PV manufacturing capacity expansion plans in 2016 exceeded 55GW

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ABSTRACT

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In this quarterly report on global PV manufacturing capacity expansion announcements we will provide a detailed analysis of 2016. Despite a significant slowdown in new announcements in the second half of the year, 2016 surpassed 2015 by around 16% to exceed a total of 55GW of thin-film, dedicated solar cell and module assembly and integrated PV expansion plans.

A game of two halves

As Figure 1 shows total global PV manufacturing capacity expansion announcements in 2016 were heavily weighted to the first half of the year with a total of nearly 48GW. The strongest quarter in 2016 was the first as May signalled a significant fall-off in announcements.

In stark contrast, the second half of 2016 accounted for only just over 8GW of planned expansions; July was he low point with just one 20MW planned solar cell capacity expansion announced. Only in November did total announcements push past 2GW in the second half of the year.

As shown in Figure 2, thin-film expansion announcements barely topped 1GW and were primarily (800MW) from CdTe leader, First Solar, which announced upgrades to mothballed lines and a new facility to house the expansion but did not provided a geographical location. Later in the year, First Solar announced a major restructuring of its manufacturing operations with a complete migration from Series 4 modules to Series 6 large-area modules. This restructuring effectively negated plans announced in April 2016.

Figure 2 also highlights the complete lack of integrated solar cell and module assembly plant announcements in the second half of the year, compared to 4.5GW announced in the first half of the year.

Dedicated module assembly



announcements reached over 26.6GW in 2016, with around 23.5GW coming in the first half of the year. Overall, dedicated module assembly plans have typically tracked at higher figures than dedicated cell expansions, although the difference is relatively small.

High-efficiency solar cells gain momentum

The migration to high-efficiency solar cells, whether monocrystalline or multicrystalline with passivated emitter rear contact (PERC) and n-type mono heterojunction (HJ), was also a key trend in 2016, having gained strong momentum since 2015.

As shown in Figure 3, overall highefficiency monocrystalline solar cell capacity expansion announcements in 2016 accounted for around 40% of the global total of c-Si cell expansion plans, up from around 26% of the total in 2015.

In 2016, a total of around 38GW of c-Si solar cell expansion plans were announced globally, which included almost 11GW of dedicated mono c-Si cell capacity, compared with almost 27GW of multi c-Si solar cell plans.

However, many announcements in the multi-gigawatt scale were expected to be phased over several years. A more realistic analysis, with first-phase plans in the 500MW range, indicate around 23GW of total cell expansions, upgrades and new plant plans were announced.

In this analysis, we have only included solar cell expansion announcements that specifically stated that the plans relate to p-type or n-type mono as well as heterojunction and hybrid n-type mono cell architectures.

A key reason for this is that a number of PV cell and integrated manufacturers that can produce both p-type mono and p-type multi cells have typically not broken out whether the cell capacity expansions include both wafer types. Indeed, another challenge has been examples of later conversion of p-type multi cell lines to allocate some capacity to mono cell production.

With 2014 classified as the year that capacity expansions restarted after several years of chronic overcapacity, it is interesting to note that the ratio of mono to multi c-Si solar cell capacity plans was almost equal, albeit at low levels of 2.9GW and 3GW, respectively.

The significant amount of capacity expansion announcements in the later

part of 2015 shifted the emphasis to multi c-Si cell lines and away from mono. In 2015, dedicated mono expansions totalled nearly 4.5GW, while multi cell expansions almost topped 17GW. Mono cell planned expansions fell to only around 26% of the total.

One of the key reasons for the dominance of p-type multi c-Si cell capacity expansions in 2015 was the significant expansions being made by the 'Silicon Module Super League' (SMSL) members (Trina Solar, Canadian Solar, Jinko Solar, JA Solar and Hanwha Q CELLS) with high reliance on multi and the establishment of meaningful new PERC cell technology capacity.

Another aspect that hindered mono capacity expansion plans was the lack of low-cost p-type mono wafers and limited 'effective' capacity expansions in 2015, which at around 3GW were actually less than the mono cell line expansions (4.5GW).

2015 can be seen as a transitional year for mono wafer cost competitiveness and availability, while 2016 can be seen as more transformative on both levels.

Not only did 2016 provide more than a doubling (10.96GW) of mono c-Si cell capacity expansion



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Capacity Expansion Announcements by Product Type per Month 2016 (MW) Thin Film @c-Si Cell @c-Si Module @cell/module

Figure 2. Capacity expansion announcements by product type per month 2016 (MW).



announcements, a conservative 20GW of mono ingot/wafer capacity expansion plans were also announced that year.

The greater availability of mono wafers at cost-competitive pricing will remain a key adoption driver and could accelerate solar cell production migration away from multi to mono over the next few years. However, multi c-Si solar cell production is still expanding at higher capacity volume rates than mono and is expected to remain the workhorse of the industry through the next few years.

PERC on the rise

As with wafer type, not all multi and mono solar cell capacity expansion

plans cite specific cell technologies being deployed. Indeed, even when a technology such as PERC is cited it is not always apparent as to the percentage of PERC capacity to standard BSF (Back Side Field) cell technology that is included in the total new nameplate capacity being added. There have been incidences in 2015 when PERC was announced but not actually deployed in the initial ramp of new facilities.

Therefore, even when only citing figures for PERC that were specifically stated in planned capacity expansions in 2015 and 2016, these figures could be compromised to some degree.

This also relates to BSF-to-PERC upgrades at existing manufacturing facilities. Not all PERC upgrades at exiting facilities are announced, although tracking cell equipment supplier orders does indicate higher amounts of upgrades via this route than the number of announced upgrades.

In 2015, PERC solar cell upgrades at existing facilities that were officially announced by manufacturers totalled only 460MW (see Figure 4), while tool orders were in the several gigawatt range. However, in 2016, PERC solar cell upgrade announcements reached 2,500MW.

Actual new capacity expansion announcements related to PERC in 2015 reached 7,200MW, while in 2016 the figure was lower at around 6,900MW. Again, it should be highlighted that any apparent decline is suspect, especially considering the significant increase in overall solar cell capacity expansion plans seen in 2016. The lower figure is more likely due to the lack of detail provided by manufacturers on the process technology or technologies being deployed.

Another interesting development is the momentum being built for HJ technology. In 2015, only 250MW of HJ cell expansion plans were officially announced, while this figure jumped significantly to 2,360MW in 2016.

Some of the announcements lacked timelines and other crucial information but around 1,000MW of HJ solar cell expansion plans in 2016 seem to have a good level of legitimacy, not least due to the end of year plans announced by Panasonic in partnership with Tesla at the SolarCity/Silevo 1GW Buffalo fab in the US.

Although both parties failed to highlight the planned nameplate capacity, we have estimated the plans to be around an initial 400MW.

With nearly 27GW of multi c-Si cell capacity expansion plans announced

in 2016, the vast majority of which occurred in the first half of the year, it will not become clearer as to the amount of effective capacity that comes on stream or process technology deployed until the second half of 2017, notably due to facility construction and equipment lead times.

However, what is apparent from the capacity expansion announcements is growing momentum towards higher efficiency mono c-Si production and high-efficiency solar cells, primarily through PERC migration, a trend expected to continue over the next three to five years.

Key location trends in 2016

As Figure 5 shows, Asia has continued to dominate planned new PV manufacturing capacity expansions in 2016. The top seven countries (India, China, Vietnam, Malaysia, Thailand, South Korea and Taiwan) are all in Asia and accounted for around 46.2GW of new production plans from a total of around 49.2GW, globally or almost 94%. Capacity expansions were announced in 21 countries in 2016, compared to 20 countries in 2015. However, the concentration of announcements in Asia has increased as Asia accounted for the top five selected destinations in 2015.

India surpassed China for the first time in 2016, accounting for just over 17GW of total announcements. New capacity plans in India increased by around 118%, compared with 2015.

However, the disparity between announcements and 'effective' capacity in India remain significantly high with much of the 7.8GW of announcements made in India in 2015, still unrealised into effective manufacturing capacity.

Capacity expansion announcements in China have slowed slightly in the last two years. Having peaked in 2014 at over 19GW, announcements fell to around 17.5GW in 2015 and topped 17GW in 2016.

Basically all of the 2016 announcements in China were made in the first half of 2016 with less than 50MW announced in the second half of the year. This is in contrast to 2015 when the majority of announcements were made in the second half of the year, providing over 34GW of announcements in a straight 12-month period.

However, China-based companies did not stop making announcements altogether in these periods of nonactivity in China. Instead, plans were being announced by Chinese manufacturers for production plants outside China, predominantly in Vietnam, Malaysia and Thailand.

Perhaps the surprise location for capacity expansion announcements in 2016 was Vietnam which totalled almost 4GW, driven by some of the leading Chinese PV manufacturers such as JA Solar, Trina Solar, Canadian Solar and GCL System (GCLS).

Strong competition between Malaysia and Thailand as a major destination for PV manufacturing in Asia continued in 2016. Thailand (2.2GW) just topped Malaysia (2.1GW) in 2015, while the positions were reversed in 2016 with Malaysia attracting nearly 2.9GW of new capacity plans and Thailand 2.7GW. Fab &



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The two other Asia countries accounting for the major share of announcements in 2016 were South Korea and Taiwan, both with over 2.3GW of expansion plans.

Despite the continued decline in the European downstream market, new PV manufacturing capacity plans are still being announced.

In 2016, European Union member countries announced just over 900MW of planned expansions, which included the acquisition and re-start of solar cell production by Trina Solar at the former Solland Solar facility in the Netherlands.

Within the EU, Germany remained the key destination with over 650MW of primarily reinstated module assembly capacity but significantly below the near 1,500MW announced in 2015. Overall, European capacity expansions announcements reached around 1,200MW in 2016, down from over 1,700MW in 2015.

Although Latin America is becoming a key emerging downstream market, manufacturing announcements remain limited in both number and scale, compared to emerging markets such as India.

In 2016, only Brazil announced new manufacturing capacity plans, but only 360MW compared to nearly 1,200MW in 2015. However, very few plans from 2015 materialised into effective capacity in 2016, yet indications are that some of the plans previously announced could materialise in 2017.

Other emerging markets such as

those in the Middle East and North Africa (MENA) are also starting from scratch. In 2015, around 150MW of initial module assembly plans were announced in Egypt only. However, 2016 indicated over 2,300MW of manufacturing plans were being considered in the MENA region. The bulk of this comes from two 1,000MW planned facilities in Saudi Arabia and Iran. However, less ambitious plans exist in Morocco (220MW) and Algeria (120MW).

The vast majority of capacity expansion announcements in 2016 that have either been converted to effective capacity or are expected to become effective capacity in 2016 are located in China, Vietnam, Malaysia, Thailand, South Korea and Taiwan.

Although expansion announcements in India have been significant in both 2015 and 2016, many remain highly speculative at this time. However, with plans previously announced by the likes of Adani now becoming effective capacity, 2017 should see further conversions as the downstream market matures in India.

Outside of the seven key Asia countries, both Europe and the US expansion plans have a high probability of becoming effective capacity in 2017. A key measure will be the eventual manufacturing ramp at the Tesla/ SolarCity/Panasonic facility this year.

On a geographical basis the emphasis in 2017 may turn to emerging markets and companies establishing local manufacturing albeit at small-scale capacity levels. However, as seen already in late 2016, manufacturing curtailment has already started and previously announced expansion plans being put on hold or cancelled outright may become the norm, regardless of location.

Conclusion

Despite the drastic slowdown in announcements in the second half of the year, 2016 activity proved to be a new record high for the solar industry. Chinese PV manufacturers continued to broaden their manufacturing footprints in response to antidumping policies in the US and EU, with much of the attention on Southeast Asia.

The drive to higher efficiencies, whether new build or upgrades at existing facilities also gained significant momentum. It would also seem that a period of digestion following the high activity levels seen in the fourth quarter of 2015 through to the end of the second quarter of 2016 is also underway.

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