

**HAZARDOUS MATERIALS PROGRAM ENVIRONMENTAL FACT SHEET**

## End-of-Life Solar Panels

The use of solar panels for electric power generation has increased significantly in recent decades, and with it, the number of end-of-life solar panels in need of proper disposal has increased. This growing waste stream must be managed safely in order to protect public health and the environment—particularly when it comes to solar panels manufactured with materials that make them hazardous waste at end-of-life. This fact sheet provides a summary of how the [Vermont Hazardous Waste Management Regulations](#) (VHWMR) apply to managing end-of-life solar panels.

### What is a solar panel?

Solar panels are devices that convert electromagnetic radiation from the sun (i.e., sunlight) into electricity. They are also referred to as photovoltaics, or PVs. They are commonly used to power residential and commercial buildings, but they have many applications including energy storage, remote power, industrial processes, and transportation.

While the design and construction of solar panels varies, most consist of photovoltaic “cells” that are soldered together and protected by glass in a metal frame. They typically contain wiring, semiconductors, and other electrical components. Although they are largely made up of non-hazardous materials, solar panels may contain hazardous materials, including but not limited to silver, lead, cadmium, and other heavy metals. These materials are most likely to be found in the solder and/or semiconductor of the solar panel. Solar panels at end of life, particularly those that are damaged or subject to damage, pose a greater risk to the environment, as they may not effectively contain hazardous constituents.

### Do end-of-life solar panels need to be managed as hazardous waste?

If end-of-life solar panels contain specific heavy metals at high enough concentrations, they are regulated as hazardous waste due to the characteristic of toxicity ([§ 7-208 of the VHWMR](#)). If any one of the contaminants listed in § 7-208 is present in end-of-life solar panels at or above the regulatory level, those solar panels must be managed as hazardous waste. The table below includes examples of hazardous wastes that may be present in PVs and their associated regulatory level.

Contaminant	Hazardous Waste Code	Regulatory Level (mg/L)
Silver	D011	5.0
Lead	D008	5.0
Cadmium	D006	1.0
Arsenic	D004	5.0
Selenium	D010	1.0

Note that some solar panels constitute hazardous waste, and some do not, even within the same model and manufacturer. It is the responsibility of the generator to determine whether their end-of-life solar panels are hazardous waste and to manage them according to the applicable regulatory requirements.

The test for determining whether a waste meets the characteristic of toxicity is referred to as the [Toxicity Characteristic Leaching Procedure](#) (TCLP). If a generator of end-of-life solar panels has knowledge that a material would fail the TCLP test (e.g., fail results from a previous TCLP test on the same make and model of solar panel), they can determine that the waste is hazardous without the need for testing. Additionally, the American Society for Testing Materials (ASTM) has developed a standard practice for extracting representative samples from PV modules for TCLP toxicity testing purposes: [ASTM E3325-21: Standard Practice for Sampling of Solar Photovoltaic Modules for Toxicity Testing](#).

#### **Are there standards for managing end-of-life solar panels as universal waste?**

As the solar industry evolves, recycling technologies and processes are also advancing. Newer methods and techniques are continually being developed to increase the efficiency, affordability, and effectiveness of solar panel recycling. Currently, there are no universal waste management standards that are applicable to solar panels in Vermont. However, the US Environmental Protection Agency (EPA) is in the early stages of working on a proposal to add hazardous waste solar panels to the federal universal waste regulations. EPA's proposal is in part in response to a [petition](#) submitted to EPA in 2021 by a broad coalition of industry associations affiliated with the electric power industry. More information on EPA's proposal is available on the [EPA website](#). Vermont will continue to follow EPA's progress as they work on developing this new federal rule.

#### **Are there any unique considerations when it comes to managing end-of-life solar panels?**

All household-generated wastes, including end-of-life solar panels, are exempt from regulation as hazardous waste under § 7-203(a) of the VHWMR. Considering that, this guidance only applies to end-of-life solar panels generated by entities that are *non-households* (i.e., businesses, schools, government facilities, etc.).

Please be aware that the *generator* of the waste is the deciding factor for determining whether end-of-life solar panels might be regulated as hazardous waste, *not* the type of building associated with the solar panels. For instance, solar panels that are leased by a household and then removed and managed by the lessor (i.e., a non-household) at end of life, are regulated as hazardous waste. In a similar example, if solar panels are taken out of service at end of life by a contractor (i.e., a non-household) as part of a replacement job, they are regulated as hazardous waste. Manufacturers and retailers that generate hazardous waste solar panels (e.g., products that are expired, damaged, or off-spec) are also regulated as hazardous waste generators.

If you have questions about managing household hazardous waste (HHW); Please refer to your local solid waste management entity (SWME) or the Vermont DEC Solid Waste Program. Contact information is listed at the end of this fact sheet.

### **Additional Resources**

- EPA webpage: [End-of-Life Solar Panels: Regulations and Management](#)
- EPA's [Solar Panel Frequent Questions](#)
- EPA guidance on [Solar Panel Recycling](#)
- If you have questions about managing household hazardous waste (HHW) solar panels, refer to your [solid waste management entity \(SWME\)](#) or contact the Vermont DEC Solid Waste Program.
- We are aware of four vendors providing solar panel reuse and recycling services in Vermont. The following list is not intended to be exhaustive, and inclusion does not constitute an endorsement by the Program:
  - [Universal Recycling Technologies \(URT\)](#): Ray Zielke - rzielke@urtsolutions.com
  - [Complete Recycling Solutions \(CRT\)](#): Keith Boyea - kboyea@crsrecycle.com
  - [Veolia](#): Jason Regan - jason.regan@veolia.com
  - [Goodpoint Recycling](#): Robin Ingenthron - robin@goodpointrecycling.net

---

***For more information regarding solar panels, or if you have other hazardous waste management questions, please contact:***

Hazardous Materials Program – Hazardous Waste Section  
Waste Management and Prevention Division  
Vermont Department of Environmental Conservation  
1 National Life Drive – Davis 1  
Montpelier, VT 05620-3704  
802-828-1138  
<https://dec.vermont.gov/waste-management/hazardous>