Can Solar PV Array Prices Go Down Further?

Rajesh Bhargava[*], *Digambar Singh Govind*[**], *Sonali Sharma*[**]

Abstract

Solar technology is not new. Its history spans from the 7th century BC till today. Now a day, we have everything from solar-powered buildings to solar powered vehicles. Firstly photovoltaic technology was born in 1954 in the United States when Daryl Chapin, Calvin fuller, and Gerald Pearson developed the silicon photovoltaic (PV) cell at bell labs. Now, photovoltaic's solid-state junction devices, often made of silicon, have dominated the conversion of sunlight to electrical power. This dominance is now being challenged by the emergence of a new generation of photovoltaic cells, based on nano-crystalline materials and conducting polymer films, making solar power much more expensive in comparison with conventional fuels. A newer type of solar cell made from a material called 'perovskite' is significantly cheaper to obtain and use than silicon material. It could generate as much power as today's commodity solar cells. Highly efficient solar cells using perovskite can be made using a simple and inexpensive technology. While the policy and regulatory environment played a vital role in the ramping up of solar capacity in India, the impact of the sharp reduction of prices of solar PV systems. Especially solar PV systems which have fallen by more than 40 percent in the last three years cannot be overlooked. The critical question is that will the price of solar PV continue to drop or will they start increasing from now on?

Keywords: Solar Technology, Photovoltaic Cell, Polymer Films.

Introduction

Perovskite based solar cells

Perovskite is a calcium titanium oxide mineral species composed of calcium titanate, with the chemical formula $CaTiO_3$. It has a formula mass of 135.96. it is available in black reddish brown, pale yellow, and in yellowish-orange color. While conventional silicon solar panels use materials that are about 180 micrometers thick, the new solar cells use less than one micrometer of material to capture the same amount of sunlight. When perovskite were first tried in solar cells in 2009, efficiencies were low. They only converted about 3.5 percent of solar energy into electricity. However, replacement of a liquid electrolyte with solid materials solved this problem. Solar cells made up of perovskites have a simple architecture and can easily be produced in large quantities

[*]M. Tech. Scholar, Department of Mechanical Engineering, L.I.E.T., Alwar (Raj), India.
[**]B. Tech. Final Year, Department of Electrical Engineering, L.I.E.T., Alwar (Raj), India.
Correspondence to: Mr. Rajesh Bhargava, M.Tech. Scholar, Department of Mechanical Engineering, L.I.E.T., Alwar (Raj), India. ***E-mail Id:*** rajeshbabal73@gmail.com

because the vapor deposition process used to make them is compatible with conventional processing methods for fabricating such solar cells. Prototype solar panels incorporating nanotechnology are more efficient than standard designs in converting sunlight to electricity, promising inexpensive solar power in the future.

Figure 1.Pervskite in Mineral Form

How a Perovskite Solar Cell Works?

Organo-metal-trihalideperovskite semiconductors, with the formula (CH_3NH_3) PbX_3-where Pb is lead and X can be iodine, bromine, or chlorine-were first employed in 2009 as the lights-absorbing component in so-called dye-sensitized solar cells. In these devices, the perovskite were coated onto the surface of a film made of titanium dioxide (TiO_2) nanoparticles. When the perovskite layer absorbs light, electrons, and holes are generated. These charge carriers are subsequently transferred to different transport materials-TiO_2 for the electrons and to another material for the holes. The transport materials then carry the charges to separate electrodes, and a voltage is produced. These solar cells have light-converting efficiencies of 12-15 percent. These perovskite-based solar cells have opened up whole new vistas of opportunity. Contrary to expectation, some of the new devices have strikingly high conversion efficiencies, which compete with those of conventional devices. The new solar cell has entered the official tables of efficiency records published by the national renewable energy laboratory (NREL).

Benefits of Using Nanoparticles in the Manufacture of Solar Cells

- Reduced manufacturing costs as a result of using a low temperature process.
- Reduced installation costs achieved by producing flexible rolls instead of rigid crystalline panels.
- Currently available nanotechnology solar cells are not as efficient as traditional ones; however, their lower cost offsets this. Nanotechnology solar cells using quantum dots would increase efficiency levels significantly.
- It is believed that solar cell technology will be contributing significantly to our energy needs by 2020 as costs are dropping rapidly.
- According to Deli Wang, the efficiency of nanowire solar cells have been increasing dramatically in the past few years, from tenth of 1 percent to 15-16 percent. While it is still lower than the best silicon cells, but it is fast improving.

In the series of photovoltaic cells, which convert sunlight into electric current, quantum, dot-based (QD) solar cells have also shown great potential as next generation, high

performance,, and low cost photovoltaics due to the outstanding optoelectronic properties of quantum and their multiple excitation generation (MEG)capabilities. The recent development of organic-inorganic perovskite hetrojunction solar cells has shown great future as light harvesters. Lioz Etger in his article titled 'semiconductor nanocrystals as lights harvesters in solar cells' published in materials journal has described mechanisms, procedures, advantages, disadvantages, and the lasted results obtained in this field. Semiconductor QDs are promising alternatives to be used as light harvesters in solar cells. The properties of semiconductors QDs can be changed by tailoring their size. In addition, their band gap can be tuned to different wavelengths of light, allowing them to harness energy from easy to manufacture, making it possible to fabricate QD solar cells at a low cost.

Challenges Ahead

Like any other new entrant into the highly competitive solar-panel market, perovskites will have difficulty taking on silicon solar cells. Also, since cost of silicon solar cells are falling and some analysts think they could eventually fall as low as 25 cents watt, the financial aspect of both silicon and perovskites would have to be taken into consideration. Thus it is better to augment perovskites rather than replace silicon solar cells to improve their efficiency. This might be an easier way to break into the solar market than trying to introduce an entirely new king of solar cell. Dot-based (QD) solar cells have shown great potential as next generation, high performance low cost photovoltaics due to the outstanding optoelectronic properties of quantum dot and their multiple excitation generation (MEG) capabilities. The recent development of organic-inorganic perovskite hetro-junction solar cells has shown great future as light harvesters. There is however one small challenge associated with the use of perovskite. The material contains small amount of lead, which is toxic. Tests will be needed to show how toxic it is. Steps can also be taken to ensure that the solar cells are collected and recycled to prevent the materials from getting into the environment-the approach pursued now with the lead-acid starter batteries used in cars. It may also be possible to substitute lead with tin or some other element in the cells.

Recent Researches

Flexible solar cells: The currently developed low-cost, light weight and flexible solar cell, from the Massachusetts Institute of Technology, based on sheets of flexible graphene coated with a layer of nanowires can transform the light of the sun for an onsite source of power.

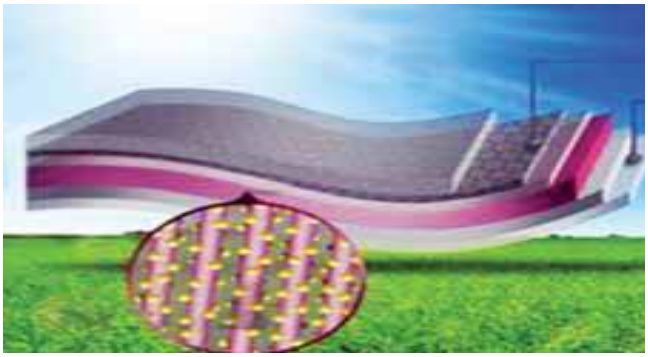

Figure 2.Flexible Solar Cells

ISSN: 2456-1401

Illustration shows the layered structure of the new device, starting with a flexible layer of graphene, a one-atom-thick carbon material. A layer of polymer is bonded to that, and then a layer of zinc-oxide nanowires (shown in magenta), and finally a layer of a material that can extract energy from sunlight, such as quantum dots or a polymer-based material. Low cost, light-weight and flexible solar cells are envisaged for the next generation construction materials known as building integrated PVs windows, roofs and facades that could transform the light of the sun for an on-site source of power.

Now, researchers from the Massachusetts Institute of Technology have come up with a new solar cell that could fulfill these three requirements and has an added benefit of being transparent. The new cell is based on sheets of flexible graphene coated with a layer of nanowires. According to associate professor of materials science and engineering, Silvija Gradečak, building semiconducting nanostructures on a graphene surface without impairing its electrical and structural properties is a challenge. To overcome this, the team used a series of polymer coatings to allow the graphene to bond a layer of zinc oxide nanowires.

They then overlayed a material that responded to light waves. The team also used and tested a series of overlay materials in their devices-including lead-sulfide quantum dots and a polymer calle P3HT. They achieved the best result with the quantum dots, getting a efficiency of 4.2 percent. Currently only proof-of-concept of devices about a half-inch in size have been demonstrated. Even so, Gradečak and her colleagues believe that the manufacturing process is highly scalable and larger commercial sized devices based on these cells will be developed within a couple of year.

Conclusion

The solar PV capital costs have been reducing drastically over the last few year, thereby bringing solar closer to the traditional fuel sources. The increased affordability of solar has helped the penetration of this renewable energy source in almost every part of the world, including India. However, it is quite likely that the solar PV capital cost has hit the bottom. Solar PV module prices are likely to remain stable at the current price levels for the medium term, while inverter prices could go down further. But the decrease in inverter prices will be negated by the increase in prices of other balance of system (BOS) components like steel, electrical equipment, cables and other services. However, a major technological breakthrough-increased efficiencies of modules, inverter technology or other aspects of system-has the potential to completely change this. So, we need to work toward developing solutions that are suited to Indian conditions.

References

[1] Collavini S, Völker SF, Delgado JL. Understanding the Outstanding Power Conversion Efficiency of Perovskite-Based Solar Cells. *Angew Chem Int Ed* 2015; 54: 9757-59.

[2] Kojima A, Teshima K, Shirai Y et al. Organometal Halide Perovskites as Visible-Light Sensitizers for Photovoltaic Cells. *Journal of the American Chemical Society* 2009; 131(17): 6050-51.

[3] Sha WEI, Ren X, Chen L et al. The efficiency limit of CH3NH3PbI3 perovskite solar cells. *Appl Phys Lett* 2015; 106(22): 221104.

[4] Oxford Photovoltaics. Oxford PV reveals breakthrough in efficiency of new class of

solar cell. 10 Jun 2013. Available from: www.oxfordpv.com.

[5] Wang U. Perovskite Offers Shot at Cheaper Solar Energy. *The Wall Street Journal* 2018.

[6] The future of solar: lightweight, flexible and as cheap as wallpaper.

[7] Sivaram V, Stranks SD, Snaith HJ. Outshining Silicon. *Scientific American* Jul 2015: 44, 45, 46.

[8] Eperon GE, Stranks SD, Menelaou C et al. Formamidinium lead trihalide: a broadly tunable perovskite for efficient planar heterojunction solar cells. *Energy & Environmental Science* 2014; 7(3): 982.

[9] Industry Market Trends. Is Perovskite the Future of Solar Cells?

[10] Feng W. Garfunkel Group. Perovskite Solar Cells. Rutgers University. 7 Mar 2014.

[11] Snaith HJ. Perovskites: The Emergence of a New Era for Low-Cost, High-Efficiency Solar Cells. *The Journal of Physical Chemistry Letters* 2013; 4(21): 3623-30.