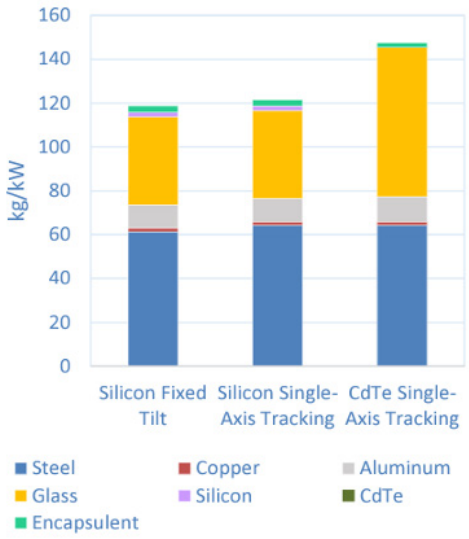
Solar Panels and Your Community

Solar energy has been growing rapidly across the United States. As facilities are proposed in more and more communities, community members have questions about what materials are included in solar photovoltaic (PV) panels, and if they pose an environmental or health risk to surrounding neighbors. The fact sheet below explores the materials in solar panels, and how utility-scale solar facilities are safe for your community.

What is inside of a solar panel?

Solar panels consist of glass, aluminum, copper, and semiconductor materials. Solar cells are made of either connected silicon atoms or thin layers of photovoltaic material that have been placed onto glass or metal and are responsible for converting energy from sunlight into electricity. The thin layer of solar cells is sealed on both sides and covered with glass and an aluminum frame. The primary solar cell technologies used are Crystalline silicon (c-Si) and thin film Cadmium telluride (CdTe). While several different solar cell technologies exist, over 90% of the U.S. solar market uses Crystalline silicon (c-Si) cells.[1]

20 MV PV Plant Component Materials by Weight (kg/kW)



Source: U.S. Department of Energy Solar Energy Technologies Office. Photovoltaics End-of-Life Action Plan. March 2022. Accessible: https://www.energy.gov/sites/default/files/2022-03/Solar-Energy-Technologies-Office-PV-End-of-Life-Action-Plan.pdf

Are the materials in solar panels safe?

Modern commercial solar panels do not contain sufficient hazardous materials to pose a danger to the environment and human health. The primary component in crystalline silicon solar cells is silicon, the second-most common element on earth and found in most consumer electronics, from cell phones to computer chips.[2,3] An assessment by the Ohio Department of Health highlighted the safety of crystalline silicone panels, concluding "Information to date does not indicate a public health burden from the use of crystalline silicone (c-Si) in solar farms…[as] crystalline silicone itself is non-toxic to humans."[4] Other components used in c-Si cells include boron and phosphorus, which are also non-hazardous to the environment and human health. While some older panels may contain trace amounts of lead used to join the c-Si cells, manufacturers are increasingly ceasing use of lead. Furthermore, the amount of lead needed to solder the cells is roughly 1/750th of the amount used in a conventional car battery or half of the amount in a single 12-gauge shotgun shell. While a large solar energy project contains hundreds of panels, the leaded portions of the panel are enclosed in nonporous, non-toxic substances like glass, preventing the lead material from escaping or leaching into the ground.[5]

Another trace element found in c-Si solar panels is cadmium, which is sometimes used in the glass frit, materials used for the electrodes to make electrical contact with the PV cell, or the solder, which is used to join cells. However, according to the North Carolina Clean Energy Technology Center, research demonstrates the amount of cadmium found in solar panels poses negligible toxicity risk to public health and safety.[6] Additionally, an assessment by the Ohio Department of Health determined that "the trace amounts of hazardous components used in solar panels…are not likely to enter the environment," as the materials are fully encapsulated by glass.[7]

Cadmium telluride (CdTe) is another trace component found in thin film solar panels; however, CdTe contains 1/100th the toxicity of free cadmium[8], has a much lower risk of being released, and is not soluble in water.[9] Additionally, researchers have found that use of cadmium telluride solar cells reduces the public's exposure to cadmium – as solar energy reduces the need for fossil fuel generation, which is a major source of cadmium exposure. For every five megawatts of solar power installed, it is estimated that 157 grams of cadmium are prevented from being released into the environment because of the reduction in traditional energy generation.[10]

Can solar panels leach chemicals or metals?

Solar panels are designed and manufactured to withstand harsh environmental conditions and extreme weather events. These hardened structures protect the solar cells from the elements and support plans to keep the facilities operating for 35+ years; therefore, the panels pose little risk of leaching during operation or during removal and disposal. In order to operate, the internal components of modules must be protected from the elements, particularly moisture, in order to prevent corrosion and the release of materials.

Furthermore, the EPA requires that solar panel modules pass toxicity characteristic leaching procedure (TCLP) testing before being disposed of in a landfill. TCLP testing assesses impacts of landfill conditions on solar panels, including leaching potential. This test is typically conducted during manufacturing to ensure the solar panels will meet the requirements of disposal at end-of-life. Testing has found that panels are durable and even capable of withstanding extreme weather events without leaching. In 2013, researchers at the University of Tokyo tested the environmental impact of CdTe panels being exposed to fires, floods, and earthquakes, and found that even under worst-case-scenario conditions, it is unlikely that the cadmium concentrations in air and sea water will exceed the environmental regulation values.

For more information on decommissioning solar facilities and disposal, please visit What Happens When a Solar Project is Decommissioned and Solar Panel Recycling and Disposal.

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[1] 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

[2] Department of Energy. 2022. "Solar Photovoltaic Cell Basics." Accessed at: https://www.energy.gov/eere/solar/solar-photovoltaic-cell-basics

[3] U.S. Geological Survey. 2016. "A World of Minerals in Your Mobile Phone." Accessed at: https://pubs.usgs.gov/gip/0167/gip167.pdf

[4] Ohio Department of Health. 2022. "Ohio Department of Health Solar Farm and Photovoltaics Summary and Assessments." Accessed at: https://ohiodnr.gov/wps/wcm/connect/gov/fc124a88-62b4-4e91-b30b-bc1269d0dde5/ODH+Solar+Farm+and+PVs+Summary+Assessments_2022.04.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE.Z18_K9I401S01H7F40QBNJU3SO1F56-fc124a88-62b4-4e91-b30b-bc1269d0dde5-o3S-Ssh

[5] Ohio Department of Health, 2022.

[6] NC Clean Energy Technology Center. 2017. "Health and Safety Impacts of Solar Photovoltaics." NC State University. Accessed at: https://content.ces.ncsu.edu/health-and-safety-impacts-of-solar-photovoltaics

[7] Ohio Department of Health, 2022.

[8] NC Clean Energy Technology Center, ibid.

[9] Bonnet, Dieter and Meyers, Peter. 1998. "Cadmium-telluride-Material for thin film solar cells." Journal of Materials Research. Accessed at: https://www.cambridge.org/core/journals/journal-of-materials-research/article/abs/cadmiumtelluridematerial-for-thin-film-solar-cells/8BEF27C9423BD204A4BC0AD1C34F2983

[10] NC Clean Energy Technology Center, 2017.

[11] NC Clean Energy Technology Center, 2017.

[12] North Carolina Department of Environmental Quality and the Environmental Management Commission. 2021. "Final Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment." Accessed at: https://files.nc.gov/ncdeq/documents/files/DEQ_H329%20FINAL%20REPORT_2021-01-01.PDF

[13] Matsuno, Yasunari. December 2013. Environmental Risk Assessment of CdTe PV Systems to be considered under Catastrophic Events in Japan. First Solar. Accessed at: https://www.firstsolar.com/-/media/First-Solar/Sustainability-Documents/Sustainability-Peer-Reviews/Japan_Peer-Review_Matsuno_CdTe-PV-Tsunami.ashx.