



# SUSTAINABLE SOLAR — EUROPE 2024

# Session 9: Prolonging Solar Lifetime Through PV Module Reuse

12 December 2024

# Session 9: Prolonging Solar Lifetime Through PV Module Re-use



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SUSTAINABLE  
SOLAR \_\_\_\_\_  
EUROPE 2024



# Roger Nyffenegger

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Bern University of Applied Sciences

# Prolonging the Lifetime of Solar PV through Module Reuse – a business model and policy view

12.12.2024 – Roger Nyffenegger, Brian Baldassarre & Nancy Bocken



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Haute école spécialisée bernoise  
Bern University of Applied Sciences



**Maastricht  
University**



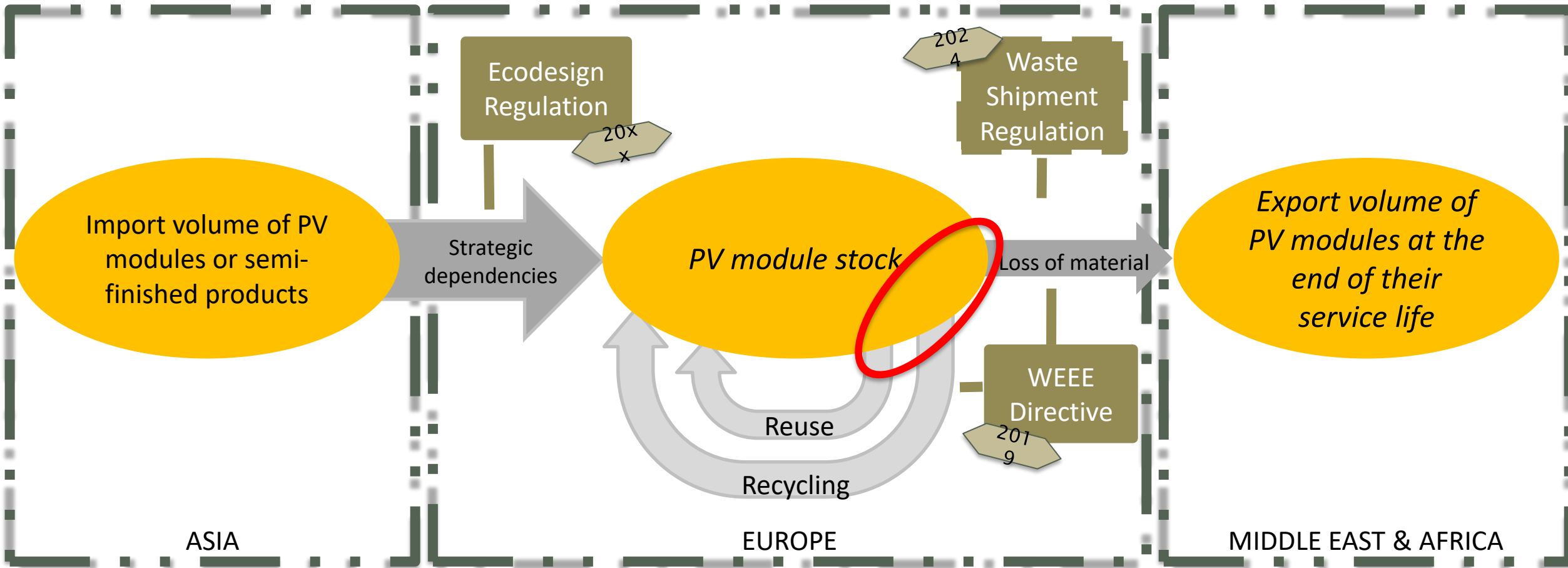
European  
Commission

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# European dependencies in PV industry

And efforts by the EU to reduce import and export dependencies by means of circular strategies

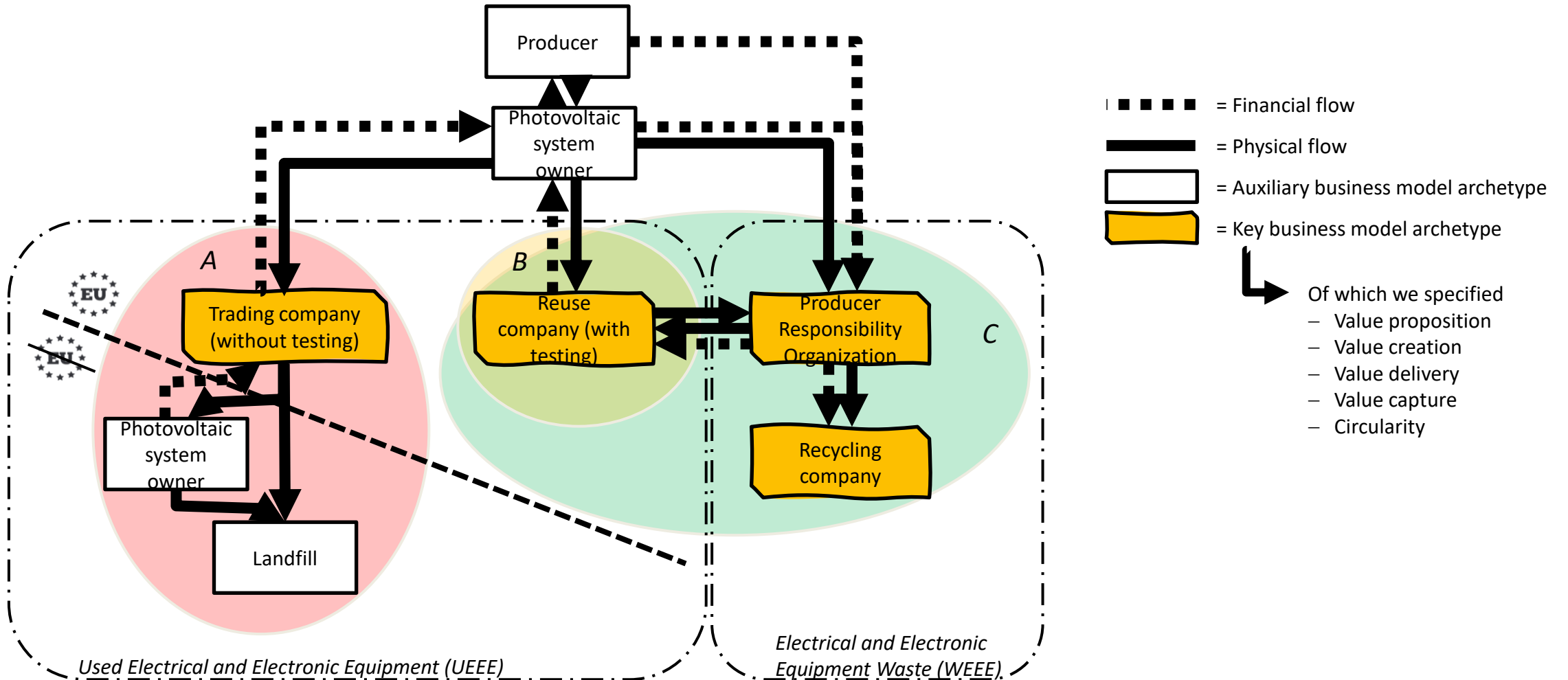


Source: Nyffenegger et al., 2023



# PV system end-of-first-life scenarios in Europe

Politically intended vs. actual routes and the involved business models



Source: own research, 30+ interviews with European EoL actors



# Two key challenges for Reuse in Europe

And how industry and policy interventions can mitigate those challenges

Challenge	Export	Recycling prioritization by policy
Challenge explanation	<ul style="list-style-type: none"><li>Export of end-of-life PV modules as used products (UEEE) bypassing WEEE Directive</li><li>Limited business case for reuse operationalization</li></ul>	<ul style="list-style-type: none"><li>Prioritization of recycling over reuse in EU policy, contradicting the European waste hierarchy</li><li>Limited business case for reuse operationalization</li></ul>
Affected area	A	C
Industry intervention	<ul style="list-style-type: none"><li>Establishing collaborations as Producer Responsibility Organizations (PRO) with (large) PV system owner and Operation &amp; Maintenance companies</li></ul>	<ul style="list-style-type: none"><li>Developing standards for preparing PV modules for reuse</li><li>Building alliances to advocate for a more supportive political framework</li></ul>
Policy intervention	<ul style="list-style-type: none"><li>Tighten the rules and their enforcement in the shipment regulation</li><li>Establish clearer distinction between UEEE and WEEE in the forthcoming WEEE Directive</li></ul>	<ul style="list-style-type: none"><li>Specific PV product category in forthcoming WEEE Directive</li><li>Align forthcoming WEEE Directive with waste hierarchy by favouring reuse over recycling</li></ul>



# Swiss Reuse Project «Swiss PV Circle»

Setting the basis for reuse business models in Switzerland

## Feasibility



No unsolvable technical or organizational obstacles

- Good degradation results (0.24% per year)
- High reusability rate (fail rate below 3%)

## Desirability



- Interesting niche markets such as spare part for single modules or public procurement
- Too little volume demand for scaled reuse business models

## Viability

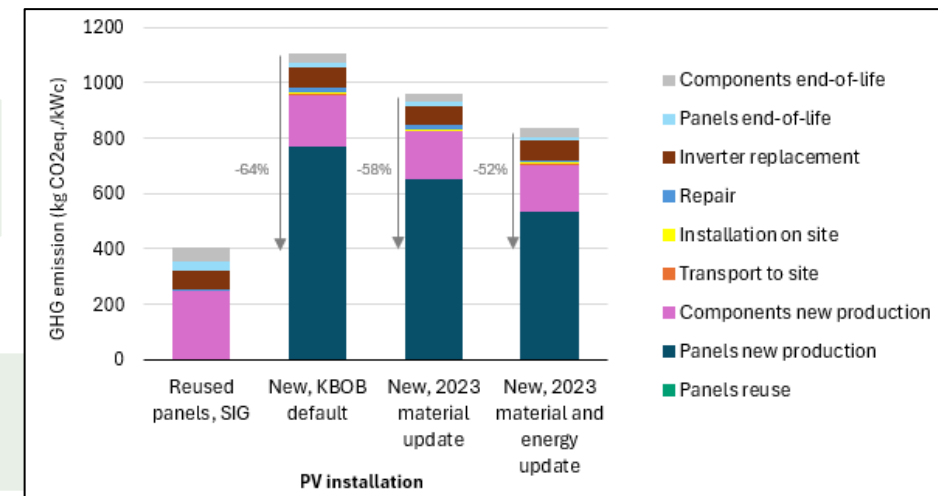


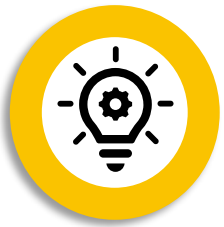
- Testing costs of € 0.24 per Wp → € 38 per module
- Economic efficiency mainly depending on new module prices (€ 0.26-0.36 per Wp)

## Circularity



- Total GHG emission of reused PV installation 66% lower compared to new, but more space needed
- Main reason is panel production emissions

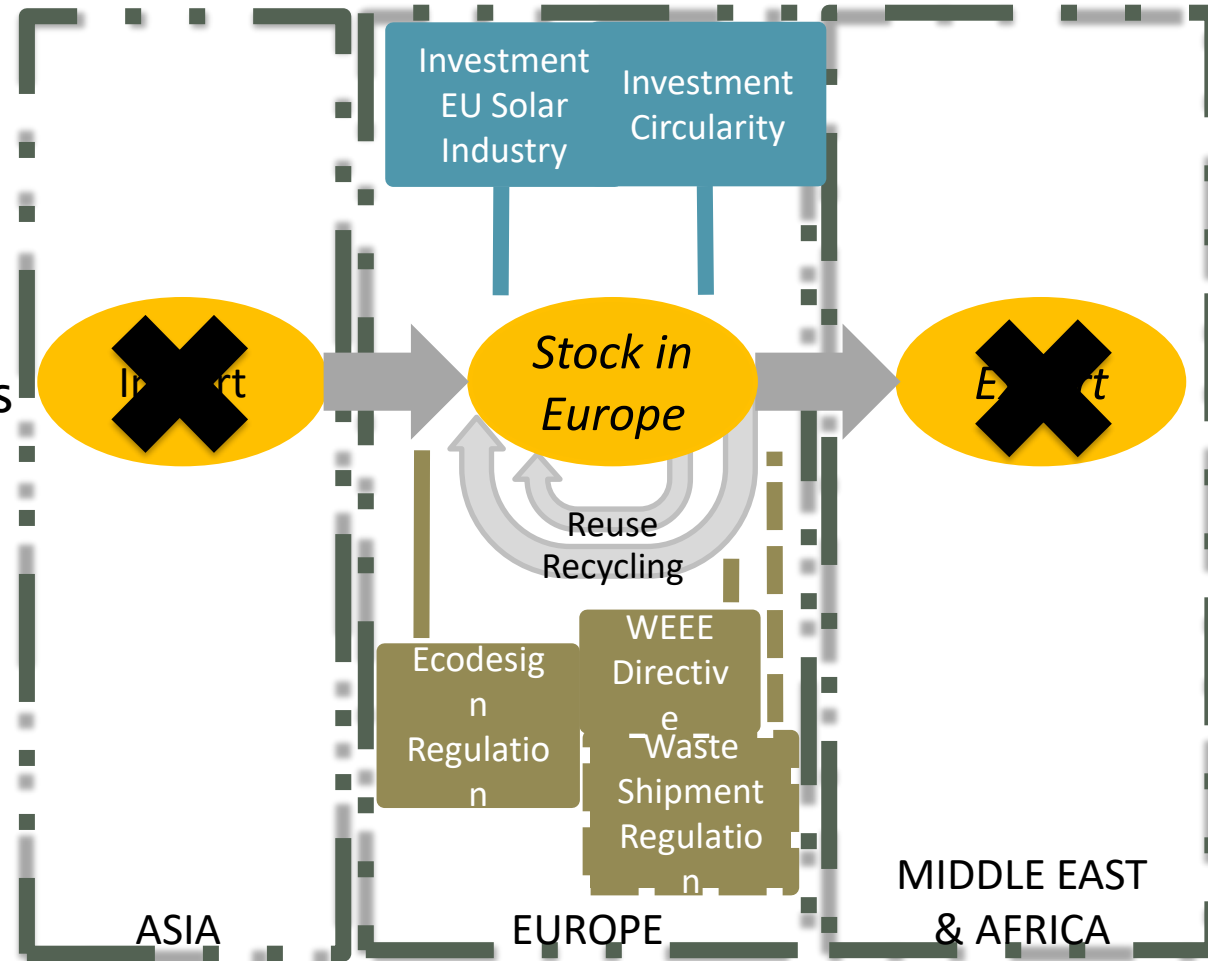


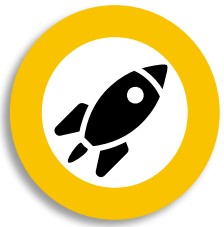


# Key points for discussion

What can we say from a business model and policy perspective

- Solar industry was designed in a linear way
- Circularity effort were introduced later to fix end-of-life challenges by regulation
- Regulatory efforts for circularity come with limits
  - Waste shipment regulation <> free trade
  - Ecodesign <> production in Asia
- To avoid export industrial basis is needed, which would also limit import
- Should we invest in an EU solar industry basis in a circular way?





# Call to action: Solar Reuse Europe consortium

Contact me for more information: [roger.nyffenegger@bfh.ch](mailto:roger.nyffenegger@bfh.ch)

- A diverse network of reuse partners is driving *preparation for a reuse of PV systems*, mainly modules, across Europe.
- *Regional disparities* in solar energy production between northwestern and southeastern Europe shall be addressed.
- *Reuse of PV systems presents an opportunity* to simultaneously reduce CO2 emissions, decrease the use of critical materials, and expand solar energy capacity.
- The project focuses on *strengthening the European solar reuse value chain* by
  - advancing standardization and industrialization of testing processes,
  - fostering ecosystem and business model innovation,
  - analyzing the policy framework,
  - and improving selling platforms through data collection and harmonization.



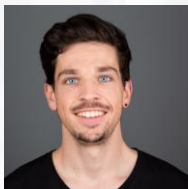
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Haute école spécialisée bernoise  
Bern University of Applied Sciences



ENERGYCITIES

ZONNEXT





**Roger Nyffenegger**

Bern University of Applied Science, Switzerland & Maastricht Sustainability Institute, The Netherlands



**Brian Baldassarre**

Joint Research Centre of the European Commission, Spain & Maastricht Sustainability Institute, The Netherlands



**Nancy Bocken**

Maastricht Sustainability Institute, The Netherlands

Thank you!



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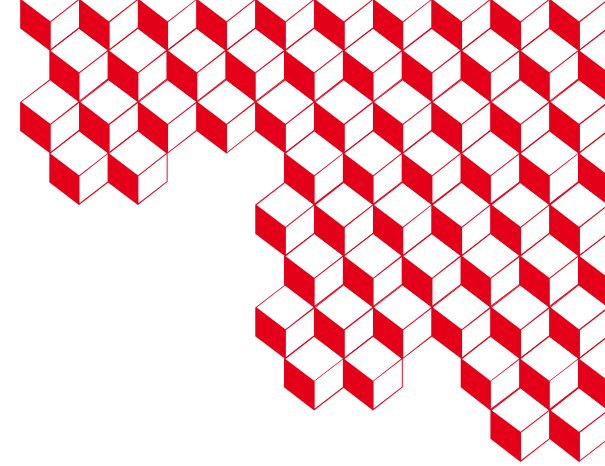
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# Jérémie Aimé

Head of Applied Systems Laboratory,  
CEA-INES



# **‘Prolonging Solar Lifetime Through PV Module Reuse’**

## **Challenges & Solutions**

**Jérémie Aimé**

**Head of Applied Systems laboratory**



22 000 sqm  
120 M€ Equipment  
500 employees  
50 M€ Annual Budget

**Premium PV Cells and modules** | Process & equipment | X-IPV | Power electronics | Plants Architectures

**Hardware ...**

Research & Education  
for **Solar Energy**

**... & software**

Grid integration | Diagnosis & Data | Energy management systems | Storage | **Smart grids & Smart cities**

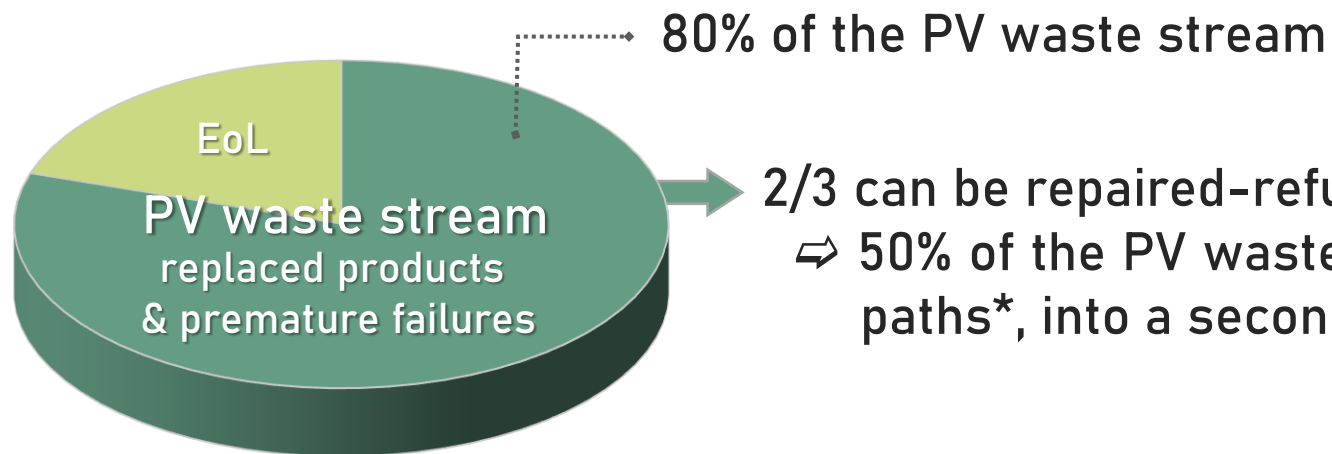
# Expected volumes



PV fleets installed during the boom of FIT schemes, have now passed mid-life (10+yr old)

⇒ unprecedented wave of revamping and repowering

⇒ well-functioning 10-15yr old PV modules being replaced in utility-scale PV plants.



80% of the PV waste stream

2/3 can be repaired-refurbished and reused.

⇒ 50% of the PV waste can be diverted from the recycling/disposal paths\*, into a second-life cycle.

\* today's default strategy for decommissioned PV modules in Europe

Need to optimize EoL management strategies in the PV industry from design to O&M level



►► Higher reuse readiness of PV

# Outlook towards PV reuse: Regulatory framework

To justify the bankability of PV reuse, considering the very low prices of new PV modules.

Key point: Avoiding that healthy modules are prematurely sent to waste (very short financial life).



Enforce state-of-health (SOH) analysis in case of PV modules reaching the end of their first life ten years earlier than their warranty period end.

*For example, for modules with 30 years warranty, SOH check is enforced if owners want to perform repowering/revamping before 20 years of lifetime.*

Such policy could become relevant and come into action as early as by 2030.



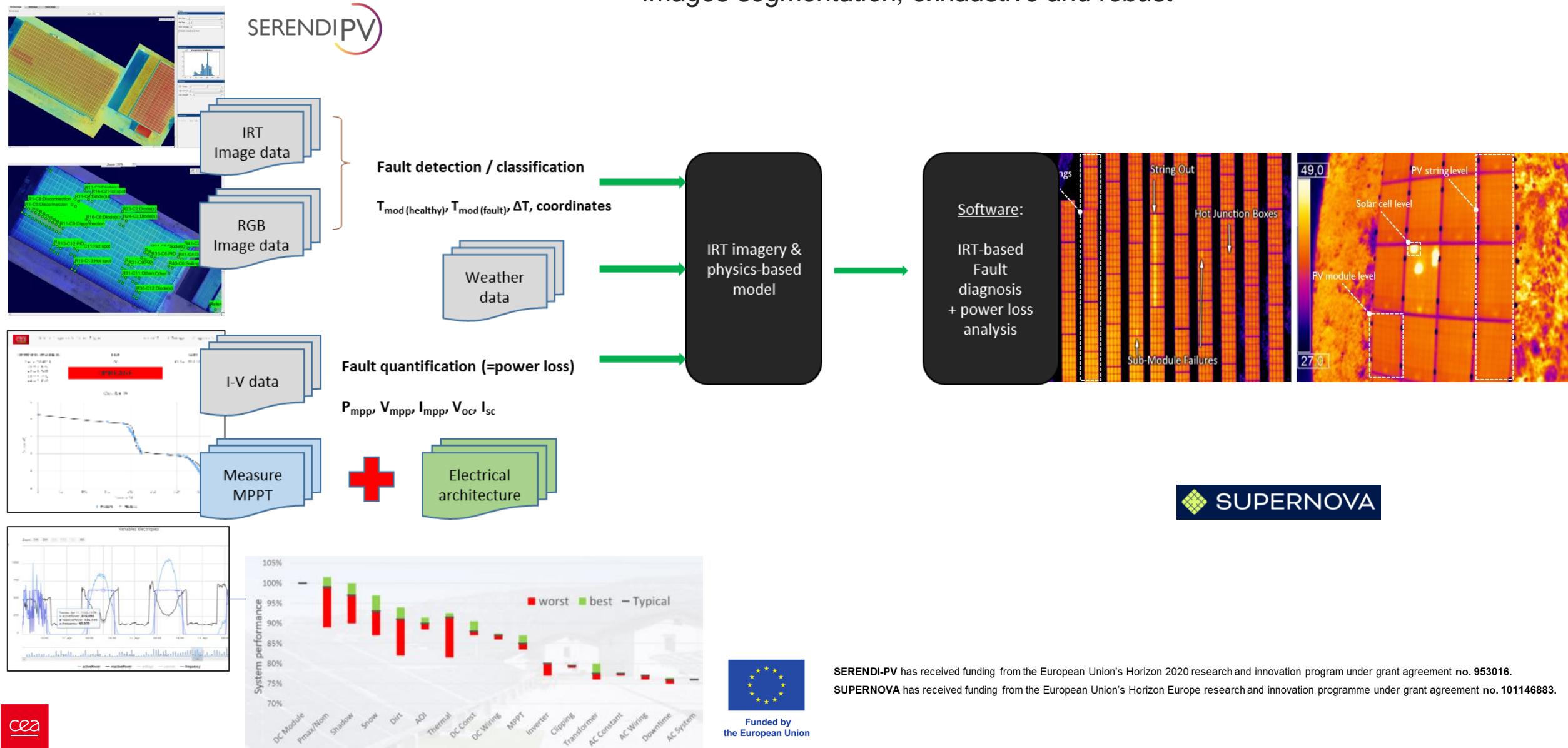
Policy needs to have a science/technology based foundation

## Critical building blocks

- 1) PV failure diagnosis
- 2) Understanding failure mechanisms
- 3) Database, use cases

# Diagnosis tools

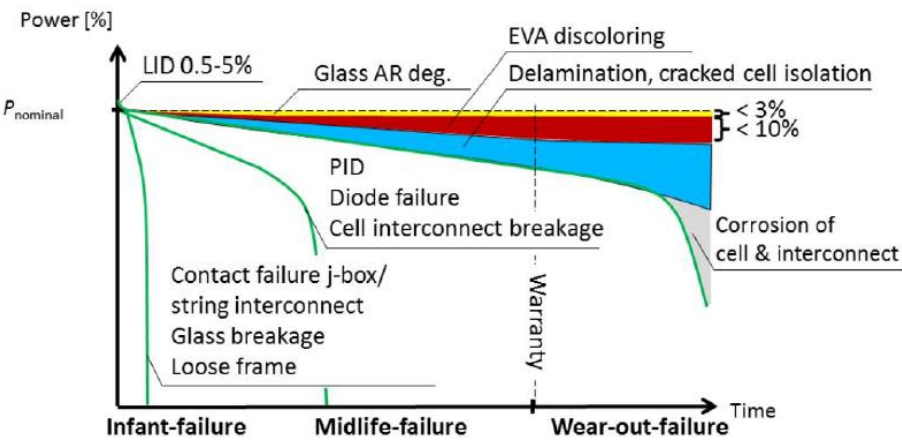
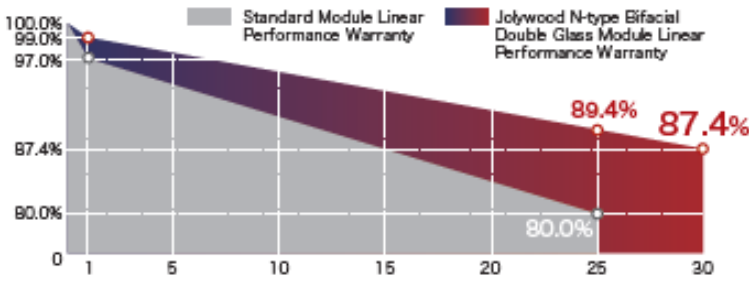
Diagnosis tool using thermal images and cross-linked analysis  
*Images segmentation, exhaustive and robust*



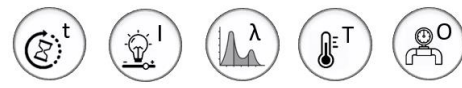
SERENDI-PV has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 953016.  
 SUPERNOVA has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101146883.

# Reliability, durability

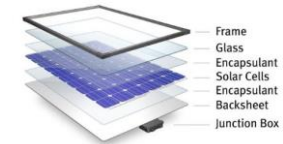
-1.00% 1st-year Degradation | 15 Years Product Material & Workmanship  
-0.40% Annual Degradation | 30 Years Linear Performance Warranty



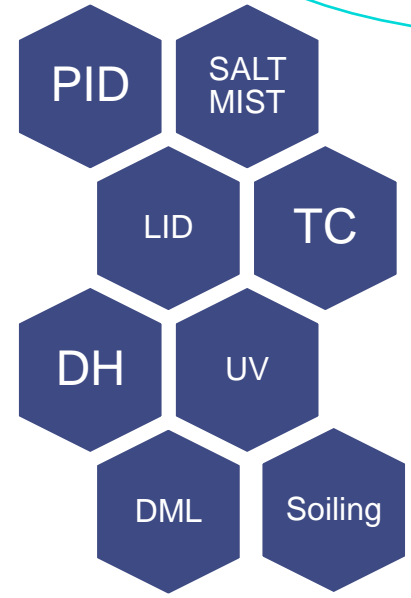
Floating Desert



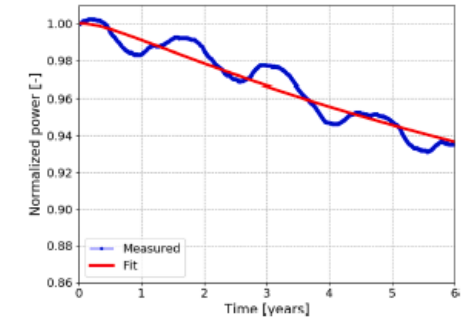
Conditions



BOM



Prediction of performances



CHALLENGE

➤ Modelling of modules degradation in real conditions

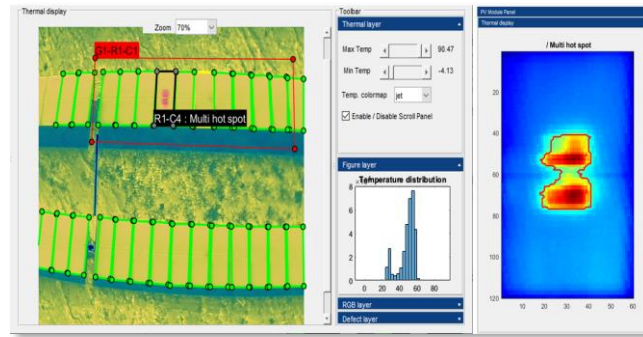
# Data base generation, controlled environment



Data generation, diagnosis of modules/systems:

- No defect
- With known defect
- Repaired

Test sequences using mobile test lab  
Creation of database (min 400 ref), guidelines  
Durability using accelerating ageing sequences



Multi-spectral images  
End of life management dashboard



Funded by  
the European Union

SUPERNOVA has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101146883.

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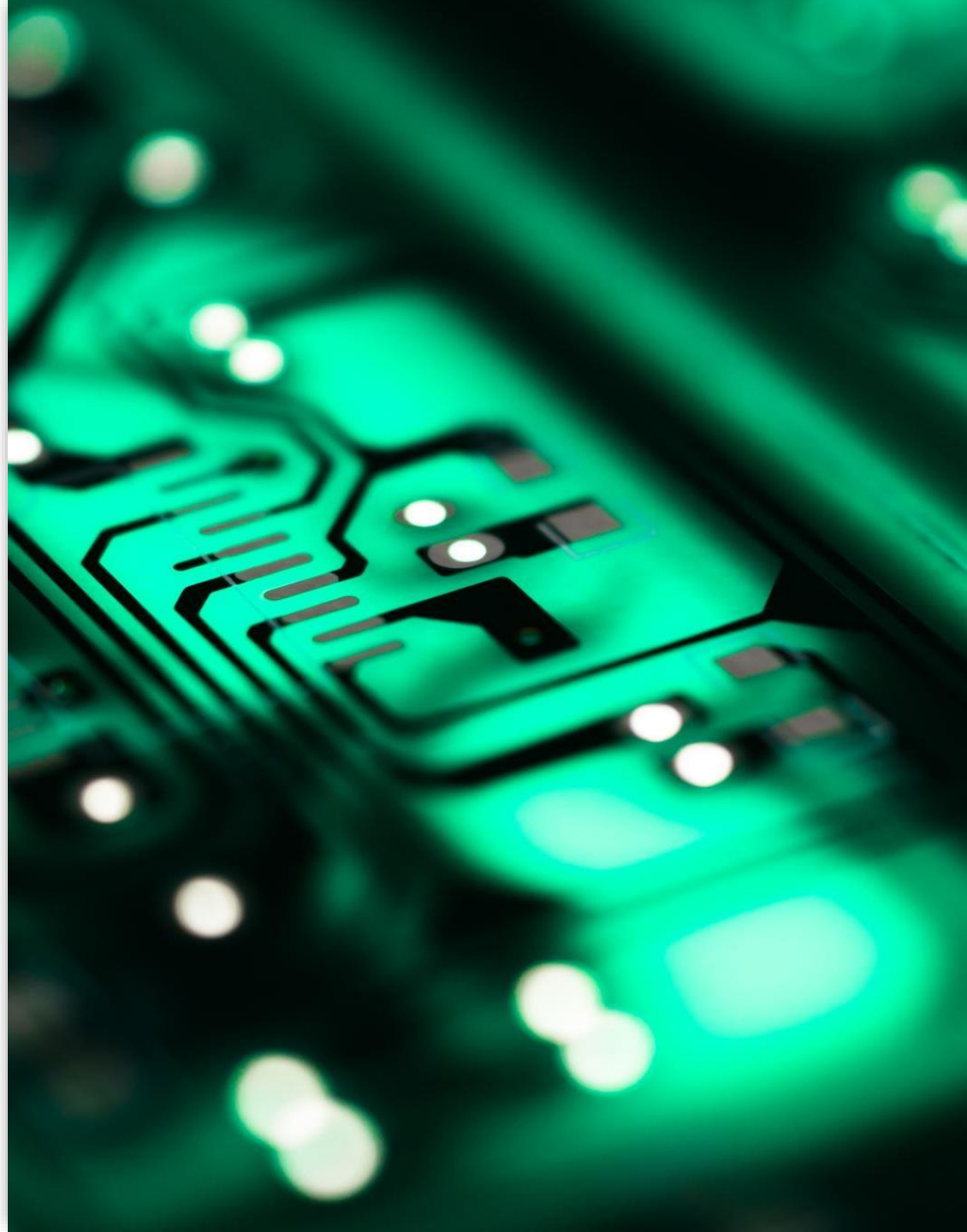
# Technology and innovation

## Innovations from CEA:

We use technological advances in the field of photovoltaic module monitoring and diagnostics to detect problems early and accurately.

## SolReed expertise:

We have developed exclusive repair techniques that enable us to maximise the reuse of these modules, thereby reducing waste and enhancing sustainable development.





## **Contact information :**

SolReed Teams

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*SolReed*



**Thank you**



# Stefan Wippich

Managing Director,  
SecondSol GmbH

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 **SECONDSOL™**  
THE PHOTOVOLTAIC MARKETPLACE



**SolarPower  
Europe**

# Sustainable

Solar Europe 2024

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# SecondSol GmbH

## Business units



### Online Marketplace

60k users across Europe  
2 million items online (new, used, repaired)



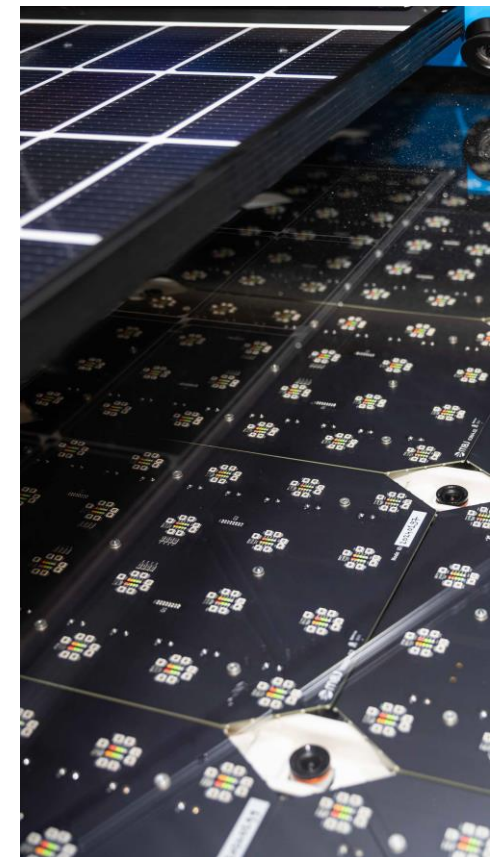
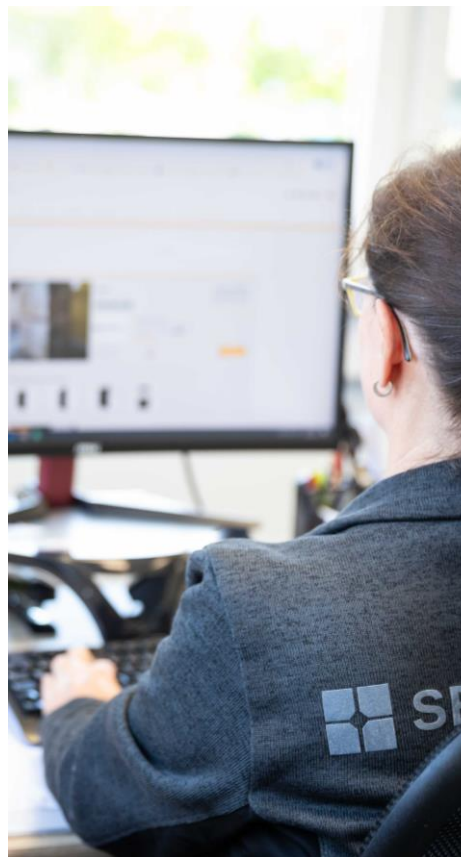
### Parts and Spare Parts

250k spare parts (modules) in stock  
We deal with new and used products



### PV Testcenter

Electroluminescence  
Power measurement



# Recycle or reuse?

*We believe in a marketplace*



Source: ENERGYBIN

Functionality  
Age  
Degradation  
Free of defects

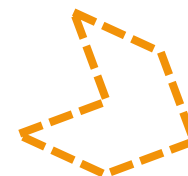
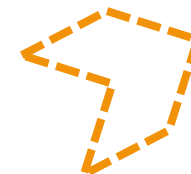


**IMPORTANT QUALITY !!!**



**SecondSol Marketplace**

Supply and demand  
will drive the price and  
the channel.



**Reuse**



Source: United Nations

**Recycling**



# PV Circular economy – what we need for reuse

Get more quality with data analysis



## Standardization

We need a product data standard that allows us to track products across the entire value chain.



## Collect product data

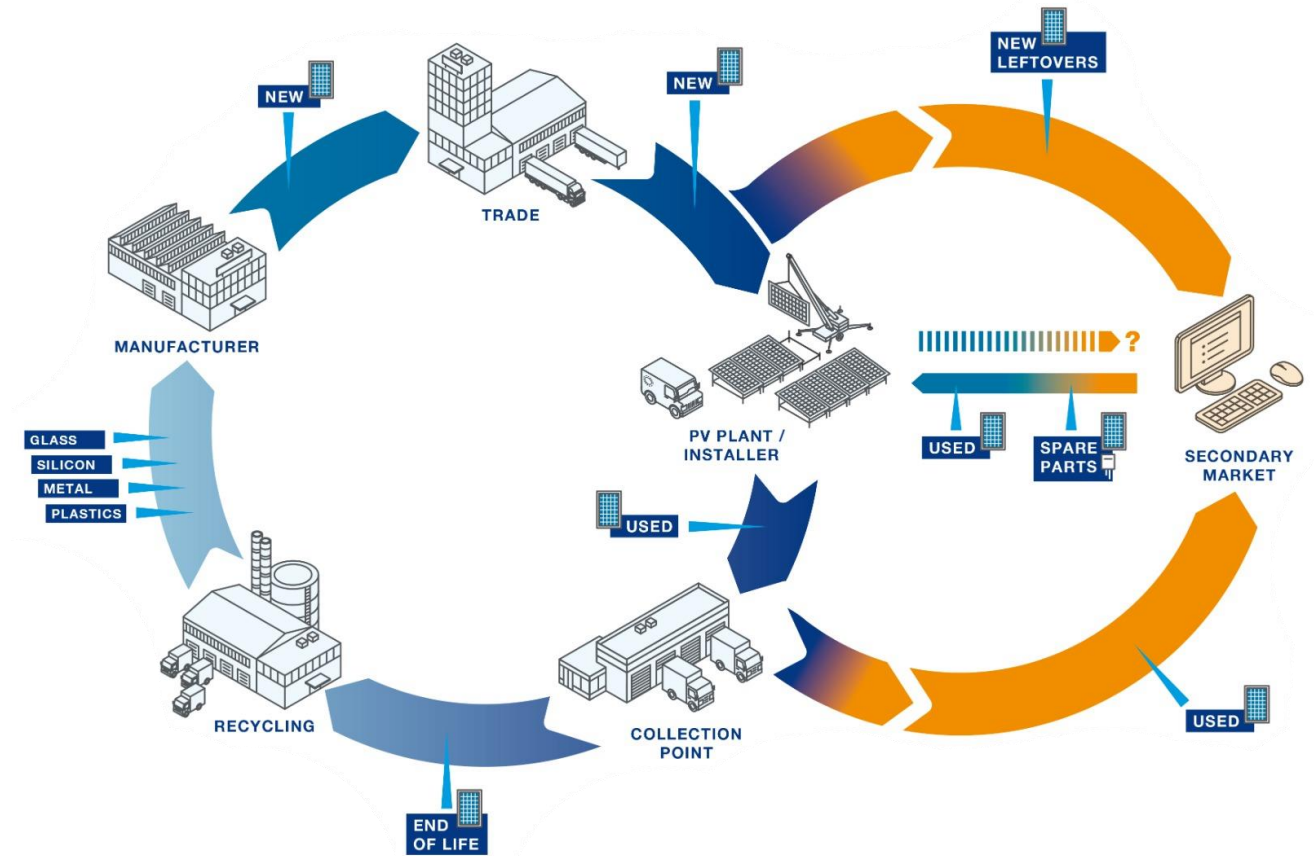
Data collection along the entire value chain in the operating time.



## Data analysis

Analyze data at the point of sale. Decision on general reuse potential.

➤ No waste to Africa



# At end...

We need to recycle.



## If we reuse...

- we have to make sure that the goods are in good condition.
- the goods are also recycled at the end.
- we may have to help set up a collection system in the destination countries.



Source: Reiling



Source: ZDF/Juan Solera

# Contact



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# Panel discussion



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# THANK YOU



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