

R&D spending analysis of 20 key PV manufacturers in 2017

By Mark Osborne, senior news editor, Photovoltaics International

Abstract

An analysis of R&D spending of 20 publicly listed PV module manufacturers in 2017 has been undertaken to replace *Photovoltaics International's* previous list of 12 companies tracked over a 10-year period. A number of the original companies tracked have subsequently de-listed from stock markets and gone private, which meant that a broader analysis, including other listed companies was required to provide a good representation of global R&D spending trends in the PV wafer, cell and module segments of the upstream solar market.

Selection criteria

Historically, we had tracked 12 publicly listed PV module manufacturers, which had included First Solar, the only thin-film module manufacturer amongst the group, and 11 crystalline silicon module manufacturers: Canadian Solar, Hanwha Q CELLS, JA Solar, JinkoSolar, REC, ReneSola, SolarWorld, SunPower, Suntech, Trina Solar and Yingli Green.

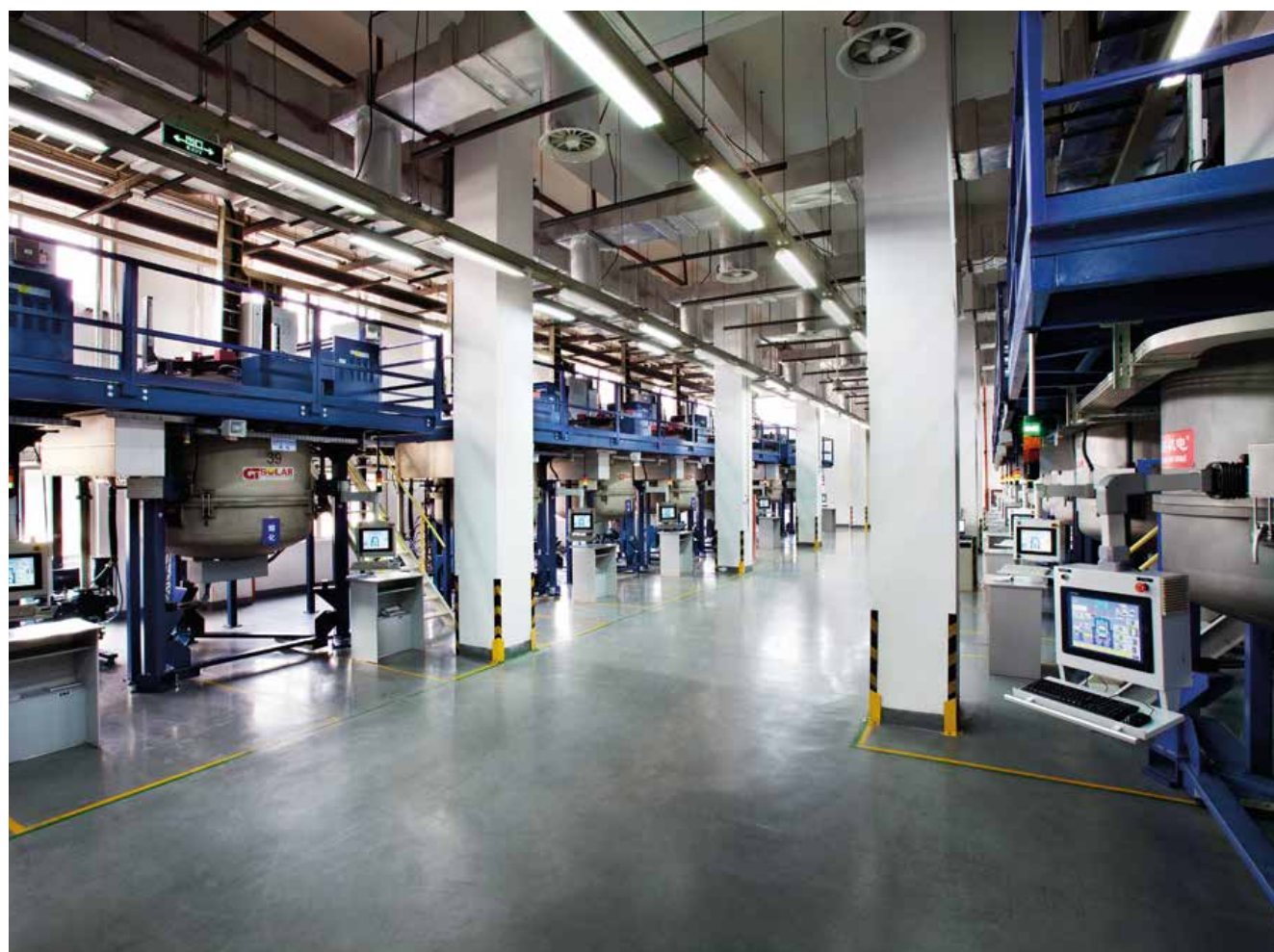
In the 2016 R&D spending report we highlighted that due to a number of these companies

withdrawing from stock markets, verifiable data from publicly available annual financial reports was in decline. This trend escalated in 2017, with the result that we could no longer track four companies (REC, Trina Solar, ReneSola and SolarWorld) from the original group of 12.

In the evaluation process of replacing those four module manufacturers it was apparent from long-term broader analysis of R&D spending that a number of emerging major manufacturers had moved into solar cell and module manufacturing in recent years. Notable among these are GCL Group and LONGi Group, which were historically from the upstream polysilicon and wafer sectors.

Being the largest wafer producers, with GCL-Poly dominant in multicrystalline wafer production and LONGi the dominant monocrystalline wafer producer, the emergence of these companies provided the opportunity to

Trina Solar is one of a growing number of PV manufacturers to go private, necessitating a revamp of our R&D tracking.



Credit: Trina Solar

broaden the R&D expenditure analysis beyond the original scope of the last 10 years.

Indeed, the likes of JinkoSolar and JA Solar have historically had meaningful wafer capacity in-house. Both have been aggressively adding new monocrystalline wafer capacity in-line with in-house module assembly capacity expansions. This has always meant that R&D spending within these companies included expenditure on wafer-related technology.

With other upstream manufacturers, such as module encapsulant material specialist Jolywood, moving into cell and module manufacturing and the chance to include some of leading Taiwanese cell producers, such as Motech, NSP and Gintech, which have all had module manufacturing operations, we had the opportunity to analyse R&D spending trends from a larger pool of companies and a larger part of the upstream manufacturing sectors.

As a result, the 2017 R&D spending analysis includes the following 20 PV manufacturers: Canadian Solar, Eging Photovoltaic, First Solar, GCL-Group, Gintech, Hanergy Thin Film, Hanwha Q CELLS, Hareon Solar, JA Solar, JinkoSolar, Jolywood, LONGi Group, Motech Industries, Neo Solar Power, Risen Energy, Solartech Energy, SunPower Corp, Tongwei Group, Wuxi Suntech and Yingli Green.

Analysis criteria

Although we have historically analysed R&D spending of primarily module manufacturers, this and subsequent reports analyse total R&D spending, which in the case of GCL includes GCL-Poly (polysilicon and multi c-Si wafer) and GCL System Integrated (cell and module), combined.

In the case of LONGi, R&D spending is across mono c-Si wafer and subsidiary, LONGi Solar (cell and module), combined. The spending analysis of Tongwei includes polysilicon, cells and modules.

Although all companies in the new selection produce modules at varying capacities, the cases of Neo Solar Power, Motech, Gintech and Solartech have historically been concentrated on merchant cell production.

Therefore, we no longer rank companies specifically from a module R&D spend perspective. Instead, this and subsequent reports will look more holistically at R&D spending trends from the broader upstream supply chain of selected publicly listed companies.

It is also important to note that we have retained historical R&D spending data from the PV module companies that were previously tracked and remain publicly listed but all new additions are tracked from 2012 onwards.

However, in the case of Tongwei the data is compiled from 2014 as it was a new entrant into the PV industry in that year. In the case of Jolywood, data available starts in 2013, as the company became publicly listed in 2014.

Historical R&D spending trends from 2007 to 2016

In retaining historical data that tracked 12 module manufacturers from 2007 through to 2016, combined with data from the expanded list of PV manufacturers, primarily from 2012 through to 2016, (Figure 1) shows a sharp increase in R&D spending in 2014, compared to the two previous years. This increase coincided with a recovery



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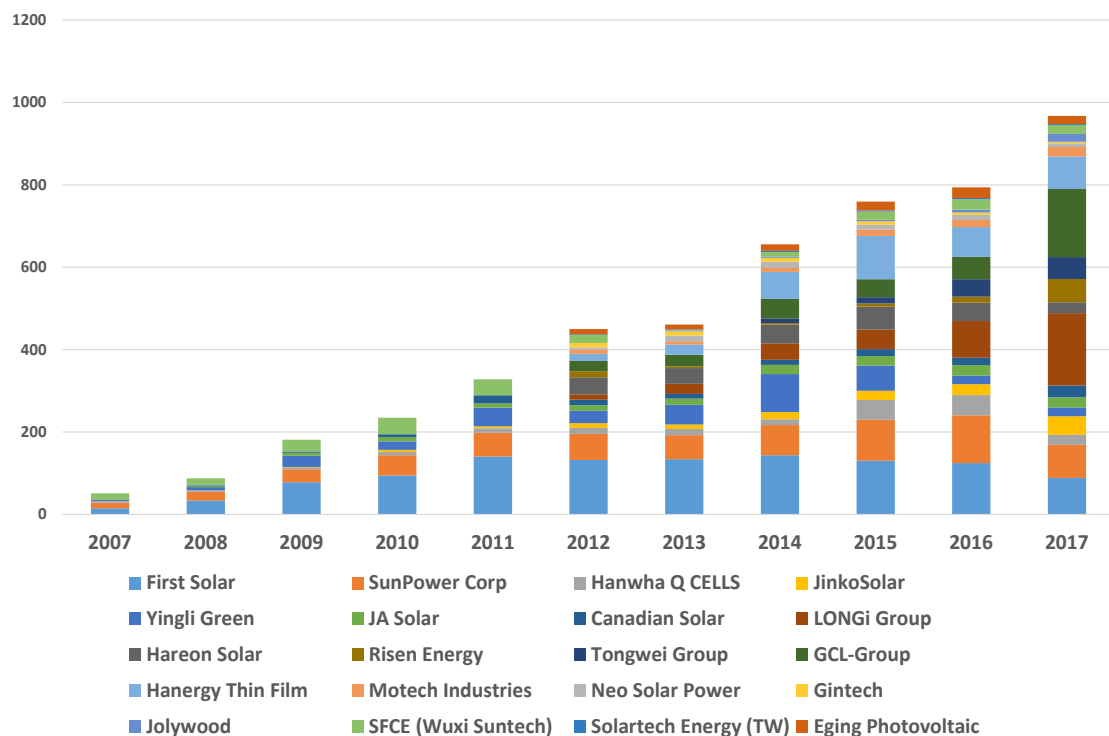
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in the PV industry, after several years of extreme overcapacity throughout the supply chain and was a new record at the time.

Cumulative annual R&D spending reached US\$880.41 million in 2015, up from US\$781.5 million in 2014, up around 12.5%, or almost US\$100 million from the previous year.

However, a trend not seen before 2012, which accounted for strong sequential R&D expenditure growth has remained ever since, which has been selective company R&D spending behaviour.

This manifested itself in 2012, when seven companies reduced R&D spending, whilst the others expanded spending. In 2013, the number reducing spending increased to 10 and only three of these (Eging, Suntech and Trina Solar) continued to lower spending in two consecutive years.

In 2014, a total of only three companies (Gintech, Hanwha Q CELLS and Risen) actually lowered R&D spending, reflecting the overall global solar market recovery. Gintech was the only company to lower spending in two consecutive years.

By 2016, the number of companies reducing spending had increased back to seven. This may have been a key factor in cumulative R&D spending only increasing by about 3% that year, which reached US\$907.46 million, another new record.

R&D spending trends in 2017

In 2017, with four companies (REC, Trina Solar, ReneSola and SolarWorld) no-longer tracked, due to stock market de-listings, it would be understandable that further R&D spending growth could be problematic.

However, R&D spending hit a new record of US\$967.28 million in 2017, an increase of around 6.6%, year-on-year, more than double the relative small increase seen in 2016.

Interestingly, spending growth would seem to have been hampered by a total of 10 companies reducing R&D spending in 2017, compared with the previous year, a new record number.

In the 2017 analysis, Gintech had reduced R&D spending in five consecutive years, First Solar had reduced spending in three consecutive years, while only Hareon Solar had reduced spending in two consecutive years.

Four companies (SunPower, Hanwha Q CELLS, Eging and JA Solar) had lowered spending in 2017, compared to 2016, when spending had reached record levels.

SunPower had only lowered annual R&D spending once before, in 2013, while in the case of JA Solar, 2017 was the first year its annual spending had declined.

In total, nine companies increase R&D spending

Figure 1. PV manufacturers (publicly listed) annual R&D expenditure, US\$ millions 2007 to 2016.

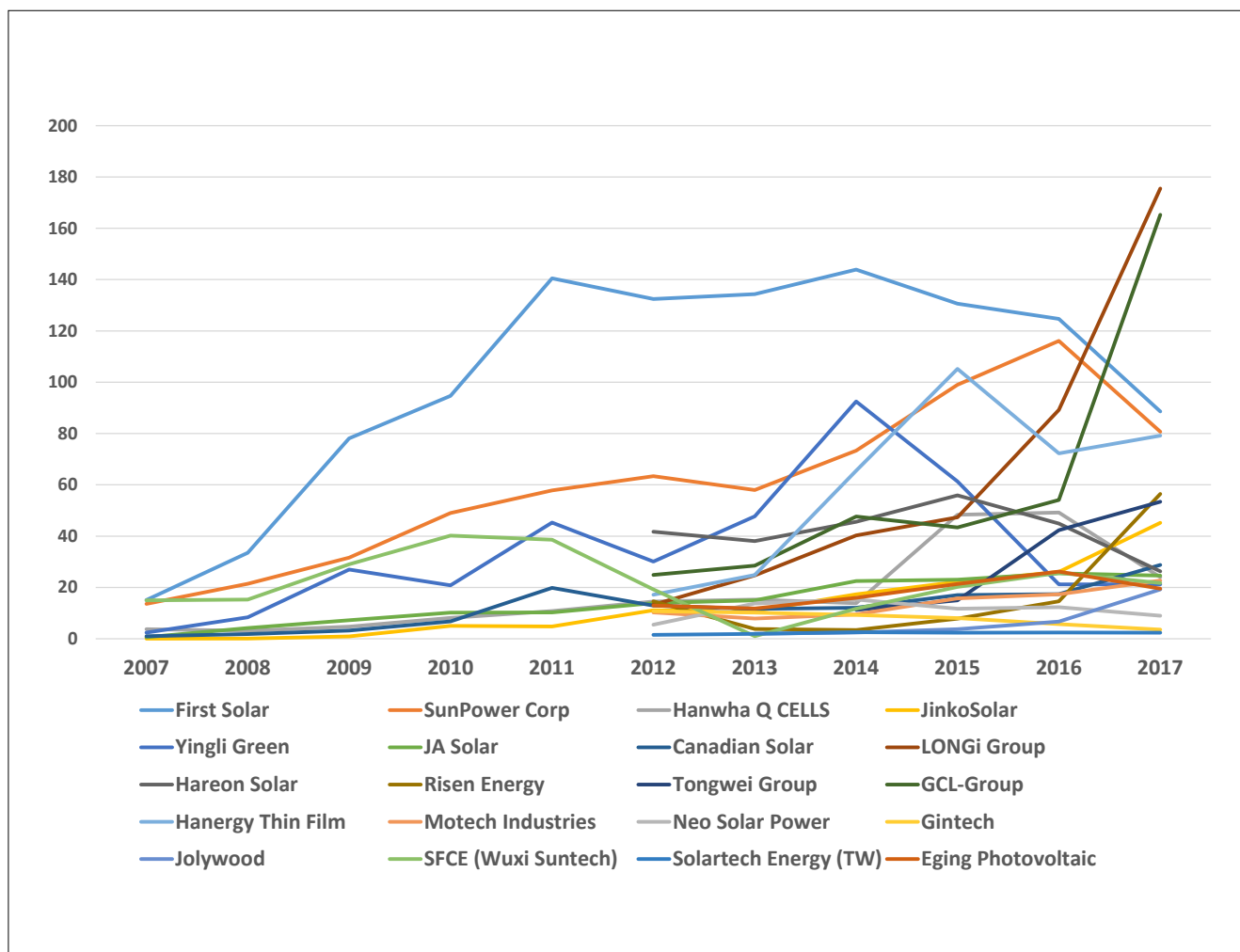


Figure 2. PV manufacturers (publicly listed) annual R&D expenditure, US\$ millions, 2007 to 2017, flow chart.

year-on-year, while one (Yingli Green) spent exactly the same amount (US\$21.2 million) as it did in the previous year. The first company to achieve that feat.

Spending pattern divergence

With the loss of the four companies previously tracked, coupled to an equal split of covered companies either reducing or increasing spending, year-on-year, there has been a marked divergence in spending behaviour, notably since the overall global solar market reached another year of record installations that almost reached the 100GW milestone.

Part of the divergence could be attributed to several of the 10 companies (First Solar, SunPower, Hanwha Q CELLS and Eging) that lowered spending in 2017, were near completing various significant R&D programmes that had led to peaks in annual spending in recent years.

Also contributing to the decline has been the financial condition of some of the companies, such as Hareon Solar, which drastically cut spending from a peak of US\$55.9 million in 2015 to US\$26.28 million in 2017. The company lost approximately US\$707 million in 2017 and had been loss making for at least six years. The company is technically bankrupt in 2018.

This may also be a contributing factor in SunPower reducing spending as the company reported a GAAP net loss of US\$851 million in 2017, its fifth consecutive year of losses.

In the case of First Solar, which is shifting production from its small form factor Series 4 modules to the large-area Series 6 modules and building three new plants, restricting overall spending could have been a factor in R&D spending declining to US\$88.6 million in 2017, compared to US\$124.7 million in 2016.

In contrast, a number of the nine companies in 2017 that increased spending (GCL, LONGi, JinkoSolar, Canadian Solar, Risen and Jolywood) did so at significantly higher levels than in the previous year. All of these companies had major R&D programmes in full swing in 2017, not least GCL and LONGi across materials, wafers, cells and modules.

High rollers

In the case of LONGi, R&D spending increased from US\$89.23 million in 2016, to US\$175.5 million in 2017, a year-on-year increase of 96.67% from US\$89.2 million in 2016.

LONGi set a new solar industry record, not only by surpassing the two historical R&D spending leaders (First Solar and SunPower) but also

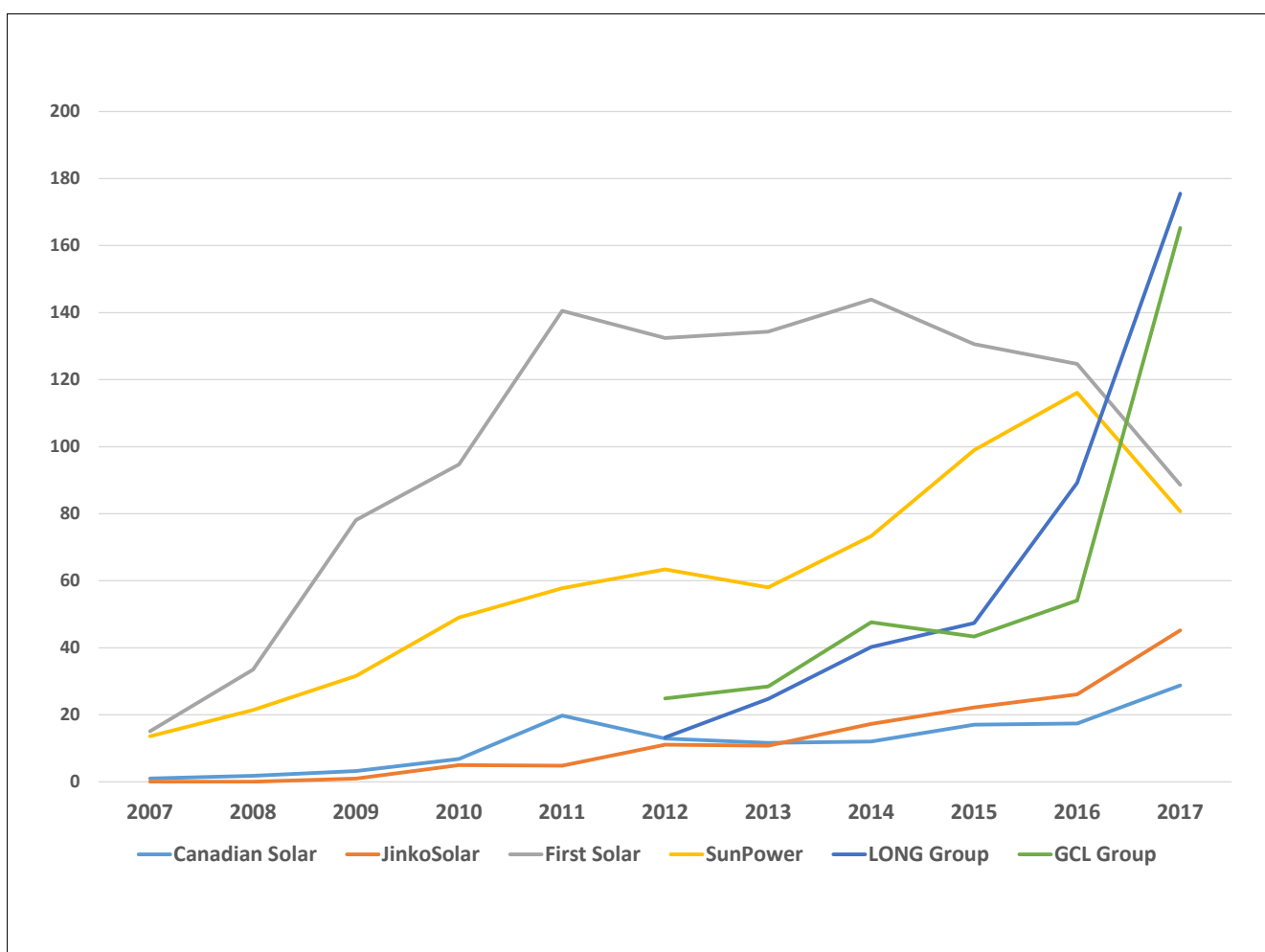


Figure 3. Annual R&D expenditure: historical leaders and laggards, (US\$ millions).

spending more in one year than any other PV manufacturer to date.

LONGi reported total revenue of US\$2.59 billion in 2017, up almost 42% from the previous year, with R&D spending accounting for 6.77% of revenue.

Only SunPower has come close to that ratio when in 2015, R&D spending accounted for 6% of revenue and First Solar's R&D spending ratio to revenue topped 5.1% in 2011.

LONGi has increased R&D spending for six years in row and has maintained a high-level of R&D investment over the last four years.

LONGi has been the largest monocrystalline wafer producer but notably since 2015, the company started production of monocrystalline solar cells and modules. Focused on high-efficiency PERC (Passivated Emitter Rear Cell) technology, R&D spending almost doubled each year since 2016.

Leading polysilicon and solar wafer producer GCL-Poly Energy Holdings, part of the GCL Group had also reported a massive increase in R&D spending in 2017.

The company developed new mono-silicon crystal growth techniques and FBR (Fluidized Bed Reactor) technology as well as advances in diamond wire saw cutting and 'Black Silicon' wafer

texturing for multicrystalline wafers.

GCL-Poly's R&D expenditure increased from US\$39.1 million in 2016 to US\$151.22 million in 2017, an increase of 288%. When R&D spending is combined with GCL-SI (cell and module manufacturer and downstream project developer, GCL New Energy), total spending reached US\$165.27 million in 2017. GCL group revenue topped US\$6.66 billion in 2017.

Major China-based PV module and materials manufacturer Risen Energy, which entered PV Tech's Top 10 module manufacturer rankings (by module shipments) for the first time in 2017, increased R&D spending from US\$14.6 million in 2016 to US\$56.54 million in 2017, an increase of around 280%, compared to the previous year. The company had reported revenue of US\$1.56 billion in 2017, a 63.21% increase from the prior year and new record for the company.

In 2017 the company launched a number of R&D programmes related to mono PERC high-efficiency solar cells as well as N-type mono bifacial solar cell manufacturing processes and multi-busbar technologies as part of a CTM (Cell to Module) loss reduction strategy, amongst other programmes to boost conversion efficiencies.

Risen also initiated R&D programmes related to

EVA module films, such as a 'super' anti-PID EVA film and work on enhanced POE-based backsheet film and production process as well as flexible cell lamination technology research.

Also of note in ramping R&D spending was two 'Silicon Module Super League' (SMSL) members, JinkoSolar and Canadian Solar, known historically for low-spending on R&D.

As the leading (by shipments) module manufacturer, JinkoSolar increased R&D spending to US\$45.2 million in 2017, up from US\$26.1 million in 2016, an increase of around 73%, year-on-year.

R&D activities had spanned thinner wafers, longer carrier lifetime of wafers, through to improved passivated emitter and rear cell processes and improved dielectric rear reflectors and interconnects.

The company recently reset the P-type monocrystalline cell conversion efficiency record at 23.95%, through a range of wafer to cell optimisation, notably its selective emitter (SE) formation.

JinkoSolar had said that a combination of enhancements and optimisation, which included highly doped and low defect mono wafers, which improves the bulk quality, coupled to further optimization of SE formation as well as silicon oxide passivation and the rear side passivation had added to conversion efficiency

gains. JinkoSolar also used its proprietary light-capturing technology, which employs black silicon and multi-layer ARC (Anti-Reflective Coating) technology that reduces the front side reflectivity of cells, said to be lower than 0.5%, boosting the short-circuit current.

Additionally, JinkoSolar said it deployed an advanced grid design and a new type of screen-printing paste to reduce the series resistance and the metal/silicon interface compound, enabling improved cell fill factor (FF).

SMSL member Canadian Solar took R&D spending from US\$17.4 million in 2016 to US\$28.77 million in 2017, increasing by almost 69%, year-on-year. However, R&D development expenses as a percentage of total revenues were 0.6% in 2016 and 0.8% for 2017.

The company has focused R&D activities on n-type bifacial cells, PASSCon cells, heterojunction cells as well as IBC cells and other high efficiency cell designs in 2017.

The SMSL also finished commercializing its in-house developed 'black silicon' technology on multicrystalline wafers in 2017, which led to all cell capacity converted to using the technology by the end of the year. Improving PERC (passivated emitter and rear cell) technology for multi-c-Si cells is also an ongoing project.

Although the total spending figure is relatively

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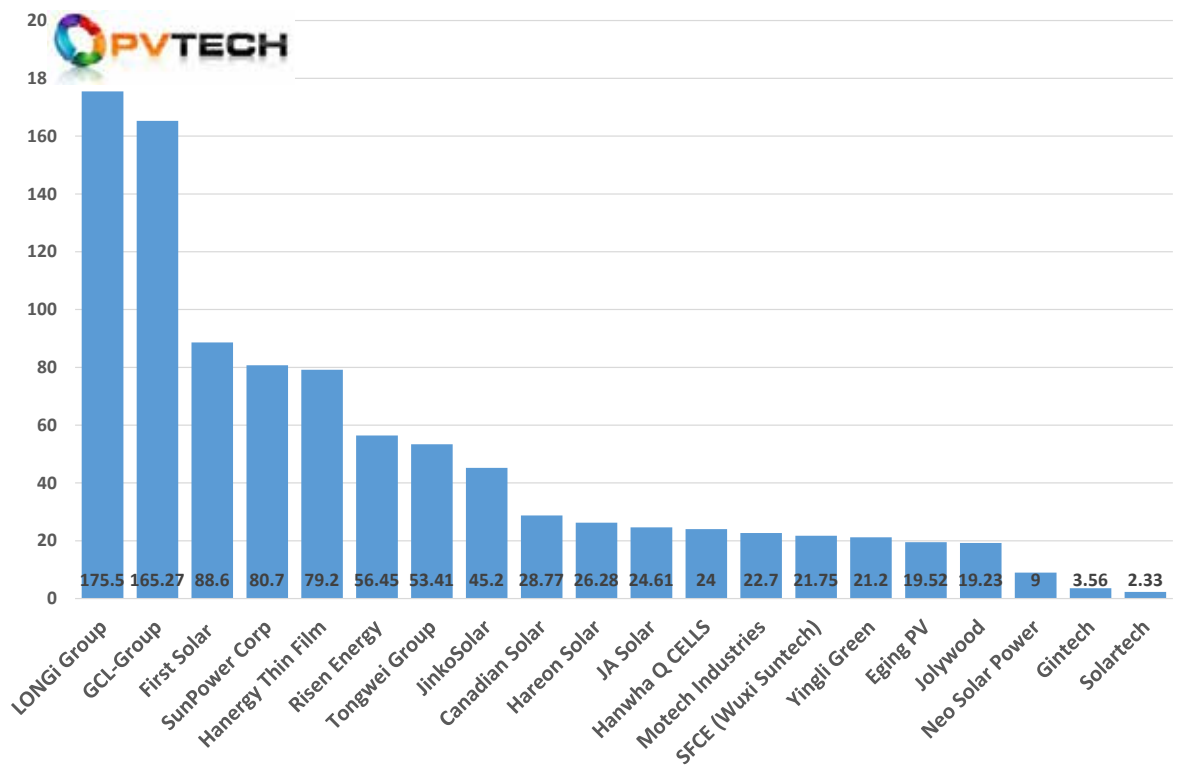
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low, Jolywood increased R&D spending from US\$6.67 million in 2016 to US\$19.23 million in 2017, around a 185% increase over the prior year and accounting for 3.47% of annual revenue.

On the materials front, Jolywood included inorganic Nano UV-resistant self-cleaning coating technology, micro-foam technology, and high water vapour barrier technology as key research and development projects in 2017.

In solar cells, Jolywood was active with N-PERT monocrystalline bifacial solar cell development, and continues to develop N-type mono bifacial TOPCon solar cells as well as N-type mono bifacial IBC solar cells in advance of mass production.

Spending clusters

The highest R&D senders in 2017 were LONGi and GCL, respectively. Both have significantly increased spending since 2015 and both spent in excess of US\$160 million each in 2017.

Only two other companies had R&D spending over US\$80 million each in 2017, First Solar and SunPower, respectively. Although thin-film firm Hanergy came close to that level at US\$79.2 million.

Two companies are clustered in the US\$50 million plus range (Risen and Tongwei), while JinkoSolar stands alone in spending in the mid-US\$40 million range. There are no companies in the US\$30 million spending range in 2017.

The largest cluster of seven companies is led by

Canadian Solar, which spent US\$28.77 million in 2017 and is held-up by Yingli Green at US\$21.2 million.

Eging and Jolywood just skirt the US\$20 million range at US\$19.42 million and US\$19.23 million, respectively.

The sub-US\$10 million per annum spenders are Taiwan-based Neo Solar Power, Gintech and Solartech.

Conclusion

The year under review resulted in another record for solar industry R&D spending (selected 20 companies), despite the forced removal of four companies from historical analysis undertaken since 2007.

New record levels of absolute spending on a company basis were achieved as well as some on a year-on-year percentage basis.

However, a growing number of companies reduced R&D spending in 2017, only negated by a select number increasing spending, significantly.

Overall, the trends in R&D spending remain fluid as they can be positively impacted by the continued pace of new technology adoption as well as being impacted negatively by individual companies technology development cycles and financial condition. As seen in the 2012/13 period, industry overcapacity can stifle spending growth but the growth trajectory has remained consistent with global market installation growth.

Figure 4. Annual R&D expenditure: 20-company sample ranked (publicly listed) in 2017, US\$ millions.