



Current PV Panel End-of-Life (EOL) Management: An Industry Perspective

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Florida Power & Light is the leading solar power company in Florida

Florida Power & Light Co. (FPL) and clean energy

- **FPL is the largest producer of solar power in Florida and the nation's largest owner and operator of solar**
 - ~ 4700 MW
 - 63* solar energy centers that provide power to 945,000 homes
- **In June 2022, NextEra Energy, parent company of FPL, announced its goal to eliminate carbon emissions from its power plant fleet no later than 2045**
 - Install 90,000 MW of solar and 50,000 MW of battery storage with no incremental cost to customers
- **Our customers expect affordable, reliable, and clean energy**
- **FPL is committed to environmental excellence and has a dedicated team that is actively involved in our environmental management and stewardship**

FPL strives to reuse/ repurpose/ and recycle as much as possible to minimize waste generation, this includes PV panels

FPL's Overall Waste Management Strategy

- **FPL believes in the basics of waste minimization**
 - Reduce
 - Reuse
 - Recycle
- **FPL continuously seek opportunities to identify and implement reuse and recycling programs that results in economic and environmental benefits**
 - The FPL Corporate Recycling Services team won the 2021 Florida Recycling Partnership Foundation Trail Blazer Award



FPL has a robust recycling program, as shown by 2022 recycling statistics

FPL CRS Operations: Recycling

- **In 2022, FPL recycled:**
 - More than 19.4 million pounds of scrap wire and metal
 - Nearly 521,000 pounds of electronic waste
 - More than 22,000 tons of vegetation waste
 - Approximately 9,400 yards of wood (donated to local recyclers)
 - 88,200 pounds of cardboard
 - More than 1.4 million gallons of mineral oil
 - Scrap rail cars: 6.8 million pounds (scrap metal)

Wire and cable recycling at the FPL CRS just one example of waste minimization processes in place

FPL CRS Operations: Wire and Cable

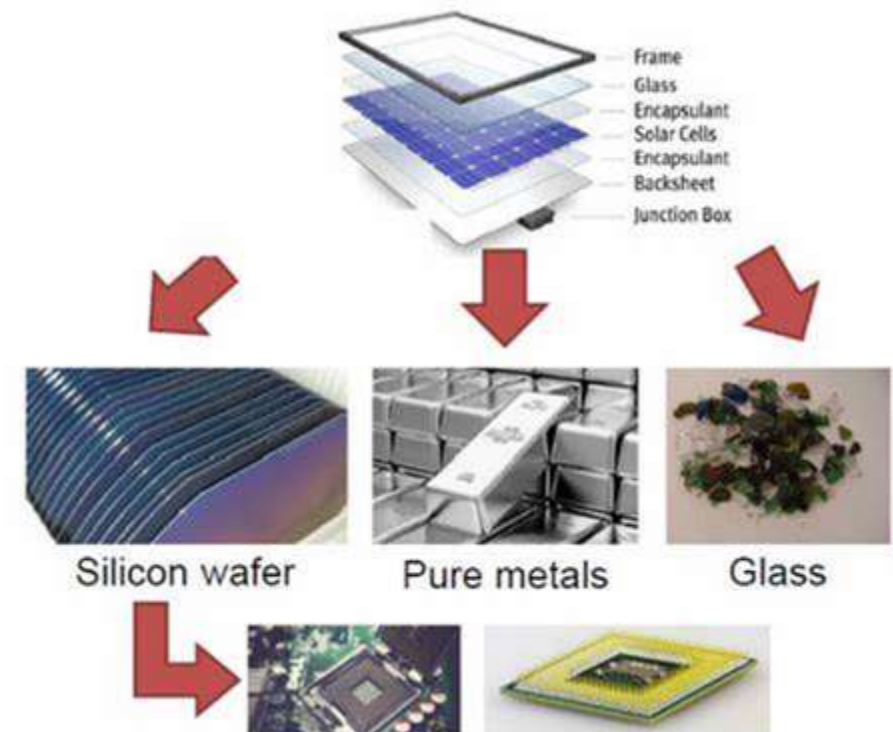
- **Underground cable**
 - Contains an oxidation inhibitor
 - Removed from jacket and cut into 4' pieces
- **Overhead wire/ cable**
 - Granulated or chopped
- **Submarine cable**
 - Sheathed
 - Placed in lined/ covered containers
- **Once processed, these materials are sent to appropriate recycling vendors**



FPL manages solar panels, as with all waste, in adherence to all applicable regulations and industry best practices

Solar Panel Management

- FPL complies with all local and state regulations, as well as industry best practices
- FPL works at all levels to encourage and promote solar panel recycling
- FPL partners with solar panel recycling vendors to ensure panel recycling capabilities continue to keep up with expected future needs



Federal regulations for managing waste have been around since the 1970s

Resource Conservation and Recovery Act (RCRA)

- **RCRA was created in 1976 and provided a framework for identifying and managing hazardous waste**
 - Created cradle-to-grave liability for managing hazardous waste
 - Defined hazardous waste
 - Listed
 - Characteristic
 - Established generator categories
 - Requirements vary by generator status
- **Provides criteria for managing specific categories of waste**
 - Used oil
 - E-waste
 - Universal waste

There are no current federal regulations specific to solar panels disposal and/or recycling

What Does EPA/ RCRA Say About PV Panels?

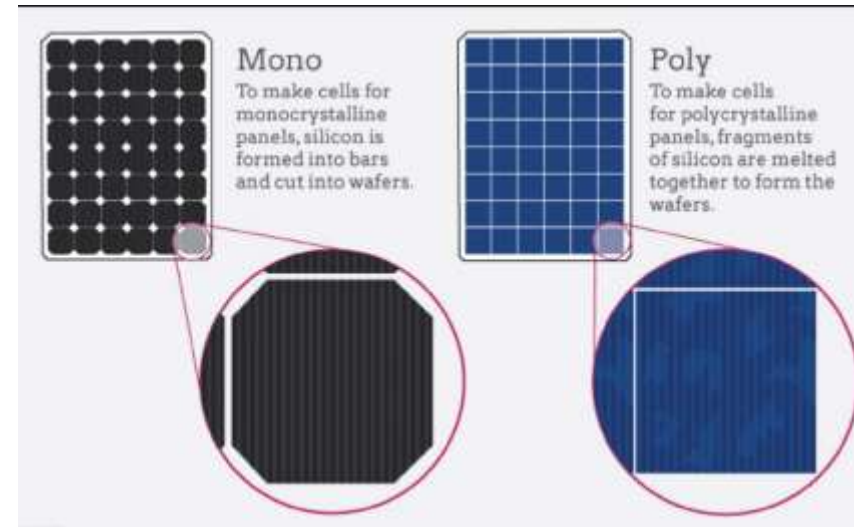
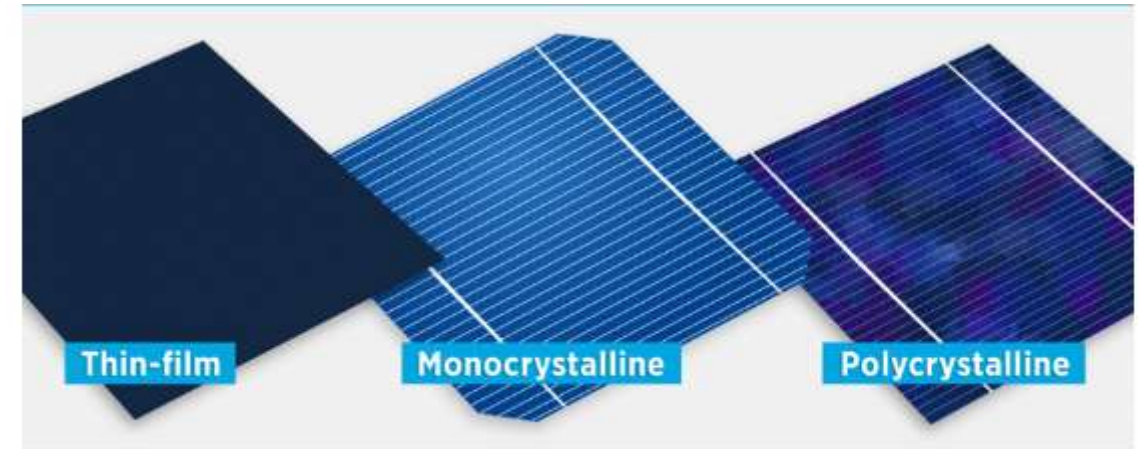
- **As with all waste, it is the responsibility of the waste generator to characterize waste**
 - Depends on leachability of certain metals that may be present in the panels
- **If the panels are hazardous, there are time constraints on when they have to be disposed of depending upon hazardous waste generator status**
 - A storm event can change a very small quantity generator into a large quantity generator



There are several types of solar panels

Solar Panel Variability

- **Most common types of panel**
 - Thin film
 - Cadmium telluride (CdTe)
 - Copper indium gallium diselenide (CIGS)
 - Crystalline-silicon (95% of panels)
 - Monocrystalline
 - Polycrystalline



There are multiple options for managing solar panels at End-of-Life

Options for Solar Panels

- **Routine Waste Minimization**
 - Refurbish
 - Reuse
 - Recycle
 - Panels are not considered a solid waste when recycled and therefore RCRA does not apply
 - Some recyclers won't take certain panels
 - Using the Transfer-Base Exclusion for the reclamation of hazardous secondary material is another option
 - Disposal
 - Current guidance is to assume panels are hazardous unless you can document that they aren't
 - SDS/ TCLP from manufacturers are difficult to get and may not be enough

The new ASTM standard for sampling solar panels is very specific and finding a contractor to do this is difficult

Sampling Solar Panels

- **ASTM E3325-21: Standard Practice of Sampling of Solar Photovoltaic Modules for Toxicity Testing**
 - Designed to ensure representative and repetitive samples
 - Only applies to certain panels
 - Coupons must be cut using a waterjet
 - Sample pieces must be 9.3-9.5 mm square
 - Multiple samples per panel
 - Total weight must be 100 g
- **How many panels need to be sampled?**

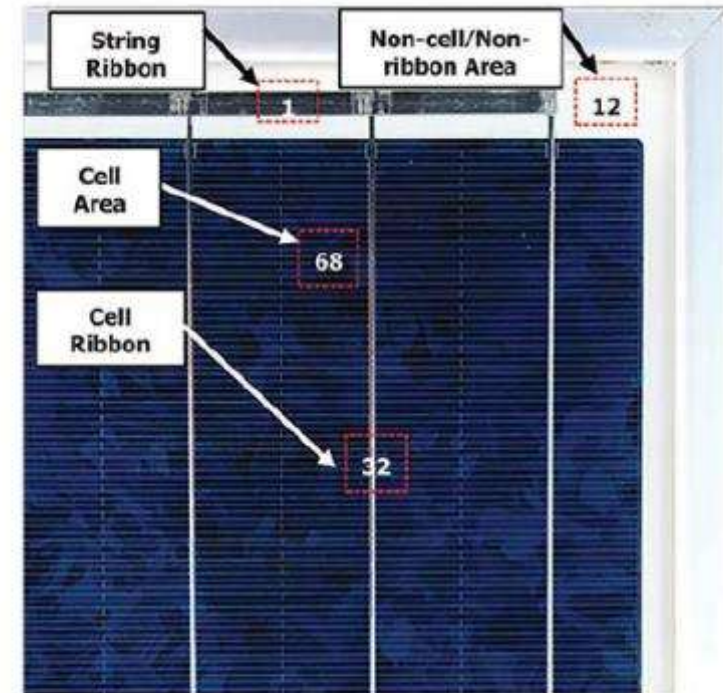
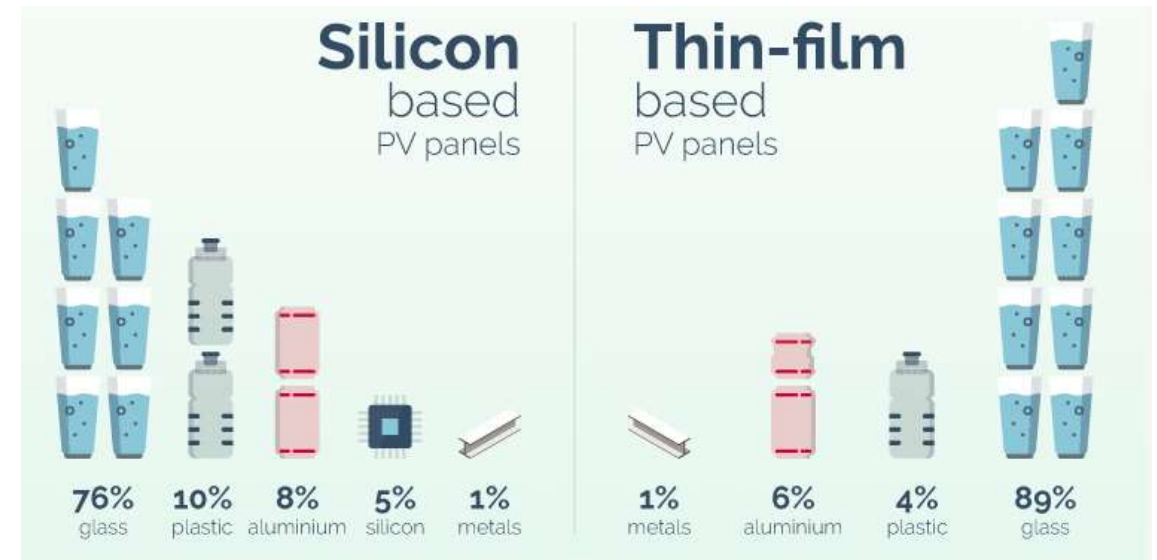


FIG. 1 Laminate Area of a Multi-crystalline PV Module With Representative Sampling Locations (the numbers inside the squares indicate the approximate number of required 9.5 mm by 9.5 mm pieces in a typical c-Si module)

Recycling solar panels are the preferred option, but may not always be feasible

What are some challenges to recycling solar panels?

- **Logistics**
 - Location of facilities
 - On-site storage
 - Limited market
- **Process**
 - Very manual process
 - Recovery of metals difficult
- **Cost**
 - Current costs for recycling panels is 10-15 times that of disposal



FPL has a process to evaluate all potential waste and recycling vendors

Solar Panel Recycling Vendors

- Evaluate all potential waste vendors to ensure cradle-to-grave liability protection
 - Especially since the market is growing and there are more vendors
- Different types of vendors
 - Industrial/e-waste recycler
 - Solar panel recycler
 - Broker
- RCRA cradle-to-grave liability means you need to know where the panels are going



