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# If Solar Panels Are So Clean, Why Do They Produce So Much Toxic Waste?



**Michael Shellenberger** Contributor ①

**Energy**

*I write about energy and the environment*



Bell Labs, 1954. Solar Panel Waste, 2014 BELL LABS & PV CYCLE

*Para la traducción al español, haga [clic aquí](#)*

The last few years have seen growing concern over what happens to solar panels at the end of their life. Consider the following statements:

- The problem of solar panel disposal “will explode with full force in two or three decades and wreck the environment” because it “is a huge amount of

waste and they are not easy to recycle.”

- “The reality is that there is a problem now, and it’s only going to get larger, expanding as rapidly as the PV industry expanded 10 years ago.”
- “Contrary to previous assumptions, pollutants such as lead or carcinogenic cadmium can be almost completely washed out of the fragments of solar modules over a period of several months, for example by rainwater.”

Were these statements made by the right-wing Heritage Foundation? Koch-funded global warming deniers? The editorial board of the *Wall Street Journal*?

None of the above. Rather, the quotes come from [a senior Chinese solar official](#), [a 40-year veteran of the U.S. solar industry](#), and [research scientists](#) with the German Stuttgart Institute for Photovoltaics.

With few environmental journalists willing to report on much of anything other than the good news about renewables, it’s been left to environmental scientists and solar industry leaders to raise the alarm.

“I’ve been working in solar since 1976 and that’s part of my guilt,” the veteran [solar developer](#) told *Solar Power World* last year. “I’ve been involved with millions of solar panels going into the field, and now they’re getting old.”

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### The Trouble With Solar Waste

The International Renewable Energy Agency (IRENA) in 2016 estimated there was about 250,000 metric tonnes of solar panel waste in the world at the end of that year. [IRENA projected](#) that this amount could reach 78 *million* metric tonnes by 2050.

Solar panels often contain lead, cadmium, and other toxic chemicals that cannot be removed without breaking apart the entire panel. “Approximately 90% of most PV modules are made up of glass,” [notes](#) San Jose State environmental studies professor Dustin Mulvaney. “However, this glass often cannot be recycled as float glass due to impurities. Common problematic impurities in glass include plastics, lead, cadmium and antimony.”

Researchers with the Electric Power Research Institute (EPRI) [undertook a study](#) for U.S. solar-owning utilities to plan for end-of-life and concluded that solar panel “disposal in “regular landfills [is] not recommended in case modules break and toxic materials leach into the soil” and so “disposal is potentially a major issue.”

California is in the process of [determining how to divert solar panels](#) from landfills, which is where they currently go, at the end of their life.

California's Department of Toxic Substances Control (DTSC), which is implementing the new regulations, [held a meeting last August](#) with solar and waste industry representatives to discuss how to deal with the issue of solar waste. At the meeting, the representatives from industry and DTSC all acknowledged how difficult it would be to test to determine whether a solar panel being removed would be classified as hazardous waste or not.

The DTSC described building a database where solar panels and their toxicity could be tracked by their model numbers, but it's not clear DTSC will do this.

"The theory behind the regulations is to make [disposal] less burdensome," explained Rick Brausch of DTSC. "Putting it as universal waste eliminates the testing requirement."

The fact that cadmium can be washed out of solar modules by rainwater is increasingly a concern for local environmentalists like the Concerned Citizens of

Fawn Lake in Virginia, where a [6,350 acre solar farm](#) to partly power [Microsoft data centers](#) is being proposed.

“We estimate there are 100,000 pounds of cadmium contained in the 1.8 million panels,” Sean Fogarty of the group told me. “Leaching from broken panels damaged during natural events — hail storms, tornadoes, hurricanes, earthquakes, etc. — and at decommissioning is a big concern.”

There is real-world precedent for this concern. A tornado in 2015 broke 200,000 solar modules at southern California solar farm Desert Sunlight.

"Any modules that were broken into small bits of glass had to be swept from the ground," Mulvaney explained, "so lots of rocks and dirt got mixed in that would not work in recycling plants that are designed to take modules. These were the cadmium-based modules that failed [hazardous] waste tests, so were treated at a [hazardous] waste facility. But about 70 percent of the modules were actually sent to recycling, and the recycled metals are in new panels today."

And when Hurricane Maria hit Puerto Rico last September, the nation's second largest solar farm, responsible for 40 percent of the island's solar energy, [lost a majority of its panels](#).



Destroys Solar Farm in Puerto Rico BOB MEINETZ

Many experts urge mandatory recycling. The main finding promoted by IRENA's in its [2016 report](#) was that, “If fully injected back into the economy, the value of the recovered material [from used solar panels] could exceed USD 15 billion by 2050.”

But IRENA's study did not compare the value of recovered material to the cost of new materials and admitted that “Recent studies agree that PV material availability is not a major concern in the near term, but critical materials might impose limitations in the long term.”

They might, but today recycling costs more than the economic value of the materials recovered, which is why most solar panels end up in landfills. “The absence of valuable metals/materials produces economic losses,” [wrote a team of scientists in the \*International Journal of Photoenergy\* in their study of solar panel recycling last year](#), and “Results are coherent with the literature.”

Chinese and Japanese experts agree. “If a recycling plant carries out every step by



the book,” a Chinese expert told *The South China Morning Post*, “their products can end up being more expensive than new raw materials.”

Toshiba Environmental Solutions told *Nikkei Asian Review* last year that,

“ Low demand for scrap and the high cost of employing workers to disassemble the aluminum frames and other components will make it difficult to create a profitable business unless recycling companies can charge several times more than the target set by [Japan’s environment ministry].

### Can Solar Producers Take Responsibility?

In 2012, First Solar stopped putting a share of its revenues into a fund for long-term waste management. “Customers have the option to use our services when the panels get to the end of life stage,” a spokesperson told *Solar Power World*. “We’ll do the recycling, and they’ll pay the price at that time.”

Or they won’t. “Either it becomes economical or it gets mandated. ” said EPRI’s Cara Libby. “But I’ve heard that it will have to be mandated because it won’t ever be economical.”

Last July, Washington became the first U.S. state to require manufacturers selling solar panels to have a plan to recycle. But the legislature did not require manufacturers to pay a fee for disposal. “Washington-based solar panel manufacturer Itek Energy assisted with the bill’s writing,” noted *Solar Power World*.

The problem with putting the responsibility for recycling or long-term storage of solar panels on manufacturers, says the insurance actuary Milliman, is that it increases the risk of more financial failures like the kinds that afflicted the solar industry over the last decade.

[A]ny mechanism that finances the cost of recycling PV modules with current revenues is not sustainable. This method raises the possibility of bankruptcy down the road by shifting today's greater burden of 'caused' costs into the future. When growth levels off then PV producers would face rapidly increasing recycling costs as a percentage of revenues.

Since 2016, Sungevity, Beamreach, Verengo Solar, SunEdison, Yingli Green Energy, Solar World, and Suniva have gone bankrupt.

The result of such bankruptcies is that the cost of managing or recycling PV waste will be born by the public. "In the event of company bankruptcies, PV module producers would no longer contribute to the recycling cost of their products," [notes](#) Milliman, "leaving governments to decide how to deal with cleanup."

Governments of poor and developing nations are often not equipped to deal with an influx of toxic solar waste, experts say. German researchers at the Stuttgart Institute for Photovoltaics [warned](#) that poor and developing nations are at higher risk of suffering the consequences.



Maharashtra, India, 2014 DIPAK SHEELARE

“Dangers and hazards of toxins in photovoltaic modules appear particularly large in countries where there are no orderly waste management systems... Especially in less developed countries in the so-called global south, which are particularly predestined for the use of photovoltaics because of the high solar radiation, it seems highly problematic to use modules that contain pollutants.

The attitude of some solar recyclers in China appears to feed this concern. “A sales manager of a solar power recycling company,” the *South China Morning News* reported, “believes there could be a way to dispose of China’s solar junk, nonetheless.”

“We can sell them to Middle East... Our customers there make it very clear that they don’t want perfect or brand new panels. They just want them cheap... There, there is lots of land to install a large amount of panels to make up for their low



performance. Everyone is happy with the result.”

In other words, there are firms that may advertise themselves as "solar panel recyclers" but instead sell panels to a secondary markets in nations with less developed waste disposal systems. In the past, communities living near electronic waste dumps in Ghana, Nigeria, Vietnam, Bangladesh, Pakistan, and India have been [primary e-waste destinations](#).

According to a [2015 United Nations Environment Program \(UNEP\) report](#), somewhere between 60 and 90 percent of electronic waste is illegally traded and dumped in poor nations. Writes UNEP:

“ [T]housands of tonnes of e-waste are falsely declared as second-hand goods and exported from developed to developing countries, including waste batteries falsely described as plastic or mixed metal scrap, and cathode ray tubes and computer monitors declared as metal scrap.

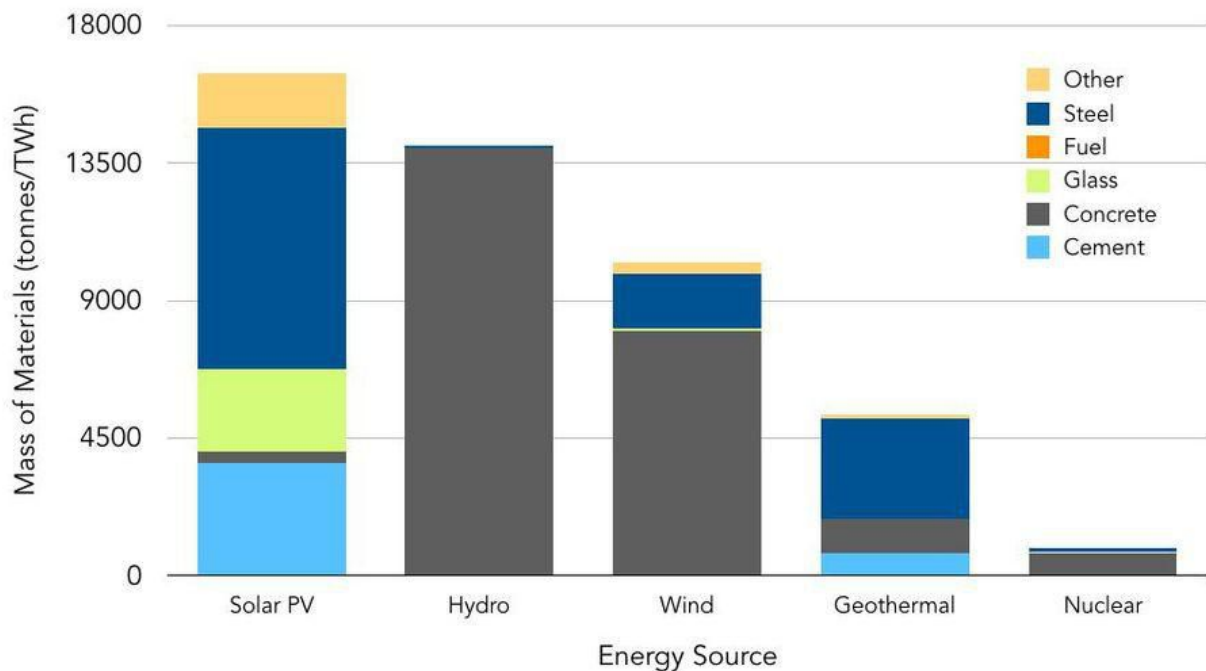
Unlike other forms of imported e-waste, used solar panels can enter nations legally before eventually entering e-waste streams. [As the United Nation Environment Program notes](#), “loopholes in the current Waste Electrical and Electronic Equipment (WEEE) Directives allow the export of e-waste from developed to developing countries (70% of the collected WEEE ends up in unreported and largely unknown destinations).”

## **A Path Forward on Solar Panel Waste**

Perhaps the biggest problem with solar panel waste is that there is so much of it, and that's not going to change any time soon, for a basic physical reason: [sunlight is dilute and diffuse](#) and thus require large collectors to capture and convert the sun's rays into electricity. Those large surface areas, in turn, require an order of magnitude more in materials — whether today's toxic combination of glass, heavy metals, and rare earth elements, or some new material in the future — than other

energy sources.

## Materials throughput by type of energy source



Sources: DOE Quadrennial Technology Review, Table 10.

Murray, R.L. and Holbert, K.E. 2015. Nuclear energy: an introduction to the concepts, systems, and applications of nuclear processes (7th ed.). Elsevier.

Solar requires 15x more materials than nuclear EP

All of that waste creates a large quantity of material to track, which in turn requires requires coordinated, overlapping, and different responses at the international, national, state, and local levels.

The local level is where action to dispose of electronic and toxic waste takes place, often under state mandates. In the past, differing state laws have motivated the U.S. Congress to put in place national regulations. Industry often prefers to comply with a single national standard rather than multiple different state standards. And as the problem of the secondary market for solar shows, ultimately there needs to be some kind of international regulation.

The first step is a fee on solar panel purchases to make sure that the cost of safely removing, recycling or storing solar panel waste is internalized into the price of solar panels and not externalized onto future taxpayers. An obvious solution would be to impose a new fee on solar panels that would go into a federal disposal and decommissioning fund. The funds would then, in the future, be dispensed to state and local governments to pay for the removal and recycling or long-term storage of solar panel waste. The advantage of this fund over extended producer responsibility is that it would insure that solar panels are safely decommissioned, recycled, or stored over the long-term, even after solar manufacturers go bankrupt.

Second, the federal government should encourage citizen enforcement of laws to decommission, store, or recycle solar panels so that they do not end up in landfills. Currently, citizens have the right to file lawsuits against government agencies and corporations to force them to abide by various environmental laws, including ones that protect the public from toxic waste. Solar should be no different. Given the decentralized nature of solar energy production, and lack of technical expertise at the local level, it is especially important that the whole society be involved in protecting itself from exposure to dangerous toxins.

“We have a County and State approval process over the next couple months,” Fogarty of Concerned Citizens of Fawn Lake told me, “but it has become clear that local authorities have very little technical breadth to analyze the impacts of such a massive solar power plant.”

Lack of technical expertise can be a problem when solar developers like Sustainable Power Group, or sPower, [incorrectly claim](#) that the cadmium in its panels is not water soluble. That claim has been contradicted by the previously-mentioned Stuttgart [research scientists](#) who found cadmium from solar panels “can be almost completely washed out...over a period of several months...by rainwater.”

Third, the United Nations Environment Programme's [Global Partnership for Waste Management](#), as part of its [International Environmental Partnership Center](#), should more strictly monitor e-waste shipments and encourage nations importing used solar panels into secondary markets to impose a fee to cover the cost of recycling or long-term management. Such a recycling and waste management fund could help nations address their other e-waste problems while supporting the development of a new, high-tech industry in recycling solar panels.

None of this will come quickly, or easily, and some solar industry executives will resist internalizing the cost of safely storing, or recycling, solar panel waste, perhaps for understandable reasons. They will rightly note that there are other kinds of electronic waste in the world. But it is notable that some new forms of electronic waste, namely smartphones like the iPhone, have in many cases replaced things like stereo systems, GPS devices, and alarm clocks and thus reduced their contribution to the e-waste stream. And no other electronics industry makes being "clean" its main selling point.

Wise solar industry leaders can learn from the past and be proactive in seeking stricter regulation in accordance with growing scientific evidence that solar panels pose a risk of toxic chemical contamination. "If waste issues are not preemptively addressed," [warns Mulvaney](#), "the industry risks repeating the disastrous environmental mistakes of the electronics industry."

If the industry responds with foresight, Mulvaney notes, it could end up sparking clean innovation including "developing PV modules without hazardous inputs and recycled rare metals." And that's something everyone can get powered up about.

*I am a Time Magazine "Hero of the Environment," Green Book Award Winner,*



*and President of Environmental Progress, a research and policy organization. My writings have appeared in The New York Times, Washington Post and Wall Street Journal, Scientific American, Nature Energy,...* [MORE](#)

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