

# Solar Panel Recycling and Disposal

Solar energy plays a vital role in growing the United States' domestic clean energy resources. Rapid technology improvements have enabled utility-scale solar energy to grow exponentially; there is enough solar capacity in the U.S. to power more than 12.8 million homes. According to the U.S. Department of Energy, the U.S. can meet 40% of its electricity needs by 2035 with solar power.<sup>1</sup>

## Solar Photovoltaics & Public Safety

Solar panels are designed to provide safe, reliable, and affordable energy for 35 years. Most of a solar panel's weight (75%) is glass; other materials include aluminum, copper, and semiconductor materials. The primary component in solar cells is silicon, which is the second-most common element on earth and used in a variety of consumer electronics, from cell phones to computer chips.<sup>2,3</sup> Modern commercial solar panels do not contain sufficient hazardous materials to pose a danger to the environment and human health, and generally may be disposed of in an ordinary landfill.

After a panel's useful life, it may continue to operate, albeit at reduced efficiency. A study from the National Renewable Energy Laboratory calculated panels lose approximately 0.5% efficiency per year, meaning by Year 20 the facility can operate at 90% of its original output.<sup>4</sup> Should the owner of a solar facility decide to restore the site to another land use – known as decommissioning – there are many options for the used panels.

## Reuse

Panels can continue to be operational after surpassing their warranted lifetime. Through maintenance and repair aimed at reducing waste from early or unexpected decommissioning, many solar panels can be refurbished and reused. The lower resale price makes these panels attractive to buyers that have fewer financial resources.<sup>5</sup> There is a small but growing market for secondhand solar panels, enabling residential customers to install solar panels at a significantly reduced cost. Resale or donation of PV panels presents an opportunity for communities to reduce exposure to air pollution emissions through renewable energy deployment, while advancing low-cost electricity access.<sup>6</sup>

## Recycle

The bulk of a solar panel's weight is glass and aluminum: materials commonly recycled in the U.S. With current technology, up to 95% of semiconductor material and 90% of glass used in panels can be recycled.<sup>7</sup> While the solar panel recycling industry is relatively small at present, it is likely to grow as more solar facilities reach the end of their operational life in the next decade and beyond. It is estimated that by 2030, the cumulative value of recoverable materials from decommissioned solar panels will be approximately \$450 million. The U.S. Environmental Protection Agency notes that many solar panels may contain materials deemed critical to national security such as tin and aluminum.<sup>8</sup> Presently, it is estimated that about one in ten solar panels are recycled,<sup>9</sup> though it is anticipated that as more panels reach the end of their useful life, the price of recycling will fall, and the rate of recovery will increase.

The solar industry, research organizations, government agencies, and other stakeholder groups are also taking steps to increase solar panel recycling and apply technological advances for alternative uses for the decommissioned panels and materials. For example, takeback programs run by major panel manufacturers collect and recycle their panels at the end of their lifetime, creating a closed-loop system. One manufacturer has reported capacity to successfully recycle over 90% of collected materials for both reuse in new panels and diversion into other products like rubber mats and shoe soles<sup>10</sup>

## Landfill

Solar PV panels are primarily made up of non-hazardous materials (refer to Solar Panels and Your Community Factsheet), thus most modern panels can be safely disposed of in municipal landfills. For more information on the contents of solar panels, please review “Solar Panels and Your Community.”

Solar panels currently make up a small percentage (0.006%) of total waste;<sup>11</sup> and according to the U.S. Department of Energy, in the absence of new recycling initiatives, by 2050 decommissioned solar PV panels may account for just .1% of total solid waste.<sup>12</sup> As waste diversion efforts increase in the U.S., solar recycling will likely become more common, but in the meantime, landfills can be a safe means of disposal for most solar panels.

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<sup>1</sup> Department of Energy. 2022. “Solar Futures Study.” Accessed at: <https://www.energy.gov/eere/solar/solar-futures-study>

<sup>2</sup> Department of Energy. 2022. “Solar Photovoltaic Cell Basics.” Accessed at: <https://www.energy.gov/eere/solar/solar-photovoltaic-cell-basics>

<sup>3</sup> U.S. Geological Survey. 2016. “A World of Minerals in Your Mobile Device.” Accessed at: <https://pubs.usgs.gov/gip/0167/gip167.pdf>

<sup>4</sup> Lifetime of PV Panels. National Renewable Energy Laboratory. 2018. Available: <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>

<sup>5</sup> International Renewable Energy Agency (IRENA). 2016. “End of Life Management of Solar Photovoltaics.” Accessed at: <https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels>

<sup>6</sup> Heath, Garvin; Ravikumar, Dwarakanath; Ovaitt, Silvana; Walston, Leroy; Curtis, Taylor; Millstein, Dev; Mirlitz, Heather; Hartmann, Heidi; and McCall, James. “Environmental and Circular Economy Implications of Solar Energy in a Decarbonized US Grid.” NREL. Accessed at: <https://www.nrel.gov/docs/fy22osti/80818.pdf>

<sup>7</sup> IRENA, 2016.

<sup>8</sup> EPA. 2022. “Solar Panel Recycling.” Accessed at: <https://www.epa.gov/hw/solar-panel-recycling>

<sup>9</sup> Crownhart, Casey. 2021. “Solar panels are a pain to recycle. These companies are trying to fix that.” MIT Technology Review. Accessed at: <https://www.technologyreview.com/2021/08/19/1032215/solar-panels-recycling/>

<sup>10</sup> IRENA, 2016.

<sup>11</sup> IRENA, 2016.

<sup>12</sup> Department of Energy. 2022. “Solar Energy Technologies Office Photovoltaics End-of-Life Action Plan.” Accessed at: <https://www.energy.gov/sites/default/files/2022-03/Solar-Energy-Technologies-Office-PV-End-of-Life-Action-Plan.pdf>



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