

Solar PV technologies status and evolutions

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Executive summary

The rapidly developing global photovoltaic market constantly demands technology which is more efficient and cost-effective in order to compete against conventional energy sources as well as the other renewables. During the last decade solar PV panels through various innovative approaches have improved substantially in terms of their efficiency and power output. The efficiency value of silicon solar cells has approached the maximum achievable limit of 29.4 %, the so-called Auger limit.

Efficiency values exceeding 22%, which were feasible only with laboratory solar cells ten years ago, can be achieved today with industrially produced cell structures, whereas cell prototypes already reach values above 26%.

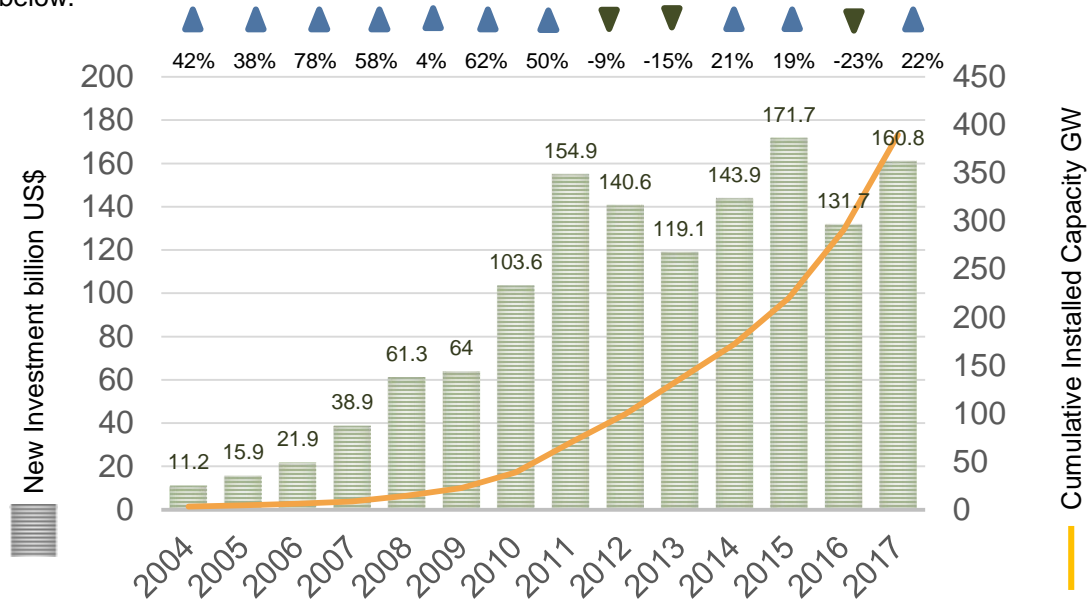
Today, manufacturers are exploring the overall value chain from the polysilicon to the kilowatt-hour (end users). Specific innovations are raising the bar for the solar industry in terms of power output, higher efficiency, quality, reliability production efficiency, and boosts system performance. This trend is much different to the past, where the focus was mainly on how to improve the efficiency to reduce the cost.

The report will review certain innovations that are revolutionizing the sector such as :

- Process improvements for the crystal growing, the penetration of the diamond wire technology and its potential for high throughput, lower kerf loss and thinner wafers.
- The cells efficiency improvements through PERC/PERT, HJT, IBC and the new cell designs like of bifacial technology in boosting system performance and energy yield.
- The advantages offered by half-cut cells, and the challenges of manufacturing these products.
- The shingle modules, similar to the half cells. However, here the cells are sliced into several pieces and connected in a shingled manner.
- The multi-bus bar cell technology that represents a vital step forward.
- Additional innovations in the module assembly that help push the efficiency needle, such as reflective ribbons and other design tweaks that boost performance.
- The introduction of 1500 V modules and their impact on the overall BOS cost reduction.
- The tracking system and their advantages vs. fixed structure.
- The storage systems as an ultimate solution for solar PV deployment and usage.

Global solar power investments vs cumulative installed capacity

The global PV market has experienced vibrant growth since the early 2000 as it shown in the chart below.

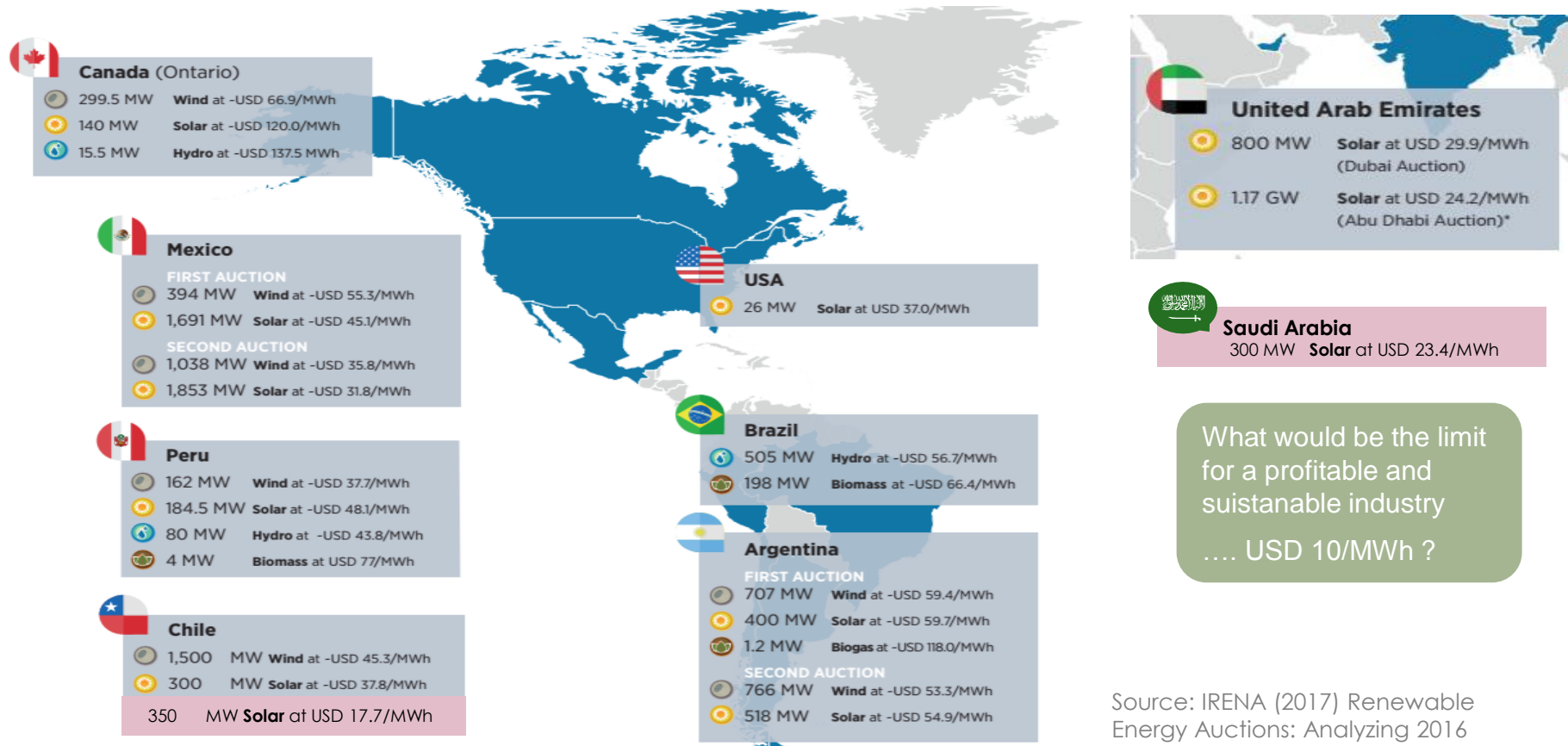


- The investments in Solar PV overpassed \$160 billion USD annually. The lower investments compared to other years reflects the effect costs reductions. The investment expected to reach \$2 trillion USD by 2030.
- The global cumulative installed capacity for photovoltaic power had reached an estimated 402GW, indicating nearly 50 times the growth in cumulative installed capacity within a decade

Source: Frankfurt School-UNEP Center/BNEF.2017. Global Trends in Renewable Energy Investment 2017, www.fs-unep-centre.org
Note: Investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Continuous record solar PV prices

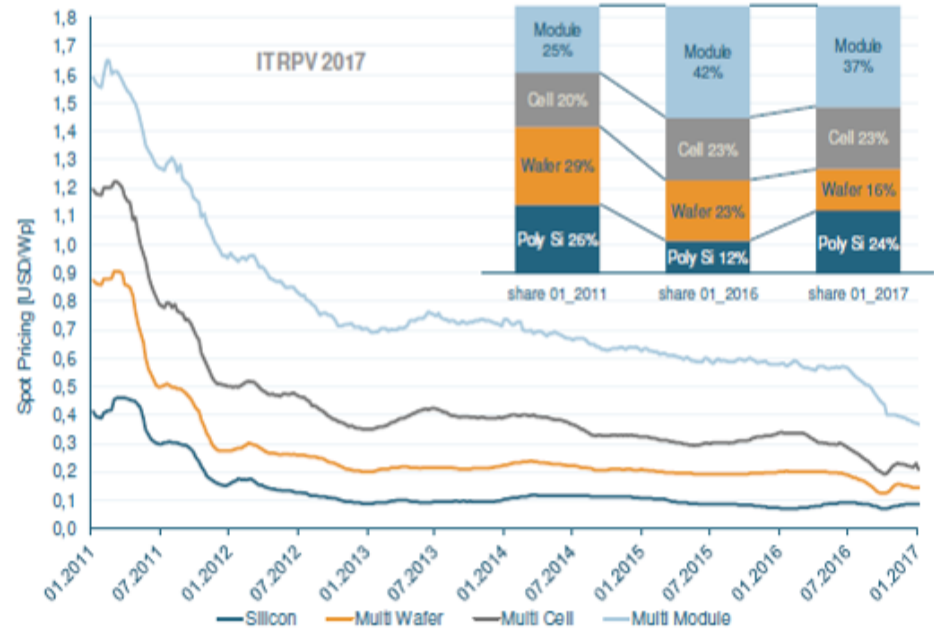
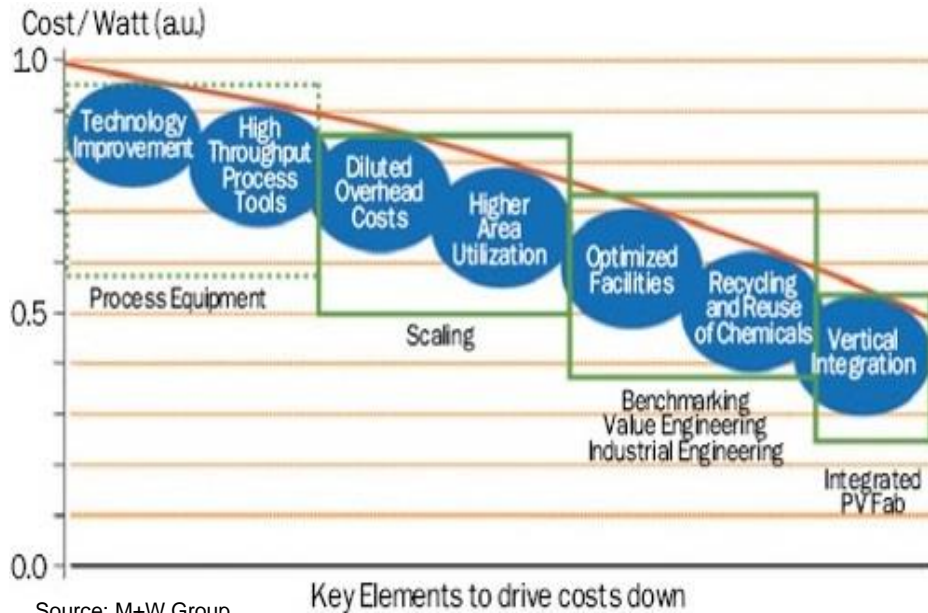
Besides of the governments ambitions implementing renewables in their energy mix. The development of RE sector remain mainly driven by the LCOE reduction



Source: IRENA (2017) Renewable Energy Auctions: Analyzing 2016

Solar PV cost trends

About 77% cost reduction has been operated since 2011 with the aim of achieving further significant cost reductions in R&D which is predicted to continuously progress in improving existing technologies and developing new technologies. It is expected that a broad variety of technologies will continue to characterize the PV technology portfolio, depending on the specific requirements and economics of the various applications.



The ITRPV figure is rather an average cost price.

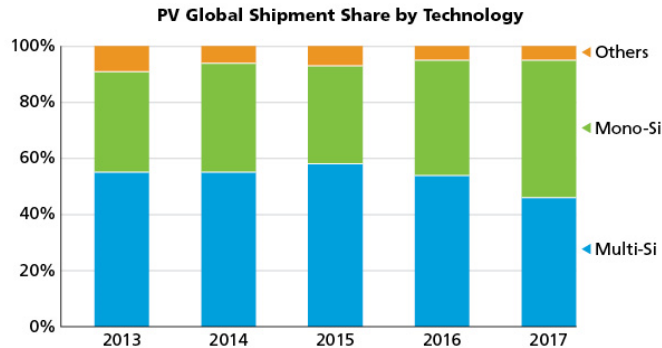
Technology improvements in order to increase the conversion efficiency of PV modules, as well as high throughput process equipment with high uptime and increased yield are main factors for future cost reduction. This is mainly driven by the process equipment industry.

Technology development is the key of the success

PV systems are rapidly becoming a very competitive power supply option. As a result of the drop in the cost of PV generated electricity and the increase of the global demand for solar PV power plants, the solar PV market is continuously growing with trillions of U.S. dollars at stake. The Compound Annual Growth Rate (CAGR) of PV installations was 40% between 2010 to 2017.

This development is supported by advances in solar technology and manufacturing.

Multicrystalline-silicon PV modules have dominated the global PV market over monocrystalline-silicon due to the cost advantage. However, the trend is mono's taking more market share and it will continue in 2018 and beyond. PERC has become a mature technology and will be put more in mass production.



In terms of technological innovations in modules, bifacial modules and AC modules that lives up to the technology's true potential, by utilizing N-type Mono-Si as the fundamental technology. Bifacial modules can utilize light from both sides and therefore significantly increase the electricity yield of PV systems.

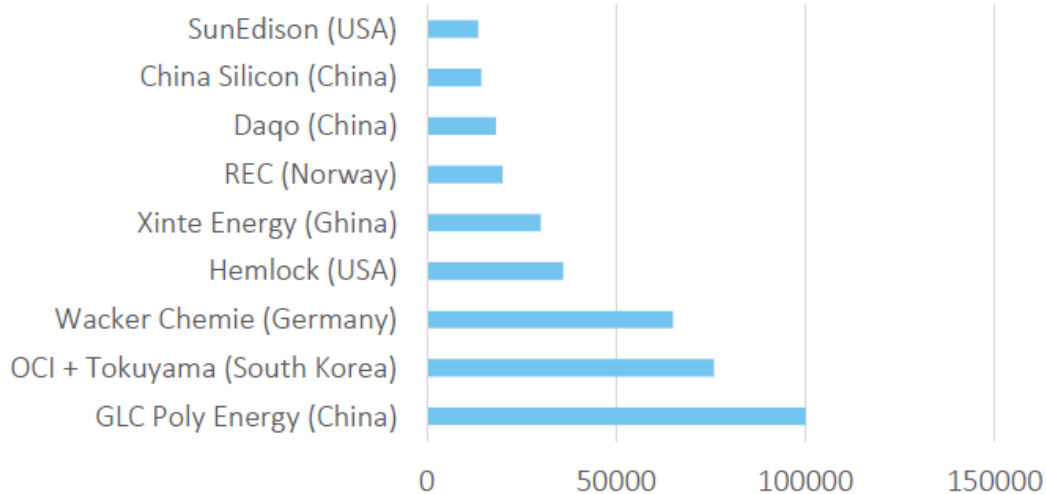
With an AC Modules, there is no inverter installation and no DC wire management. As PV projects continue to trend toward larger systems, three-phase string and higher voltage inverters have started gaining a market share in large central inverters and utility-scale markets.

Polysilicon

Polysilicon is the basic raw material used to produce solar cells. The growing market for high-efficiency cells requires a supply of high purity polysilicon to meet global production demands. Besides, as the polysilicon accounts for over 20% of the total module production cost, the focus was given to low energy consuming production technologies. Process improvements including increased productivity and polysilicon yields from larger, better-performing reactors and higher energy efficiency for chemical vapor deposition processes along with increasing economies of scale were key drivers of cost reductions.

Largest Polysilicon Producers

Estimated data end 2016 – Source IHS

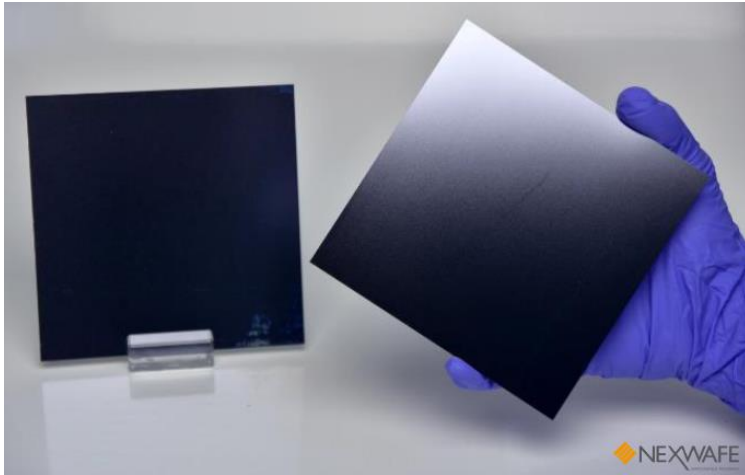


After the polysilicon industry recovered from oversupply in 2013, its global output sharply increased from 228,000 metric tons (MT) in 2013 by 37% to 313,000 MT in 2014 and by another 16% to 363,000 MT in 2015. However, demand from the photovoltaic (PV) industry, which consumes approx. 90% of polysilicon produced worldwide, did not grow at the same pace. Annual PV system installations only rose by 9% to 42 gigawatts (GW) in 2014 and by 28% to 54 GW in 2015. Consequently, polysilicon inventories swelled again and drove the average polysilicon spot price down to a new record low of 12.93 US\$/kg in January 2016.

Source: BERNREUTER RESEARCH

Crystal growing technologies development

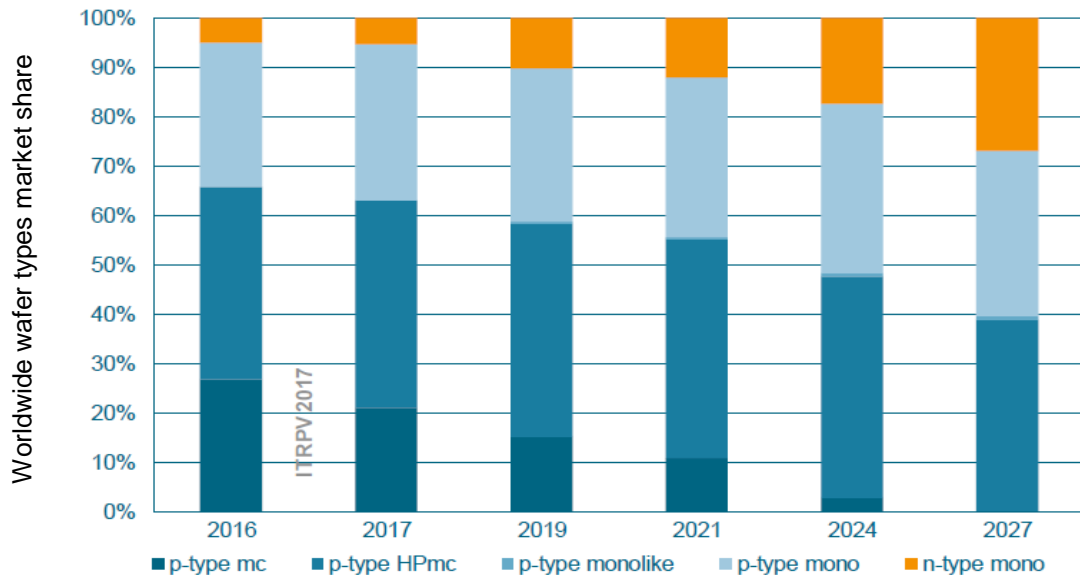
The strong demand on silicon requires wafer manufacturers to produce high-quality material through high productivity processes with low-cost. Due to the higher energy conversion efficiency of mono crystalline silicon (mc-Si), the Czochralski (Cz) pulling remains the key technology in photovoltaics. However, the ingot casting process can produce high-performance multi-crystalline wafers that are almost as good as Cz wafers. This could be achieved through a tight focus on impurities. The lifetime of multi-crystalline wafers could be improved and then get roughly about the same performance as mono-crystalline Cz technology.



Besides, Several alternative crystallization techniques aimed at lowering material-cost and improving energy conversion efficiency are being developed. These include Mono-like Silicon aimed at producing monocrystalline silicon (mono-Si) wafers using mc-Si technology, Kerfless Epitaxial Silicon (KE-Si) and Liquid to Wafer aimed at reduction of some of the process steps such as ingot growth and wafering, and Non-contact Crucible Silicon (NOC-Si) aimed at quality improvement of crucible-cast silicon through reduction of stress and impurity contamination during ingot growth. Despite the impressive achievements in these emerging technologies, many challenges including inhomogeneity in material properties still remain.

Wafer types

Recent advances in crystal growth technology have resulted in a new generation of cast-grown multicrystalline silicon materials with low dislocation density, the so-called high-performance multicrystalline (HPmc) silicon, which is becoming mainstream within the photovoltaic industry. More recently, there have also been significant advances in the understanding and control of defect generation and multiplication in cast-grown mono-like silicon materials. Although mono-like silicon technology is not as well established as HPmc, mono-like silicon can be grown with mostly (100) crystal orientation, which can be textured using alkaline texturing, and is therefore compatible with diamond-wire sawing technologies. As such, mono-like silicon offers the potential of a low-cost cast-grown silicon substrate for solar cells.



The debate mono vs multi:

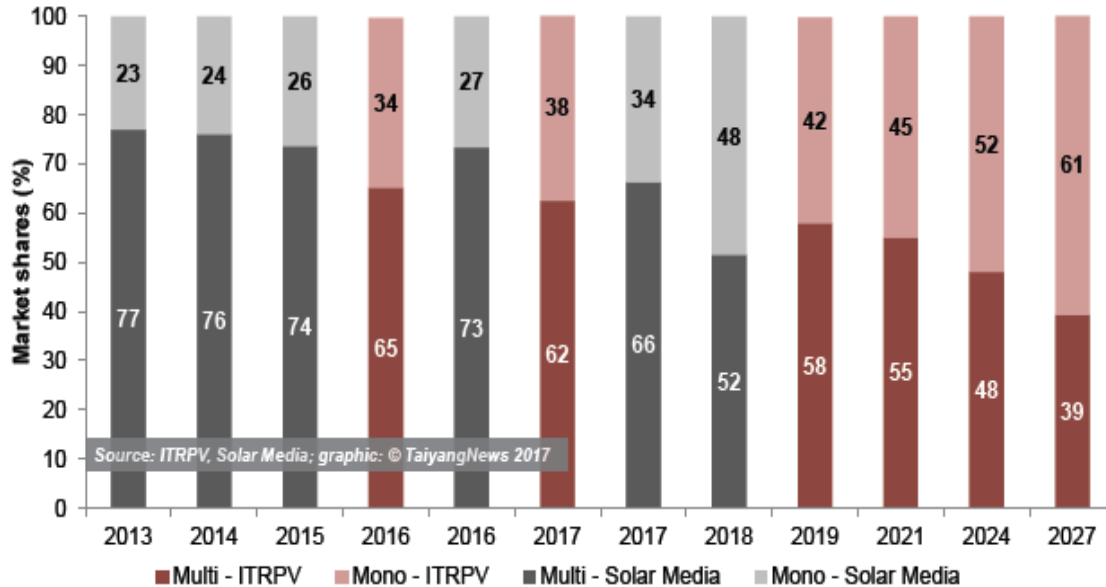
Both multi and mono have their own advantages indeed. The cost of a mono wafer has trended down while multi has tried very hard to increase efficiency and power output. They will coexist for quite a long period of time.

Wafer technologies

The diamond wire technology development, with more reliability, contributes actively offering a major progress to the wafering technology. Productivity has increased and the kerf loss has been reduced. As a result, the cost has fallen to the point where the price of a monocrystalline wafer cut with diamond wire is approaching the price of a multicrystalline wafer cut using slurry.

The Mono vs Multi debate

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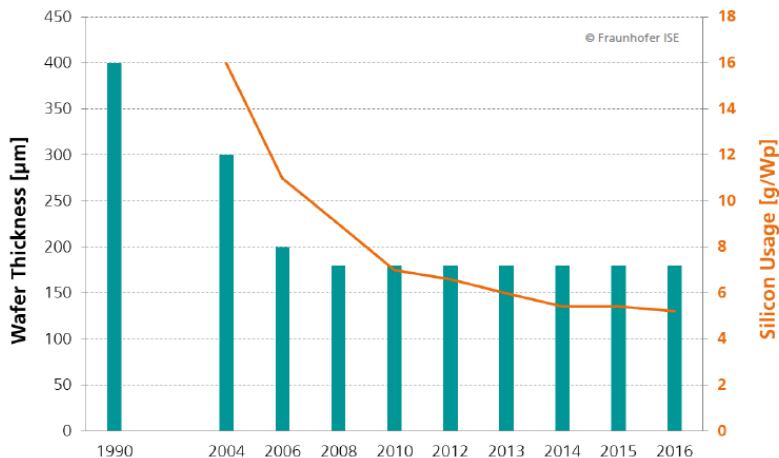
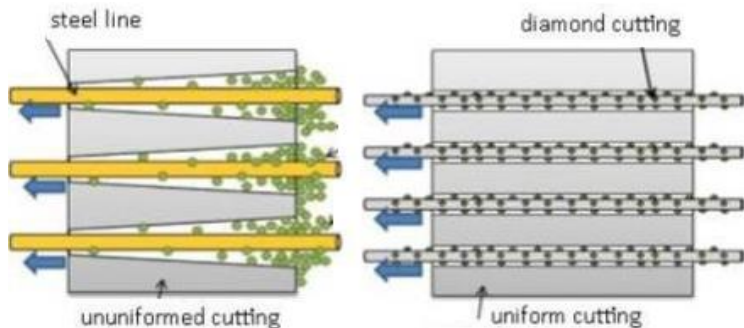
Emerging technologies

1366's Direct Wafer™ process which is a one-step, kerfless wafer-making technology. The semi-continuous, high-throughput process eliminates silicon waste, resulting in a more powerful, low-cost wafer.

The continuous wafer synthesis technology is based on crystal growth by mean of CVD process. The Twin Creeks technology is based on a beam of hydrogen ions that bombards thick disks of c-Si after heating in the furnace a thin layer of 20µm of silicon is peeled off the surface of each substrate.

Wafering trends

After long development period, reliable at a reasonable cost, wire diamond is now available on the market. It allows the diamond wire slicing technology to become the technology of choice. In fact, by means of a minor upgrade, the existing wire saws could be modified to apply it.



Data: until 2012: EU PV Technology Platform Strategic Research Agenda, from 2012: ITRPV 2015; ISE 2016 without recycling of Si. Graph: PSE 2017

Diamond wire slicing features:

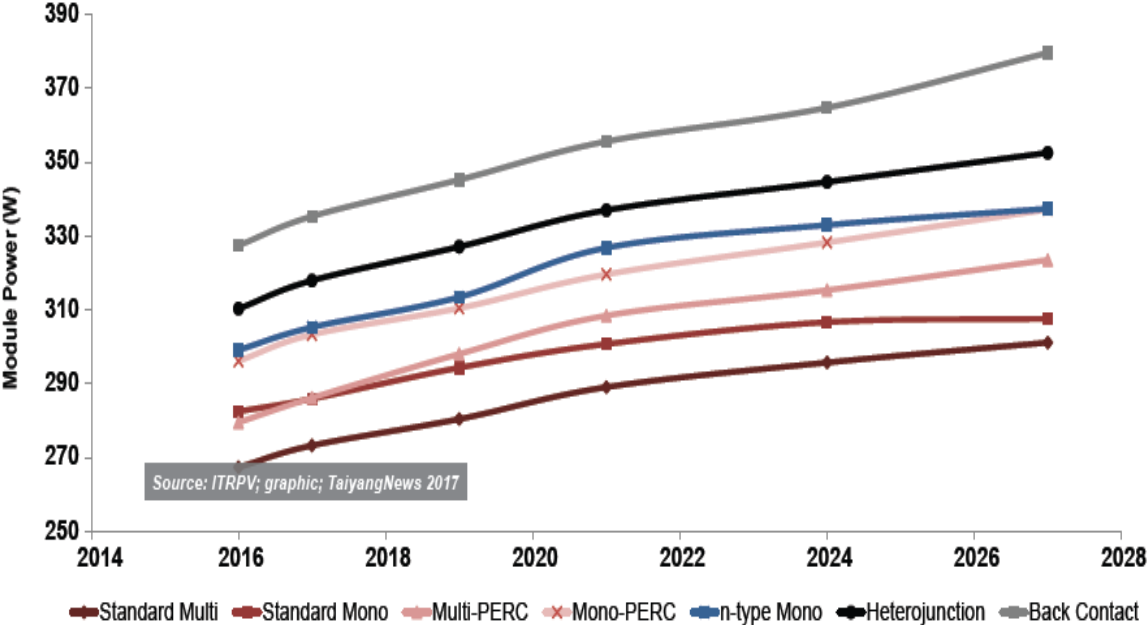
- Dark-grey color appearance → Improved light absorption.
- Uniform cut, smaller thickness variation → More even & precise thickness.
- Less sub-surface damages on wafer → Higher reliability.
- Faster process → higher throughput.

Being a diamond wire cut sector going into 2019, the prospects for thinner wafers are much more encouraging than any other point in the past. For anyone looking at technology disruption over the next few years, this must be high up on the list. It is also worth noting that cell lines are more automated now, and this is one of the other key factors needed to move to thinner wafer use.

Material usage for silicon cells has been reduced significantly from around 16g/Wp to less than 6g/Wp due to increased efficiencies and thinner wafers. It is expected that the consumption of polysilicon will decline to below 4g/W during 2018.

Cells technologies efficiency status and perspectives

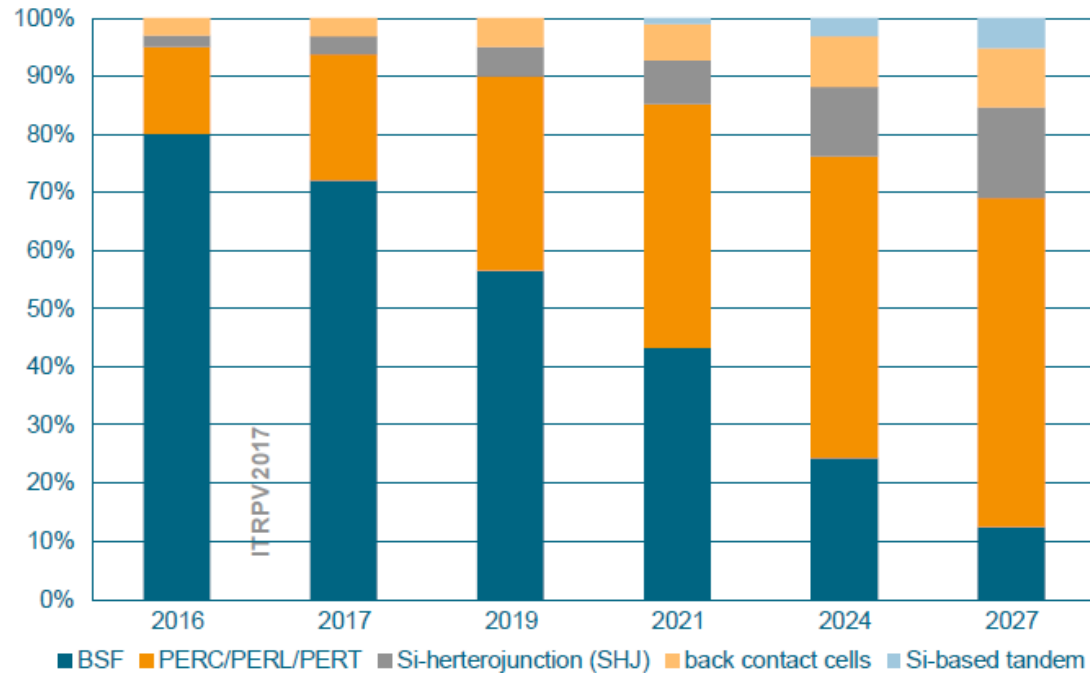
The graph below shows the expected average stabilized efficiencies on state-of-the-art mass production lines for double-sided contact and rear-contact cells on different wafer materials. The plot shows that there is big potential for all technologies to improve their performance. N-type cells show the highest efficiency potential. Nevertheless, there will be nearly no efficiency delta for double-side connected mono n- and p-type cells in the future. It is expected that p-type mono cells will reach 23%. N-type-based cell concept like HJT and back-contact cells will reach higher efficiencies.



- LDE & PERC is still the majority with PERC gaining share.
- Adoption of N-type, IBC, HJT is still uncertain due to the high technology content and investment threshold.

Cells technologies market share projections

Passivated emitter rear contact (PERC) production is forecast to exceed 20GW in 2017, accounting for more than 20% of all p-type solar cells produced in the year. PERC has become the first major application for lasers in the mainstream c-Si cell sector in the solar industry.

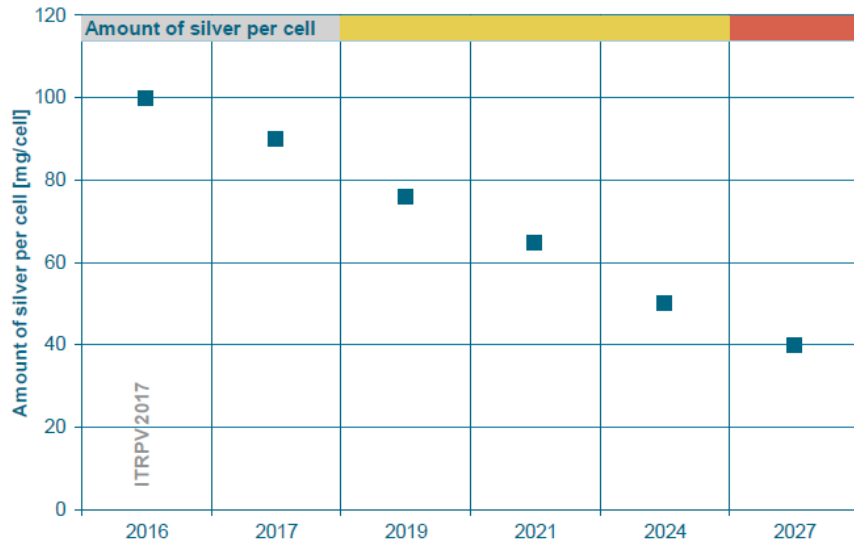


The investment to move to a PERC technology line requires minimal modifications to existing cell manufacturing lines. Manufacturers can easily make the jump to produce a superior product without having to outlay large capital expenditures for a complete overhaul of existing equipment. There has been a boom in adding PERC capacity to the global market and it is set to continue at a rapid pace for the next several years. Additionally, panel manufacturers are now able to produce a more energy dense module without much of an increase in build cost.

- BSF technology is shrinking
- Si-based tandem is still under development

Cell technologies – Silver reduction

The efficiency improvement was always the route explored to reduce the production cost of the solar PV panels. Since few years, a focus was also given to the processing materials. At the cell level, metallization pastes/inks containing silver and aluminum are the most process-critical and most expensive non-silicon materials used in current c-Si cell technologies. Efforts by fabricators to reduce silver loadings in PV cells started since 2011, indeed. Therefore, it has become the main focus in cost reduction.



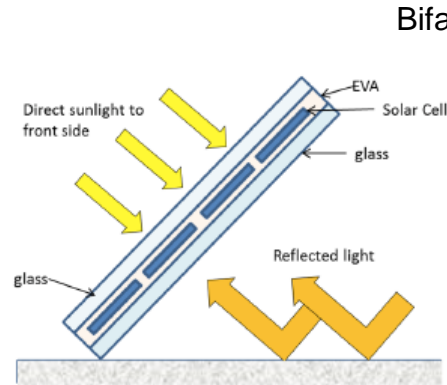
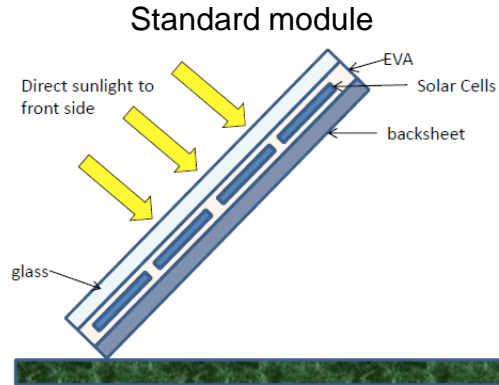
Average silver loadings per cell have sunk from more than half-a-gram 10 years ago to barely 0.1 grams for 'best in class' PV products according to industry data. A reduction down to 0.04 grams per cell is expected to be possible by 2027. New developments in pastes and screens will enable this reduction.

The average silver price of 548 US\$/kg end of January 2017 will result in a cost of 5.2 US\$/cell (1.1 US\$ cents/Wp, for a 19.6% mc-Si PERC cell), or about 13% of the non-Si cell price.

- Material suppliers have to provide innovation
- Tool suppliers have to support implementation

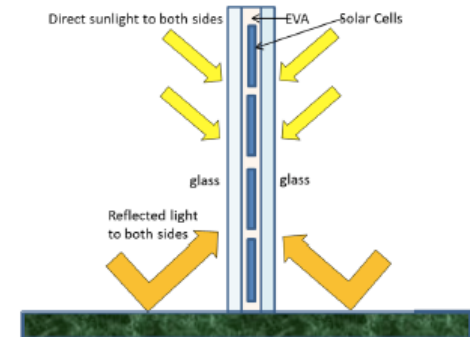
Cell technologies: Bifacial cells

Bifacial solar PV modules have the capability to generate electricity by capturing light from both sides of the module and thus offer great potential to increase the yield of PV power plants. The additional yield of 5 to 30 % in comparison to conventional modules depends on the amount of back-surface irradiation and efficiency.



Installation with high reflection:

- More albedo → higher yield
- +10..... + >30% [kWh/kWp]
- Solar farms, white rooftop, ...

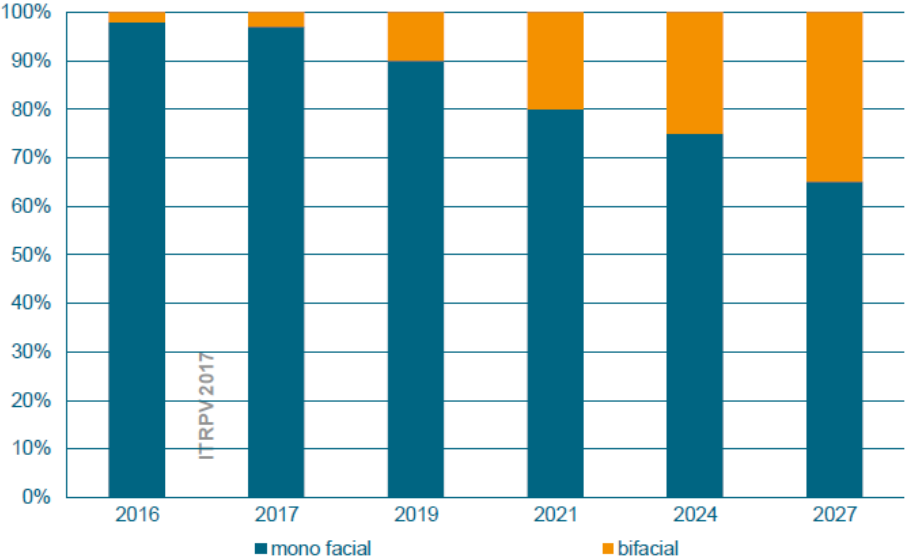


Vertical installation:

- ~100% yield compared to south-facing
- Noon peak shaving
- “rectangle” solar power generation
- Noise barriers, fences, ...

Cell technology: Bifacial cells:

As the PV industry looks to squeeze more out of current solar cell technology. Bifacial cells are more and more appearing on the market. Historically, bifacial solar cells were targeted towards BIPV applications or in areas where much of the available solar energy is diffuse sunlight which has bounced off the ground, water surface and surrounding objects i.e. lakes, extreme latitudes and snow-prone regions. However, the combination of plateauing peak efficiencies from standard screen printed solar cells and significant reductions in the cost of solar glass in recent years – making the use of double-sided glass encapsulation viable – has pushed bifacial solar modules back into the spotlight. Therefore, the bifacial PV looks to work its way towards a larger share of the PV market.



In the meantime, bifacial technology has to overcome a number of teething problems. This includes missing bankability, questions how to rate and price the products. But the major issue is the lack of standardization. An IEC standard is in the final stages and expected to be ready for publication in 2018.

Bifacial cells:

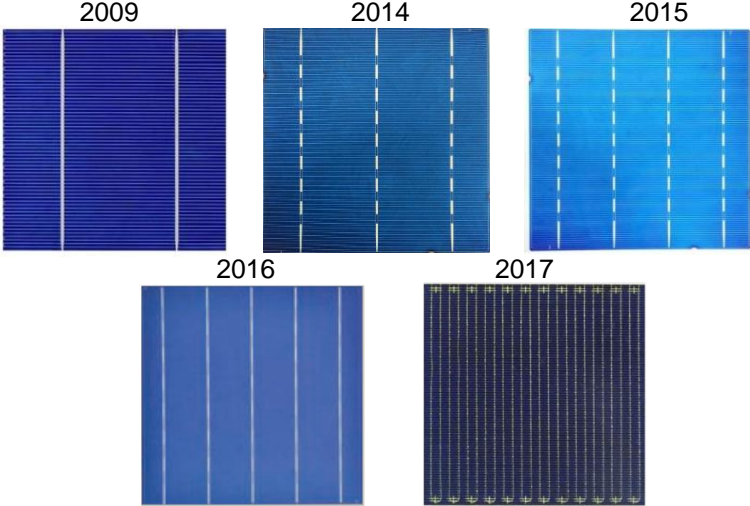
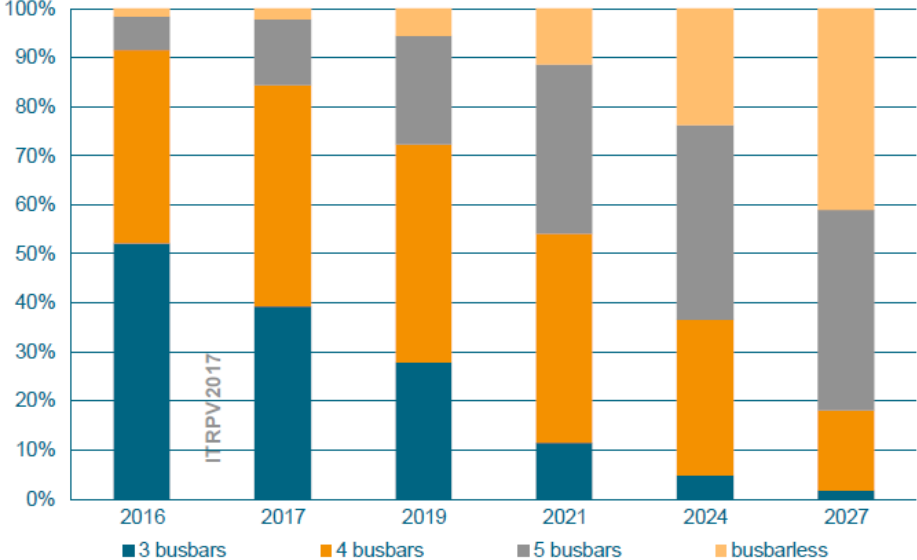
Bifacial modules concept could be applied to all cells technologies: HJT, PERT / PERL as well as PERC+. Moreover, they also work very well with half cells. Since current is getting high, so do losses, which makes the half-cell configuration a very good fit for interconnecting bifacial cells.

The table below summarizes the bifacial cells metalization: specifics, strength, and challenges.

	HJT	PERT / PERL	PERC+
Specifics	TCO + Low T Ag paste or plating front and rear	Ag/Al paste front and Ag paste rear	Ag paste front Laser opening + Al paste rear
Strength	Good line definition, High bifaciality	Good line definition High bifaciality	Easy upgrade from PERC, Mainstream
Challenges	Low T metallization Need special module technology	Limited efficiency due to spiking of Ag/Al in emitter contacts	Limited bifaciality due to wide Al lines - lower ρ_{line} Alignment to laser line
Solutions	Smartwire (MB) or conductive adhesives	Selective emitters, reduce emitter area	Multi-Busbar (>5BB) Pattern recognition

Multi Busbar evolutions:

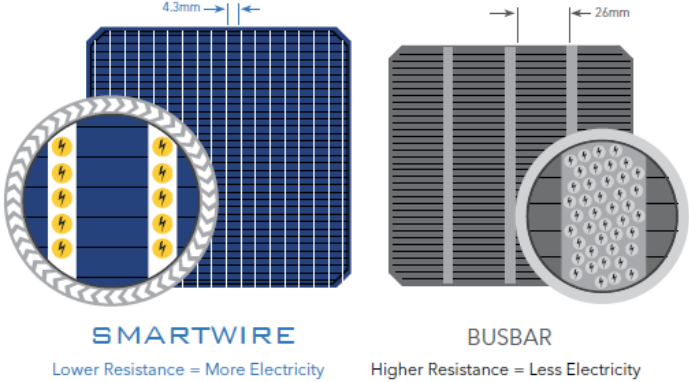
SmartWire Technology (SWT) is a breakthrough that outrivals busbar technology by collecting the electric current more efficiently and providing protection against micro-crack effects. SWT is especially attractive for high-efficiency solar cells because of the lower temperature cell connection and the superior energy extraction obtained with the micro-wires' properties



A current trend in metallization relates to the number of busbars used in the cell layout. As for each new development, the transition always needs some times. The 3-BB, still dominating in 2015, was quickly replaced by 4 and 5BB which become the industry current standard. The BB-less (multi-BB) layout is the new trend. The BB-less technologies support mini finger widths. Nevertheless, this will require new interconnection technologies in module manufacturing that cannot be implemented by upgrading existing production tools.

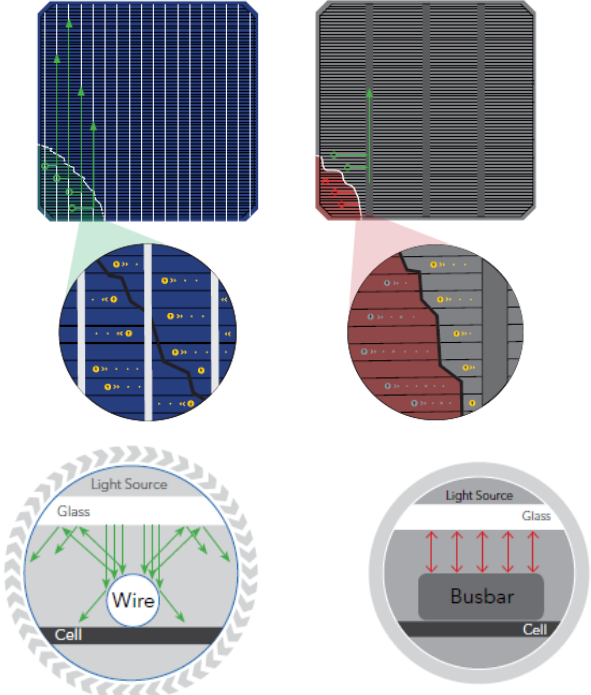
Multi Busbar evolutions:

The superior efficiency of SmartWire Technology is driven by multi-micro-wires that form a dense grid of up to 2,660 contact points on the solar cell. This structure allows electrons to travel a shorter distance in order to be collected, thus reducing resistive losses. The lower resistance enables the extraction of more power from each individual finger, thereby increasing the power density when compared to traditional busbar panels.



The round shape of the micro-wire introduces a light trapping effect which reduces the shading by 25% compared to busbar technology.

Micro-cracks have a minimum effect on modules with Smart Wire since the Foil Wire Assembly acts as a protective layer for the solar cell with the dense grid of up to 2,660 contact points. Even a micro-cracked cell remains contacted, maintaining the energy collection at high levels.



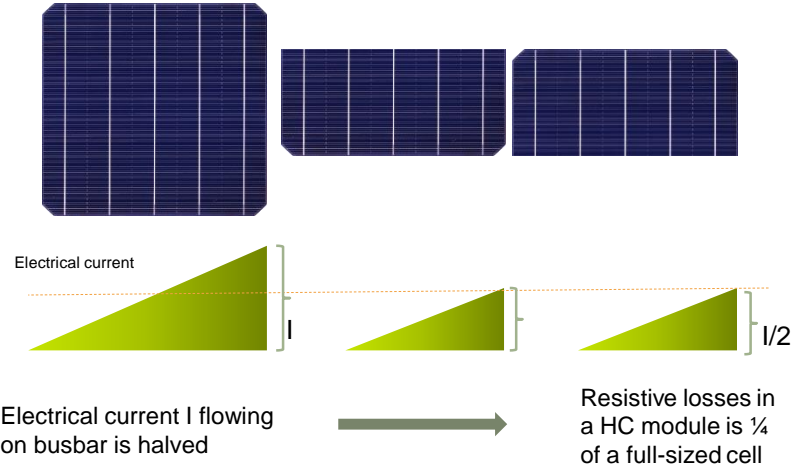
Modules technologies: Half Cell

The half-cut cells generate half the current of a standard cell, reducing resistive losses in the interconnection of solar modules. Less resistance between the cells increases the power output of a module. Solar Power World Online has noted half-cut cells can potentially boost power output between 5 to 8 W per module, depending on the design.

Since this technology requires the additional process step of cutting the cells, as well as a modification of the stringer equipment, it has an impact on cell and module manufacturing.

Because of its performance gains, many companies have already switched to half-cut designs, which should further increase market share for these PV products. It is expected that the market share of half cells will grow from 2% in 2016 to about 35% to 27%.

$$P_{\text{loss}} = I^2 * R_s$$



Lower losses → *higher power*

Lower operating temperature → *higher yield*

Lower hot-spot temperature → *more reliable in operation*

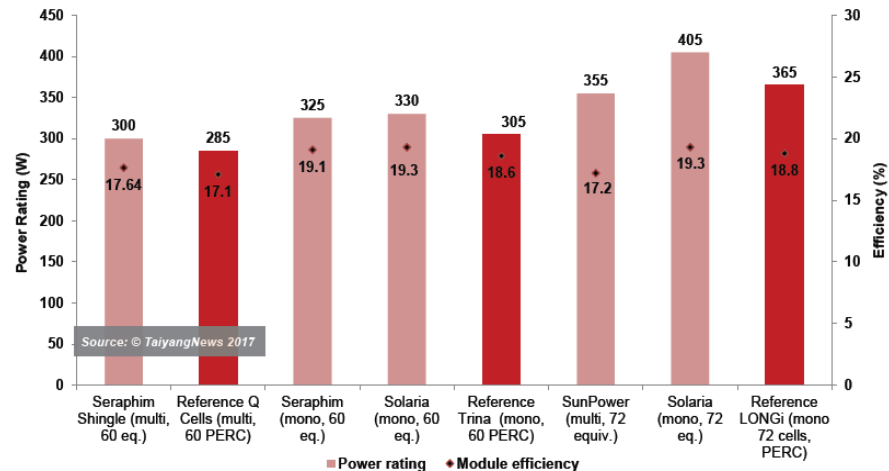
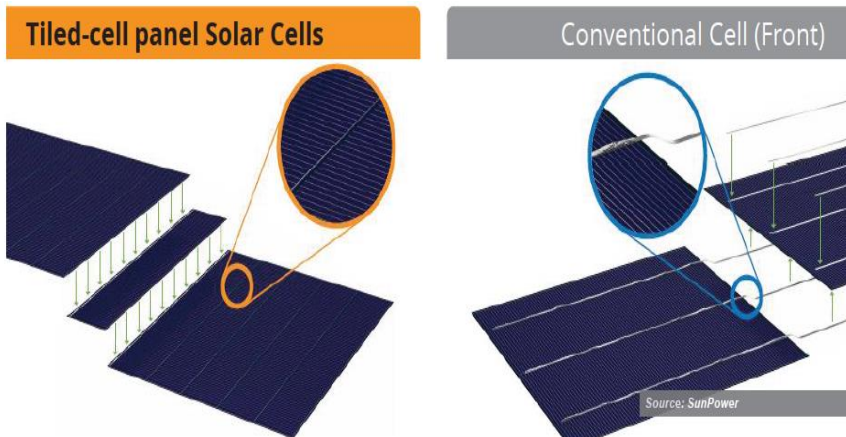
Symmetrical module design → *better shadow management*

Modules technologies: Shingle Cells

New merging modules concept shingles or tiles based interconnection maximizing direct sunlight exposure and raising the module efficiency up to 15%. The full sized cells are sliced into several strips along the busbars. These busbars are used to interconnect two adjacent cells, which means that the busbars are covered in the overlap area.

By shingling the solar cells, the space between the cells is reduced, allowing more cells to be included in each panel. As a result, nearly 100 percent of the panel is covered with solar cells

Shingling, though a bit more complicated in production than standard panels, results in very high module output power.



Bifacial Modules

Bifacial solar PV modules are a disruptor technology to be excited about. The versatility of these products will allow a diverse portfolio of customers to invest in solar because of the benefits bifacial modules can deliver. These modules work great for utility projects, rooftops and specialty installations, such as floating solar projects.

Novel applications: PV on water

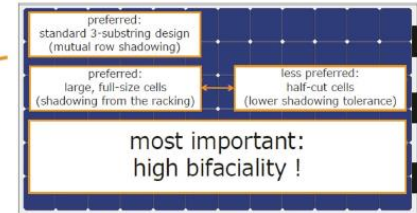


- Use of unexplored, available space
- Contribute to natural ecosystem
- Bifacial energy gain up to 30%
- Systems can be south facing, or vertical east-west
- Ideal for matching electricity generation with consumption peaks!

R. Kreiter, 4th bifiPV workshop, Konstanz, Germany, 2017



Novel applications: Agri PV



Remaining grass below modules

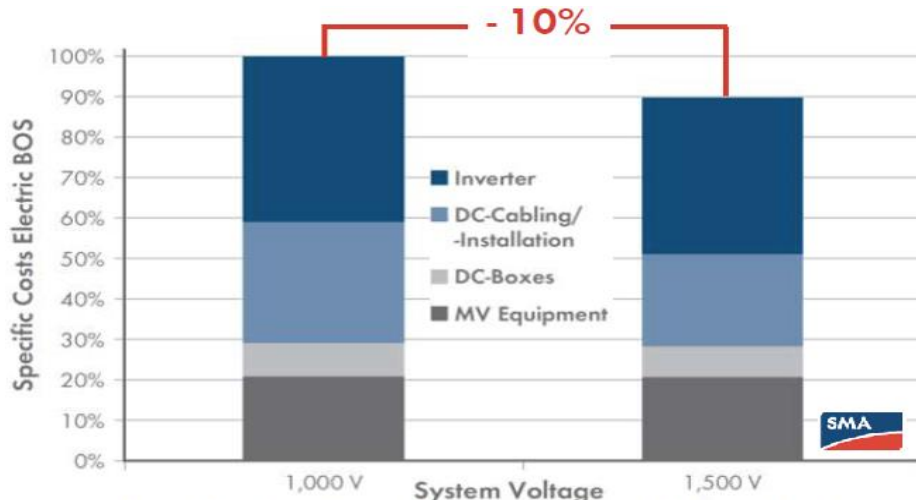
- Bifacial energy gain 10%: proven
- Electricity production in morning & afternoon
 - Better matching with electricity need
 - Higher electricity price

H. Hildebrand, 4th bifiPV workshop, Konstanz, Germany, 2017

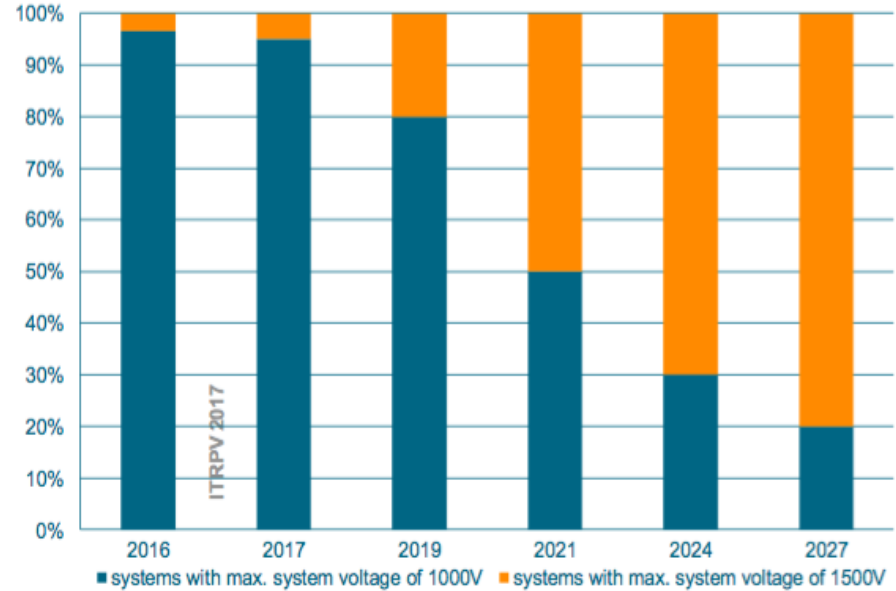


1500V module benefits

The utility solar PV market is undergoing a significant transformation as demand grows around the world. With much of this growth driven by continued cost reductions, we are beginning to see a transition to 1,500 volt DC systems. Higher voltage systems minimize balance of systems requirements and contribute to lower overall PV system costs. Similar to the global switch from 600 volts to 1,000 volt PV systems that occurred in 2012 and 2013, we expect the transition to occur rapidly as the supply chain scales and the value proposition is proven.



* Evaluation based on analysis of 4 major electrical BOS cost components. Excluding panels, mounting structure, tracker etc. Calculation should be used as an example, cost savings highly depend on project conditions.



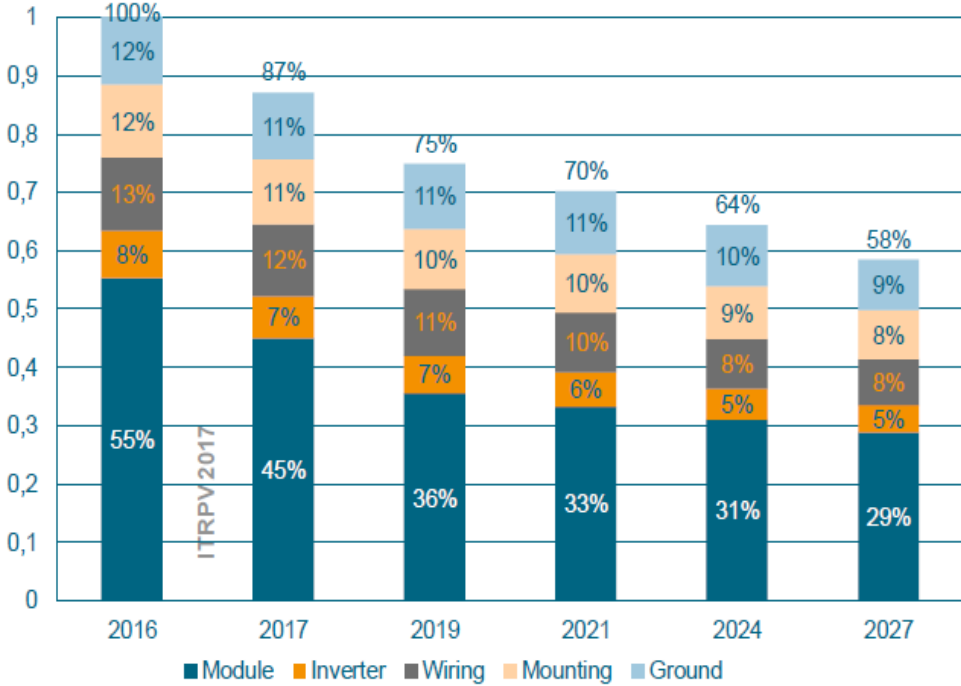
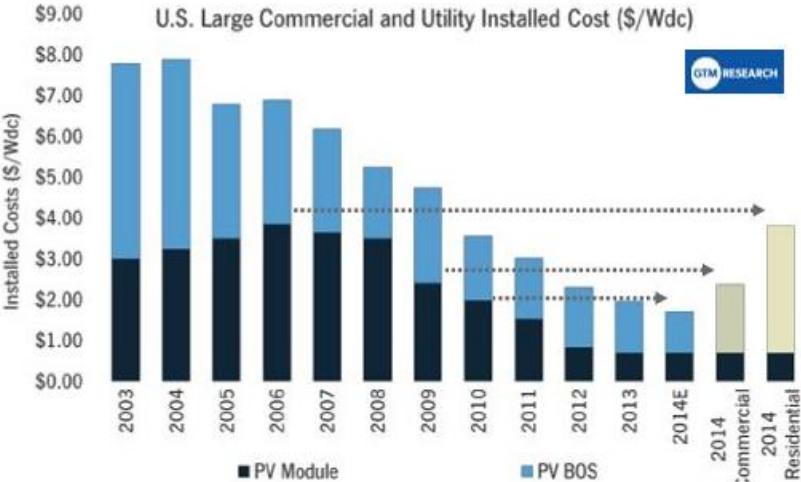
GTM Research expects 1,500-volt systems to account for 9 percent of worldwide utility solar installations in 2016, accounting for 4.6 GW of demand.

The need to reduce price will accelerate demand for 1,500-V components. The market is expected to grow greatly year on year.

Balance of System (BOS) trends

Due to the significant reduction of PV module prices over the last few years, balance of System (BOS) cost has become a crucial factor in overall system costs that impact the levelized cost of electricity (LCOE).

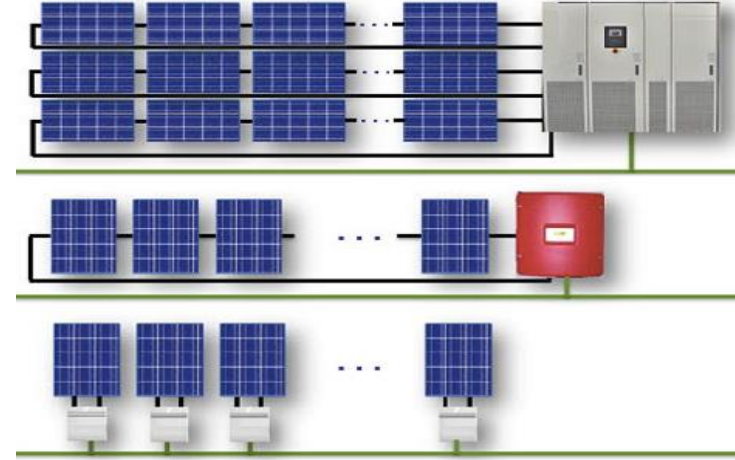
Historically, innovation in the BOS space has been somewhat limited, given its smaller share of the total system. Since the BOS costs represent more than half of total project costs, the attention from developers and EPCs is increasingly placed on a project's balance-of-system (BOS) costs.



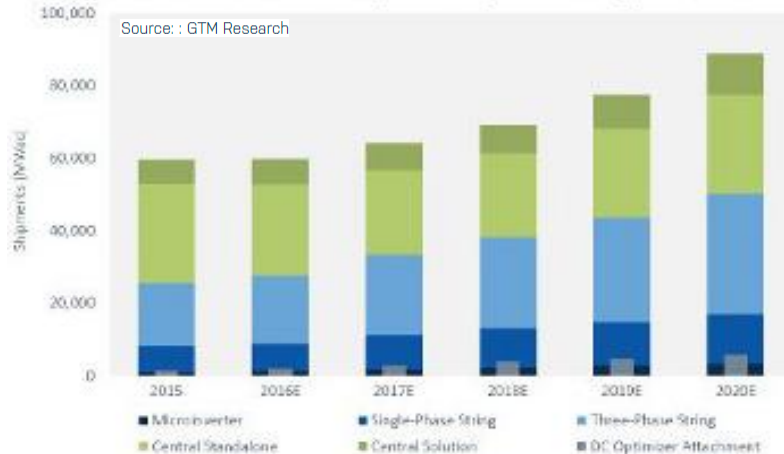
The LCOE future cost reductions are expected to be highly dependent on BOS (e.g. inverters, wiring, racking and mounting systems, civil works, etc.) rather than PV modules, despite continued cost reductions expected from modules.

Inverter developments

Impressive progress has been achieved during the last decades not only at the module/cell level of photovoltaics but also in the inverter technology. Costs came down from over 1€/Wp in 1990 to almost 0.10€/Wp 2014. Efficiencies and power density have increased significantly. At the same time inverters became “smarter” by offering advanced monitoring and communication interfaces that help to improve the availability and performance of PV installations. The electronics of these systems allow for high efficiencies in partial and peak loads and feed the alternating current into the grid with a synchronous frequency.



Global PV Inverter Shipments by Product Type, 2015-2020E

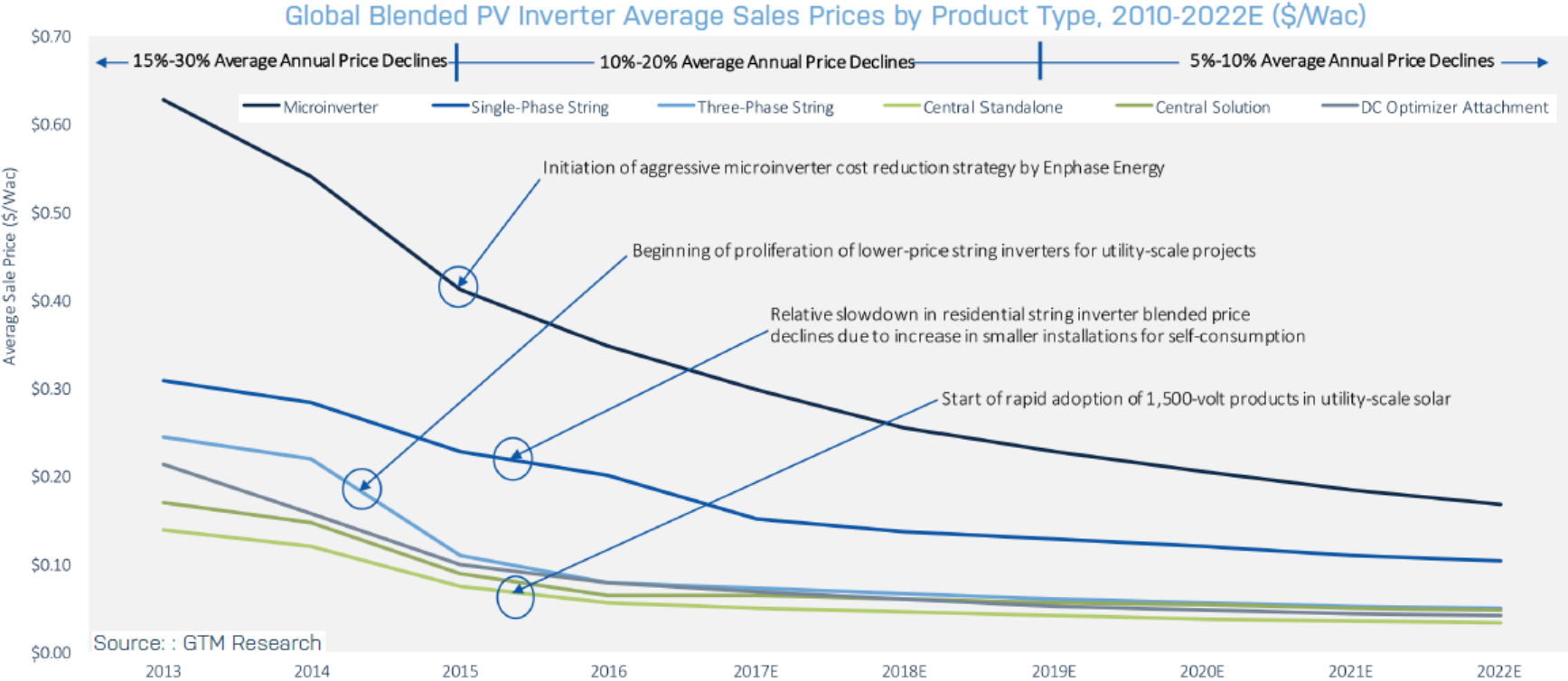


There are three types of inverters: central inverters, string inverters and micro inverters.

Global PV inverter shipments reached a record 80GWac in 2016, up from 59GWac in 2015 and 98.4GWac in 2017. A new report suggests that PV inverters and module level power electronics will grow at an average annual rate of 11% between now and 2020, with central inverters set to relinquish market dominance

Inverter price trends

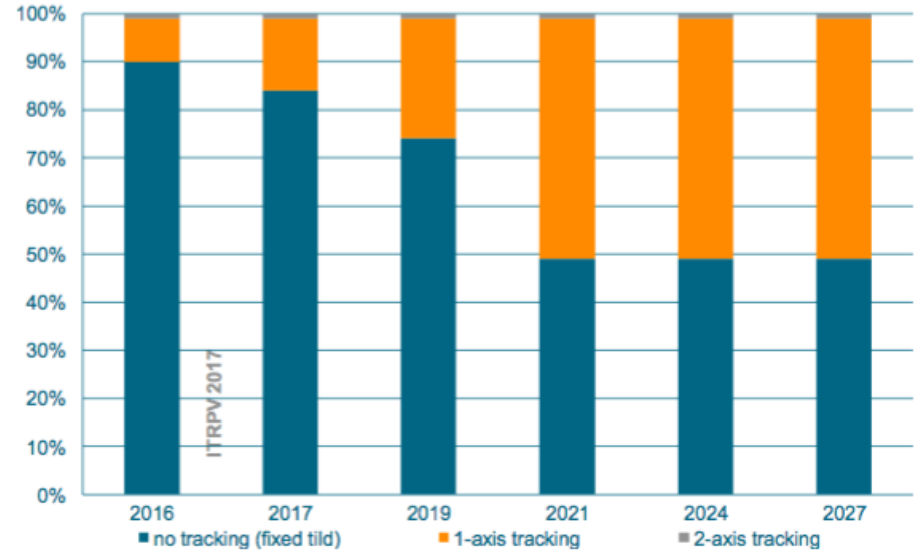
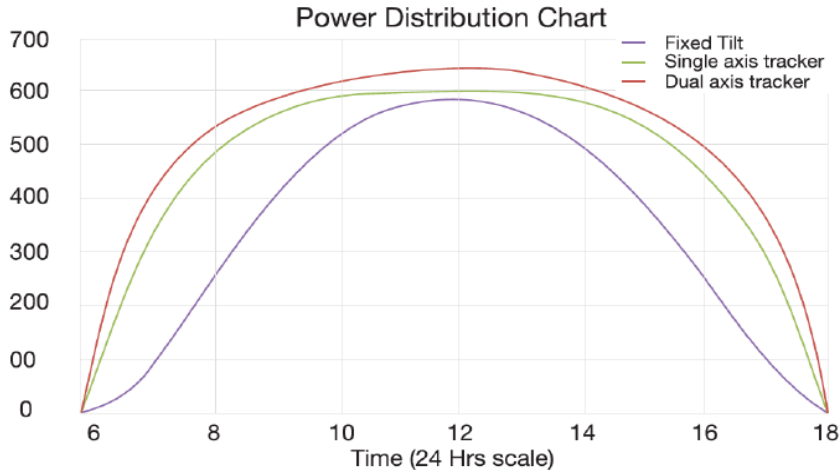
Technological advancements including higher-voltage inverters, more power-dense products, and next-generation switching materials, have yet to exhaust their cost-reduction potential. This will result in continued price declines through 2022.



Tracking vs. Fixed structure

To capture the maximum amount of irradiance, the array needs to be focused towards the sun position, thus maximizing effective area and receiving direct beam radiation. Trackers increase the production of a site by 20+ percent over fixed-tilt. Not only will the site see increased annual production, but increased production during peak hours which provides added value in territories with Time-of-Use rates.

Tracker costs are also dropping significantly, partly due to price competition from suppliers and partly due to design innovations.

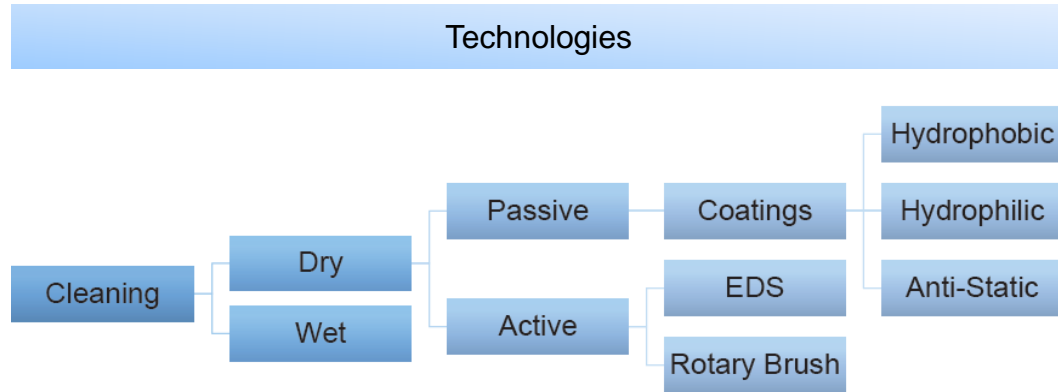


Taking these factors in combination, utility-scale single-axis tracking systems provide the lowest solar LCOE.

In the battle for ground mount market share, single-axis trackers are steadily penetrating the solar market and this trend is expected to continue for at least the next few years

Dust issue and cleaning technologies

Soiling is a very site-dependent characteristic. The cost/benefit trade-off for deploying cleaning procedures depends on the (local) costs for cleaning and energy gain. Regular cleaning of all the PV modules can be considered if the annual soiling loss factor is 5–6% or more.



Challenges



The factors that influence dust settlement are:

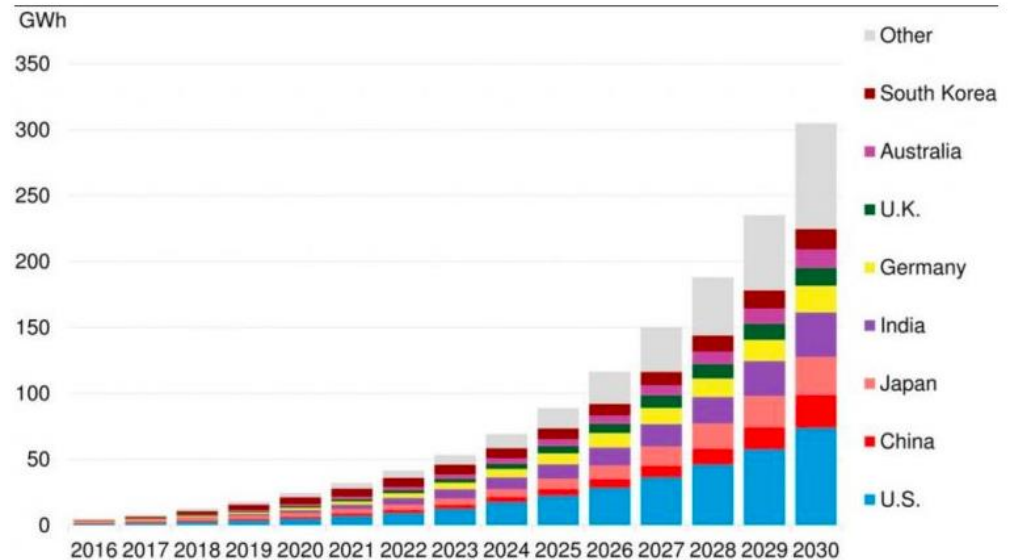
- Site characteristics: vegetation, traffic, air pollution
- Ambient temperature, humidity, and precipitation
- PV system tilt angle and orientation,
- Dust properties: type, size, density and shape
- Wind speed and wind rose
- Texture and characteristics of the glass



Storage deployment

Energy storage technologies are emerging as a critical part of the solution to increase access to electricity in conjunction with solar PV applications. Energy storage can be deployed in most PV markets today, including residential, commercial and utility segments. It can reduce grid power usage at certain peak electricity demand times, which can help drive down customers' electricity bills, and it can also be used to smooth system output to overcome grid integration challenges in both new solar installations and those that are retrofitted with storage. In the past, the majority of storage usage was in the off-grid market; however, storage is now being used to back up grid-connected projects. If solar PV systems are expected to replace existing energy sources, it is crucial that storage will be used.

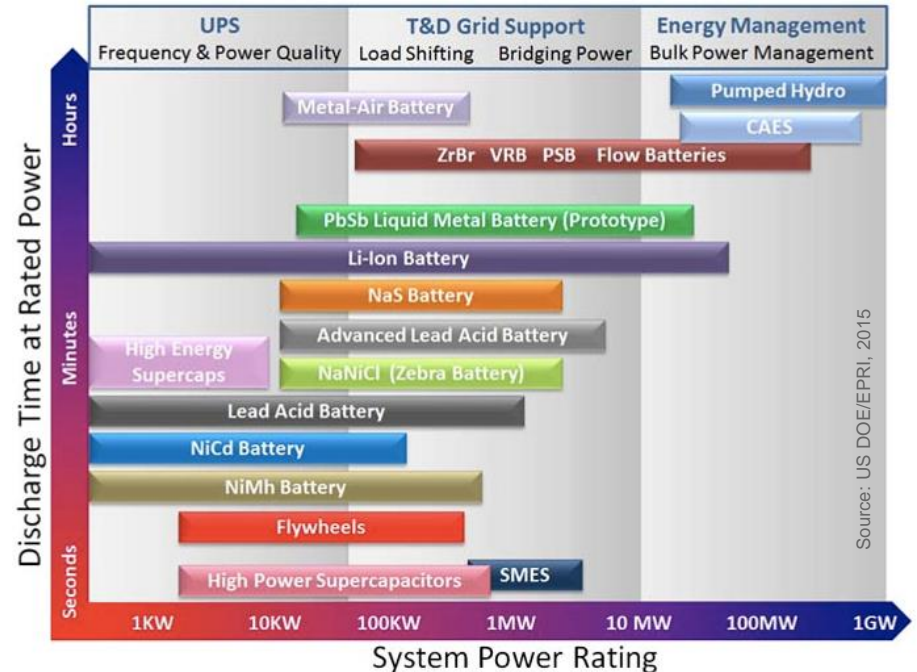
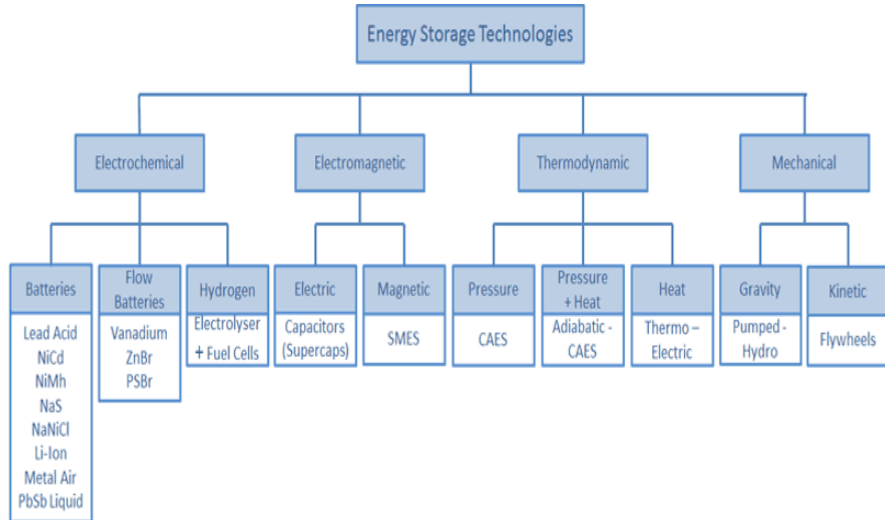
The rise of energy storage will enjoy a similar meteoric trajectory to that enjoyed by solar PV deployment in the past and could reach 305GWh of installation by 2030, BNEF has predicted.



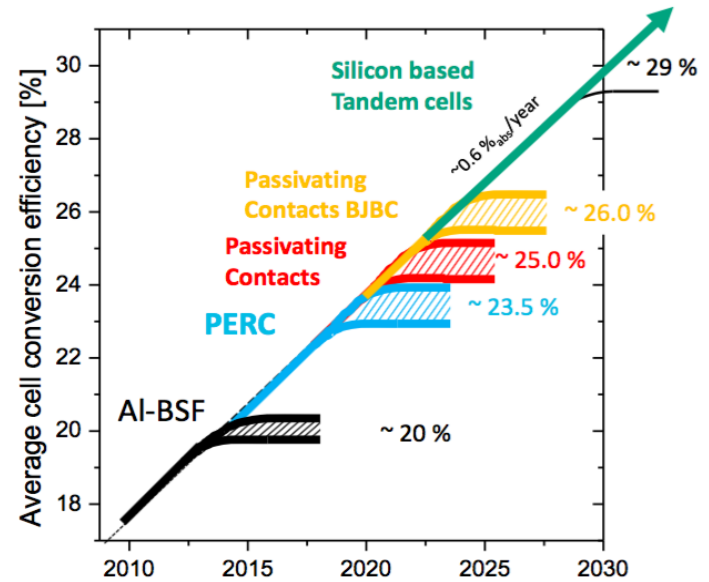
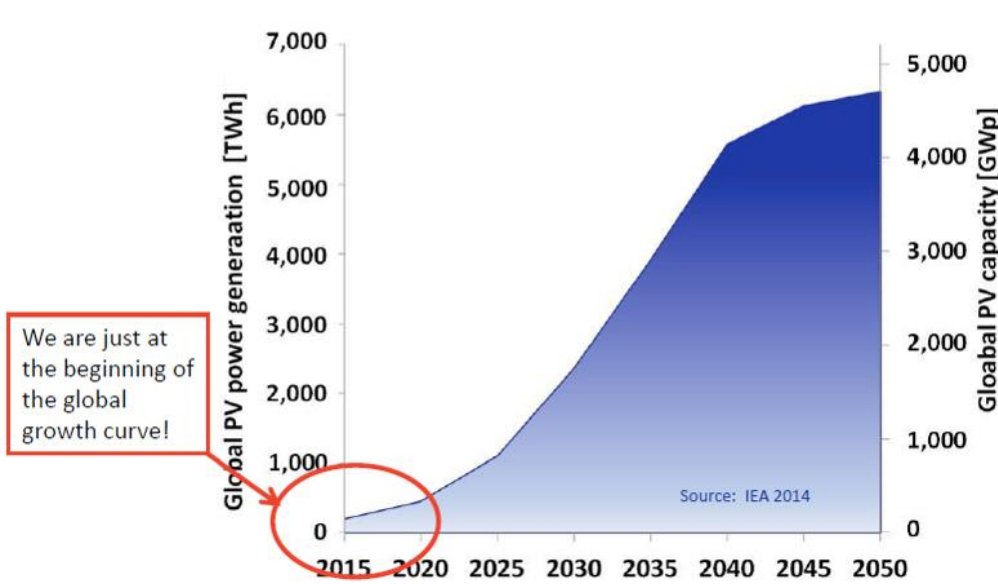
Global cumulative storage deployments. Image: BNEF.

Energy storage technologies and application

There are numerous energy storage technologies, each one has different intrinsic properties that determine its technical suitability for certain applications or provide certain services to electricity systems. For example, depending on their discharge times — at a rated power ranging from seconds to hours and with system power ratings from the kW level up to the GW order – these technologies are more suited to specific applications within electricity systems.



Solar age is at its start ; more innovation requested



Technology development combined with the rapid growth of production volumes resulted in an unprecedented reduction in PV production cost and prices. The next PV module generation will be a combination of different technologies at both Cell and Module level. Mono PERC is at present the most cost-effective c-Si high-eff. leading technology that is best used at multi-gigawatt scale industrial production. Half cells modules, currently present the most advantageous cost-benefits balance. The Multi Bus Bar is the next evolution of traditional busbar-based technology. The Bifacial module offers the highest potential for reducing LCOE. Additional significant cost reduction is possible on a system level.

Technology report, H1-2018

The solar PV is a fast moving developing technologies. The information provided in this report is very concise by its nature. The purpose of this report was to provide a rough overview of the technology status and its potential for further development and thus cost reduction.

The technologies listed in the this report as well and the trends are not exhaustive. The report was specifically designed this way to highlight the potential for solar PV to significantly impact the electricity generation portfolio and explore the challenges likely to be encountered as the market growth and diversifies. Its rather a description of technologies that are revalorizing the solar PV sector. The given information in these report is a result of divers investigations, compilation of information and data.

My thanks goes to all the institutes, organizations, intelligence firms, magazines etc.. Active in the sector providing valuable information and data.

Special thanks goes to SolarUnited and Becquerel Institute for their support

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Disclaimer:

This report has been written based on compilation of information from divers reports, articles and data intelligence. All have been referenced.