Explained | India's solar push augurs a looming waste management challenge

PREMIUM

India is expected to become one of the top five leading photovoltaic waste producers globally by 2050.

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Solar panels atop a Mysuru Railway Station platform, May 8, 2022. | Photo Credit: Sriram M.A./The Hindu

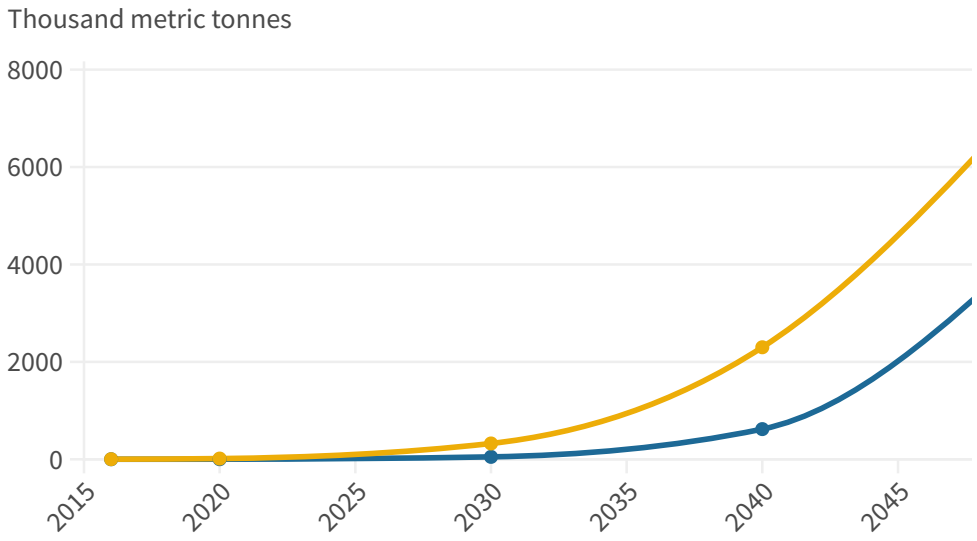
There has in the last few years been a concerted push from policymakers and thought leaders in India to transition to a circular economy to, among other things, enable effective waste management. However, waste management in the solar photovoltaic sector still lacks clear directives.

At the same time, there have been interesting policy announcements and initiatives vis-a-vis photovoltaic waste management, especially since last year. For example, the Ministry of Environment, Forests and Climate Change's revised electronic waste (e-waste) management Rules in 2022 brought solar photovoltaic cells, panels, and modules under its ambit. Similarly, the Green Credit Programme under the Environmental Protection Act, announced in the 2022-2023 Union Budget, aimed to promote green growth and sustainable practices. While these measures are noteworthy, have we thought through the effective handling of photovoltaic waste in India?

What is photovoltaic waste?

Globally, India stands fourth in solar photovoltaic deployment. India's solar power installed capacity had reached nearly 62 GW by November 2022. While this is certainly encouraging, it also augurs a colossal amount of solar photovoltaic waste in future. According to a 2016 report by the International Renewable Energy Agency, India could generate 50,000-3,25,000 tonnes of cumulative photovoltaic waste by 2030 and more than 4 million tonnes by 2050. In fact, India is expected to become one of the top five leading photovoltaic waste producers globally by 2045-2050.

How much waste will used photovoltaic panels generate?



A Flourish chart

India's solar photovoltaic installations are dominated by crystalline silicon (c-Si) technology. A typical photovoltaic panel is made up of 93% of c-Si modules and 7% of cadmium telluride (CdTe) thin film modules. A c-Si module mainly consists of a glass sheet, an aluminium frame, an encapsulant, a backsheet, copper wires, and silicon wafers. The metals used to manufacture c-Si modules are silver, tin, and lead. The CdTe thin film module is made of glass, encapsulant, and compound semiconductor.

Is this waste recovered or recycled?

As these photovoltaic panels reach their end of lives, some portions of the frame are extracted and sold as scrap; junctions and cables are recycled according to e-waste guidelines; the glass laminate is partly recycled; and the rest is disposed of as general waste. Silicon and silver can be extracted by burning the module in cement furnaces. According to a 2021 report, approximately 50% of total materials can be recovered through such waste management and recycling processes.

India's challenge is the growing informal handling of photovoltaic waste. Only about 20% of the waste is recovered in general; the rest is treated informally. As a result, the waste often accumulates at landfills. Landfill disposal in turn causes acidification, leaching of

toxic metals (such as lead and cadmium) into the soil, and contaminates the local water. Gradual incineration of the panel encapsulant also releases sulphur dioxide, hydrogen fluoride, and hydrogen cyanide into the atmosphere.

A view of the Bhalswa landfill in Delhi, December 7, 2022. | Photo Credit: Sushil Kumar Verma/The Hindu

This is why it's unclear whether the environment ministry's guidelines to include solar photovoltaic waste as e-waste could lead to an actual ban on landfills in India or offset the adverse impact on the environment.

With this in mind, India needs to surmount significant challenges – in the collection, storage, recycling, and repurposing of photovoltaic waste. The growing number (and sizes) of India's landfills is a sign of misinformation about and ignorance of appropriate disposal practices among multiple actors and institutions across the supply chain, including producers, owners, consumers, and waste disposal facilities.

Further, the market to repurpose or reuse recycled photovoltaic waste is minuscule in India because of a lack of suitable incentives and schemes in which businesses can invest. The absence of a body to measure, monitor, and report solar photovoltaic waste isn't helping either.

How have other countries responded?

The methods other countries have adopted to manage solar photovoltaic waste could be a good reference point for India to develop 'Made in India' manufacturing capabilities, recycling technologies, and waste management strategies in this field. Many Western and Asian economies have well-established regulatory guidelines for photovoltaic waste management and are actively investing in building awareness on effective waste management practices.

For example, the European Union's 'Waste Electrical and Electronic Equipment Directive' makes producers responsible for safely and responsibly disposing of end-of-life photovoltaic panels.

In the U.S., states have the freedom to establish their own solar photovoltaic regulatory standards. Its National Renewable Energy Laboratory is also exploring ways to boost the circular economy in the solar photovoltaic sector.

Manufacturers in Japan are responsible for developing environment-friendly recycling technologies through public-private partnerships and launching awareness campaigns about their benefits.

China has introduced an implementation plan for life-cycle management and to improve the resource efficiency of solar photovoltaic panels. Chinese researchers are also developing recycling processes to recover silicon from end-of-life panels and process them back into solar wafers.

What are the gaps in India's PV waste management?

First, simply clubbing photovoltaic waste with other e-waste could lead to confusion. Instead, India should formulate and implement provisions specific to photovoltaic waste treatment within the ambit of the e-waste guidelines. The government should also build a legislative framework to enforce the Extended Producer Responsibility Rules. And a Central insurance or a regulatory body should be set up to protect against financial losses incurred in waste collection and treatment.

Second, the waste generated from photovoltaic modules and their components is classified as 'hazardous waste' in India. To further drive home the necessity of this label, pan-India sensitisation drives and awareness programmes on photovoltaic waste management will be beneficial. Clear recycling targets and recycling rates in the photovoltaic waste management policy directive will be good as well.

Third, considering India's local solar photovoltaic-panel manufacturing is limited, we need to pay more attention to domestic R&D efforts. Depending on a single module type will disuniformly deplete certain natural resources and stunt the local capacity for recycling and recovery of critical materials. The domestic development of photovoltaic waste recycling technologies must be promoted through suitable regulatory incentives, recycling programmes, appropriate infrastructure facilities, and adequate funding.

Why should India act now?

It is encouraging that the latest production-linked incentive scheme promotes the domestic manufacturing of high-efficiency solar photovoltaic modules. Considering the rate at which these panels are being installed around the country, India is expected to generate an enormous amount of waste over the next 15-20 years.

Now is the right time for it to install clear policy directives, well-established recycling strategies, and greater collaboration, so that it doesn't find itself neck-deep in a new