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Issue No. 12 | Spring/Summer 2019 **Is It a REC? – Photovoltaic Panels**

We welcome summer by shedding some light on a less obvious potential recognized environmental condition (REC) – photovoltaic (PV) solar panels. What can be more eco-friendly and seemingly low-impact than tapping the limitless energy of the sun to provide clean, renewable energy? The ASTM International E1527-13 Standard Practice for Environmental Site Assessments does not even mention the words solar, photovoltaic, or any other direct reference to solar panels. But there are some environmental considerations related to a power plant that uses PV solar panels, both before and after it is built.

Before the Sun Rises

It is not unusual to encounter solar panels almost anywhere, from urban rooftops to rural landscapes. The Smart Electric Power Alliance reports that in 2018 the solar market grew by 20.1%, with even higher growth in individual states (CA, TX, FL, NC). This explosive market has a host of permitting and environmental issues to consider (not all within a Phase I ESA scope) before PV solar panels begin generating electricity, such as:

- *Permitting* – significant zoning changes and permitting for storm water and construction disturbance can be required on the local level prior to development of ground-mounted solar arrays.
- *Brightfields* – solar power projects are increasingly at the forefront of transforming underutilized properties into community assets, in particular when brownfield sites such as closed landfills or other dormant properties are redeveloped with a solar power plant. These types of projects will almost always be preceded by a Phase I and Phase II ESA.
- *Agricultural Sites* – farming areas being redeveloped may need to consider soil or groundwater impacts from historic application of pesticides (HAP) developing such property for a solar project.
- *Heat Island Effect* – this controversial topic is often cited in opposition of solar projects, claiming that PV solar plants can change local ambient temperatures due to increased heat absorption of the panels and create lost cooling effects from removed vegetation at installation sites. There also is concern that ground-mounted PV panels can block the upwelling radiation that would otherwise cool the soil at night.

PVs Place in the Sun

The trade group Solar Power Rocks (solarpowerrocks.com) claims that nearly all PV solar panels in the world were installed after 2009, and lifecycles of PV panels are estimated to average 30 years. This appears to suggest that a significant problem for managing PV panel waste is still years away. But on a site by site scale, PV panels will need replacement when they break, malfunction, or are destroyed by natural disasters. Also, solar plants may be decommissioned as property use changes or facilities are bought and sold.

What Are Solar Photovoltaic (PV) Panels Made of?
Crystalline Silicon (c-Si) or Amorphous Silicon (A-Si) – soda lime or boro-silicate glass with silver and lead in wiring.
Cadmium Telluride (CdTe) – thin, multi layers containing cadmium; older types may have copper.
Copper Indium Gallium Selenide (CIGS) – also a thin film technology containing zinc, aluminum, molybdenum and other rare earth metals.
Junction boxes, cables, connectors – can contain lead solder and copper wiring.

Are PV Panels Hazardous?

Early studies (*Solar Cells, 2013*) report that if PV modules end up in landfills there is potential for heavy metals to leach out in the soil, and some early CdTe panels have failed the Toxicity Characteristic Leaching Procedure (TCLP) for cadmium and lead. Conversely, the National Renewable Energy Laboratory reports in a 2003 study that "the environmental risks from CdTe PV are minimal."

At least two recent studies provide more reproducible, though still conflicting, data to predict leachability of metals from PV panels under laboratory test conditions. A 2017 study published in the *Journal of Hazardous Materials* showed that crushed CdTe solar cells subjected to TCLP and the California Waste Extraction Test (WET) exceeded the TCLP limit of 1 mg/L for Cadmium. A 2017 Arizona State University study used a standardized procedure to extract samples from an end-of-life PV panel for TCLP testing by an independent laboratory. The samples for this test also included portions of junction boxes with interconnect ribbons that can contain lead solder, in order to simulate a "worst case scenario" of PV

materials entering the waste stream. Results of this test showed lead was the only detected metal, at a maximum of 3.39 mg/L, close to but below the lead TCLP limit of 5 mg/L.

The European Union directive on Waste Electrical and Electronic Equipment (WEEE) cites test results to support its requirements for PV recycling in European countries. The WEEE studies link lead leaching to 1st generation c-SI PV panels, reporting that leaching is negligible if the lead remains at normal pH, but exposure to low pH such as nitric acid or rain can cause leaching of 13% to 90% of the lead found in a typical c-Si PV panel. WEEE also identifies cadmium as a risk specific to 2nd generation thin film panels using CdTe and CIGS technologies, which can leach up to 40% of cadmium content in low pH conditions.

What to Shed Light on in the Phase I Report

Some of the environmental issues specifically related to solar energy facilities are outside the scope of a typical Phase I ESA. However, questions regarding PV solid and hazardous waste and future property use limitations, for example, are emerging issues that an Environmental Professional should consider when assessing a property with PV panels.

Questions still remain as to whether PV panels can leach hazardous levels of metals into the soil of a solar facility. The sealed and multi-layered construction of glass panels makes leaching a low-probability. But where panels become broken, cracked, or fragmented, it is not unreasonable to consider exposure to soils from the metal components. Where there is evidence of broken PV panel fragments in soil that is to be disturbed or reused, testing for total metals or TCLP may be the only way to make the case that the soil was properly characterized.

Current and future waste handling of PV panels also should be addressed in a Phase I of solar facilities.

If the panels can be recycled to avoid solid and hazardous waste regulations, this would be worth elaborating in the Phase I. While still behind Europe in waste management regulations governing PV, the US is catching up. The California Department of Toxic Substances Control is considering regulations to designate end-of-life PV modules that are identified as hazardous waste as a Universal Waste and subject those modules to universal waste management. Because a violation of these regulations would be a crime, the proposed bill also would impose a state-mandated local program. Washington state has a similar proposed law. Some states stop short of specific regulations and say disposed PV panels must be "properly managed" which strictly interpreted means to test waste prior to disposal.

Also check if the facility has a written Decommissioning Plan that addresses how PV panels will be handled at end of life, or if a recycling program exists. Such programs may increasingly be privately driven, where the panel manufacturer has a take back program for reclamation of glass as well as metals and semiconductor materials.

Finally, be sure to fully address if the solar facility was built on a closed landfill or other brownfield property.

According to the Electric Power Research Institute…
No federal, state, or local regulations require PV panel recycling in the U.S., and there are no third-party or public recycling programs in the U.S. (with exception of limited manufacturer take-back programs).
Recycling technologies exist to extract/reuse at least 80% of PV panel material.
PV panels are not classified as hazardous waste, but they contain hazardous materials.
Consistent with existing solid waste regulations, photovoltaic panel waste that fails the Toxicity Characteristic Leaching Procedure (TCLP) must be disposed of as hazardous waste.