Why p-type multi c-Si is seeing strong market-share gains

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ABSTRACT
Modules based on p-type multi c-Si technologies look set to dominate the PV industry over the next five years, continuing a trend that has developed over the past two years. This paper explores why high-efficiency p-type multi seems destined to remain the workhorse of the global PV industry.

Introduction

According to analysis in the new Solarbuzz "PV technology roadmap" report [1], modules based on p-type multi c-Si technologies are set to dominate the PV industry over the next five years. The findings from the new studies show that there has been a dramatic shift to high-efficiency (HE) p-type multi c-Si module production and shipments in the past two years, together with a softening in the focus assigned by many of the market leaders to mono-based technologies.

> "There has been a dramatic shift to high-efficiency p-type multi c-Si module production and shipments in the past two years."

Across China and Southeast Asia, the push to improve multi performance – while driving down costs far more than in any other PV technology – has revitalized the prospects for multi c-Si technologies, and provides a stark contrast to the somewhat academ ic, and idealistic, PV technology roadmaps that have often been shown as a means of conveying technology leadership.

A subset of manufacturers is fixed on higher-quality c-Si shipments. At the top end, SunPower and Panasonic have no option but to use the highest-quality n-type ingots being produced. A few others have n-type capacity, but based on more standard cell architectures that do not need the silicon grade of a SunPower cell, such as those in Yingli's 'PANDA' modules.

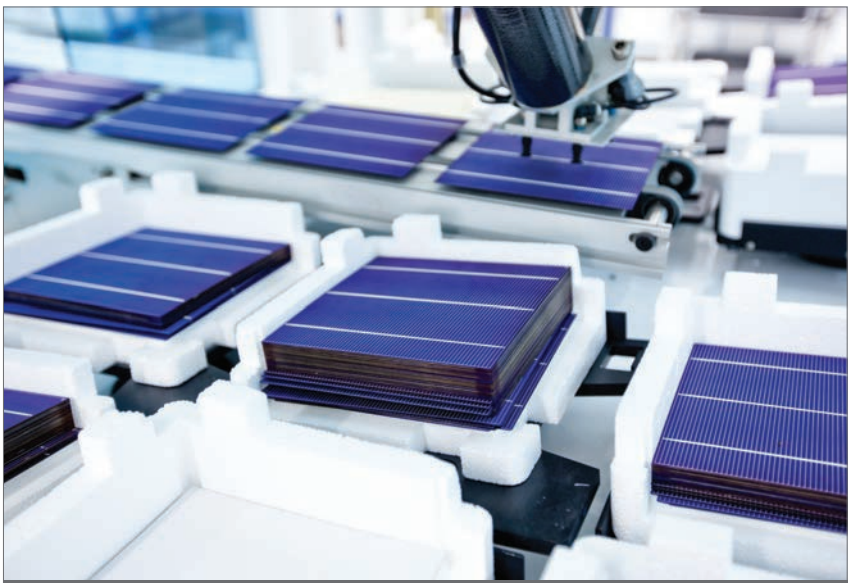
And then there are the cell makers that are able to flip lines over from mono to multi and vice versa, needing only p-type wafer supply. Taiwan cell makers have done the multi-to-mono flip of late, but it is questionable whether this is sustainable in the long term as the Japanese market finally succumbs to global price drivers over the next 18 months.

But p-type multi is winning the battle now, and is seeing strong market-share gains. In fact, it is really the HE multi wafer that has won the day here. Most – but not all – of the market-share gains from HE multi module shipments in the last 12 to 18 months can be tracked back to improvements in ingot growth. Interestingly, having an HE multi module is not necessarily contingent on having the best cell line. This has enabled selected Chinese makers (that have stuck to standard cell operation) to increase module power ratings in the past couple of years.

It is possibly time for some observers to change their views on p-type multi, with many having considered it of insufficient quality to feature prominently on PV technology roadmaps. There is no shortage of solar cell physics and chemistry on offer to back up this statement, but another crude way to look at this is as follows: if you keep improving multi quality, then at some point it becomes possible to do advanced process changes on multi that were previously only considered viable on mono. Indeed, adding the passivated emitter rear cell (PERC) structures will work quicker on mono (everything works quicker on mono), but that by no means precludes efficiency improvements on multi as the substrate quality keeps getting better.

It is no coincidence that the top two module suppliers to the PV industry (Yingli Green Energy and Trina Solar) are choosing p-type multi c-Si as their key offering to the industry from now on. Nor should it be a surprise that GCL is putting so much effort into having better ingot growth and wafer supply of p-type multi substrates to much of the key Asian suppliers today. Some may argue that the pull of Yingli, Trina and GCL alone effectively sets the deal in terms of HE p-type multi c-Si technology's domination, but there is more.

Perhaps one of the other factors in multi's resilience and potential can be found with REC Solar and Hanwha Q CELLS in their fabs in Southeast Asia. From a technology standpoint, REC Solar and Hanwha Q CELLS arguably have the most experienced c-Si R&D teams (outside of SunPower) in the industry, and are certainly aware of all the risks and opportunities that would come from adding any unknown process change (or anything that is prohibitively high cost) to multi c-Si manufacturing lines that are meeting customer needs.



Source: Hanwha Q CELLS.

Figure 1. Hanwha Q CELLS p-type multicrystalline PV cells.

Both REC and Q CELLS (Fig. 1) are staunch p-type multi c-Si cell proponents, with p-type multi module supply accounting for their entire end-market shipments. Expansions are p-type multi based, with module power increases again being mainly tracked back to the improvements in multi c-Si ingots in the past couple of years. Each company is tinkering with PERC additions, presumably once all front-side upgrades are complete.

As REC captured contract after contract for module supply recently in the USA, did anyone bat an eyelid at the fact that these entire shipments will be from p-type multi c-Si panels? Of course not: shipping 260–265W 60-cell panels (for rooftops or ground-mount) at the right cost point is readily accepted by the market. If need be, create a 72-cell equivalent (300W plus). But how many developers or engineering procurement and construction (EPC) companies are insisting that mono modules be supplied?

The new PV technology roadmap studies at Solarbuzz [1] involved looking separately at what technology means from every aspect of the solar PV industry, something that had been a key omission in all technology roadmaps outlined previously to the industry. In fact, in the past, roadmaps were typically compiled by scientists who were not necessarily privy to end-market activity, or by R&D teams at companies that often just took their lead from the scientists' wish-lists.

There is nothing wrong with that, but the previous roadmaps that claimed the big market-share swings to n-type – or (dare we say it) thin-film technologies – were just not of the real world. The reality was that the roadmaps were simply changed each year on the basis of what the end market was actually doing. And all too often, the end market was choosing simplicity and gradual cost reduction and small (but meaningful) efficiency gains. Every year, moreover, the momentum and critical mass of p-type multi manufacturing have only added weight and traction, raising the bar for almost every other competing PV technology.

> "Pulling apart every end market was one of the most valuable parts of the overall Solarbuzz PV technology roadmap methodology."

End-market pull on technology is made

Had the PV technology analysis been terminated once the study of end-market trends was complete, the conclusions would not have been that far off the final output from the whole-industry analysis on technology.

Pulling apart every end market – the rooftop supply activity, the commercial rooftop sector, and the small and large ground-mounted systems – was one of the most valuable parts of the overall Solarbuzz PV technology roadmap methodology. This was followed by looking at the project pipeline across all developers and EPC companies, and reviewing who supplies what and from whom. And at the micro-segment level (one specific country, one specific application segment), the trends were identified for c-Si versus thin-film, mono vs. multi, multi vs. HE multi, etc.

Just one of the final graphics to come out of this study is shown in Fig. 2. In this case, what is effectively the serviceable available market (SAM) for SunPower, Panasonic, TetraSun and Silevo has been extracted, to derive the forecast geographic end-market demand for c-Si premium modules. A secondary level of technology segmentation also falls out here, in that the split by country/region is provided for residential, commercial rooftops and ground-mounted segments. So almost by default, the roadmap starts to provide sales targets for technology-specific module suppliers, from both an application and a geographic standpoint.

Fig. 2 also shows that even the technologies with a small market share can have strong growth trajectories. Growing from 1 to 6GW sounds great, but remember that it is likely that 2014 will end up close to 50GW and that the growth trends to 2018 will remain strong. So even extracting 6GW in 2018 for premium n-type module supply (and similarly removing thin-film additions) still leaves a huge amount of market demand, and this is exactly where the p-type multi activity fits in.

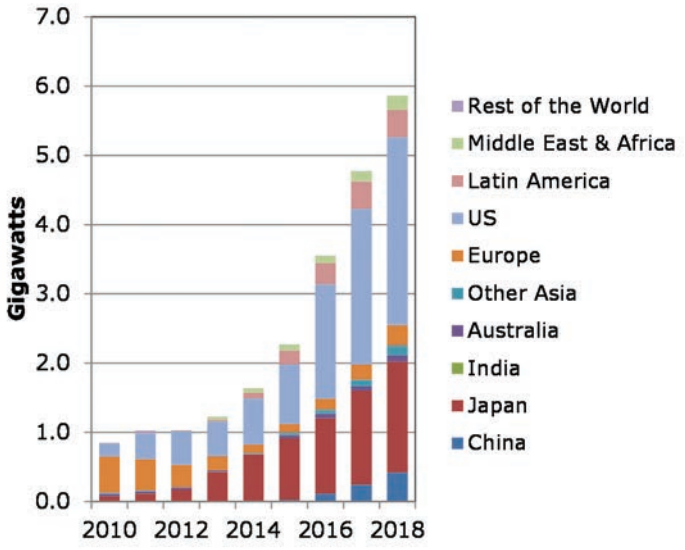
Analysis of mono and multi splits

Once the above two sub-segments are removed from the end-market technology analysis (premium n-type and thin-film), the focus then returns to the standard n-type, p-type mono and p-type multi debate. This therefore required a dive into all the activities of the tier-one supply-chain from polysilicon to ingot/wafer and cells and all the way down to the branded shipments of the top 20 module suppliers to the industry.

Eventually, it is possible to extract the p-type multi demand, and, as shown in Fig. 3, separate out in a way that shows the incredible gains made since 2011 by HE multi in the market. In effect, this derives empirically what was alluded to at the beginning of this paper: the market leaders continue to prioritize p-type multi, with the shift from standard to HE multi module supply being the catalyst in revitalizing what many had assumed was a technology destined to be replaced by the more esoteric alternatives.

The methodology used to derive the technology roadmap enables plenty of technology-related trends to be reviewed and discussed, down to process flow arrangements across cell makers, or technology shipments on rooftops, by country and technology type. One particularly interesting output, however, relates to the module power rating forecasts.

To do this, the focus was placed



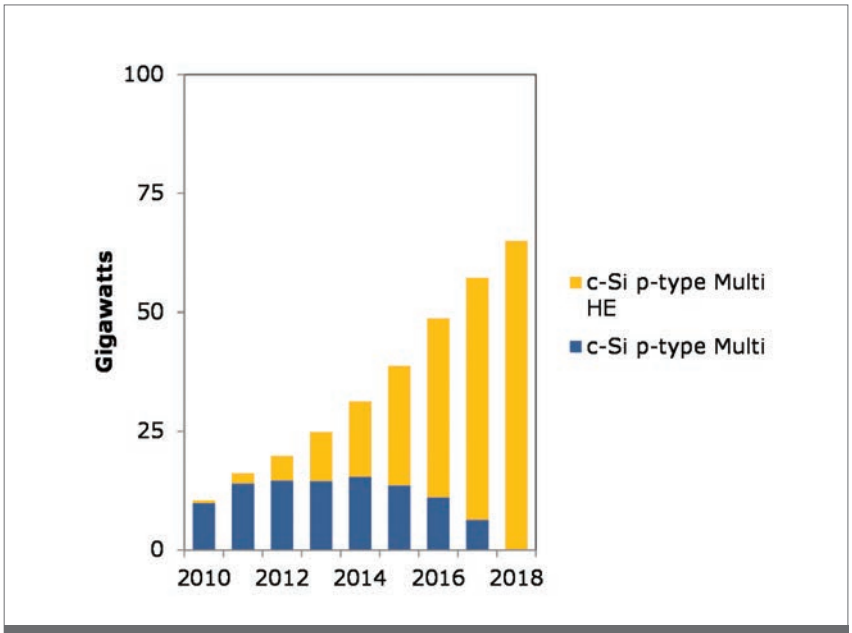
Source: Solarbuzz [1].

Figure 2. Global demand for premium c-Si premium modules: forecast shipment locations to 2018, derived bottom-up from end-market demand and project developer/EPC company/installer supply activity.

specifically on the module shipment volumes of the top 20 module suppliers, effectively removing variants that are offered to the market but whose market-share level is somewhat in the noise. Therefore, knowing what is being installed in the end market is essential here, not necessarily what is being offered on datasheets to the market.

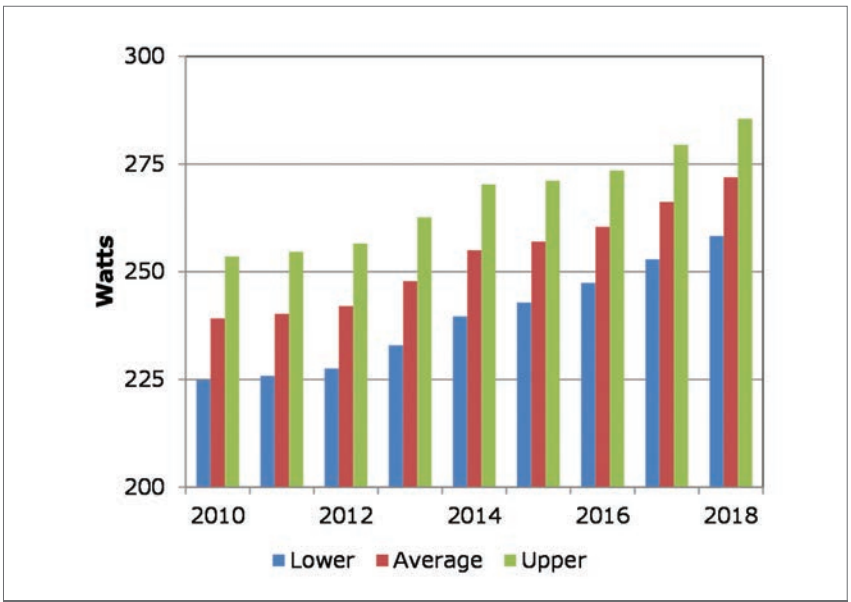
When 48, 60, 72, and 96 cell variants were considered, across 5 and 6" cell types, and splitting into the relevant premium n-type, mono and multi types, the end result was 16 c-Si module variants. The power ratings (historic, current and forecast to the end of 2018) were analysed for each of these 16 c-Si module types, and compared with existing data points from average mass production data of the top 20 module suppliers to the industry. But, if one module type has to be ring-fenced for display here, it is undoubtedly the 60-cell, 6" c-Si multi HE panel – the clear market-leader in the PV industry today.

Fig. 4 shows the trends in mass production for this module type, with typical upper/lower ratings that fall outside of the distribution curves. The strong growth in power ratings from 2010 to 2014 confirms the ingot/wafer trends discussed at the beginning of this paper. The slight upward trend again in 2017 and 2018 assumes that some of the cell changes (largely thought to be mono specific) are implemented in mass production for multi cells.



Source: Solarbuzz [1].

Figure 3. Most likely technology forecast for c-Si p-type multi variants: c-Si p-type multi is set to see further market-share gains until 2018, driven by the high-efficiency (HE) module variants that have helped salvage profitability across much of the upstream manufacturing segment during 2013 and 2014.



Source: Solarbuzz [1].

Figure 4. Historical, current and future panel ratings (Wdc-p, STC) for the industry's most popular module, the 6" c-Si p-type multi HE panel comprised of 60 cells.

> "For those looking to address a large segment of the PV industry, keeping a focus on p-type multi HE activity will be essential."

Conclusion and outlook

As materials and equipment suppliers review their strategies for the next few years, it is hard to imagine how anyone can choose to ignore the opportunity from the supply of p-type multi HE, unless the sole target is to play within more technology-specific lower-volume addressable markets. For some suppliers, this will be perfectly acceptable, with the strong growth in the end market ensuring ongoing supply. But for those looking to address a large segment of the PV industry, keeping a focus on p-type multi HE activity will be essential.

Finally, the evolution of technology supply and geographic variations will also have a direct impact on planned capacity additions. Are companies limiting themselves through choice of technology, in terms of which end markets to go after?

While a few gigawatts here and there is not going to change the overall picture in 2018, knowing what the competition is likely to be offering, and which countries and segments will be awash with p-type HE multi modules, is simply prudent housekeeping which should limit the surprises that might be encountered in the future.

References

[1] Solarbuzz 2014, "PV technology road map report", September [http://www.solarbuzz.com/reports/pv-technology-report].

About the Author

Finlay Colville is vice president at Solarbuzz and leads the Solarbuzz team of analysts dedicated to PV market research and strategic consulting activities. He is also directly responsible for the "PV equipment quarterly" and the "UK deal tracker" reports. Dr. Colville holds a B.Sc. in physics from the University of Glasgow and a Ph.D. in nonlinear photonics from the University of St. Andrews.

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Trina Solar to be crowned leading PV manufacturer in 2014, surpassing Yingli Green

Trina Solar has become the biggest module supplier of 2014.

Source: Trina Solar.

Based on analysis of the leading PV manufacturers and their latest shipment guidance for 2014, PV Tech has compiled the preliminary top 10 rankings for 2014.

Since the second quarter of 2014, a fight has been underway between Yingli Green and Trina Solar over which company would top the shipment figures after it also became clear that the likes of Sharp (ranked third in 2013) would not grow shipments.

PV Tech was first to highlight the battle between the two Chinese rivals in late August, just after Yingli Green had lowered its shipment guidance to be exactly the same as Trina Solar's at 3.6GW to 3.8GW.

However, Trina Solar has also slipped on its guidance, forecasting shipments to be in the range of 3.61GW and 3.66GW for 2014, after releasing third quarter results.

PV Tech also highlighted from shipment growth analysis that Yingli Green had become a laggard this year with shipment growth guidance given in the second quarter that would only generate shipment growth of 15% to 20%.

On the other hand, despite the lowering of shipment guidance by Trina Solar, it still expected shipment growth of between 40% and 42% this year, indicating that the number 2 ranked producer had the momentum over Yingli Green.

However, Yingli Green has released third quarter results and slashed its full-year shipment guidance to be in the range of 3.30GW to 3.35GW, resulting in shipment growth of only 3% to 4.6% compared to 2013.

On a shipment basis, quarter-on-quarter the battle between the two companies has been intense with Yingli Green quite a bit ahead of Trina Solar in the first quarter of 2014.

However, shipment figures swung the other way, despite Yingli Green posting shipments of 887.9MW in the second quarter. But Trina Solar had surpassed Yingli Green at 943.3MW.

With third quarter shipment figures just released, Trina Solar's shipment momentum has continued to rise, while Yingli Green's is slowing. Trina Solar shipped over 1GW in the third quarter and guided the same for the fourth quarter. Yingli Green shipped 903.4MW in the third quarter and guided similar levels for the final quarter of the year.

The shipment gap of approximately 300MW between Trina Solar and Yingli Green after both revised down shipments should be large enough for Trina Solar to secure the top-ranked PV manufacturer in 2014, with Yingli Green dropping to second position, after two years of reign.

Interestingly, in the last 10 years those that have reached the top-ranked position have failed to retain dominance for more than two years. This includes the likes of First Solar and Suntech Power Holdings.

Major ranking reshuffle in top 10

The PV industry continues to be highly dynamic and this is being reflected in some significant ranking reshuffles in 2014.

JinkoSolar has continued to build on its market share gains over the last few years and with shipment guidance of 2.9GW to 3.2GW, despite the wide range, is set to become the third largest PV manufacturer this year, moving up the rankings from 5th position in 2013.

With Canadian Solar tightening its 2014 shipment guidance to 2.72GW to 2.78GW recently and Sharp lowering its forecasts, JinkoSolar's momentum is impressive.

Only two companies are to retain the same ranking this year as last year – Canadian Solar, which is ranked fourth, and Renesola, ranked sixth.

However, the biggest mover is not JinkoSolar. Instead, JA Solar has moved up five positions from being ranked 10th in 2013 to being ranked fifth in 2014. The major leap by JA Solar reflects its switch from being a merchant solar producer to a major module supplier in only a few years. As PV Tech has already highlighted, JA Solar has the highest shipment growth guidance of 105% to 114% this year, while shipment guidance is 2.4GW to 2.5GW.

The other shipment growth laggards, including Hanwha SolarOne, Sharp and First Solar, all drop positions in 2014 compared to the previous year.

Hanwha SolarOne's 10-15% shipment growth is relatively anaemic, meaning it loses one position to be ranked ninth in 2014 with shipment guidance recently lowered to 1.43GW to 1.46GW.

First Solar also loses one position (ranked eighth) with shipment growth of 12% to 19% and guidance of 1.8GW to 1.9GW.

First Solar's lack of shipment growth compared to its peers in the top 10 rankings was made evident early in the year, when after a year of building large-scale utility projects its 2014 project pipeline was insufficient to keep production utilization rates at high levels, something that has persisted all year.

Sharp soared up the rankings table in 2013, due to the boom in Japanese PV installations on the back of a highly attractive FiT. However, primarily due to the introduction of a consumption tax in Japan, Sharp warned that it did not expect shipments in 2014 to meet 2013 levels. As a result, Sharp is guiding negative growth within the range of 5-9% for 2014 and therefore tops the laggards list this year.

The lack of shipment growth by Sharp has really impacted its ranking position given the fact that manufacturers with 2GW or more of nameplate capacity dominate the middle rankings and most importantly have shipment growth forecasts significantly higher. Sharp falls from third in 2013 to seventh in 2014.

However, there is a major battle happening over the 10th ranked company, with Wuxi Suntech rebounding this year and just hedging SunPower, Kyocera and Hanwha Q CELLS.

But only with final shipment figures from these companies will the 10th ranked company be known. The reason for this is how close shipment guidance ranges are for these four companies.

Wuxi Suntech has guided shipments of between 1.3GW and 1.5GW, SunPower 1.3GW to 1.4GW, Kyocera at 1.2GW to 1.4GW and Hanwha Q CELLS has guided 1GW to 1.2GW.

What is also interesting from the 2014 rankings compared to the 2013 rankings is that shipments of 1.3GW will be required to enter the top 10, up from 1.1GW required last year.

Also joining the battle outside the top 10 rankings has been Solar Frontier, REC Solar and SolarWorld. Indeed, REC Solar and SolarWorld are reporting strong shipment growth in 2014 and both adding moderate capacity in 2015. However, they would need to have more capacity and further shipment growth to properly challenge for a top 10 position.

Source: Yingli Green.

Flat growth for Yingli in 2014 saw it lose the top slot.

A year of recovery

Unquestionably, 2014 has been a recovery year for major PV manufacturers as supply and demand has rebalanced after several years of chronic oversupply. Effective capacity at the beginning of the year stood at around 45GW, which has had to expand to meet demand that looks likely to reach around 50GW in 2014.

Effective capacity expansions, primarily by tier-one module manufacturers and the majority of the 2013 ranked top 10 producers has been successfully moderated, indicating that lessons have been learned from the dire consequences of overcapacity and a two-year period of profitless prosperity.

Rank 2013	Rank 2014	Company	Guided shipments (GW)
C1	1	Trina Solar	3.61-3.66
2	2	Yingli Green	3.3-3.35
5	3	JinkoSolar	2.9-3.2
4	4	Canadian Solar	2.73-2.78
10	5	JA Solar	2.4-2.5
6	6	ReneSola	2.3-2.5
3	7	Sharp Corp	1.9-2
7	8	First Solar	1.8-1.9
8	9	Hanwha SolarOne	1.43-1.46
NA	10	Wuxi Suntech	1.3-1.5

Source: PV Tech analysis.

Company rankings for 2014 based on guided shipments.

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