

Photovoltaik in Europa – eine Übersicht



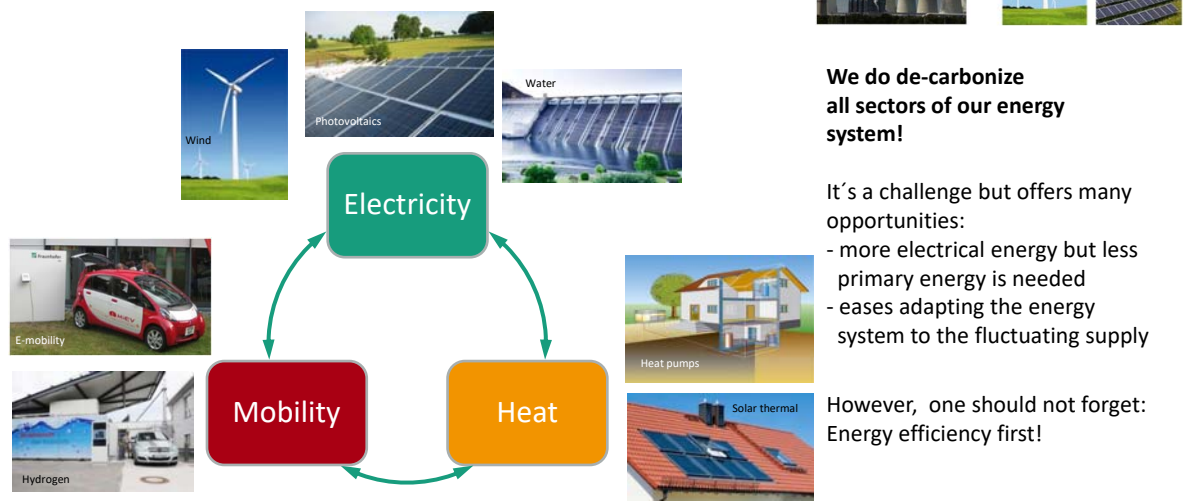
Prof. Dr. Andreas Bett

Fraunhofer Institut für Solare Energiesysteme ISE

20. Nationale Photovoltaik-Tagung
Kursaal Bern, 30. März 2022

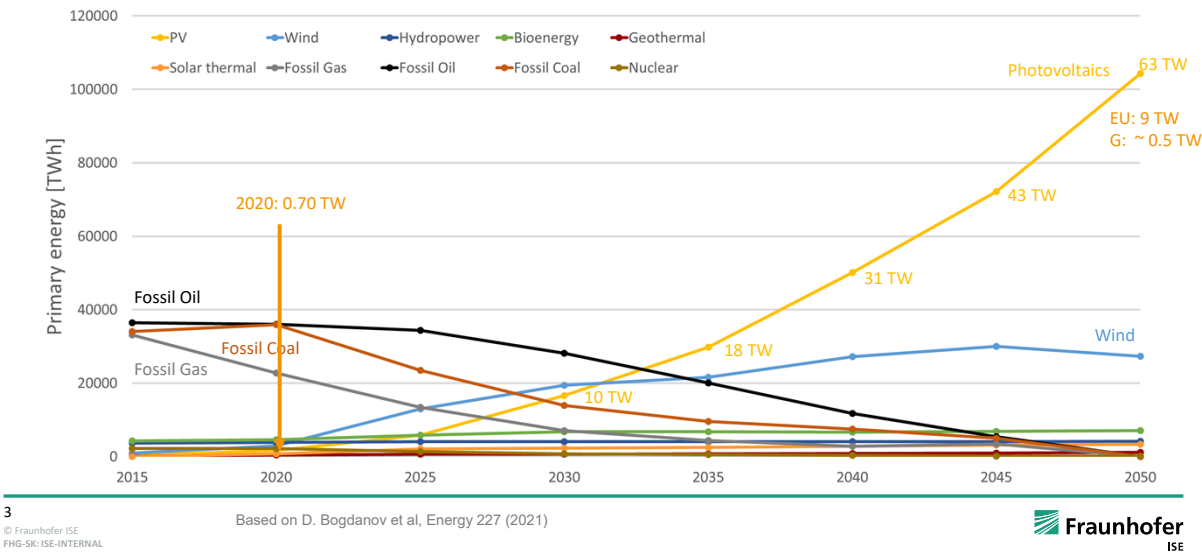
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The CO₂-free Energy System in the Future



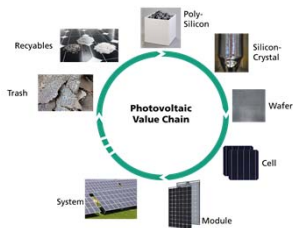
Transformation of the Global Energy Supply to be CO₂-free in 2050

Market: Photovoltaic is Needed in Huge Quantities!



Sustainability in Photovoltaics

- Huge resources are mandatory:
 - ~ 300.000 km² area
 - ~ 3.000.000.000 tons of material (glass, silicon, aluminum, silver, polymers.....)
- Circular economy is desirable

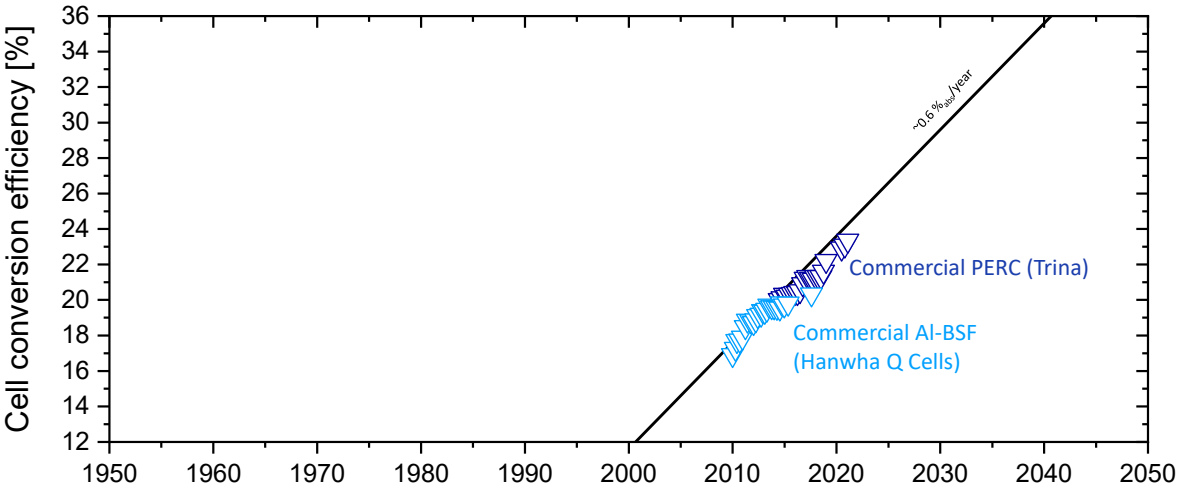


- Highest efficiency is essential



Industrial Cell Production – Development and Status

Solar Cell Efficiency



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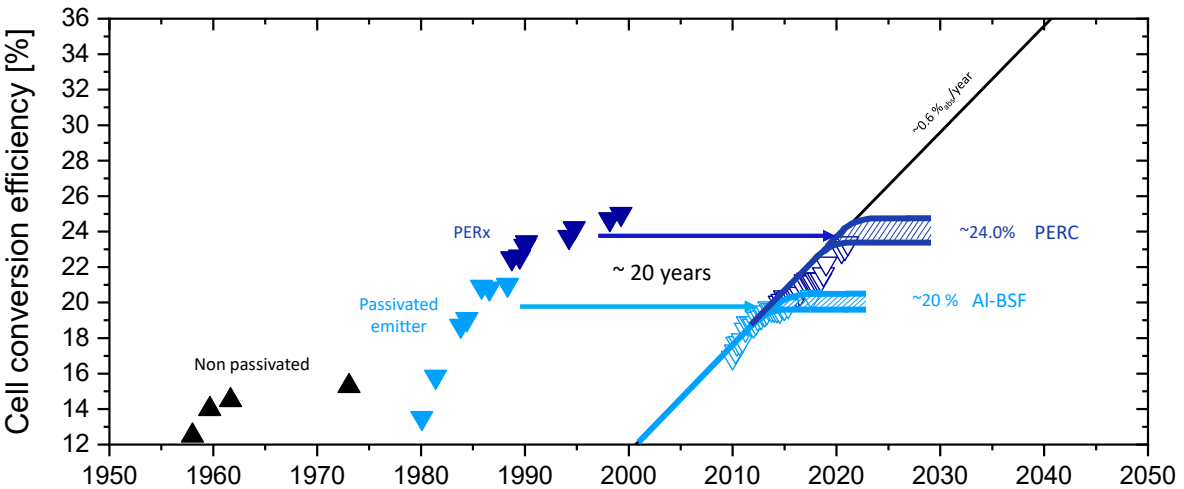
F. Stenzel et al, 36th EUPVSEC (2019), P. Altermatt, PV Cell Tech (2020)

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How the PV-Technology Developed

Laboratory Records and Timeline for Transfer into Industrial Product



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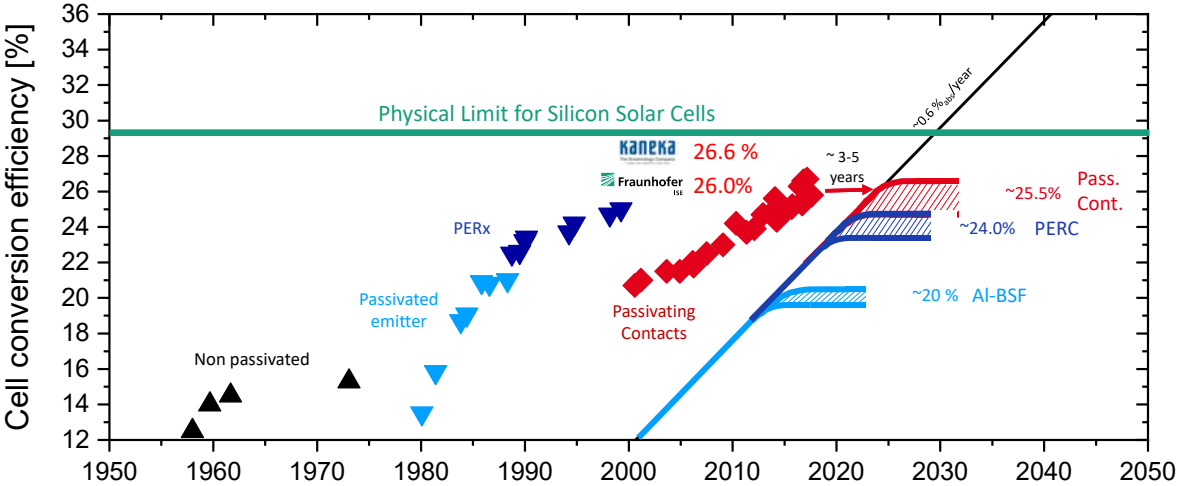
F. Stenzel et al, 36th EUPVSEC (2019), P. Altermatt, PV Cell Tech (2020)
Y. Chen et al, IEEE Journal of PV 8 (2018), A. Richter et al, Nature Energy 6 (2021)
M. Hermle, ETIP PV Conference, Brussels (2017)

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How the PV-Technology Recently Develops

What's Next?



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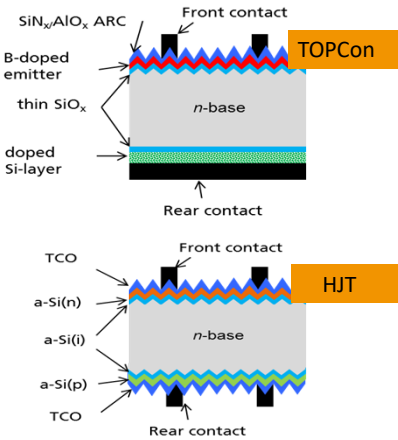
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F. Stenzel et al, 36th EUPVSEC (2019), P. Altermatt, PV Cell Tech (2020)
Y. Chen et al, IEEE Journal of PV 8 (2018), A. Richter et al, Nature Energy 6 (2021)
M. Hermle, ETIP PV Conference, Brussels (2017), <https://www.kaneka.co.jp/en/topics/news/nr201708252/>

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Solar Cells in PV-TEC – Passivated Contact Solar Cells

Transfer to Industry

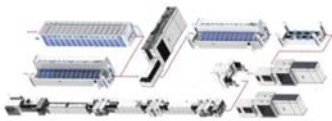


CEA-INES, France;
CSEM, Switzerland; IPVF, France;
ISC-Konstanz, ISFH, Germany;
Fraunhofer ISE, Germany;

Typ	V _{oc} (mV)	J _{sc} (mA/cm ²)	FF (%)	η (%)
TOPCon	711	41,4	81,8	23,8*
HJT ¹	742	38,1	80,6	23,3**

Example of
Fraunhofer ISE

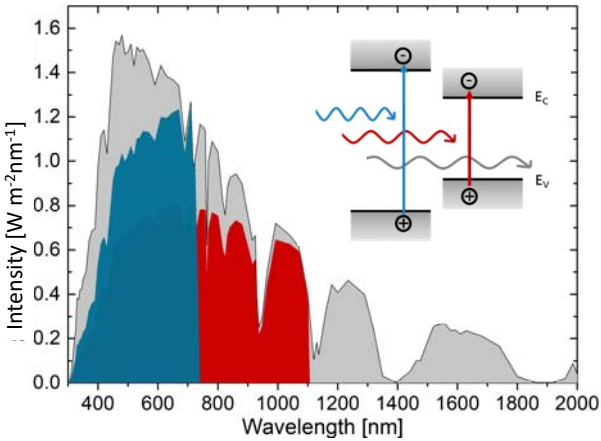
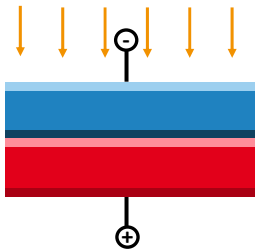
Transfer



Going Beyond the Limit

Build a Tandem Solar Cell

- The sun has a wide spectrum of colours / wavelengths
- Only one wavelength can be used efficiently by one solar cell type
- Two solar cell materials can split up the spectrum
- Tandem solar cells

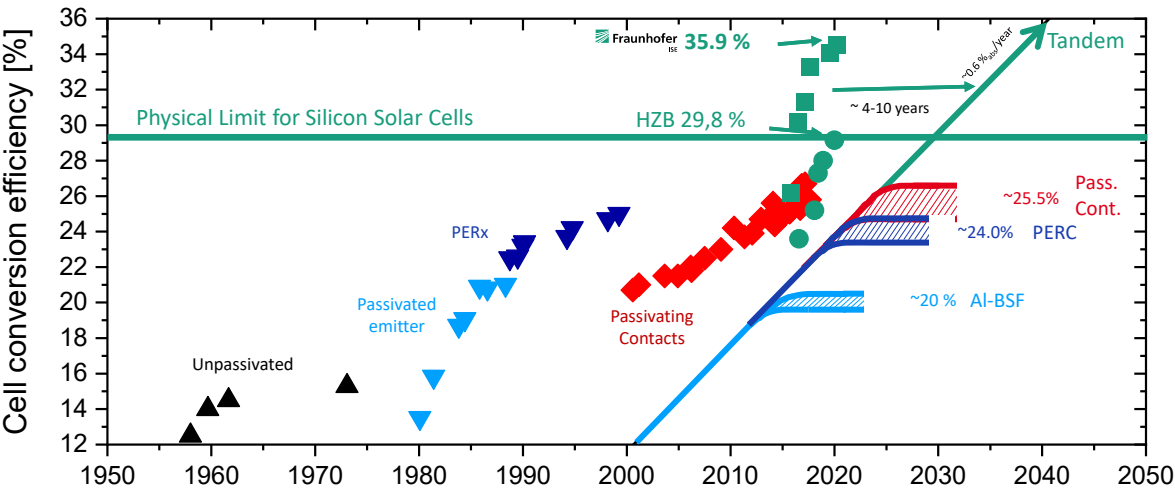


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How the PV-Technology Recently Develops

What's Next?



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Solar Cell in Modules and Applications

Classical: Rooftop and Free Space Power Plants



18 MW-Solarpark Senftenberg
©Phoenix Solar AG



5 kW Rooftop
©Bett

Solar Cell in Modules and Applications

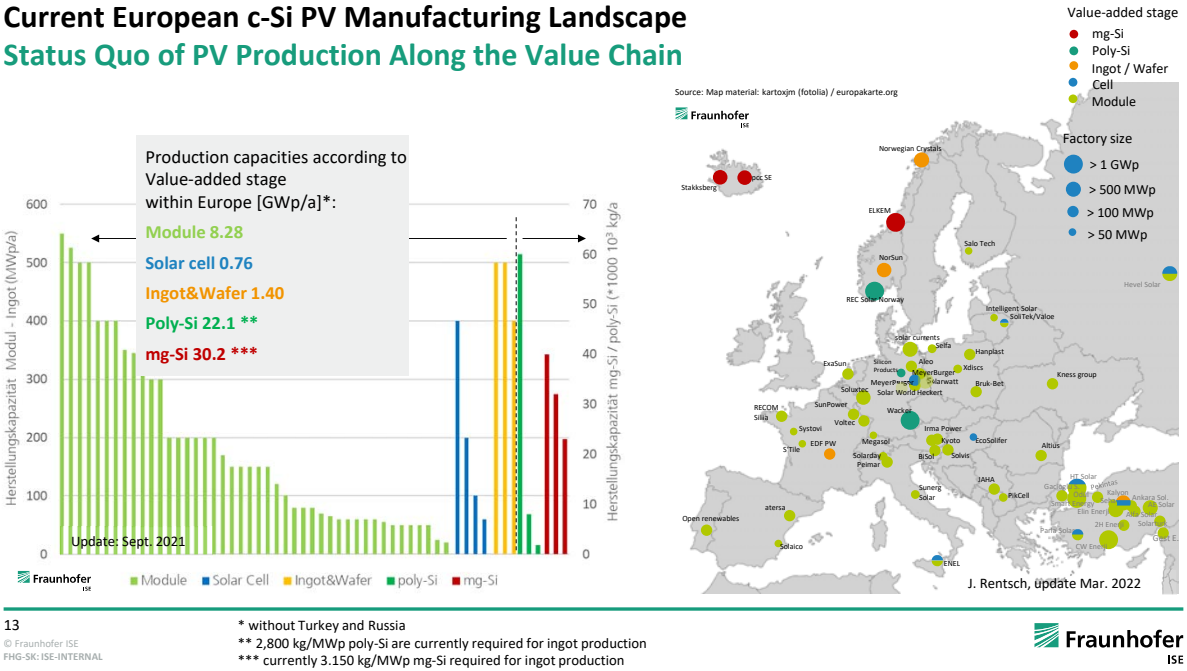
Upcoming: Integrated Photovoltaics – Advantages



- No additional area needed
- Opens up synergies (substructure, covering material)
- Improves acceptance for PV expansion
- Offers opportunities for European PV production

Current European c-Si PV Manufacturing Landscape

Status Quo of PV Production Along the Value Chain



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* without Turkey and Russia
** 2,800 kg/MWp poly-Si are currently required for ingot production
*** currently 3.150 kg/MWp mg-Si required for ingot production



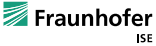
2018 White Paper: The 10 GW GreenFab

Take the Challenge and Make Business!

- 10 GW_p fully integrated production in Europe is competitive
- Key arguments
 - Strong growing European PV market will come
 - Cost saving >10 % due to reduced logistic costs
 - Production with less CO₂ emission
 - Technological Sovereignty to keep independency



For more see: <https://www.ise.fraunhofer.de/en/renewable-energy-data.html>



Market in Europe

Only one Direction: Up!

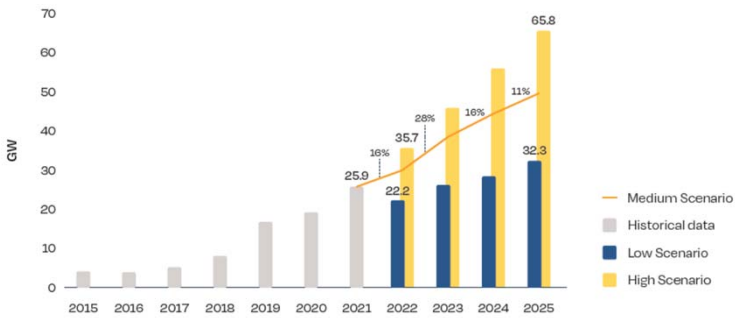
- Market stimulation through
- Low cost for PV

→ Integrated PV is possible
- Achieving Paris goals
- Green Deal efforts

→ Fit for 55
- Court decisions

Germany: constitutional court decided that German climate protection law needs adaptations

The Netherland: Shell is forced to do more climate protection



Costs for Logistics Becomes Notable!

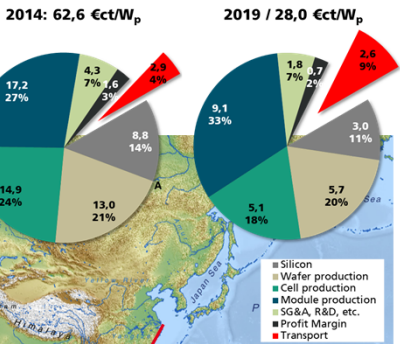
In 2022: More than 10% of Full Delivery Costs!

2-3 €ct/W transport cost & CO₂ emission
Production cost 2022: ~ 20 €ct/W



[https://de.wikipedia.org/wiki/Containerschiff#/media/Datei:NYK_Virgo_\(8154929586\).jpg](https://de.wikipedia.org/wiki/Containerschiff#/media/Datei:NYK_Virgo_(8154929586).jpg)

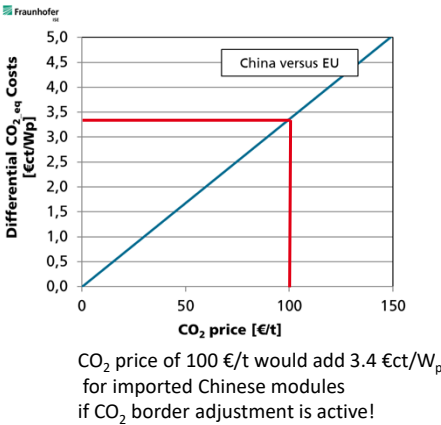
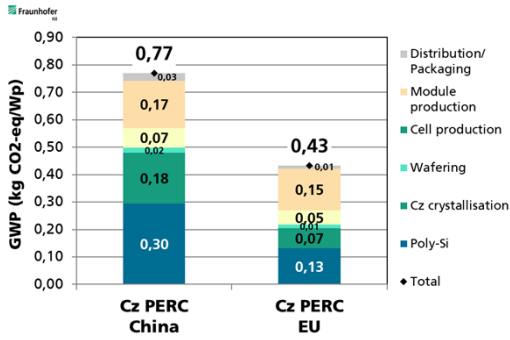
Share of transport in the past:



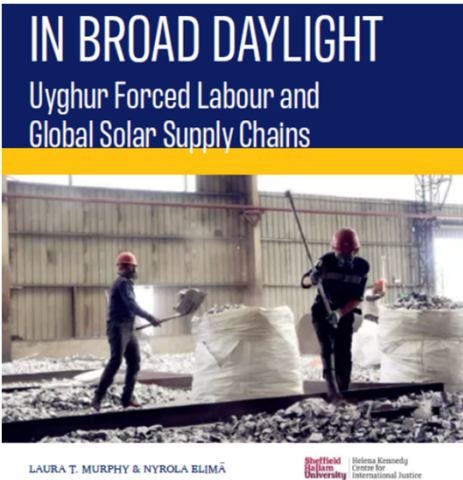
Effect of CO₂ Pricing on Competitiveness

Life-Cycle Analysis: CO₂ Emissions (Greenhouse Warming Potential GWP)

Ecological footprint*:



Sustainability for Material Supply, Production Includes Labour!



Due to Current Events: Secure Independency for Energy! Corona Virus and Ukrainian War Clearly Reveals Dependency



2. Photovoltaic panels and technologies

Solar photovoltaic (solar PV) technologies have become the world's fastest-growing energy technology and play an important role in securing sufficient amounts of decarbonised electricity to meet the goals of the European Green Deal.. ..

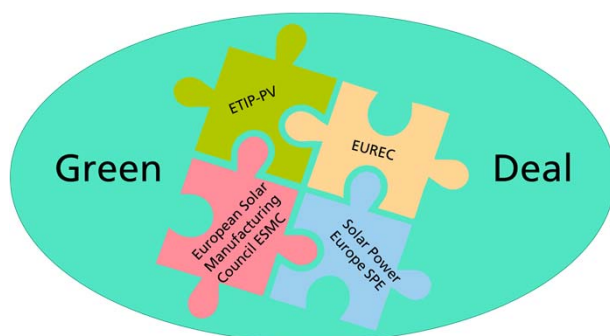
The EU's strategic dependencies in the manufacturing segment of the PV value chain are linked mainly to the absence of significant production capacities for ingots, modules and in particular solar cells based on silicon wafer.

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<https://ec.europa.eu/docsroom/documents/48878>, download March 27th

What Is Needed for PV-Production Renaissance in Europe?

1. **Awareness of society and politics that PV production helps to secure energy security**
 - provide suitable frame conditions, i.e. access for financing, fair industrial playing field
 - align PV stakeholders along the value chain
2. **Investments from financial world to support upcoming industrial players**
 - demonstrate competitiveness of European production



- Initiative to make use of Recovery and Resilience and Just Transitions Funds for PV
- Generate an Important Project of Common European Interest - **IPCEI** - for PV

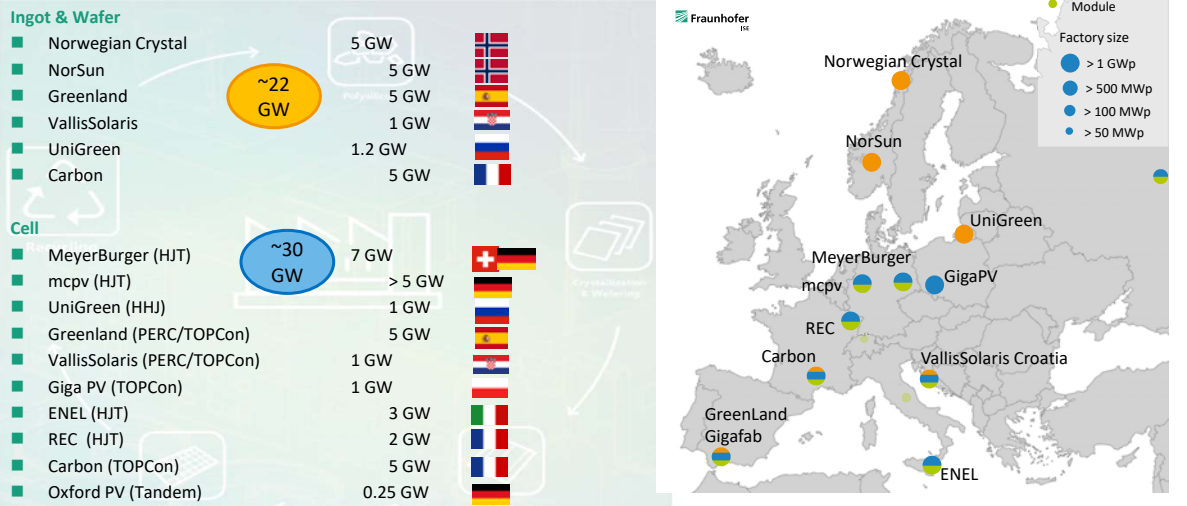
- Manufacturing accelerator

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New Initiatives in Europe: Ingot & Wafer & Cell Manufacturing

Newly Announced Entrants and Capacity Expansions Until 2025



Summary

- Photovoltaic is the key pillar for the coming energy supply
 - Society and politics do understand this fact more and more
- Photovoltaic R&D in Europe is still leading edge
- Photovoltaic production in Europe is believed to come back – a time of Renaissance!
It has to be along the whole value chain – including supply chain!
 - Excellent market perspectives
 - Green and sustainable manufacturing in Europe will be advantageous
 - Keeping the PV Technological Sovereignty as base for Energy Security is today more understood

Thank You for Your Attention

Thanks to all colleagues form Fraunhofer ISE which contribute to this presentation

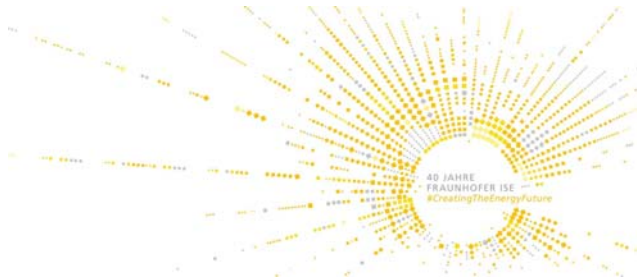


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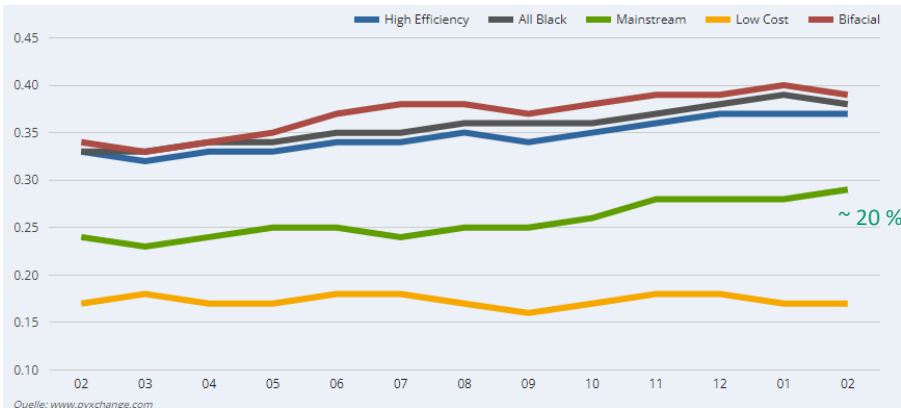


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Actual Trend: Rising Prices for PV Modules in Europe
Secure Independency for Energy!



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<https://www.pvexchange.com/Preisindex> , download, March 20th, 2022

