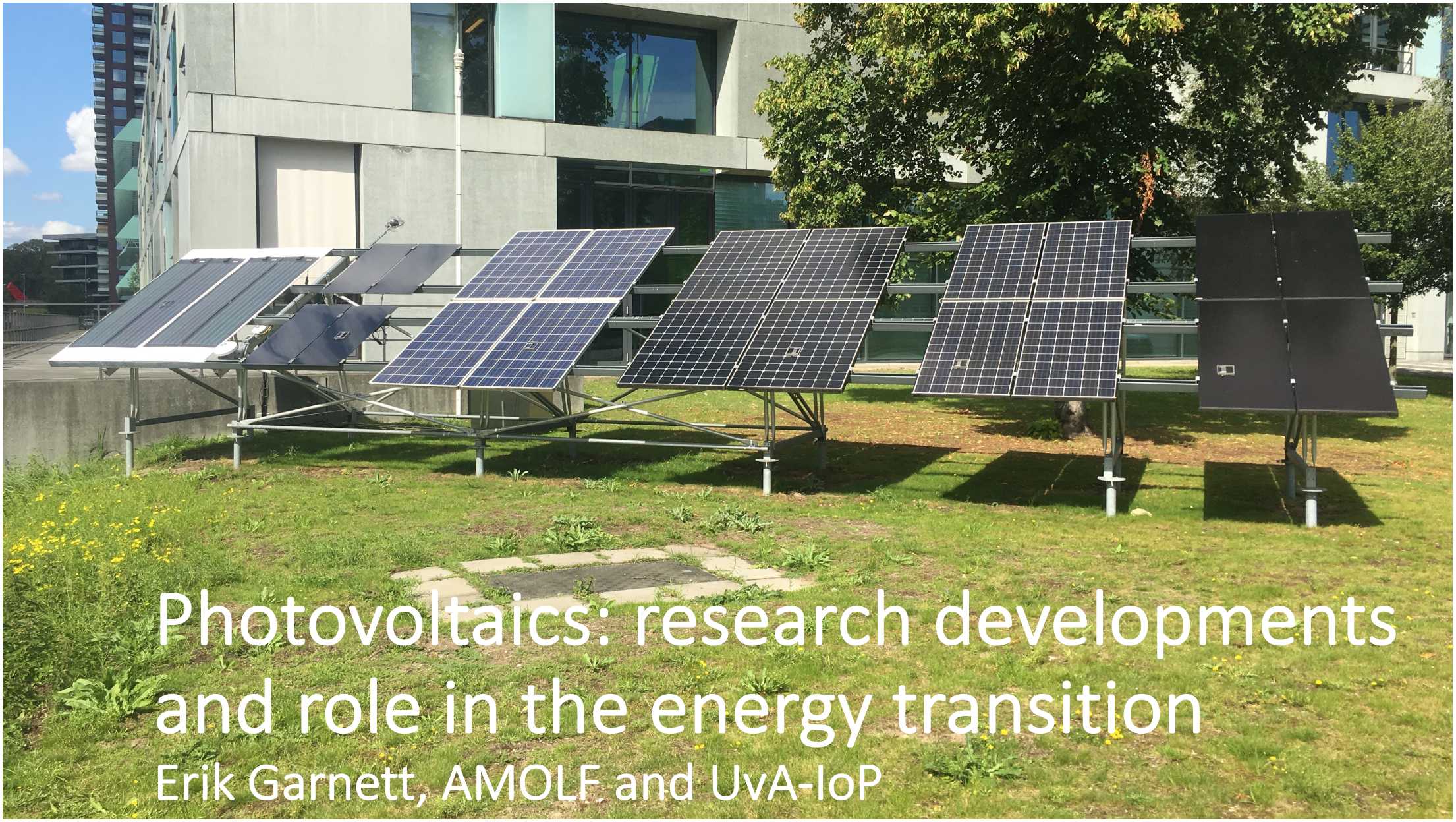
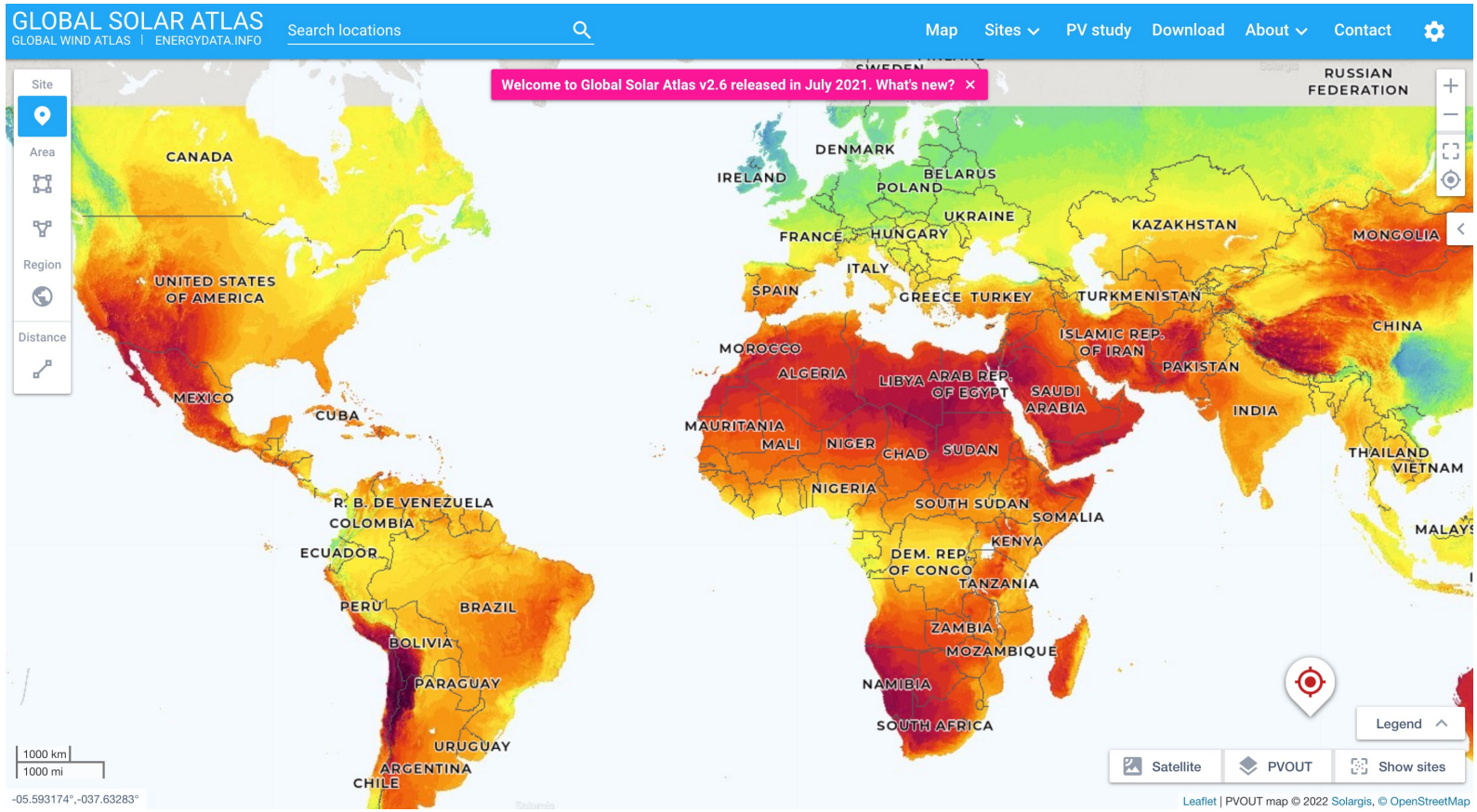


Photovoltaics: research developments and role in the energy transition

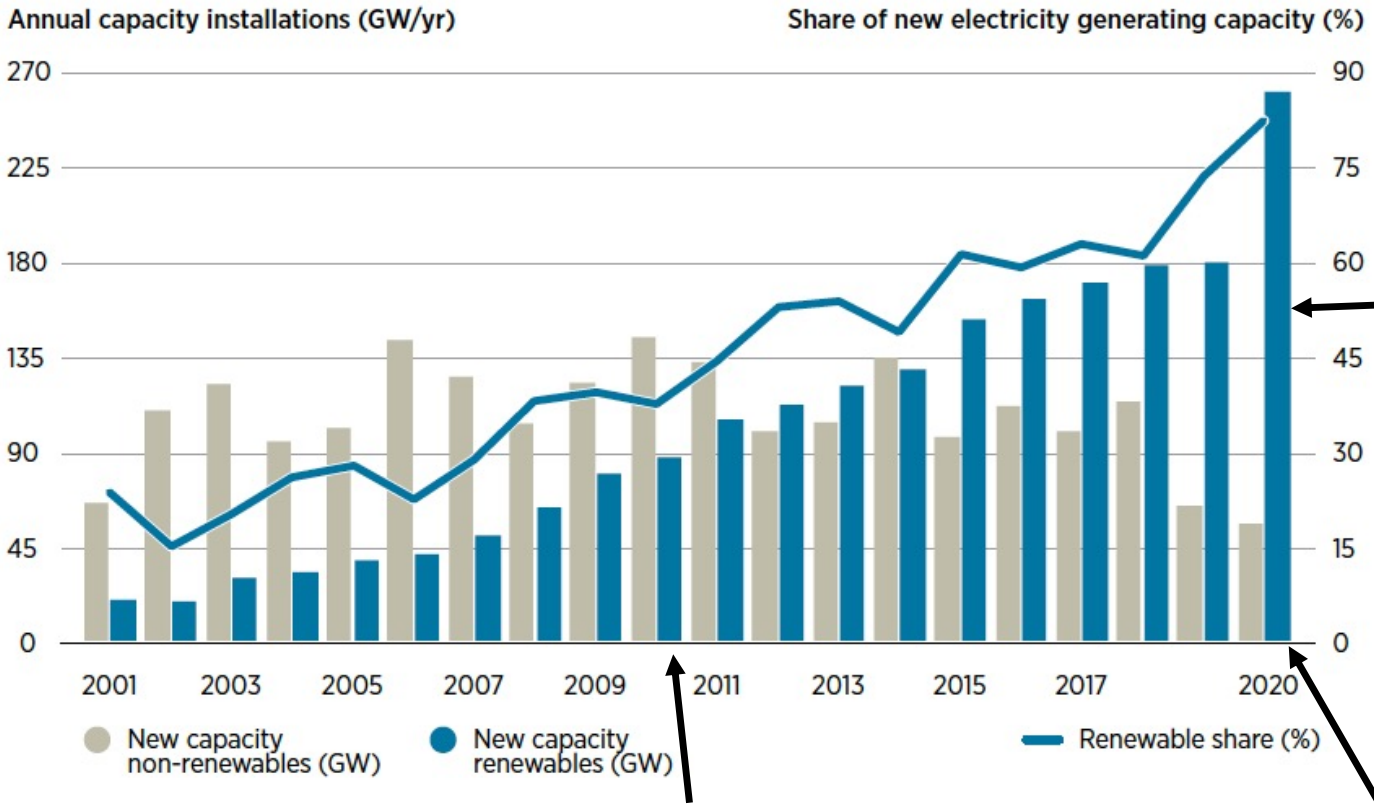
Erik Garnett, AMOLF and UvA-IoP

Solar resource only varies by 2.5X over whole world



<u>Solar resource (kWh/kWp)</u>
Glasgow/Belfast: 850
Ams/London/Oslo: 1000
Barcelona/Rome: 1500
Marakesh/Mex City: 1800
Sahara: 2000

PV already dominates new electricity capacity today!



Based on IRENA's renewable energy statistics.

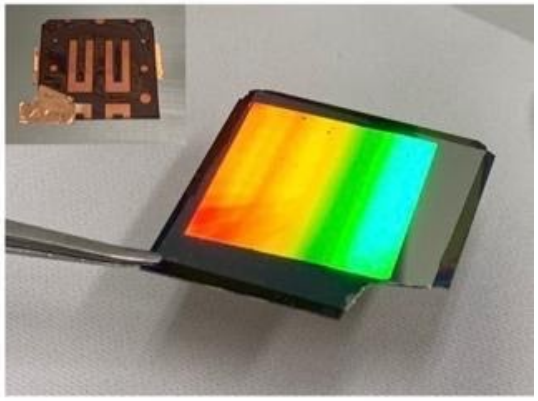
>50% from PV, nearly all remainder from wind

Global average PV cost
38 cents/kWh

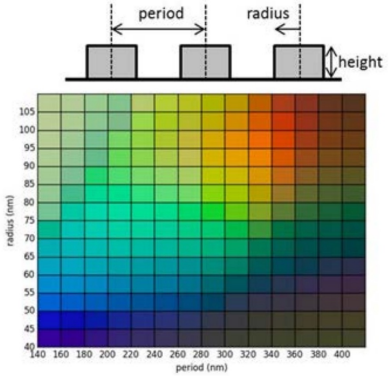
Global average PV cost
5.7 cents/kWh

Challenges still remain for high PV penetration

Intermittence – storage requires highly efficient/adaptive PV



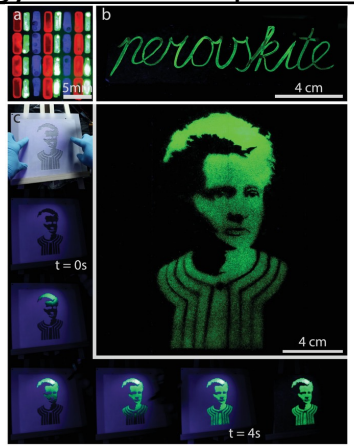
Integration – need flexible, colorful, lightweight PV





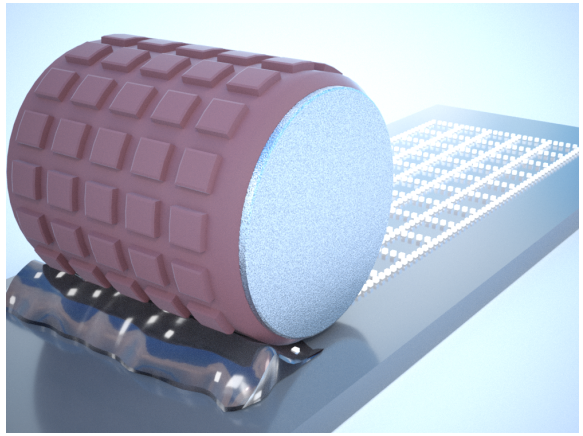
Verena Neder, PhD thesis, 2021

Embedded Energy - lower temperature manufacturing

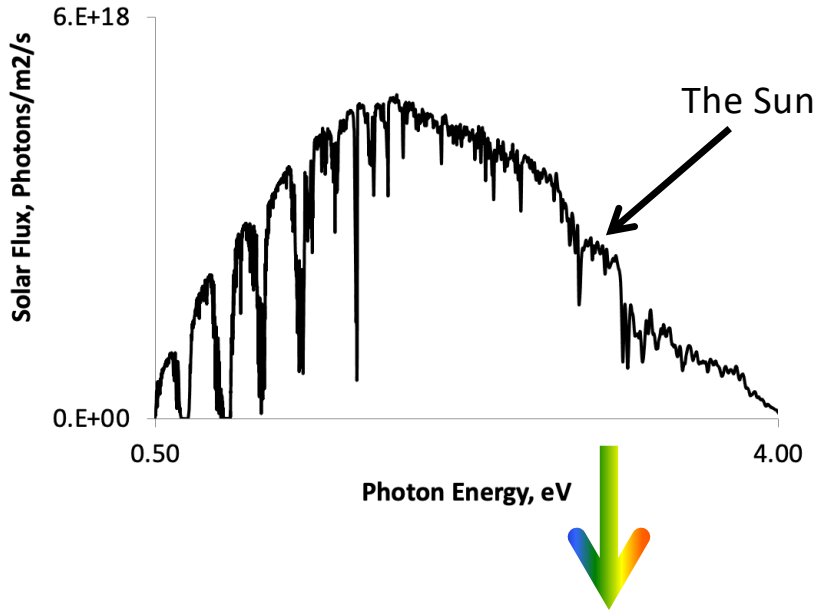


Helmbrecht et al., "Ion exchange lithography: Localized ion exchange reactions for spatial patterning of perovskite semiconductors and insulators", *Advanced Materials*, 2021

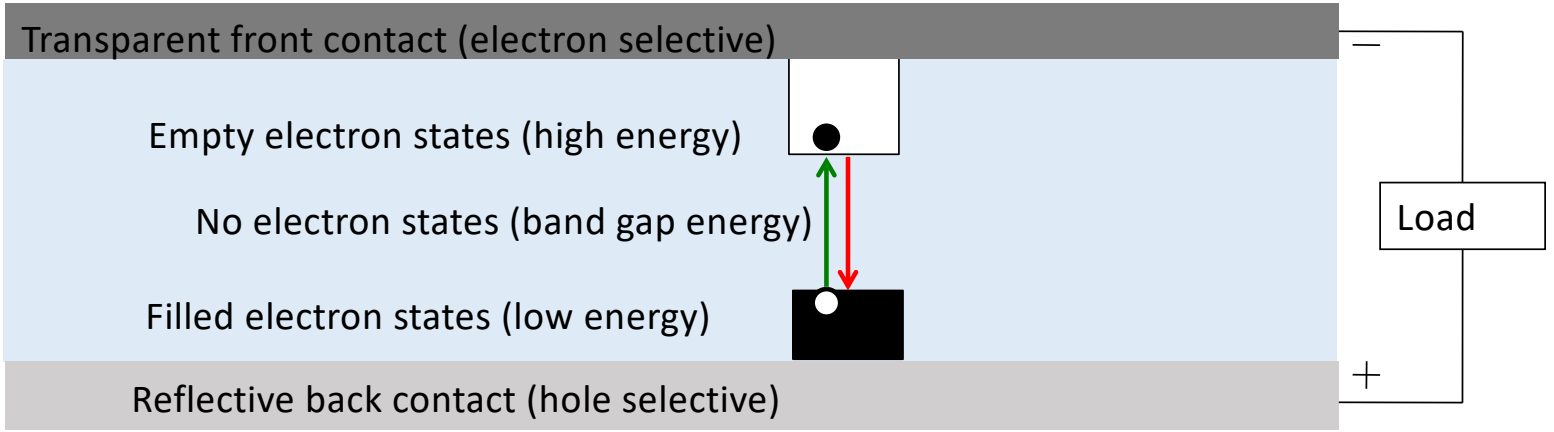
Rapid scaling (and resources) – roll to roll manufacturing



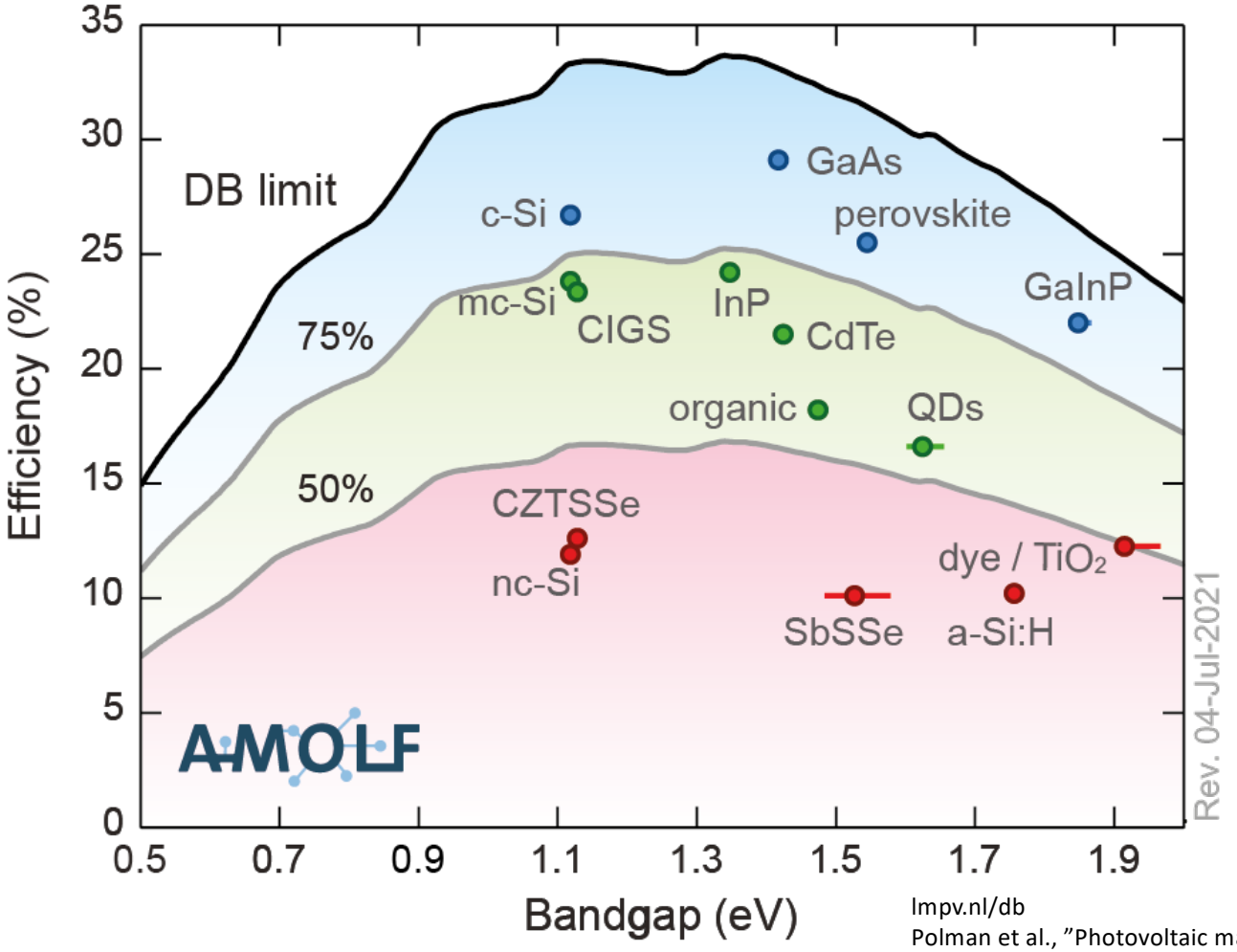
Photovoltaic Basics

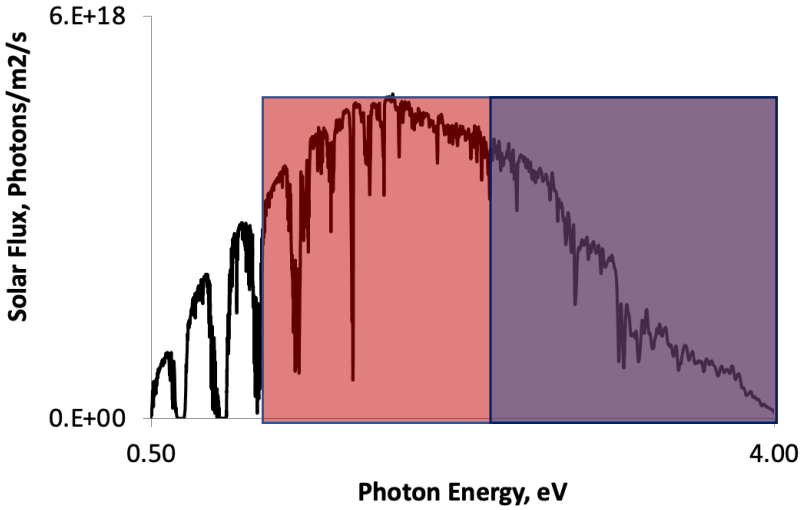


1. Absorption
2. Recombination
3. Carrier collection



Efficiency = #absorbed photons*energy/photon



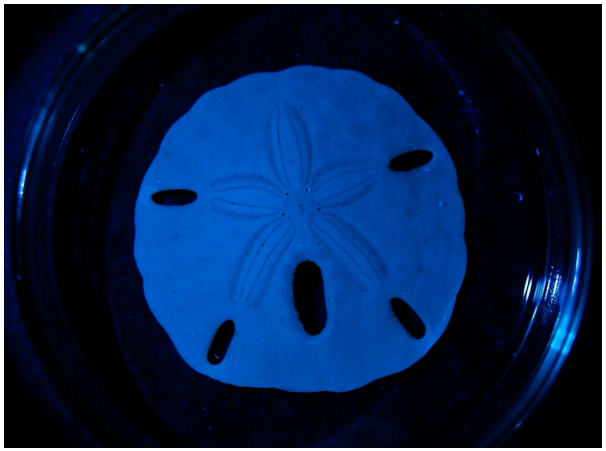


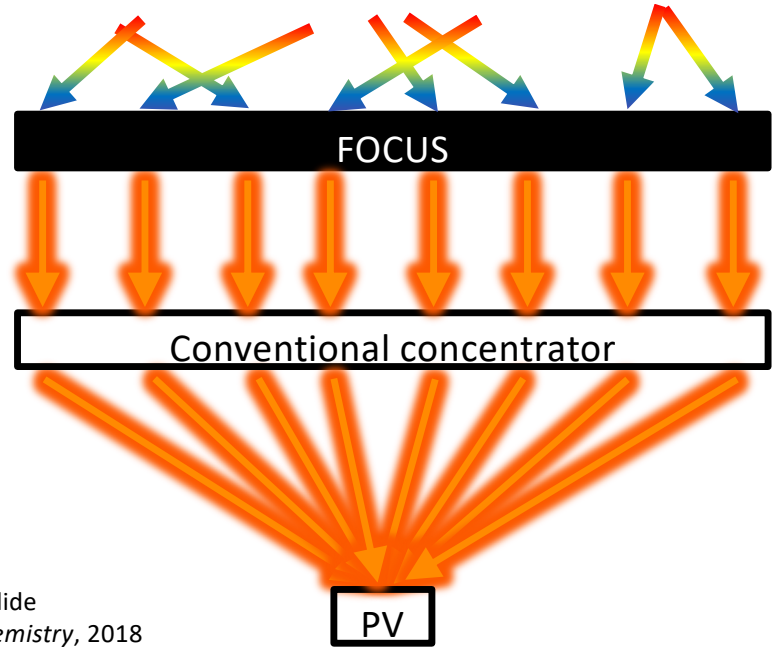
lmpv.nl/db

Polman et al., "Photovoltaic materials: Present efficiencies and future challenges" *Science*, 2016

Si still rules but halide perovskites are rising star: light absorbing/emitting salt!

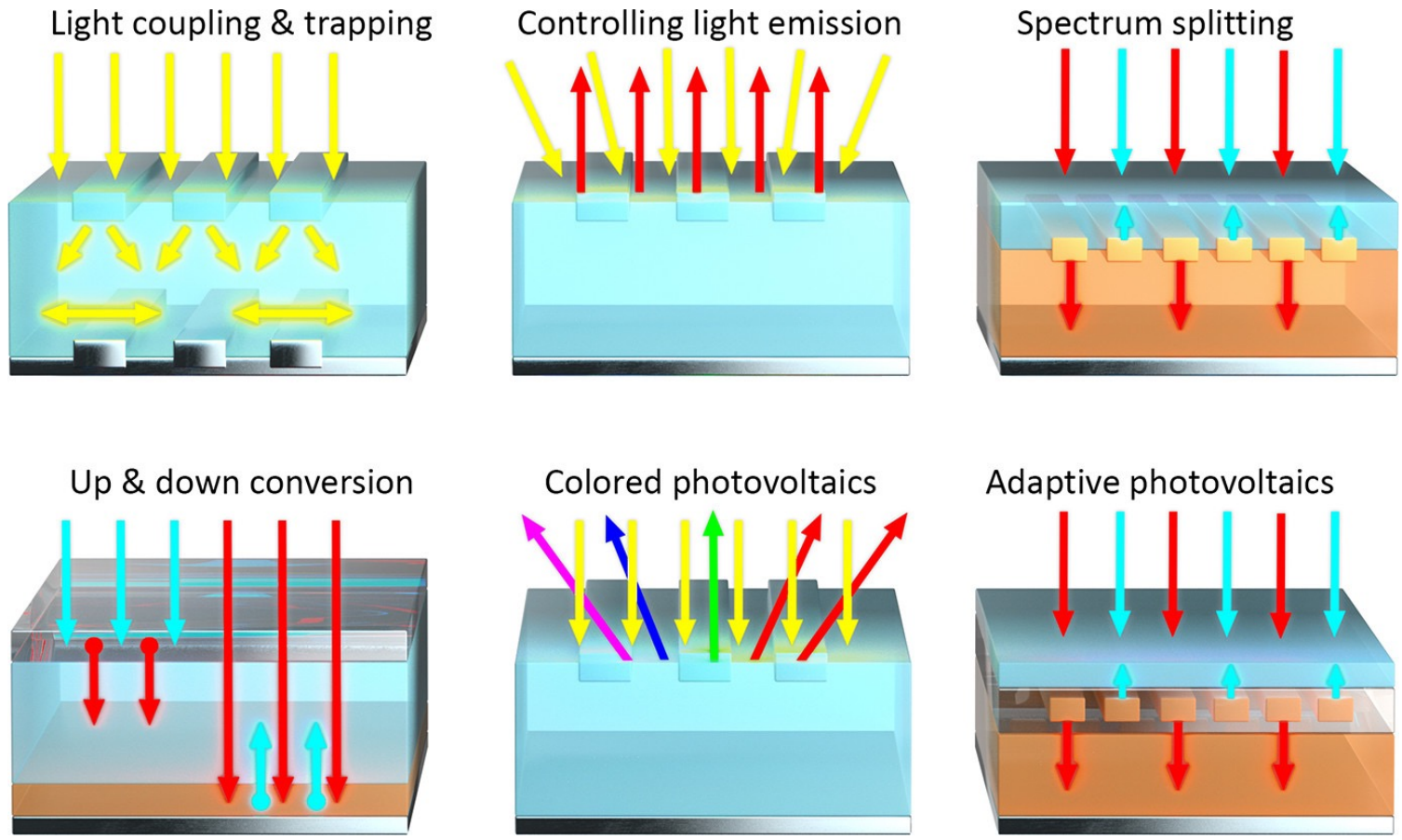
- Highly efficient and adaptive properties
- Strong tunable absorption/emission – ultrathin, colorful light, flexible
- Form at/near room T – little energy input
- Easily dissolve in solution – rapid scaling with roll-to-roll printing





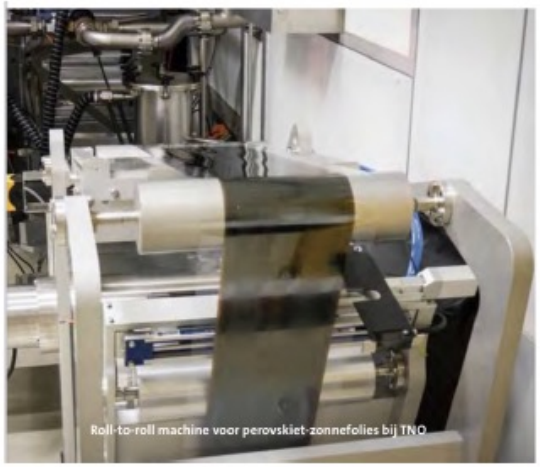
Holtus et al., "Shape-preserving transformation of carbonate minerals into lead halide perovskite semiconductors based on ion exchange/insertion reactions" *Nature Chemistry*, 2018

Nanostructures are antennas for light



Garnett et al., "Photonics for Photovoltaics: Advances and Opportunities" *ACS Photonics*, 2020

PV breakthroughs can lead to Dutch industry



In 2020 in the Netherlands: 22,000 jobs
World: €100 billion + 10x growth

Four reasons why PV fabrication is now feasible in NL/EU
1) Reduced costs of automation
2) Local production vs. transportation costs
3) Integrated applications (BIPV)
4) Stricter EU sustainability & environmental regulations

Potential in NL: turnover > €1 billion
(annual 4 million tons of CO_2)

Roland Berger

MaterialenNL Platform