Recycling Solar Panels: The Next Great Challenge

Preventing the Earth's temperature rising above 1.5 °C will require a global effort to reach net-zero emissions by 2050. In this scenario, solar energy will play a fundamental role. The power sector is the highest-polluting industry globally, accounting for 27% of total greenhouse gases alone. Hence, a deep shift away from fossil fuel energy production is necessary. However, with the growth in solar, we must also look at the enormous amount of waste it will generate. Recycling solar panels becomes an urgent priority.

A Solar Panel Tsunami

The International Energy Agency (IEA) forecasts that, by 2050, our solar energy capacity should be around 20 times higher than it is at present. The Agency recommends ramping up production from 480 GW in 2018 to 8,519 GW by 2050.

Yet, scaling up could create negative environmental effects. That could include a massive rise in:

- PV panel waste.
- demand for mineral resources used in PV manufacture.

Solar panel waste is expected to rise around 80% by 2050, reaching around 78 million tonnes. This suggests a 'solar waste tsunami' is inevitable.

Moreover, the limited availability of minerals and metals (e.g., tellurium, silver, aluminium, high-purity-silicon, copper, cadmium, indium etc.) may not only hinder the development of the solar power sector, but also amplify socio-environmental impacts from intense mining.

Currently, PV production consumes about 2% of the global supply of silver, and 11% of copper. We expect growth in solar panel installation to peak within a decade, and maintain a steady rate until 2050. However, the global supply of zinc, copper and tellurium may peak by mid-century.

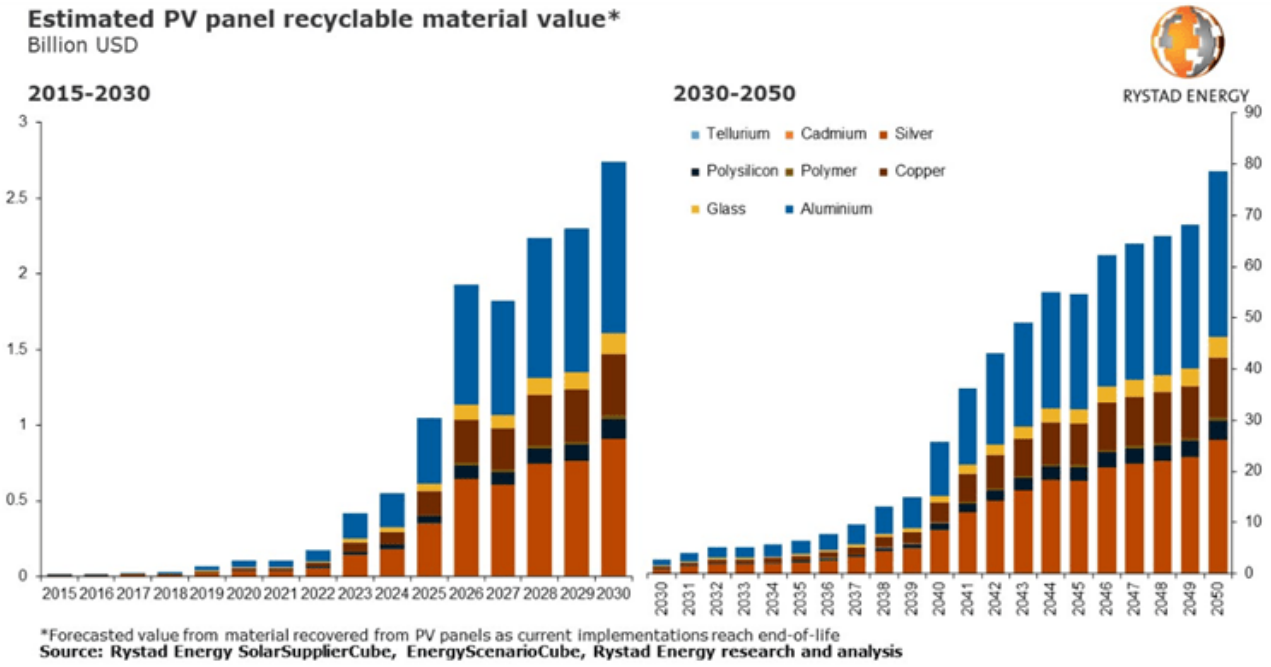

Fig. 1- Estimated value of ecyclabe materials used in PV manufacturing (Source)

Closing the Loop – Are solar panels recyclable?

The solution for both waste management and resource scarcity in the solar power industry lies in creating recycling, manufacturing, and reusing pathways. Developing a 'circular economy' in the production of photovoltaics will result in benefits far beyond the creation of raw materials security and minimising waste. Its advantages also include:

- the recovery of the economic value held in solar panel contents.
- extension in the capacity of existing landfills.
- support to local economies with the creation of jobs and infrastructure.

Recycling solar panels can recover up to 95% in mass of the modules. That includes all components except some polymers. The process involves a series of phases including disassembly, separation, thermal separation, acid etching, and pyrometallurgy, as illustrated in **Fig 2** below.

'Crystalline' solar panels dominate the market. Here, quantities of silver, copper, high-purity silicon and small amounts of hazardous lead are sandwiched between a front glass panel and a plastic backsheet. The panel is then wedged into a recyclable aluminium frame. For proper recycling, these panels need to be separated and the elements recovered with minimal damage to the component parts.

After recycling, the materials in solar panels can be re-used to manufacture new panels or be used in other industrial applications. The glass panel fronts, for example, can be transformed into insulation. Also, silicon cells can be recovered and used again.

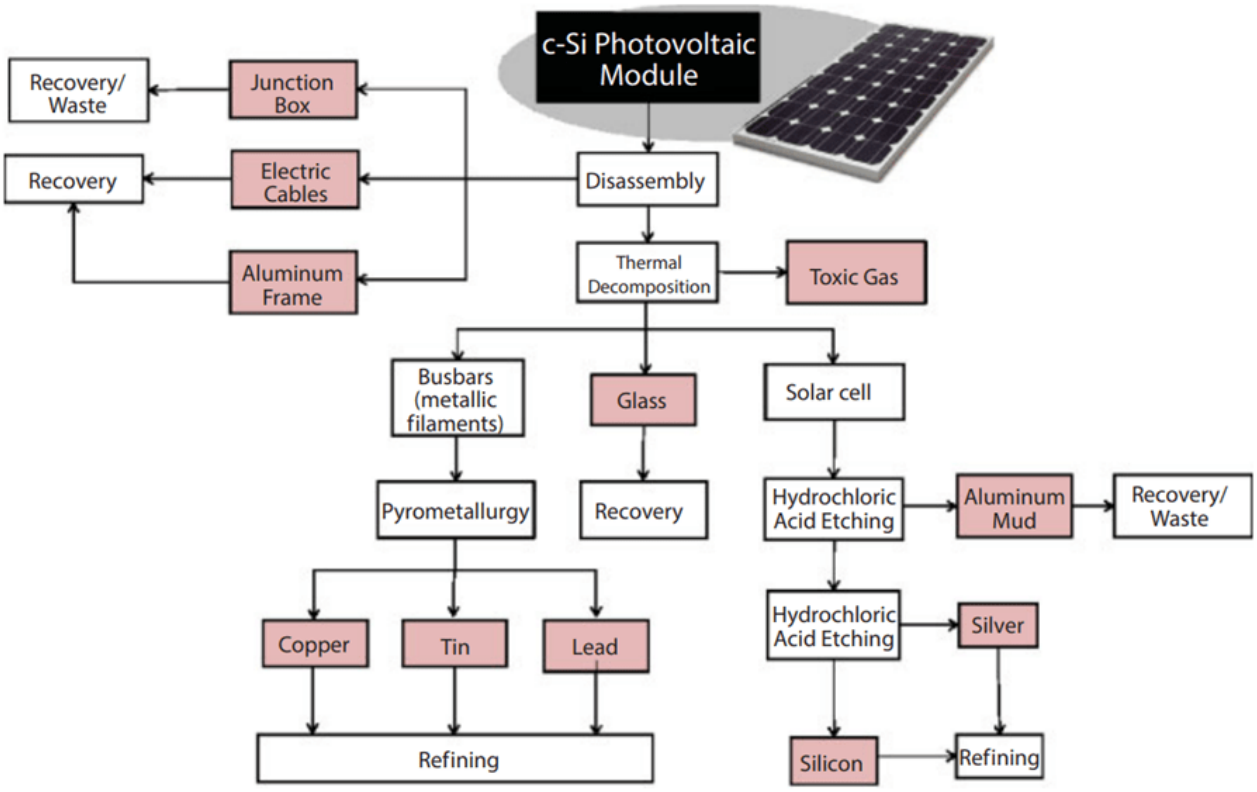

Fig. 2 – Recycling scheme for a c-Si photovoltaic module (Source)

Is it worth Recycling Solar Panels?

The main challenge that industry faces when it comes to close the solar energy loop is that PV recycling may not always be profitable, despite its positive environmental impacts.

Those crystalline silicon panels, which represent 90% of the market, are in fact mostly glass and plastic. Unfortunately, these components have very low-added value after recycling. The most profitable elements are the high-purity silicon and metals, which account for less than 6% in the mass. This creates a situation where the total cost of recycling is higher than the costs of diverting panels to landfill.

A lack of recycling infrastructure can also be a big limitation, especially when looking at downstream phases. Mechanical disassembling, chemical leaching, and metallurgical processing require a solid and well set-up industrial infrastructure, as well as skilled labour. Countries that rely most on solar power tend not to include these two costly items in their political agendas.

Australia, for example, is the third highest country for installed PV capacity per capita (390 Watts per capita), yet it lacks e-waste recycling facilities. The reason is that it is cheaper to simply outsource. However, when a country exports waste for recycling, it loses control of the process the moment the materials leave its borders. Consequently, recycling of Australian e-waste cannot be guaranteed. Further, research indicates proper end-of-life management is unlikely.

Overcoming challenges

Specialists argue the cost of recycling should be factored into production. This strategy could help us to move away from a linear model that puts constant pressure on virgin materials. Research also indicates that a thorough recovery of materials tends to offset the overall cost of the process. Specifically, by delivering a larger number of valuable products, like silicon and silver.

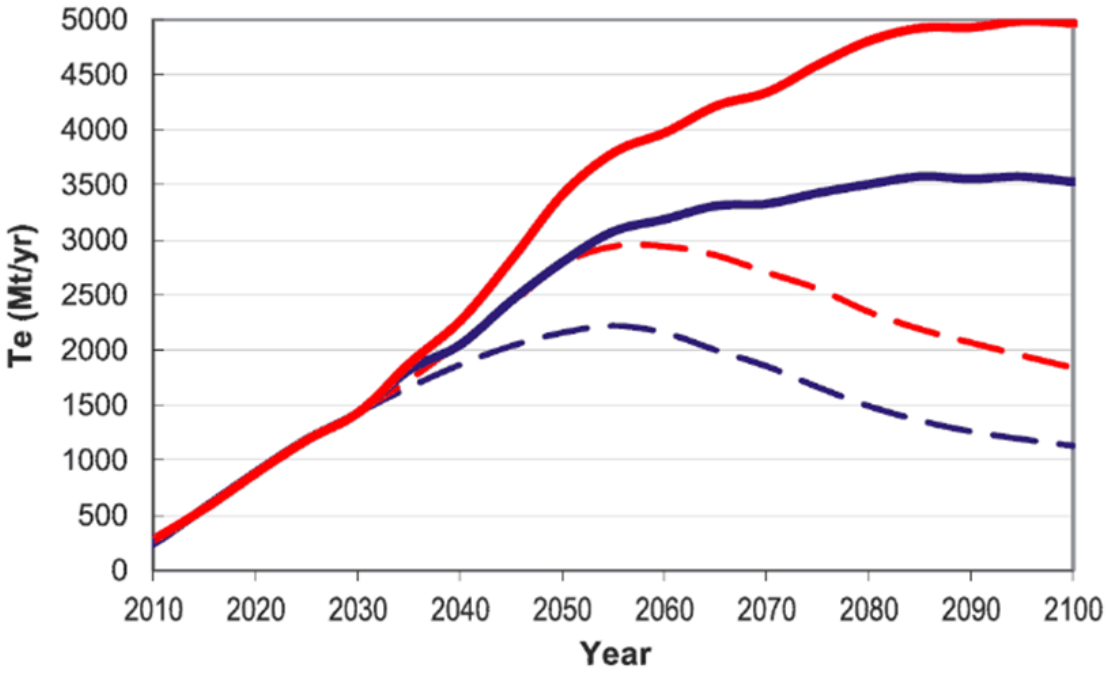

Fig. 3 – Projections of tellurium (Te) availability for PV industry. Dashed lines indicate supply of Te from copper smelters, whereas solid lines forecast the supply from copper smelters and recycling of end-of-life photovoltaics modules. Red and blue curves in each pair correspond to high and low projections, respectively. (Source)

Fortunately, advanced solar panel recycling is a technology that just needs a little push from government to become mainstream.

If developed countries like Australia wish to ensure compliance with their own standards, they could either invest in national and international monitoring or domestic downstream recycling. An achievement that will require government and private enterprise to work together.

Solar power is indeed one of the most powerful tools in the fight against climate change. However, for solar to truly meet its sustainable potential, we need to create renewable supply chains. In addition, we must instigate a vibrant secondary market for used panels and recycled materials.

In fact, recycling solar panels could produce up to 2 billion new panels by 2050. The movement could turn solar panels into a “double green” product. Not only would they serve the renewable energy industry, but also provide primary materials for other sectors. When fully injected back into the economy, recovered materials could exceed USD 15 billion by 2050.

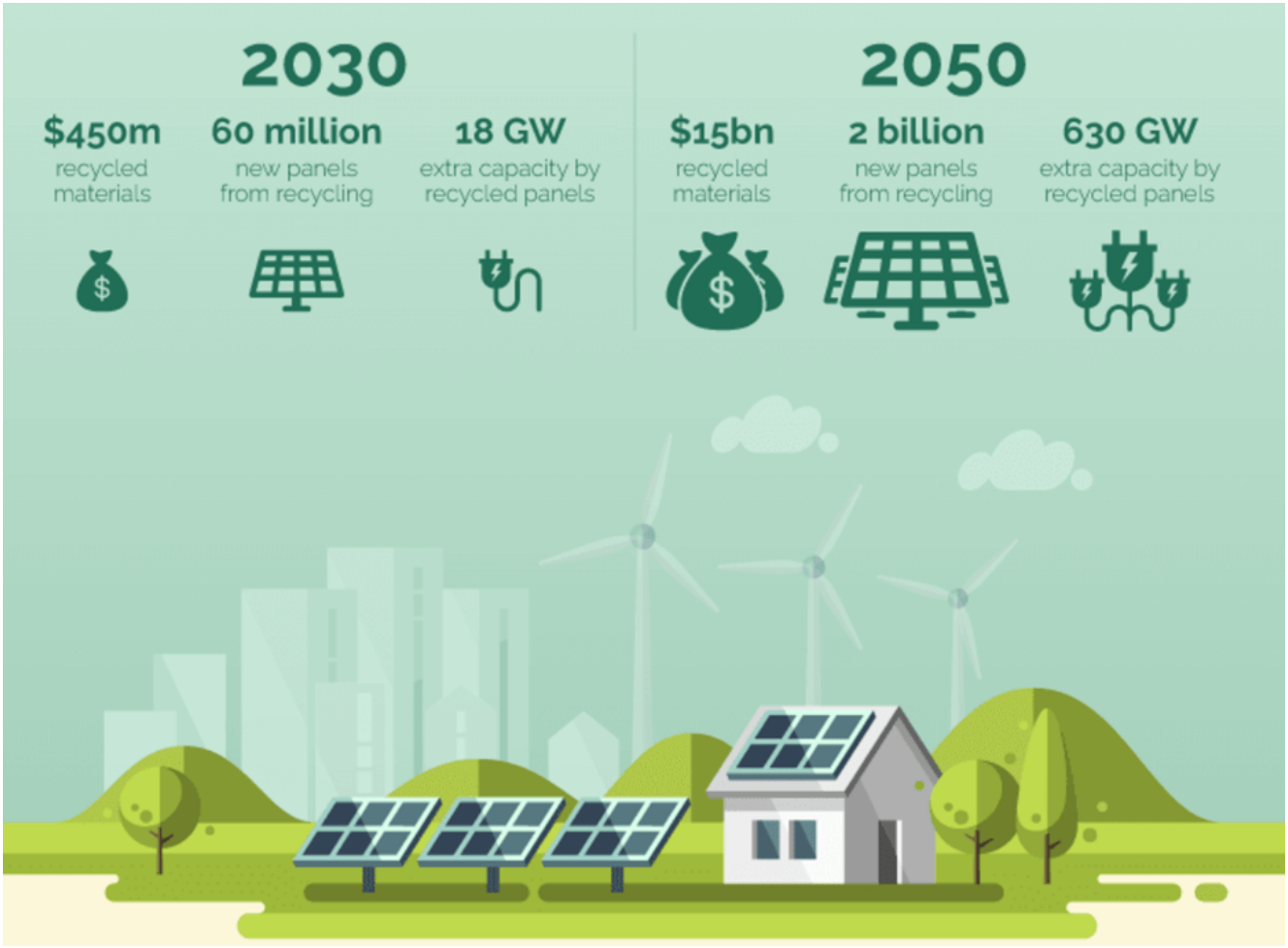

Fig.-4 – The value hidden in PV recycling (Source)

Conclusion

Solar panel recycling companies are already popping up worldwide. Many of these businesses are keeping secret their patented recycling technologies. This is an indication of the likely value of discarded solar panels, despite the fact that there are some challenges to overcome.

Regulations for managing PV in a closed-loop system, and frameworks that impose design and manufacturing standards will leverage the recycling industry even more.

In summary, eco-design, investments in recycling technologies, and policies for extended producers' responsibility seem to be the route for establishing the viability (and sustainability) of a future powered by sunshine.

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