Photovoltaic and Optoelectronic devices group

UNIVERSITY OF OXFORD

Department of Physics

Solar PV

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OXFORD PV™ The Perovskite Company

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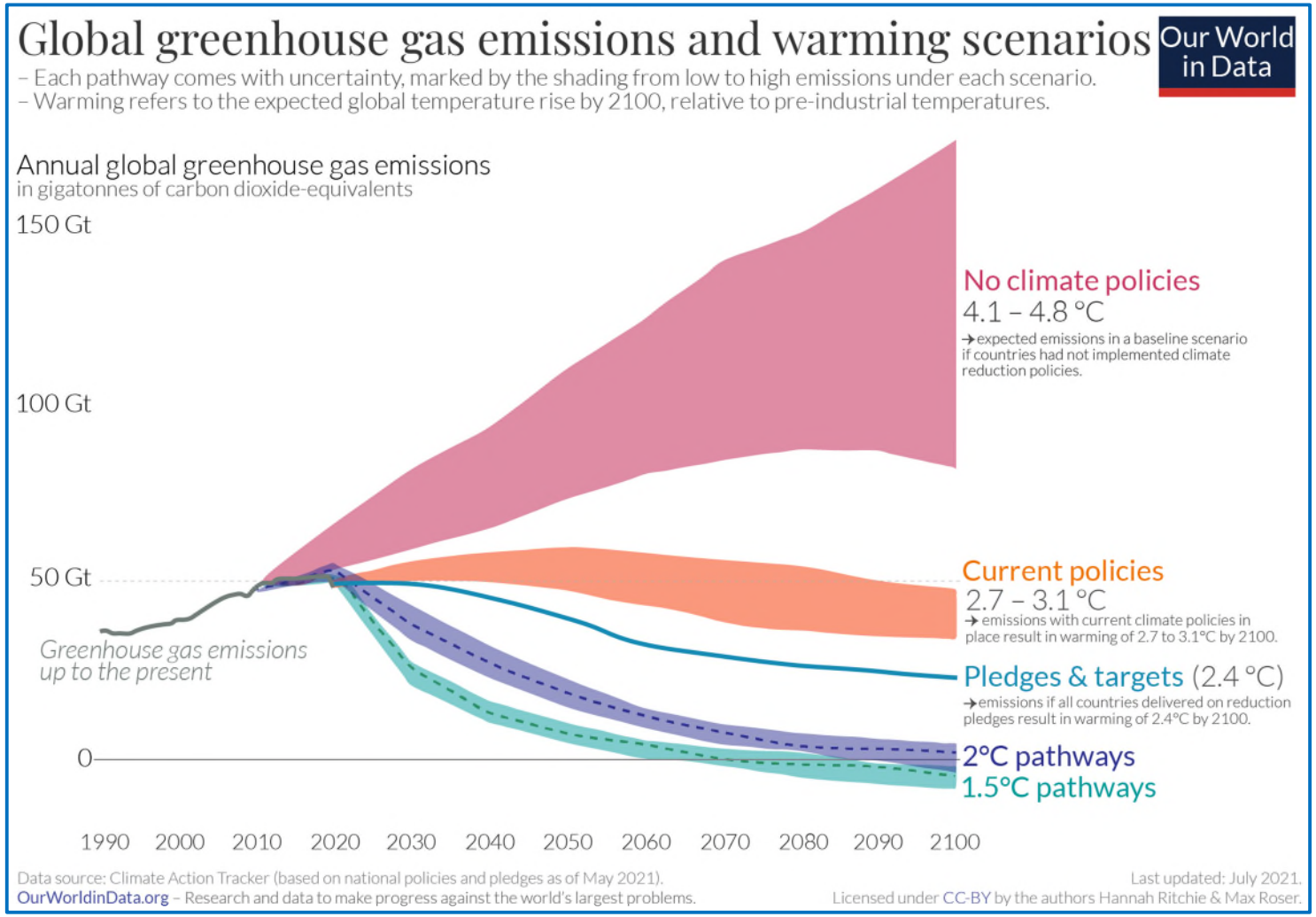
Emission Trajectory

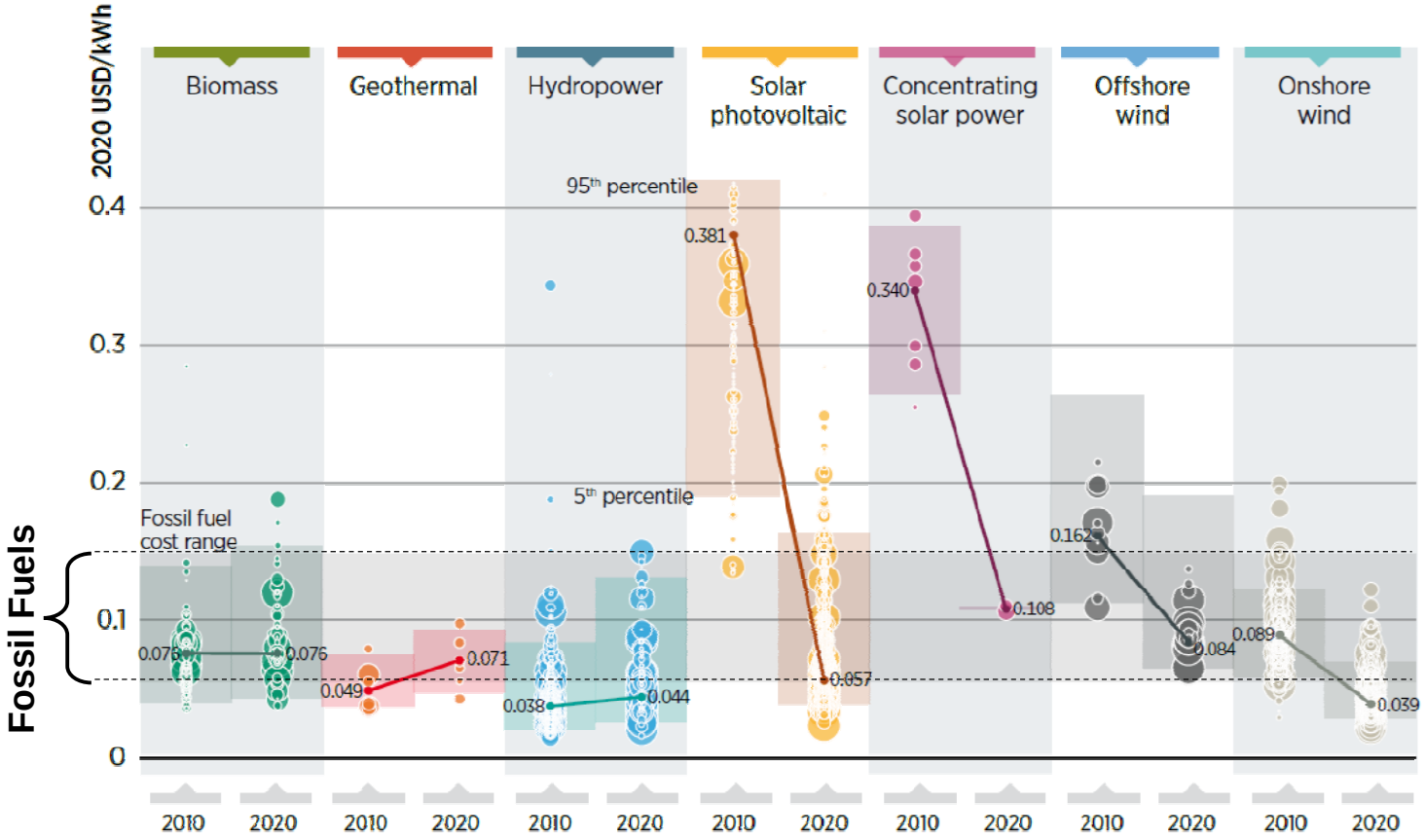


Current policies aren't enough to reach the goal

https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Renewable Energy Cost-Competitiveness

Levelised Cost of Electricity (LCOE)



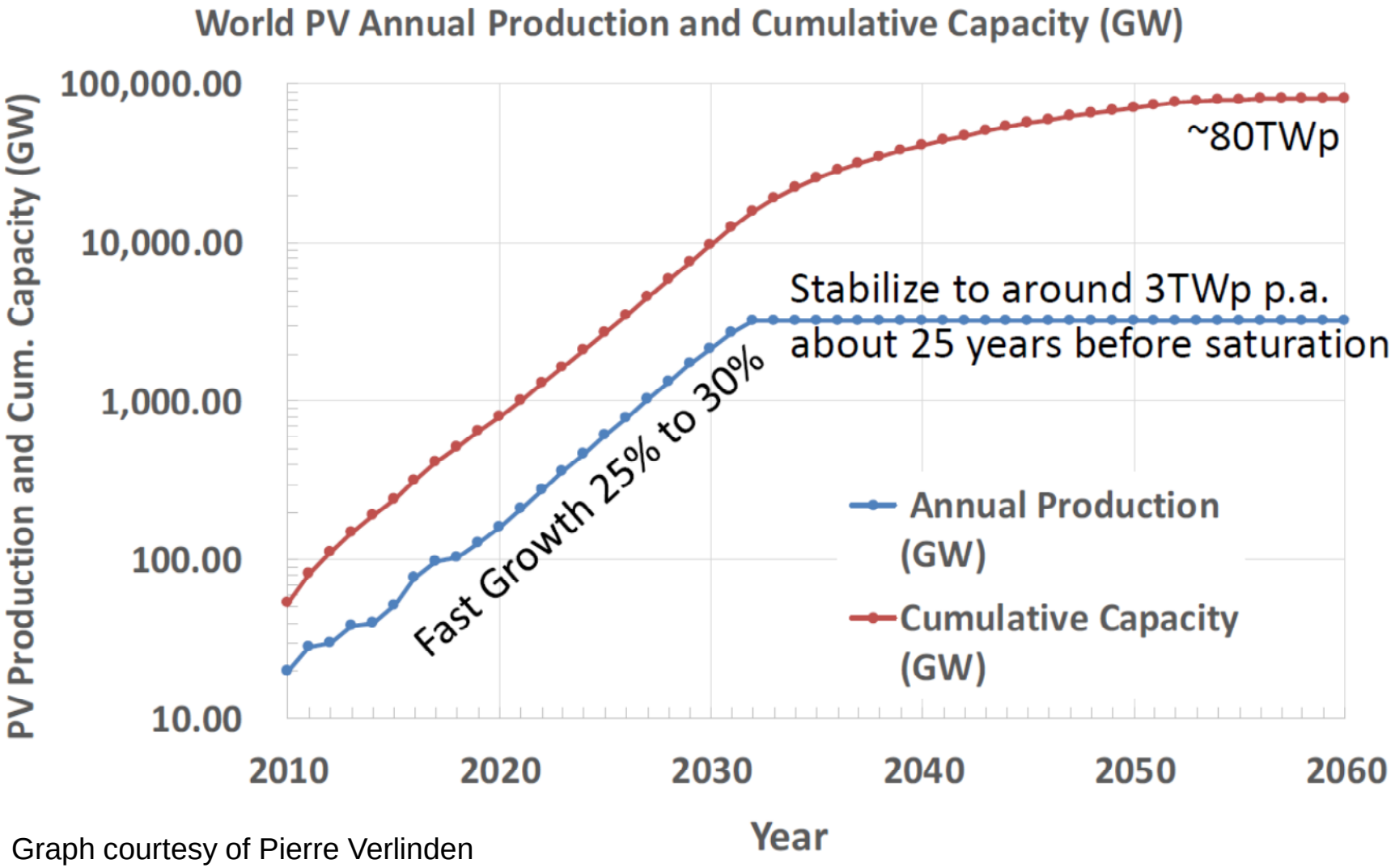
Source: (IRENA, 2021b)

- **Hydropower** and **Onshore Wind** are the cheapest energy sources
- **The cost of Solar PV has dropped by 85% in 10 years**
- Price of PV electricity is dropping faster than any other technology!

Whereas compared to 10 years ago (Source: World in Data):

- **Nuclear** is now 26% more expensive
- **Coal** is only 2% less expensive
- **Natural Gas** (combined cycle) is 32% less expensive

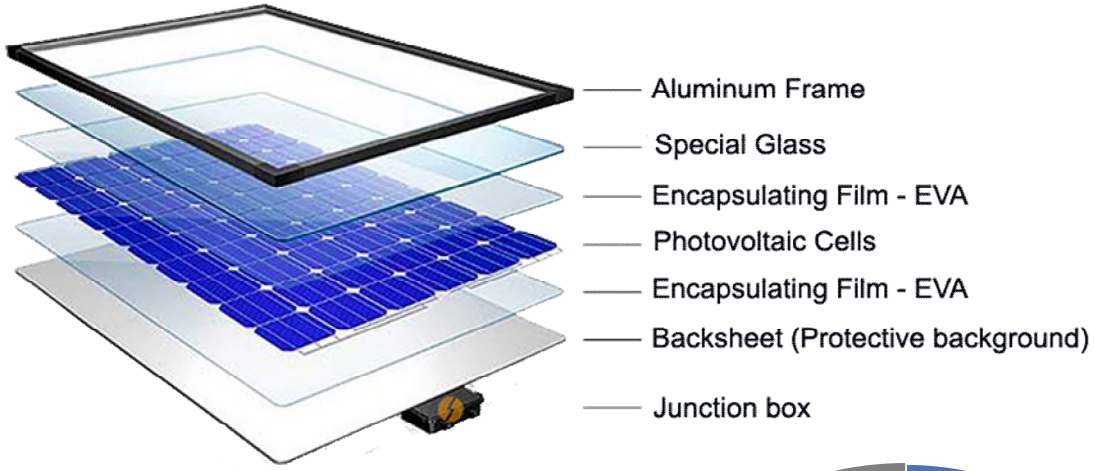
Can PV realistically supply most of our power?

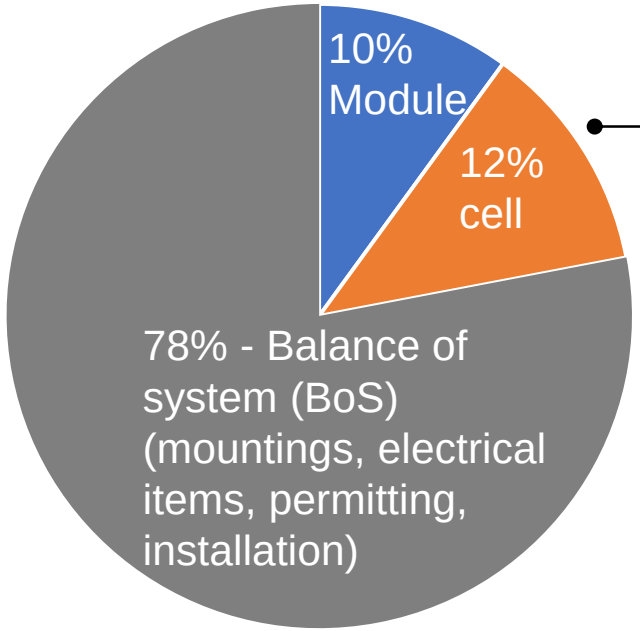


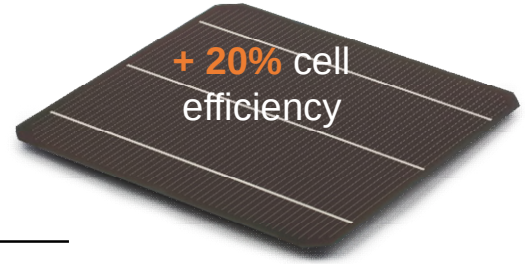
Graph courtesy of Pierre Verlinden

The industry needs to grow to ~ 30 times production capacity by the early 2030's :-
That's not impossible

Make it cheaper or make it better?







=

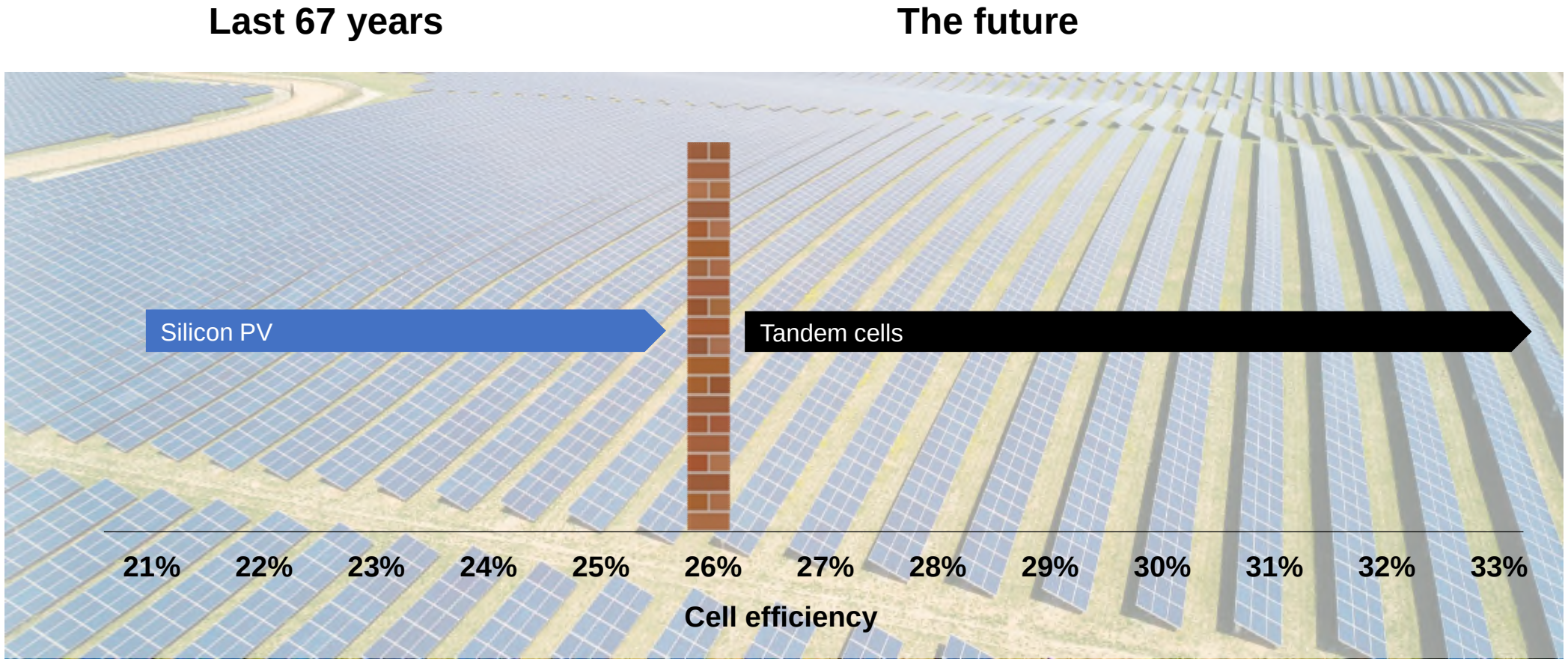
15%

lower cost per unit of electricity produced ($/kWh)

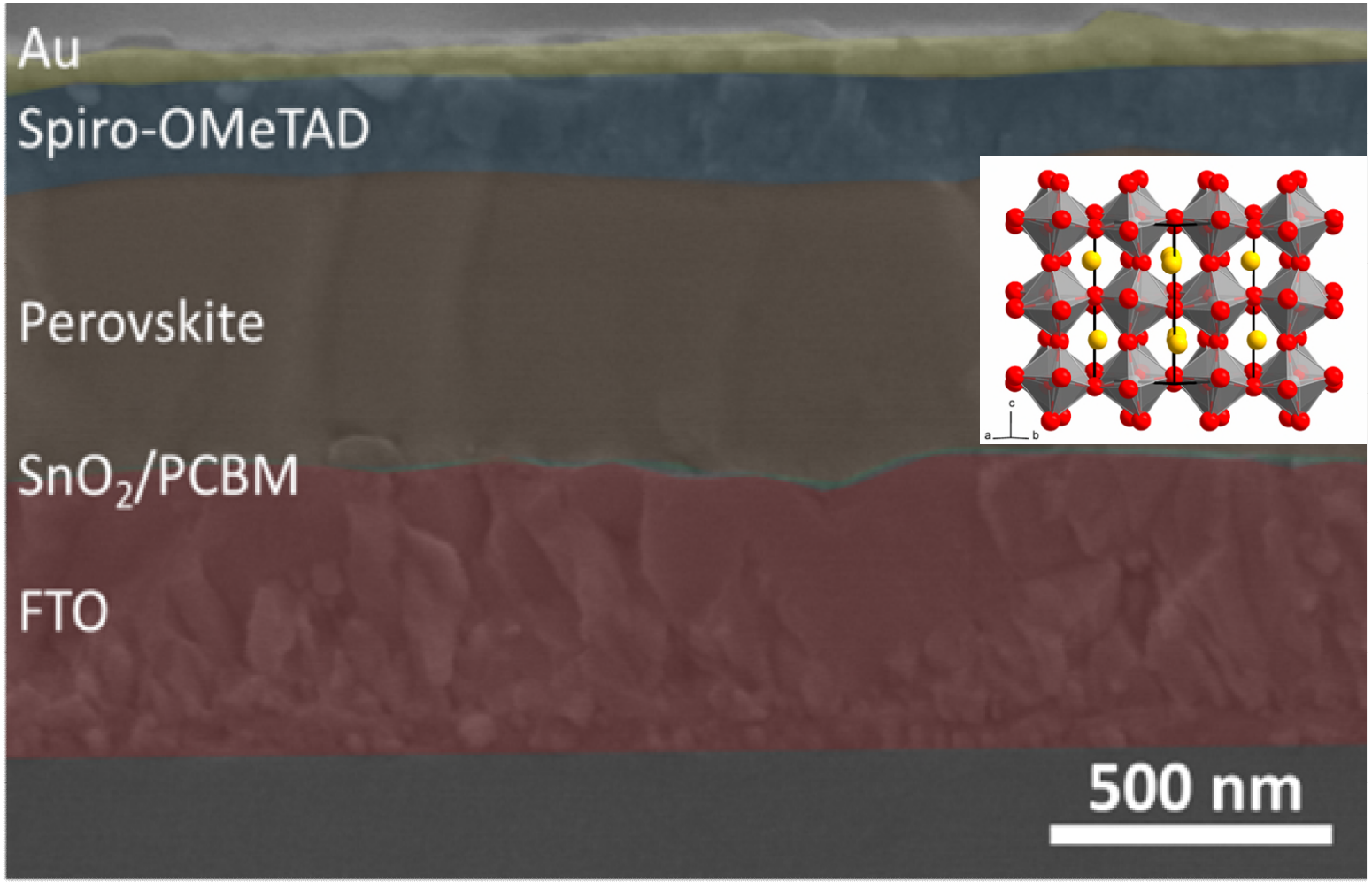
Source: Apricum, 2019

Is there a limit to efficiency improvements?

- Only multi junction solar cells can break the solar efficiency barrier



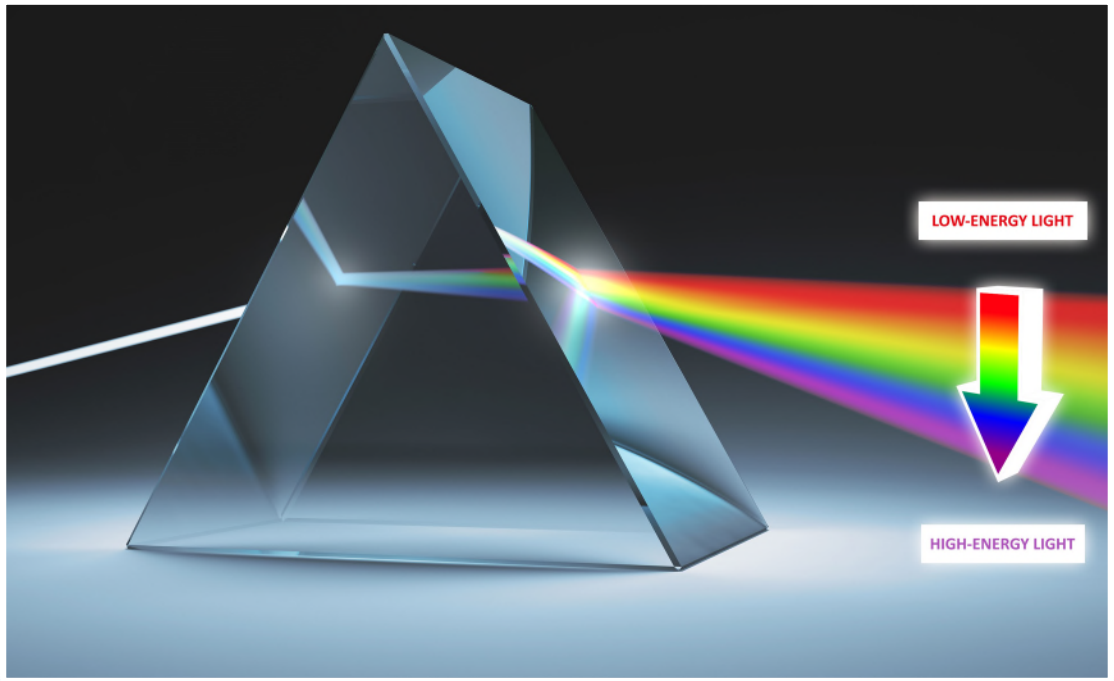
Perovskite PV cells

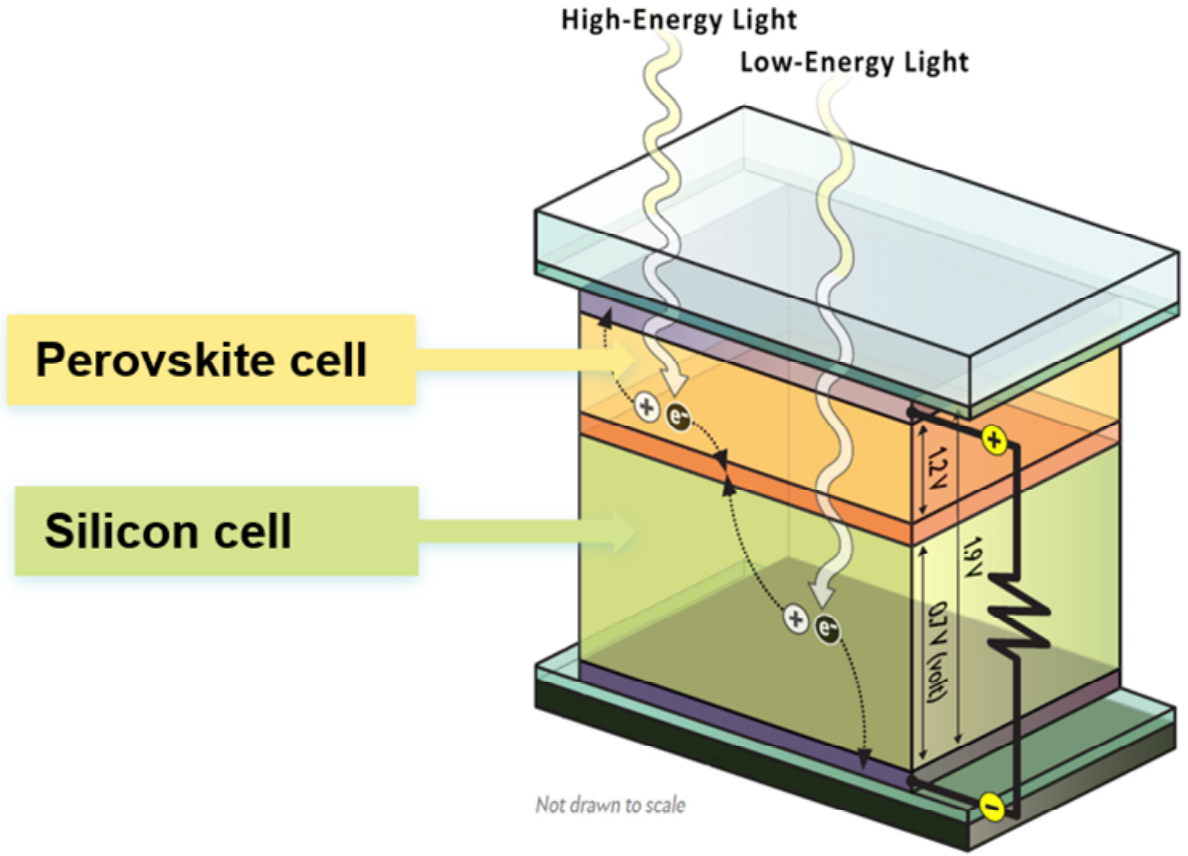


Surprise discovery:

- Very high performance
- Simply processed semiconductor material
- Low embodied energy
- High abundancy
- Easily tuneable optical properties.

Converting more energy from sun light



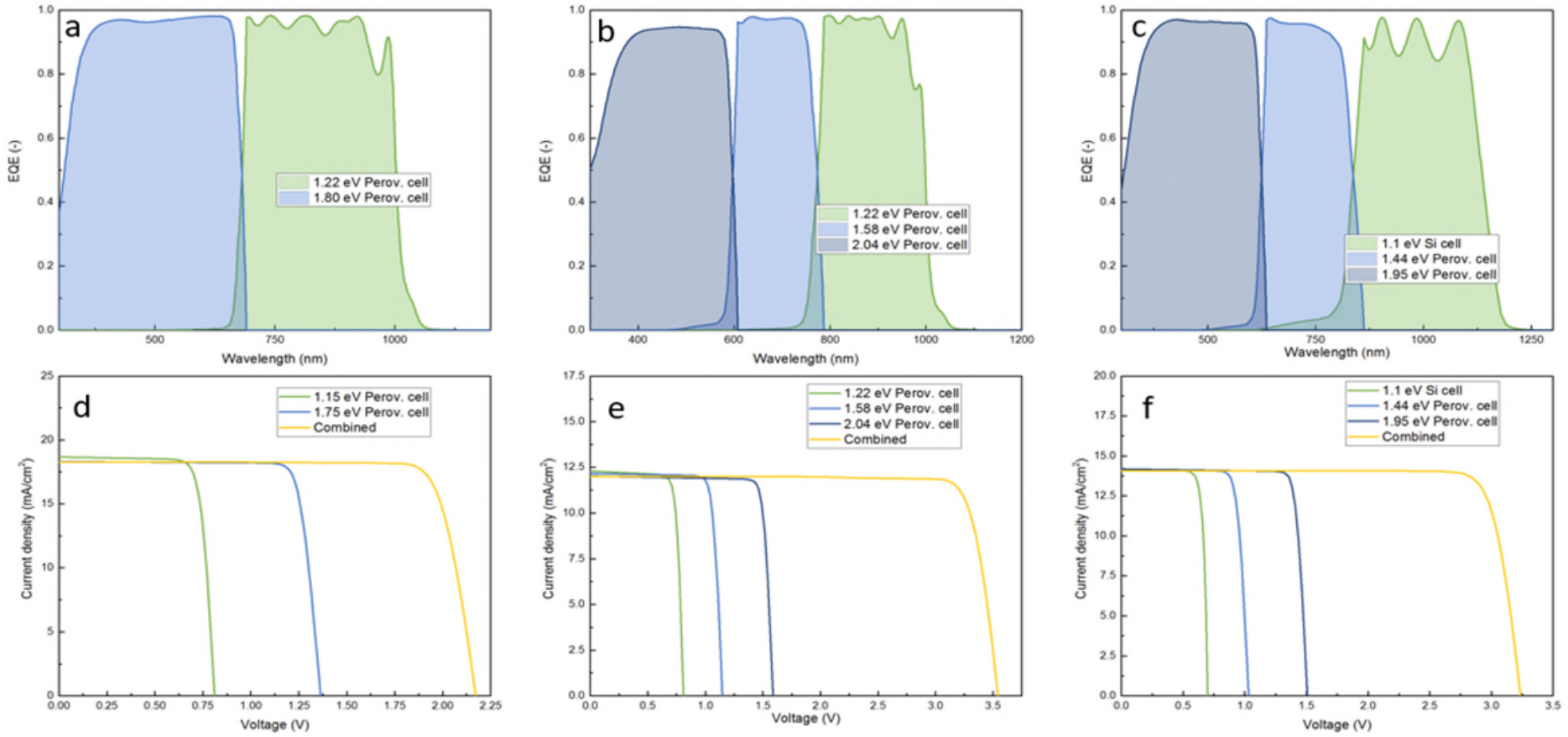


Theorized efficiency targets for perovskite multi-junctions

PCE ~ 33.8%

PCE ~ 36.6%

PCE ~ 38.8%



Hörantner et al. ACS Energy Letters 2017

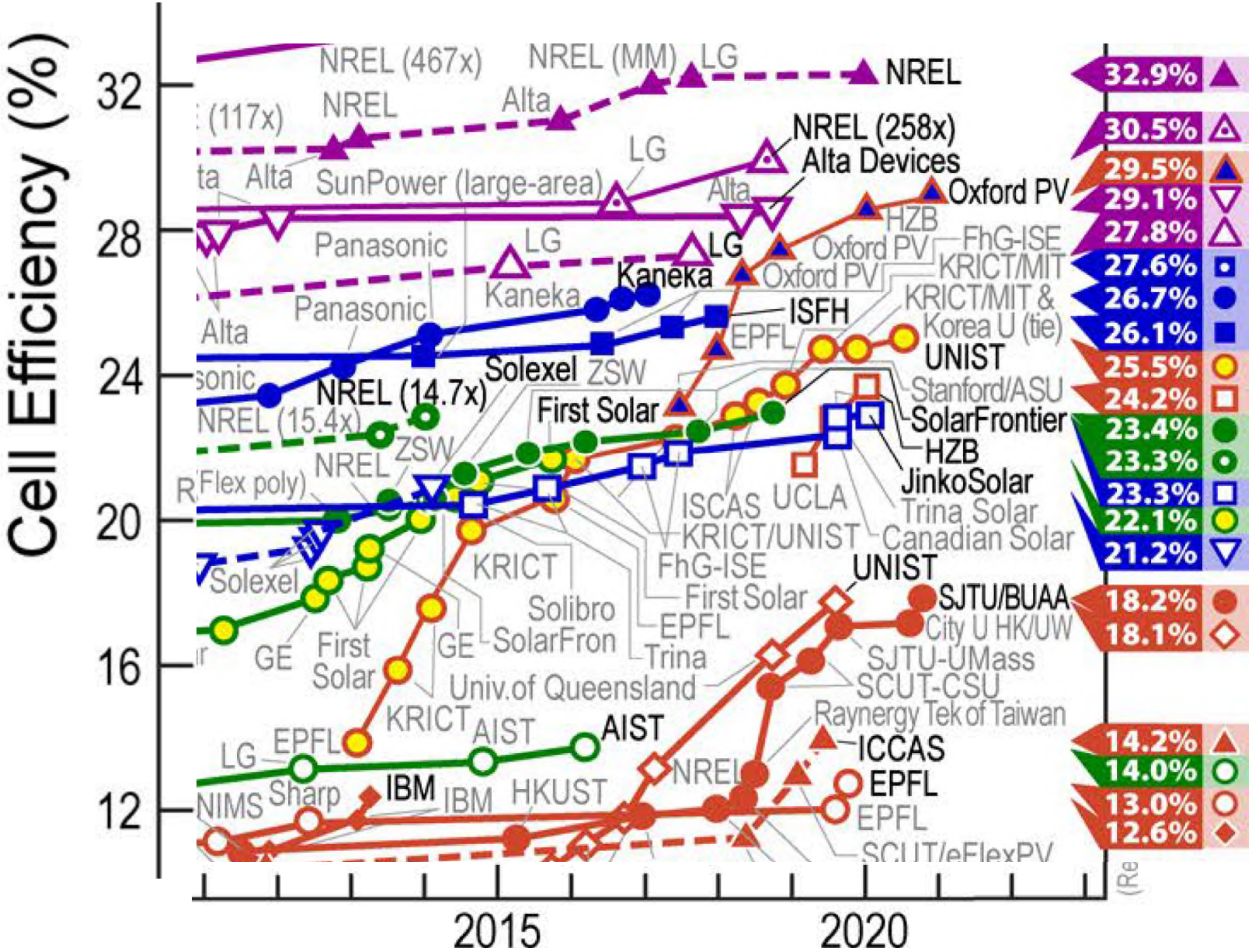
Best Cell Efficiencies

Emerging PV
- Dye-sensitized cells
- Perovskite cells
- Perovskite/Si tandem (monolithic)

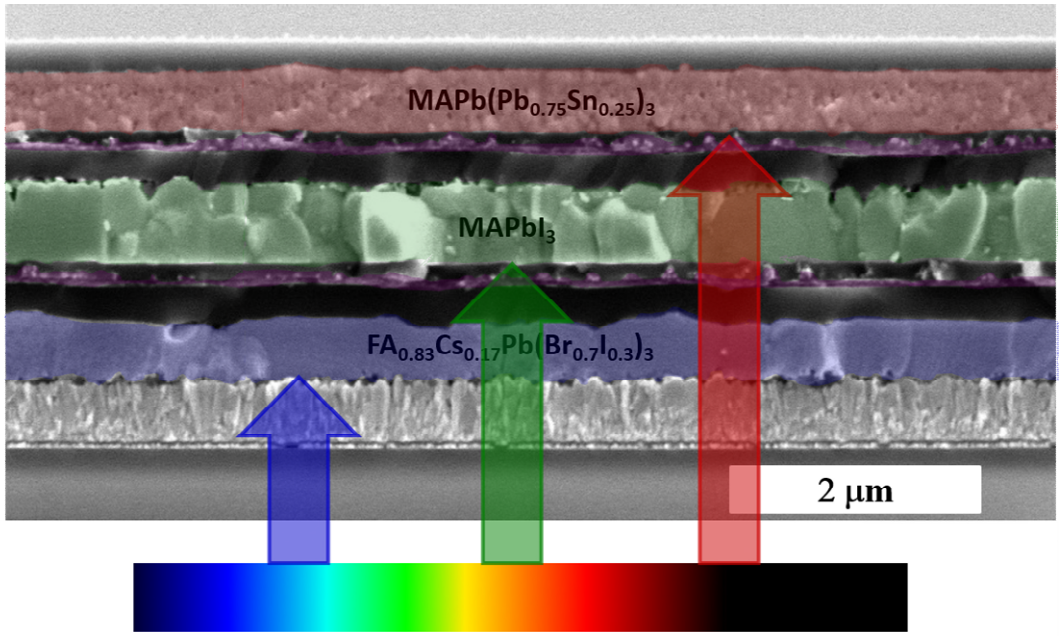
Single-Junction GaAs
- Single crystal
- Concentrator
- Thin-film crvstal

Multijunction Cells (2-terminal, monc
- Two-junction (non-concentrator)

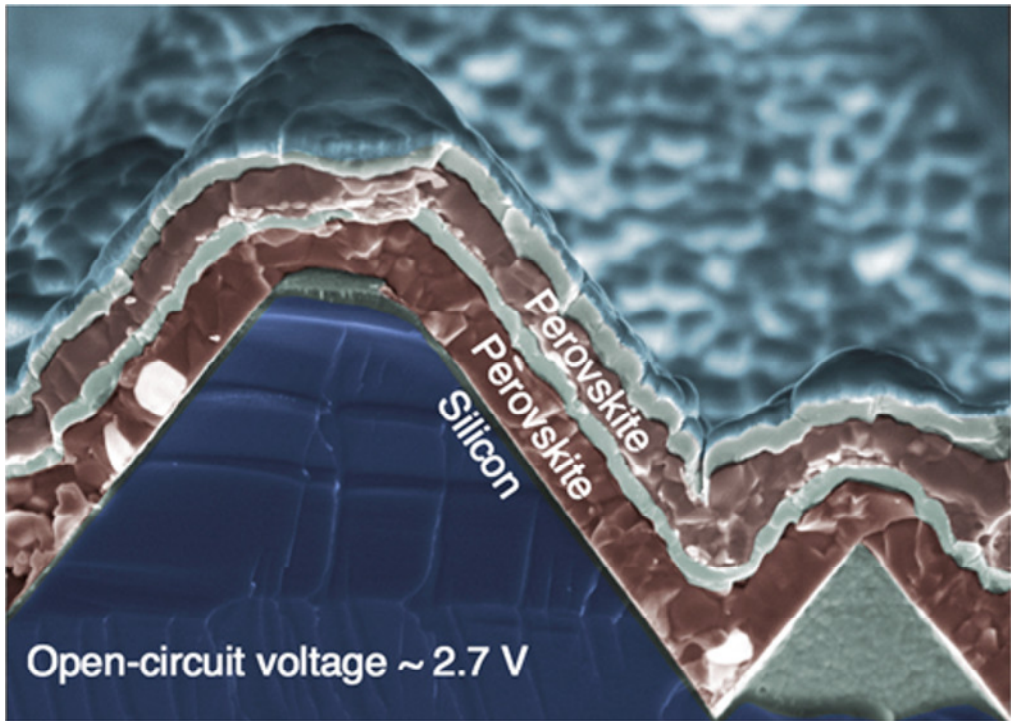
Crystalline Si Cells
- Single crystal (concentrator)
- Single crystal (non-concentrator)



Realised triple-junction cells



D. McMeekin et al. 2019 Joule



J. Werner et al. 2018 ACS Energy Letters

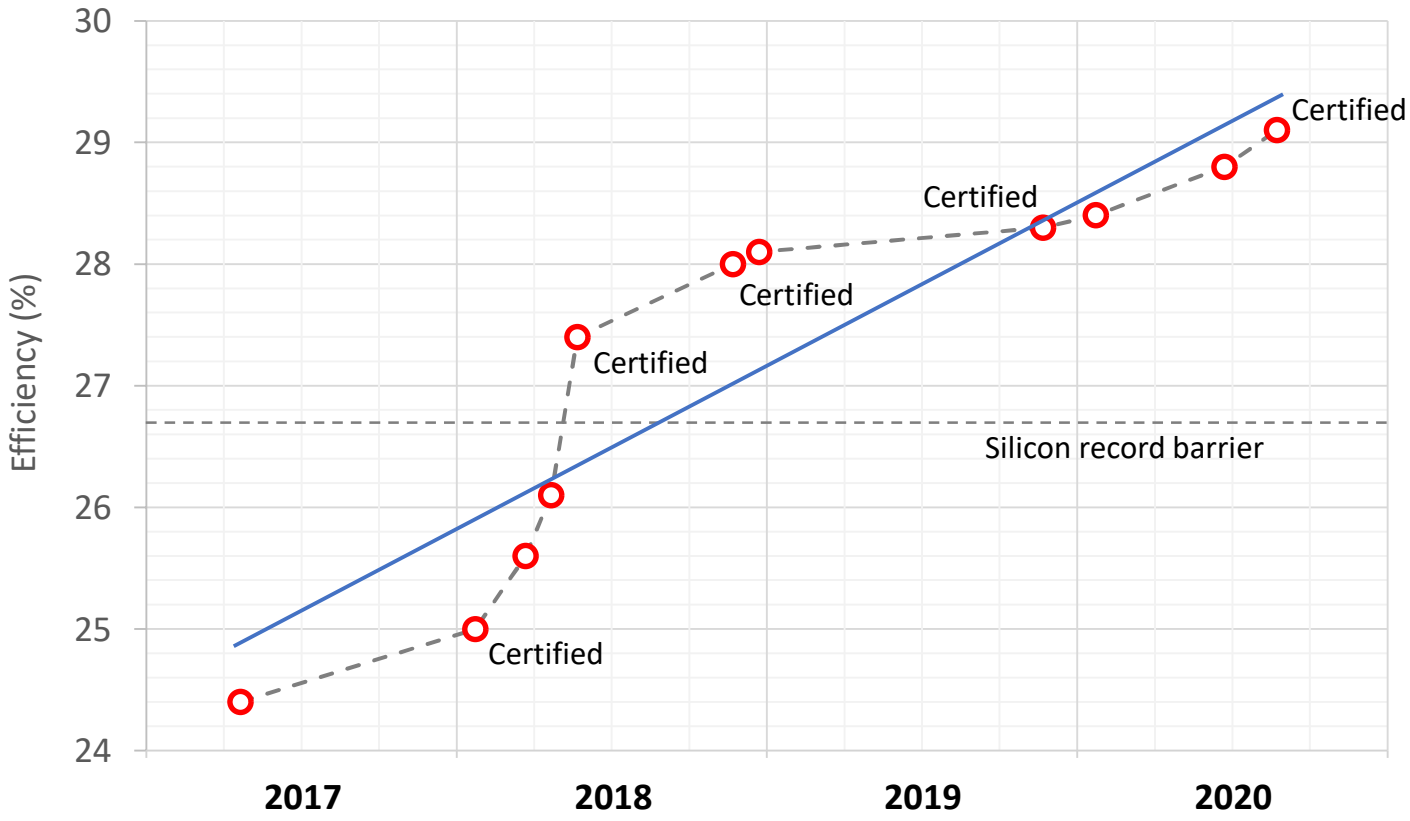
Industrial Activity

OXFORD PV™
The Perovskite Company

Oxford, UK
R&D: Develop process of record (POR), assess and enhance device reliability, drive efficiency roadmap and develop next generation technology

Brandenburg, Germany
17,000m2 pilot line: Process transfer from R&D, establish production readiness, module technology readiness and testing

Efforts on improving efficiency and stability



1 $mAcm^{-2}$

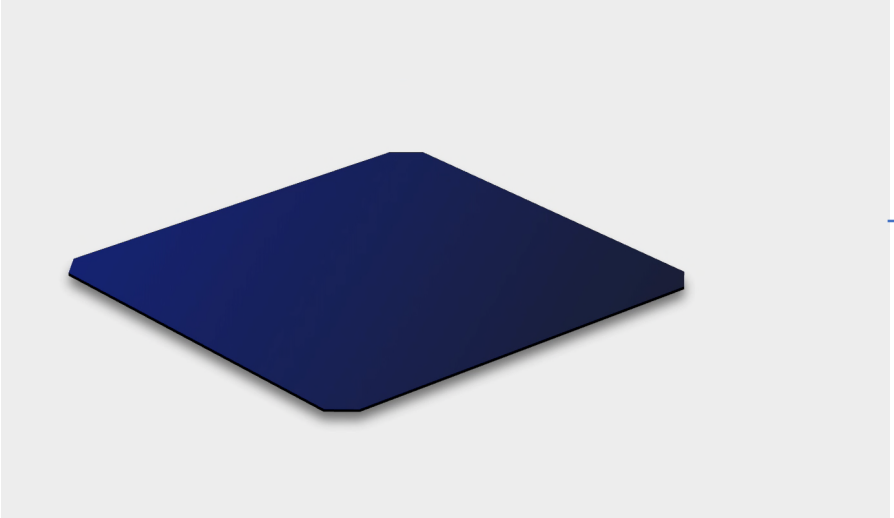
29.5% + 100 mV_{OC} = **33%**

5% FF

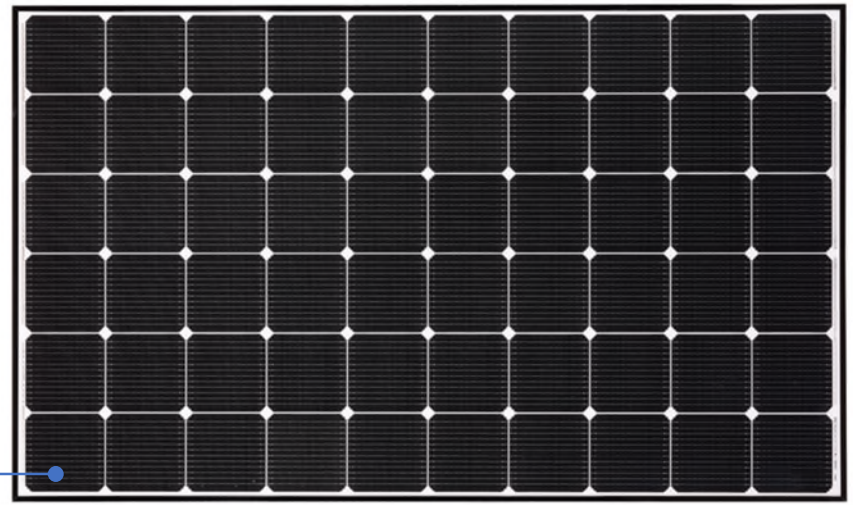
Scaling up to Industrial modules

- **‘Plug and play’ technology**

Oxford PV’s perovskite-silicon solar cell

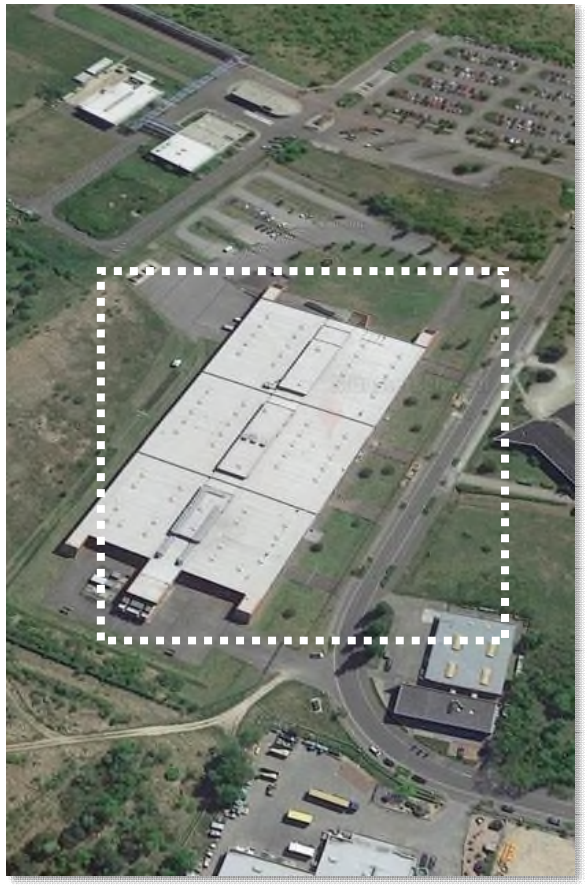


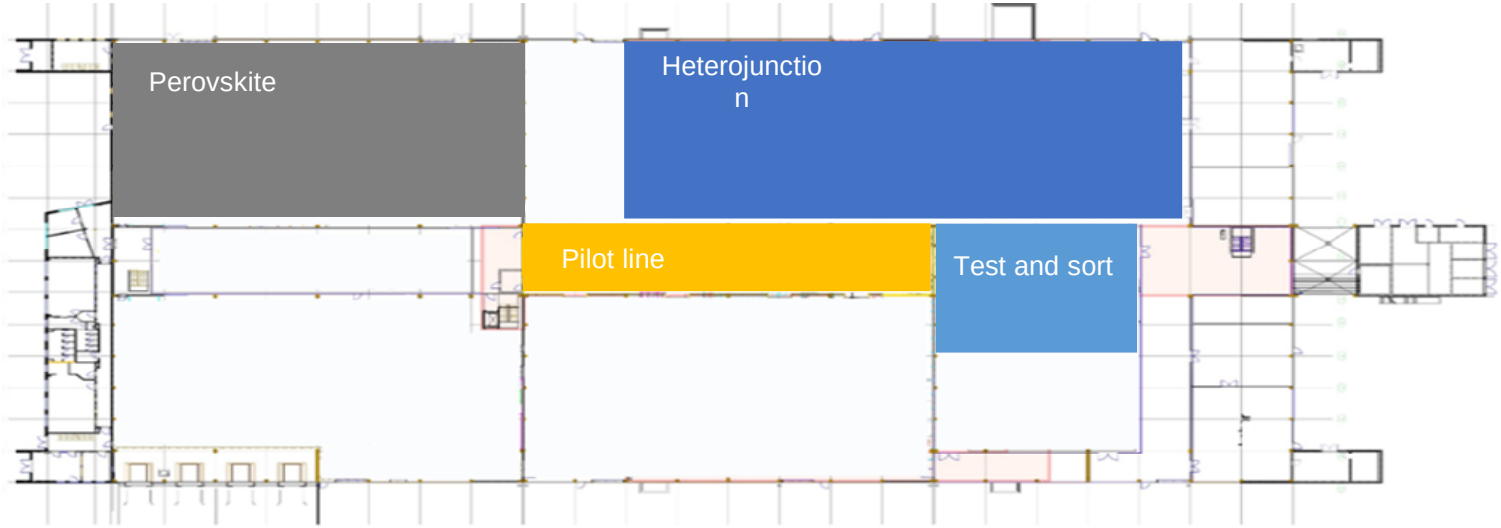
Industry standard PV module



Building the factory

Established commercial production facility with room for expansion





Target Product Specification

PEROVSKITE-Si®
Cell – M6

Oxford PV CELL

Features

27% Efficiency
Most efficient on the market

Multi-busbar
Busbar-free option

Reliable
LID and PID free

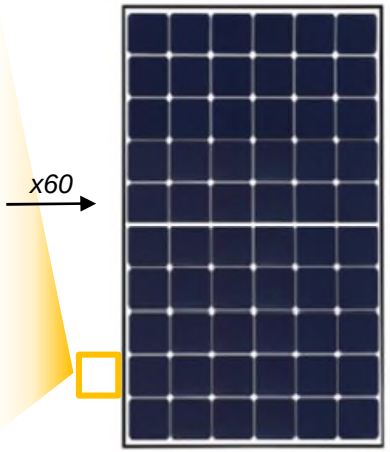
Certified Cell
Calibrated by Fraunhofer

European
Made in Germany

The Perovskite-Si® is the first of its kind solar cell featuring Oxford PV's proprietary perovskite-Si tandem technology, making it the most efficient in the market.

Full size 60 Cell
Module

434 Module Product target



The Perovskite-Si® is the first of its kind heterojunction solar module featuring Oxford PV's proprietary perovskite tandem solar cell technology, significantly improving the power output, making it one of the most powerful modules in the market.

Features

60 cells
M6, perovskite silicon tandem solar cells

434 Watts
Power output range

23.7% module efficiency
Most efficient on the market

25 year
Performance warranty

Companies active in perovskite

Company	Target technology	URL	Country of origin/activity
OXFORD PV™ The Perovskite Company	Perovskite-on-silicon tandem	www.oxfordpv.com	UK, Germany
SwiftSolar	Thin-film lightweight all-perovskite tandems	www.swiftsolar.com	USA
CUBIC PV	Perovskite on kerfless Si	https://cubicpv.com/	USA
SAULE TECHNOLOGIES	Flexible, lightweight perovskite	www.sauletech.com	Poland
GCL	Rigid monolithic, silicon tandem	www.en.gcl-power.com	China
MICROQUANTA SEMICONDUCTOR	Rigid monolithic	www.microquanta.com	China
Tandem PV	4T or mechanically stacked tandem	www.tandempv.com	USA

Companies active in perovskite

Company	Target technology	URL	Country of origin/activity
TOSHIBA Leading Innovation	Thin-film modules	https://www.toshiba.co.jp/	Japan
SOLAR-TECTIC	Perovskite silicon tandem	http://www.solartecticllc.com	USA
SHARP	Thin film modules, Tandem?	https://global.sharp/	Japan
MITSUBISHI CHEMICAL	Flexible modules	https://www.m-chemical.co.jp/en/	Japan

Thanks to……

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Collaborators:
Over 250 collaborators and co-authors, including:
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Paolo Radaelli
Moritz Reide
Peter Nellihst

IIT Millan: A. Petrozza et al.

HZB Berlin: PV ComB team

Cambridge: RH Friend et al.

UNISt (Korea): Bo Ram Lee et al.

Linköping: Feng Gao & Sai Bai

USA:
S. Marder et al.
D. Ginger et al.
M. McGehee et al.
A-KY Jen et al.
J. Berry et al.

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