WHAT ARE SOME OF THE UPCOMING PV MODULE TECHNOLOGY INNOVATIONS THAT WILL BRING DOWN THE SOLAR COSTS IN THE COMING DECADE?

In the 2020s, solar module costs will continue to fall, albeit at a much slower rate. Instead, improvement in module efficiency and power class will propel the declining capex trend forward and ultimately lower the solar levelised cost of energy (LCOE), new research from Wood Mackenzie found. Wood Mackenzie examined three technologies that have the potential to improve solar module power class and performance: large wafer, n-type cells, and cell- and module-level techniques. Module technology innovations, in addition to hardware cost reduction, will be the quintessential driving force that propels the continuous reduction of solar LCOE in the new decade, let's find out more

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Solar PV has been one of the pioneering renewable technologies for more than a decade and is turning out to be an environmental savior. The various technological changes in Solar PV modules has resulted in significant cost reduction in capital cost of setting up large Solar PV Project. The Technological changes in module technology has made solar power affordable globally and is going to become the cheapest and sustainable source of energy. In recent bidding by Solar Energy corporation of India (SECI) the tariff derived is INR 2/Kwh.

The total installed capacity of solar PV reached more than 550 GW globally (excluding CSP) by the end of 2019, representing one of the largest renewable energy sources globally.

The evolution of the solar PV industry so far has been remarkable, with several milestones achieved in recent years in terms of installations (including off-grid), cost reductions and technological advancements, as well as establishment of key solar energy associations such as International Solar Alliance. Solar power will clearly continue to be an essential renewables option in the coming decades.

Today, the photovoltaic modules are a well-known product. Everybody knows the differences among monocrystalline and polycrystalline modules, but not everyone knows that there are some peculiarities that determine performances, duration and reliability. Thin film technology is also an option but not getting favorable support from the industry due to techno-economical reasons.

Together with other innovations, many players have introduced modules with PERC technology (Passivate Emitter and Real Cell) which are made with monocrystalline silicon cells with the back layer passivation. In this way, it is possible to increase the possibility of the photons recombination and to increase the internal reflection at the junction.

The main producers have introduced PERC technology, certain measures to counteract the phenomena of performance degradation over time and some.

The Industry is continuously revolving and the new norm is bifacial Perc technology modules which will increase energy yield depending upon the albedo of the surface installed. The countries such as India and the Middle East where solar projects are being installed on sandy soil are focusing more on bifacial Monperc module with tracker.

It can be concluded that with innovation in Module technology the solar tariffs will keep on reducing resulting in the cheapest source of energy with environment protection.

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The rapid introduction of high-power modules across the PV industry in 2020 signals a new phase, where the module assumes an enhanced role in bringing down the levelized cost of electricity (LCOE).

The PV module manufacturers no longer compete only on a $/W basis, but also on a LCOE, $/kWh basis. Of course, the latter calculation can be very complex, and country and project specific, but, overall, we see projects being won on this basis, with the manufacturers getting premiums in return. However, these premiums will be temporary, as the fundamental costs are down, and competition will eventually push prices down. There are several paths towards LCOE reduction.

The introduction of bigger wafers and bigger modules has a clear cost advantage on the module cost. Equally important, the introduction of dense interconnection technologies, such as paving, tiling and shingling, combined with multi busbar and half-cut cells, increases the module area efficiency, and decreases the $/W module cost. As said above, the cost savings will eventually be given to the buyers, but even so, bigger, more efficient modules require less, land, steel, labor and electrical components, bringing down the balance of system costs and reducing the LCOE. There is another potentially important driver of LCOE reduction, based on energy yield increase, due to the trend towards improved power temperature coefficients, better yield at low sun angles, increased bifaciality etc.

However, these newly introduced module-level technological improvements will be soon reaching their limits, as, for example, it is not practical to increase either the wafer size or the module size beyond certain limits. Eventually, the manufacturers will have to readjust their focus on developing and scaling up higher efficiency cell technologies, such as n-type passivated contacts (also known as TOPCon) or heterojunction and abandon the PERC cell platform, which will soon reach its limits. The move to n-type has been pushed back, because of "lower hanging fruit" improvements being reaped first, but eventually the tough competition on a LCOE and module cost basis will force them to move ahead, probably in the next 2-3 years.

However, single junction silicon-based PV has maximum efficiency limits, so there are new candidate technologies, such as tandem thin film perovskite on heterojunction silicon cells, that can give us 30%+ efficient modules. There are huge technological hurdles to overcome, of course, but the rewards are so high, and the amount of effort and innovation will be so intense, that it is certain that by the end of the decade, advanced module technologies will be available in vastly massive volumes, bringing down the LCOE from PV plants to "penny" level, and the focus of the energy industry will gradually shift to making this, almost free energy, dispatchable to the grid or directly to consumers, by integrating storage technologies and time-shifting these ultra-cheap electrons to the time slots that they are needed or even use them to produce valuable molecules, such as hydrogen.

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As of 2018-19, India's per capita electricity consumption is 1,181 units, which is lower than half of the world's average. With a population of 1.3bn people, a massive increase in electricity production is required to support economic and population growth. Almost all of the new capacity would come from renewables. DNV GL's Energy Transition Outlook 2020 forecasts that the share of electricity in final energy demand in Indian subcontinent will almost triple to a 42% share in 2050.

Based on the Central Electricity Authority (CEA) report on optimal generation capacity mix for 2029-30, the solar generation capacity in India is slated to increase from 34.6GW in March 2020 to 280GW by March 2030. Solar has already reached tariffs lower than conventional sources, and in the recent auction it reached a new minimum of 2 Rs. per unit. There are currently research and innovations going on throughout the supply chain which have the potential to further reduce the cost.

The solar industry will continue to move towards larger wafers that have the potential to reduce the CapEx further for the utility scale solar project. It is expected that in the next 10 years, M10 and G12 wafer-based modules will dominate the production facilities while currently dominated wafers of less than M6 will be gradually phased out. Larger wafer sizes increase power output, thereby reducing the per-watt production cost. However, in order to limit the weight, the glass needs to be made lighter thereby reducing the wind loads and making microcracks more likely to happen.

The current preference for PERC (passivated emitter and rear cell) modules would continue before switching to n-type modules and finally to introduction of tandem cells for higher efficiency in the coming decade. PERC technology increases the efficiency by increasing the possibility of the photon absorption and reducing electron recombination and heat absorption. Though p-type cells have dominated the market so far, the industry will move towards n-type in the coming decade for higher efficiency. N-type modules such as HIT and TOPCon have already proven higher cell efficiency, however, the gains achieved by these efficiencies have been negated by high production costs. There is a need to reduce the cost of production of these cells in order to increase uptake.

Tandem technologies can increase performance beyond the single junction theoretical limit. For example, a combination of silicon as the bottom cell with III–V based top cells has already demonstrated in laboratories efficiencies well above 30%. The major challenges, though, are to produce defect-free III–V layers at a lower cost.

Another emerging technology is perovskite solar cells (PSCs) made with metal halide base, which has several advantages such as strong absorption coefficient, long carrier lifetime and diffusion length. PSCs can be easily integrated with other technologies to create hybrid tandem. For example, combined perovskite and Si-PV materials have shown a record efficiency of up to 28% under laboratory conditions.

Perovskite-Perovskite tandem solar cell (PPTSC) has shown huge potential in terms of fewer fabrication processes, higher efficiency and lower cost for the recycling at the end of their lifecycle. The current research on tandem is more focussed towards reliability, lower cost processes and durable materials.

While the last decade mostly saw the significant drops in solar tariffs largely on account of economies of scale, the coming decade will see the overall optimisation and innovation in all facets, including pushing efficiency boundaries. It will also see significant diversification of solar usage mainly in the areas of floating solar, building integrated PV and agrivoltaics.