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*all-in-one solutions for your profit.*



# Overview of the Current Recycling and Treatment Technologies for PV Technologies

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## bifa – some facts

- foundation 1991
- 40 employees
- approx. 4 mil Euro turnover/year
- legal form: Limited company, non profit oriented
- the shareholders:

Free State of Bavaria



City of Augsburg



Chamber of Industry  
and Commerce for Swabia



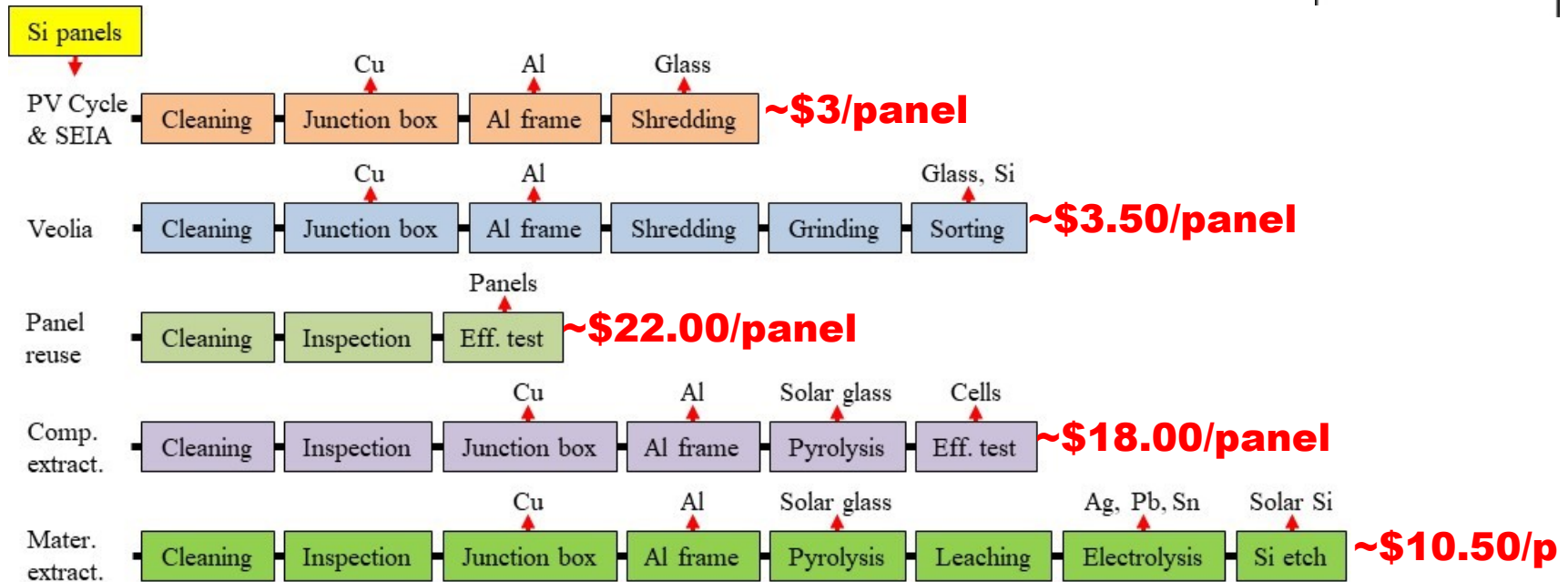
- **PV waste amounts are small today**
  - but may increase faster than expected
- **PV modules may contain small amounts of scarce, valuable and toxic materials**
- **Better statistical data required to support:**
  - Development of regional policies
  - Implementation of regulations
  - Implementation of circular economy

## **Large Scale Processing in existing recycling plants**

advantage: investments moderate

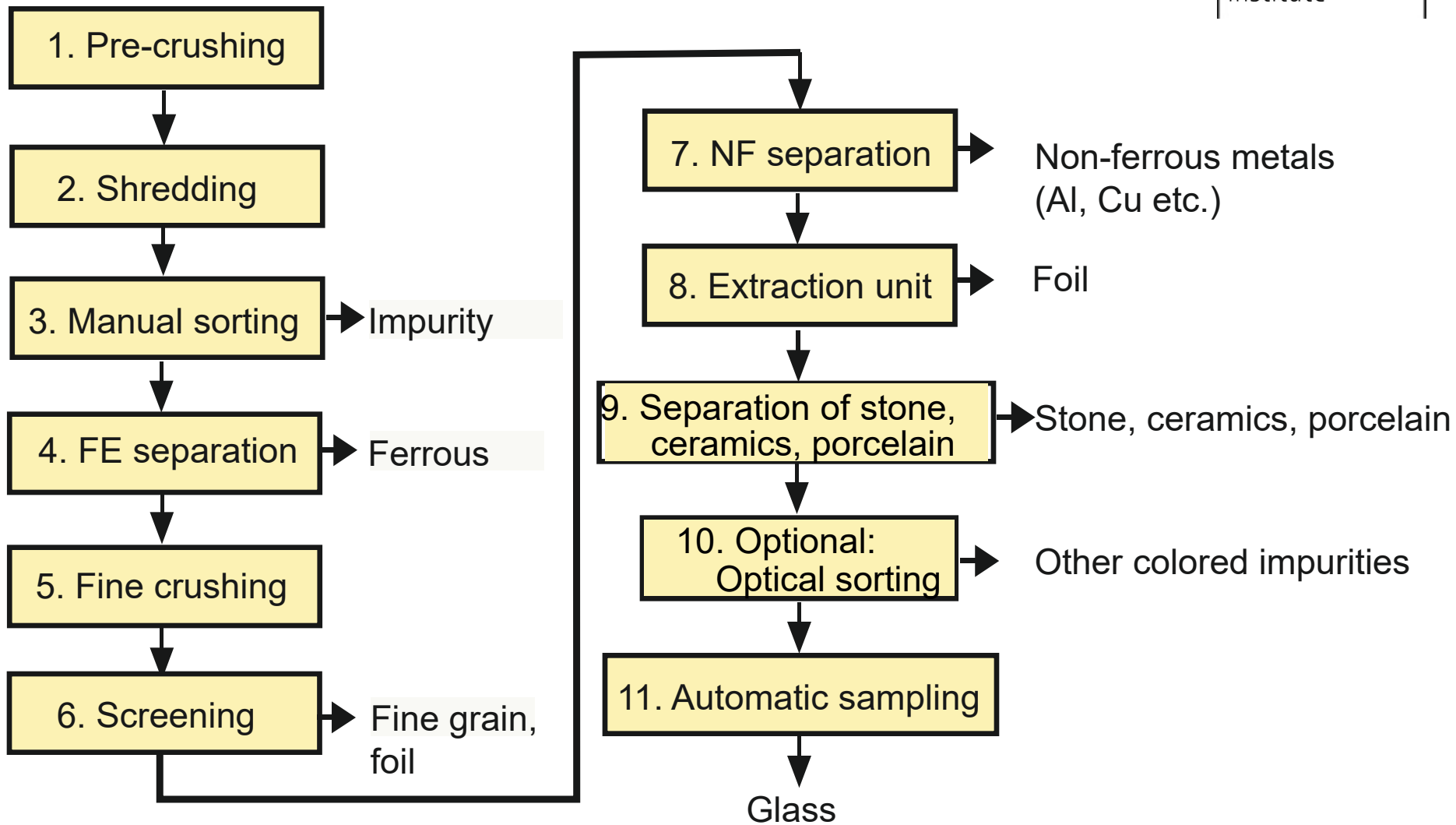
### **Annual capacity for mechanical PV, metal and glass recycling plants:**

5,000 tons (dedicated PV) up to 100,000 tons (laminated glass)



- **Two commercial processes by physical methods for ~\$3/panel**
- **Three proposed processes (reuse of panels, components or materials) for \$10–20/panel**
- **Simpler process generates higher revenue for the proposed processes**

# Example: Laminated Glass Recycling Plant



## **New recycling approaches to achieve higher output values**

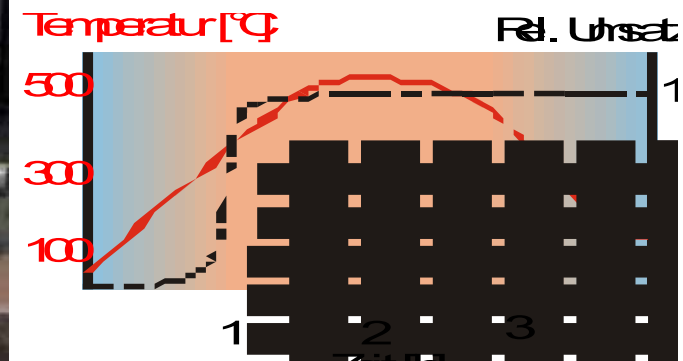
(yield and quality optimisation)

### **Combined processes (variable)**

mechanical

thermal

chemical

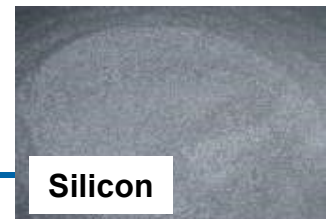


Credits: SolarWorld





**Separation after thermal treatment**



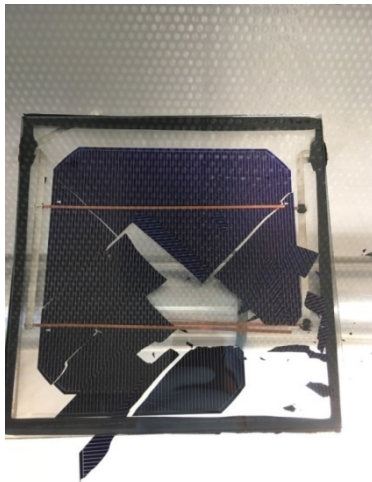
**Silicon**

## Separation of materials

- **Flash lamp annealing (Flaxres, von Ardenne, LuxChemtech)**
  - Energy efficient
  - Low thermal stress on the glass



Flash lamp annealing device  
Credits: Von Ardenne, Germany



Solar cell after flash lamp annealing



Microscope slide with PIB residues after flash lamp annealing.

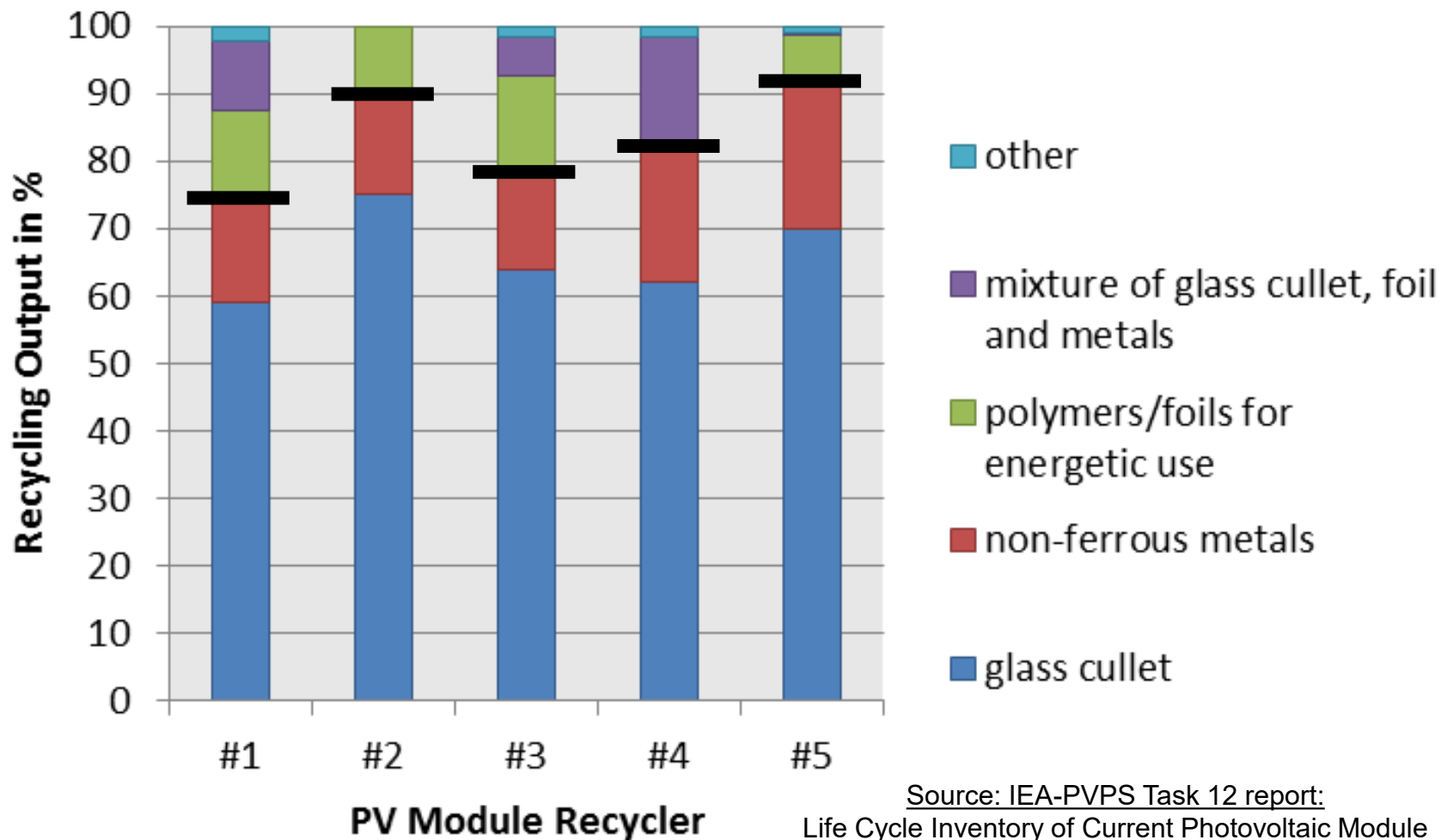


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- **Glass recycling**
  - float, container, glass foam, fiber insulation material
- **Aluminum:**
  - reuse of aluminum frames if intact
  - remelting for different applications
- **Copper:**
  - Reuse as secondary feedstock material in the copper production
- **Silver:**
  - Removal from the solar cell by etching or melting
- **Steel:**
  - Utilization by steel smelters
- **Polymers**
  - Incineration, blending (recycling)

# Results Of Some Recyclers



Source: IEA-PVPS Task 12 report:  
Life Cycle Inventory of Current Photovoltaic Module  
Recycling Processes in Europe, 2017

- **High raw material value stored in PV, but decreasing value**
- **Mechanical recycling processes dominate the current market (laminated glass, metal and e-waste recyclers)**
- **Quality and yield of output optimized for both compliance with laws and economics (frequently loss of Si and Ag)**
- **Better recycling quality and yield require investments**  
**Intensive international R&D observed**
  - **New technologies are combining several methods (mechanical, thermal, chemical) in R&D and pilots**
  - **New, advanced processes are ready for investment, but require stable and sufficiently large input streams**





**Thank You!**

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