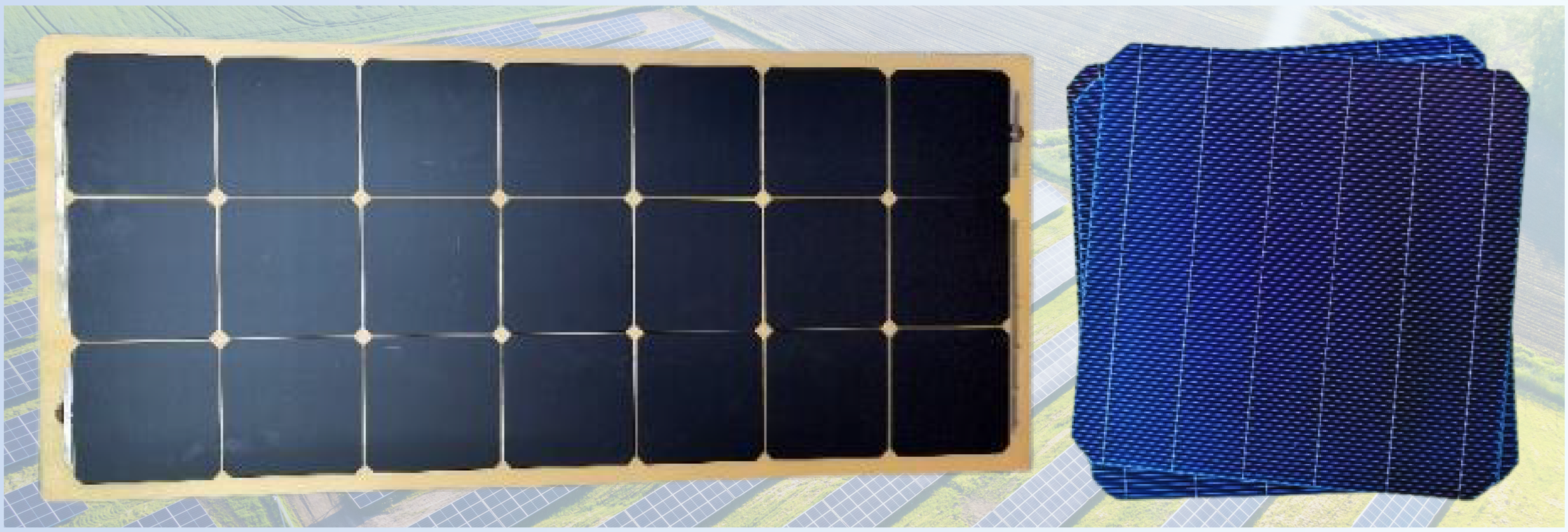
FACTSHEET #12

Silicon is considered a critical raw material for the EU due to its high supply risk and economic importance, mainly because of heavy reliance on imports. The objective of RESiLEX is to improve the resilience and sustainability of the entire Silicon value chain and reduce EU dependence on critical raw materials for solar panel and battery production. This factsheet is based on the document "Roadmap for the eco-design of silicon solar cells & modules technologies" by the partner CSEM.

Testing the eco-design of solar cells and modules "made in Europe"

The photovoltaic industry is transitioning from conventional design to eco-design, a systematic approach that integrates environmental considerations throughout the entire product life cycle (extraction, production, use, and end-of-life). RESILEX partners have successfully built prototype panels for testing a series of innovative solutions developed within the project.



(Left) PV module with a wood plank as a backsheet, (right) Solar cells fabricated for the tests

Solar Cell Level Innovations (SHJ)

Silicon Heterojunction (SHJ) cells have been optimized to reduce the use of rare and expensive materials:

- **Indium Reduction** (In-less & In-free): Indium content was reduced by over 77% by using ultra-thin transparent conductive oxide (ITO) layers without significant efficiency losses (<0.1% absolute). Indium-free oxides, such as AZO (aluminum-doped zinc oxide), were also tested.
- **Silver Replacement** (Ag-less & Ag-free): Silver was replaced by copper using silver-copper screen-printing pastes (70% Ag reduction) or through copper electroplating, which almost entirely eliminates the need for silver.
- **Thinner Silicon**: The use of reduced-thickness wafers (down to 130 µm or less) reduces energy consumption and the carbon footprint of production.

Module Level Innovations

Module design has been revolutionized by replacing high-impact components with sustainable alternatives:

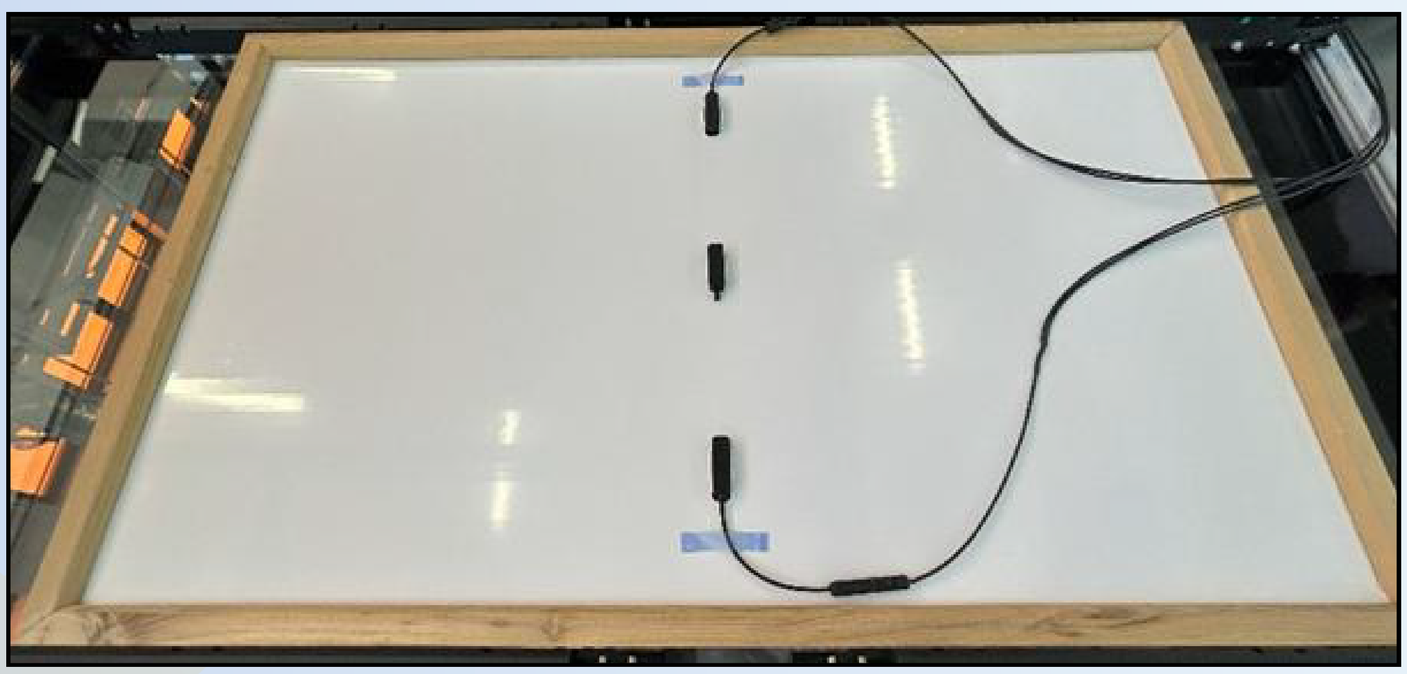
- **Wooden Frame**: Replacing the aluminum frame with wood (e.g., Acacia) drastically reduces the carbon footprint and the use of fossil resources.
- **Fluorine-free Materials**: Use of fluorine-free backsheets and frontsheets to facilitate recycling and eliminate the risk of PFAS pollution.
- **TPO Encapsulants:** Utilizing Thermoplastic Polyolefins (TPO) instead of conventional EVA facilitates the separation of components at the end of life, significantly improving recyclability.
- **Lead-free Interconnections**: Use of copper-based Electrically Conductive Adhesives (ECA) to eliminate lead and further reduce silver in cell-to-cell connections.

Woood frame assembly

The Milestone: The 60-Cell Demonstrator

The project reached a major milestone with the production of a full-scale 60-cell photovoltaic module (120 half-cells) combining all innovations:

- **Composition**: Thin European wafers (130 µm), low-indium and low-silver cells, copper interconnections, TPO encapsulant, fluorine-free backsheet, and a wooden frame.
- **Performance**: The module achieved a maximum power output (Pmax) of 325 W, proving that extreme sustainability is compatible with competitive industrial performance.



Junction box bending for the eco-design module.

Impact on Recycling and Circularity

Eco-designed choices influence end-of-life operations. As a result, the eco-designed PV modules developed in this project present positive and challenging features which are:

Positive Impacts: Fluorine-free materials and non-crosslinked encapsulants (TPO) make the mechanical separation of components and treatment much simpler and safer.

Challenges: While beneficial for the environment, the reduction of silver decreases the economic value of the material recovered by recyclers—a factor that necessitates new circular business models. Separation and valorization of wooden frame is new to PV recyclers and will require some process developments.

RESiLEX investigated in detail the impactof eco-design strategies on PV devices' (cell & module) manufacturing, by investigation their initial performance, reliability and end-of-life. By combining those developmentsfindings in a 60-cell demonstrator.

The finished eco-designed module

RESILEX shows that it is possible to combine high level of sustainability and high power. In particular, this demonstrates that it is possible to reduce dependence on foreign imports and protecting the environment through the use of local, renewable materials like wood and the avoidance of hazardous substances (such aslead, PFAS).

Find out more on our channels

resilex-project.eu

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