium Scenario estimates that the number will significantly increase to 16 countries in 2019. In fact, we had assumed that already in 2018, the number of GW markets would reach 14, but for different reasons these countries (Egypt, France and Taiwan, which missed the GW level by a few MWs) will reach that level in 2019 (see Fig. 17).

Like in the previous GMO, for this chapter we have invited solar associations from last year's GW markets 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 the local solar associations, 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	Australia	Smart Energy Council
6	Germany	SolarPower Europe
7	Mexico	Mexican Solar Energy Association (ASOLMEX)
8	South Korea	Korea Photovoltaic Society (KPVS)
9	Turkey	GÜNDER Turkish Solar Energy Society
10	The Netherlands	Holland Solar
11	Brazil	Brazilian Photovoltaic Solar Energy Association (ABSOLAR)

FIGURE 17 WORLD GW-SCALE SOLAR MARKETS 2017 - 2019



1. CHINA

Overview of solar PV in China

The Chinese solar industry showed strength all across the production value chain again in 2018. Polysilicon output exceeded 259,000 tonnes, equal to 7.0% growth year on year. Production of silicon wafers, cells and modules reached 107.1 GW, 85.0 GW and 84.3 GW – that translates to growth rates of 16.8%, 18.1% and 12.4%, respectively. In summary, China's solar sector continued to invest and grew further; benefiting from overseas markets' demand and sustaining the growth momentum the beginning of 2019.

Chinese Solar Targets

According to the "13th Five-Year Plan for Solar Energy Development" issued by the National Energy Administration (NEA) at the end of 2016, the installed capacity of photovoltaic power generation was planned to reach 105 GW by 2020. However, by the end of 2017, the above target has been exceeded – China had installed over 130 GW at that time. In order to control the pace of development and avoid excessive growth of the domestic PV market following the record 2017 year, with 53 GW of newly installed capacity in one year, subsidy policies were adjusted on the 31st of May 2018, when the "2018 Solar PV Generation Notice" was published.

TABLE 1A CHINA'S PHOTOVOLTAIC PRODUCT OUTPUT AND GROWTH IN 2018

	POLYSILICON	SILICON WAFERS	CELLS	MODULES
Output	259,000 tonnes	107.1 GW	85.0 GW	84.3 GW
Growth rate	7.0%	16.8%	18.1%	12.4%

Source: CPIA.

Under the new policy guidance, China's PV market is now gradually shifting from the phase of extensive growth to a new phase of elaborate market design and high quality. On the 7th of January 2019, the National Energy Administration issued the "Actively Promoting Subsidy-free Wind Power and Photovoltaic Power Generation Notice" after which China's PV market has begun to be driven by both FIT and subsidy-free projects.

Drivers for Photovoltaic Growth in China

- Feed-in Tariff: The feed-in tariff has been the main driver for solar in China. NEA adjusted the tariffs on the 31st of May 2018 (see Table 1B).
- Top Runner Program: In 2015, NEA, the Ministry of Industry and Information Technology (MIIT) and the National Certification and Accreditation Administration jointly issued the "Opinions on Promoting the Application and Industrial Upgrade of Advanced Photovoltaic Technology Products", which was the base for the implementation of the "Top Runner Programme". The aim was on the one hand to promote the application of advanced PV products and on the other hand result in the closing of outdated production facilities. By the end of 2017, a total of 3 "Top Runner Programme" project plans were approved, with a total scale of 12.5 GW. In 2017, a Technology Top Runner Demonstration Project for innovative products was launched with the aim to create a market place for ultra-efficient cells & modules; the total scale of the first project phase was 1.5 GW.

  By the end of 2018, all Top Runner projects have been either fully or partially connected to the grid, the Technology Top Runner projects were under construction. In November 2018, NEA released a "Notice on Issues Related to Incentives for "Top Runner Programme" Photovoltaic Power Generation Projects," and officially launched the "Top Runner Programme" Award Projects. The notice pointed out three projects with a total capacity of 1.5 GW.
- Poverty Alleviation: At the end of 2017, the first batch of PV poverty alleviation projects under the "13th Five-Year Plan" was issued with a total scale of around 4.18 GW. In March 2018, NEA and the State Council Poverty Alleviation Office jointly issued the "Measures for the Management of Photovoltaic Poverty Alleviation Power Stations" to regulate the photovoltaic poverty alleviation industry. By the end of August 2018, the cumulative poverty alleviation scale was about 15.44 GW. With 13.63 GW grid-connected photovoltaic poverty alleviation projects completed in 26 provinces across the country, the programme has helped 2.24 million poverty-stricken households. In 2019, the second batch of photovoltaic poverty alleviation plans will be issued in due course.

Solar Market in China 2018

In 2018, China's newly installed photovoltaic grid-connected capacity reached 44.26 GW – that's 16.6% lower than the previous year. Still, China was again the leading solar market in the world. The cumulative

TABLE 1B 2018 NATIONAL PHOTOVOLTAIC POWER GENERATION ON-GRID FIT PRICE LIST*

RESOURCE ZONE	PV UTILITY PLANTS BENCHMARK ON-GRID PRICE		DISTRIBUTED GENERATION FIT STANDARD	
	ORDINARY UTILITY PLANTS	VILLAGE POVERTY ALLEVIATION PLANTS	ORDINARY PROJECTS	DISTRIBUTED POVERTY ALLEVIATION PROJECTS
Class 1 Resource Zone	0.5 RMB	0.65 RMB		
Class 1 Resource Zone	0.6 RMB	0.75 RMB	0.32 RMB	0.42 RMB
Class 3 Resource Zone	0.7 RMB	0.85 RMB		

*: Came into effect on the 31st of May 2018. **Source**: CPIA.

photovoltaic installation capacity totalled 174 GW, more than any country. To the newly installed 2018 capacity, utility scale plants (over 6 MW) contributed 23.3 GW, while distributed plants contributed 20.96 GW. The annual photovoltaic power generation in 2018 amounted to 177.5 billion kWh: a 50% year-on-year growth over 2017.

Challenges

The main challenges for solar in China haven't changed – late FIT payments and high non-technical costs for PV power plants. In addition, market environment changes, uncertainties regarding the new subsidy policy guidelines, and developments as a result of technical innovation are challenges China's PV industry is facing.

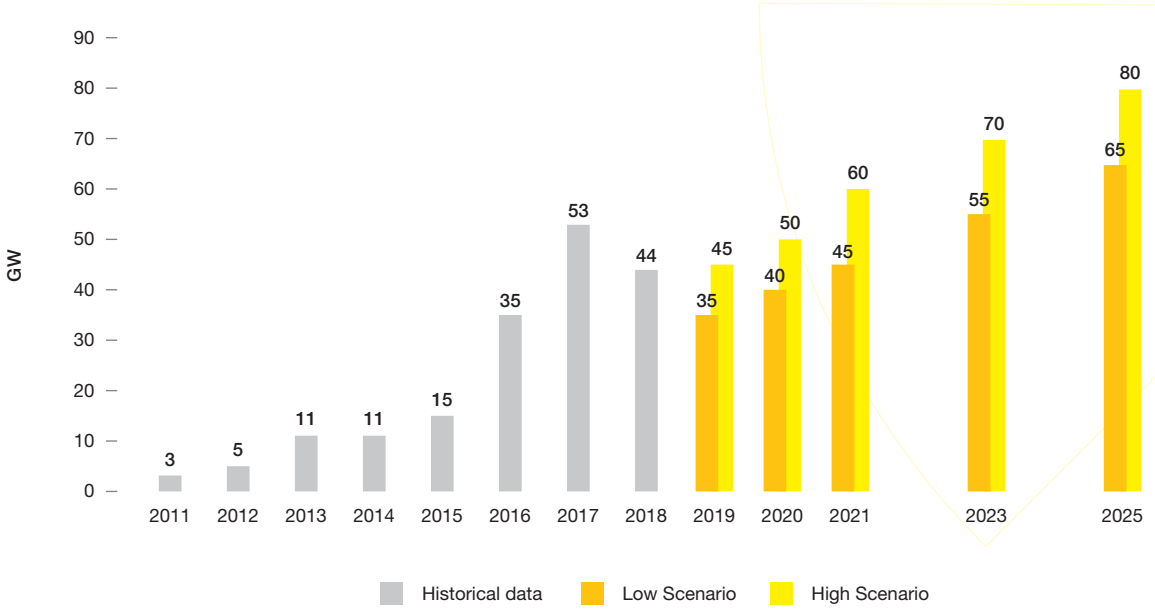
Outlook

Under the new policy framework, China's PV industry will further strengthen technological innovation and further accelerate the pace of upgrading, reducing costs and increasing efficiency.

However, it is difficult to announce the future market growth as the final details for the new solar policy framework were not published until the end of April 2019. CPIA in January assumed that the market in 2019 will range between 35 GW and 45 GW – and, depending on the final outcome of the new solar framework, will grow to between 40 and 50 GW next year. As of 2021, it is expected to be larger than in 2018 in any case, even in the low scenario (see Fig. 18).

Author: *China Photovoltaic Industry Association (CPIA)*

FIGURE 18 CHINA SOLAR PV MARKET SCENARIOS 2019-2025, BY CPIA



Source: CPIA.

2. UNITED STATES

US solar industry expected to double as we enter 'The Solar Decade'

Solar in the United States is expected to resume record-breaking capacity additions over the next five years, and if things fall into place, can hit a double-digit share of electricity generation in the middle of the next decade.

Strong clean energy and tax policy in federal and state governments could add hundreds of billions of dollars in investment to the US economy, and hundreds of gigawatts in new electricity generation over the next 11 years. This follows what will be seen historically as relatively slow solar additions in 2017 and 2018.

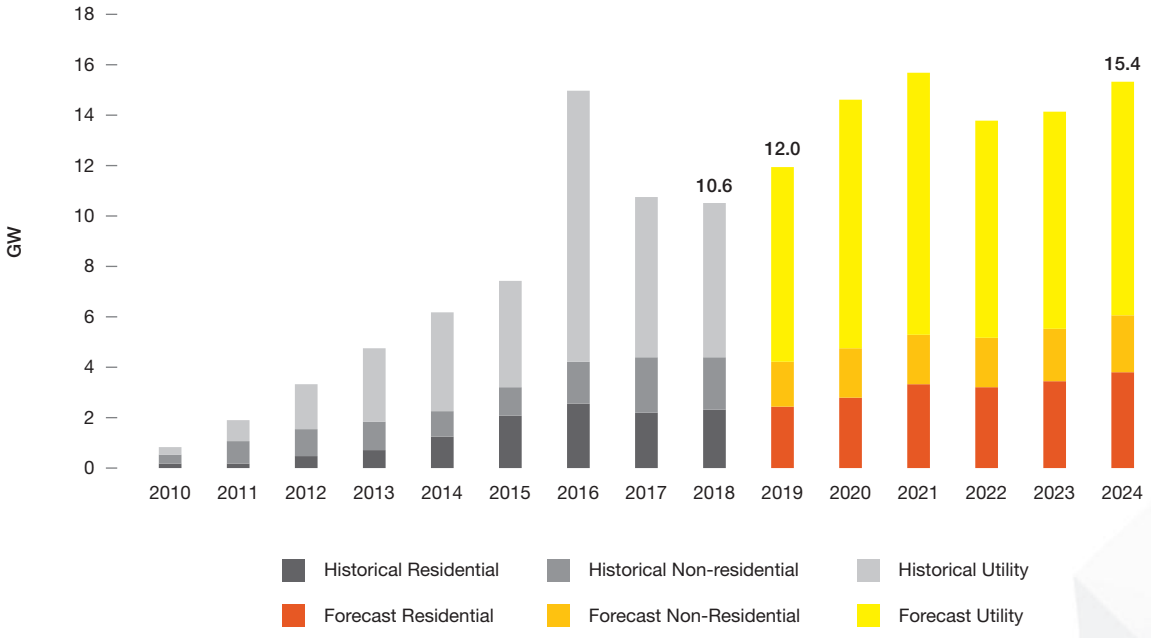
The last two years, while strong compared to pre-2016 levels, have not been as robust as they could have been, largely due to a trade case that resulted in tariffs against virtually all imported solar panels. However, lower costs and strong public and bipartisan sentiment in favour of clean energy will lead to solar generation capacity more than doubling in the next five years.

Overall, the last few years have been outstanding for the US solar industry. Last year was the sixth straight year in which solar was one of the top two sources of new electricity generation capacity in the US. Additionally, for the third year in a row, the US solar industry installed double-digit gigawatts of solar PV capacity, with 10.6 GW coming online in 2018.

These gains marked a 2% drop from 2017. However, forecasts show the market rebounding in the years ahead, according to the U.S. Solar Market Insight 2018 Year-in-Review Report from Wood Mackenzie Power & Renewables and the US Solar Energy Industries Association (SEIA) released in March.

Total installed PV capacity in the US is expected to rise by 14% in 2019, with annual installations reaching 15.8 GW in 2021 (see Fig. 19).

FIGURE 19 UNITED STATES SOLAR PV MARKET SCENARIOS 2019 - 2024, BY SEIA



Source: SEIA.

In 2018, non-residential PV saw an annual decline of 8% due to policy transitions in major markets. Utility-scale solar also underwent a 7% contraction in 2018, largely related to the tariffs.

Yet, while annual growth fell in both the non-residential and utility-scale solar sectors, residential solar growth stabilised in 2018 after the previous year's 15% contraction. The US residential solar market has now seen five consecutive quarters of growth and the fourth quarter of 2018 was the largest quarter for residential solar in two years. Impressively, nearly 315,000 households added solar in 2018.

A number of emerging state markets helped lead the way in 2018. Texas and Florida, two states with traditionally low solar penetration, stood out, adding more capacity than some of the highest penetration states. These emerging solar markets are poised to become the engines of growth for residential solar in the US.

In total, solar PV accounted for 29% of new electricity generating capacity additions in 2018, slightly less than in 2017 due to a surge in new natural gas plants. However, in 2018, 13.2 GW of utility-scale solar power purchase agreements were signed, pushing the contracted project pipeline to its highest point in the history of US solar (see Fig. 20).

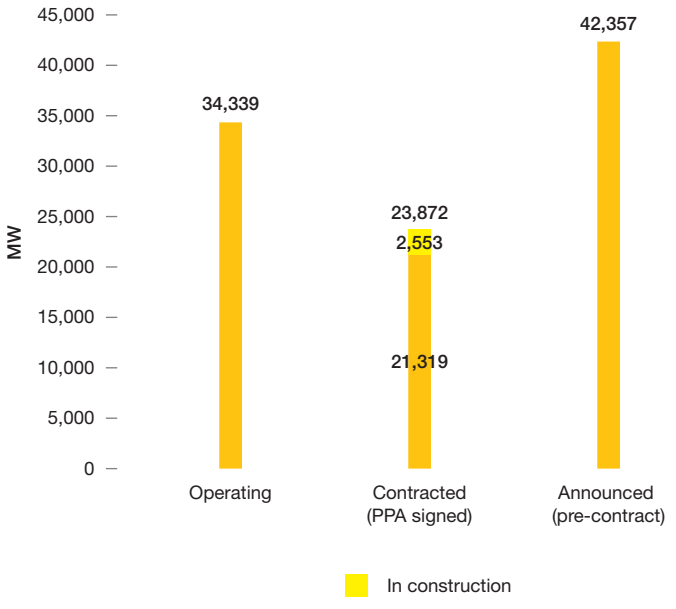
Wood Mackenzie/SEIA also increased its five-year forecast for utility PV by 2.3 GW since Q4/2018. This was the result of a large volume of project announcements, the inclusion of more solar in long-term utility resource planning, and an increase in project development driven by renewable portfolio standards and growing corporate interest in solar.

All in all, as we contemplate the 2020s being "The Solar Decade", a stronger public stance in favour of clean energy, corresponding bipartisan focus on action to address rising global temperatures, and states establishing aggressive Renewable Portfolio Standards are factors that we think are going to drive solar and clean energy inexorably forward more broadly.

We as an industry are looking forward to doing all the work it's going to take to get there.

Author: *Dan Whitten, Vice President of Public Affairs; US Solar Energy Industries Association (SEIA)*

FIGURE 20 UNITED STATES UTILITY PV PIPELINE, BY SEIA



Source: SEIA.

3. INDIA

Overview of PV developments

2018 has been a slower year for solar in India with just over 8.3 GW of installations compared to 9.6 GW in the previous year. India still remains the third largest market in the world – and is on its way to becoming the second largest, which is likely to be achieved in 2019. In 2018, 74% of India's new power generation came from renewables, with solar contributing 50%. Despite some road blocks, 2019 looks much brighter for solar in India than the year before.

The current project pipelines indicate that around 10.9 GW alone will be realised through utility-scale plans in 2019. Overall, the Indian solar market is looking at capacity additions of 13 GW. MNRE plans to tender around 30 GW of renewable projects this year, out of which 24.75 GW is foreseen for solar plants.

Indian Solar/RE Targets

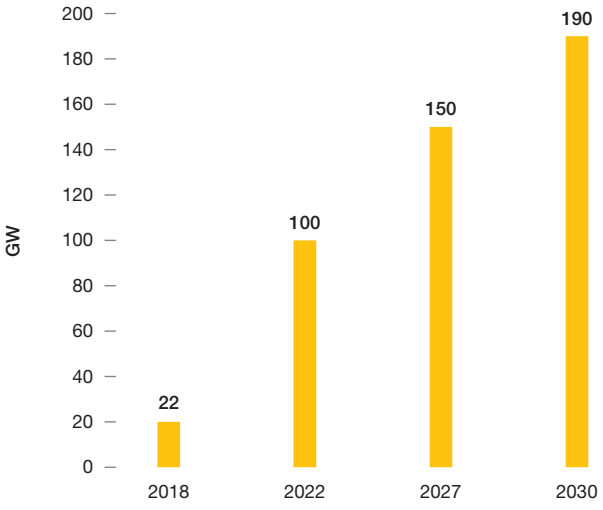
India's government targets 100 GW of solar installations by 2022. This ambitious goal has triggered the high intensity of solar energy proliferation in India. By 2022, India wants to install 175 GW of RE – while solar will provide the largest share, wind power is targeted to contribute 60 GW, bioenergy 10 GW and small hydro power 5 GW. The Indian government has set a target of achieving 40% of its generation by 2030 through renewable sources, up from 21.4% today. It targets 150 MW of solar by 2027 and 190 MW by 2030 (see Fig. 21). At the end of 2018, India's solar capacity stood at 28.3 GW out of a total installed renewable power generation capacity of 77.5 GW.

Drivers for Solar Growth

India's government has taken several key policy measures to meet its 100 GW solar target.

In January, the Solar Energy Corporation of India (SECI), the government body that implements India's solar mission, issued a tender, inviting developers to build 3 GW of solar power capacity. This tender had a condition that winning developers would be required to create manufacturing facilities, which can produce 1.5 GW of solar cells and panels domestically. India's central cabinet also sanctioned 85.8 billion INR (around 1.2 billion USD) for the second phase of the Central Public Sector Undertaking (CPSU) scheme, which stipulates that state-owned firms must buy 12 GW of locally-made solar panels to generate power for their own use over the next four years. This is aimed at increasing domestic manufacturing capabilities in the midst of import tariffs imposed on solar modules from China.

FIGURE 21 SOLAR CAPACITY ASSUMPTION IN INDIAN GOVERNMENT'S CURRENT POLICY SCENARIO



Source: Government of India.

Under the Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI), the Indian government recently approved a total funding of 1.7 billion USD for phase 2 of the grid connected rooftop solar programme to accelerate the installation of rooftop solar, which has a target of 40 GW by 2022. This funding is aimed at improving the proliferation of rooftop solar which currently only stood at around 3.5 GW at the end of last year.

India's government is also in the process of establishing transmission lines for projects, with a total capacity of 66 GW by March 2020, which will help in bolstering solar growth by facilitating seamless grid integration.

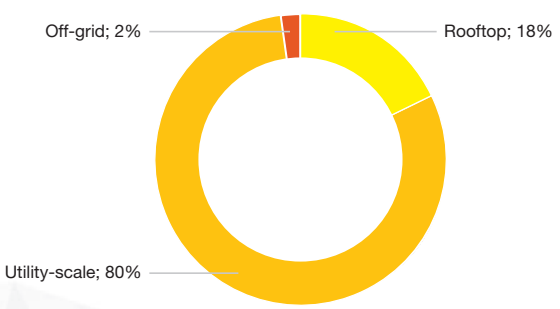
The Ministry of New and Renewable Energy (MNRE) has introduced a new mode for development of renewable energy parks that includes wind, solar & hybrid energy to intensify large-scale RE integration.

The government has also published guidelines for the implementation of the Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) scheme for the installation of solar pumps and grid-connected solar power plants by farmers. Under this scheme, the government targets to develop decentralised solar energy and other renewable energy generation plants with capacities up to 2 MW.

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

In 2018, 82.3% of India's installed solar capacity came from utility scale plants. With many utility scale projects in the pipeline, this trend is likely to continue. Installed rooftop capacity is projected to touch 6 GW with over 2.5 GW capacity additions this year. The government is also looking to introduce innovative solutions like PV Port & Store, a plug and play residential solar kit including battery for self-consumption, to bring rooftop solar to the mainstream.

FIGURE 22 INDIAN PV MARKET SEGMENTATION 2019, BY NSEFI



Source: NSEFI.

Challenges

The Indian solar market is currently witnessing a transition to the next growth phase, and in order to achieve the target some supportive policy measures are required.

- **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 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 carefully position India as a quality producer of PV modules.
- **Decentralisation**: While large scale utility-plants are fostering capacity additions to address the energy access issue and spread power generation equally, the Indian government should concentrate on decentralised solar energy. In the last two years, no more than 10% of the newly installed capacity was distributed solar, while off-grid was often even less than 2%. Policy support is required to intensify off-grid and rooftop installations across the country.
- **DISCOMs**: Electricity distribution companies play a key role when it comes to solar proliferation in India. The slow growth rate of Indian rooftop solar is an indication that things need to improve to increase investor confidence. Financially stressed and suffering from under-performance, it is natural that DISCOMs see PV installations as a liability. It is therefore imperative to involve DISCOMs in the ongoing dialogue. New schemes such as the Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) and the Kisan Urja Suraksha Evam Utthaan Mahaabhiyan (KUSUM) require the participation of DISCOMs; without their support the schemes will not work as originally planned.

Authors: *Subrahmanyam Pulipaka, CEO; Pranav R. Mehta, President; National Solar Energy Federation of India (NSEFI)*

4. JAPAN

The Japan Photovoltaic Energy Association (JPEA) estimates that around 6.6 GW DC (5.2 GW AC) was installed in 2018, resulting in a cumulative installed PV capacity of 55.7 GW DC at the end of 2018.

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 is mainly due to grid constraints (e.g. limited grid capacity and curtailment risks) and FIT reductions (i.e. from 40 JPY/kWh in 2012 to 14 JPY/kWh in 2019 for non-residential systems).

According to "PV OUTLOOK 2050" published by JPEA in 2017 (that is under revision), the Japanese PV market will see a downward trend to 4 GW of new installations in 2024 before it trends upward again. This will be after overcoming grid constraints and improving cost competitiveness (see Fig. 23).

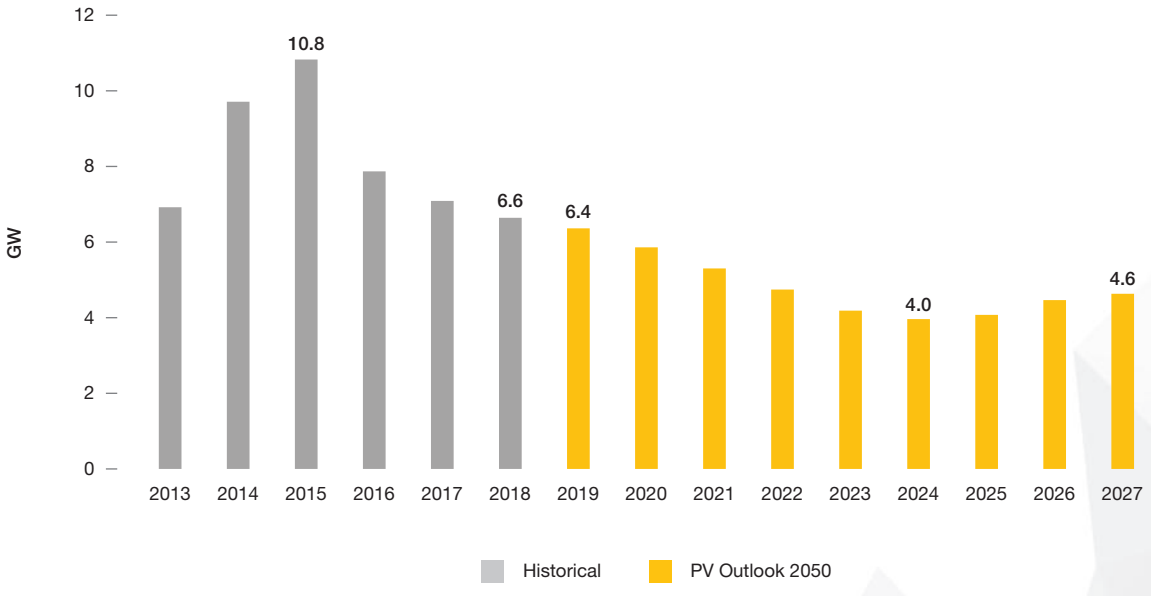
Japanese Solar/RE Targets

- **The government target:** According to the "Long-term Energy Supply and Demand Outlook" (Energy Outlook) published by the Ministry of Economy, Trade and Industry (METI) in 2015, the cumulative installed PV capacity in 2030 will be 64 GW AC (75 GW DC). This target will likely be revised in 2021.
- **JPEA's vision:** It is expected that this 64 GW AC will be achieved in the early 2020s. As stated in the "PV OUTLOOK 2050", JPEA expects that the cumulative installed PV capacity will be around 100 GW AC (120 GW DC) in 2030 and 200 GW AC (240 GW DC) in 2050.

Drivers for solar growth in Japan

- **The FIT schem** has been and will be the strongest support for solar PV growth in Japan. However, the role of FIT will gradually get smaller with the growth of the other drivers as listed below, such as on-site self-consumption business models, etc.
- **Self-consumption business model:** In the coming years, the "self-consumption business model" for commercial and industrial users is expected to grow in Japan. As the LCOE of solar PV is already close to the variable retail electricity prices for commercial and industrial users, the on-site self-consumption PV system is becoming an attractive option for corporate users.
- **Initiatives by RE-Users,** such as RE100 companies will be the next growing driver. A total of 18 Japanese leading companies made a commitment to go "100% renewable" and are now on the RE100 list as of April 2019. These initiatives are expected to promote deployment of new business models such as corporate PPAs as alternatives to the FIT scheme in Japan.

FIGURE 23 JAPAN SOLAR PV MARKET SCENARIOS 2019 - 2027, BY JPEA



Source: JPEA.

- **Net-Zero Energy House:** PThe promotion of net-zero energy houses (ZEH) by the government is expected to support the growth of the residential PV market towards 2030. According to the 'ZEH Roadmap', the government's ambitious target is to achieve net-zero energy on average for newly built houses by 2030.
- **Non-fossil fuel share** will be one of the post-FIT drivers for solar PV in the future. In Japan, power retail suppliers are obliged to ensure that the percentage of their share of non-fossil fuels reaches at least 44% by 2030. Although this non-fossil fuel share is minimal for the time being as there are no near-term targets for now, this driver is expected to grow towards 2030.

Challenges

- **Expiry of FIT for residential rooftop users:** In Japan, the FIT for residential PV systems (less than 10 kW) is set for 10 years from its first on-grid day. As of November 2019, this 10-year FIT will expire for the first residential systems installed as part of this support scheme. By the end of 2020, the cumulative PV capacity that has dropped out of the FIT will be around 3 GW, which means some 700,000 users will need to become smart prosumers to maximise the value of their assets: e.g. to increase self-consumption and/or to find reliable aggregators. This challenge will provide business opportunities for solution providers in the residential market segment.
- **Grid constraints:** Limited grid capacity and curtailment risks are the primary causes of the downward market trend in Japan. The Japanese government started several mitigation measures, such as the "connect and manage" programme for the transmission grid level to maximise grid capacity with existing assets. However, capacity constraints for the distribution grid and curtailment risks are yet to be tackled with the highest priority. Since the first curtailment on the mainland (Kyushu area) of Japan in October 2018, the curtailment risk has been highly noticed in other regions as well. In April 2019, non-residential PV instillations in the Kyushu area have been curtailed every sunny day. There is now an urgent need for mitigation measures.
- **Cost competitiveness:** The cost of solar PV in Japan is higher compared to average international levels, mainly due to expensive construction and soft costs. The FIT for non-residential PV (10 kW to 500kW) was set in fiscal year 2019 at 14 JPY/kWh. To achieve grid parity in Japan, solar LCOE needs to be reduced to the level of electricity wholesale market prices that is currently around 10/kWh. Although, this is a real challenge for the PV industry in Japan, JPEA expects that grid parity will be achieved by 2030. The government targets PV LCOE of 7 JPY/kWh in 2025-2027.

Authors: *Takeaki Masukawa, Secretary General; Hishashi Suzuki, International Department Manager; Japan Photovoltaic Energy Association (JPEA)*

5. AUSTRALIA

Overview of solar PV in Australia

Last year, we reported that the Australian market had taken off in 2017 after delays caused by political actions of a conservative national government. That take-off accelerated again throughout 2018 and will continue to do so into 2020, when we might see some slowing. A total of 5.3 GW of solar power capacity was installed in 2018, up from around 1.5 GW in 2017. As of the 31st of December 2018, Australia had added new installed capacity of just over 1.8 GW of rooftop PV and around 3.5 GW of utility-scale PV (systems larger than 3 MW) for the year. Rooftop PV is now on more than 2 million Australian homes, nearly 22% or one in every five homes. Commercial & industrial (C&I) installations, with system sizes from 30 kW to 1 MW, increased by 45% in 2018 over 2017, and utility-scale orders and commissioning grew rapidly throughout the year – the average installation rate in 2018 was six panels a minute. The total installed base at the end of January 2019 was about 11.5 GW, generating just over 6% of total generation (wind ~7%, hydro 7%).

The primary support mechanism remains 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. 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.

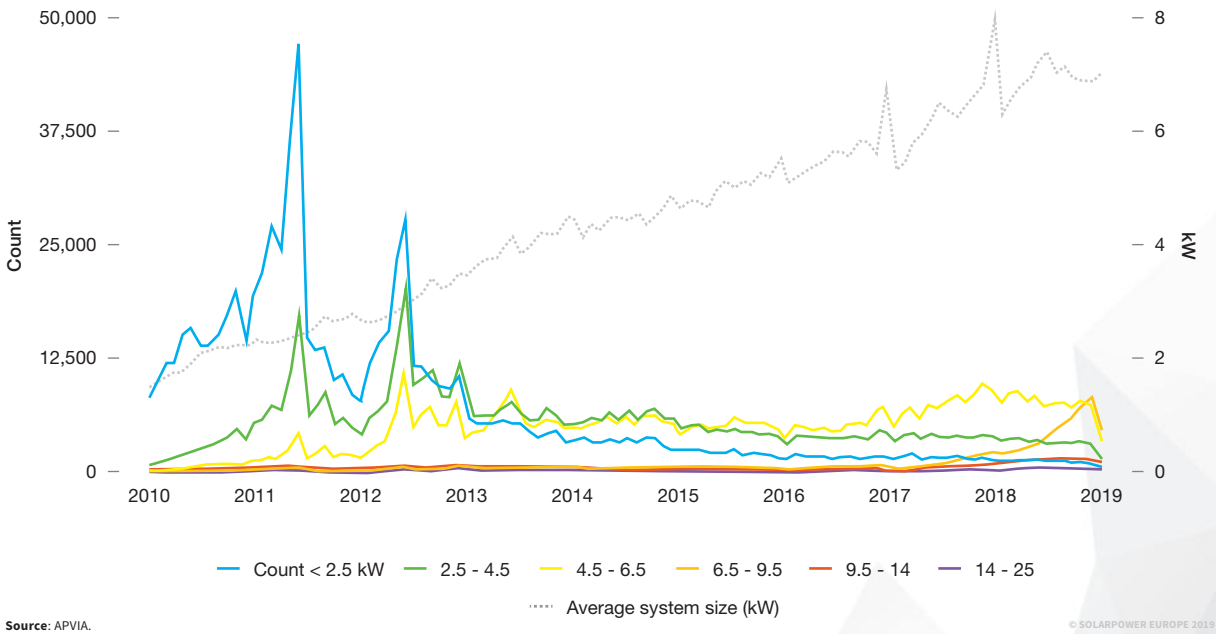
Australian PV support & export payments

A continuing feature of residential and C&I rooftop PV systems is self-consumption offsetting retail power prices, which range from 21-49 cents per kWh depending on location. Network constraints are now the cause of export limits being placed on new installations, sometimes at zero. This reinforces 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 per W to 1.65 AUD per W with a median price of 0.97 AUD per W. The average system size remained at over 6 kW, but the emphasis has moved to system design for self-consumption and battery storage systems for new installations. The market is seeing a rapid uptake of system management and monitoring software, often incorporating aggregation options to allow owners access to market opportunities. Market rules are still a constraining factor, but reform is underway.

The small-scale systems, up 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

FIGURE 24 AUSTRALIA SOLAR PV MARKET – MONTHLY INSTALLATIONS BY SIZE CATEGORY



Source: APVIA.

annually from 2017 out to 2030, but in 2018-2019, still offers a capital reduction on purchase of around 25%. These certificates have been trading at just over the 30 AUD mark.

Large scale PV arrays also under the RET have moved into a volatile stage for the value of certificates, as the LRET ends for new entrants in 2020. LGCs in 2018 dropped dramatically with spot prices of around 72 AUD in October 2018 dropping to around 39 AUD in February 2019. The rapid deployment at utility-scale means the amount being built or committed to is now more than double the remaining RET target.

A recent feature in 2018 was the return of government direct subsidies for small-scale rooftop PV and battery systems in a number of states, following election campaign commitments. Although there is some targeting towards lower income households, we have seen a number of poor design features that draw in new market entrants, with a resulting threat to quality installation standards and sub-optimal consumer outcomes.

Potential for growth & risks in Australia

Critically, the primary national support scheme, the RET, ends in 2020 for new entry large-scale systems, and already the signs are that the LGC prices will continue to fall. Financial models for out years are seeing LGC prices of around 10-12 AUD, sometimes a zero value. There remains no national replacement policy that would support large-scale PV, or other renewable energy deployment beyond 2020. A federal election held on the 18th of May 2019 might see a change of government to one that has a policy of 50% renewables by 2030 and an economy wide emissions reduction target of 46% by 2030. That will be a positive change for the solar industry, but at the time of writing this report, there is not a clear plan to manage the transition from a 76% coal & gas-based electricity system to renewables. That uncertainty remains a significant threat to the large-scale solar industry in Australia beyond 2020 – within the current planning horizon. Network constraints are being addressed too slowly, following years of pushback form incumbents. For both small and large-scale PV, removing barriers to connection and getting sensible resolutions to technical issues, rather than the often blunt and crude options offered by networks, is a critical activity for advocacy bodies like the Smart Energy Council.

Two new factors arose in 2018 that are driving large-scale investment proposals – the imminent rapid global growth of electric vehicles (EVs) and the potential of solar fuels and chemicals, and industrial processing from clean energy electrolysis of hydrogen (H2). The national government has barely paid lip service to EVs, but a change on the 18th of May would bring a highly supportive government, with a target of 25% of EVs by 2025. The national government, as well as state and territory governments, have also moved to support the development of H2 production and its downstream opportunities. A number of Smart Energy Council members are at the forefront of the H2 pipeline, with work that has already commenced on a facility that will use at least 11 GW of solar and wind in an H2 plant in Northwest Western Australia.

Outlook 2019

As it did in 2018, Australia will continue this year as the country with the highest per capita solar penetration in the world. In the first few months of 2019, as in 2018, Australia has again broken all records. Forecasts indicate about 2.5 GW rooftop PV will be installed this year, with around 40% being businesses (C&I). The large-scale pipeline is huge, with more than 87 large-scale projects committed or under construction totalling more than 11 GW, with around 5 GW planned to be commissioned in 2019-2020.

As aforementioned, the future for large-scale PV has some uncertainty after 2020, but the pipeline and continuing planning and development proposals, now commonly incorporating storage, suggest that market confidence is high. 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. Although parts of Australia have high residential PV penetration of more than 50%, there remains a potential market of between 45 GW and 65 GW. We are also starting to see a growing market in upgrades to systems installed 8-10 years ago.

The continued drivers for Australia, other than the superb solar resource, are the low costs of PV systems, high electricity prices, the impact of EVs, and increasingly, the opportunities for industrial developments based on clean solar PV and wind electrolysis of hydrogen. A primary driver is the ageing, inflexible and increasingly unreliable coal generation fleet in Australia that will need to be replaced by 2032, with most ending their commercial operating life before 2030. All that capacity will be replaced by wind and mainly solar PV. That gives a solid base for optimism in the Australian market – there are some risks to be aware of, but great opportunities to take advantage of too.

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

6. GERMANY

Overview of solar PV developments

2018 was the year when the German solar market took back the number one position in Europe. With around 3 GW installed, Germany has deployed almost twice the capacity of the second largest European market, Turkey. Positive signals had already been shown in 2017, when, with an installed capacity of 1.76 GW, solar had the best performance since 2014. But last year marked a turning point, as for the first time in years Germany passed its annual 2.5 GW target. When it comes to solar, Europe's largest economy seems to be back on a positive trajectory again, for now. In the Medium Scenario, SolarPower Europe expects about 4 GW of new capacity in 2019, with further growth in the following years (see Fig. 25).

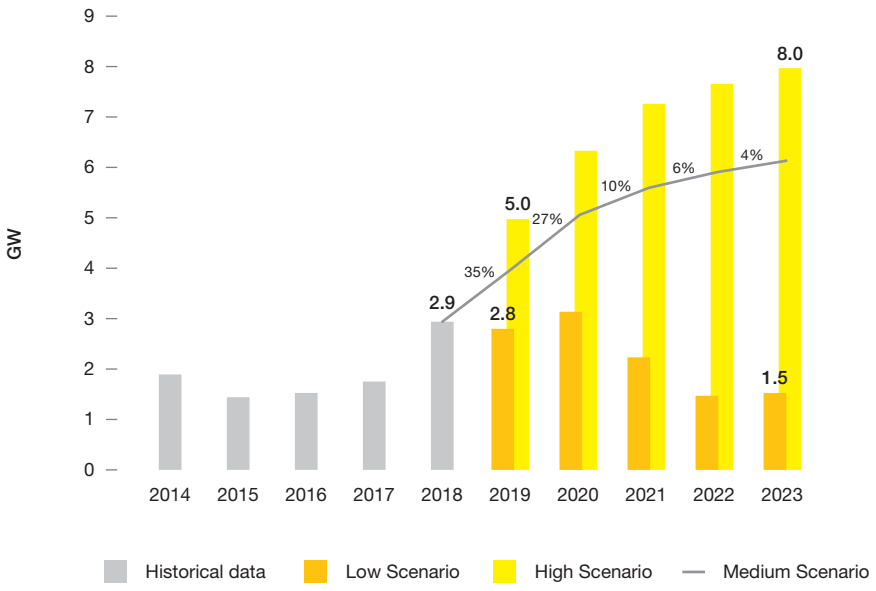
Solar PV targets in Germany

One year before the 2020 deadline, it is clear that Germany won't be able to meet its EU renewable target of 40% GHG emission reduction. The country is also expected to miss its target in the non-Emission Trading System Segment. In order to make up for failing the achievement of these targets, a government coalition agreement in March 2018 set a 65% renewable target in gross electricity consumption by 2030. This would need annual PV capacity additions of around 8 GW and 4 GW of wind.[1] The long-term target for decarbonisation foresees a renewable electricity share of 80% in 2050, although a discussion on ramping up ambition is taking place on the political level. The decision to shut down all nuclear plants by 2023 also provides a significant market opportunity for solar in the short run. A potential exit from coal by 2038, proposed by a government supported expert commission, also offers huge medium-term business potential for solar.

Drivers for Solar Growth

As outlined in Germany's feed-in tariff law, the Renewable Energy Sources Act (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 kW and 750 kW, and a tendering scheme for systems above 750 kW. In parallel, small systems below 10 kW are fully exempt from the EEG levy – the surcharge on electricity prices to finance the energy transition – whereas systems between 10 kW and 100 kW are granted a 40% reduction on the EEG levy.

FIGURE 25 GERMANY SOLAR PV MARKET SCENARIOS 2019 - 2023



1 Bruno Burger, Fraunhofer ISE (2018).

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 year lowered the benchmark from 2.5 GW to 1.9 GW, meaning that remuneration rates will digress at a faster pace than before.

Moreover, a reduction in the feed-in tariff for PV systems ranging from 40 kW to 750 kW was introduced by the government at the end of 2018, with the cuts entering progressively into force between February and April 2019. This is the reason why in December 2018 nearly 400 MW were installed, and the first two months of this year saw a record capacity of 1 GW already installed. In 2018, more than half of the new capacity was installed in the medium to large commercial 40 kW to 750 kW segment, while residential systems up to 10 kW contributed around 400 MW, and ground-mounted systems above 750 kW were responsible for around 550 MW.

In Germany there are three types of tenders for large-scale solar: regular tenders for projects between 750 kW to 10 MW; recently announced 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 200 MW each, and are technology-specific. As Germany is 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 2018 saw solar winning all the auctioned capacity. This trend continued in the first of the three auctions scheduled for 2019. In terms of bids, after the constant price decrease experienced in the last three years, final auction prices have been stabilising around the EUR 0.05/kWh range. In September 2019, a first RE technology-neutral innovation tender will be held with the aim to support balancing and grid services.

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 the 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 45,000 residential installations in 2018, up 20% from 37,500 in 2017.

Challenges

The 52 GW cap for solar feed-in tariffs, as set out in the EEG law, is on course to be reached as soon as 2020 or 2021 at the latest. Once this level is met, the federal government will cease FITs to new solar projects. While the feed-in premium is only on part of the equation of self-consumption solar systems, the main concern is on the evolution of the market, as it is not clear whether the cap will be abolished as planned or lifted.

Lowering the benchmark for annual capacity also represents a challenge for small-scale installations. With the cap reduced to 1.9 GW, remuneration rates from the feed-in tariff system will be significantly lower.

The Mieterstrommodel (on-site community solar) regulation introduced in 2017, enabling collective self-consumption of PV installations on apartment buildings continues to attract limited interest – only around 300 systems with 6.8 MW were installed, leaving a lot of room before the annual 500 MW cap is reached. 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.

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

7. MEXICO

Overview of solar PV developments

Solar energy has established itself as one of the renewable energies with the largest presence in Mexico. This is demonstrated by the 42 large-scale solar parks currently in commercial operation in 13 states of the country, with an aggregate installed capacity of 2.9 GW and direct investments of 6.3 billion USD. In 2018, the solar market reached the gigawatt scale for the first time with 2.8 GW installed, nearly factor 10 year-on-year growth, compared to the 285 MW installed in 2017.

Up until now, auctions have played a paramount role in large-scale deployment. 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 18.93 USD/MWh set a world record low at the time. Altogether, the three auctions allocated 4.8 GW of solar generation capacity.

For its part, distributed solar has also accelerated its growth significantly. In this context, there are currently more than 100,000 solar roofs distributed on homes, industrial and commercial buildings, in practically the entire country. The competitiveness of distributed solar is supported by the low installation costs and savings of up to 95% per month in the electricity rates paid by users. High competitiveness is the result of the constant reduction in technology costs, which have fallen more than 70% since 2010. Likewise, the high solar irradiation in Mexico means that more than 85% of the national territory is optimal for solar development.

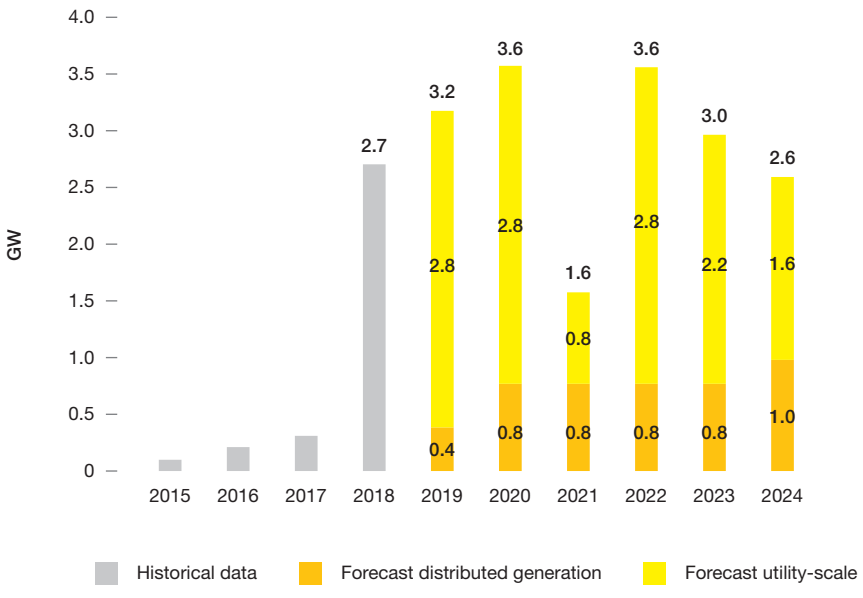
By 2023, Mexico is expected to achieve 18 GW of installed capacity. The largest share of this capacity will come from utility-scale generation, which is expected to reach around 16 GW by 2024. In terms of distributed generation, around 650,000 solar roofs with a capacity of more than 5 GW are projected for the same year.

Solar PV targets

In the lead up to the signing of the Paris Agreement, Mexico was the first country to submit its Intended National Determined Contribution (INDC), through which the country committed to a 22% GHG emission reduction by 2030, with the option to increase the target to 36%.

Looking at the power sector, as part of the energy reform introduced by the government in 2017, Mexico set a target of 35% renewable electricity by 2024, up from 21% in 2017. This reform restructures the entire electricity sector,

FIGURE 26 MEXICO SOLAR PV TOTAL CAPACITY SCENARIOS 2019 - 2024, BY ASOLMEX



Source: ASOLMEX.

starting from unbundling of the country's state-owned power utility, the Comisión Federal de Electricidad (CFE), and opens up competition in the market.

As a means to achieving 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.

Challenges and perspectives for solar PV growth

Following a temporary suspension in December 2018, Mexico's state-owned power utility, the CFE, announced in February 2019 the cancellation of the fourth round of auctions for renewable energy generation capacity. At the moment, it is still unclear whether the CFE intends to develop solar assets on its own or rather is planning to invest on conventional generation plants. This cancellation will have a negative impact on solar, which has won the largest share of renewable energy auctions – 80% of last year's solar capacity additions were from auctioned projects. While the cancellation does not affect the work on projects already tendered in the first three auction rounds, it raises serious concerns in terms of the extent of large-scale solar deployment post 2020. Corporate PPAs are forecast to make up for the auction cancellation only to a limited extent, although this trend could lead to a more sustainable solar market in the long run.

On the positive side, a 15% custom duty on solar module imports, applied in 2015 by the Mexican Tax Administration Service, through the Programas de Promoción Sectorial (PROSEC), has been lifted.

Despite the incentives provided by the ambitious renewables target and the CEC scheme, the currently underdeveloped power grid constitutes an additional challenge for 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 transmission and distribution systems, as well as incentivising more distributed generation and demand-side response.

Author: *Virdiana Vázquez Guerrero, Secretary General; Mexican Solar Energy Association (ASOLMEX)*

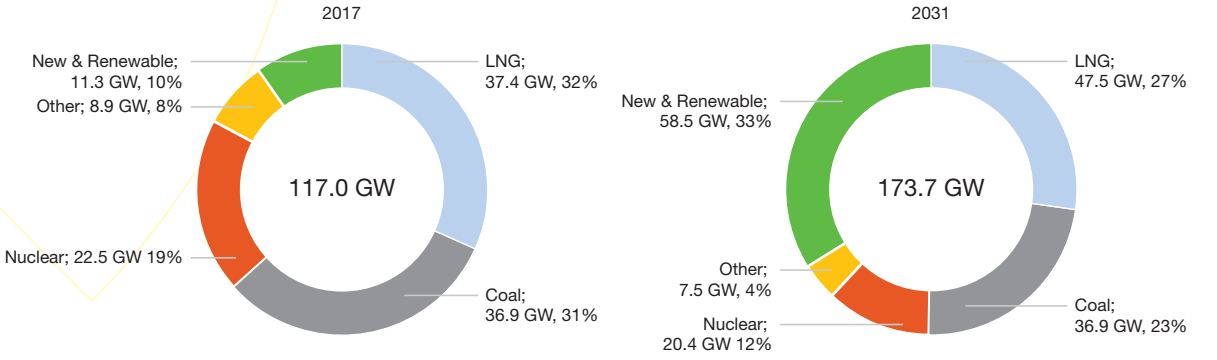
8. SOUTH KOREA (REPUBLIC OF KOREA)

South Korea added 2,027 MW of new PV installations in 2018, up from 886 MW and 1,333 MW in 2016 and 2017, respectively. Thanks to the ambitious renewable energy target ("RE3020"), PV installations in the country were booming and for the first time achieved over 2 GW in a year. The country has now reached a cumulative capacity of 7.9 GW at the end of 2018. Since 2014, Korea has steadily ranked among the top 10 PV markets.

Korean Solar/RE Targets

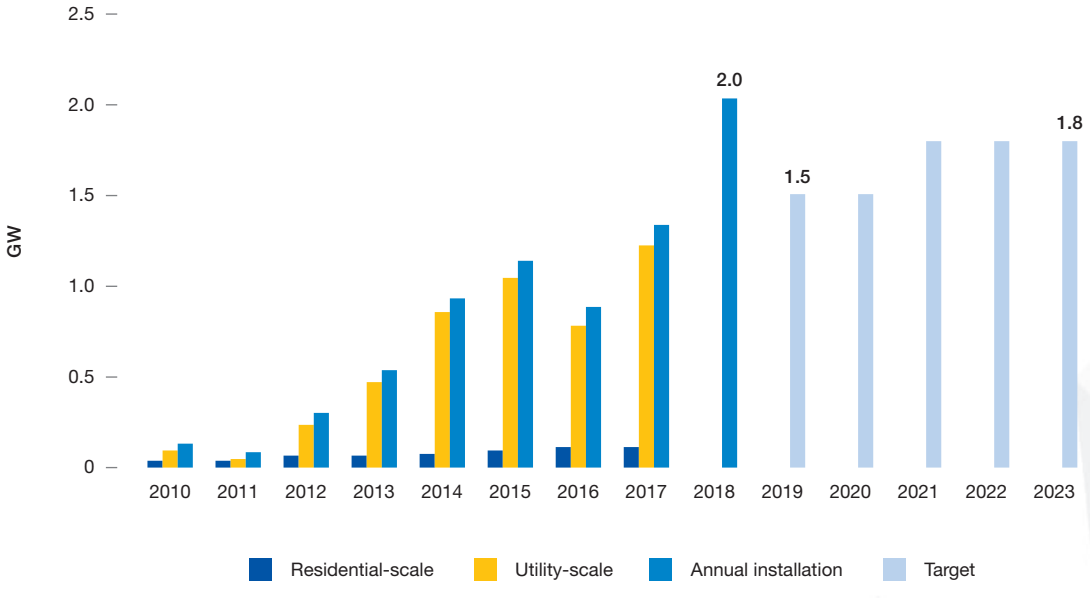
Under the governmental strategy "RE 3020" set out by the Ministry of Trade, Industry and Energy (MOTIE) at the end of 2017, renewables are targeted to generate 20% of South Korean electricity by 2030. South Korea is establishing a national energy plan in 2019, which aims to establish a safe energy system and an eco-friendly supply-demand energy structure and implement a decentralised ecosystem with public participation. The

FIGURE 27 POWER MIX TARGET ACCORDING TO MOTIE'S 8TH BASIC PLAN FOR LONG-TERM ELECTRICITY SUPPLY AND DEMAND, BY KPVS



Source: KPVS, with data from MOTIE.

FIGURE 28 SOUTH KOREA SOLAR PV MARKET SCENARIOS 2019 - 2023, BY KPVS



Source: KPVS

Korean government publishes a plan every two years to forecast mid- to long-term electricity demand and to expand electric power facilities since 2002. The '8th Basic Plan for Electricity Supply and Demand' announced at the end of 2017, predicts electric power supply and demand for the next 15 years from 2017 to 2031. This latest energy plan envisions 58.5 GW of total installed renewable electric capacity by the end of this period, compared to 11.3 GW currently installed. This would correspond to 33.7% of the nation's total installed electric capacity in 2030, a strong leap from the current 9.7%. 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.

Drivers for Solar Growth

A series of financial and non-financial incentives and programmes have been set in place to support PV development to meet South 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 2024 (from 2% in 2012), respectively. The bulk of PV installations in the country (68%) have been installed under this programme.

Utility-scale vs. residential solar development and plans

Facing an issue with its mountainous terrain that makes it difficult to find areas for very large utility-scale PV plants, the South 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 18.4% of total generation by 2030 compared to the current 11.2% in 2017. Due to its characteristics, solar will play a central role in the development of distributed generation. Currently, small utility-scale installations up to 100 kW account for roughly 90% of the total cumulative installed capacity, with distributed PV systems slightly above 10% of total installations. 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.

South 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 Programme, the Building Subsidy Programme and the Public Building Obligation Programme. The Public Building Obligation Programme sets out sustainability requirements for newly constructed or expanded large public buildings with floor areas of more than 1,000 m^2, stating that more than 15% of their energy consumption has to come from renewable sources in 2015, with the target increasing to 30% by 2020. The Zero Energy Building Obligation Programme will apply for public buildings with < 3,000 m^2 floor area from 2020, public and private buildings with <5,000 m^2 floor area from 2025, and all buildings from 2030.

Challenges

Korea Electric Power Corporation (KEPCO) still enjoys a monopoly over transmission and distribution, and also 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 the 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 system) 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.

Authors: *Son, Chang Sik, Vice-President; Cho, Eun-Chel, Director; Korea Photovoltaic Society (KPVS)*

9. TURKEY

Turkish solar market outlook

Turkey continues to be one of the fastest growing energy markets in the world; its total energy demand has been increasing rapidly. While imported fossil fuels dominate Turkey's total primary energy consumption with 75%, one of the government's priorities is to increase the ratio of renewable energy resources to 30% of total energy generation by 2023.

As shown in Table 2A, Turkey had 85.2 GW of installed electricity generation capacity at the end of 2017, and by 2018, it grew to 88.6 GW. The breakdown by generation sources in 2018 was as follows: 53% fossil fuels (natural gas, coal, liquid fuels, etc.), 32% hydro, 8% wind, nearly 6% solar and 1.5% geothermal. Almost all natural gas and around 40% of coal were imported. It is obvious that Turkey needs to become more energy independent – and exploiting its rich potential of renewable energy sources is the way to go.

Solar market development & legislation

According to a study by the Ministry of Energy and Natural Resources (ETKB), in its high demand scenario, Turkey's energy demand will increase by approximately 7.5% per year by 2023 and will reach 538 TWh. The low demand scenario expects the energy demand to reach 480 TWh by 2023, with an annual increase rate of 6.7%. Similarly, for the year of 2030, Turkey's energy demand will reach 757 TWh in the high demand scenario and 610 TWh in the low demand scenario.

Solar energy is one of the most valuable renewable energy sources, which is still untapped in Turkey, with an expected potential of at least 500 GW. Turkey's renewable energy investment totalled 2.2 billion USD in 2018, down 5% from 2017. At the end of 2018, the cumulative installed PV power in Turkey reached about 5,062.9 MW – a 48% growth compared to the previous year, when a total of 3,420.7 MW was installed. Photovoltaic installations started to take off in 2014 with 40 MW installed capacity. In 2018, about 1,642.2 MW of new PV power capacity was added (see Table 2).

In Turkey, two main laws – 6446 (New Electricity Market Law) and 6094 (Law Amending the Law on the Utilization of Renewable Energy Resources in Electricity Generation) – are directly related to the utilisation of solar energy. Law 6446 introduces important changes in the current electricity market system, including amendments to license types, framing its provisions around each type of market activity, specific provisions for certain licence types (generation, transmission, distribution, wholesale, retail, auto-producers and auto-producer groups), the introduction of a preliminary licensing mechanism and investment incentives, such as extended deadlines and grace periods for environmental compliance. Law 6094 introduces significant amendments to improve the incentive mechanism of the Renewable Energy Law (Law No: 5346) and encourage renewable energy investment opportunities.[3]

TABLE 2A BREAKDOWN OF INSTALLED CAPACITY BY ENERGY RESOURCES IN 2017 AND 2018[2]

POWER RESOURCES	INSTALLED CAPACITY (MW)(2017)	INSTALLED CAPACITY (MW)(2018)	ADDED CAPACITY (MW)(2017-2018)	INCREASE (2017-2018)
Fossil fuels-based thermal power plants	46,926.5	46,916.20	-10,3	0%
Hydroelectric	27,273.1	28,283,8	1,010.7	4%
Wind	6,516.2	7,005,4	489.2	7%
Solar PV	3,420.7	5,062,9	1,642.2	32%
Geothermal	1,063.7	1,282,5	212.8	17%
TOTAL	**85,200.2**	**88,550,8**	**3,350.6**	**4%**

Source: GUNDER, 2019 with data from Republic of Turkey Energy and Natural Resources Ministry, 2014.

2 "Statistics on Turkey's Electricity", TEİAŞ (Turkish Electricity Transmission Company).

3 "National Renewable Energy Action Plan for Turkey", Republic of Turkey Energy and Natural Resources Ministry, December 2014.

Drivers for Solar Growth

According to Law 6094, a purchase guarantee of 13.3 US cents/kWh is offered for solar electric energy production for 10 years. The incentives are available for PV power plants that are or will be in operation before the 31st of December 2020. Some supplementary subsidies for local equipment products for the first five years of operation are as follows:

- PV module installation and mechanical construction (+0.8 US cents/kWh),
- PV modules (+1.3 US cents/kWh),
- PV cells (+3.5 US cents/kWh),
- Inverters (+0.6 US cents/kWh),
- Material focusing solar energy on PV modules (+0.5 US cents/kWh).

YEKAs (Renewable Energy Resource Area) are defined under a separate regulation issued in Law 5346. They identify the areas for large-scale renewable energy projects on privately or state-owned land. The YEKA tender for the Karapinar Renewable Energy Resource Area was won in March 2017 by Kalyon-Hanwha Q CELLS. However, the second 1 GW tender (YEKA GES 2) was cancelled on the 13th of January 2019.

At the end of 2017, the Turkish Energy Market Regulatory Authority (EPDK) published a draft net metering regulation for rooftop PV installations with a power range of 3 kW to 10 kW. The Turkish solar market is expecting the monthly net metering regulations to enter into force in the first half of 2019. That will launch new schemes for residential and commercial and industrial (C&I) rooftop installation. New rules for residential PV will likely come into force in 2019, while the net metering guidelines for commercial and industrial solar power systems may be issued at a later stage.

There are many special projects supported by the government and different renewable energy and climate change mitigation EU funds. The Agricultural and Rural Development Support Agency (TKDK) projects, agricultural irrigation projects, Forest Ministry PV projects, municipality applications and ILLER BANK A.S. are other important drivers for the Turkish PV market.

TABLE 2B MONTHLY INSTALLED PV POWER PLANTS IN 2018[5]

MONTHS	CUMULATIVE INSTALLED (MW)		
	LICENSED	UNLICENSED	TOTAL INSTALLED
January	22.90	3,455.80	3,478.7
February	22.90	3,919.20	3,942.1
March	22.90	4,567.40	4,590.3
April	22.90	4,605.00	4,627.9
May	22.90	4,680.00	4,702.9
June	22.90	4,703.00	4,725.9
July	22.90	4,721.00	4,743.9
August	31.90	4,761.00	4,792.9
September	49.80	4,768.00	4,817.8
October	81.70	4,842.00	4,923.7
November	81.70	4,920.80	5,002.5
December	81.70	4,981.20	5,062.9

Source: GUNDER, 2019 with data from TEİAŞ.

By the end of 2018, there were 5,868 PV power plants (equal to 5,062.9 MW in total) in operation, of which only nine (81.7 MW in total) are in the licensed segment. The share of rooftop applications was around 15% of the total installed PV power.

PV manufacturing

Regarding PV manufacturing activities, there is currently no manufacturer of feedstock, ingots or wafers in Turkey. While three companies claim to produce solar cells, there are more than 30 PV module manufacturers in Turkey with an annual production capacity of more than 3,500 MW. Turkey also hosts a few manufacturers of PV module processing materials (glass, frames, etc.).

The Turkish government included in its Project Based Investment Incentive System a TRL4.2 billion (440 million USD) support scheme launched in August 2017 to drive investments in solar energy. Turkish renewables project developer Eko Yenilenebilir Enerjiler A.S. (EkoRE) has begun construction of a solar module manufacturing facility in Niğde, in central Anatolia. Located at the Bor organised industrial zone, the factory will have an initial production capacity of 1,000 MW, with the opportunity to expand to 2,000 MW. The facility will contain a vertically integrated production of ingots, wafers, solar cells and PV modules. EkoRE intends to complete construction within 12 months.

Challenges

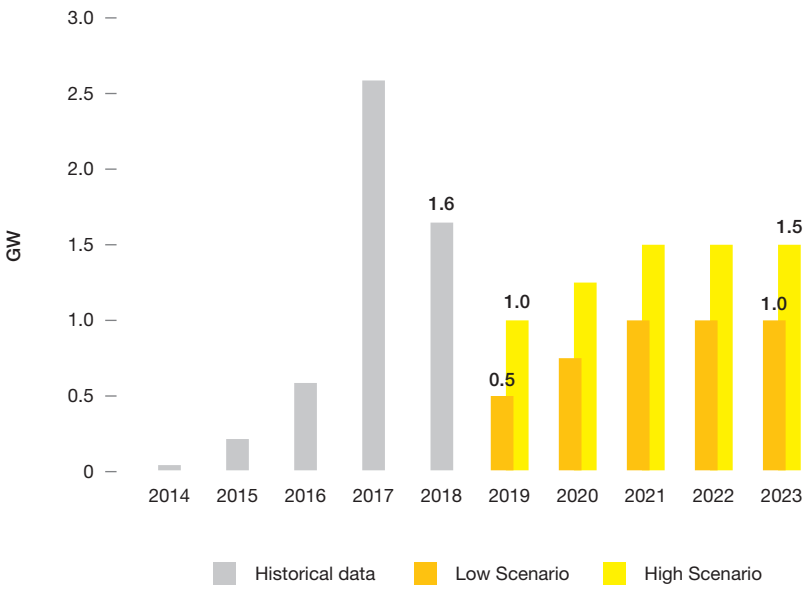
A planned 500 MW Hanwha Q CELLS factory in Konya was abandoned, as the Korean manufacturer walked away from a 1 GW project it was awarded in a public tender with Turkish partner Kalyon Enerji. According to the tender rules, 60% of the first 500 MW slice of the Konya project had to contain locally made components.

Local content requirements also featured in a 1 GW solar tender abruptly scrapped by the Turkish government in late January 2019. In that instance, 60% of the modules used in successful project bids would have to come from domestic manufacturers.

Outlook

According to Turkey's Renewable Energy General Directory (YEGM; known as a part of the General Directorate of Energy Affairs), the PV target for 2023 was

FIGURE 29 TURKEY SOLAR PV MARKET SCENARIOS 2019 - 2023, BY GÜNDER



Source: GÜNDER Turkish Solar Energy Society.

5,000 MW. In September 2017, the Turkish Ministry of Energy and Natural Resources (ETKB) announced that the new 10-year target is 10,000 MW, divided into 4,000 MW for residential rooftop PV applications and 6,000 MW for industrial and commercial rooftops.

Other drivers are rooftop solar, with monthly net metering regulations, 250 MW of licensed projects, and unlicensed projects that have to be installed in 2019. Currently, the Turkish solar market is waiting for the small size YEKA tenders for systems with capacities ranging from 10 MW to 50 MW, which was planned to be held this year. Also, the Unlicensed Electricity Generation Draft Regulation was recently revised in order to meet the electricity needs of geothermal, biomass and biogas facilities from solar power electric generation.

When considering the financial situation and creditworthiness of Turkish people today, around 3,900 MW of installed rooftop capacity seems possible. But the potential is obviously much larger. At least one third of Turkey's existing roof area is deemed to be suitable for solar installations, equal to around 467 million m^2. If solar was installed on all these roofs, that would total around 46,000 MW, with 23,000 MW on residential roofs, 21,000 MW on industrial and commercial roofs, and 2,000 MW on the roofs of public institutions. However, the Turkish Electricity Transmission Corporation (TEIAS) says that up to around 6,580 MW of rooftop solar capacity, no additional investment will be required in transmission lines.

The PV market in Turkey continued to grow very fast in 2018 – from production to installation – with support and raising awareness on all levels of society, even though it was less than in the record year 2017. Due to the current financial situation in Turkey, GÜNDER has revised both its high and low scenarios downward for each of the next five years. However, in case the macro-environment changes, demand could quickly grow again; Turkey is still one of the fastest growing energy markets in the world.

Author: *Esen Erkan; GÜNDER*

10. THE NETHERLANDS

2018 was the first year the Netherlands had a GW-scale solar market. A total of 1.4 GW PV was installed in 2018, of which around 600 MW was added on residential rooftops and 800 MW for commercial applications and utility-scale power plants.

This year, the Dutch solar market will grow to more than 2 MW, with significant growth in the utility-scale project segment. The biggest solar park at the moment has a capacity of 54.5 MW, but we expect that in September 2019, a 103 MW park will become operational in the north of Holland. Today, the Netherland's biggest rooftop PV installation has a capacity of 7.5 MW.

The residential market has seen a continuous, moderate growth – and it can be expected that this will stabilise on a level of at least 500 MW per year. In the Netherlands, the importance of this market segment is well understood. This rooftop market helps to raise awareness for the energy transition among citizens and increase acceptance of the (spatial) consequences of the introduction of wind and solar power plants.

Dutch solar/RE targets

The Netherlands will not fulfil its EU 2020 renewable energy targets of 14%. The share of renewable energy will reach only 12.2%, according to the latest estimates. However, there is quite an impressive pipeline of projects both in wind (offshore and onshore) and solar in the Netherlands. At the end of 2018, there were 7 GW of approved solar projects to be realised within three to four years.

The Dutch Energy Agreement of 2015 sets a 16% renewable energy target by 2023. It seems reasonable that this target will be met.

The Netherlands have a Climate Law with a CO_2 reduction target of 49% by 2030. In December 2018, a climate and energy agreement was reached between a broad range of stakeholders, that regulates the distribution of the CO_2 reduction shares for the different sectors: building, environment, electricity, industry, mobility and agriculture. At least 75% of electricity consumption in 2030 will have to come from renewables, while all coal power plants have to be closed and gas use will be strongly reduced. The electrification of heat (industry) and mobility (personal cars) will dramatically increase the need for electricity. The 2050 CO_2-reduction target is 95%.

Drivers for solar growth

The **residential market** is driven by net-metering and there is no limitation or charge for the net-delivery. Small businesses with a connection up to 3*80 A have – besides net-metering – a fiscal advantage in the profit tax.

The **commercial and utility scale** market is driven by SDE+, a technology neutral tendering scheme that is also competitive between renewables. However, there are different maximums depending on technology (wind, biomass, solar), size and application (ground-mounted, rooftop, water).

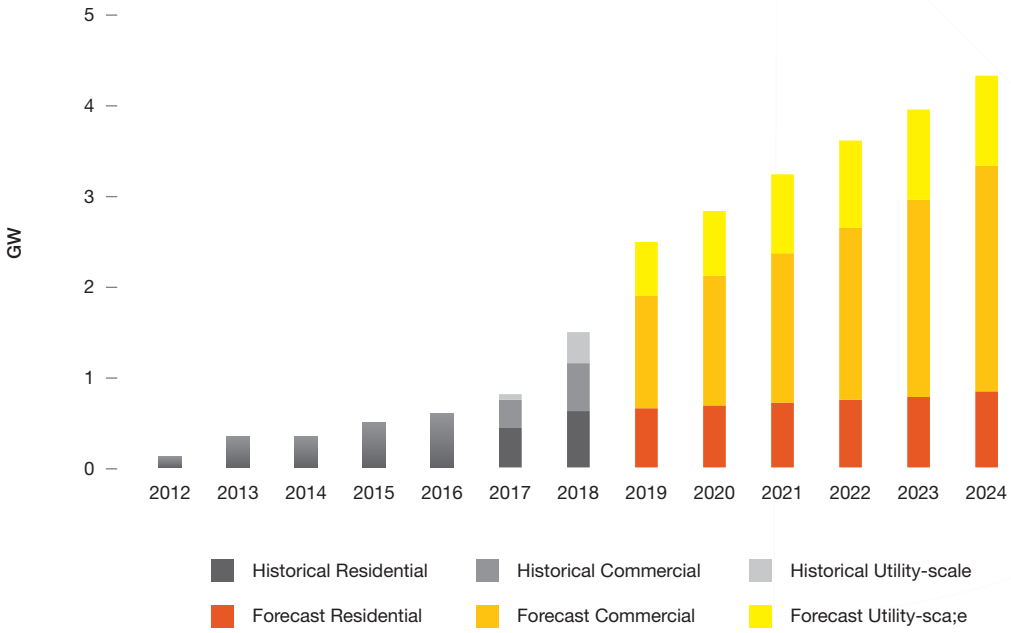
In 2019, there will be two SDE+ rounds, each with €5 billion. In 2018, there were two rounds (spring and autumn) of €6 billion each. The projects participating in SDE+ tenders will have to be at least 15 kW, and there is no maximum. The scheme is financed through a surcharge on electricity prices (ODE).

It is agreed that the SDE+-scheme will remain in place up to 2025, but the scope will be broader (energy saving projects and CCS), and the ranking will be based on euros per avoided kilo-tonne CO_2. The expectation is that solar energy can be realised by 2025 at the latest, without any incentive based on PPA contracts. The maximum SDE+-contribution will be lowered every year and it is anticipated that utility-scale solar will reach grid parity in 2022-2023. However, this will also depend on the reference price of energy, which is based on fossil fuels.

The different market segments

In Figure 30, the market development for the next five years can be seen. The Dutch solar market is divided into a residential and a small business segment (both < 3*80 A) on the one hand, and a commercial and utility-scale segment on the other. The commercial systems are usually rooftop projects, the utility-scale power plants mostly ground-mounted solar parks. Holland Solar anticipates that the commercial segment will continue its dominance over the next five years.

FIGURE 30 NETHERLANDS SOLAR PV MARKET SCENARIOS 2019 - 2024, BY HOLLAND SOLAR



Source: Holland Solar.

Challenges

The main challenge for solar in the Netherlands today is grid connection. In several areas of the country, there is the threat of a lack of capacity. Partly, this is an administrative problem, and there is optimism in the solar sector, that the problem can be solved together with the grid operators. Holland's solar sector believes it can contribute in the long run to reliable grids. Combinations of solar and wind can be part of the solution, but also (temporarily) curtailment and/or storage can help to manage flexible power generation within the grid.

Another increasing challenge is to find space, especially for utility-scale projects, and to get further social acceptance for the use of land for solar energy power plants.

In order to enable the solar sector to grow continuously, close cooperation between the sector, represented by Holland Solar, and the Dutch authorities is needed. As a sector, we need to devise market models in which solar energy in the end can contribute to the energy demand without incentives; but of course, that would mean that there would be a level playing field and that all subsidies for fossil fuels would be eliminated.

Author: *Jaap Baarsma, President; Holland Solar*

11. BRAZIL

Overview of solar PV developments

In 2018, Brazil continued to grow at a strong pace of more than 1 GW per year in newly added solar PV installed capacity, mainly in the two main market segments of the country: centralised generation (utility-scale projects, above 5 MW, commercialised in energy auctions regulated by the federal government, and through direct PPAs in the free electricity market) and distributed generation (small and medium-sized projects, equal to or below 5 MW, through the national net-metering regulation in force since 2012). In total, 2018 saw the installation of 1.2 GW in newly added solar PV capacity in the Brazilian market: 390.2 MW in the distributed generation segment and 802.7 MW in the centralised generation segment.

By the end of 2019, the Brazilian Photovoltaic Solar Energy Association (ABSOLAR) projects an additional 1 GW to be added to the grid, yet this time, spearheaded by the distributed generation market, which is expected to more than double in relation to 2018. The total cumulative solar PV operational installed capacity is projected to surpass the 3 GW mark and reach approximately 3.3 GW by the end of 2019.

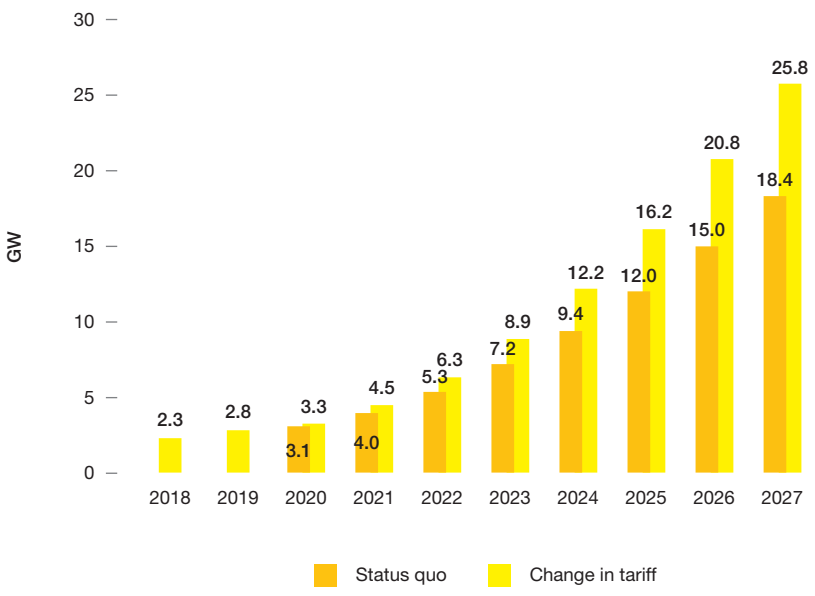
Solar PV targets in Brazil

The Brazilian Energy Research Office (EPE) forecasts in its PDE 2027 (10-Year Energy Plan) that solar PV will reach a cumulative installed capacity of 18.4 GW by 2027, within its reference planning scenario.

For the centralised generation segment, the 10-Year Energy Plan considers new energy auctions hosted by the federal government, bringing an additional yearly capacity of 1 GW from 2023 onwards.

For the distributed generation segment, the 10-Year Energy Plan builds two different scenarios: (i) the reference scenario, whereby market growth is estimated considering a change in the electricity tariff structure for low-voltage (small) consumers from 2020 onwards. Nevertheless, one should note that the revision of the electricity tariff is still under discussion and passing through public consultation with multiple stakeholders since 2018. The process is expected to be finalised throughout 2019, to be implemented in future years, with the exact conditions and dates still subject to definition; (ii) the status quo scenario, whereby the market growth of distributed generation is estimated under the assumption that the electricity tariff conditions currently in effect will remain for the 10-year horizon of the plan.

FIGURE 31 BRAZIL SOLAR PV TOTAL CAPACITY SCENARIOS 2019-2027, BY ABSOLAR



Source: ABSOLAR, 2019 with data from PDE 2027, EPE, 2019.

Considering both the centralised and distributed generation segments, the 10-Year Energy Plan forecasts a solar PV added capacity of 2 GW on average per year between 2019 and 2027. ABSOLAR evaluates the numbers as below expectations, as they were based on excessively conservative assumptions for the price of solar PV electricity. Based on actual data on the increasing competitiveness of solar PV in Brazil, ABSOLAR recommends a national PV target of at least 30 GW by 2030 considering both centralised and distributed markets.

Challenges and perspectives for solar PV growth

During 2018, the added capacity on the centralised generation market was mainly due to the delivery of solar PV projects commercialised under the federal government Reserve Energy Auctions (Leilões de Energia de Reserva – LER) of 2014 and 2015.

The New Energy Auction (Leilão de Energia Nova – LEN) held in April 2018 (LEN A-4/2018) was a milestone for the Brazilian PV market, as solar PV projects were contracted for the first time at an average selling price of 35.25 USD/MWh – that's lower than the prices of small hydroelectric, biomass and fossil fuel power plants. In total, 807 MW of projects were contracted and will be delivered and operational by January 2022.

In early 2019, the federal government announced a three-year plan for New Energy Auctions (LENs), establishing an agenda with two auctions per year. From 2019 to 2021, there will be an energy auction in the first semester with a four-year project delivery term (LEN A-4) and an energy auction in the second semester with a six-year project delivery term (LEN A-6). In total, six energy LENs have been scheduled by the federal government for the current and coming years.

The first auction will take place by the end of June 2019. For this auction, 751 solar PV projects, representing a total pipeline of 26.2 GW, were registered: a new record for the country. Additionally, solar PV will have the same 20-year contract structure used by other renewable energy sources.

Despite the positive perspective of yearly energy auctions in Brazil, 2019 is considered as a challenging year for the centralised generation segment. The added installed capacity of new projects this year is expected to be rather low, as a consequence of the absence of solar PV energy auctions in 2016. However, due to the increased competitiveness of solar PV in the country, ABSOLAR estimates a pipeline of more than 2 GW in direct PPAs being evaluated in the so-called "free electricity market" (Ambiente de Contratação Livre – ACL). On the one hand, the interest of corporate consumers from the free electricity market represents a new opportunity for project developers and investors, whereas on the other hand, there are still some challenges to be overcome related to bankability and grid connection bottlenecks, topics ABSOLAR is tackling with the sector.

On the distributed generation segment, the growth observed in 2018 was due to the increasing competitiveness of the net-metering regulation throughout the country. Several states developed local incentives and policies with favorable legal, regulatory, tax and financing frameworks.

2019 will play a crucial role for the future of net-metering and distributed generation in Brazil. Alongside the public consultation about the revision of electricity tariffs for small consumers mentioned earlier, which can considerably impact the competitiveness of distributed generation business models, a specific consultation on the net-metering regulation is also under debate.

To date, Brazil has a full national net-metering programme for projects up to 5 MW, considered as a reference programme to other countries, including both local and virtual net-metering, as well as community solar mechanisms. The successful programme allowed the development of several innovative business models for solar PV distributed generation, such as direct sales, solar communities, cooperatives, leasing, third-party ownership, solar as a service, amongst others. Throughout 2019, the public consultation taking place will assess the benefits and costs of distributed generation in the market and its impacts in electricity tariffs. ABSOLAR's position towards the national regulator has been that, with proper technical analysis, one can firmly conclude that the benefits from distributed generation greatly outweighs and compensates any impacts or costs.

The possibility of changes to the net-metering regulation, as well as changes to the electricity tariff structure for small consumers, are important challenges to follow closely in this market segment. ABSOLAR is convinced that the market is resilient, and the regulatory agency is open to host high-quality debates on the topic, bringing improvements instead of setbacks to current regulations.

Authors: *Dr. Rodrigo Lopes Sauaia, CEO; M.Sc. Stephanie Betz, Technical and Regulatory Analyst; ABSOLAR*

3

THE EUROPEAN SOLAR MARKET

UPDATE 2000 – 2018

2018 was a great year for solar in Europe. The continent added 11.3 GW in 2018, a 21% rise over the 9.3 GW installed the year before (see Fig. 32). In the European Union, demand even soared by 37% to 8.2 GW, up from 6.0 GW deployed in 2017. Europe's comparatively lower growth results primarily from the solar market contraction of Turkey, the continent's number one in 2017. On the other hand, the EU-28's switch from 'no growth' to two-digit growth, to a large extent, stems from the national binding 2020 renewables targets that many member states yet have to meet.

The growth of the European/EU solar market in 2018 was impressive, although a little below our expectations in last year's GMO (34% for Europe, 45% for EU). Turkey's sudden and strong market decline due to the financial crisis and lack of political support was neither awaited by us nor Turkish Solar Association GÜNDER. None of Spain's nearly 4 GW of solar tender-awarded projects or any of the huge merchant/PPA pipeline was grid-connected in 2018, and in France, market demand even shrank last year. On top of it all came a surprising shortage for high-efficiency modules in Europe combined with a price hike towards the end of the year, as Chinese demand was unexpectedly high in the fourth quarter.

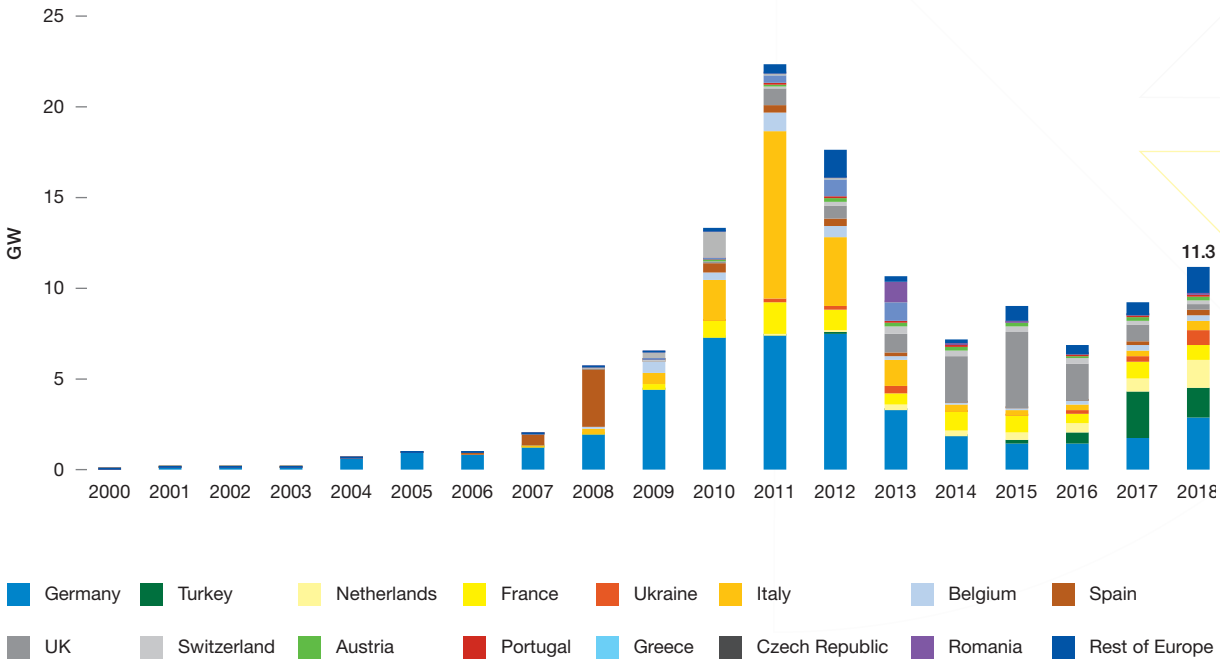
Top 5 European solar markets 2018

Germany was Europe's top solar PV Market in 2018. In 2018, four years after it lost the title to the United Kingdom in 2014, Germany took back the sceptre from previous market leader Turkey. At 2.95 GW, the German market grew 67% year-on-year, after it added 1.76 GW in 2017 and almost the same capacity in the two years before – 1.52 GW in 2016 and 1.45 GW in 2015. This is the first time Germany met its 2.5 GW target since 2013. The main driver for the country's 2018 solar boost were self-consumption/feed-in premiums for medium to large commercial systems ranging from 40 kW to 750 kW, which contributed to more than half of the new capacity, while residential systems up to 10 kW contributed around 400 MW. Tender-based ground-mounted systems above 750 kW were responsible for around 550 MW. The Mieterstrommodel (on-site community solar) regulation, introduced in 2017 to enable collective self-consumption of PV installations on apartment buildings, continues to attract limited interest as participants are subject to full EEG levy payments.

3 EUROPEAN SOLAR MARKET

UPDATE 2000 – 2018 / CONTINUED

FIGURE 32 EUROPEAN ANNUAL SOLAR PV INSTALLED CAPACITY 2000-2018



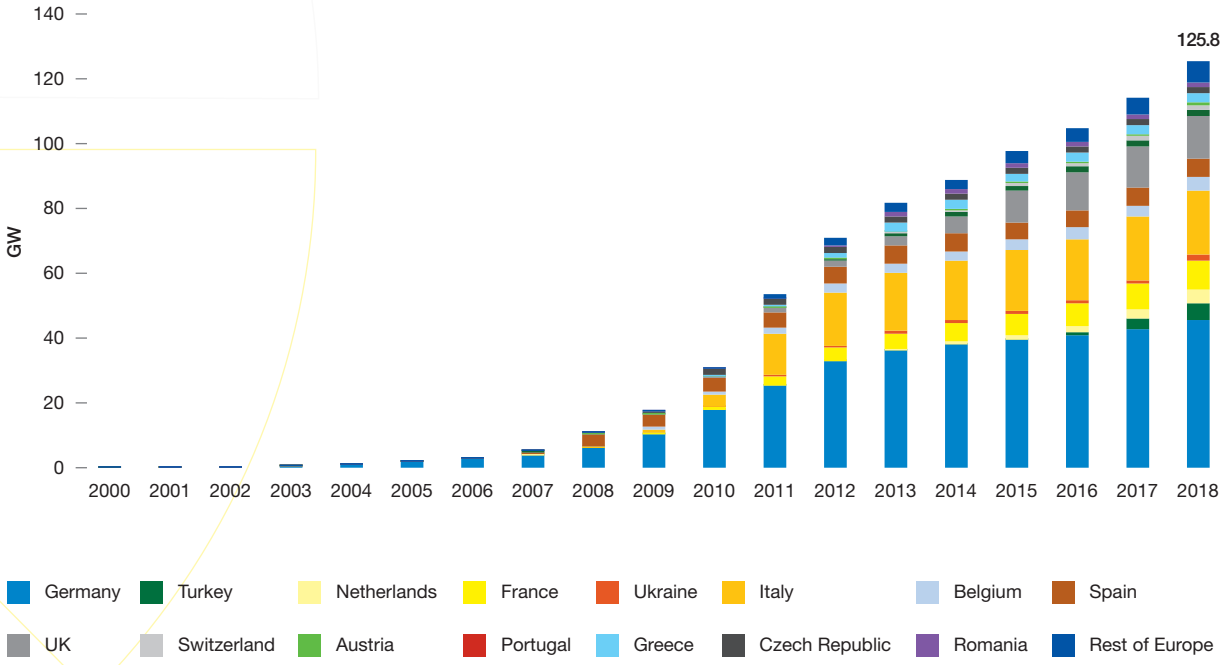
The second largest solar market in Europe was Turkey, which fully disappointed last year. After a short and very high flight in 2017, when the market rose nearly 4.5 times to 2.6 GW, compared to 584 MW the previous year, Turkey was hit by a financial crisis in 2018. It installed only 1.64 GW, a year-on-year decrease of 37%. After around 1.2 GW was grid-connected in the first quarter, less than 500 MW was added in the following 9 months. Almost all new capacity was so-called 'unlicensed' solar systems up to 1 MW but often clustered to larger project sizes, while from the 600 MW of 'licenced' systems tendered in 2014/15 only nine systems totalling 82 MW were realised by the end of 2018, with 60 MW being installed between August and December of that year.

Solar needed to become cost-competitive with other technologies for **the Netherlands** to develop from a medium-size market to one of Europe's leaders. Last year was the first time the Dutch solar market reached the GW-scale, one of three European markets in that group. The Netherlands installed 1.5 GW in 2018, almost doubling from the 770 MW it added in 2017, when it had already grown by over 50% over the previous year. While The Netherland's solar 'baseload' are net-metering incentivised residential installations, which contributed around 40% in 2018, the bulk came from commercial and utility-scale systems awarded in technology-neutral tenders of the Dutch SDE+ scheme. In the 2018 SDE+ autumn round, solar scored 55% of the tendered volume, equal to over 4,400 projects and 2.9 GW; in the 2018 SDE+ spring round, solar won 1.7 GW of the of 2.3 GW total.

The **French** solar market disappointed again in 2018. It still did not reach the GW-scale, but much worse, unlike most of the other European solar markets, it even contracted slightly by 4% to 873 MW. A complicated incentive scheme requiring solar systems as small as 100 kW to participate in tenders hasn't worked as intended so far; even regulatory changes and plans to tender more capacities as of 2018 have had no positive

In 2018 21% annual growth in Europe

FIGURE 33 EUROPEAN TOTAL SOLAR PV INSTALLED CAPACITY 2000-2018



effects so far. France missed its 10 GW cumulative solar target in 2018 by over 1 GW. However, several tenders were held and awarded in 2018, including a 200 MW technology-neutral solar/wind tender, where solar won the entire capacity.

A very generous feed-in tariff of 15 euro cents/kWh for large-scale PV systems has catapulted **Ukraine** into the top 5 European solar markets in 2018. A total of 803 MW was installed, 228% higher than the 245 MW connected to the grid in 2017. In addition to large-scale solar, a net metering scheme for PV installations up to 30 kW attracted considerable interest last year. In the first three quarters of 2018 alone, installed rooftop capacity had more than doubled to 121 MW, from 51 MW at the end of 2017.

In summary, solar in the European Union and Europe as a whole is on the upswing. From the 28 EU member states, 22 connected more solar to the grid than the year before; for the entire continent, less than a dozen countries experienced lower demand for solar power technology.

The picture of **European total solar installed capacities in 2018** is very similar to 2017 (see Fig. 33). Germany remains Europe's largest solar power plant operator with 45.9 GW of total installed capacity, followed by Italy with 19.9 GW. Again, Germany (36.5%) and Italy (15.8%) were home to over half of Europe's solar power generation capacities. However, their share slightly decreased – 52.3% vs. 54.7% in the previous year. The only other European market having more than 10 GW installed was the UK, but as it installed only 286 MW, adding up to a 13 GW total, its share decreased by 1% point to 10.3%. Next to the three European 2-digit level solar markets, 12 countries had solar capacities in the 1-digit GW-level (France, Spain, Turkey, Netherlands, Belgium, Greece, Switzerland, Czech Republic, Ukraine, Austria, Romania, Bulgaria), while most countries on the continent operated less than 1 GW of total solar power.

3 EUROPEAN SOLAR MARKET

UPDATE 2000 - 2018 / SEGMENTS

In Europe, solar market segmentation today still mirrors, to a large extent, the evolution of the respective market (see Fig. 34).

Those countries that offered at some point, and usually for a short period of time, very attractive feed-in tariff programmes are still dominated by the utility-scale solar segment in Europe. However, hardly anything has been installed since the FIT schemes were terminated. This is the case for Eastern European countries Romania, Bulgaria, Czech Republic, as well as Spain, which was almost fully dormant for years, when it added only small amounts of distributed systems. However, while the recent termination of the solar tax will drive more self-consumption systems in Spain's new solar growth phase, the bulk will be tender-based ground-mount power plants and PPA-based utility-scale systems.

In other markets with continuously functioning solar demand, like Germany, the distribution is much more even. Here, the earlier uncapped large-scale FIT schemes were replaced by tenders with decent and limited volumes, while self-consumption/premium FIT distributed systems are still uncapped – and that's where today's demand mostly takes place. In several Central European markets, like Austria, Belgium, Switzerland or the Netherlands, utility-scale solar has not played a role in the past – they have been always focussing on rooftop solar. In the Netherlands that is now changing, as auctions have started to drive growth for large commercial and utility-scale systems.

By 2018, 19% of Europe's cumulative PV system capacity was installed on residential rooftops, about 30% on commercial roofs, while the industrial segment accounted for 17% and the utility market for 34%.

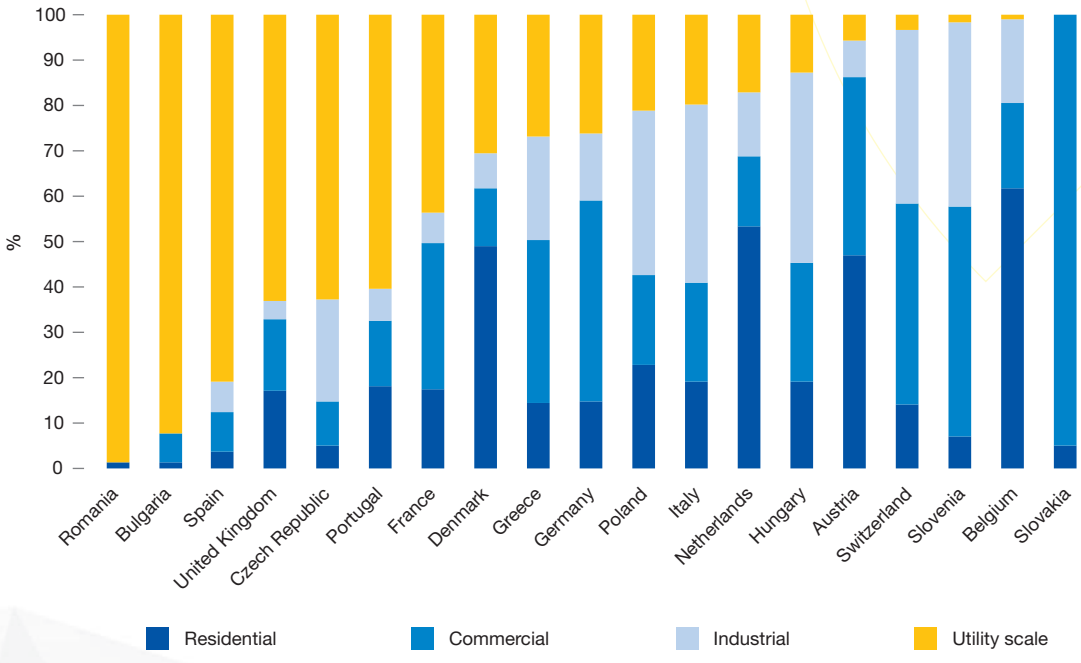
The development of the different solar segments in Europe will clearly depend on the boundary conditions and policy frameworks of the individual countries. However, utility-scale ground-mounted power plants and large rooftop systems will thrive in any country with regular tenders and attractive conditions for merchant/PPA systems, while distributed rooftop solar in particular needs environments without taxes on self-consumption.

Why solar in Europe is growing again

As forecasted in last year's GMO – Europe has returned to a growth path and is supposed to stay there for the coming years for several reasons:

- **EU 2020 targets:** The deadline for EU member states to meet their national binding 2020 renewable energy

FIGURE 34 EUROPEAN SOLAR PV TOTAL CAPACITY SEGMENTS UNTIL 2018 FOR SELECTED COUNTRIES



targets is quickly approaching. A recently published update from EU statistics office Eurostat revealed that only 11 out of 28 EU countries had already fulfilled their obligations by the end of 2017, the majority was still on its way, and several had quite some way to go. With solar being the most popular power generation source among EU citizens, the most flexible, easy to install and often the lowest cost means to expand renewables shares, governments increasingly take solar into their climate strategies. Hungary, for example, which was the fifth largest solar market in the EU in 2018 with over 400 MW, now has a clear focus on solar when it comes to renewables.

- **Tenders:** Only a few years ago, many in the European solar industry – that were used to uncapped attractive feed-in tariffs – feared that tenders were only a means to control and limit growth. In the meantime, many European countries have embraced solar tender tools, which have played a key role in bringing down solar power prices and prove to politicians, businesses and the public how quickly its cost continues to decrease. Solar has also shown in several European countries, including Denmark, Germany, the Netherlands and Spain, that it can win technology-neutral tenders against any other renewable technology if the boundary conditions are properly set. The next stop will be 'intelligent' tenders, which strive to support system and grid services. Germany will launch such a tender, which will also enable combined solar/wind solutions, in September.
- **Self-consumption, digital & storage:** Solar power is much cheaper than retail electricity in most European markets and will continue to reduce in cost, which is increasingly a major driver for people and companies to invest in on-site power generation. The quickly falling cost of battery energy storage combined with the benefits of digital and smart energy products supports the sales case for solar, as many consumers prefer to have better control over their energy bill. However, in order to empower prosumers, it is key that solar is not inappropriately taxed and that market design is adapted to the needs of the new energy world.
- **Emerging & reawakening markets:** The low cost of solar is attracting European countries that haven't been very active in the field in the past. For European solar shooting star, Ukraine, energy security was one important aspect for its incentive programmes for large-scale and residential solar. There are also European solar pioneers that have turned to low-cost solar again, such as Spain, which might even turn into Europe's largest PV market in 2019.
- **Corporate sourcing:** Sourcing renewable power has become a crucial part of the energy and sustainability strategy of many leading corporates – and with costs for renewables continuing to decrease, the appetite for cost-competitive solar and wind power is now growing quickly. Started in the US, today's leading market for corporate renewable sourcing, this trend is now quickly embraced in Europe as well. So far, corporates have chosen primarily wind over solar for renewable PPAs. Primarily, it has been easier to access large renewable power volumes from big wind farms; smaller, commercial solar has rather been directly installed on-site. With the advent of large-scale solar in Europe, low-cost solar is going to play a much bigger role in corporate sourcing.
- **Merchant solar / PPAs:** We are now starting to see direct bilateral PPAs with solar increasingly competing with wholesale power markets in a number of European countries. This development will be seen primarily in those European countries with the widest spreads between solar and wholesale power prices, and where access to ancillary service markets is granted. There had been talk about pure PPA based projects, in particular in Spain, for some time, and a huge pipeline of over 30 GW had accumulated. But it took until 2018, before the first of these systems was being built; a 175 MW system from BayWa was sold before final grid-connection to the asset manager of Munich RE/Ergo at the end of 2018, and in early 2019 the world's largest PPA was signed for a 708 MW solar project portfolio in Spain and Portugal. Also, in Germany, where wholesale power prices are lower than in Spain, development for a 'subsidy-free' 175 MW system started last year.
- **Clean Energy Package:** The outcome of Europe's 'Clean Energy for All Europeans' legislation is very positive for solar and energy storage. It has set a higher-than-expected 32% renewables target by 2030, ensures the rights for self-consumption, and maintains priority dispatch for small-scale solar installations, among many other pro-solar provisions. Finally, it has addressed many needs for a flexible, renewable energy system by creating a new electricity market design framework and implementing new tools. An important milestone has been reached, now it is about implementing the directives in the member states.

3 EUROPEAN SOLAR MARKET
PROSPECTS 2019- 2023

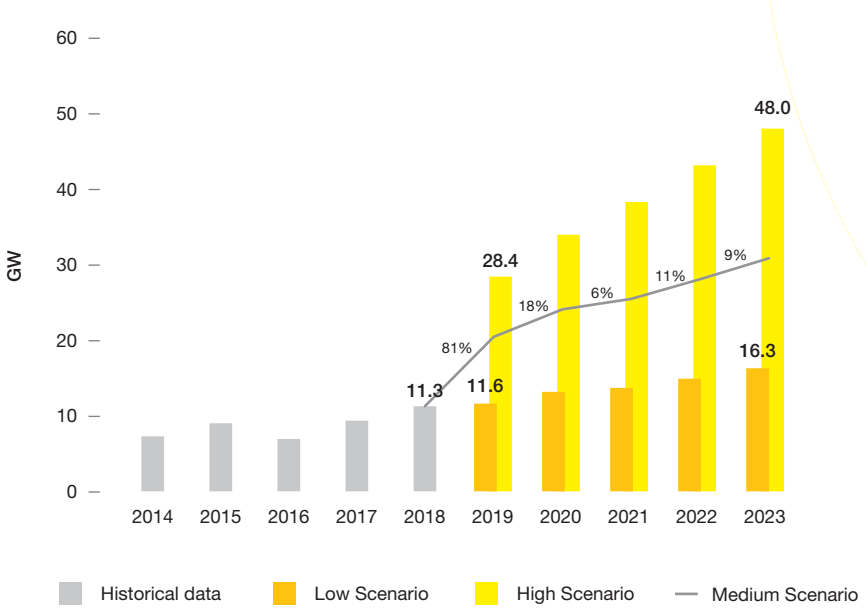
2019 will be an exceptionally good year for solar power in Europe. The Medium Scenario of our **European annual solar PV markets scenarios 2019 – 2023** expects very strong growth for the continent until 2020, even stronger than anticipated in last year's GMO. This year, we see demand surging by 81% to 20.4 GW, for 2020, we expect an 18% growth to 24.1 GW, which would be a new installation record, beating the 22.5 GW added in 2011 (see Fig. 35). The main drivers for the higher-demand assumptions are the same – the EU-28 countries have until 2020 to meet their binding national renewables targets, then, there is the volume that needs to be installed from various tenders. However, in the previous GMO, we assumed that parts of the Spanish 4 GW tender volume would have already been installed in 2018; as this did not happen, it needs to be finalised this year. None of the PV systems from the large Spanish PPA pipeline were grid-connected in 2018. Another factor is a quicker-than-anticipated price decrease. The Chinese market restructuring has freed capacities and led to unexpected price reductions for cells and modules, which has triggered demand for solar around the world.

For 2021 to 2023, our Medium Scenario also forecasts more capacity additions than the previous GMO. Back then, we had argued that after 2020, EU member states would take their time before they invested heavily again in renewables, as the next targets only need to be met in 2030. We still see a flattening of the growth curve in 2021, but that's only very short-term; rather taking a breath to prepare for the next growth phase, the momentum won't stop. Utilities, corporates, and big funds in Europe are putting renewables high on their agenda – and solar, as both the lowest cost and most versatile energy generation source, will be their favourite means for clean power sourcing and investing.

We estimate that 28.2 GW will be installed in 2022, and in 2023, even the 30 GW level will be reached. That is much more optimistic than in the GMO 2018, when our highest Medium Scenario estimate was 21.5 GW in 2022.

There is always the possibility of unforeseen changes in the economic situation or political leadership of countries and regions that can heavily impact the

FIGURE 35 EUROPEAN ANNUAL SOLAR PV MARKET SCENARIOS 2019-2023



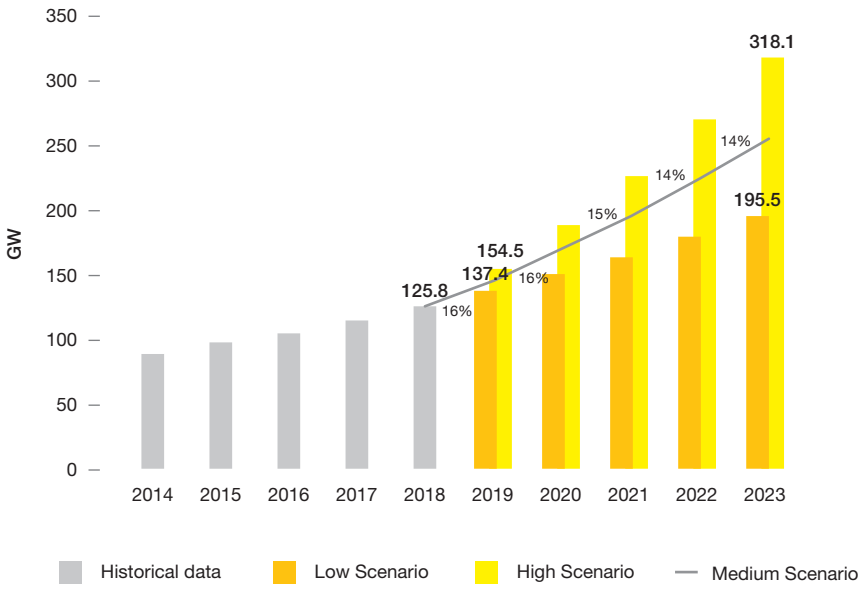
boundary conditions for solar. Turkey's sudden financial crisis is such an example that has severely worsened the solar business case in that country. In general, the short economic outlook is rather dim. On the other hand, the positive outcome of the EU Clean Energy for All Europeans legislative package is expected to support the solar business case in the EU in the coming decade, although a lot will depend on member states to turn that directive into action on a national level as intended.

If Europe really wants to meet the Paris Agreement targets and fully embrace the attractive business case of solar as one of the lowest-cost power generation source today, demand for PV on the continent in 2023 could reach 48 GW, which would be more than double the size of the record year of 2011, with 22.5 GW. EU demand would be a little smaller but it would still reach 32.7 GW.

Our High Scenario is based on a scenario where no import taxes for solar products, no prohibitive taxes on self-consumption/storage, or any other barriers could slow down flexible and distributed solar power. It also anticipates that interest rates stay low and there will be no macroeconomic issues in Europe. On the contrary, if the majority of European policy leaders fully ignore solar's huge potential and the benefits for their citizens and business to become true prosumers, or a severe economic downturn takes place and a new financial crisis resurfaces, even the Low Scenario could become a reality. The Low Scenario estimates annual additions of only 16.3 GW in Europe or 14.1 GW in the EU in 2023.

A look at the **European total solar PV market scenarios 2019 – 2023** in Europe shows constant two-digit annual growth rates, with the Medium Scenario anticipating a cumulative installed capacity of 255 GW in 2023 (see Fig. 36). While the High Scenario sees Europe exceeding the 200 GW level in 2021 and the 300 GW level in 2023, reaching 318 GW by the end of 2023, we consider solar's business case very strong in any case over the next five years – even in our Low Scenario, the continent is expected to operate nearly 200 GW of solar power plants in 2023.

FIGURE 36 EUROPEAN TOTAL SOLAR PV MARKET SCENARIOS 2019-2023



3 EUROPEAN SOLAR MARKET

PROSPECTS 2019- 2023 / CONTINUED

Our annual 'weather forecast' is mostly bright and sunny for the entire European continent. Putting the **Top 15 European solar PV markets prospects 2019 – 2023** under the microscope, we are upbeat on 12 of these countries, for only two countries the political support prospects are considered cloudy (UK and Russia), while we see a rainy outlook for just one – Turkey (see Fig. 37).

Unlike in the previous two editions of the GMO, the top 3 prospects in Europe have changed this time. Germany is still considered to add the largest solar volume in the coming five years (even though the 52 GW FIT premium cap will be reached in 2020/21, an issue that we believe will be fixed). But the next two are no longer France and Turkey – now it's Spain and the Netherlands. Recent solar developments in these two countries – strong political backing, current high installation activity, and large pipeline – are providing a solid foundation to assume that demand will be very strong until 2023: we anticipate Spain to add 19.5 GW and the Netherlands to grid-connect 15.9 GW. We will provide more details in our first European Solar Market Outlook, which we will publish in autumn.

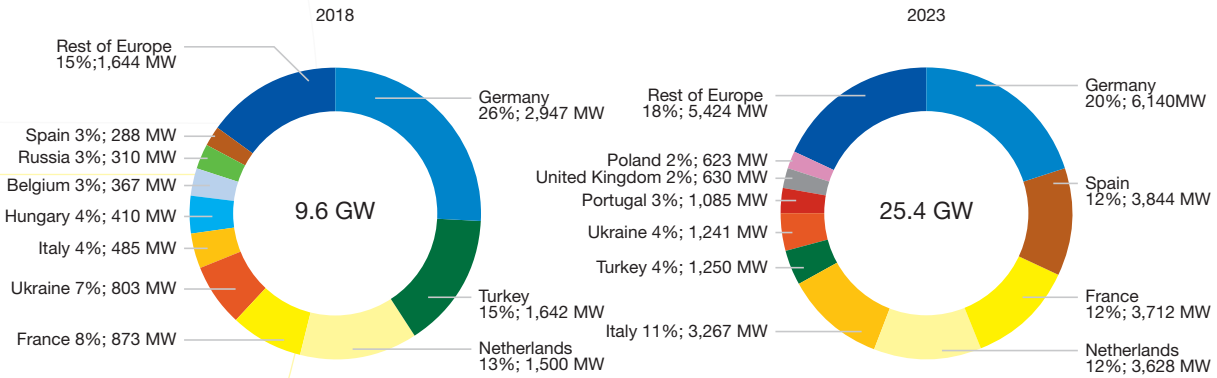
Our GMO 2019's Medium Scenario anticipates the 15 fastest growing European markets to install at least 2 GW each in the 5-year forecast period (up from at least 1.3 GW in GMO 2018), with the range stretching from Germany, adding the largest volume of 26.7 GW (up from 20.3 GW), to 2.1 GW in Switzerland, while being much smaller and growing at a higher average rate, installing the lowest volume.

In total, we expect the European countries to add 129.2 GW (up from 92.8 GW) in the 5-year forecast period, based on our most probable Medium Scenario. That's roughly as much as the total installed capacity in Europe.

FIGURE 37 TOP EUROPEAN SOLAR PV MARKETS' PROSPECTS

	2018 **Total Capacity** (MW)	2023 **Total Capacity Medium Scenario by 2023** (MW)	2019 - 2023 **New Capacity** (MW)	2019 - 2023 **Compound Annual Growth Rate** (%)	**Political support prospects**
Germany	45,920	72,611	26,692	10%	
Spain	5,915	25,367	19,452	34%	
Netherlands	4,181	20,059	15,878	37%	
France	8,920	22,259	13,339	20%	
Italy	19,877	29,498	9,621	8%	
Ukraine	2,004	7,963	5,959	32%	
Turkey	5,062	10,562	5,500	16%	
Portugal	660	4,525	3,865	47%	
Hungary	797	3,580	2,783	35%	
United Kingdom	12,962	15,674	2,711	4%	
Poland	464	3,139	2,675	47%	
Ireland	50	2,667	2,617	121%	
Belgium	4,075	6,367	2,292	9%	
Russia	518	2,770	2,252	40%	
Switzerland	2,205	4,292	2,087	14%	

FIGURE 38 CAPACITY ADDITIONS AND SHARES OF TOP 10 EUROPEAN SOLAR PV MARKETS IN 2018 AND 2023



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GLOBAL MARKET OUTLOOK 2019-2023

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For the first time, the solar sector grid-connected over 100 GW per year and exceeded the 0.5 TW level of total installed solar power capacities. Those are impressive milestones.

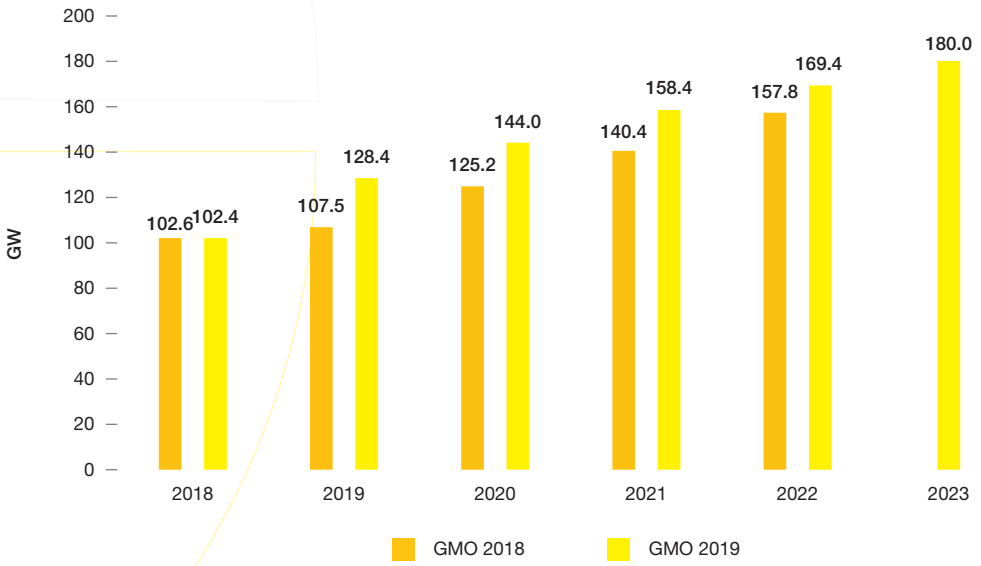
But a 4% annual growth rate is not enough to master the climate change challenge. Together with wind, which again added only half of solar's capacities, and the others in the clean energy team, net capacity additions from renewables basically stagnated in 2018; their share grew by only 1% absolute. In this environment, solar – the most versatile and often lowest-cost power generation source today – contributed only a little over 2% of the global electricity output. At the same time, global CO_2 emissions did not decrease but rose by around 1.7% to another world record high.

It is obvious that renewables have to play a key role in cutting global greenhouse gas emissions; it is simply the most efficient way. According to IRENA, an average of over 400 GW of renewables have to be installed per year until 2050 to keep temperature rise below 2°C. But last year saw additions of only around 180 GW of renewables. While it is a good sign that most analysts consider solar as the major pillar in their long-term power scenarios, this will be too late – solar, in concert with storage, wind and others, is ready to satisfy the need for much more renewable energy today.

The main reason for last year's low solar market growth was the contraction of the Chinese market by 16%. Despite causing some turmoil for the entire solar sector over the last months, this solar market restructuring effort has been necessary. As the world's largest solar market by far, China was responsible for nearly 55% of new installations in 2017. The strong demand was mostly incentivised through inappropriately high feed-in tariffs, with the solar power plants mostly installed in very sunny but distant regions that require long-distance transmission lines that had not been fully available and led to unwanted high curtailment of power. The transition to a new market design that will be based on tenders and merchant solar backed by green certificates and financing schemes is exactly what's needed to make the Chinese energy market fit for the next solar growth phase.

The European Union – where the solar market suffered for many years – has just completed a legislative energy transition exercise. The Clean Energy for All Europeans Package provides a framework with a reliable governance and a modern market design that is aimed at enabling all stakeholders – from large corporates to active consumers on the household level – to invest in renewables in the power, heat and transport sectors. It is now on the member states to put these mostly solar-benefiting guidelines into action.

FIGURE 39 COMPARISON MEDIUM SCENARIO GMO 2018 VS 2019



China is usually much faster in changing any policy guidelines than Western economies because of its political structure. From what can be seen so far, the Chinese administration has addressed certain concerns of the domestic solar industry and is in the final stages of creating a new solar incentive scheme that is supposed to reignite the market in the second half of 2019 and ensure further growth in the coming years.

However, there was an important lesson to be learned for the global solar sector from Chinese restructuring: its global dependence on China somewhat decreased in 2018 to 44%, from around 52% the year before. Even with faster recovery than originally expected this year, the Chinese market will only cover about 34%, which in return means that about two-thirds of global solar capacity will be installed outside China. With 16 countries expected to install over 1 GW this year, diversification of global solar demand is quickly developing. With solar's cost reduction continuing, the number of emerging solar markets will grow further in the next few years as well.

For flexible solar technology and its peers to be able to grow as fast as possible, it is of utmost importance that infrastructure and market design are working effectively. But this is not always the case. One example are tenders, a key dissemination tool for solar and wind in the post-feed-in tariff world. In India, the world's third largest solar market, demand decreased in 2018 among others, because its tender scheme showed serious flaws. Distribution companies retroactively asked for retendering to get better prices or tendered volumes have been combined with requirements to set up local manufacturing, which has made the process very complicated. However, if tenders should play a role in areas with large penetration of renewables, we need intelligent tenders that make use of solar's flexible nature to avoid extensive new power lines people often oppose; moreover, tenders have to be open to combining various generation technologies and storage to offer different grid services. There are many more barriers that need be cleared to free the fast lane for solar, but that's depending on policy frameworks. We have become again more optimistic in our Global Market Outlook 2109 when compared to last year's version (see Fig. 39). But again – that's not enough to stop the Climate Crisis. In any case, solar is ready today from the technology and cost side for a much steeper growth curve.

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