End-of-Life Management of Photovoltaic Panels: Trends in PV Module Recycling Technologies

Introduction

- When a product cannot be repaired or reused, recycling is the next best option.
- In the case of PV modules, recycling has become an important emerging topic and various activities have been conducted and developed.
- The purpose of this study is to provide an international survey of trends related to the development of PV module recycling technology.

Approach

- Patent analysis
  - Database used: online WIPS (worldwide intellectual property service) system covering Jan. 6, 1976 – Dec. 9, 2016.
- Overview of technology R&D
  - Survey of literature published by firms implementing R&D projects.

**Patent Analysis**

- **Procedure**
  Initial search → 6,465 patents → Screening → 178 effective patents* → analysis (based on targeted components, processing method, and recovered materials)

*directly related to PV recycling

- **Analysis results**

  **c-Si** – 128 effective patents
  - 45% focusing on module separation
  - Mechanical method for 40%
  - Many patents for recovery of components, not for recovery of individual materials.

  **Thin-film compound** – 44 effective patents
  - High value recycling recovers higher fraction of the mass
  - Combination method for 64%
  - Total recycling from module separation to material recovery.

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**Overview of Technology R&D**

**Delamination is a key recycling step including:**

- **c-Si**
  - Separation and recovery of glass, Si cells, and other metals
  - Thermal, mechanical and chemical approaches can be used.

**Thin-film compound**
- Recovery of cover and substrate glass with the semiconductor layer
- Thermal, mechanical and optical approaches can be used.