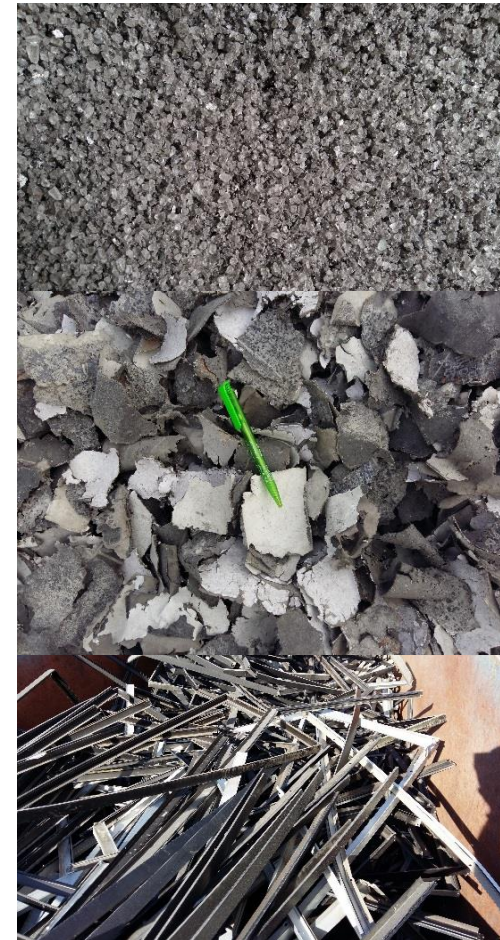


Recycling of c-Si Modules from the Perspective of Glass Recycling

Benedikt Heitmann
Reiling GmbH & Co. KG

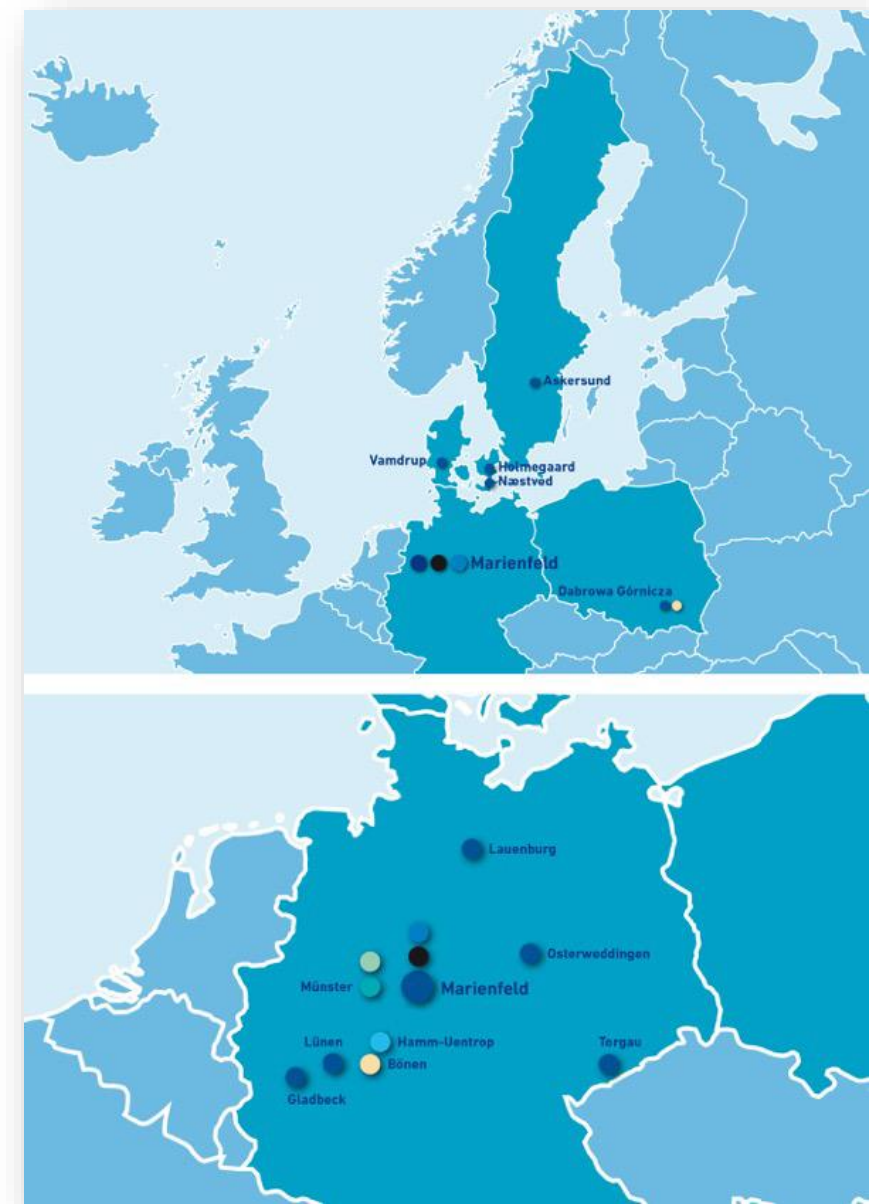


Facts

The Reiling Group is one of the leading specialists in Germany for glass, plastic, paper, wood recycling and much more.

With 15 German and international locations we are one of the most versatile recycling enterprise groups in Europe.

- Flat glass
- Container glass
- Photovoltaic modules
- Revitro
- Plastic
- Wood
- Paper
- Municipal services
- Data media destruction



Reiling PV panel recycling locations



Reiling at a glance

15
locations in
total

10
different
business areas

over
650
employees
throughout
Europe

total
25
trainees

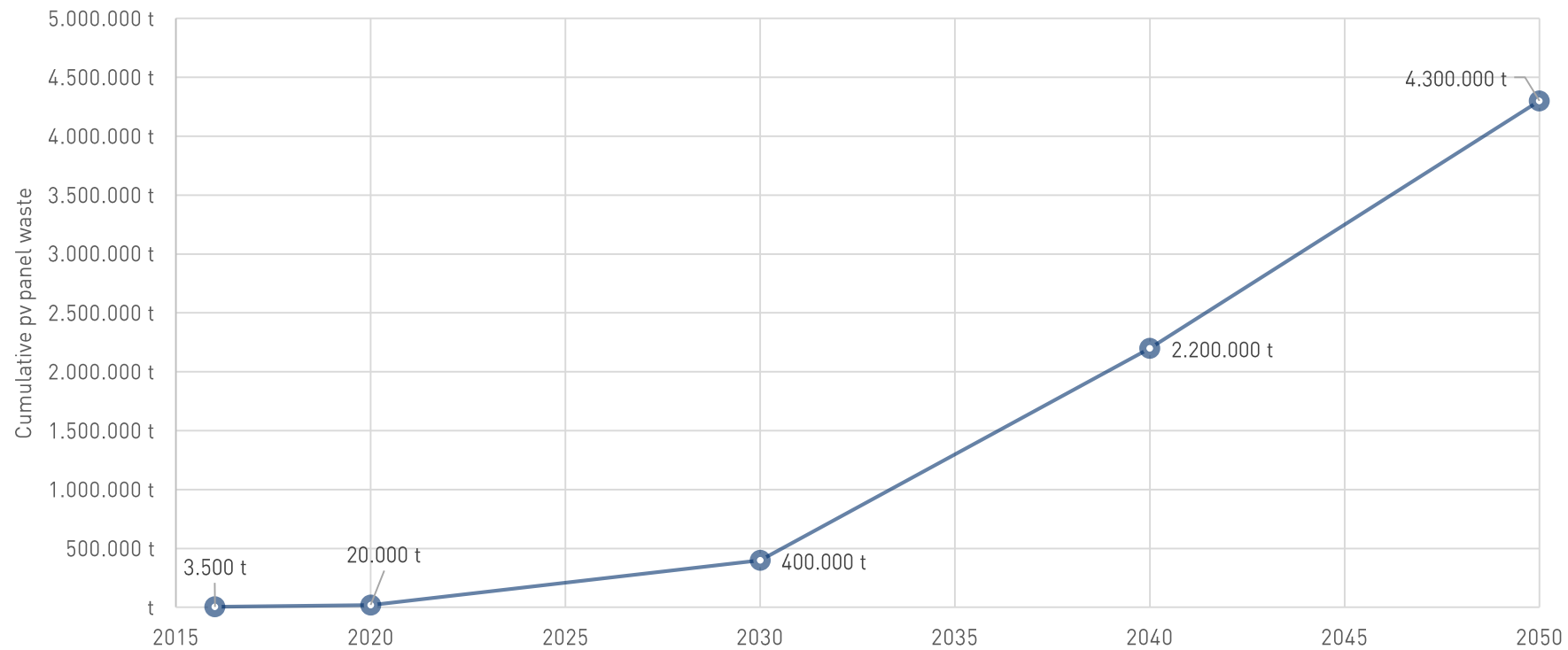
10
locations for the
processing of
glass

1 Mio. t/year
quantitative
volume

100 years
experience

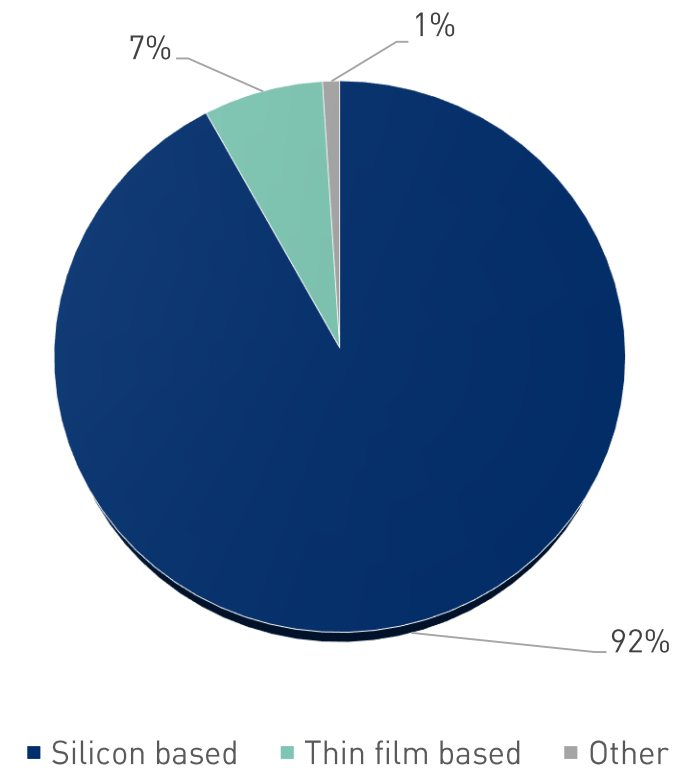
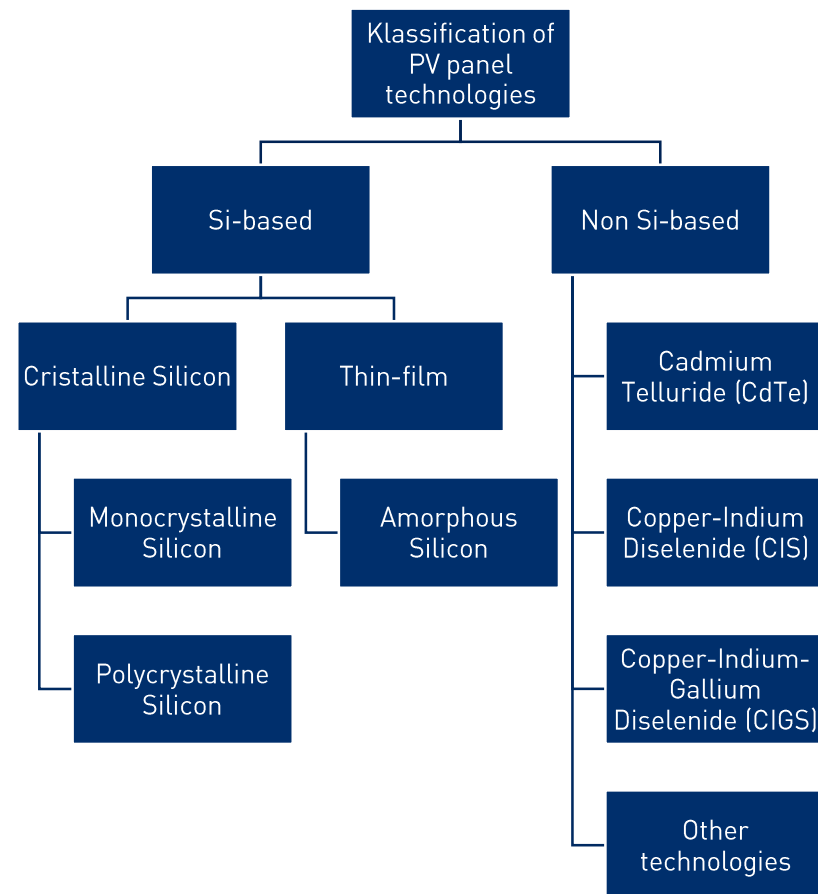
170
vehicles in
daily use

Cumulative end-of-life PV panel waste in Germany



Based on end-of-life management (irena) (2016),

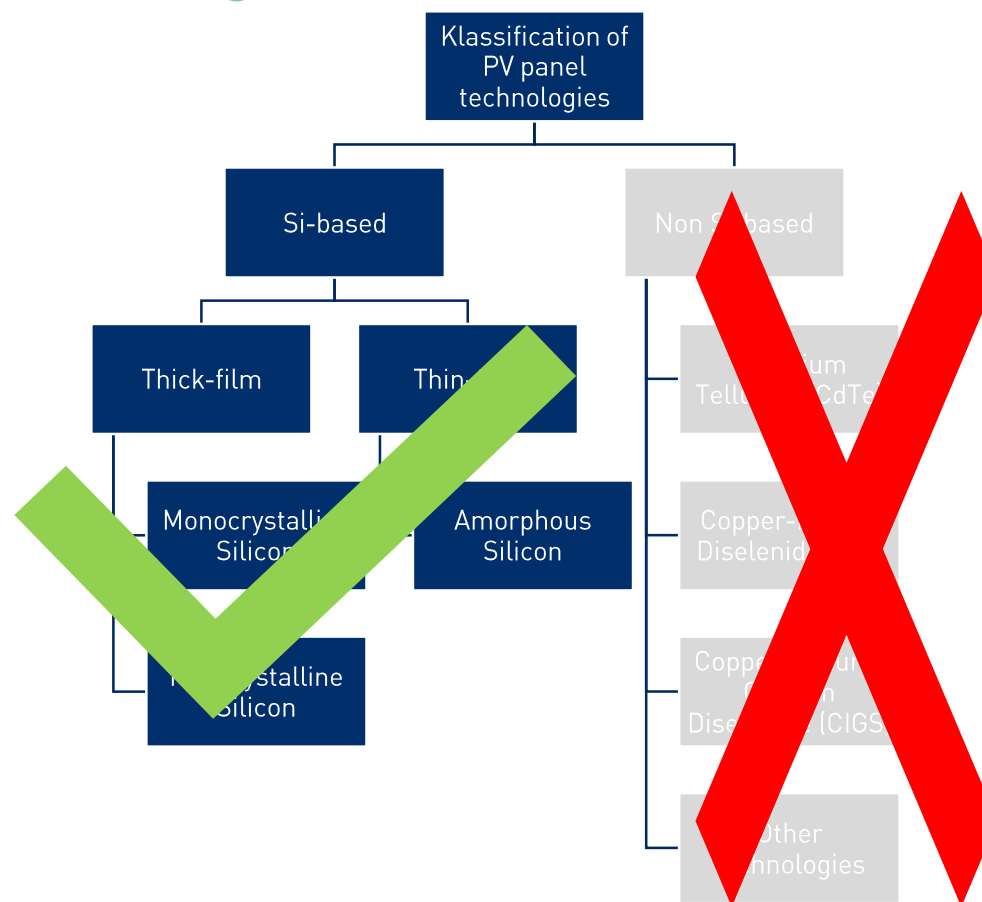
Classification and market share of PV panels by technology



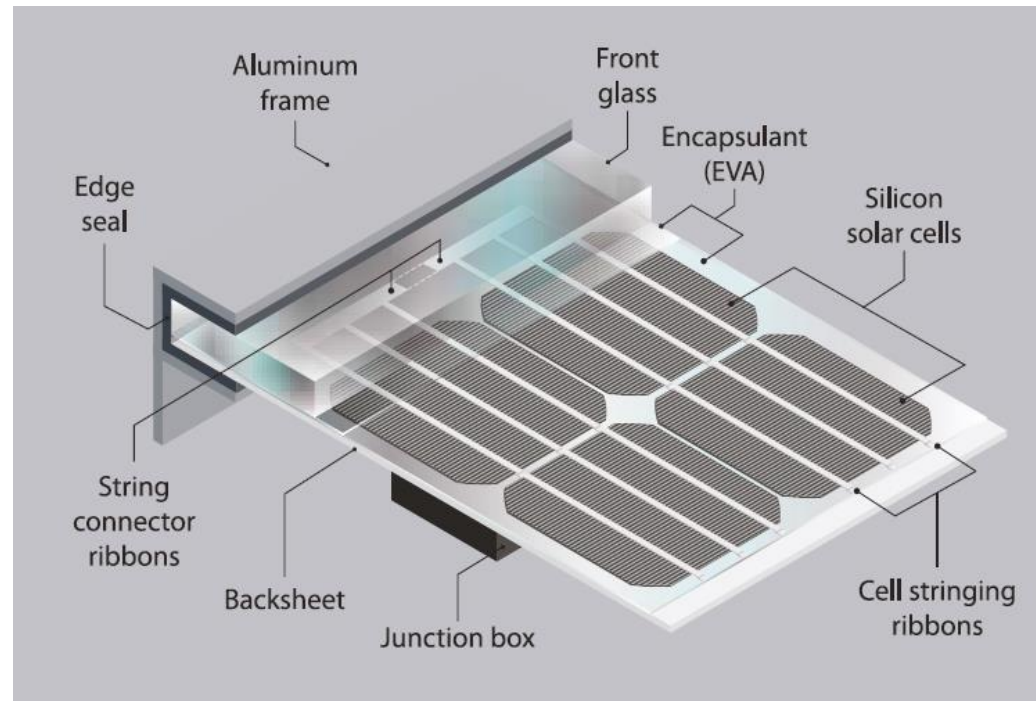
Based on Fraunhofer Institute for Solar Energy Systems (ISE) (2014),

Which panel technologies are suitable for our process?

All kinds of silicon based PV panels can be recycled with the „Reiling“ process.

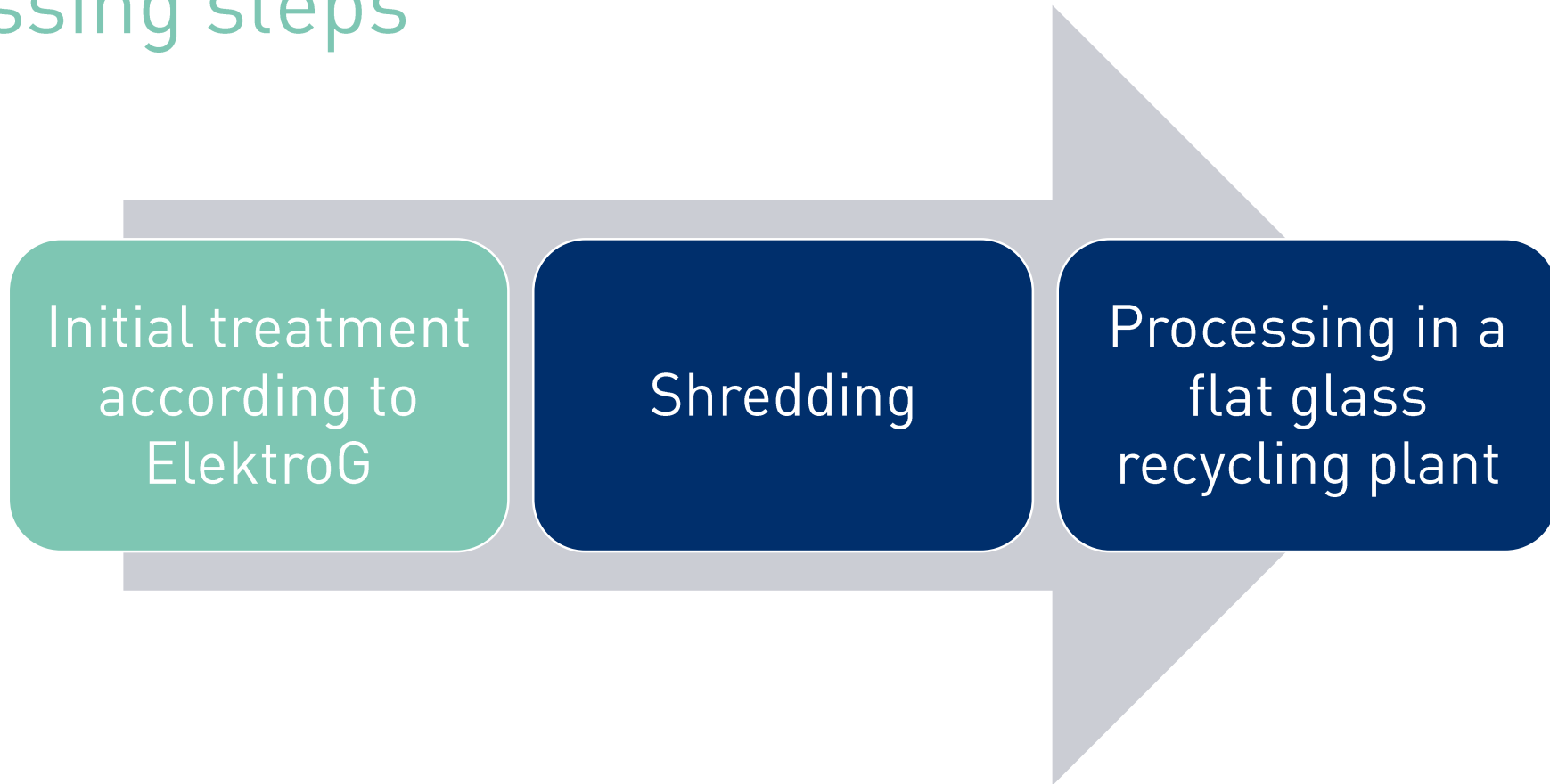


C-Si PV panel components



Source: End-of-life management (irena) (2016),

Processing steps



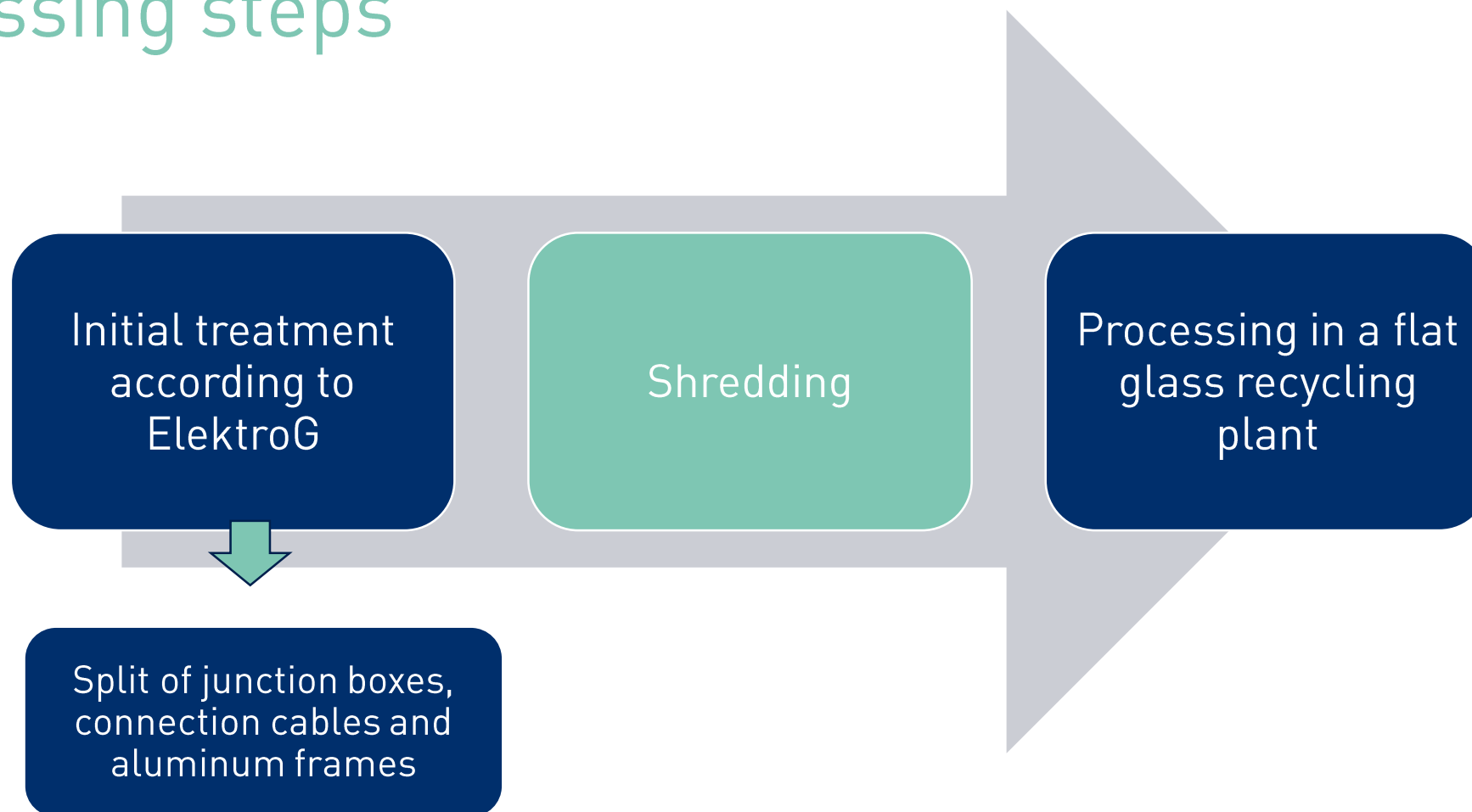
Initial treatment according to ElektroG

- Selective treatment of c-Si modules
 - Split off the connection cable, junction box and aluminum frame



Advantage	Disadvantage
<ul style="list-style-type: none">• Improvement of the glass quality	<ul style="list-style-type: none">• High manpower requirements
<ul style="list-style-type: none">• Better purity of the discharged fractions	<ul style="list-style-type: none">• Low throughput
<ul style="list-style-type: none">• Less wear in the next steps	

Processing steps



Shredding



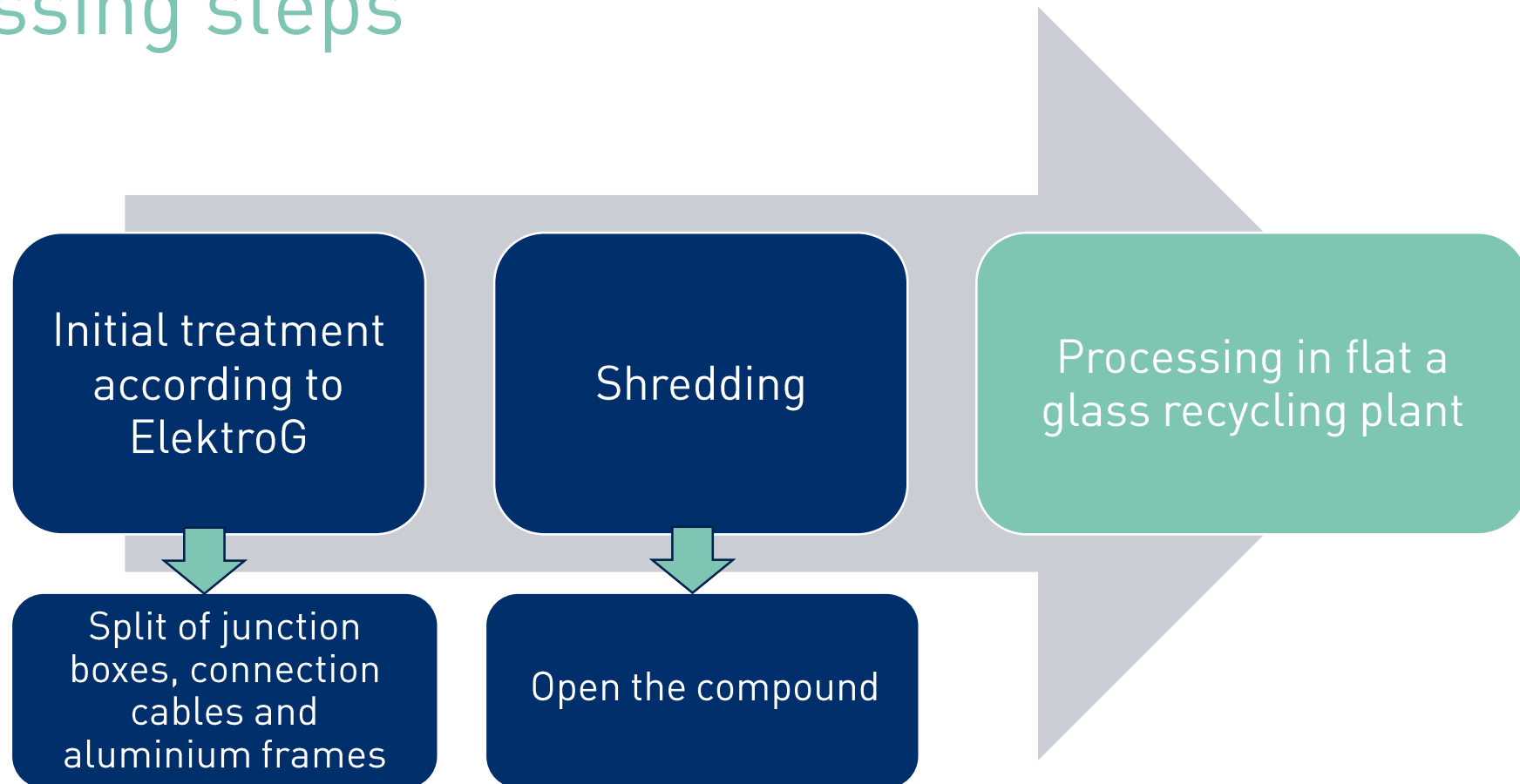
Goal

Open the compound of glass, foil and other components

The glass fraction should be as coarse as possible

EVA foil with low content of glass cullets

Processing steps



Process flow in a flat glass recycling plant

Input Hopper

Manual pre-sorting

Magnets

Eddy current sorter

XRF Sorter opt.

Exhaust system

Optical sorter

Inductive sorter

Quality control



Processing target: Remove
all kind of impurities!

Remove the impurities

Remove
foil



Remove
FE-Metals



Remove
NE-Metals



Optical
sorting

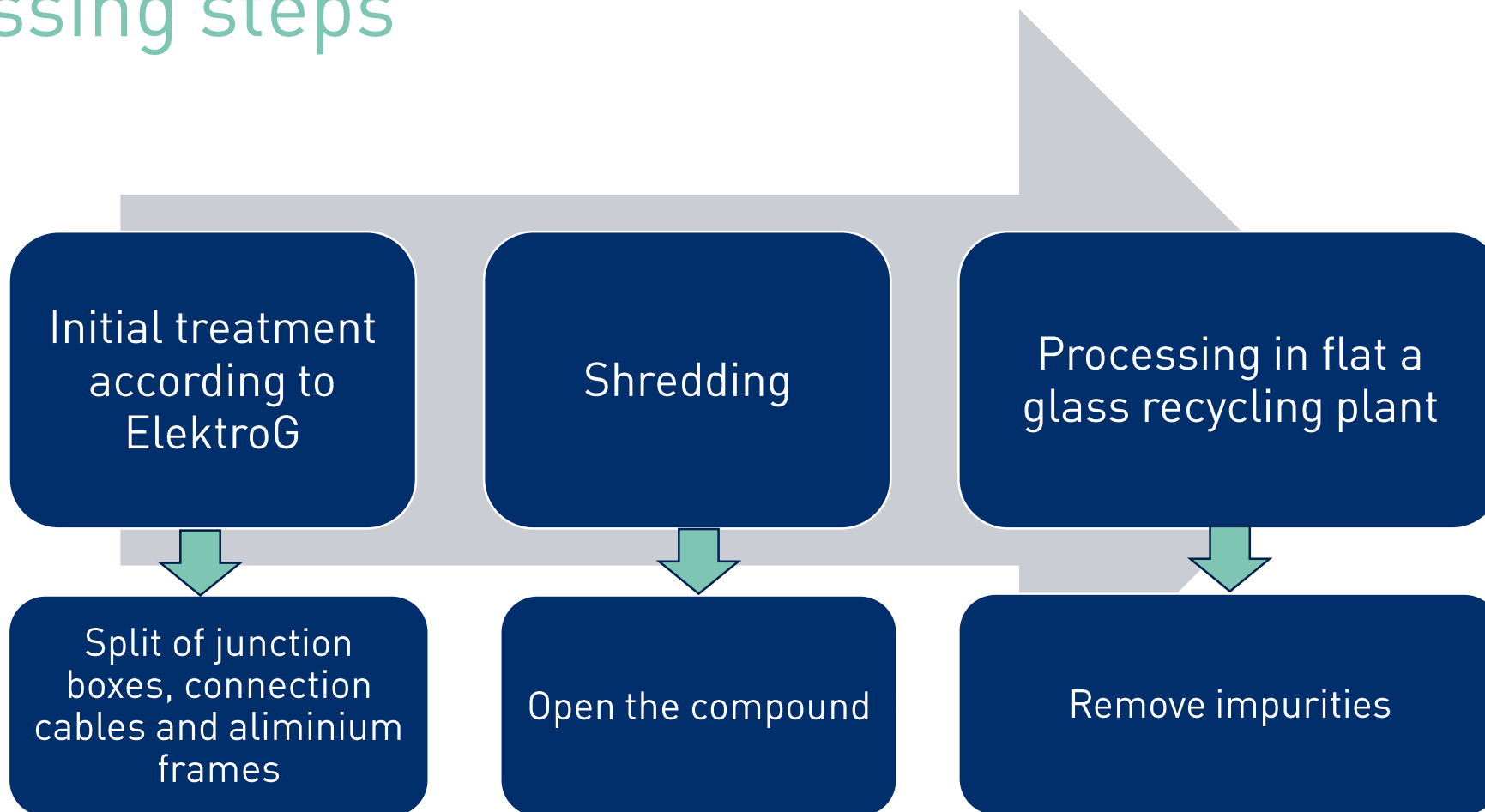


The glass product

- The pictures below show the glass fraction after the processing steps



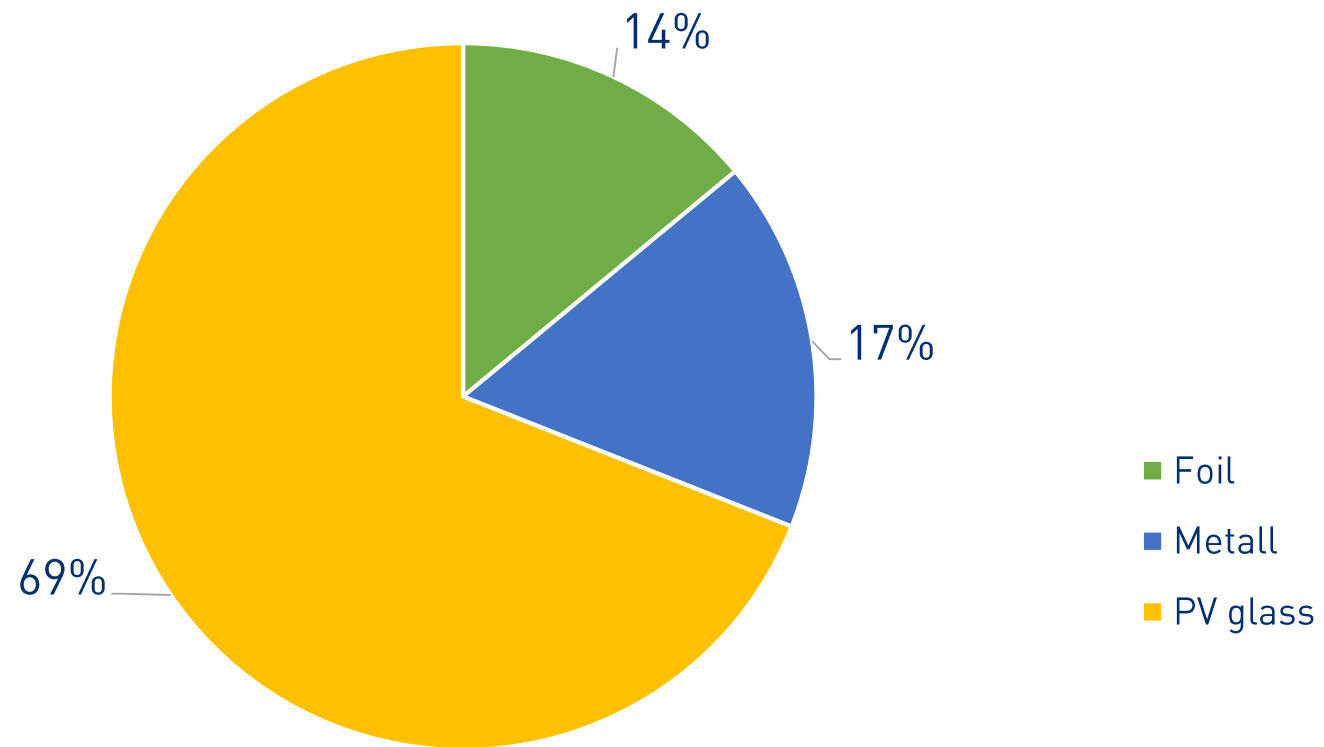
Processing steps



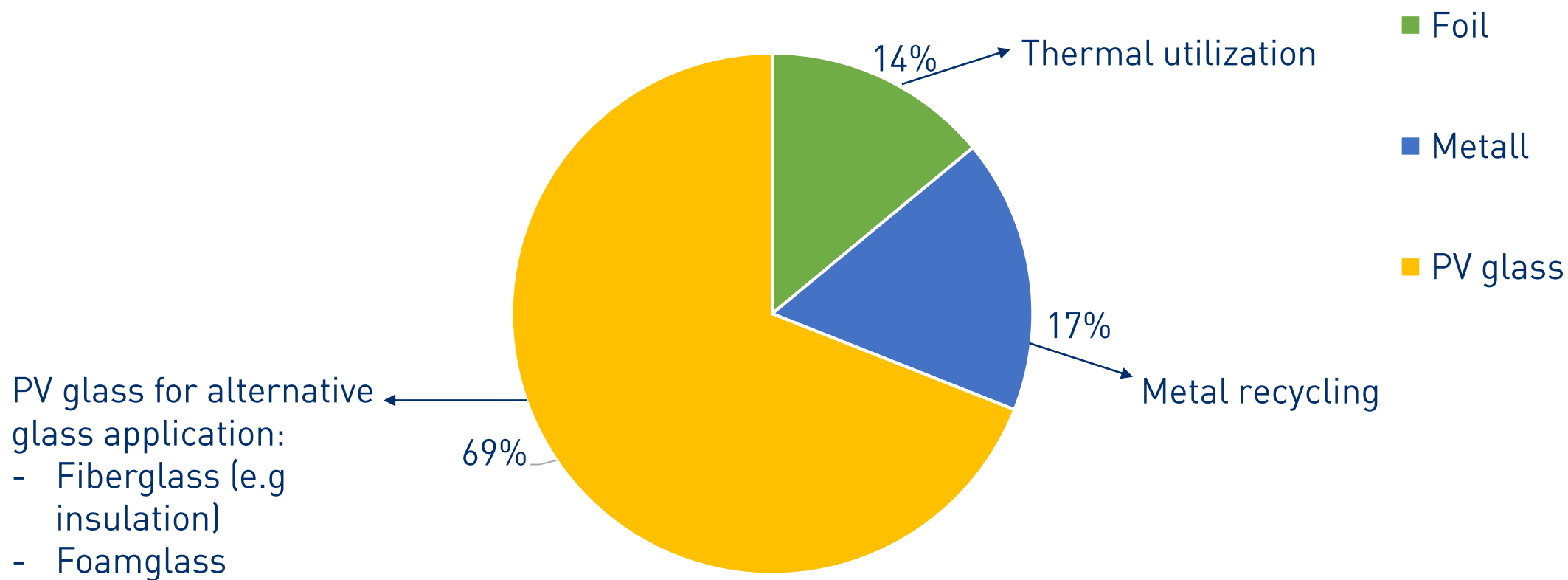
Processing results

- **Metal fractions (aluminum frames, connection cable und Fe-/NE metals)**
 - High purity
- **Foil**
 - The quality depends on the module type and producer
- **Glass product**
 - The concentration of NE metals (busbar/fine NE-particles) and adhesive foil are still high.
 - The glass product actually can't be used for re-melt application like bottle production or flat-glass industry.

Mass balance



Mass balance



Next Steps

- Optimize the disintegration
- Improving the metal separation in the processing lines
 - Specification bottle glass (T 120):
 - Fe: 2g/t (2 ppm wt)
 - NE: 3g/t (3 ppm wt)
- Reduce adhesive foil pieces on glass cullets
- Future goal: Deliver the PV glass product to re-melting applications like bottle and flat glass manufacturer

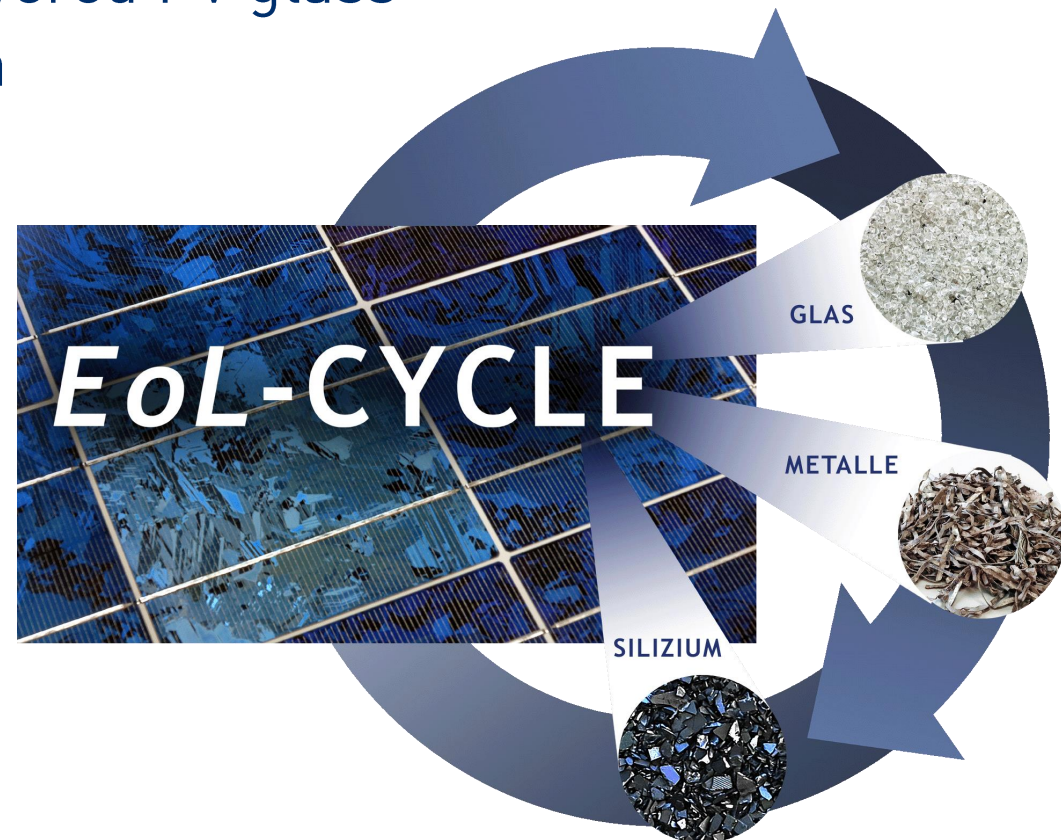
Research Project EoL-Cycle

- Together we pursue the following goals:
 - Improve the purity of the recovered PV glass
 - Recovery of metals and silicon
- Joint research project:



Gefördert durch das

Bundesministerium
für Wirtschaft
und Technologie



Thank you for your
attention

Benedikt Heitmann
Productmanagement
Research & Development

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