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TECHNOLOGY INSIGHTS

Additive Manufacturing: Supercharging the Solar Cell Industry

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SUMMARY

Global energy demand is increasing. Satisfying this rising demand using fossil fuels exclusively is neither sustainable nor feasible. There has been an abundance of research focused on how to meet a portion of this demand using renewable energy sources. Silicon solar cells have decreased in cost and can now produce electricity for less than $0.068/kWh (PV Magazine, June 2020). However, silicon remains inefficient at converting light into electricity. In order to mitigate this problem, companies are developing highly efficient solar cells based on new materials, though the price of these remains very high. Additive manufacturing, a process in which existing silicon solar cells can be made more efficient by adding an extra material layer, is a lower cost option to increase the efficiency of existing silicon solar cells. Consequently, solar power has a greater potential to meet large proportion of our future energy demand.

Additive Manufacturing:

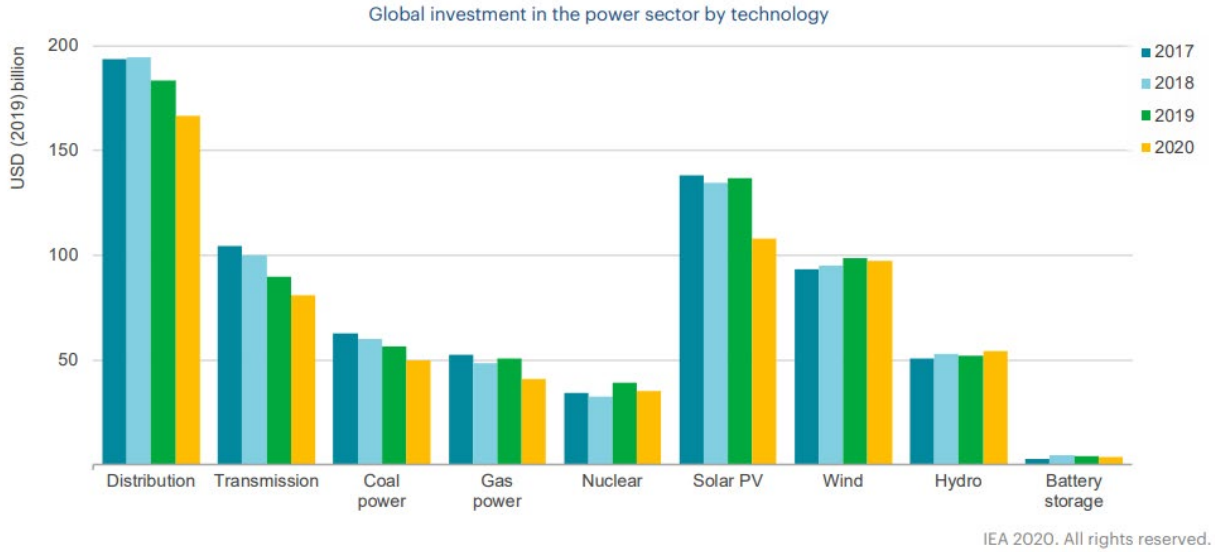
Supercharging the Solar Cell Industry

By Sarwat Baig

THE DEMAND FOR RENEWABLES

The demand for energy is expected to increase by 27% (to 193 PWh or 10^{15} watt hours) by year 2050 due to global population growth and the development of non-OECD (Organisation for Economic Co-operation and Development) economies. Satisfying this escalated demand through the use of existing fossil fuels sources such as coal, oil and natural gas is unsustainable. In order to prevent global warming from exceeding the level deemed “safe” by leading environmental experts (a temperature increase of 2°C), alternative sources of energy must be used to minimise CO_2 output. Consequently, there has been much interest in using

renewable energy to meet this demand, fuelled by ongoing research and development in the renewable energy sector and increased investment in renewable technologies. New investments into renewables stood at around to $300 billion USD in 2019, excluding distribution investments, which illustrates the growing interest in renewable energy against a reducing investment in coal, gas and nuclear.



SILICON COST VS. EFFICIENCY

The cost of producing electricity using silicon solar cells has dropped by 59% since 2010, down to less than $0.5 USD per kWh, making solar energy more competitive than ever before. This significant decrease in cost can be attributed to the decreasing cost of silicon substrates, reduced manufacturing costs and better device design, all of which have led to decrease of the USD per Watt ($/W) value.

Since production of silicon wafers is still very cost-effective, the solar cell market continues to be heavily dominated by mono-crystalline and polycrystalline silicon (comprising 90% of the market). The remaining 10% of the market consists of emerging thin-film technologies, which include cadmium-telluride, amorphous-silicon and copper-indium-gallium-selenide. In comparison to other emerging thin-film solar technologies, silicon is very inefficient at

converting sunlight to electricity. Commercially available silicon solar cells have an efficiency of up to 24% which is fast approaching the accepted theoretical limit of silicon solar cells of 30%.

EMERGING RENEWABLE ENERGY

The goal of the solar industry is to produce electricity as cost-effective as possible, at the lowest $/W. In order to realise this goal, demand must be met with panels that are highly efficient, cheap to manufacture, easy to install and simple to maintain. Several small companies within Europe and North America are developing new technologies for highly efficient solar cells. These companies are using new materials such as III-V semiconductors (NanoFlex Power Corporation, Spectrolab, Azur Space, Alta Devices), organic semiconductors (Eight19, InfinityPV, VTT, Solarte), and perovskites (Oxford PV, Dyesol). Some are working to develop their technology for commercialisation, some target very specific industries such as aerospace, and some focus on energy harvesting for handheld devices. The three biggest producers of silicon solar cells (SunTech, Trina Solar and Yingli Green) have yet to introduce non-silicon based solar cells for commercial use.

> The COST of producing electricity using SILICON SOLAR CELLS has DROPPED by 82% since 2010, down to $0.068 per kWh in 2019

OPPORTUNITY FOR INNOVATION

Despite the great potential demonstrated by the emerging players, these new technologies are many years away from being as economically viable as silicon panels. For this reason, *additive manufacturing* is the interim solution for increasing efficiency while reducing the $/W. This process involves creating an extra layer that can be affixed onto a panel. Various methods can be used to accomplish this. One option is to use a 3D printer to print a light trapping layer directly onto a silicon solar cell. This causes tiny structures to trap light within the solar cell thus enhancing absorption and increasing efficiency. Another option is to make use of solar concentrators to force the light to strike the solar panel multiple times. Furthermore, it is now possible to grow III-V semiconductors onto silicon which increases the efficiency of the solar

cell from 24% to 44%. This method has great potential since the theoretical limit for multijunction solar cells is 86%.

CONCLUSION

Silicon will always have a presence in the solar industry as a cost effective but inefficient solar cell. However, as researchers continue to develop more efficient materials for use in solar cells, we can anticipate that these materials will be able to produce electricity more cost effectively. It is reasonable to expect solar cell technology to be the driving force in the renewable energy sector in the years to come. By 2050, solar is expected to dominate global electricity production and satisfy 65-80% of energy demand worldwide.