SunShot
U.S. Department of Energy

PV Module Recycling RFI Summary

Reminder – Questions

- Is PV recycling an important problem? Why or why not?
  - What defines 'end of life' for a PV module. What are the expected volumes of PV modules that are at end of life (rather than at end of warranty) in 15 years? 30 years?
  - There are many issues within the field of PV recycling that would benefit from improvement such as establishing policy, growing the infrastructure and developing technical solutions. In the current US environment, what is the largest problem in the field of PV recycling?
- The Federal government, the industry and academia can all contribute to the development of a PV module recycling infrastructure but perhaps by addressing issues at different points of the supply chain.
  - What current US policies, if any, are related to the development of PV recycling?
  - What is the most impactful action the Department of Energy could take in terms of PV module recycling?
  - What is the most impactful action that industries related to PV module recycling could take? (such as module manufacturers, distributors, developers, waste management, recycling industry)

- A large and well-established recycling infrastructure already exists for materials that make up the bulk of common PV modules such as glass and aluminum.
  - How easily and efficiently can current PV modules be fed into the current recycling infrastructure?
  - What are the three most important technical hurdles in recycling processes that need to be overcome in order to efficiently recycle PV modules? What is needed for PV recycling to be economically profitable?
  - What industries are uniquely suited to solve PV recycling issues that are not traditional recycling or PV industries?

- List the top three areas of module design that can be improved to increase recovery rates at end-of-life without sacrificing performance or reliability.

- List the top three areas in applied science research and development that would contribute the most impact to a better understanding of PV module recycling.

Responses

- Is PV an important problem?
  - Installer can only send to First Solar
  - Missing regulations at Fed and state level
  - Need to decrease future waste volumes
  - Need to recover critical and toxic materials (2)
  - 0.05% of installed modules fail annually
  - 0.05% of modules fail before leaving manufacturer per year
  - 2% broken in production per year

Responses

- What defines ‘end of life’ for a PV module.
  - T80, cables will fail sooner than panels
  - Broken, uninstalled, lower than 80% of rated power output
  - 50% of power rating
  - 15 years
  - No longer used to generate electricity
  - From Cal DTS proposed amendment: Physically damaged, deteriorated, or altered PV modules, fractured PV modules

Responses

- What are the expected volumes of PV modules that are at end of life (rather than at end of warranty) in 15 years? 30 years?
  - 15 years: 0.3M tons, 1GW, 3GW
  - 30 years: 1M tons (cumulative), 2-3M tons, 10M tons, 12.1GW
  - 75-100 tons per MW

Responses

- There are many issues within the field of PV recycling that would benefit from improvement such as establishing policy, growing the infrastructure and developing technical solutions. In the current US environment, what is the largest problem in the field of PV recycling?
  - Policy (8)
  - Incentives (3)
  - Cost and LCA models (3)
  - Transportation and collection(3)
  - Technology (3)
    - Demonstration of, lack of for Si
  - Federal programs (2)
  - Informing consumer
  - Systems level research and modeling
  - Create a US “PV Cycle”

Responses

- What current US policies, if any, are related to the development of PV recycling?
  - Policies
    - Cal DTS – PV module waste – disapproved in Oct 2013
    - NY and CA have take back programs and bans on e-waste in landfills
    - CA SB 1020 – unclear status as of Nov 2014
    - Federal Resource Conservation and Recovery Act – controls hazardous waste; encourage solid waste management programs at state level
  - Programs
    - EPA Waste Wise
    - EPA clean air act

Responses

- What is the most impactful action the Department of Energy could take in terms of PV module recycling?
  - R&D on low cost, high impact recycling technologies (5)
  - Fund modeling and analysis of PV recycling, critical materials (3)
  - Develop “best practice” guide for recycling
  - Develop mobile recycling facilities
  - Create/manage a PV recycling network
  - Outreach and education to industry
  - Create incentives for recycling (2)
    - Procurement that requires recycling
  - Implement a take-back program for Federally purchased PV
  - Develop policy

Responses

- What is the most impactful action that industries related to PV module recycling could take? (such as module manufacturers, distributors, developers, waste management, recycling industry)
  - Distributors and installers should be collectors at EOL; extended producer responsibility (4)
  - Develop individualized recycling processes (2)
  - Join to create a recycling program
  - Create an entity willing to pay for recycling
  - Develop a plan and industrial policy for action
  - Educate how to properly dispose of panel, provide panel information
  - Decrease embodied energy and materials used
  - Perform analysis on the specific recycling processes that would most impact emission targets
  - Provide recycling facilities like First Solar
  - Reduce amount of toxic materials in panels
  - Changed Al frame design, develop a non-EVA encapsulent

Responses

- How easily and efficiently can current PV modules be fed into the current recycling infrastructure?
  - Needs cell and laminate stripped; delamination (3)
  - Al (2) and Cu is efficiently handled
  - PV materials have impurities not up to standard for recycling (ex. Glass)
  - There is no infrastructure for PV
  - Easily
  - Not easily
  - Similar to displays
  - Need to solve transportation

Responses

- What are the three most important technical hurdles in recycling processes that need to be overcome in order to efficiently recycle PV modules? What is needed for PV recycling to be economically profitable?
  - Efficient delamination processes (4)
  - Recovery of precious metals (2)
  - Cost effective Si wafer and glass recycling (2)
  - Increase purity of glass (2)
  - Environmentally friendly separation methods
  - Transportation logistics and cost (3)
  - Removable backsheets
  - LCA and system performance analysis

Responses

- What industries are uniquely suited to solve PV recycling issues that are not traditional recycling or PV industries?
  - Automotive
  - Metallurgical (2)
  - Glass (2)
  - Chemical treatment (2)
  - Former team of PV Recycling LLC
  - Electric power sector
  - Porous Si

Responses

- Module designs to increase recovery rate?
  - Eliminate backsheet or laminate (2)
  - Eliminate Pb (2)
  - Improve reliability
  - Frameless module or easily removed frames (2)
  - Reduce glass amount, design for glass recycling
  - Label modules with materials information and recycling directions

Responses

- List the top three areas in applied science research and development that would contribute the most impact to a better understanding of PV module recycling.
  - Thermal and mechanical separation of modules
  - Cost studies (2)
  - Cost studies of mobile recycling
  - Cost study of recycling vs. reuse
  - Metals refinement
  - Removal of polymeric material
  - Si cell recycling to refined Si
  - Easily removable backsheet
  - Delamination methods
  - Feasibility, LCA and policy assessments (2)
  - Waste prognosis
  - Automated recycling
  - Pilot Si reclamation plant