Technical Research Opportunities for Photovoltaic System End of Life Management

DATE: 05/19/2021
SUBJECT: Request for Information (RFI)

Description

The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Solar Energy Technologies Office (SETO) is requesting information on the possible areas of technical research that would improve photovoltaic module and component end-of-life practices.

Background

The cumulative installed capacity of photovoltaic (PV) systems in the U.S. is nearing 100 GW_{DC} and would add as much as 500 - 600 GW_{DC} more by 2030 to be on track to meet the President's goal for a carbon-free power sector by 2035. As PV deployment increases, the amount of PV system components eventually reaching their end of life (EoL) will increase as well. To make this growth as environmentally sustainable as possible, processes to handle PV EoL that have low environmental impact and are cost effective need to be developed. This RFI seeks to gain information on the current state of PV EoL in the U.S. and what research areas could result in increased PV EoL reuse and recycling.

The components in a PV system include the PV modules, racking and trackers that make up the mounting system, and piling to secure the mounting system, as well as cables, wires, and power electronics (Figure 1). While the lifetime of these different components varies, the overall rate of PV systems coming offline in 30 years will roughly reflect the current rate of installation. In the case of PV modules, the volume reaching EoL in 2050 could be 6-12% of the U.S. electronic waste volume (Figure 2), or about 0.1% of the total annual waste generated in the U.S.

In the U.S., PV module and component end-of-life practices, such as recovery, reuse, recycling, and disposal, are not well understood since EoL volumes have been low and there are few policies related to PV EoL. In the European Union, PV EoL is better tracked due to the Waste

---

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

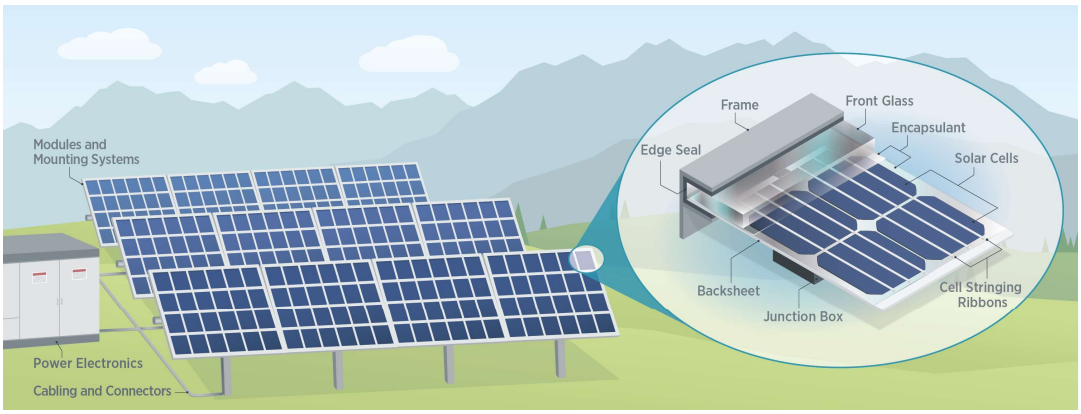

Figure 1. Components of a PV system. The inset shows the components inside a PV module.

Electrical and Electronic Equipment Directive, which sets targets for 85% of electronic waste to be recovered and 80% of that recovered waste to be recycled. To minimize the environmental impacts of PV EoL in the U.S., better data on PV EoL is needed to improve EoL handling and materials recovery practices and to inform research, so that processes and practices are in place when the PV EoL waste stream increases.

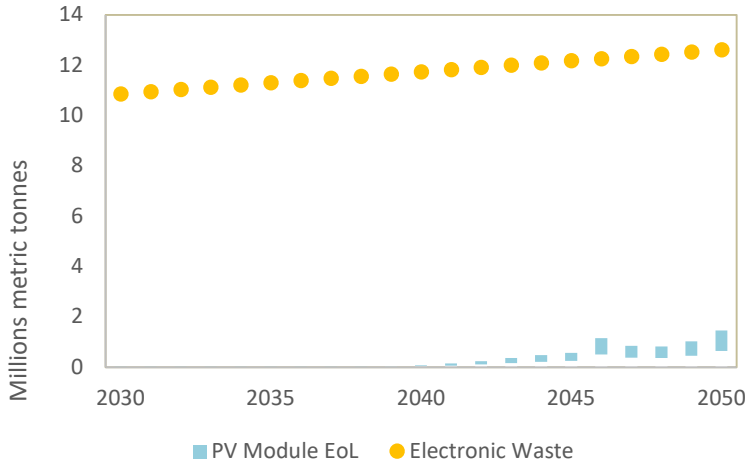

Figure 2. Estimated annual PV module waste compared to annual electronic waste in the U.S. for 2030 to 2050[1]

[1] Assuming a 30-year module lifespan and module mass to power ratio of 42-76 metric tonnes per megawatt. The electronics waste is based on EPA municipal waste data tables (https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/studies-summary-tables-and-data-related) and World Bank's *What a Waste 2.0* Report projections of waste growth. Here electronic waste includes large appliances, small appliances, and consumer electronics.

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

Recycling components at EoL could provide energy savings compared to the production of new materials. Three materials account for 90% of the mass of a PV system: steel, glass, and aluminum. Recycling of steel racking and piling would save 55% of the energy needed to make primary steel, recycled aluminum frames and wiring would save 85% of the energy needed for primary aluminum, and recycling of glass would save 45% of the energy needed for primary glass.[2]

Recycling also provides another source of raw materials that is not dependent on primary mining, which creates risks to human health and the environment, and could relieve some supply chain constraints. Recycling processes for silicon (Si) PV modules have been developed that can recycle 95% of the mass of a module[3] into constituent parts that can be used again, including the aluminum frame, glass, polymers, silicon, and metals. The full cost to recycle, however, needs to be lower than the cost to landfill for such practices to be used. Eighty-five percent of a silicon module is composed of aluminum and glass, which can be easily recycled, but may not bring in enough revenue to make recycling compelling. There are other higher-value materials within a module, such as silver, silicon, tellurium, copper, and indium but their recovery is more challenging. Developing cost-effective recycling processes for these materials would increase the overall recycling rate for PV modules. Since 2016, the PV industry has consumed between 8.8% and 9.9% of the global silver supply annually; developing cost-effective recycling would also be a way to strengthen global silver reserves.

Other potential ways that are being explored to handle EoL volumes are reuse, refurbishment, and improved disposal management of panels and components. The first two methods would reduce the rate that EoL volumes are generated. Reuse involves the recovery of EoL components and directly reusing the materials for PV or other applications. Refurbishing involves replacing failed equipment, performing inspections and tests to identify problems, and recommissioning the PV system. Disposal of EoL is a currently available option but could benefit from improved understanding of how PV EoL affects landfills. Initial leaching studies have shown that Si and CdTe PV modules can be safe for landfilling, but a deeper understanding of the potential environmental impacts and the development of testing protocols specific to PV modules would help improve disposal practices.

Purpose

[2] Values for energy savings estimated from EPA's Waste Reduction Model www.epa.gov/warm

[3] The recycling percentage is based on the PV module recycling process employed by the waste management company Veolia in their PV recycling plant located in France which processed 1,800 tonnes of materials in 2018

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

The purpose of this RFI is to solicit feedback from the solar and recycling industries, academia, research laboratories, government agencies, and other stakeholders on available data regarding PV EoL and areas of research needed to reduce the barriers to reuse and recycling.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Confidential Business Information

Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email two well-marked copies: one copy of the document marked “confidential” including all the information believed to be confidential, and one copy of the document marked “non-confidential” with the information believed to be confidential deleted. Submit these documents via email. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given

---

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Questions

1. Insufficient data are available on why PV components reach EoL and on PV EoL handling, transportation methods, and costs. This lack of data creates ambiguity about whether recycling, reusing, or recovering materials is more costly than disposal. Additional data and analysis can help EERE understand and prioritize research on PV EoL. Based on your experience,
    a. What defines 'end of life' (EoL) for a solar photovoltaic (PV) component?
    b. What are the common causes of PV EoL?
    c. How is PV EoL currently handled?
    d. What data would be useful to understand and track the PV system EoL landscape? Where is this data available?

2. What are barriers to PV component reuse at EoL for both PV and other applications, and how can the rate of PV EoL reused be increased?

3. What areas of PV component design could be improved to increase material recycling rates at component EoL without sacrificing performance, cost, or reliability and why?

4. What actions can PV module manufacturers, distributors, developers, owners, waste management, or recyclers take to increase the fraction of PV components reused or recycled?

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to SETO.RFI.PV@ee.doe.gov no later than 5:00pm (ET) on June 14, 2021. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email, and no more than 3 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.