

# PV manufacturing capacity expansion announcements in 2018

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## Abstract

PV manufacturing capacity expansion announcements in 2018 were significantly impacted by major policy changes mid-year in China. This paper looks in detail at the contrasting developments in the first half of the year, compared with the second half. Attention will also be given to the regional site selection changes as well as to the advanced manufacturing trends emerging in 2018. Finally, after five years of tracking capacity expansion plans, an overview of cumulative expansions, coupled to global solar demand and to capacity trends specifically in China, will be provided.

### First half 2018 announcements review

PV manufacturing capacity expansion announcements in the first half of 2018 almost mirrored the total figures reported in the first half of 2017 (Fig. 1). In the first half of 2018 a total of just over 55.2GW of combined (cell, module, thin-film and integrated) capacity expansions were

announced, up from over 52.7GW in the prior year period, indicating very little change.

Thin-film plans topped 3,340MW in the first half of 2018, compared with 2,720MW announced in the prior year period (Fig. 2). This level of activity has been relatively high compared with any other period since 2014. As in previous years, the majority of thin-film capacity announcements came from First Solar and Hanergy Thin Film Power Group (Hanergy TF).

CdTe (cadmium telluride) leader, First Solar, announced the building of a new 1.2GW manufacturing plant near its existing flagship facility in Perrysburg, Ohio, both part of its Series 6 large-area module transition.

Hanergy TF's plans were announced as part of a new business model in 2017 that provides new industrial parks with a selection from a portfolio of a-Si, CIGS (copper indium gallium selenide), GaAs and c-Si heterojunction (HJ) turnkey production lines to give local governments access to solar technology and attract other hi-tech companies to new industrial parks. In releasing its 2017 annual financial report, Hanergy TF noted that, as a result of its new business, dubbed 'Industrial Parks Projects', Hanergy Mobile Energy Holdings Co., Ltd., a company subsidiary, took a 20% stake in local government planned industrial parks, which were also owned by the local government and various third-party investors. The shareholders of the industrial park project become the ultimate purchaser of Hanergy TF equipment and technology, as the Hanergy subsidiary limits its shareholding to below the 30% equity interest rules, when Hanergy would be deemed an associate of a connected party. Partners have already signed up to participate in the new business model, primarily related to CIGS plants, which totalled 2,140MW.

The significant change, however, was in the shift away from c-Si solar cell expansion plans that dominated proceedings in the first half of 2017, to much greater attention to module assembly. Total solar cell expansion plans topped 17,340MW in the first half of 2018, while in the prior year period this

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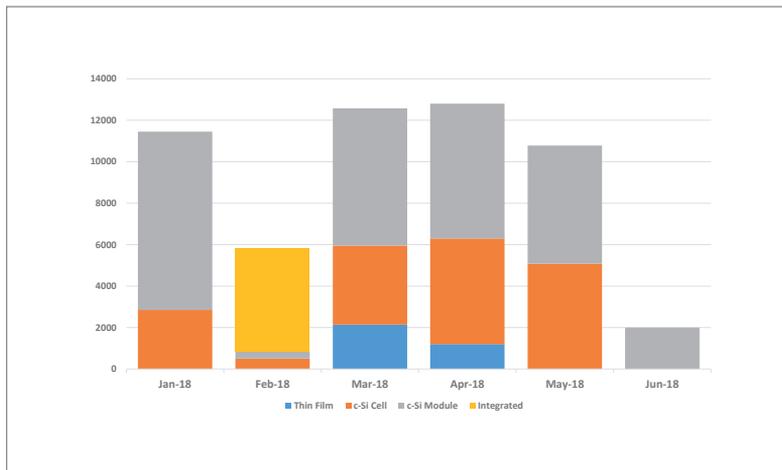


Figure 1. Capacity expansion announcements by product type in 1H 2018 (MW).

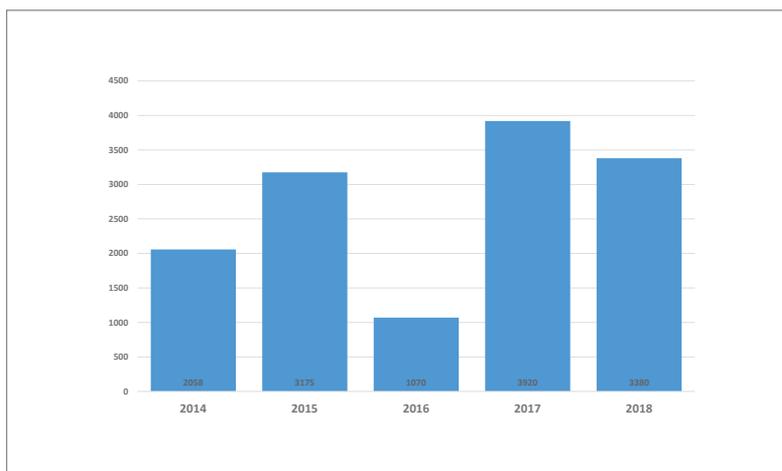


Figure 2. Total thin-film capacity expansion announcements 2014–2018 (MW).

stood at 35,439MW, more than double that in the first half of 2018.

In contrast, new module assembly plans amounted to 29,570MW in the first half of 2018, compared with 14,595MW in the prior year period, less than half the figure announced in the first half of 2018. Adding to the contrast was a single announcement from major China-based PV module manufacturer Risen Energy, which entered PV Tech’s top-10 module manufacturer’s rankings for the first time in 2017.

Very few integrated facilities were announced in 2017, totalling only 1,150MW. Risen announced a 5,000MW phased capacity expansion for a single-site integrated cell and module assembly complex to be situated in the Yiwu Information Optoelectronics High-tech Industrial Park, Zhejiang, China. The initial production capacity in the Phase 1 expansion was said to be 2GW, which would be operational in the next three years. Volume production would be highly flexible, enabling p-type mono PERC (passivated emitter and rear cell) production, as well as bifacial cell production and half-cut cells for 5BB/6BB high-efficiency single- and double-glass modules. Risen had previously announced that total capital expenditures for the new production facility, as well as R&D activities, would be approximately RMB 8bn (US\$1.23bn). The company started construction of the new manufacturing hub in July 2018.

In hindsight, arguably the biggest change to occur in the first half of 2018 was China’s decision to suddenly cap utility-scale and distributed generation (DG) projects at the end of May, now known as the ‘531 New Deal’. The impact was immediately felt in China, as no China-based company announced new capacity expansion plans in the month of June. Indeed, June stands out for being the only month in the first half of 2018 when a Chinese manufacturer did not announce new expansions.

Capacity announcements in June only related to module assembly plans, which totalled 2,000MW from just three companies. June would prove to be a significant milestone in that respect.

### First half 2018 geographical review

On a geographical basis, the first half of 2018 would, on the surface, seem to be business as usual (Fig. 3). Capacity expansion plans in China totalled 20,740MW, the clear preferred country for expansions. In the second quarter, however, only 1.5GW was announced, all from JA Solar. Though China was dominant, four other countries (India, Egypt, USA and Turkey), all with multi-megawatt totals combined, reached 31,790MW. Leading the pack was India at 15,710MW of new capacity plans, which included over 6,000MW in the first quarter of 2018 and 9,500MW in the second quarter.

A notable contrast with the prior year period was the lack of new activity across South East Asia. In the first half of 2017, Malaysia at 4,050MW was second to China as a major destination, followed

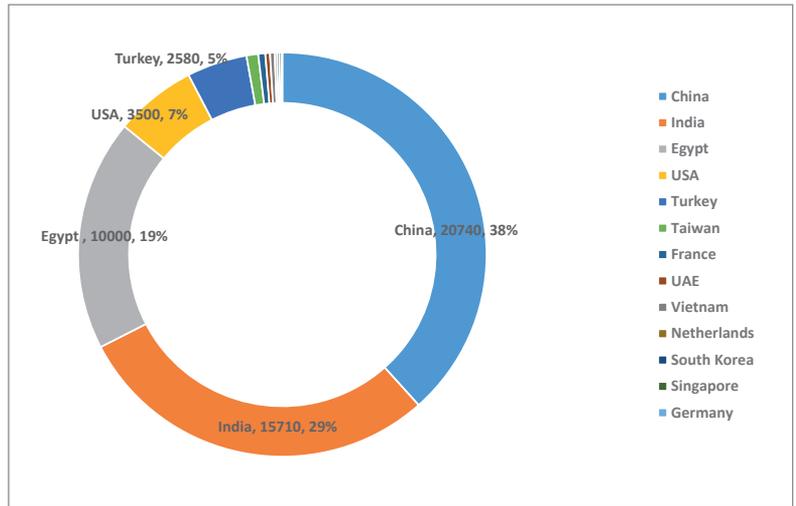


Figure 3. Total capacity expansion announcements by country in 1H 2018 (MW).

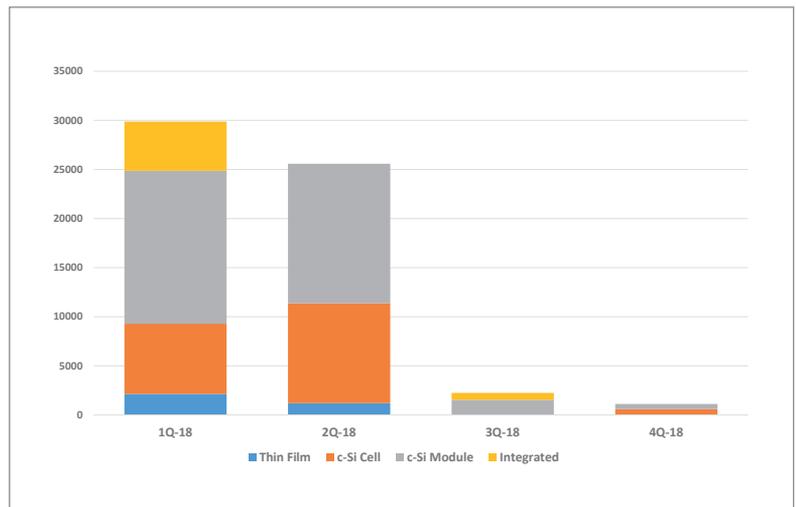


Figure 4. Quarterly capacity expansion announcements by product in 2018 (MW).

by Taiwan at 3,900MW. In the first half of 2018, however, Taiwan could only muster 500MW, while no new capacity expansions were announced for Malaysia.

### Second half 2018 announcements review

Following on from June 2018, when only 2,000MW of total module assembly capacity expansion plans were generated by India (1,500MW) and the USA (500MW), July saw a total of only 150MW of capacity plans, all in the module assembly segment and all outside China.

In the third quarter of 2018, new capacity expansion announcements totalled 2,245MW, compared with 4,121MW in the prior year period, although this is typically a slow quarter (Fig. 4). The majority of new expansion plans (1,205MW) came from the module assembly segment, while integrated cell and module accounted for 700MW

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and flexible thin-film (CIGS) accounted for a preliminary estimate of 40MW. No new solar cell expansions were announced in the third quarter of 2018, which is significant because of the fact that there has not been a quarter in the last five years when there have not been any expansion announcements related to solar cells.

The situation drastically deteriorated in the fourth quarter of 2018, with total combined capacity expansions reaching only 1,120MW. Not only was this a significant decline, quarter-on-quarter, but it was in stark contrast to the 40,100MW total capacity announced in the fourth quarter of 2017. Although solar cell expansions rebounded to 590MW in the fourth quarter of 2018, the prior year had witnessed announcements totalling 28,100MW. Module assembly plans fell to just 530MW in the fourth quarter, compared with 9,800MW in the fourth quarter of 2017.

### Second half 2018 geographical review

In line with the collapse in capacity expansion announcements in the second half of 2018 (primarily due to the lack of activity in China), which plummeted to a staggering 40MW, the number of countries where expansions were announced declined to only nine, down from 13 in the first half of the year (Fig. 5). Following China in the lack of announcements were key manufacturing hubs in South East Asia (Taiwan, Malaysia, Indonesia and Vietnam).

Historically strong countries in Asia gave way completely to three countries (Armenia, Ukraine and South Africa) that have few, if any, PV manufacturing facilities, and to a further three (Canada, France and Russia) that have rarely logged any meaningful expansions in the last five years. Of note, this included European PV manufacturer Recom, which would soon have a 700MW integrated manufacturing plant online in Armenia to serve the US, European and Middle East markets. The company would also be expanding module assembly capacity (150MW) at its existing facility in France.

In December 2018, China-headquartered Seraphim Solar System Co announced a new 500MW solar cell plant in Port Elizabeth and a module assembly expansion at a recently opened plant in Eastern Cape, both in South Africa. These facilities are expected to primarily serve the US market.

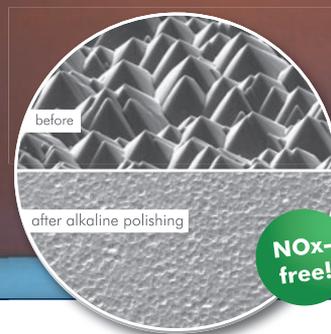
### 2018 round-up

Total manufacturing capacity expansion announcements totalled 58,815MW in 2018, down from 96,996MW in 2017. On a segment basis, thin-film expansion plans reached 3,380MW, compared with 3,920MW in 2017 (Fig. 6), while solar cell (c-Si) manufacturing expansions reached 17,930MW in 2018, significantly down from 64,630MW in 2017.

Module assembly expansion plans reached 31,805MW in 2018, up from 26,265MW in the previous year. Integrated manufacturing plant announcements were 5,700MW from only two companies in 2018, although significantly higher than the 1,151MW announced in 2017 (also from two, but different, companies).

On a geographical basis, China accounted for a total of 20,780MW of combined capacity expansion announcements in 2018, down from 71,110MW in 2017 (Fig. 7). However, China retained its position for the second year running as the number

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one destination for expansion announcements in 2018.

India bounced back in 2018 with announcements totalling 15,710MW, compared with only 2,790MW in 2017. India had been the top destination in 2016 with 17,040MW of capacity expansion announcements.

Egypt was ranked third in 2018 with solar cell and module assembly each at 5GW, which was entirely thanks to plans approved by the National Authority for Military Production for the China-based GCL Group to establish a manufacturing hub that would include wafer production in the country. This project remains at an early stage of evaluation, despite being rubber stamped by the Egyptian government.

### 2018 manufacturing trends

Outside of the significant fall-off in announcements, notably from China-based manufacturers in the second half of 2018, it is interesting to observe several other trends at play during the year.

### Industry 4.0

The drive for high-efficiency solar cells (PERC, n-PERC, HJ, IBC) and modules (half-cut, shingled, half-module) is proving to be a catalyst for higher levels of manufacturing automation, beyond the conventional drivers such as high quality at high volumes and reductions in workforce in order to reduce manufacturing costs. The PV industry is also starting to adopt the general concept of 'Industry 4.0', which includes a suite of advanced tool processing control technologies through to data logging and analysis in order to further drive manufacturing efficiencies at the wafer, cell and module levels.

In late 2017, China-based integrated and merchant PV manufacturer Tongwei Group opened its completed high-efficiency p-type mono PERC solar cell plant (S2), which included the world's first technically unmanned monocrystalline solar cell production line. The S2 plant, located in Chengdu, China, has an initial nameplate capacity of 2GW, while housing an Industry 4.0-inspired 200MW solar cell line that is completely unmanned in order to test intelligent fully automated manufacturing tools and software systems (Fig. 8).

Barely nine months later, in August 2018, Tongwei announced that it would begin pilot production of heterojunction (HJ) solar cells by the end of 2018, primarily as a result of the success of its 200MW Industry 4.0 line. Importantly, the favourable evaluation of the Industry 4.0 line could lead to the longer-term migration of all cell production to intelligent manufacturing. Tongwei said that ongoing R&D activities, as part of an advanced collaboration effort on next-generation HJ solar cells, would lead to pilot volume production evaluations by the end of 2018. HJ cell production requires more stringent cleanroom contamination requirements and automated

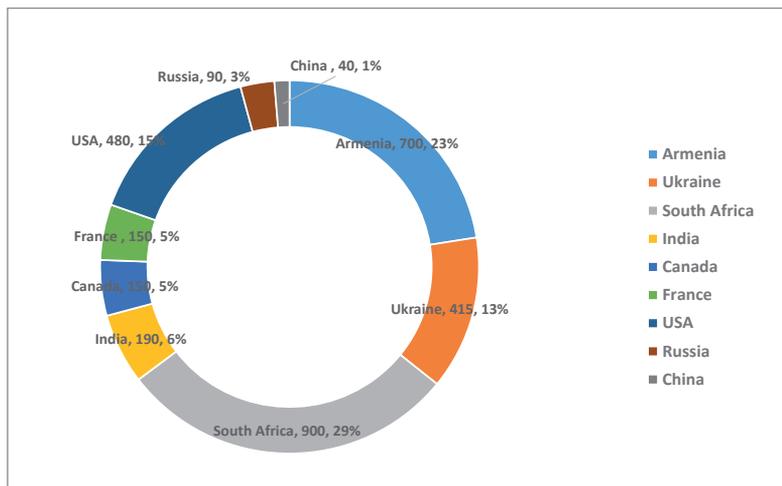


Figure 5. Total capacity expansion announcements by country in 2H 2018 (MW).

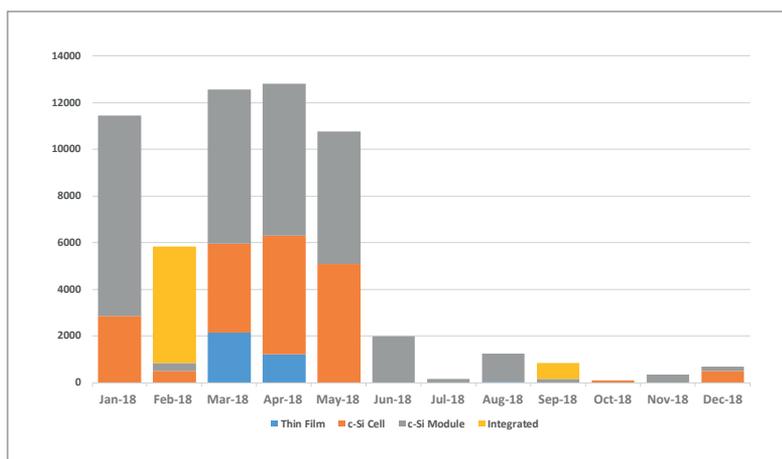


Figure 6. Monthly capacity expansion announcements by product type in 2018 (MW).

handling and processing, in line with Industry 4.0 objectives. Any contamination of an HJ cell before the deposition of the a-Si layers degrades the cell conversion efficiency.

Importantly, Tongwei noted that, on the basis of the current data analysis, the Industry 4.0 cell line had operated in a stable condition, while improving cell product quality and overall productivity, compared with non-fully automated lines. The company indicated that, when conversion efficiency, yield and CTM (cell to module) criteria were used, the overall in-house cell production in the first half of 2018 was as much as 60% higher than the Chinese industry benchmark average. The company claimed that it was at the leading level within the industry in view of the operating stability of the line, coupled with the ability to reduce production costs, which were said to be in the range of 0.2–0.3 yuan/W (US\$0.029/W). These costs were significantly below benchmarked Chinese cell producers' costs of more than 0.45 yuan/W, according to data released in January 2018

**“Total manufacturing capacity expansion announcements totalled 58,815MW in 2018, down from 96,996MW in 2017.”**

by the China Photovoltaic Association.

The company has also been ramping up R&D spending for several years now, and spent almost US\$55m on solar-related (polysilicon, cell and module) R&D in 2017. Group R&D spending in 2017 was over US\$80m.

Other pilot projects have been ongoing at SMSL (silicon module super league) member GCL System Integrated (GCL-SI), which established a module assembly workshop that is completely unmanned in order to test intelligent, fully automated, manufacturing tools and software systems (Fig. 9). The company indicated that it is cooperating closely with Chinese domestic equipment manufacturers, and has independently researched and developed a series of intelligent tools and systems, which include a high-speed automated tabbing machine, a high-precision layout machine and a robotic palletizing system. In all, GCL-SI said that 26 separate systems developed so far have been industry firsts. Key aims of the tests are to achieve a 50% improvement in efficiency, a 60% decrease in online manpower, and a 30% reduction in processing costs. Product quality improvement targets were being set at an overall improvement of 21%. The intention is to implement the improvements across the company's volume manufacturing operations in the future.

In 2018 leading SMSL member JinkoSolar also initiated intelligent, highly automated, manufacturing tools and software systems into its volume PV module assembly facilities in China, followed by its 600MW assembly plant in Florida, USA, which is expected to be operational in early 2019. The company is expected to implement a range of Industry 4.0 initiatives at its manufacturing plants in 2019.

SunPower, a leading high-efficiency solar cell and module producer, is planning its first 100MW 'NGT' cell line in Malaysia within the Industry 4.0 framework, following on from development work at a pilot line established at its California headquarters in mid-2017.

REC Group's Singapore integrated cell and module facility also has a pilot line for evaluating a range of Industry 4.0 initiatives, ahead of the small-scale production of heterojunction solar cells, a major departure from its volume production of multicrystalline products.

Preliminary analysis indicates that the mainstream (SMSL) and niche high-efficiency PV manufacturers combined have Industry 4.0 migration plans in excess of 10,000MW, although the migrations, which include retrofit as well as new manufacturing plants announced in 2018, could stretch over several years. However, such Industry 4.0 adoption is ongoing and is highly expected to surpass 20,000MW of capacity in the next few years as more and more companies develop migration plans in order to remain competitive with the early adopters.

It should also be noted that thin-film module leader First Solar is also driving advanced manufacturing strategies with its complete migration (including retrofit and new build) to its Series 6 large-area CdTe modules. The manufacturing plants, including those in the USA, Malaysia and Vietnam, are in many respects Industry 4.0.

Of particular note is that specialist manufacturing equipment suppliers have also benefited from the



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Industry 4.0 activity. China-based PV module assembly equipment specialist Yingkou Jinchen Machinery Co has provided fully automated module assembly lines to SMSL members LONGi Solar, GCL-SI and JA Solar, as well as to Risen Energy, a top-10-ranked PV manufacturer in 2018.

**Section 201**

The US anti-dumping Section 201 case rulings by President Trump at the beginning of 2018 had already sparked a renaissance in PV module assembly announcements in the country in 2017, and were a key driver of further announcements in 2018.

A total of around 2,000MW of new module manufacturing plans were announced for the USA in 2017, which increased to over 4,000MW in 2018. With a downstream market demand of around 10,000MW per annum, major PV manufacturers were forced to establish production bases in the country, or expect to lose a key volume business to rivals that took the decision to produce modules in the country in order to avoid at least one layer of the initial 30% import tariffs. Notable major announcements included SMSL leader JinkoSolar (600MW), Hanwha Q Cells (1,200MW) and LG Electronics (500MW).

Section 201 also forced US-headquartered SunPower Corporation to buy the bankrupt facilities of SolarWorld Americas and establish 200MW of capacity for its P-Series (performance-series, p-type mono PERC, shingled) modules. Indirectly, Section 201 included a retrofit of an existing facility by First Solar, dubbed ‘Ohio S6 Factory 1’, with 600MW of capacity, and later a new plant close to the existing facility, dubbed ‘Ohio S6 Factory 2’, with a nameplate capacity of 1,200MW, which should be fully operational in 2020.

Announcements of new capacity plans at existing US manufacturing plants extended through to November 2018; these announcements included plans by Canadian module assembly firm Silfab (150MW estimated) to invest in ITEK Solar, and by Seraphim USA to add an expected 330MW of module capacity to its plant in Mississippi.

**India**

Should there be a debate over the validity of tracking capacity announcements, then it would be hard to refute India as an example. In 2014 total capacity expansion announcements were 1,425MW, jumping to 7,850MW in 2015 (Fig. 10). During that two-year period, less than 400MW was converted to ‘effective capacity’.

A similar trend extended through 2016, with total capacity announcements reaching 17,040MW while effective capacity touched around 1,500MW.

“Specialist manufacturing equipment suppliers have also benefited from the Industry 4.0 activity.”

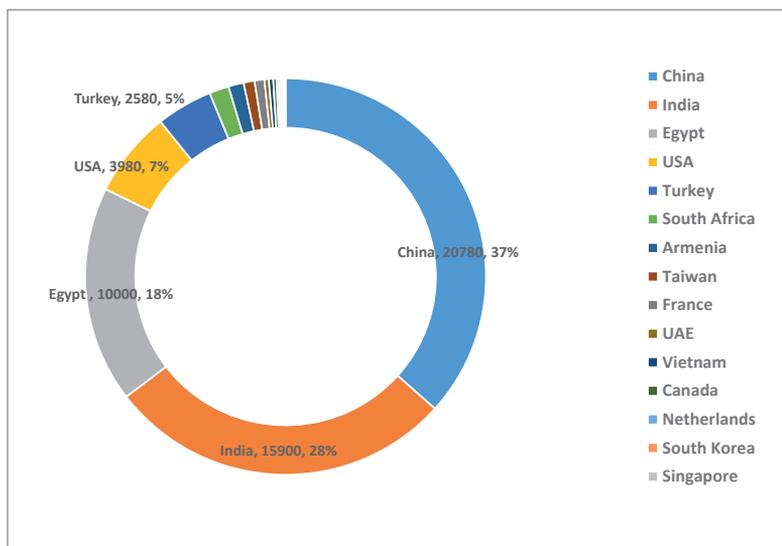


Figure 7. Total capacity expansion announcements by country in 2018 (MW).

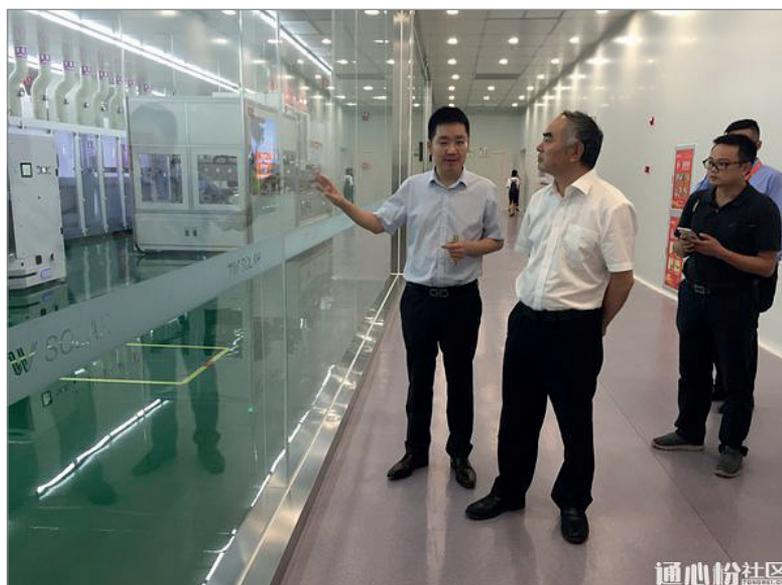
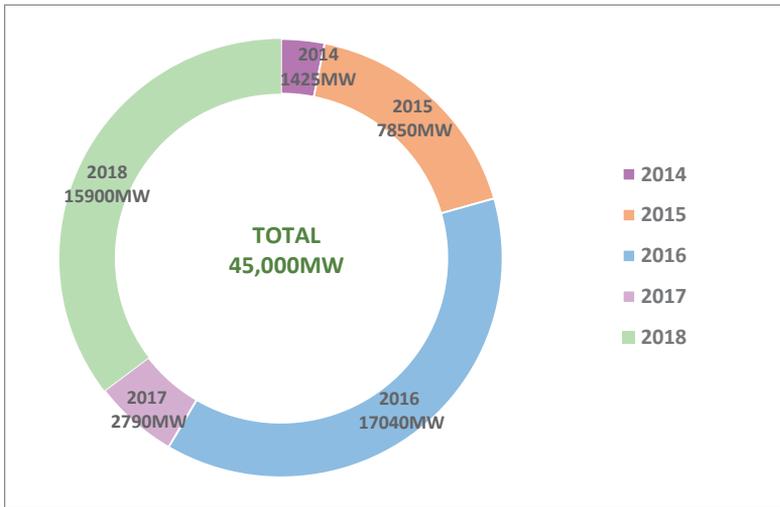


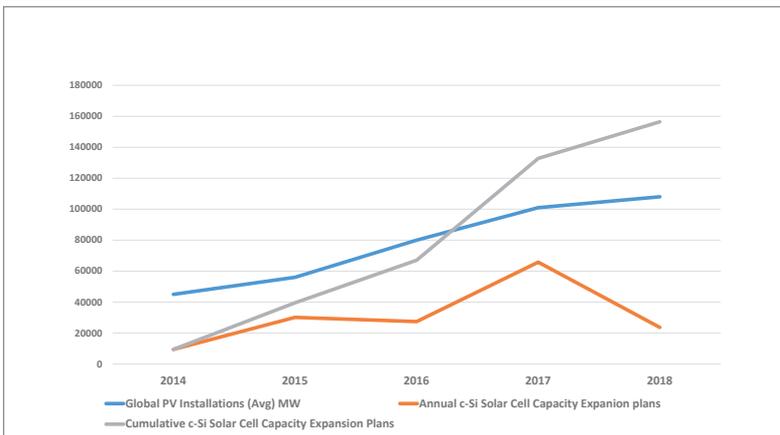
Figure 8. The S2 plant in Chengdu, China, which has an initial nameplate capacity of 2GW, while housing an Industry 4.0-inspired 200MW solar cell line.



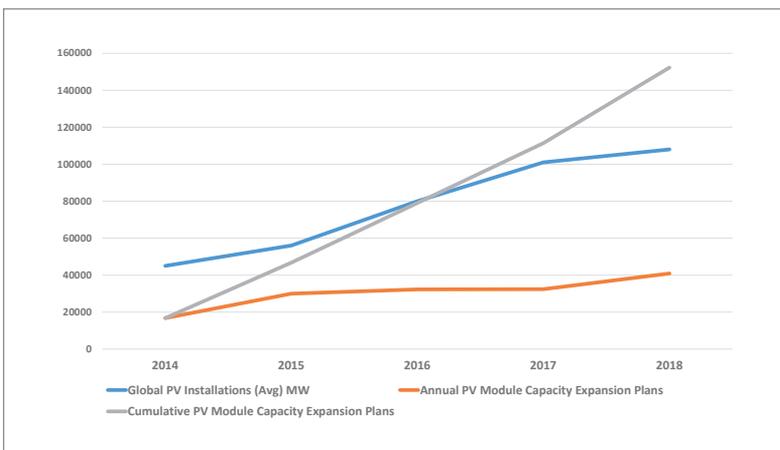
Figure 9. GCL-SI's module assembly workshop: a completely unmanned set-up, with the aim of testing intelligent, fully automated, manufacturing tools and software systems.



**Figure 10. India: total capacity expansion announcements (cell and module) 2014 to 2018 (MW).**



**Figure 11. Annual global PV installations in relation to annual and cumulative solar cell capacity expansion plans 2014–2018 (MW).**



**Figure 12. Annual global PV installations in relation to annual and cumulative module capacity expansion plans 2014–2018 (MW).**

A lull ensued in 2017, when only 2,790MW of total capacity expansion announcements were made, yet rebounded in 2018 to reach 15,900MW. The cumulative total of announcements since 2014 has reached 45,000MW.

Since 2014 only a handful of India-based companies have converted announcements to effective capacity at volume nameplate figures; these

companies include Adani Solar, Waaree Energies and Vikram Solar. Although there are many reasons why India-based companies have struggled to convert announcements to effective capacity, raising finance at competitive rates has been a prevailing issue.

There have been a number of grand speculative announcements in this timeframe, however, from foreign firms, such as Softbank and SunEdison (who have meaningfully added to the cumulative 45,000MW figure), which failed to be converted to effective capacity.

Multiple gigawatts have also come from China-based PV manufacturers in this period, but many plans have remained on the drawing board. Nevertheless, some examples, although delayed for various reasons, are in a drawn-out process of becoming effective capacity sometime in the next few years. These include manufacturing plants by Trina Solar (500MW cell and module) and LONGi Group (1,000MW cell and module), which go back to 2015 and 2017 respectively.

In 2018 grand speculative announcements included a deal between GCL System Integration Technology Co and Softbank Vision Fund to establish a joint venture company in Andhra Pradesh, India, to operate 4,000MW of integrated wafer, cell and module capacity, which would be implemented in two 2,000MW phases.

At least 28 different India-based PV manufacturers announced plans in the first quarter of 2018 to increase capacity, which totalled around 4,000MW. The vast majority of these plans, however, had not been initiated by the end of 2018.

It should be noted that India was home to around 3,000MW of effective solar cell capacity and close 9,000MW of effective module assembly capacity at the end of 2018; however, with over 100 module producers, utilization rates are low.

### Capacity expansion trends since 2014

We now have five years of capacity expansion data to share. The chart in Fig. 11 tracks annual global PV installation figures (an average from market analyst firms, including IHS Markit & BNEF) against both annual and cumulative c-Si solar cell capacity expansion announcements from 2014 through to the end of 2018. The period 2014 through 2016 highlights the strong cumulative growth in solar cell expansion plans, closing the wide gap that had existed between global PV installation figures. However, with a significant increase in cell expansion announcements in 2017, cumulative plans surpassed installation figures by over 30GW.

It should be reiterated that these are cumulative plans, rather than effective capacity. Nevertheless, this chart signifies that, since 2017, cumulative solar cell capacity expansion plans are well ahead of actual global end-market demand. Indeed, if China had not changed its solar policies in 2018, cumulative solar cell capacity expansion plans could have pulled ahead of actual global end-market demand to the tune of over

50GW. With no new capacity expansions announced in China after the 531 New Deal, announcements returned to the levels seen in 2015 and 2016.

In the chart in Fig. 12, which plots the same criteria as above but for c-Si module assembly, a clear crossover point is observed in 2016, when cumulative module assembly capacity expansions matched actual global end-market demand, but then went on to race ahead through 2018. The cumulative module assembly announcements exceeded global end-market demand by 44GW.

With China dominating PV manufacturing, the chart in Fig. 13 highlights the annual global solar installations vs. China’s c-Si solar cell capacity expansion announcements and cumulative c-Si solar cell capacity expansion plans. Also included are the Chinese government official figures for effective c-Si solar cell capacity.

Through to 2016, cumulative c-Si solar cell capacity expansion plans were keeping pace with global end-market demand. The significant 53,000MW of announcements in 2017, compared with just under 12,000MW per annum in the previous two years, has meant the difference between end-market demand has narrowed significantly, with a gap of just 20GW, compared with more than 41,000MW in 2014.

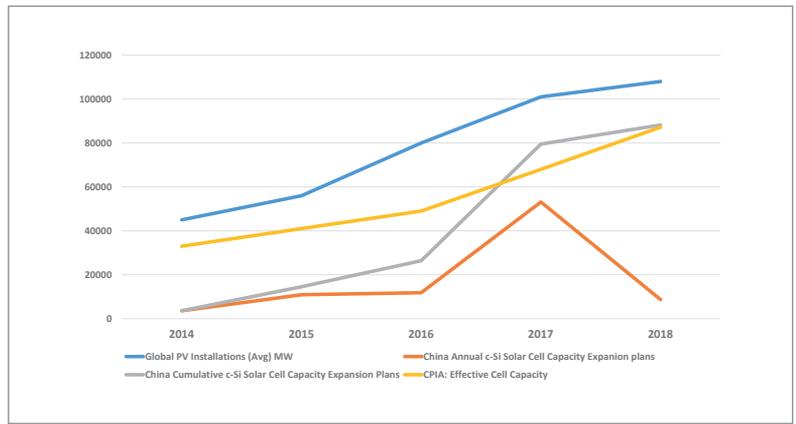
Cumulative c-Si solar cell capacity expansion plans were almost identical to effective capacity figures in 2018. Although the lack of announcements in China in the second half of 2018 has masked the gap between effective capacity and expansion plans, much of the 53,000MW of announcements in 2017 were for phased expansions over as much as five years for some companies. However, many plans remain multi-gigawatt in scale and could further close the gap with end-market demand, as many projects are ongoing from 2017.

The final chart, shown in Fig. 14, again highlights the same criteria but in terms of c-Si module assembly. The plots of cumulative and effective module assembly actually follow similar paths, but have not shown any signs of expansion plans exceeding either end-market demand or outpacing effective capacity. Part of the reason for this has been the greater emphasis on adding solar cell capacity than on increasing module assembly in China. However, through this period major Chinese producers, such as Trina Solar, JinkoSolar and Canadian Solar, had been adding primarily module assembly and some cell capacity in South East Asia, such as Malaysia, Thailand and Vietnam.

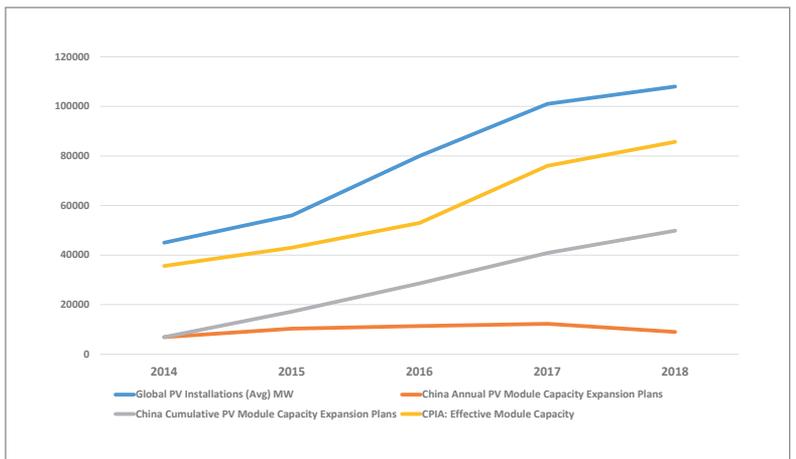
As already noted, the likes of JinkoSolar have also added module assembly capacity in the USA. This could also account for the widening of the gap between effective module assembly capacity in China and global PV installations.

**Conclusions**

As shown, the first half of 2018 kept up the pace of capacity expansions seen in 2017, but the China 531 New Deal significantly impacted announcements



**Figure 13. China: solar cell effective capacity in relation to annual and cumulative capacity expansion plans 2014–2018 (MW).**



**Figure 14. China: solar module effective capacity in relation to annual and cumulative capacity expansion plans 2014–2018 (MW).**

from China-based manufacturers, whether for domestic or overseas expansion plans, in the second half of the year. Nevertheless, China was still the main location for planned expansions.

The USA saw a revival in at least module assembly, while South East Asia (Taiwan, Malaysia, Thailand and Vietnam) capacity announcements significantly slowed in 2018, compared with the last few years, potentially indicating the end of an expansion phase. In the case of Taiwan, effective c-Si solar cell capacity in particular is in a sharp decline, because of the competitive position of China, which has driven plant closures and consolidation of manufacturers.

Some emerging markets, notably Turkey, on the other hand, could see several major announcements become effective capacity in 2019, while announcements in other emerging markets such as Egypt and the Middle East remained speculative at the end of 2018.

**“The first half of 2018 kept up the pace of capacity expansions seen in 2017, but the China 531 New Deal significantly impacted announcements from China-based manufacturers in the second half.”**