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DISCUSSION-OPINION-EDITORIAL

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Replacement and cost of replacement of solar panels

Importance of Solar PV Cells in the power scenario

Almost all solutions addressing global warming and sustainable development depend upon the reduced emissions resulting from the substitution of PV power production for fossil fuel based generation. Consistent with this goal, PV power production trends are accelerating worldwide. In the U.S., about 80 GW of power were produced in 2020, and this number is expected to reach as much as 3,200 GW by 2050. To boost the renewable energy installation drive in the long term, India in 2020 set a target of 450GW of RE-based installed capacity to be achieved by 2030, within which the target for solar was 300GW. PV panels have a technical lifetime of 25-30 years, and as existing panels reach their projected end-of-life (EOL), by 2030 the cumulated e-waste volume will hit 200,000 tonnes and grow to seven million tonnes in 2050. However based on economic and technical trends, a break-even analysis in a recent study demonstrates that replacements due to economic considerations could happen after as few as 7 years. The early replacements will result in a large volume of discarded solar panels that might not be reused, mostly going to landfills. The process of removal can damage solar panels – however, damaged solar panels and solar panels that are EOL can still convert sunlight into electricity. A sustainable option for functioning EOL PV modules will be a proper second-life option. Solar panels are expensive to install and for residential projects, the installation cost can equal the cost of the panels. Small portable panels can be inexpensively set up and easily moved. Small panels can also power most portable electronics, charge automotive batteries, and in remote areas, provide a source of power when no alternative is available.

Reusing modules (potentially preceded by repairing) is conceivable, but practically and economically challenging. Recycling processes for thin-film and crystalline silicon PV panels have been developed and to some extent implemented on industrial scale (outside US mostly), but more

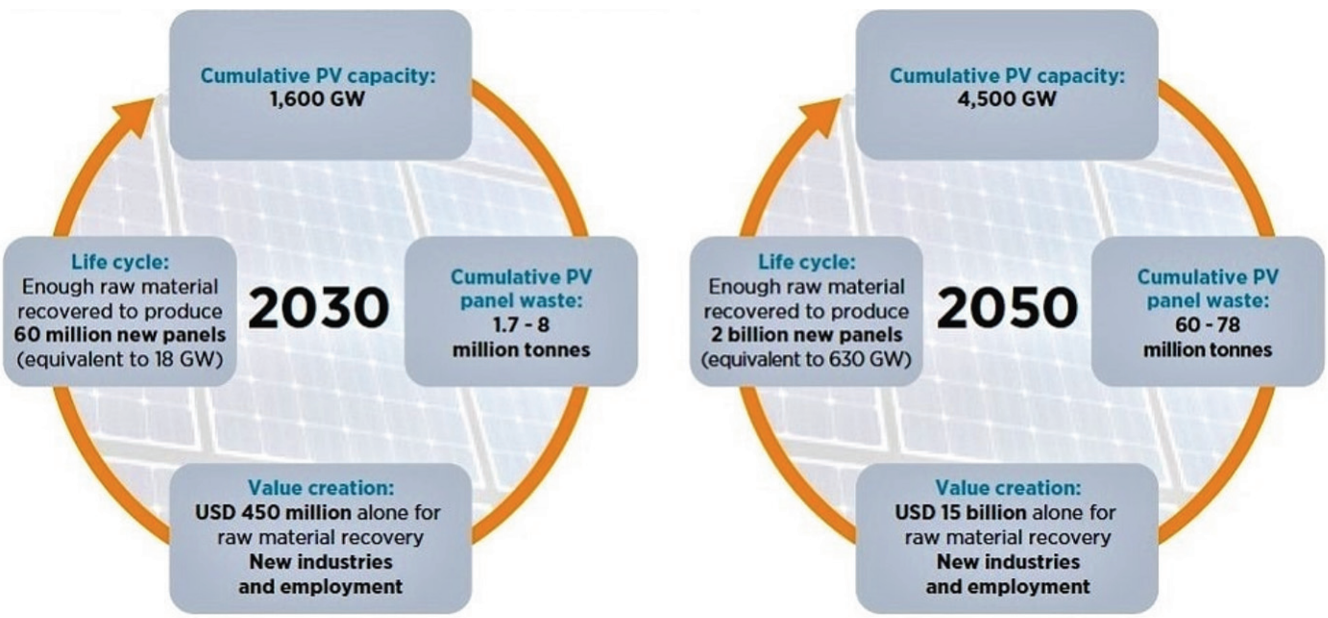

Fig.1 Potential value creation through PV end-of-life management

development is needed. Significant recovery potential for different material streams can be realized through high-value recycling which is not common today. PV R&D has set priority topics for material use reduction or substitution for different components commonly used in today‘s PV panels (e.g., Si, Ag).

The construction

The basic construction of PVs is almost always the same: 36 to 96 silicon cells are arranged rectilinearly and connected in a loop to generate 100 to almost 450 watts. Each cell is made of crystalline silicone and the current is bled by tiny wires of silver conductors, leading to larger bus bars that connect to the panel junction box. The fingers and bus bar metals are silver and copper. The string of cells is laminated between two layers of EVA (ethylene vinyl acetate) foil and covered by tempered glass on the upper side and by a PVF (polyvinyl fluoride) cover on the lower. This multi-material sandwich provides high environmental protection. The tempered glass also adds to the structural stability of the PV panel. An extruded aluminum channel frame adds rigidity, and the junction box is wired to external circuits.

The materials assembled, including their weight share in the entire module, are shown in Table 1. Weight of typical module is about 18.5 kilograms. The glass used in solar panels has a higher transparency than glass commonly used for windows. Aluminum and glass, about 84% of a PV panel’s weight, are easily recyclable by conventional recycling technologies like crushing and sorting. However, the glass gets contaminated during the shredding process – it is reused mostly for construction materials or reflective paint. The most valuable materials in the panel – silicon, copper, and silver – are less than 5% of the total weight.

Replacement of solar panels

There are several reasons for replacing solar panels. The first is physical damage caused by wind, hail, sand or, for example, falling branches due to intense weather conditions. The second reason for replacing panels is a continuous performance decline of about 0.5% to 3% per year caused mainly by thermal cycling, damp heat, humidity freeze and UV exposure. This decline is usually the main factor limiting a panel’s life to 20-30 years. However, in one instance solar panels produced in 1976 still had a performance of 96%, 39 years later. As manufacturing technology has improved, solar panels lifetimes may increase to 40 years. The third reason for replacing panels is economical. If an installation is considered an investment, the cost-benefit analysis that goes into a replacement decision will factor the current cost of grid power, the cost of a new panel, the conversion efficiency differential between the old and new panel, and, the associated removal and installation costs. Based on these, it may be economically viable to replace panels’ midlife by more efficient panels. Additional factors to consider are subsidies given by authorities and costs for disposal of old panels.

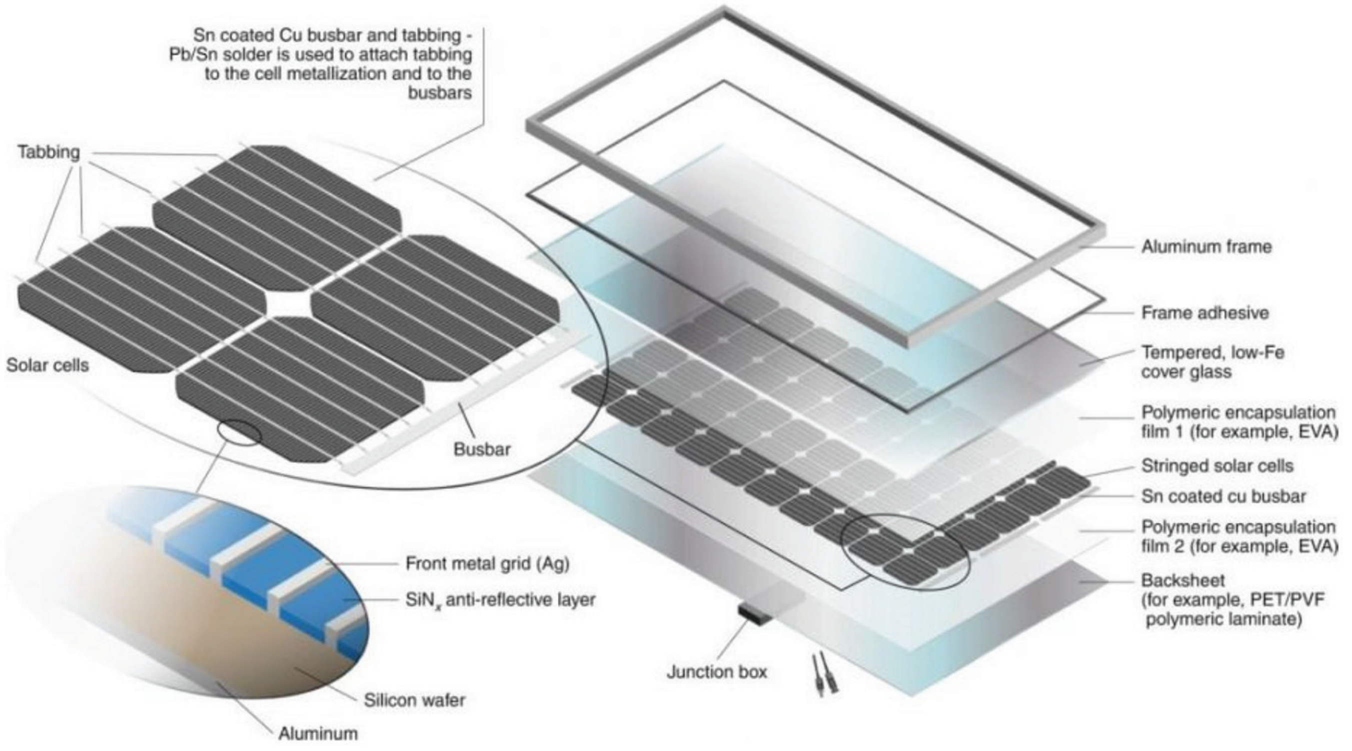

Fig.2: The construction of solar PV cells

Early loss scenario

The early loss scenario for PV panel loss is: 0.5% PV panels will be lost before installation, 0.5% will be lost in the first two years due to installation faults, 2% will become waste in ten years and 4% will become waste in 15 years due to technical failures. Based on the projections, one can add the projection that most panels currently installed may be candidates for replacement within 10 years of their installation based solely on financial considerations. If a small fraction of this is realized, the number of PV panels that may need to be recycled would be far greater than the earlier projections. Overall, solar system losses, including power loss in solar panels account for approximately 24% of the power generated, so whatever we can do to improve output could have a substantial impact on running and payback costs.

Cause of energy loss	Percentage loss	Design or maintenance	Total Losses
Shading	7%	Both	23.8% lost
Dust and Dirt	2%	Maintenance	
Reflection	2.5%	Design	
Spectral losses	1%	Design	
Irradiation	1.5%	Design	
Thermal losses	4.6%	Design	
Array mismatch	0.7%	Design	
DC cable losses	1%	Design	
Inverter losses	3%	Design	
AC cable losses	0.5%	Design	

Fig.3: Soiling losses

What is ahead?

Solar panels are expected to last 25 to 30 years. However, considering the current and projected costs of electric power, the rapidly falling costs of PV panels and the increasing conversion efficiency of new materials, the financial case for replacing panels after just a few years of use is strong. The assessment may undergo complete changes in the aftermath of Ukraine crisis and re-setting of the world order. Panels installed between 2010 and 2020, with an expected replacement dates in 2040-2050 could, under very conservative assumptions, be replaced as soon as 2030. This will also be true of installed panels with conversion efficiencies of up to 30% or higher (by mid 2020s). Increased demand for electric power may result in higher electricity rates, further shortening the replacement horizon for PV panels. Because of small degradation rates, a majority of discarded PV panels will still be capable of significant power generation. Material recovery and landfills are the most common EOL destinations for PV panels. Although a market for second hand panels is emerging, high collection and transportation costs as well as local factors such as installation costs, prime space available for PV installations and damage resulting from rough removals may limit the volumes of materials that can be traded. Legislation encouraging careful removal of PV panels could help spur growth of these secondhand PV markets. The removal of international barriers throttling the flow of used PV panels may also be helpful.

In India the prices of domestic solar panels have jumped over 50% in the last two months to over Rs 30 per watt owing to imposition of 25% import duty on cells and higher commodity prices caused by the Ukraine crisis. Domestic panel prices are on par with imported panels from China or even higher, forcing many developers to put their projects on hold as they have turned unviable given the rates built into the existing power purchase agreements. The government on April 1, 2022 imposed 40% import duty on solar panels, and 25% on solar cells to help domestic manufacturers expand their capacities. However, in the interim, the sector is seen suffering from the double whammy of higher commodity prices and the imposition of import duties for both developers as well as manufacturers. China used to supply around 85% of India's panel requirements for solar projects. The manufacturers sourced raw materials such as cells, polysilicones , ingots from them. However, the duties coupled with higher raw material prices have increased the input cost for domestic manufacturers, making domestic panels costly. The Chinese panels have become costly for developers due to 40% duty.