Creating a Sustainable and Circular Solar Industry

Thursday, December 7
15:30 – 16:30

SUSTAINABLE SOLAR EUROPE 2023

Manfred Spiesberger

Project Manager & Researcher,
Centre for Social Innovation (ZSI)

7 December, Brussels, Belgium

Anna Sobczak

Policy Coordinator,
European Commission

7 December, Brussels, Belgium

European Commission

The revised SET Plan

Sustainable Solar Europe 2023

Anna Sobczak

DG Energy

#SetPlan

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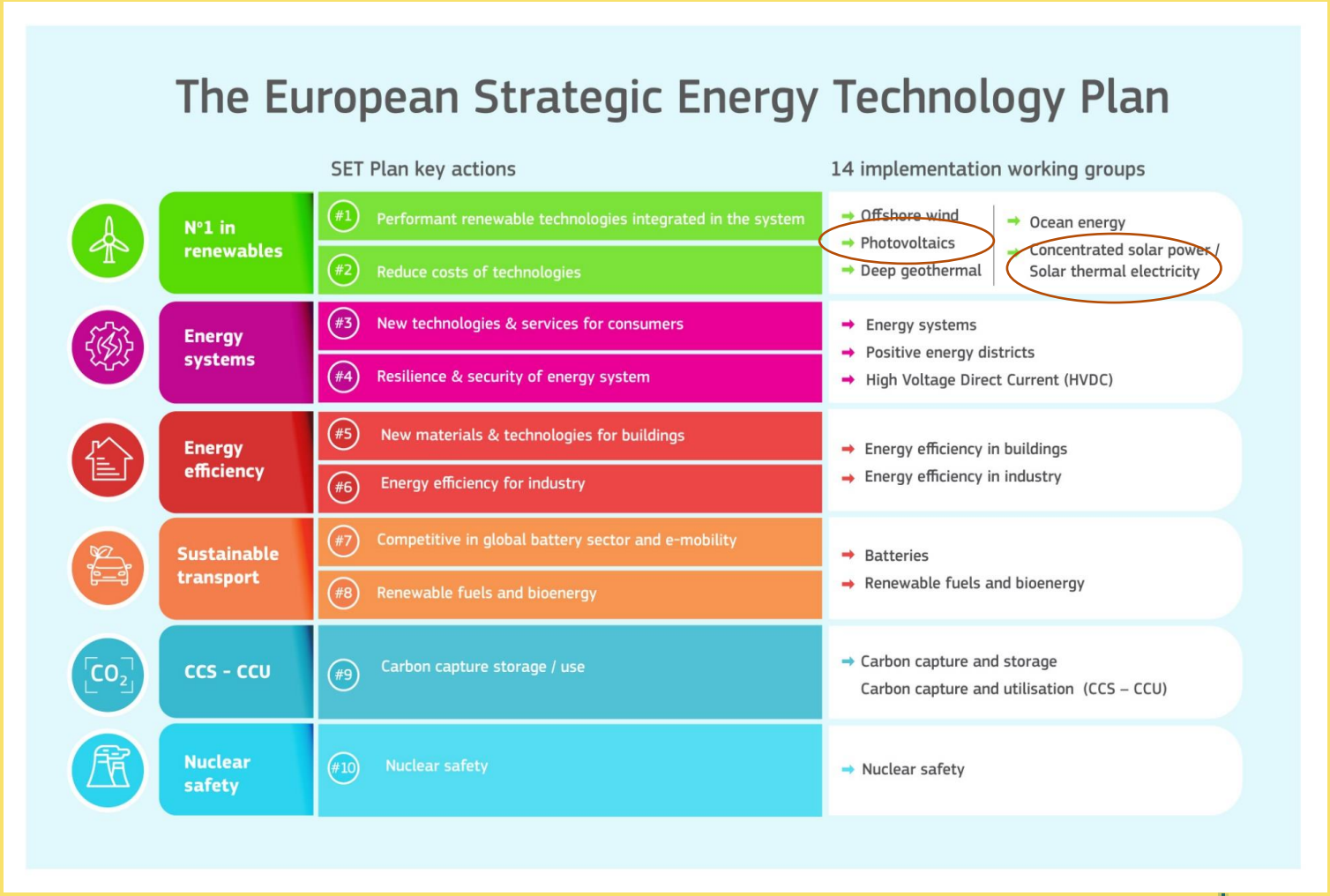

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- helped align the R&I efforts of the participating countriesin solar photovoltaic (PV), contributing to significant technology progress towards the world’s most efficient solar cell to date.
- inspired most of the concentrated solar thermal topics in the EU’s for Research and Innovation programmes Horizon 2020 and Horizon Europe

the SET Plan

Achievements so far

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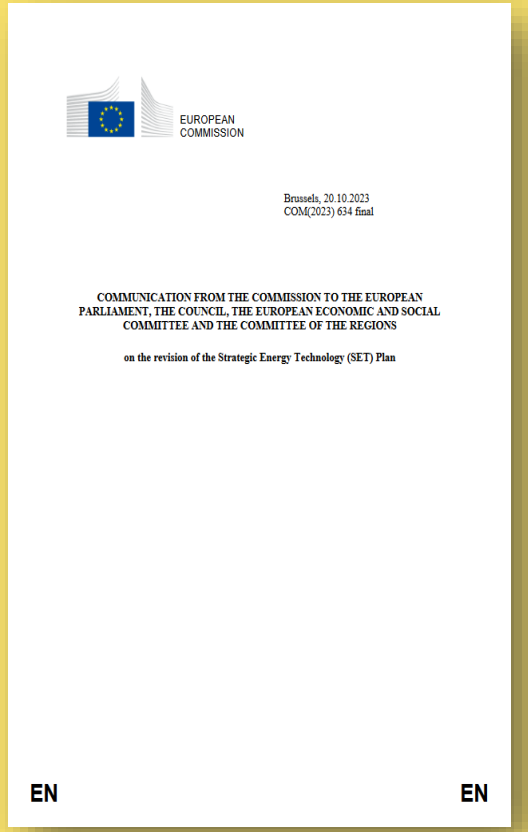
The 2023 Communication on the revised SET Plan

Adopted on 20 October 2023

Communication: Revision of the Strategic Energy Technology Plan (SET Plan) | Research and innovation (europa.eu)

EC press release: Updated Strategic Energy Technology Plan for Europe (europa.eu)


EUROPEAN COMMISSION

Brussels, 20.10.2023
COM(2023) 634 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

on the revision of the Strategic Energy Technology (SET) Plan

EN EN

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Why the SET Plan revision?

- Harmonisation of the strategic objectives.
- Upgrading to the status of expert group under ERA.
- New priorities on cross-cutting issues, through a task force approach.
- Expansion of the current technology scope
- Establishment of a dedicated workstream on hydrogen
- Forged cooperation between the ETIPs and the European industrial alliances
- Updated roadmap for progress
- The Clean Energy Transition Partnership instrumental to underpin the extended scope.

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6 priorities

1. Become number 1 in renewables
2. Deliver a smart, consumer centric energy system
3. Develop and strengthen energy-efficient system
4. Diversify and strengthen energy options for sustainable transport
5. Drive ambition in carbon capture, utilization and storage
6. Maintain and strengthen safety in the use of nuclear energy

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Expansion of the current technology scope

N°1 in renewables	• Extend activities to onshore wind and low and medium geothermal • Establish a new IWG on hydrogen • Deliver a joint solar energy strategic R&I agenda
Energy systems	• Accelerate the development of innovative and flexible solutions (e.g. demand response, storage) • Extend its scope to low and medium voltage direct current technologies & help reducing number of converters
Energy efficiency	• Give heat pumps a more prominent role within the IWG on energy efficiency in buildings • Accelerate the development, integration, testing and validation of key industrial technologies
Sustainable transport	• Strengthen the European battery manufacturing value chain • Support the monitoring of batteries value chain • Address innovative storage technologies beyond electrochemical batteries.
CCS - CCU	• Align its targets and activities with the new energy and climate policy landscape • Support the identification of the most appropriate CO2 storage options
Nuclear safety	• Increase emphasis on safety of SMRs, diversification of supply chains, industrial hubs • Foster the development of centres of excellence, competencies, and the availability of the world class research infrastructure

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Next steps…

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Setting up the Expert Group in the framework of ERA

- To reinforce the legitimacy of the SET Plan Steering Group
- To reinforce the link with R&I policy for clean energy
- To strengthen the commitment of participants
- To be better equipped to work towards the new targets
- To quickly assess the EC proposals and to start implementing them.

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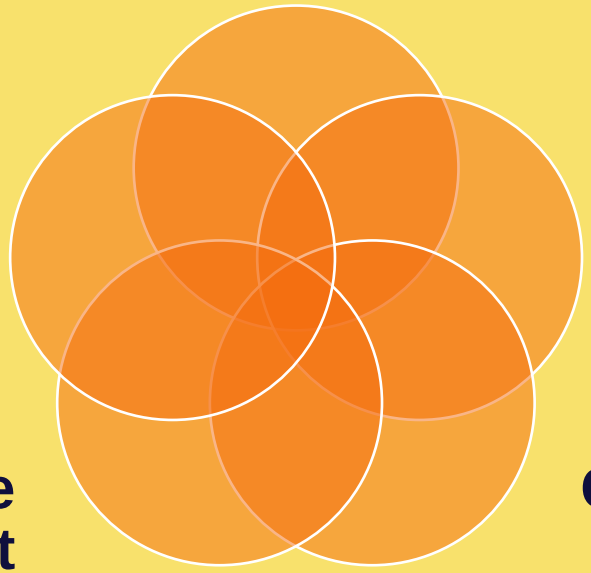
Setting up cross-cutting task forces

Digitalisation

Upskilling and reskilling



Societal needs

Accelerate the market uptake

Circularity and materials

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Digitalisation

Support closer cooperation between digital and energy areas across the entire strategic technology value chains in EU and national R&I programmes.

Create the ‘Gathering Energy and Digital Innovators from across the EU’ GEDI EU platform for cooperation

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Circularity and materials substitution

Mainstreaming the recovery, recycling and substitution of critical raw materials into the research, development, and manufacturing of clean energy technologies.

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R&I for societal needs

Pursue a user-centred approach by mainstreaming issues such as health, gender, safety, security, accessibility, affordability, as well as the needs of aging or disabled consumers.

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Skills –
upskilling & reskilling

Engage in the new EU large-scale skills partnership for onshore renewable energy under the Pact for Skills.

Support the European Net-Zero Industry Academies.

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Access to the market

Share best practices on regulatory issues, liaising with the Net-Zero Europe Platform

Identify the needs and feasibility of technology infrastructures in the EU.

Develop strong links between ETIPs and industrial alliances to promote viable investment projects.

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Improve access to funding to scale up innovations

- Secure increased financial support for the Clean Energy Transition Partnership
- Support links between funding instruments and improve access to the clean energy technology market
- Call on countries to spend 3% of their GDP on R&I to foster the scale up innovation

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In new SET Plan

- deliver on a joint solar energy strategic R&I agenda encompassing photovoltaics, concentrated and non-concentrated solar thermal
- develop strong links with the Solar PV Industry Alliance, to promote the development of viable investment projects and manufacturing capacity in clean energy technologies,
- address market, regulatory, infrastructure and technological barriers to their large-scale deployment.

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Conclusions

- Strengthening the cooperation with the SET Plan stakeholders;
- Developing and delivering on the new actions and targets;
- Increasing efforts in supporting research and innovation in innovative clean energy solutions;
- Looking for support (Call for tenders CINEA/2023/OP/0017)

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Structure of the Solar Strategy

2020	2030

EU total PV capacity installed (AC)

136 GW → Almost 600 GW

Sustainable supply

- Overreliance on imports from one country
- Sustainability requirements for PV systems sold in the EU

Solar value for EU citizens

- Provide citizens with the right incentives
- Use PV to address energy poverty
- Energy Communities and collective self-consumption

Accelerate expansion

- Large-scale deployment based on RES auctions and market signals, PPAs
- Decentralised rooftop deployment linked to self-consumption
- Innovative forms of deployment
- Faster permitting procedures
- Addressing bottlenecks in skilled workforce

Solar internationally

- Existing initiatives e.g. EU-India Clean Energy and Climate Partnership
- New initiatives e.g. Regional Energy Transition Outlooks for Africa, Latin America and the Caribbean and Europe

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SUSTAINABLE SOLAR EUROPE 2023

Arvid van der Heide

Researcher PV Modules,
IMEC

7 December, Brussels, Belgium

Re-use of PV modules: opportunities and challenges

Arvid van der Heide, Daniela Maria Godinho Ariolli, Guillermo Oviedo Hernandez, Serge Noels, Jan Clyncke

Sustainable Solar Europe, Brussels, December 7th, 2023

TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

BayWa r.e.

PV CYCLE

Energy Ville

IMO-IMOMEC

UHASSELT

imec

public

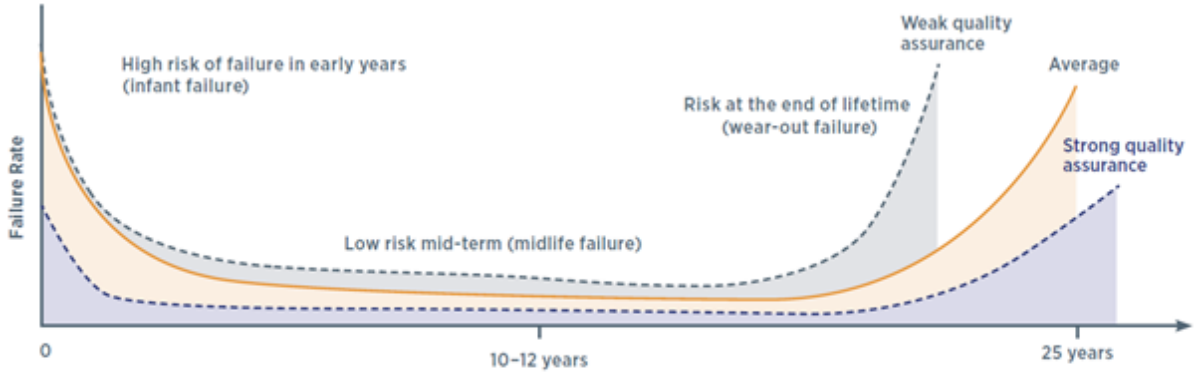
Contents

- ✓ Re-use of PV modules: requirements
- ✓ Application examples
- ✓ Repowering/re-use in Europe
- ✓ Standardisation: Technical Report (TR) in IEC TC82
- ✓ Case study for module re-use: plant inspection Italy
- ✓ Summary

public

Re-use of PV modules: requirements

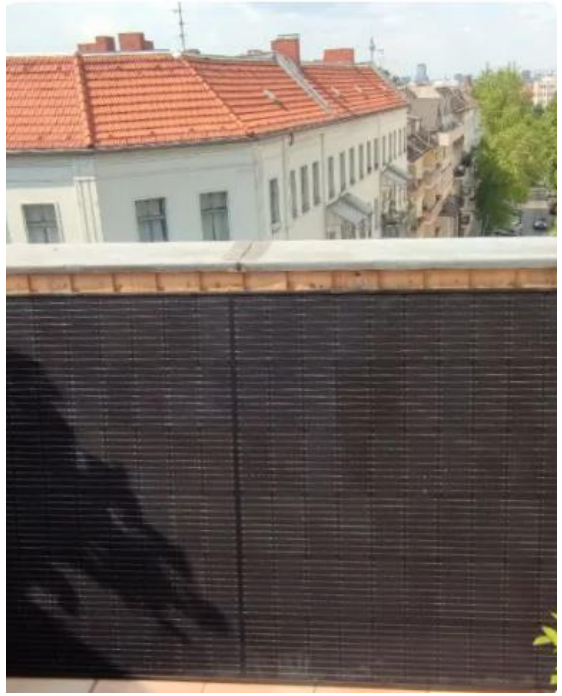
- ✓ Creation of trust of potential customers in PV modules for re-use, concerning:
  - ✓ Safety 
  - ✓ Electric performance 
  - ✓ Enough remaining lifetime 



- ✓ And cheaper than the (cheap) new modules 

Specifications for preparation for re-use required: need for (international) standard(s)

Examples of applications for re-use of PV modules



Modules for balconies (Germany)

Charging station for steps, bikes, etc. (Germany)

Off-grid system (Brazil)

Note: if a product includes a second-hand module, manufacturer takes over responsibility for total product safety.

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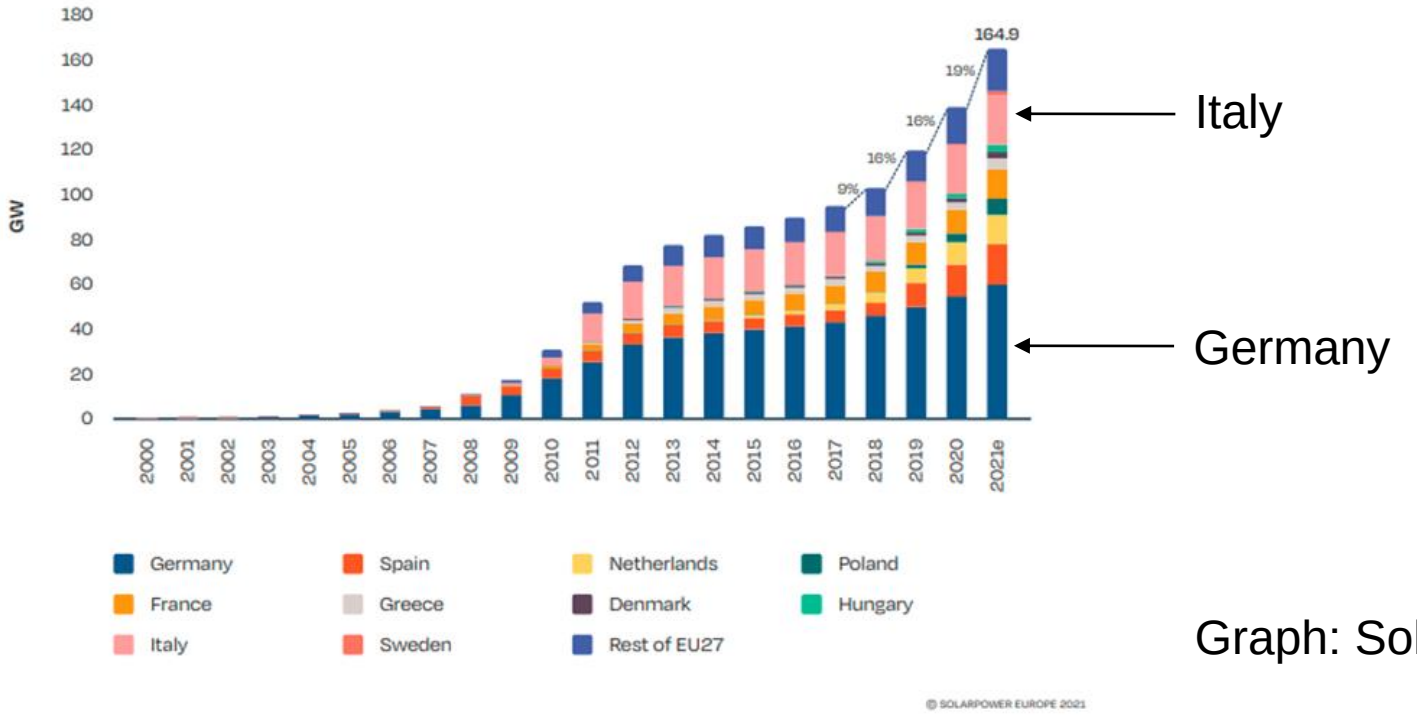
Examples of applications for re-use of PV modules

- ✓ Within European project Circusol, system of re-used modules built in Waasland (BE)
  - ✓ Each modules inspected on safety (dry insulation resistance), I-V and EL
  - ✓ Business case very difficult for new systems in Western-Europe: many modules currently exported to low-income countries.

PV repowering/re-use in Europe

- In Europe, feed-in tariff durations of 20 years were used, postponing repowering.
- Feed-in-tariff requires replacement by similar modules: prices up to 5 euro/Wp (!) for rare modules. Business case now changes to larger volumes of mainstream modules.
- PV installation started in Germany: most important market for re-use, Italy 2nd.



Italy

Germany

Graph: Solar Power Europe

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Current practices in Europe for re-use of modules

- ✓ No registration for PV module re-use: market information to be obtained via contacts
- ✓ Some companies only interested in installations > 1 MW, measuring on site (but not all)
- ✓ On-site measuring is too slow for checking every module. Recently, companies in Germany started automated indoor lines, checking dry insulation resistance, I-V and EL.

35 modules/hour

150 modules/hour

Standardisation: project team on re-use of PV modules in IEC TC82

International Electrotechnical Commission

- ✓ Task: Preparing IEC TR: "Reuse of PV modules and circular economy"
- ✓ Started January 2022, led by Serge Noels. ~ 30 IEC experts involved
- ✓ TR has simplified approval flow compared to standard (less time required)
- ✓ Note: "A TR shall be entirely informative in nature and shall not contain matter implying that it is normative"
- ✓ Current draft ~ 70 pages, still to be reduced (made more concise)
- ✓ Aim: acceptance of draft Q1 2024

Simplest (but slowest) approach: testing every PV module

- ✓ Utility plant (partially) damaged by (weather) disaster
- ✓ Modules with unknown history stacked in warehouse

- ✓ **Tests** (indoor, after initial visual inspection):
  - ✓ I-V flash test
  - ✓ dry insulation test (faster than in IEC61215)
  - ✓ bypass diode test (both shorted/open)
  - ✓ EL (only with automated evaluation, and if reliable)

- ✓ As mentioned before, companies in Germany also use this for modules from non-damaged plants. Unclear if costs are low enough (new modules are very cheap)

Complex (but fast) approach: sampling of PV modules

Only intact large PV plants

- ✓ Decide about PV module re-use **before** removal
- ✓ Analyse yield monitoring data, use most recent drone IR imaging

- ✓ **Suggestion:** use encircled sampling rates from this table, designed for inspection of new plants (Solar Power Europe, rates derived from ISO 2859-1)

TYPE OF TESTING	SAMPLING RATE ACC. TO ISO 2859-1
Performance characterisation testing	
Maximum power determination at Standard Test Conditions (STC)	G I
Efficiency loss at low irradiance	S 1
Electroluminescence inspection	G I
Qualification testing	
Visual Inspection	S 3
Insulation test under wetting (wet leakage test)	S 3
Degree of ethylene-vinyl acetate (EVA) cross linking	S 1
Adhesion strength EVA/backsheet	S 1
Power loss due to light induced degradation (LID)*	S 1
Power loss due to power induced degradation (PID)**	2 modules per BOM and test
Power loss due to light and elevated temperature induced degradation (LeTID)	2 modules per BOM and test
Reliability testing	
Design suitability (extended stress testing i. e. damp heat, thermal cycling, humidity freeze, UV exposure, mechanical load), relevant for all BOM used	2 modules per BOM and test

Case study: plant inspection Italy

- ✓ Plant inspection by BayWa/imec in July within EU project TRUST-PV
- ✓ 5 MW plant (12 years) in Italy: mc-Si modules of 280 W, to be recycled (plant will be revamped)
- ✓ No monitoring data available before inspection
- ✓ Checks for possible re-use:
  - ✓General visual inspection
  - ✓I-V measurements on strings & separate modules
  - ✓Insulation measurements (dry and wet) on strings and modules
  - ✓IR inspection with special smartphone

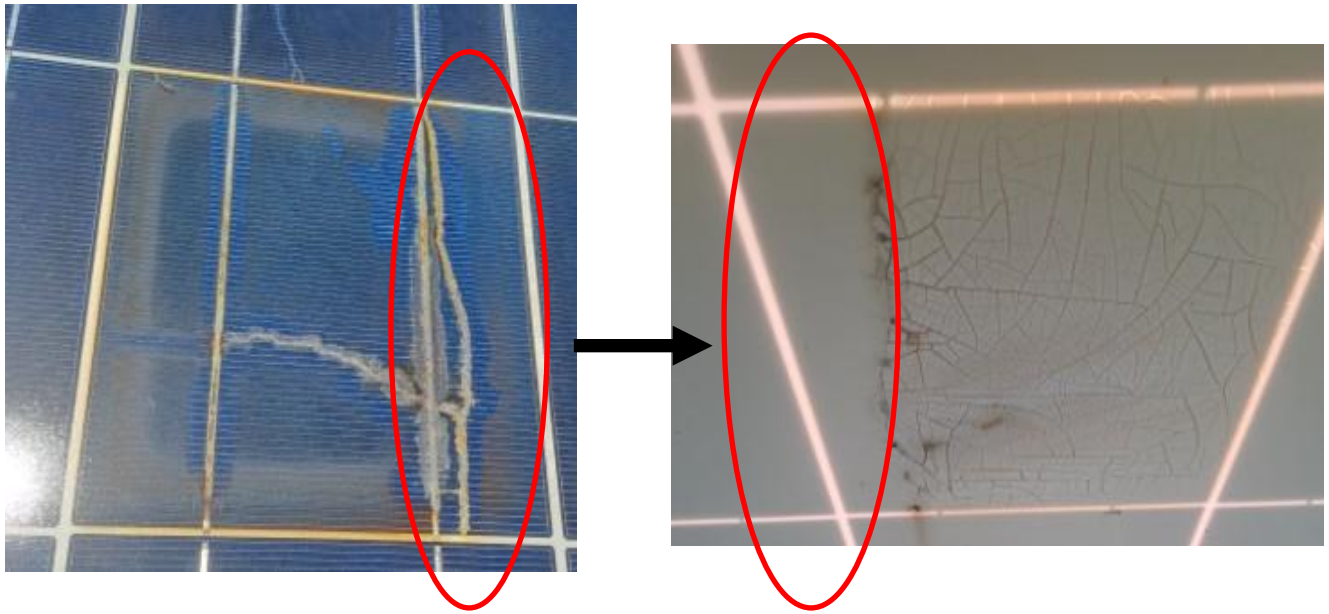
General visual inspection (1):

- ✓ Many “snail tracks”: cell cracks visualised by chemical reactions
- ✓ Cracks lead to significant power loss
- ✓ Can lead to strong variation of power between modules

General visual inspection (2)

✓ Hot spots/hot cells caused by part of the cell being isolated by crack(s)

✓ This also caused cracks/burn marks in the back sheet, isolated cell part remains cool



✓ Hot spots also caused internal delamination of back sheet: probably different back sheets in same plant (for same module type)

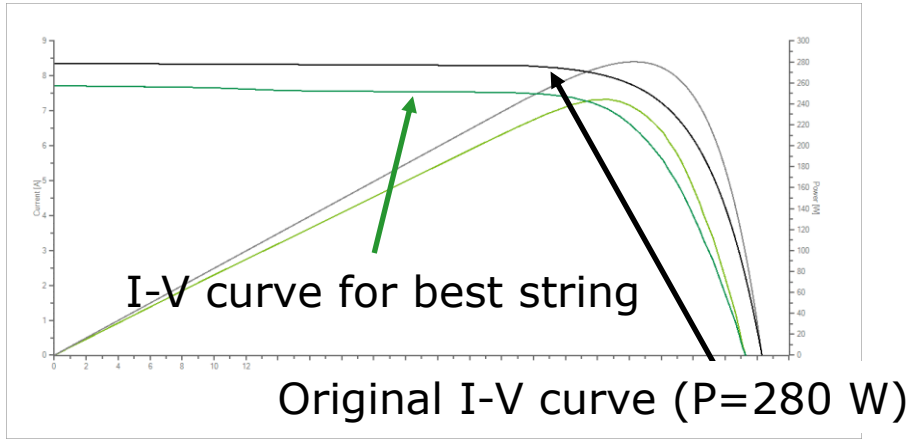
General visual inspection (3):

✓ Temperature sensor for monitoring detached: monitoring not always considered to be important

I-V results measured on several module strings

- ✓ Power loss 12.5%-35%, varying much and always > guarantee of 0.8% per year...
- ✓ Influence of soiling negligible here: ~2-3% loss
- ✓ Difficult to specify power without measuring every module...

Example string I-V curves at STC :
Voltage divided by 19 (modules in series)

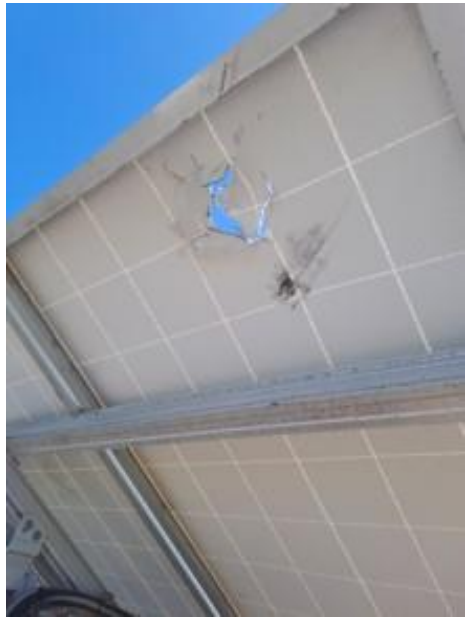


Insulation testing strings/modules

✓ Insulation testing with hand-held tool, wet and dry

✓ Dry testing not always useful when "OK": module with hole passed dry testing (R > 100 MΩ). After spraying water around the hole, it failed (R < 1 MΩ).

✓ Function "insulation error localisation" tested on some strings: difficult to interpretate if it worked or not. Dry & warm conditions were not optimal for this check



Summary

✓ Re-use of PV modules is growing, some companies measuring every module

IEC Technical Report

✓ IEC TR draft includes testing every module and sampling. To be put into different future standards?

✓ Testing every module involves I-V, (fast) dry insulation test, bypass diode test, EL

✓ Sampling: using table of Solar Power Europe for new PV plants, rates based on ISO2859-1.

Learnings from case study

✓ Large variation in power loss (12-35 %), criterion needed to determine when sampling is justified

✓ Passing dry insulation test no good criterion in warm/dry conditions, do wet testing when in doubt

✓ Even for same module type, materials can be different

Acknowledgements

TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

This work has been funded in part by the Trust-PV project, that has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement number 952957.

Claire Agraffeil

Project Coordinator,
CEA

7 December, Brussels, Belgium

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PV Recycling in Europe

Karsten Wambach

PHOTORAMA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958223.

Introduction of bifa

foundation 1991 as limited company, non-profit oriented, 40 employees

approx. 4 mil Euro turnover/year

Relevant PV activities

collection and treatment of PV module waste, waste assessment, eco-efficiency analysis, monitoring of legislative measures, market survey and business plan, material analytics, exploitation and dissemination with workshops

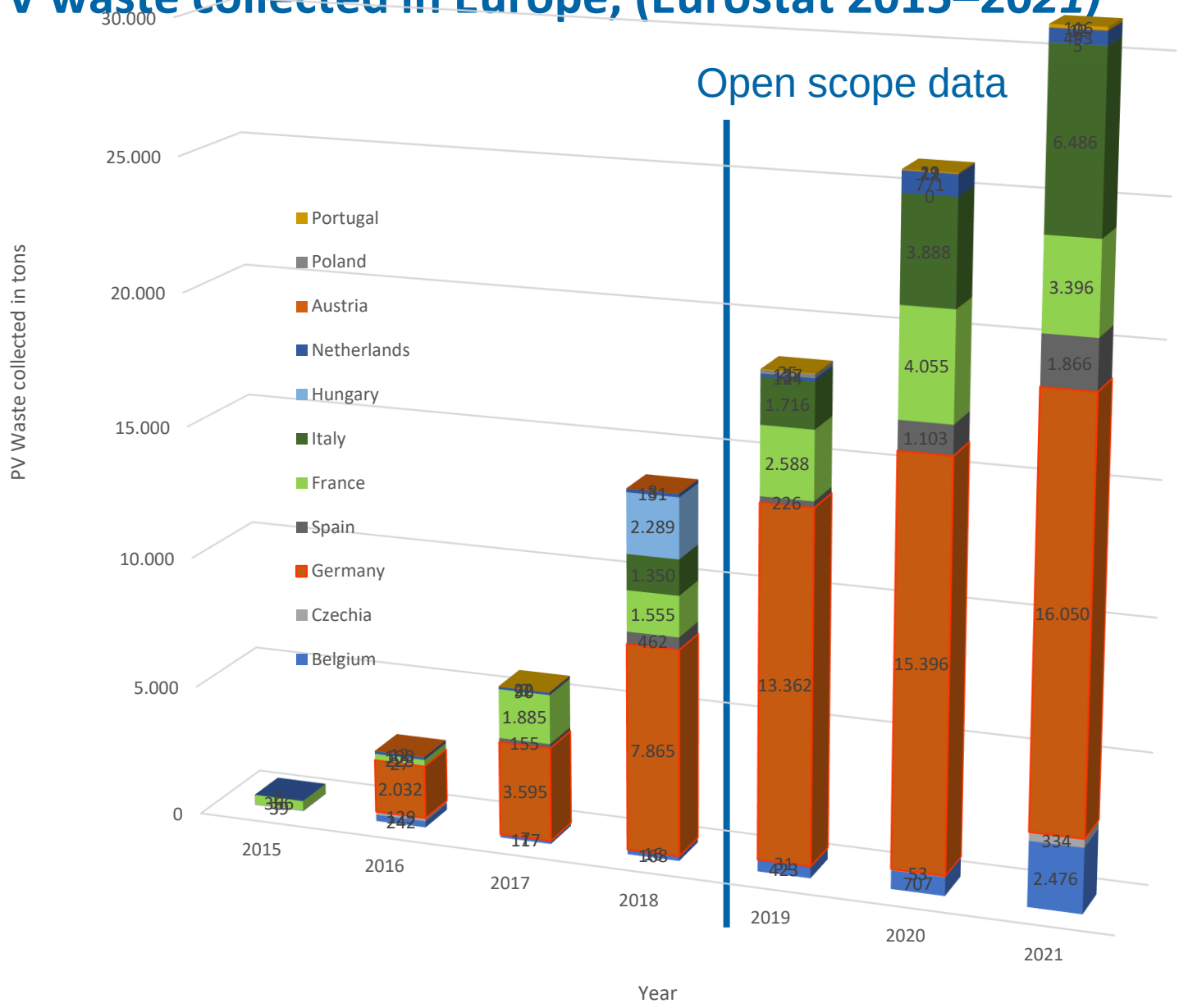
Chemical laboratories, workshops, analytics, access to recycling technologies

Free State of Bavaria

City of Augsburg

Chamber of Industry and Commerce for Swabia

PV waste collected in Europe, (Eurostat 2015–2021)



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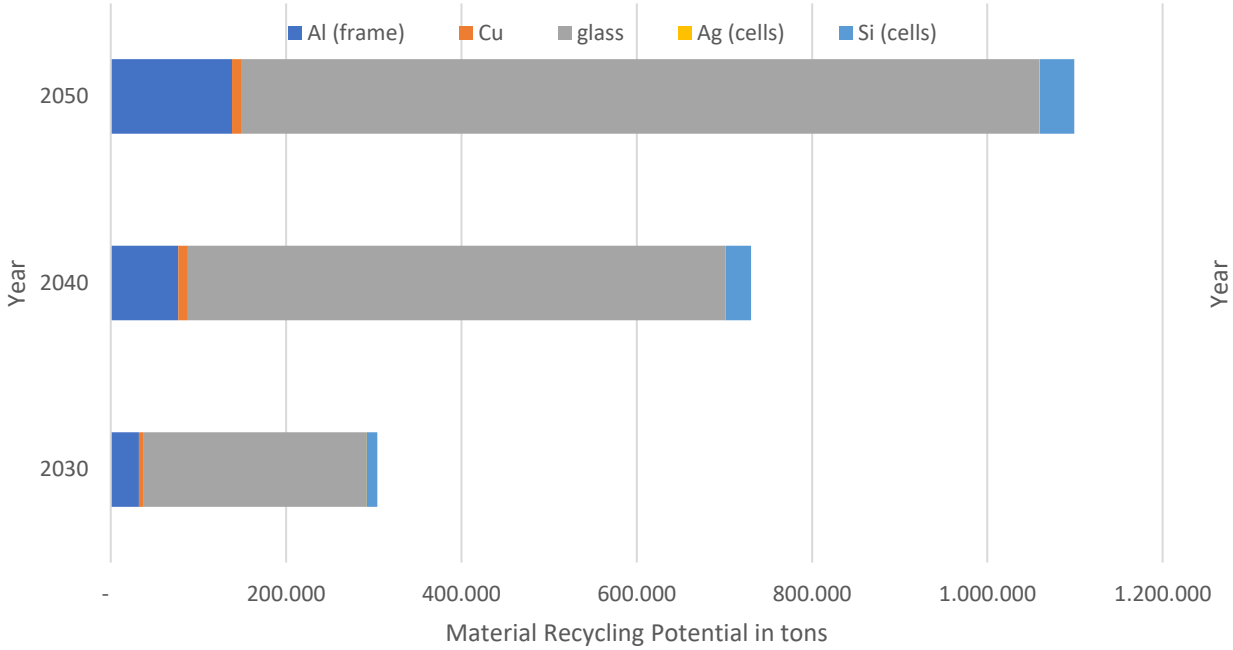
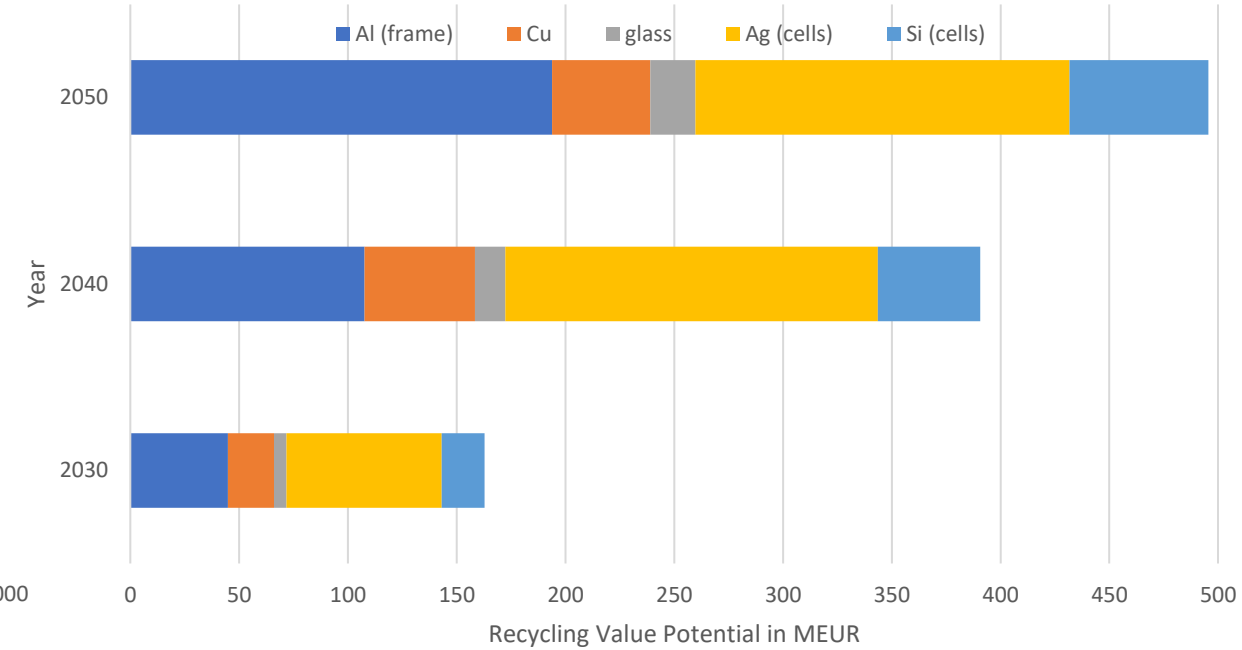
2045+: the estimated annual PV waste amounts will exceed the PV-tonnage put on market (POM)

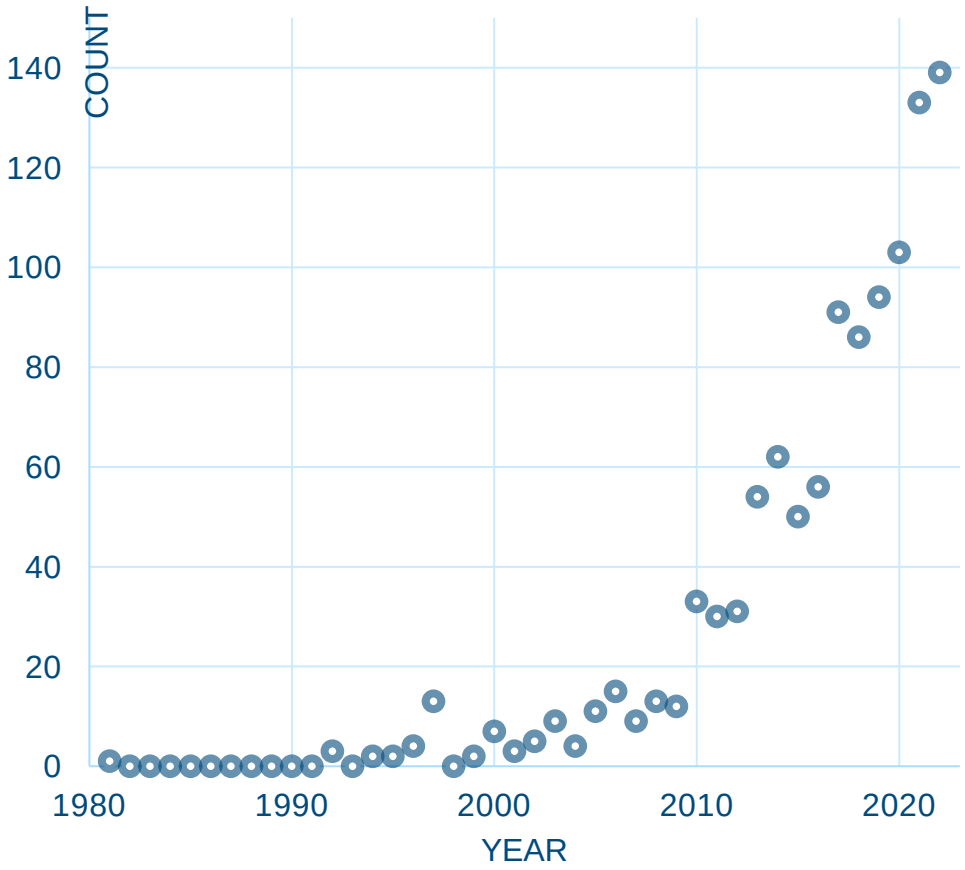
Recycling Material and Value Estimation

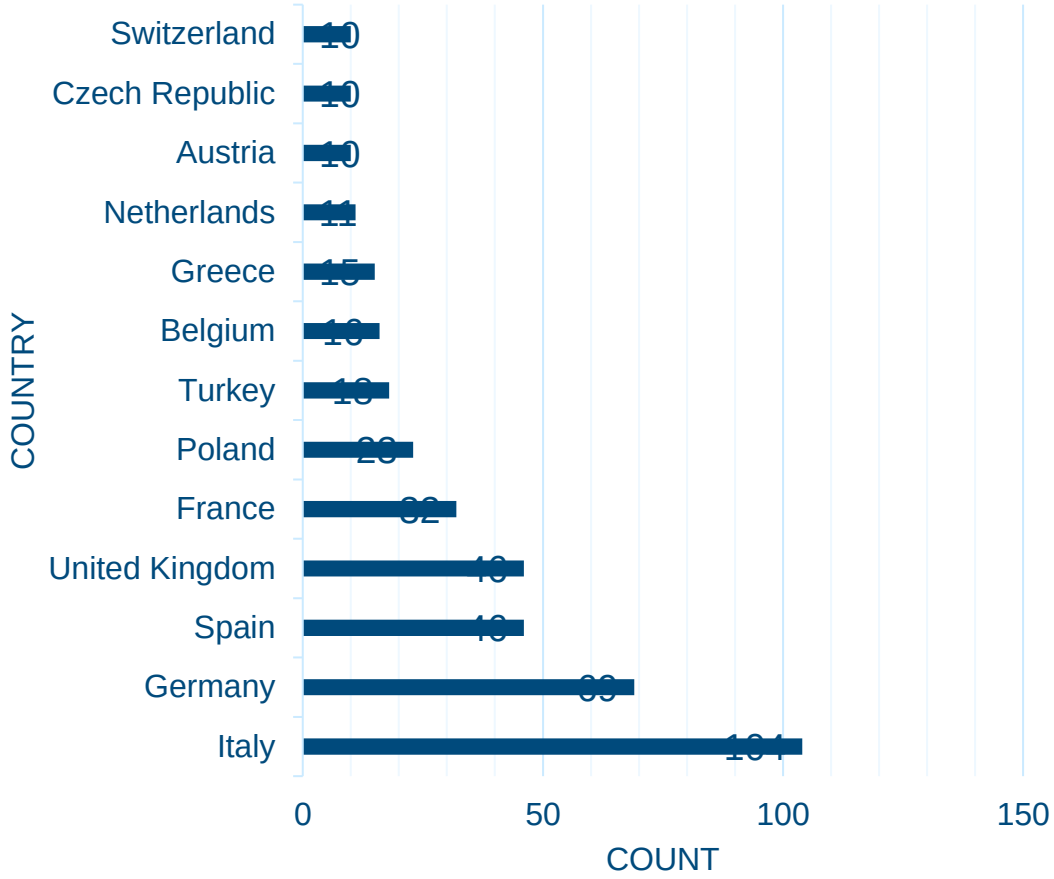




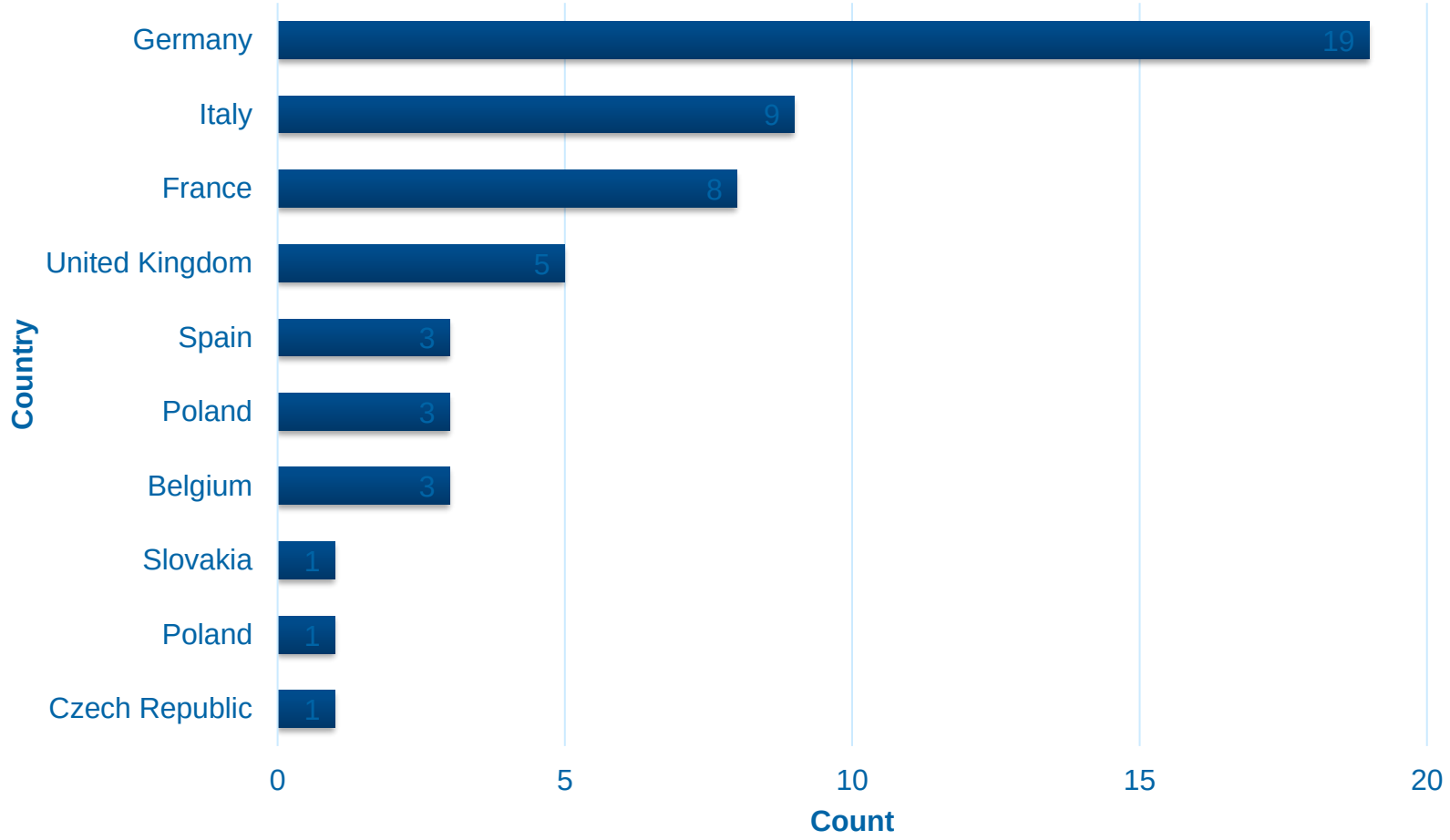
Polymer recycling not included,
under development

Publications (as of 3rdQ2022)





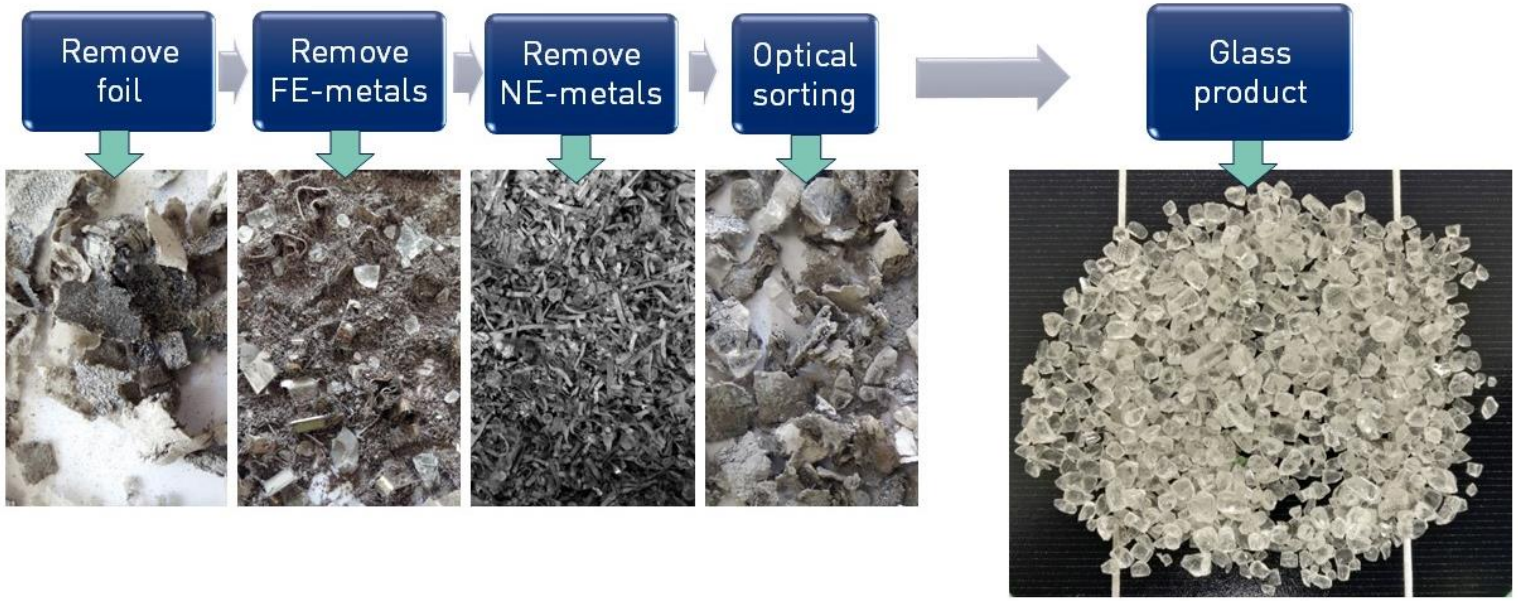
Recyclers (non-exhaustive)



Reiling Glas Recycling GmbH & Co. KG, Germany

Four glass-recycling plants in Germany accept c-Si and a-Si modules
- Modules are processed on a batch basis
- ~4,200 tons of PV modules recycled in 2022

A new 50,000 ton/yr facility dedicated to PV recycling is in operation in Münster
- Electricity is be supplied by Reiling's own PV plant
- Modules are screened for reuse (second life) potential

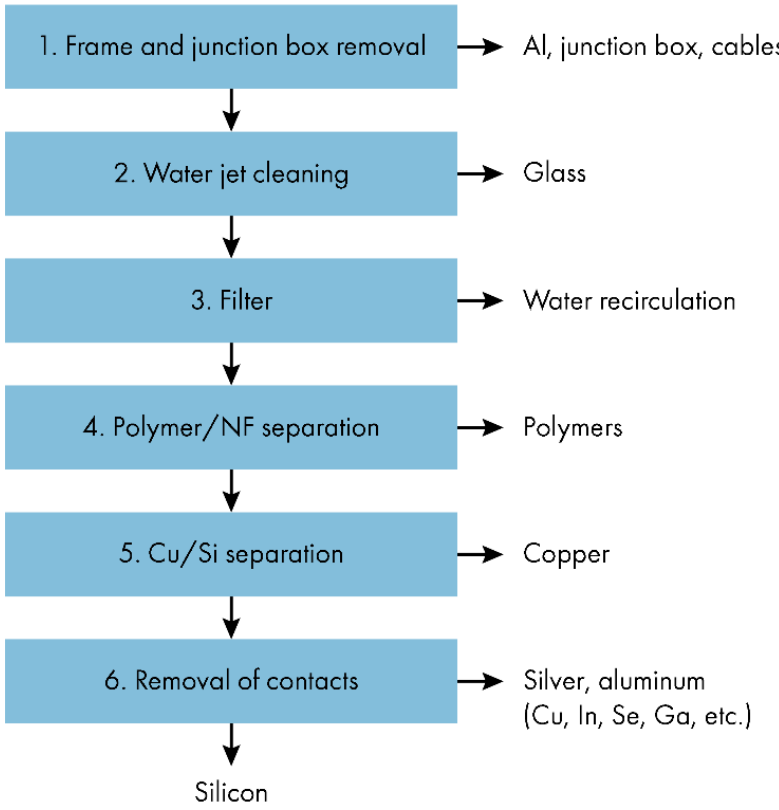


Improved, pure-mechanical process represents commercial best available technology and sets a benchmark for maturity, cost, and low energy consumption

LuxChemTech GmbH, Germany

2 recycling facilities in Germany
R&D on recycling for c-Si, CIGS, and CdTe modules
A new 1,000 tons/yr pilot system under construction will employ 2 advanced technologies in addition to chemical recovery processes:

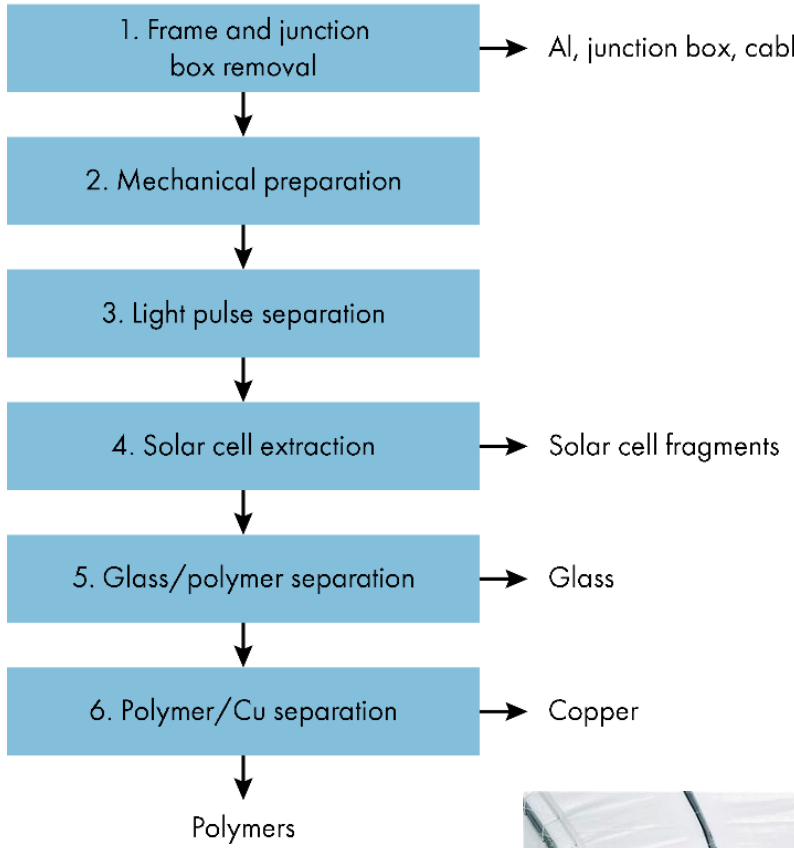
- Water jet (glass/backsheet modules)
- Light pulse (not included in flow chart)



Water jet and chemical recycling processes accommodate different types of PV modules

Flaxres GmbH, Germany

Company founded in 2017 to develop a mobile process to separate composite materials, including PV
FLAXTHOR® technology applies short, high-intensity light pulses to heat silicon and enable delamination
Third parties process the solar cell fragments to recover silver and silicon



Thermal treatment enables delamination of c-Si, CdTe, and CIGS modules, producing clean glass and enabling subsequent recovery of metals

A unique and innovative process from ROSI

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Delamination by pyrolysis


Pyrolysis furnace


Conveyor


Pyrolysis residue

Pyrolysis residue including all PV modules materials mixed (glass, copper, silicon, silver, etc.)

First mechanical sortation (copper & glass)

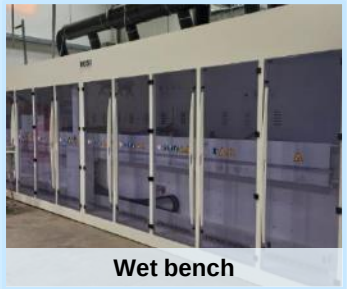

Sorting machine


Fragmented cells(1)


Copper ribbons


Glass cullets

Chemical etching (separation of silver & silicon)


Wet bench


Silver fingers & silicon chips

Separation of silver fingers from silicon cells through chemical etching

Second mechanical sortation (silver & silicon)


Sorting machine


Silver fingers


Silicon cell fragments

Conclusions

- Anthropogenic material stock will exceed other E-waste streams within next decade
- Increasing international activities in PV recycling, information gaps present
- Increasing variety of products
  - newer modules with lower recycling values than older ones
  - Variety of materials, designs and formats rapidly increasing
- Consequences:
  - Policies and circular economy for PV development required by applying international rules and standards
  - Secured financing of circular economy essential

Credits

- PHOTORAMA This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958223.
- EPRI, *Advances in Photovoltaic Module Recycling: Life Cycle Inventory Assessment for Six Recycling Facilities*. EPRI, Palo Alto, CA: 2023. 3002025345 to be published
- IRENA (to be published)
- Reiling
- Rosi
- Luxchemtech
- Flaxres

PHOTORAMA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958223.

Alexis Barrou

R&D Engineer,
CSEM

7 December, Brussels, Belgium

Yun Luo

CEO,
ROSI

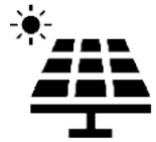
7 December, Brussels, Belgium

public


ROSII
A truly circular economy for the photovoltaic industry

Executive summary

- The photovoltaic industry faces 2 challenges:
  - **Reduce its reliance** on primary raw materials
  - Keep **increasing its competitiveness**
- **ROSI** is the leading company able to **recover the high purity materials** lost by the photovoltaic industry
- ROSI opened the **1st recycling line worldwide** allow full recycling of end-of-life photovoltaic panels
- ROSI will offer its services to **all European countries by 2025** and worldwide by 2027



up to 95%
of PV module value recovered

Apr. 2023
opening of the first site in France

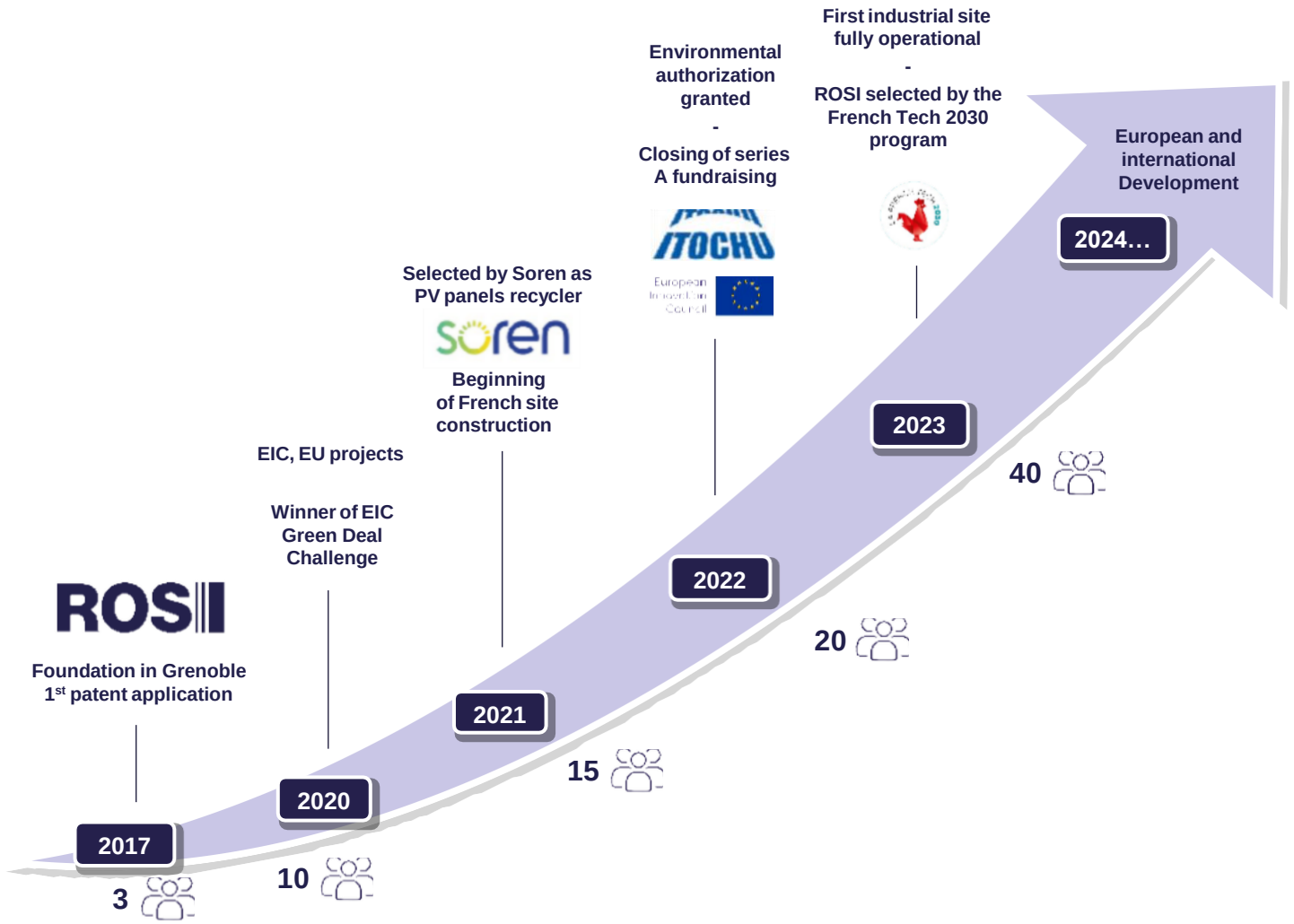
4
European core markets by 2025

6
patents

40+
employees

€7.5M
financing round completed in 2022

From deeptech to industrial reality



Executive management team

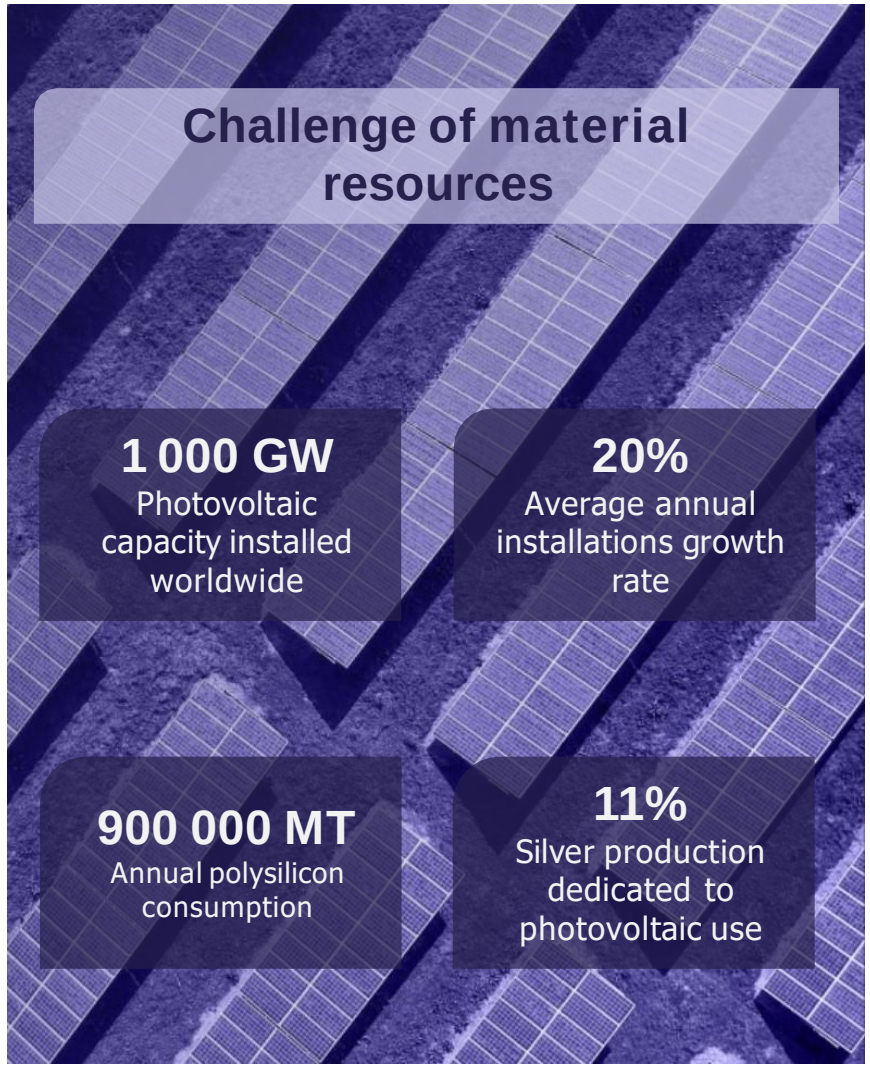
Yun Luo
CEO & cofounder

Guy Chichignoud
CTO & cofounder

Antoine Chalaux
CMO

Sébastien Schneider
CFO

A growing opportunity for circular materials



30% loss

of polysilicon as kerf powder
during manufacturing of photovoltaic panels

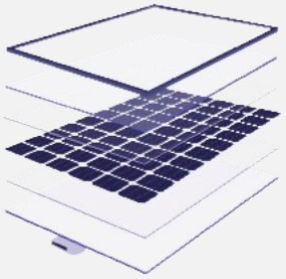
Challenge of cleaning a nano-powder
polluted by polymers and water
and to remelt it

60 bn tons

Of photovoltaic panels to be recycled by 2050

Massive opportunity to recover
high-value materials:

- Silver
- High-purity silicon
- Copper
- Aluminium
- High-transparency glass



Breakthrough technologies enabling a circular economy

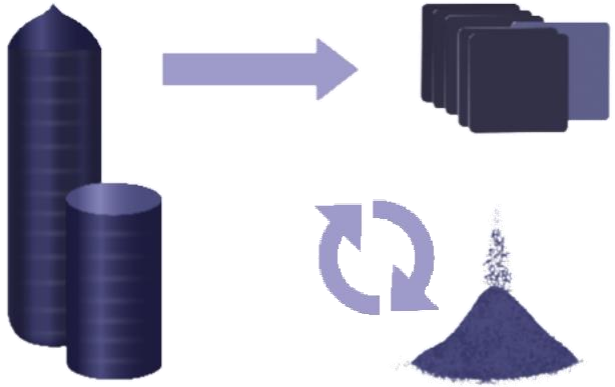
Natural resources

Manufacturing

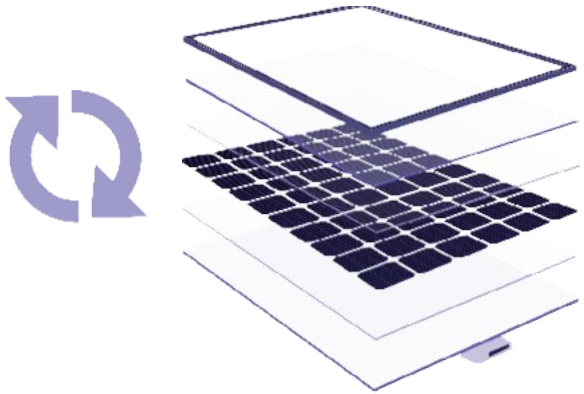
Use phase

End-of-life

Kerf recycling



End-of-life panels recycling



Tech driven company

6 years of R&D

10 FTE R&D team

6 patents

Targeting large scale and high value industrial sites

- **1st recycling line worldwide**
  able to recover high-purity silicon
  and silver from end-of-life PV panels

  - Start of operations: 1st trimester 2023

  - Treatment capacity: 3’000 tons/year
    then 10’000tons/year

  - Recycling contract with Producer Responsibility Organization Soren

- **Kerf recycling platform**
  under industrialization phase

  - Targeting 5 000 tons/year capacity

ROSI, the partner for circularity

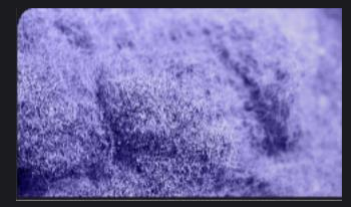
Our recycling services

Dedicated to transforming the PV industry

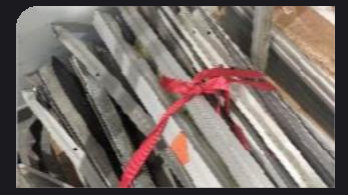
Our circular materials

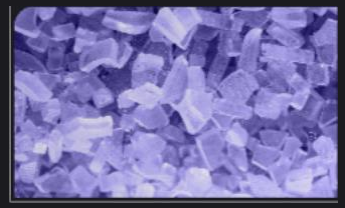
First supplier of high-purity secondary raw materials from the PV industry

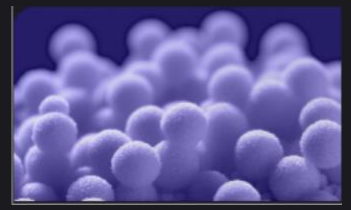

Silicon


Silver


Copper


Aluminium


Glass


Advanced materials

ROSI

c/o Linksium
Rue Gustave Eiffel
38000 Grenoble
France

info@rosi-solar.com

www.rosi-solar.com

With the support of…

Creating a Sustainable and Circular Solar Industry

SUSTAINABLE SOLAR EUROPE 2023

Alexis Barrou

R&D Engineer,
CSEM

Arvid van der Heide

Researcher PV Modules,
IMEC

Manfred Spiesberger

Project Manager & Researcher,
Centre for Social Innovation (ZSI)

Anna Sobczak

Policy Coordinator,
European Commission

Claire Agraffeil

Project Coordinator,
CEA

Yun Luo

CEO,
ROSI