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"RECYCLING PHOTOVOLTAIC COMPONENTS"

PART 2

Mª Rocío Rodríguez Barroso
Prof. Titular. Dpto. Tecnologías del Medio Ambiente
rocio.rodriguez@uca.es

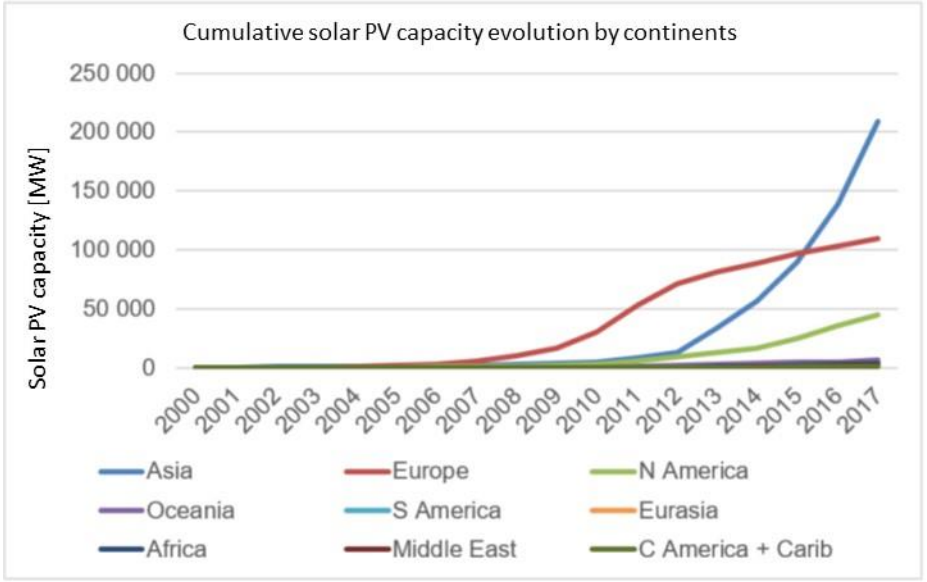
Universidad de Cádiz

RECYCLING PHOTOVOLTAIC COMPONENTS

PV modules as waste

eco-concepción: Prevención

...In a nearly future



2030: the first residues of PV panels will appear

2050: (European Commission) - it will reach 60 million tons.

(Reference: IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi)

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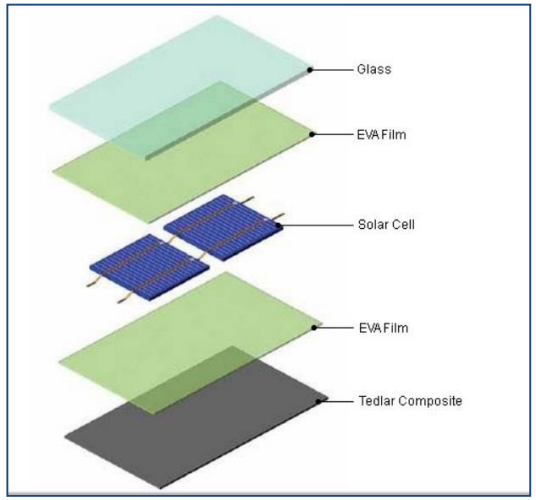
Crystalline silicon solar PV module



Types of waste (Silicon module):

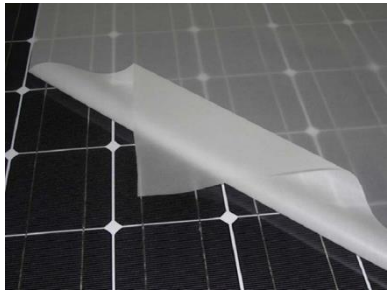
- Glass (74.16%)
- Aluminum (10.3%)
- Silicon (3.35%)
- Silicone (1.16%)
- Copper (0.57%)
- Silver (0.005%)
- Sn (Tin) (0.12%
- Zinc (0.12%)
- Lead (0.6%)

Our estimations

2017: World - 384.62 GW (Cumulative solar PV capacity)

2042: Worldwide cumulative solar PV waste

- 24,7 million tons of glass
- 3.4 million tons of aluminum
- 3.7 million polymer Tm
- 1.1 million Tm Silicon
- 190 thousand copper Tm
- 1,6 thousand Tm silver
- 40 thousand Tm Sn
- 40 thousand Tm Zinc
- 200 thousand Tm lead



Reference: Source: IRENA (2018), Renewable Energy Statistics 2018, The International Renewable Energy Agency, Abu Dhabi.

Polymers (EVA-6.5% and Tedlar 3.6%)

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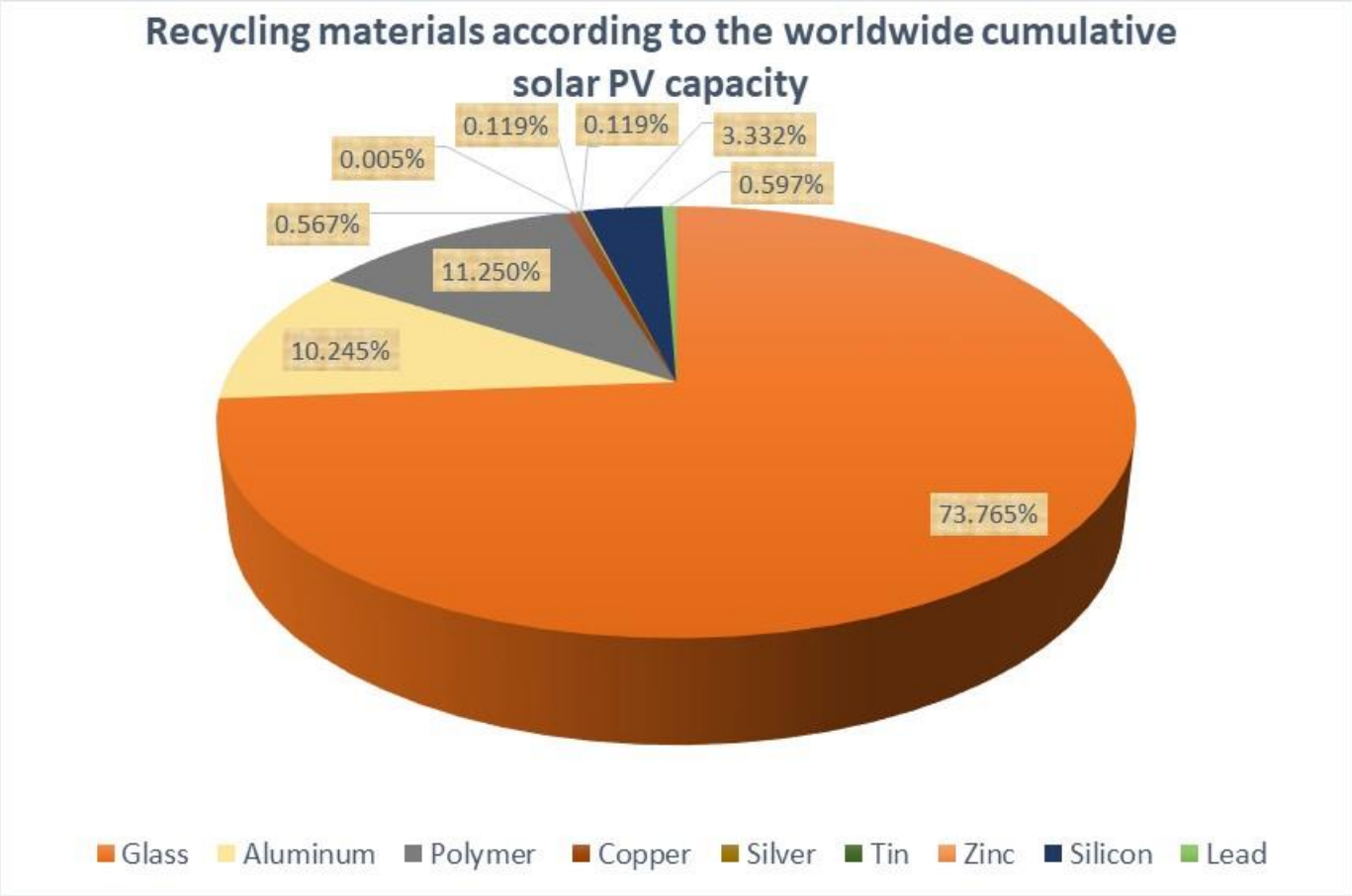

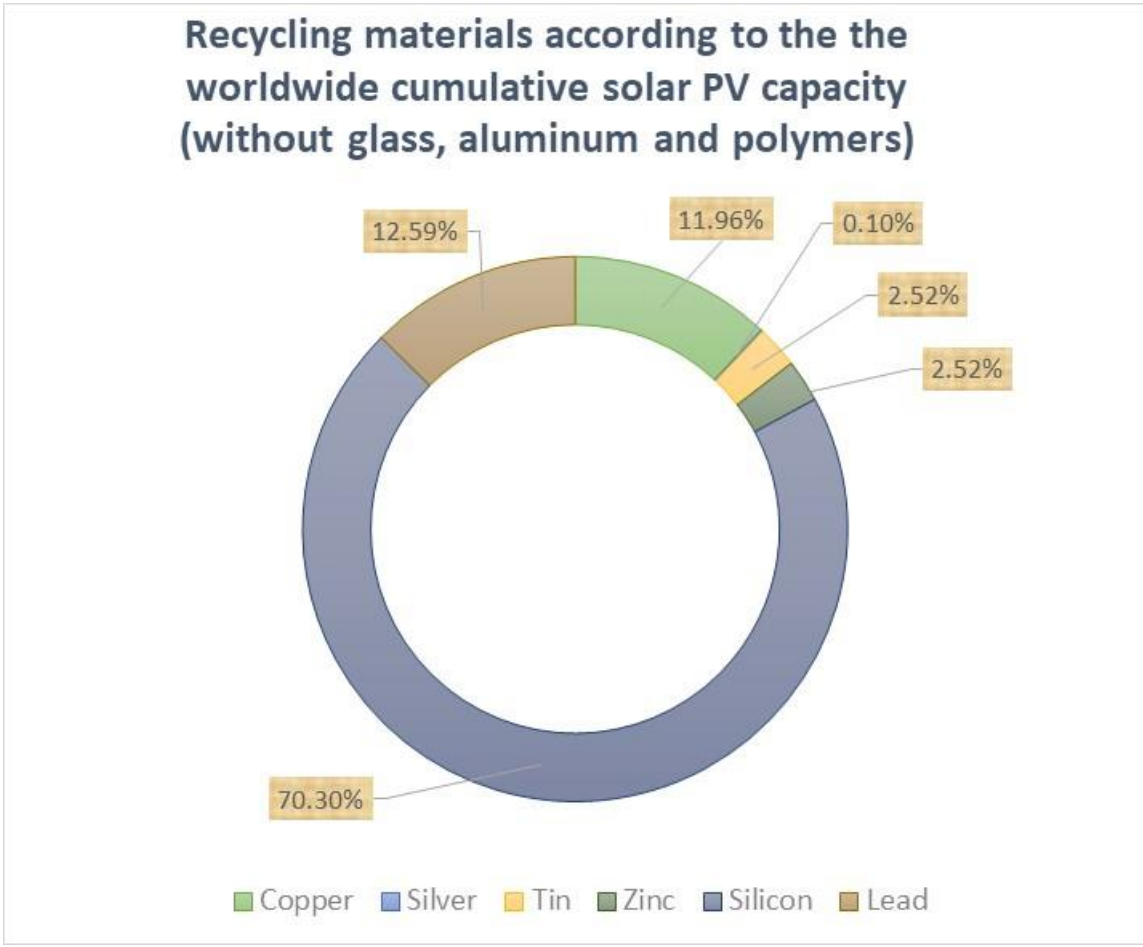

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Potential End-of-Life Hazards for Solar PV Products

Solar panels contains, apart from electronic waste, a growing number of new and emerging materials that present complex recycling challenges, leaving a toxic legacy if they end up in landfills (where the materials they contain can leach into groundwater) or incinerators (Air pollution)

¿LANDFILLS?

Waste recovery facilities are often **low-tech** and in need of **substantial research and development to improve their environmental footprint** with such toxic materials from PV panels

"Plans for recovering and recycling materials at the end of product life should be standard practice for any product identified as a "renewable" energy source"

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Regulations of application as waste

In 2012, the European Union formally revised the Waste Electrical and Electronic Equipment Directive (**WEEE**), adding photovoltaic components as rejects to be included in ten categories of WEEE. Photovoltaic solar cells are now included in the electronic waste management system and must be collected and recycled.

Main environmental problems

If the solar panels are not properly eliminated, are: lead leaching, cadmium leaching, loss of recoverable resources (1 million tons of aluminum, 0.3 million tons of silicon, 7.4 million tons of tons of glass at this time) and loss of rare recoverable metals (mainly silver, along with indium, gallium, germanium, and other metals).

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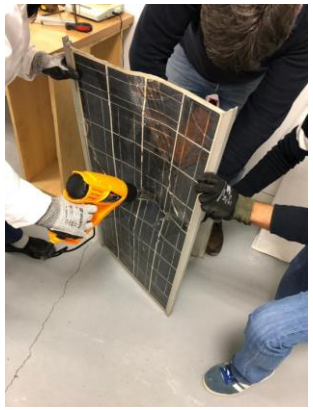
Trends in technology R&D for PV module recycling

Stage 1. Mechanical process or **Disassembly**: Includes the separation of the aluminum frame, cables, back (if desired) and junction box of the PV sandwich panel, which is composed of polymers, semiconductor and glass. This process is basically a preparatory process for further processing in order to separate metals. Among the advantages, it is less energy-intensive, but the question arises of the competent disposal of chemical wastes that are used in post-processing.



TEDLAR

INTERCONECTORS

MIXTURE

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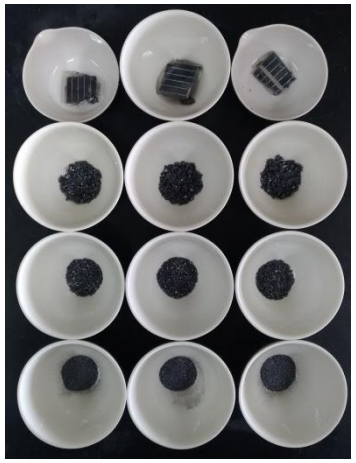
Trends in technology R&D for PV module recycling

Stage 2. Thermal process. As a result of exposure to high temperatures, glass, silicon modules and electrode tapes are extracted. However, most glasses and modules can be reused if there are no chips or microcracks. Disadvantages of the process - high electricity costs.



FURNACE 600 ºC

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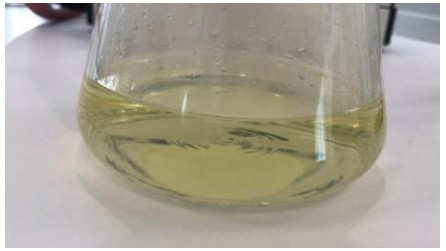
Trends in technology R&D for PV module recycling

Stage 3. Chemical methods. For the extraction of metals (silver), acid solutions or alkali metal hydroxide are usually used. It also entails the proper management of this waste



Extraction of metals with acids

Extract Ag

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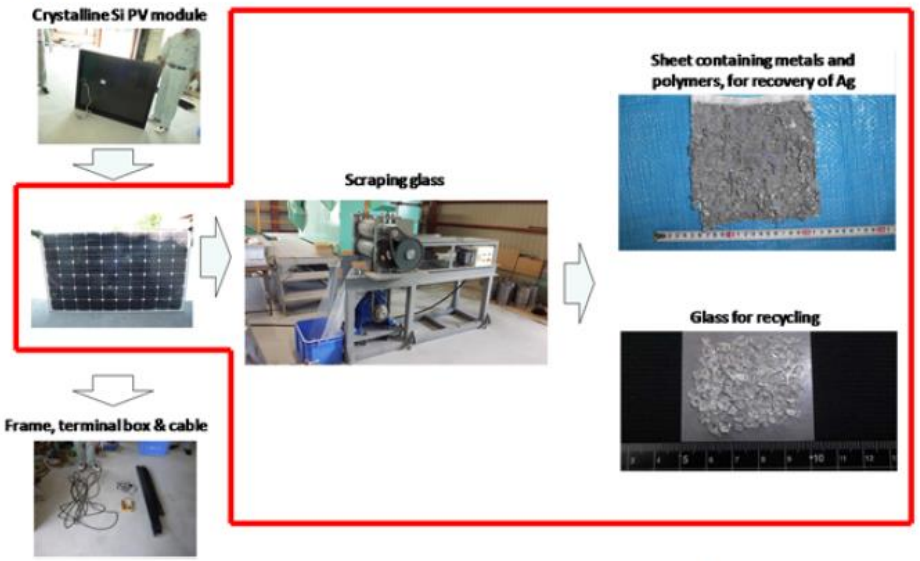
Country/region	Japan
Project title	Development of recycling technology for crystalline Si PV modules
Granting agency	NEDO (New Energy & Industrial Technology Development Organization)
Implementing organization	Mitsubishi Materials Corporation
Project period	FY2015-2018
Targeted PV module	c-Si
Project target	5 JPY/W (as supposed capacity: 200MW/year)
Technology type	Mechanical
Targeted and recovered subjects	Frame, glass, Ag containing material

- Removal of Al frame and terminal box by machine
- Scraping cover glass, and recovering remaining sheet consisting of EVA and metals containing Ag concentrated
- Sorting and separating glass scraped for glass cullet and other particles containing Ag

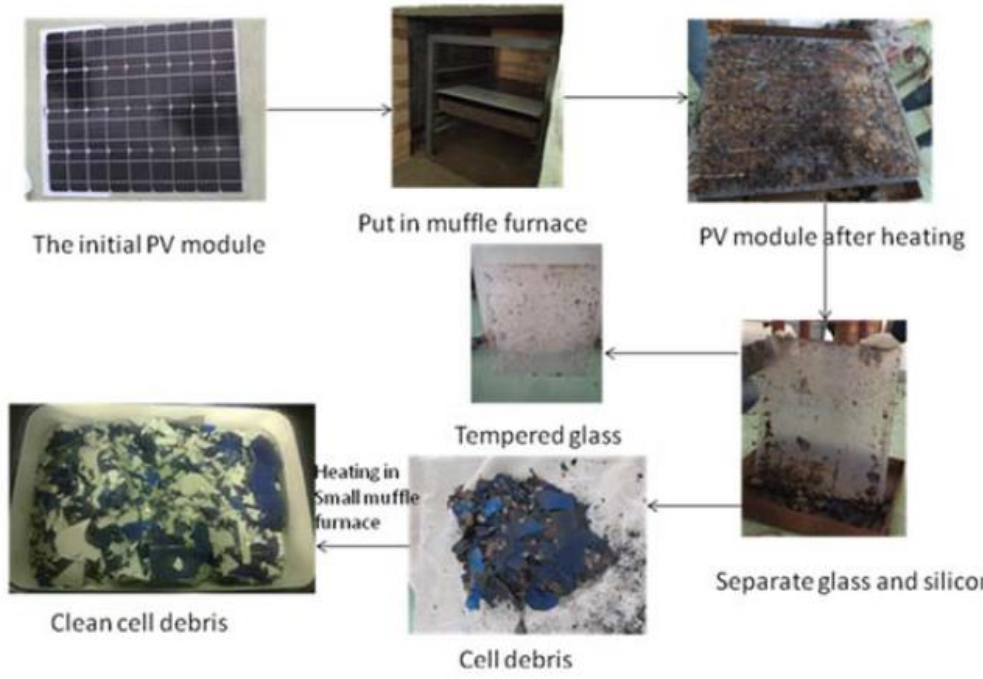


[Courtesy of Mitsubishi Materials Corporation]

RECYCLING PHOTOVOLTAIC COMPONENTS

Country/region	China
Project title	Thermal method of PV module recycling
Framework	National High-tech R&D Program "PV Recycling & Safety Disposal Research"
Implementing organization	Chinese Research Academy of Environmental Sciences, Institute of Electrical Engineering
Project period	2012 - 2015
Targeted PV module	c-Si
Technology type	Thermal & chemical
Targeted and recovered subjects	Glass and metals

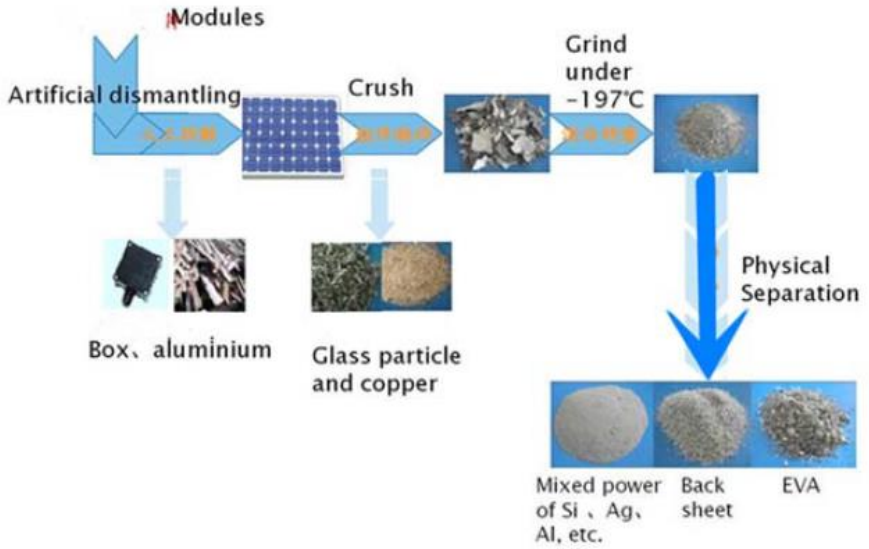
- Recovery of glass and metals such as Si cells by combustion process
- Separation and recovery of metals contained in Si cells by chemical processes.



RECYCLING PHOTOVOLTAIC COMPONENTS

Country/region	China
Project title	Mechanical method of PV module recycling
Framework	National High-tech R&D Program "PV Recycling & Safety Disposal Research"
Implementing organization	YingLi Solar, Institute of Electrical Engineering
Project period	2012 - 2015
Targeted PV module	c-Si
Technology type	Mechanical
Targeted and recovered subjects	Glass, metals and plastics

- Removal of Al frame and terminal box
- Crushing and refrigerating to -197 degree C by using liquid nitrogen
- Grinding module refrigerated
- Separating particles of encapsulation (EVA), glass and mixed powder of Si, Ag, Cu, etc. physically



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