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Position Paper

Why Crystalline Silicon Photovoltaics Must Remain a Key Research Priority in the 8th Energy Research Programme

Broad Support from Industry, Research and the Region

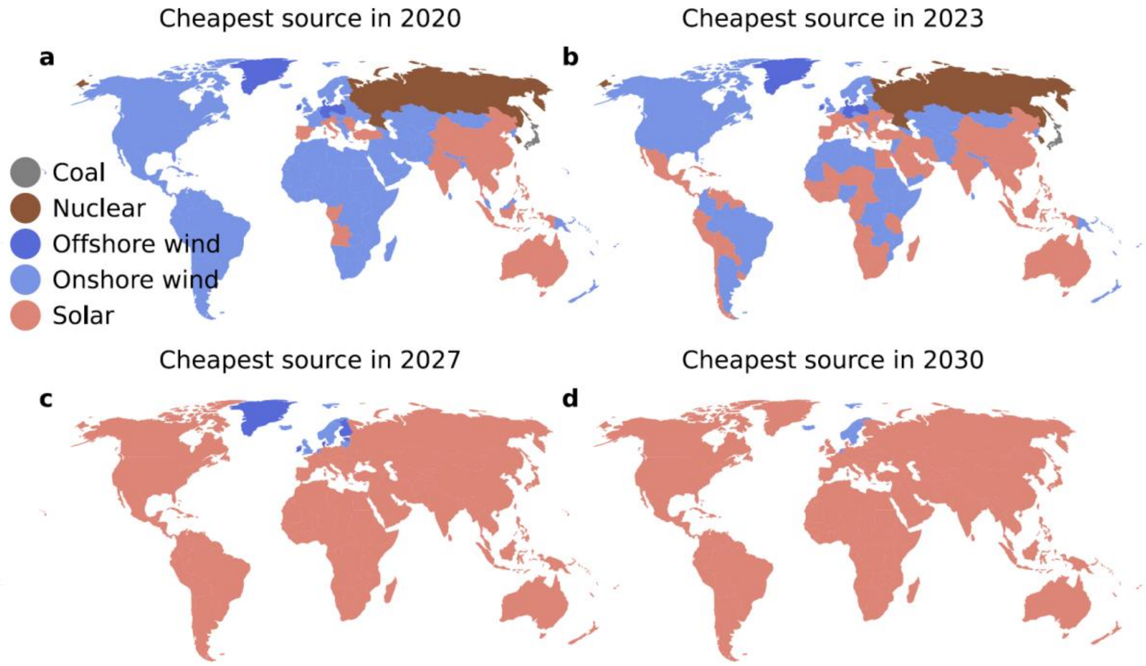
The key messages and recommendations of this position paper are explicitly supported by the following companies and institutions:

Company / Institution	Location
centrotherm international AG	Blaubeuren, Germany
Energy Depot EU GmbH	Konstanz, Germany
FuturaSun Holding S.r.l.	Cittadella, Italy
HTWG Konstanz – Hochschule Konstanz Technik, Wirtschaft und Gestaltung	Konstanz, Germany
Kontron AIS GmbH	Dresden, Germany
Next2Sun Technology GmbH	Dillingen, Germany
RCT Solutions GmbH	Konstanz, Germany
RENA Technologies GmbH	Gütenbach / Freiburg, Germany
SoliTek R&D	Vilnius, Lithuania
SOLYCO Solar AG	Berlin, Germany
Stadt Konstanz – Wirtschaftsförderung	Konstanz, Germany
VON ARDENNE GmbH	Dresden, Germany

This broad support underlines the industrial relevance of maintaining crystalline silicon technologies and their further development as a key pillar of German energy research funding in the future. The corresponding letters of support have been submitted to Project Management Jülich (PtJ).

Germany continues to possess internationally leading expertise across the entire value chain of crystalline silicon-based photovoltaics, despite the substantial loss of domestic solar cell and module production. German and European companies are particularly strong in machinery and equipment manufacturing, production processes, automation, metrology, materials and industrial research.

According to all international roadmaps, crystalline silicon (c-Si) will remain the dominant photovoltaic technology over the next ten years, accounting for well over 90% of solar cells produced worldwide. This technological dominance is no coincidence. It is based on the exceptional competitiveness of crystalline silicon photovoltaics. As the following figure illustrates, solar energy combined with storage technology is developing into the lowest-cost form of electricity generation worldwide.



Electricity generation technologies with battery storage showing the lowest LCOE by year and region. (Source: Nijsse, F.J.M.M., Mercure, J.F., Ameli, N. et al. The momentum of the solar energy transition. Nature Communications 14, 6542 (2023))

The reason is clear: today's c-Si technology has reached a level of efficiency and cost that enables extremely low levelised costs of electricity (LCOE) of only 1 to 6 euro cents per kilowatt-hour[1], making it cheaper than coal and, in most cases, wind power. Even though the potential for further efficiency gains and cost reductions at cell and module level is gradually approaching physical and economic limits, c-Si remains the reliable engine of the global energy transition. It is the undisputed lowest-cost form of electricity generation and is favoured by investors due to its excellent risk profile and decades of proven experience (bankability).

The focus of further development is therefore increasingly shifting. Key priorities at cell and module level in the coming years include:

- Unlocking remaining potential: Maximising the remaining efficiency potential without increasing manufacturing costs.

[1] depending on location

- Sustainability & resource conservation: Using more resource-efficient and environmentally friendly processes and reducing the use of critical raw materials in production.

The competitiveness of c-Si production will therefore be a decisive factor in determining

- whether German companies can participate in the continued global expansion of photovoltaics,
- whether European production equipment remains internationally competitive,
- whether new generations of solar cells can be successfully industrialised,
- and whether future technologies such as silicon-perovskite tandem cells can be implemented economically at all.

The share of research funding dedicated to crystalline silicon technologies[2] should therefore not decline further under the 8th Energy Research Programme, but should instead continue to be strengthened in line with their long-term industrial importance.

1. ENERGY RESEARCH MUST ENABLE INDUSTRIAL VALUE CREATION

The German Federal Ministry for Economic Affairs and Energy does not pursue scientific excellence alone through its research funding. Rather, research should generate innovations that

- create industrial value,
- secure international competitiveness,
- preserve high-quality jobs,
- strengthen technological sovereignty,
- and enable private investment.

The existing Energy Research Programme already contains important guidelines explicitly aimed at close cooperation between science and industry. In particular, the involvement of machinery and equipment manufacturers, production companies, material suppliers and research institutions along the entire value chain is a key success factor for German energy research.

This industry-oriented approach has made a significant contribution to ensuring that, despite the decline in domestic solar cell production, Germany continues to possess internationally recognised expertise in production equipment, process technologies and industrial research. This approach should be consistently maintained and further strengthened in the 8th Energy Research Programme.

In photovoltaics in particular, Germany continues to possess exceptionally strong industrial capabilities despite the loss of large parts of domestic solar cell production.

These capabilities include, in particular:

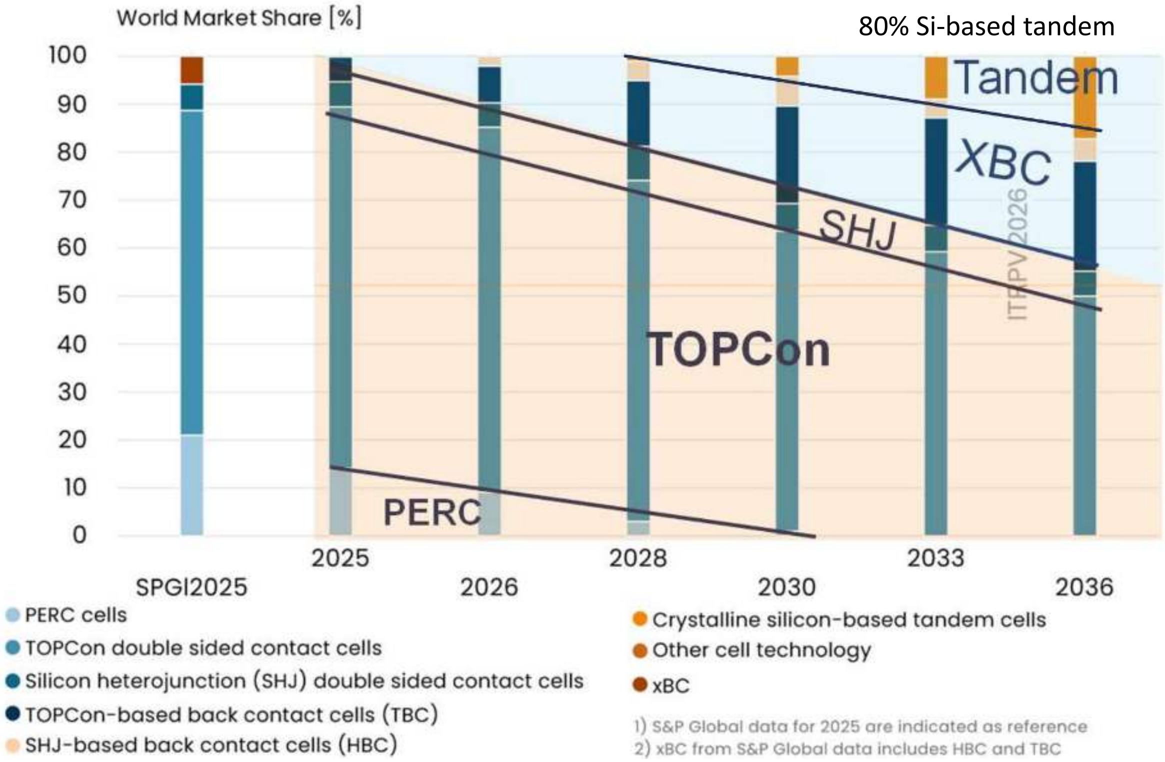
- production equipment,
- automation,
- metrology,
- process development,
- specialty materials,

[2] including their further development (TOPCon, HJT, BC, tandem bottom cells)

- production software,
- quality control,
- and industrial research services.

These capabilities are in demand worldwide. For the foreseeable future, the global market will remain dominated by c-Si.

2. WHY CRYSTALLINE SILICON WILL REMAIN THE FOUNDATION OF FUTURE PHOTOVOLTAICS



Expected market shares of different solar cell technologies until 2035 (ITRPV, 17th Edition, 2026).

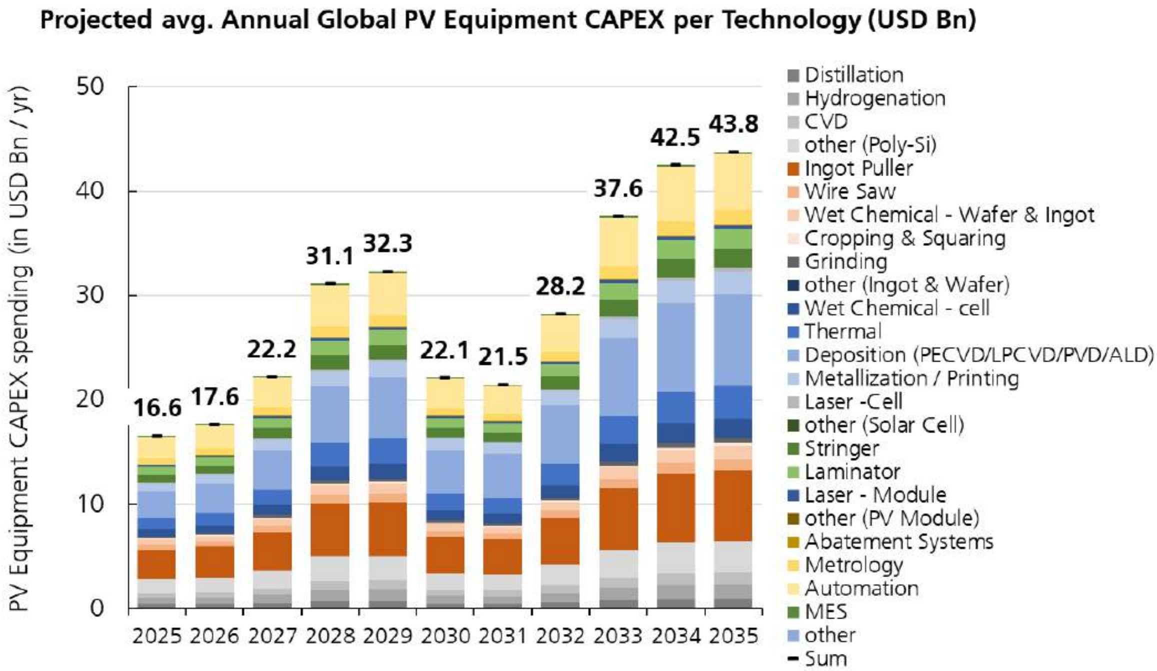
Even when silicon-based tandem cells are included, crystalline silicon remains the technological basis for the vast majority of the PV market throughout the period considered. At the same time, the increasing market share of back-contact (BC) technologies increases the relevance of 3- and 4-terminal architectures for future tandem concepts. These approaches should therefore be considered in research and development alongside 2-terminal tandem technologies.

The latest ITRPV confirms that crystalline silicon will remain the technological basis for the vast majority of global solar cell production over the next ten years. This applies both to established single-junction technologies and to future silicon-based tandem cells. Taking into account the c-Si-based tandem technologies expected by the ITRPV, around 95% of projected global solar cell production in 2036 will still be based on crystalline silicon.[3]

[3] ITRPV, Results 2025, 17th Edition, June 2026. For 2036, around 80% of tandem cells are expected to use a c-Si bottom cell (ITRPV Presentation, p. 14).

3. WHY GERMANY CAN BENEFIT NOW

The Equipment Study[4] jointly prepared by VDMA, Fraunhofer ISE and ISC forecasts an increase in annual global investment in PV production equipment from USD 16.6 billion in 2025 to USD 43.8 billion in 2035. This represents a cumulative market volume of approximately USD 250–300 billion over the coming decade. The breakdown by production step demonstrates that this growth affects numerous areas of expertise within the German and European machinery and equipment industry.



Projected annual global investment in PV production equipment by process and technology area.
Source: VDMA Equipment Study, prepared with contributions from Fraunhofer ISE and ISC Konstanz.

4. RESEARCH AND INDUSTRIAL IMPLEMENTATION MUST GO HAND IN HAND

Germany has excellent fundamental research capabilities. However, international competition is increasingly decided at the level of industrial implementation.

To create competitive advantages, the Energy Research Programme should therefore continue to give particular support to research that

- improves production processes,
- increases yield,
- reduces costs,
- improves reliability,
- enables automation,
- integrates digitalisation,

[4] https://www.vdma.eu/documents/d/group-34568/vdma-pv-equipment-study_ise_isc_2026-03-09_final

- transfers AI into production processes,
- reduces material consumption,
- enables recycling,
- and accelerates the industrialisation of production lines.

5. BALANCED FUNDING ACROSS TECHNOLOGY READINESS LEVELS

The energy transition requires both visionary future technologies and the continuous further development of technologies that are already established on an industrial scale. Balanced research funding should therefore cover the entire innovation pathway – from fundamental research through piloting and demonstration to industrial implementation.

From the perspective of industrial value creation, it is essential that funding decisions support a balanced portfolio of different technology pathways. A funding focus directed exclusively towards future technologies carries the risk that existing industrial strengths in Germany and Europe will not be developed sufficiently.

From the perspective of the signatories, this became apparent, for example, in the "Test Infrastructures" funding call. Research infrastructures focused on perovskite-based technologies received funding, while proposals aimed at advancing industrially relevant crystalline silicon technologies were not selected.

Irrespective of the individual funding decisions, this example illustrates the importance of a balanced funding strategy that adequately supports both future technologies and the continuous development of today's market-dominating c-Si technologies.

Particularly with regard to the transfer into industrial applications, research funding should ensure that established value chains are not weakened, but instead further developed as the foundation for future technologies.

6. RECOMMENDATIONS FOR ACTION

For the German 8th Energy Research Programme, we recommend:

6.1 Maintain c-Si as a Key Pillar

The share of research funding dedicated to crystalline silicon technologies should not decline further, but should instead be strengthened in line with their long-term industrial importance.

For the German machinery and equipment industry, the technology roadmaps of major international c-Si manufacturers – including those in India and the United States – are particularly important. These roadmaps increasingly extend beyond the further development of today's TOPCon and BC technologies towards future tandem concepts.

Given the growing share of BC technologies, 3- and 4-terminal architectures should therefore be developed in a technology-open manner alongside 2-terminal architectures.

6.2 Further Strengthen Industry-Oriented Research

Funding should continue to focus on projects involving

- machinery and equipment manufacturers,
- manufacturing companies,

- material suppliers,
- research institutions,

along the entire value chain.

6.3 Increase Support for Production Technologies

In addition to cell efficiency, greater emphasis should be placed on:

- production processes,
- digitalisation,
- AI,
- automation,
- quality assurance,
- reliability,
- sustainability,
- recycling,
- scaling.

6.4 Expand Demonstration and Piloting

New technologies must be demonstrated under industrial conditions. Pilot lines and industry-oriented research infrastructures are indispensable for this purpose.

6.5 Align Research with Industrial Exploitation and Impact

In addition to scientific quality, the selection of research projects should give greater consideration to:

- exploitation potential,
- industrial applicability,
- contribution to European competitiveness,
- benefits for the German machinery and equipment industry.

7. CONCLUSION

Germany continues to have excellent opportunities to play a leading role in the global photovoltaic industry – not through mass production, but through innovation, production technologies and industrial know-how.

The German 8th Energy Research Programme makes a decisive contribution to this, and this should remain the case.

A balanced funding strategy that combines scientific excellence with industrial value creation and recognises crystalline silicon technologies as the foundation for future developments will strengthen both the competitiveness of the German economy and Europe's technological sovereignty.