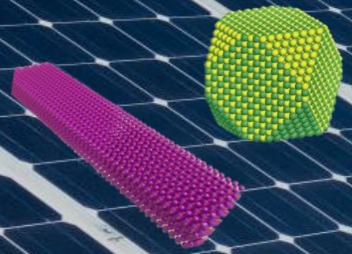
Exploiting Nanomaterials for Energy Conversion and the Green Economy

Nanocrystals
(Quantum dots)

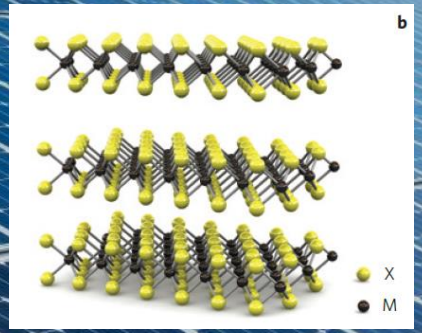


Peter Schall

Institute of Physics

UvA

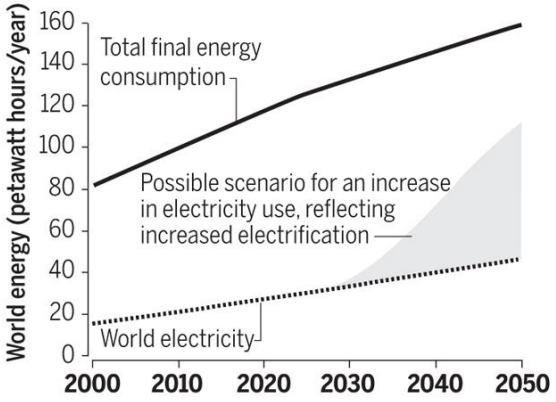
2D Materials



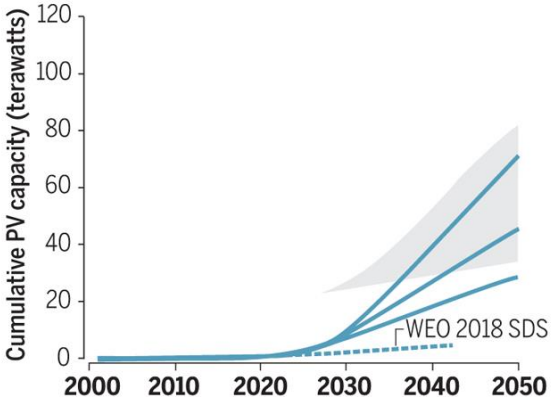
The Terrawatt challenge

Total world energy consumption

(according to 2018 World Energy Outlook, WEO)

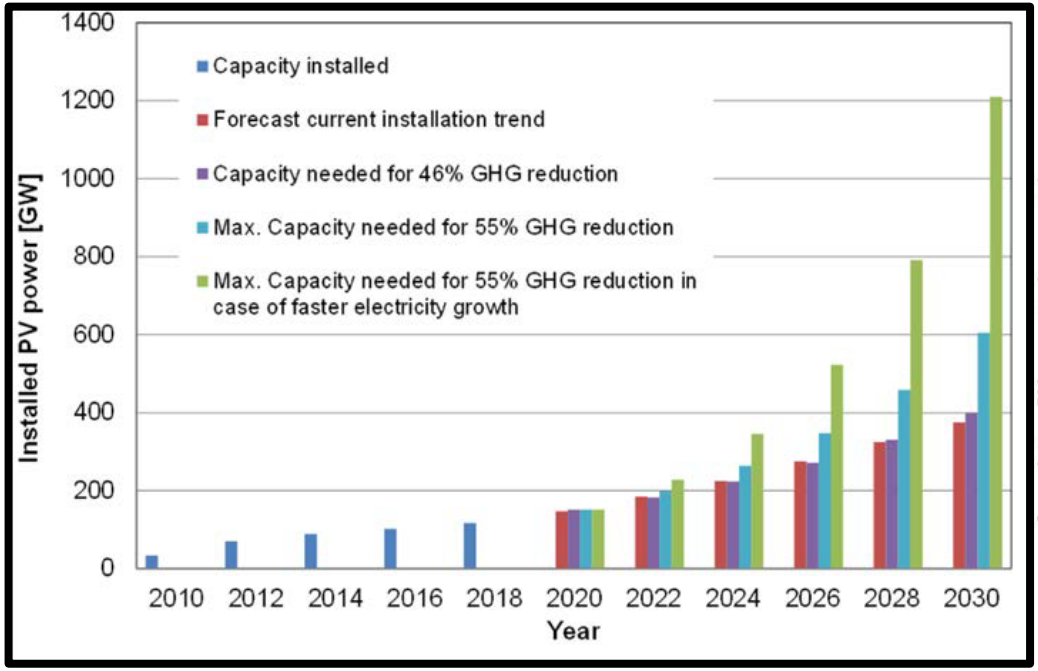


PV cumulative capacity

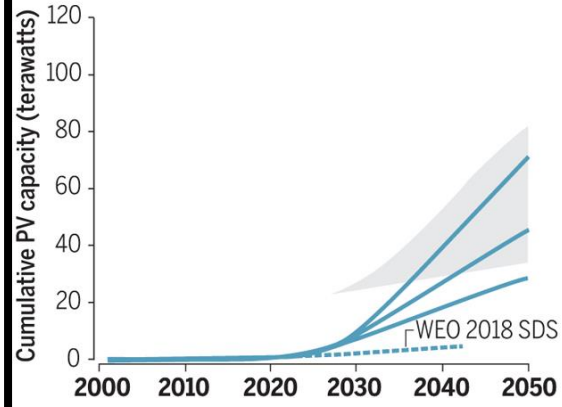


Haegel et al. *Science* (2019)

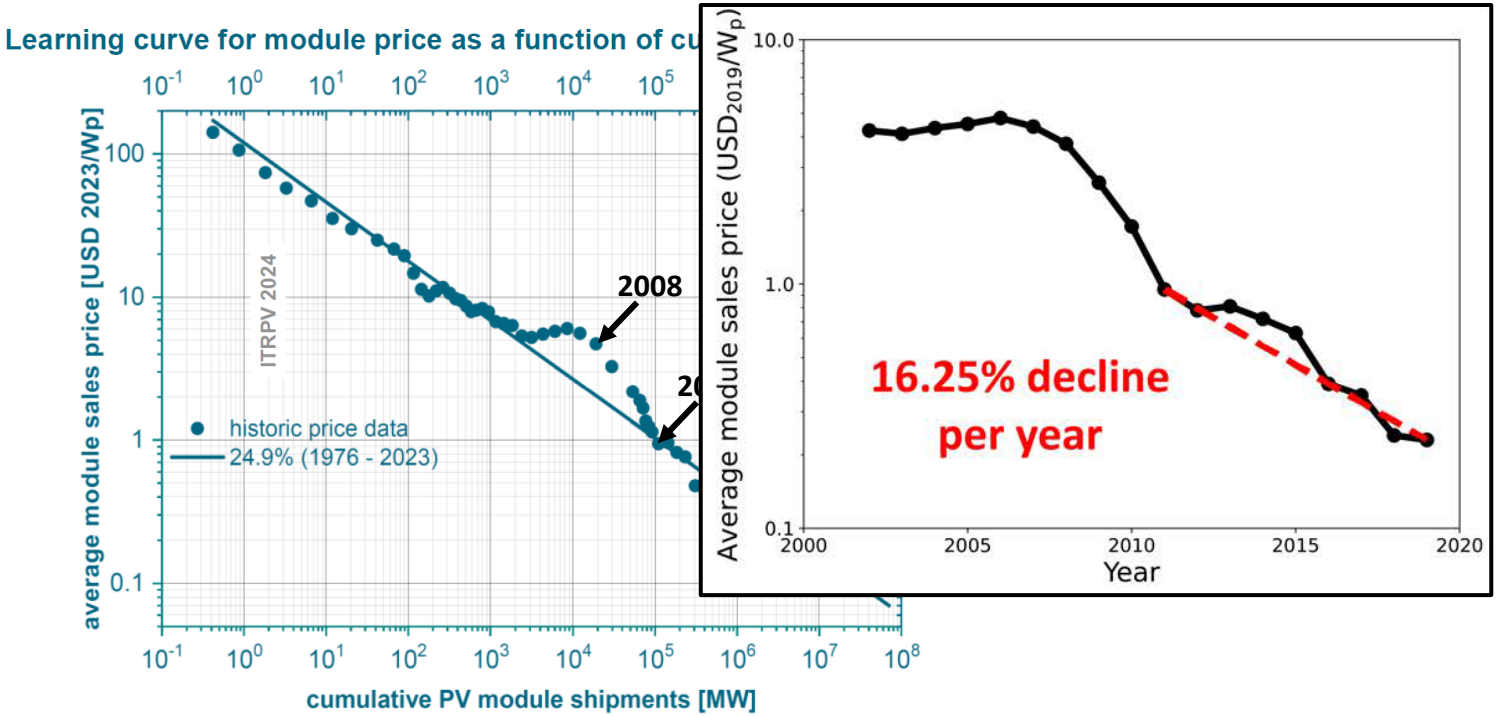
The Terrawatt challenge



PV cumulative capacity



Drop of module prices



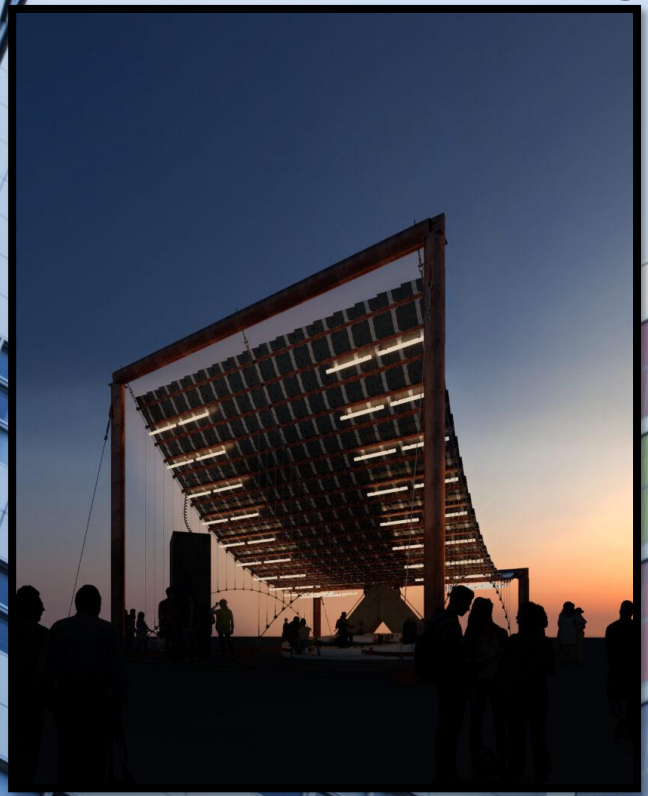
Area needed for PV to cover 50% of total energy demands of NL in 2050



Building-integrated PV (BIPV)



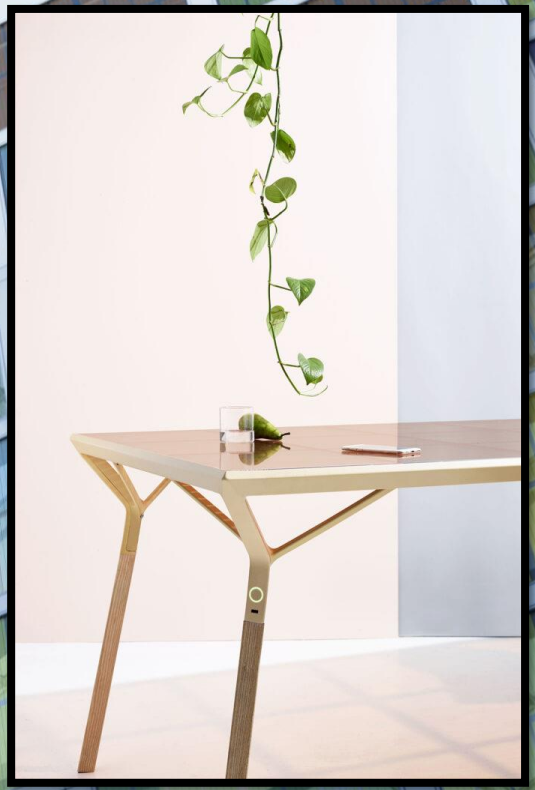
Building-integrated PV (BIPV)



Solar Pavillon



Current window



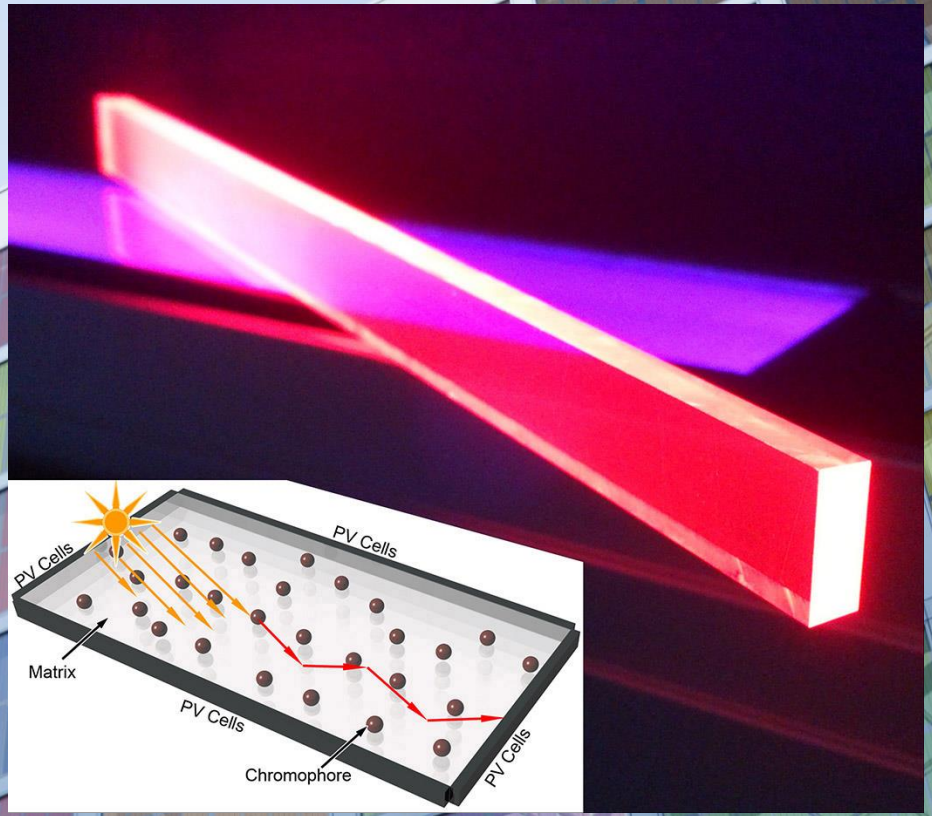
Current table

Marjan van Abel, marjanvanaubel.com

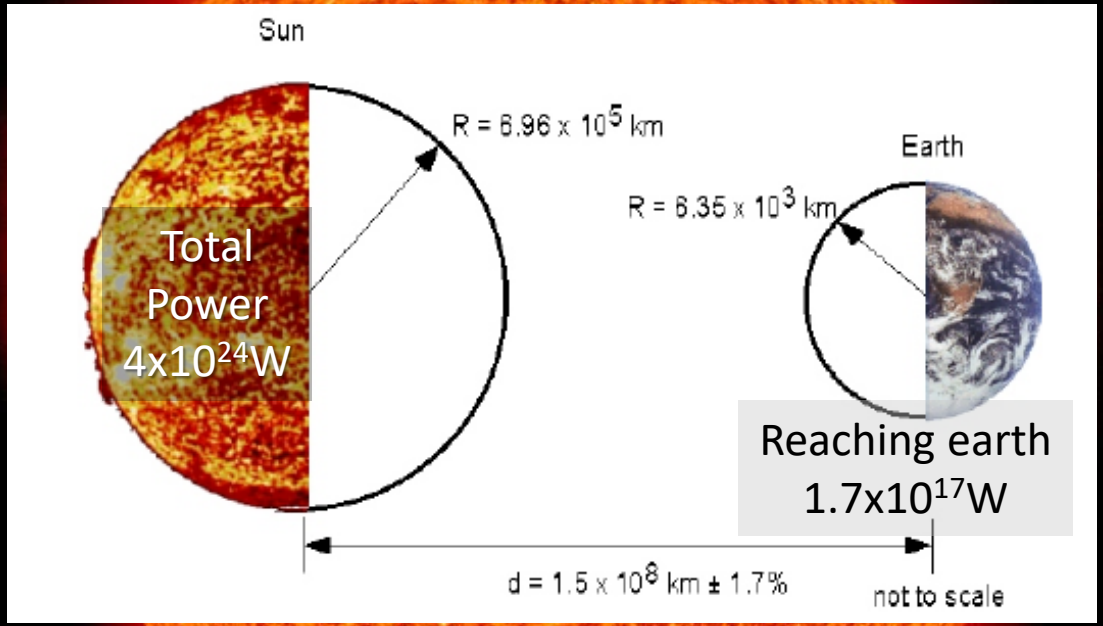
Building-integrated PV (BIPV)

Window-integrated:

Luminescent Solar concentrator



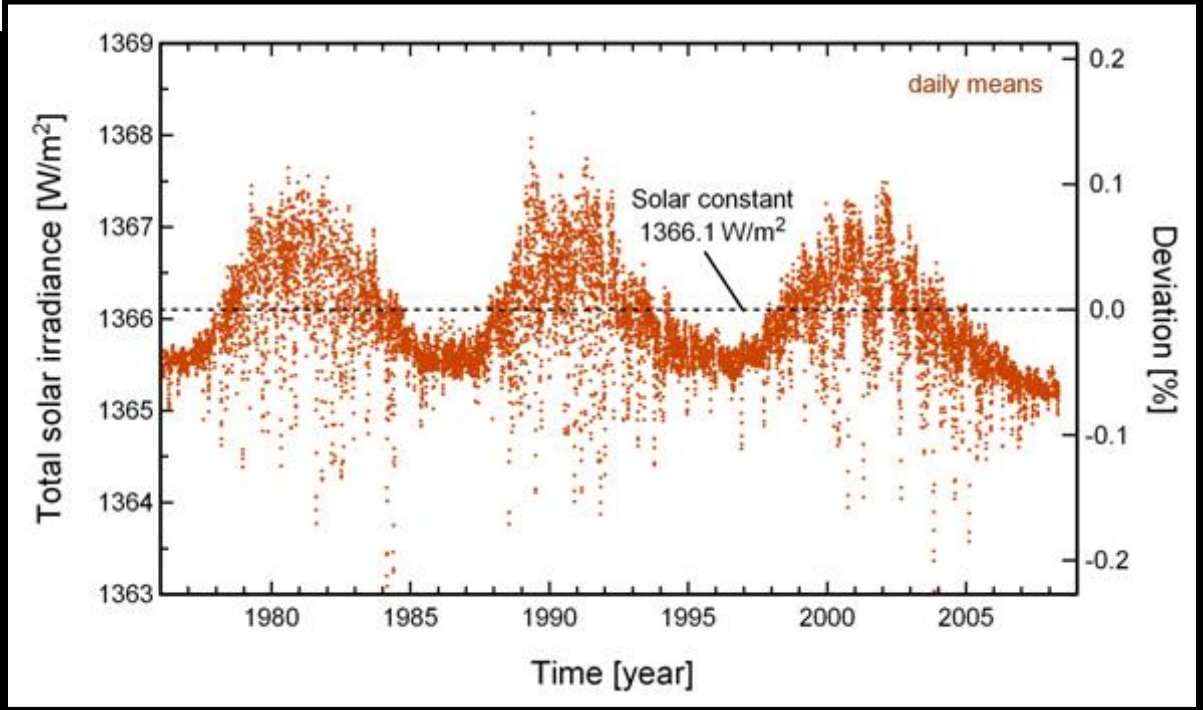
The sun



1.36 kW/m²

Solar energy reaching earth per hour =enough to cover electricity per year

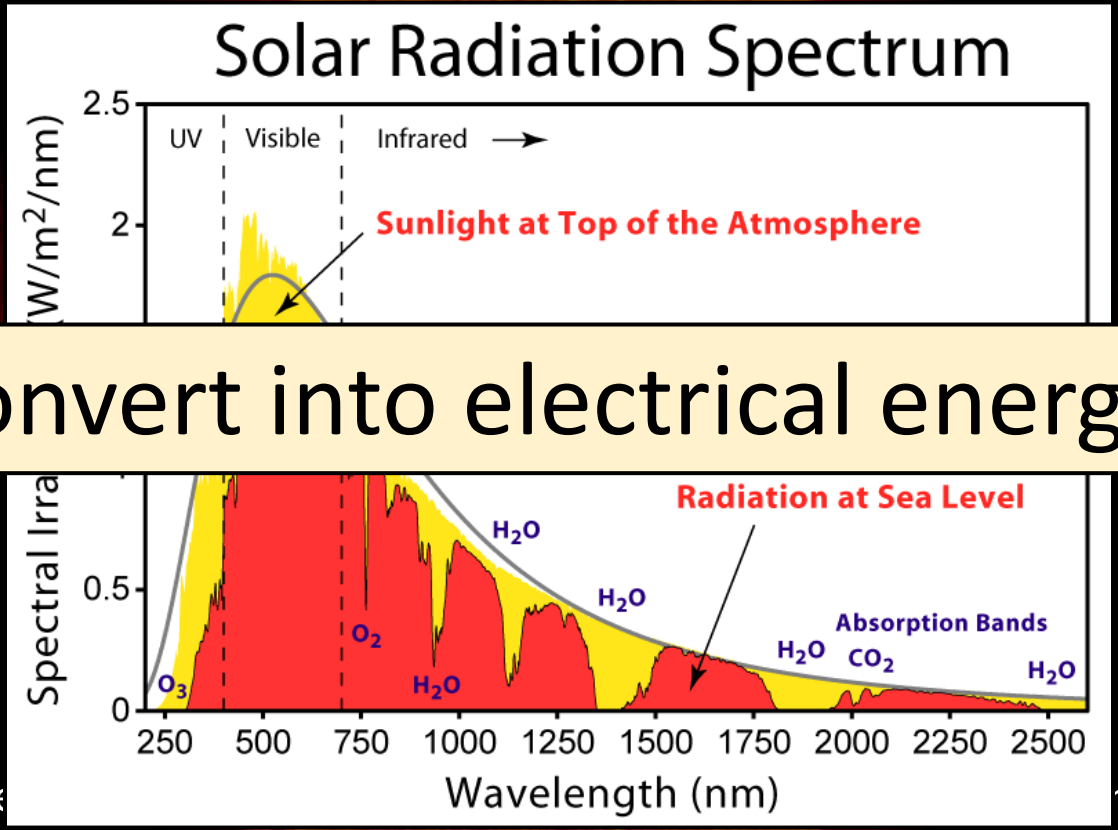
The sun



1.36 kW/m²

Solar energy reaching earth per hour =enough to cover electricity per year

The sun

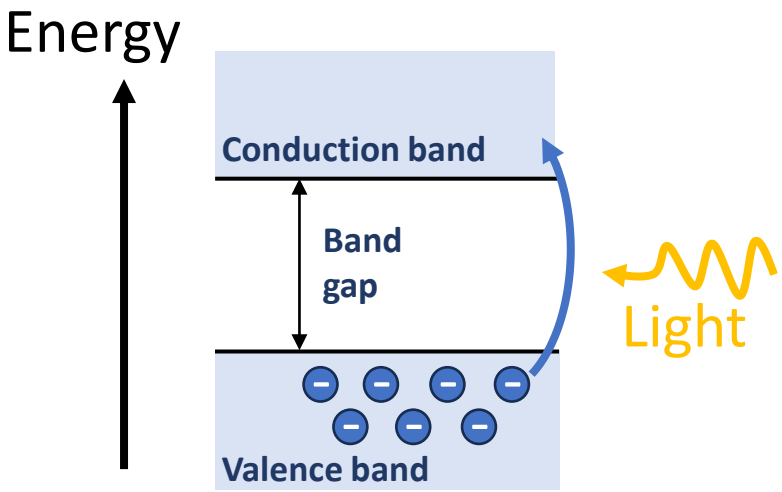


Convert into electrical energy?

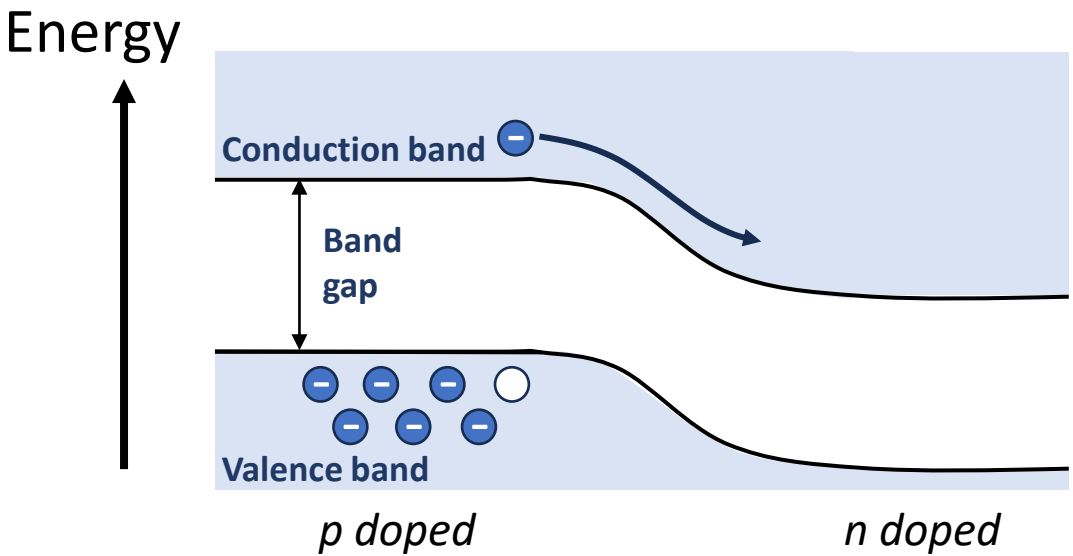
Solar e

year

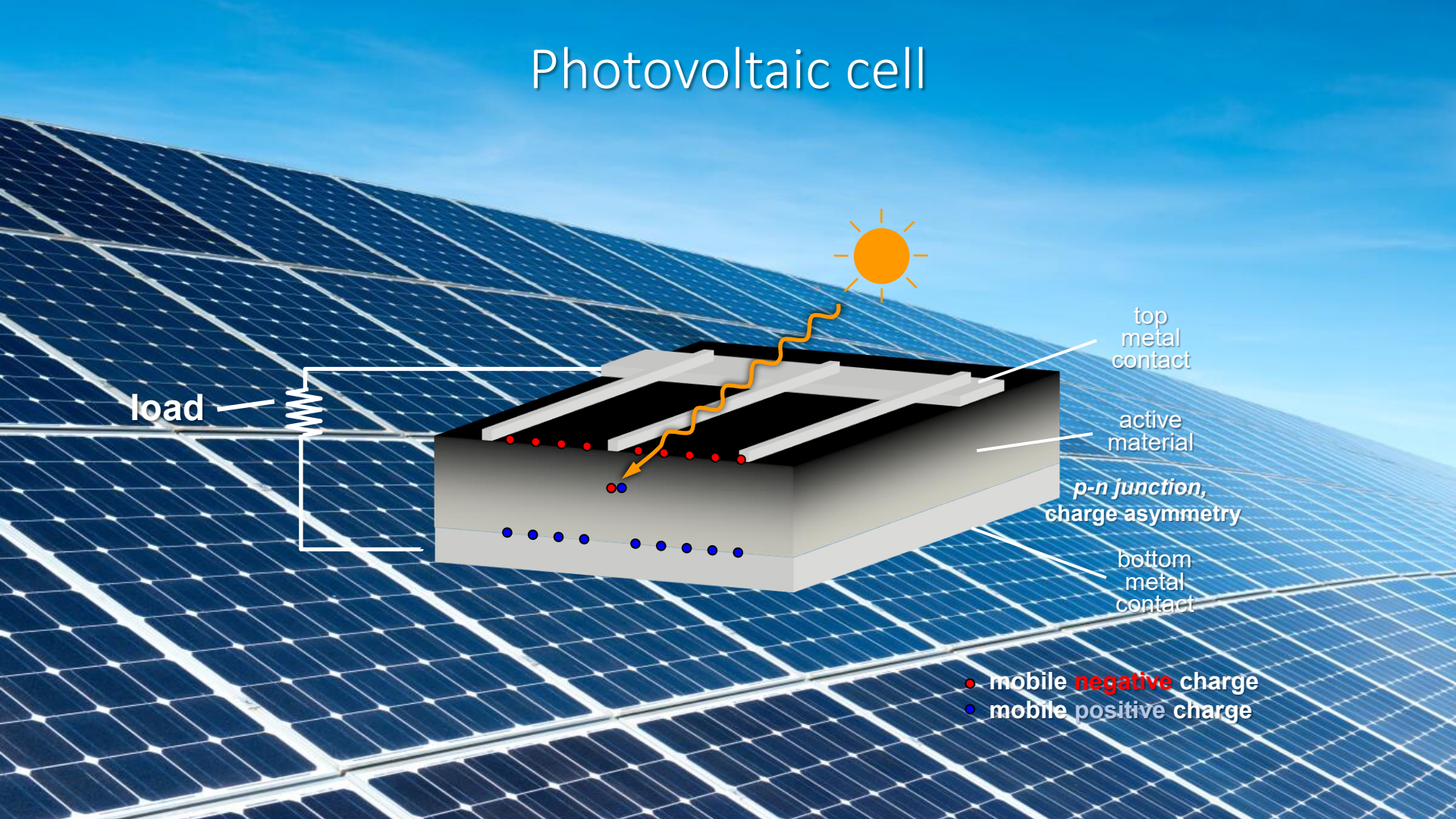
Photovoltaic cell



Photovoltaic cell

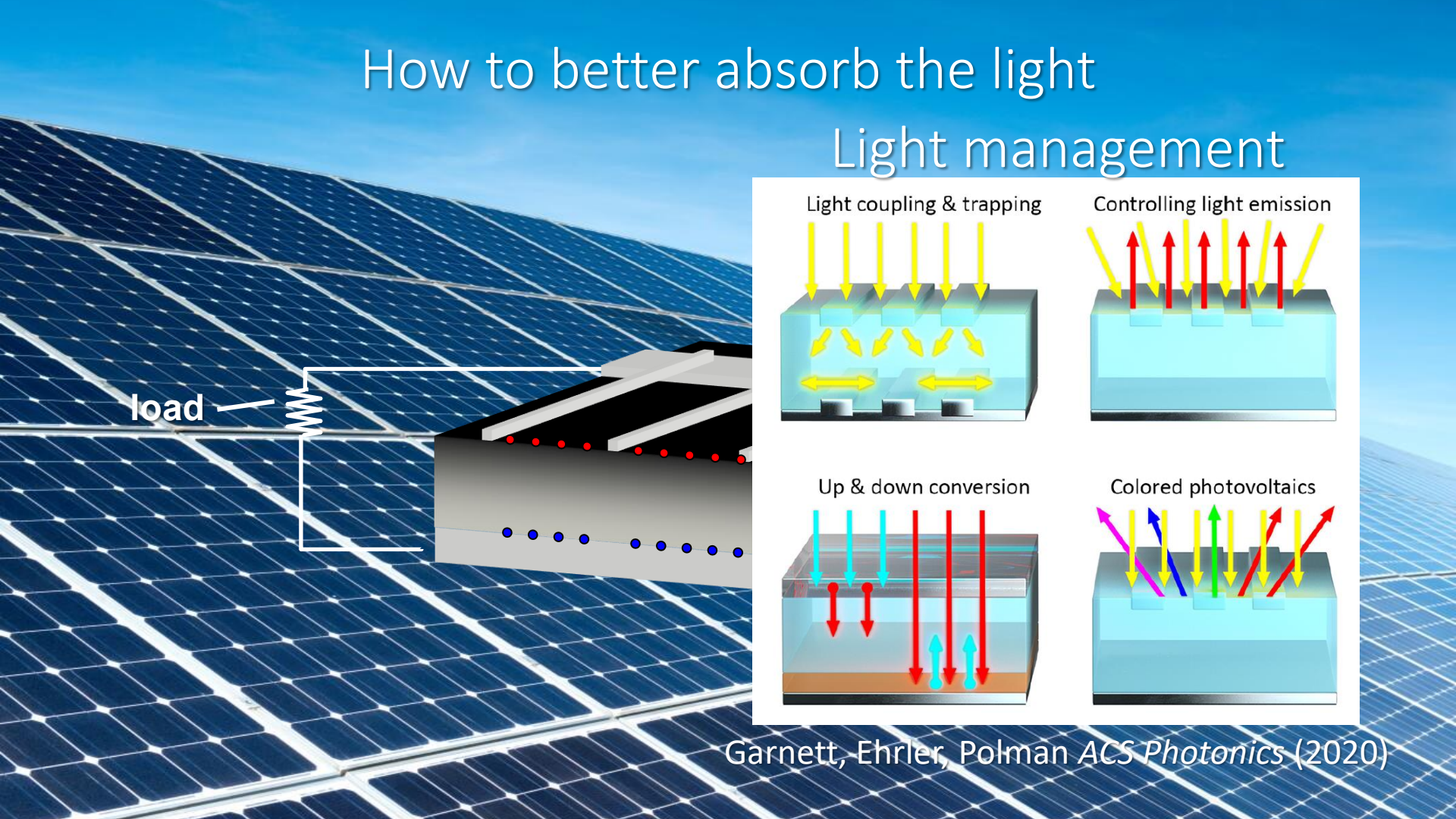


Photovoltaic cell



How to better absorb the light

Light management

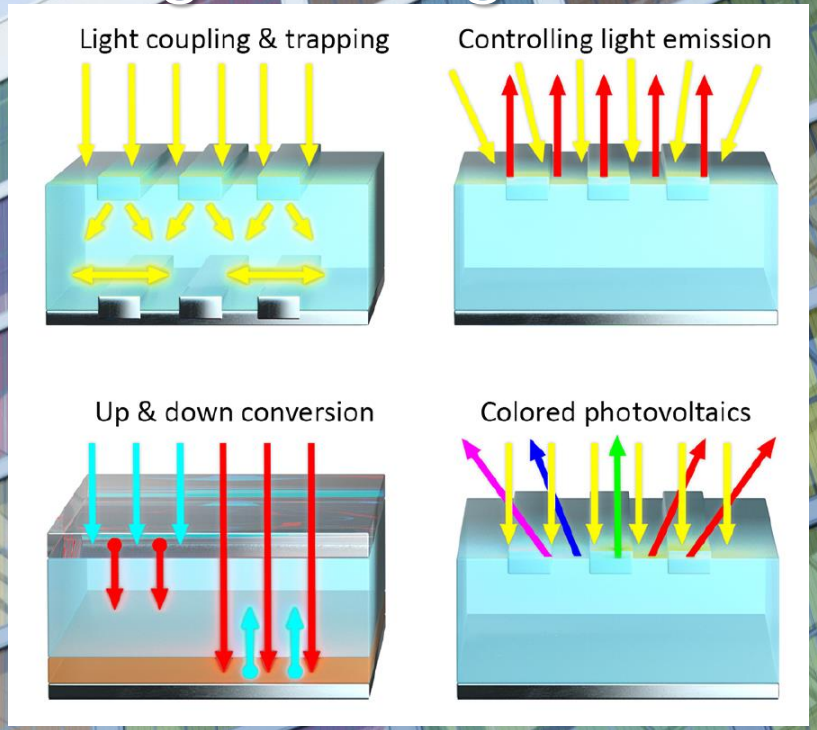


Garnett, Ehrler, Polman *ACS Photonics* (2020)

Building-integrated PV (BIPV)

Light management

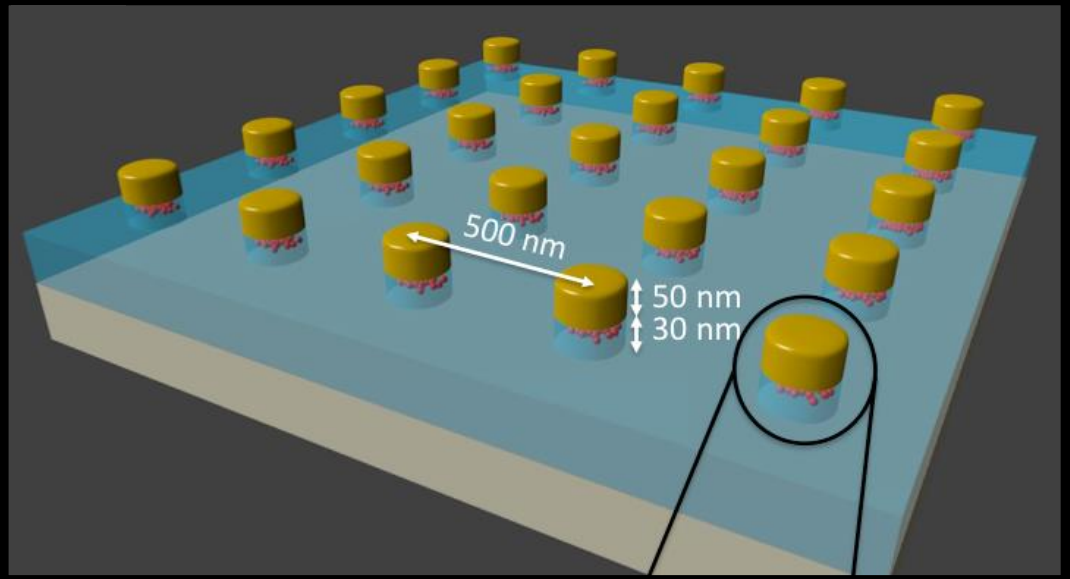


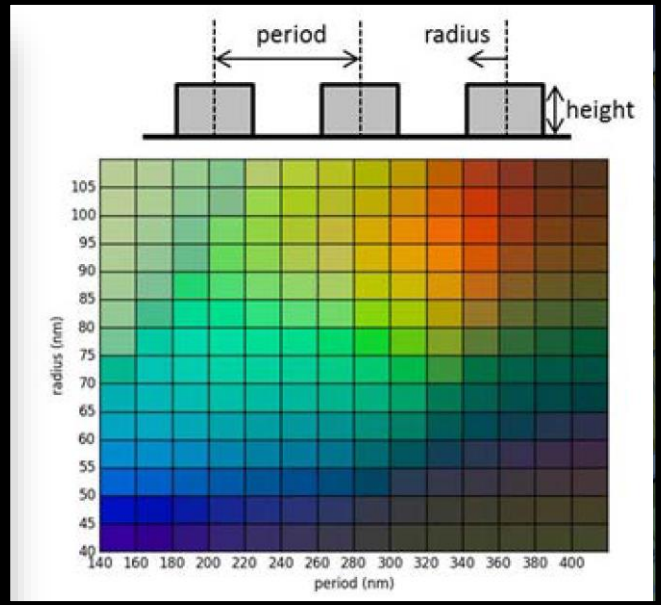


Garnett, Ehrler, Polman *ACS Photonics* (2020)

Building-integrated PV (BIPV)

t management

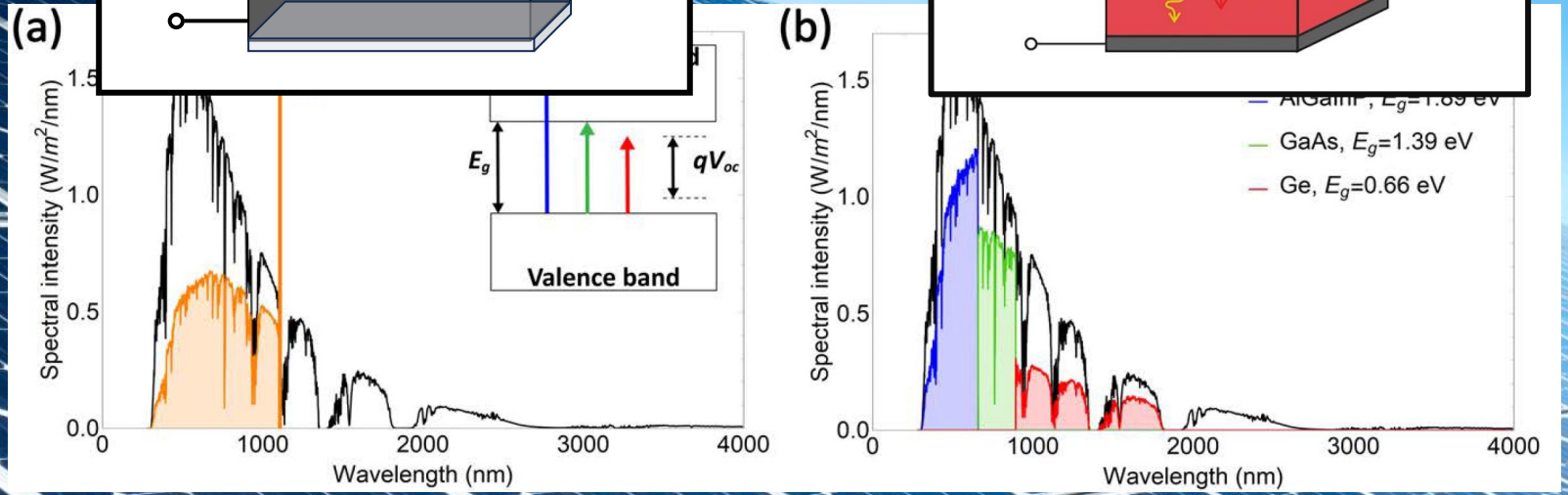




V. Neder (PhD thesis, Amolf)

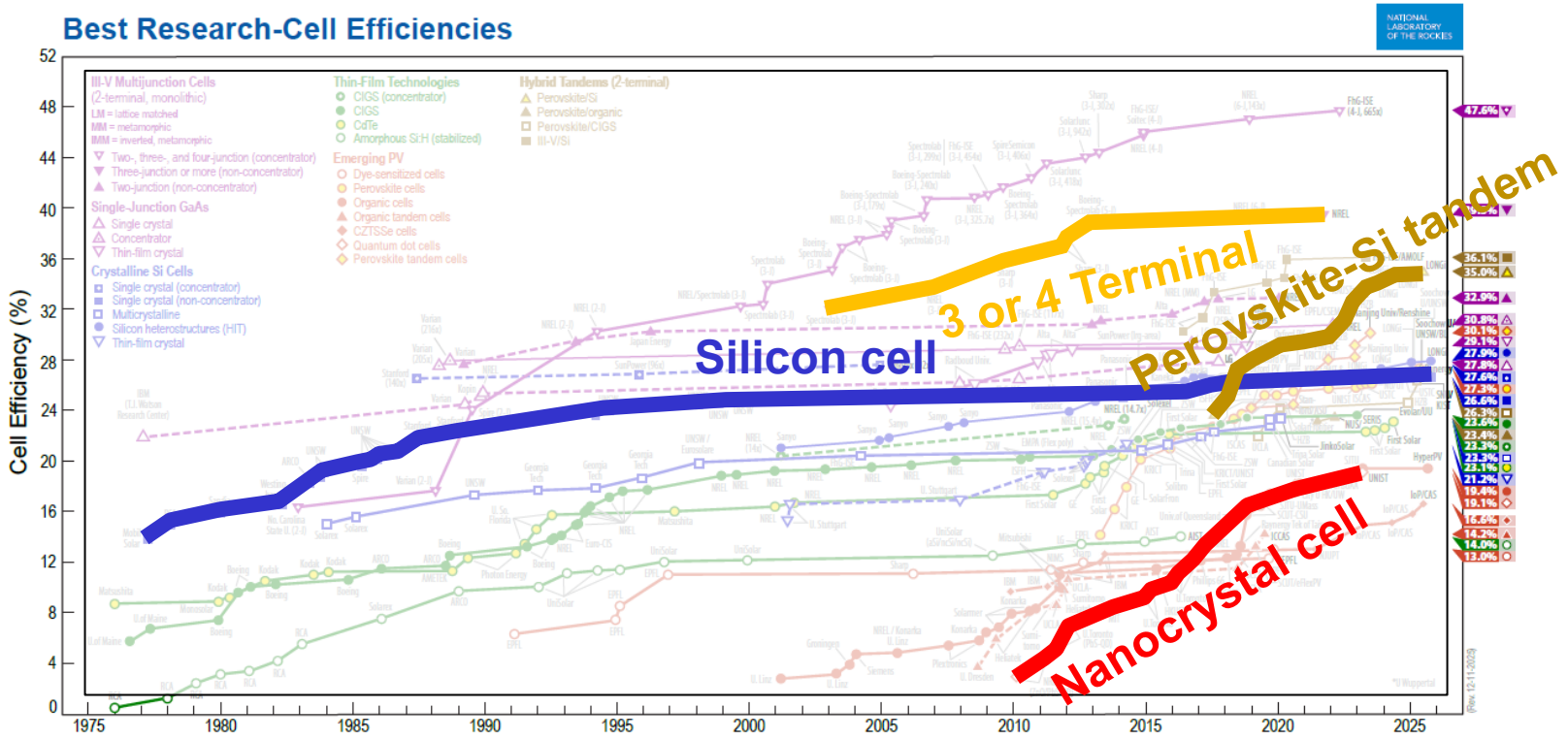
Garnett, Ehrler, Polman *ACS Photonics* (2020)

Enhance Efficiency

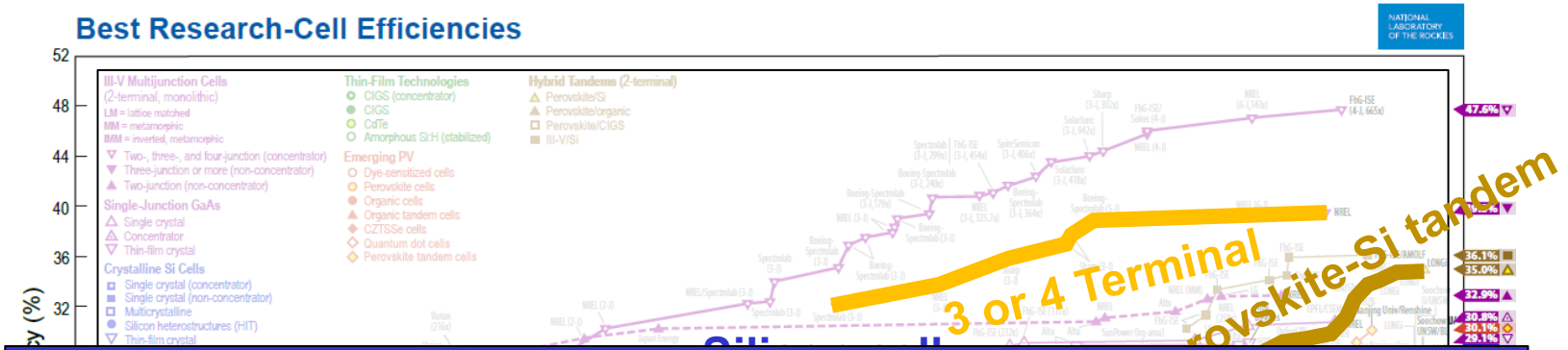


(PhD thesis Tom Veken, Amolf)

Perovskite-based PV films

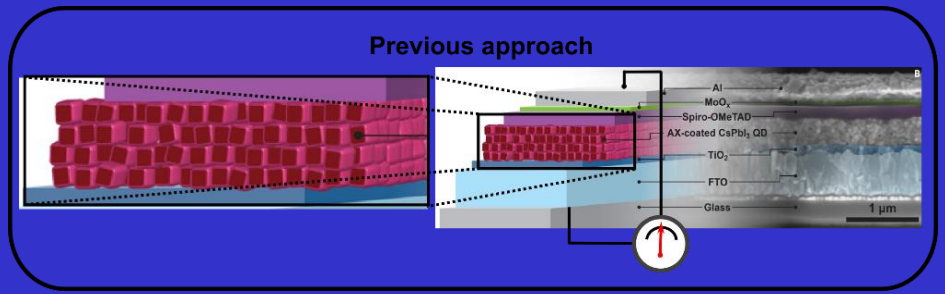


Perovskite-based PV films



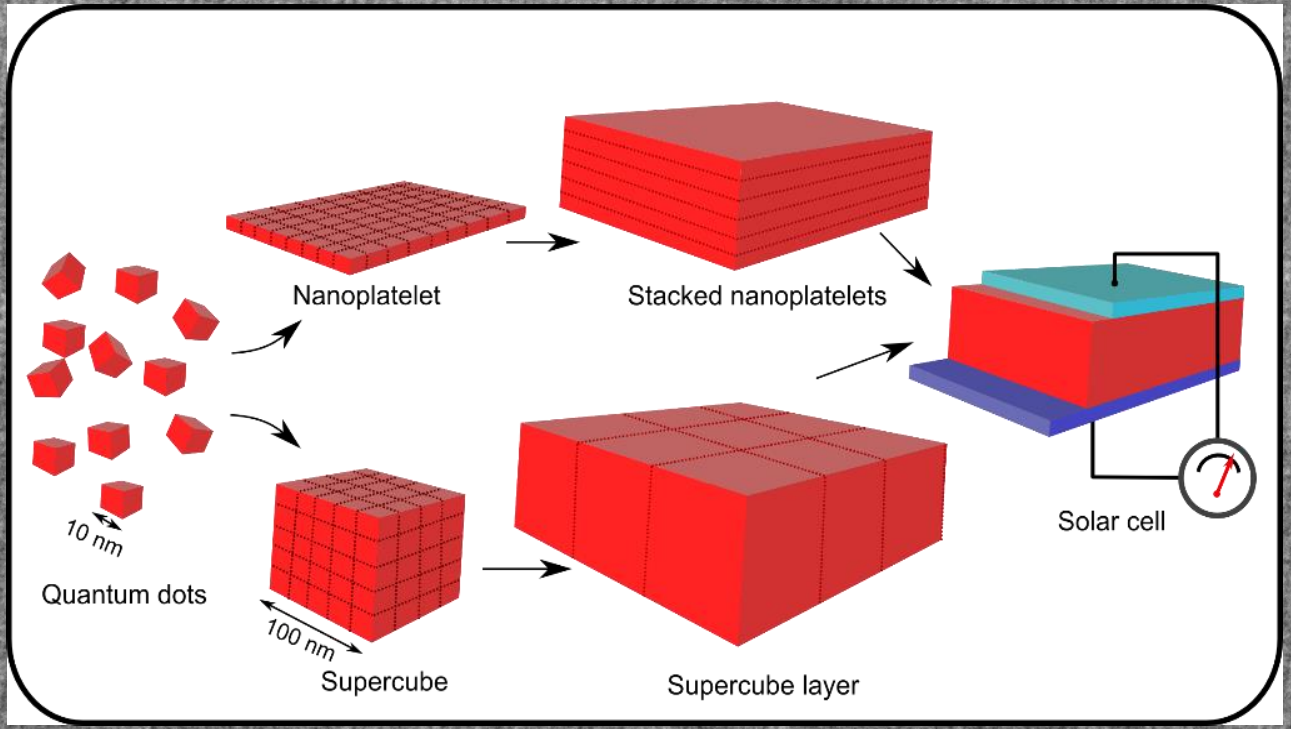
Perovskite Nanocrystal cell (Swarnkar *et al. Science* **2016**)

Efficiency ~11%



Phase stabilized by nanocrystal dimension

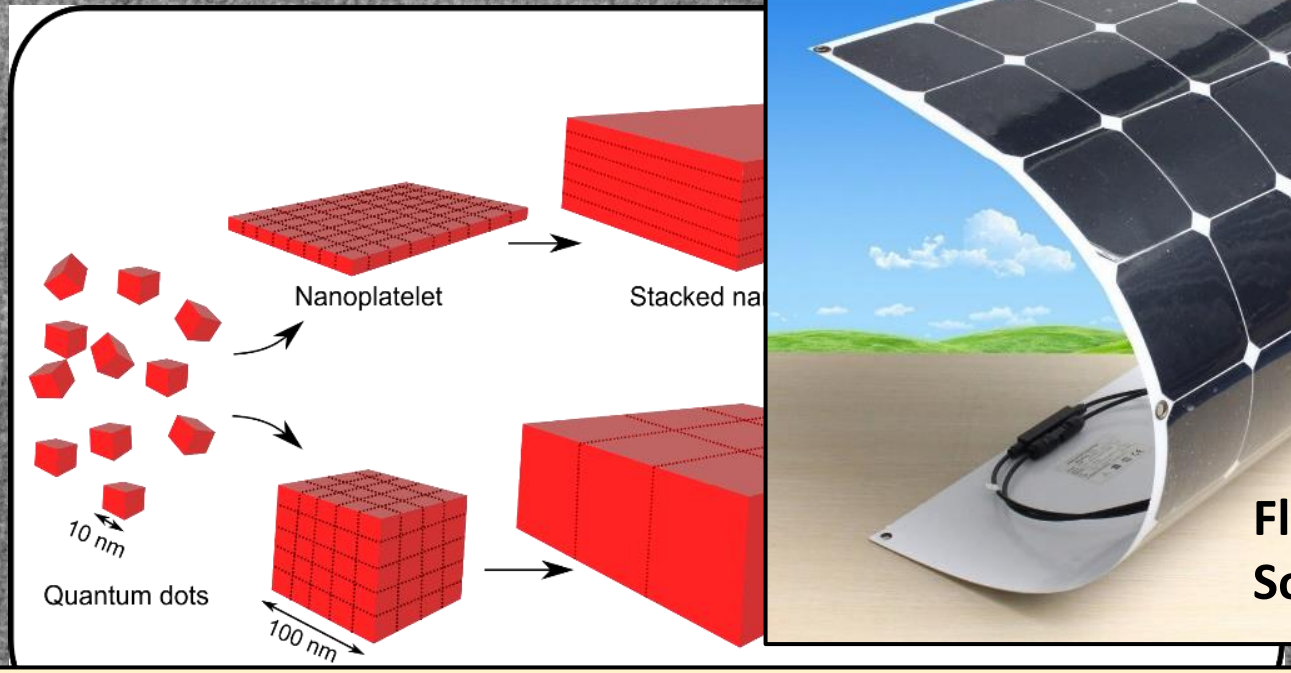
Assembled Nanocrystal Layers



Collaboration with E. Garnett (Amolf)

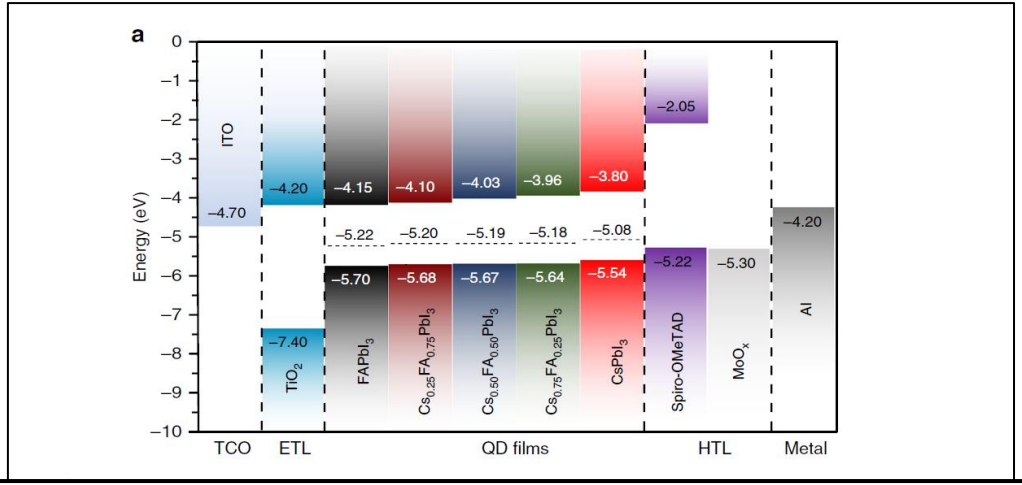
– 50nm

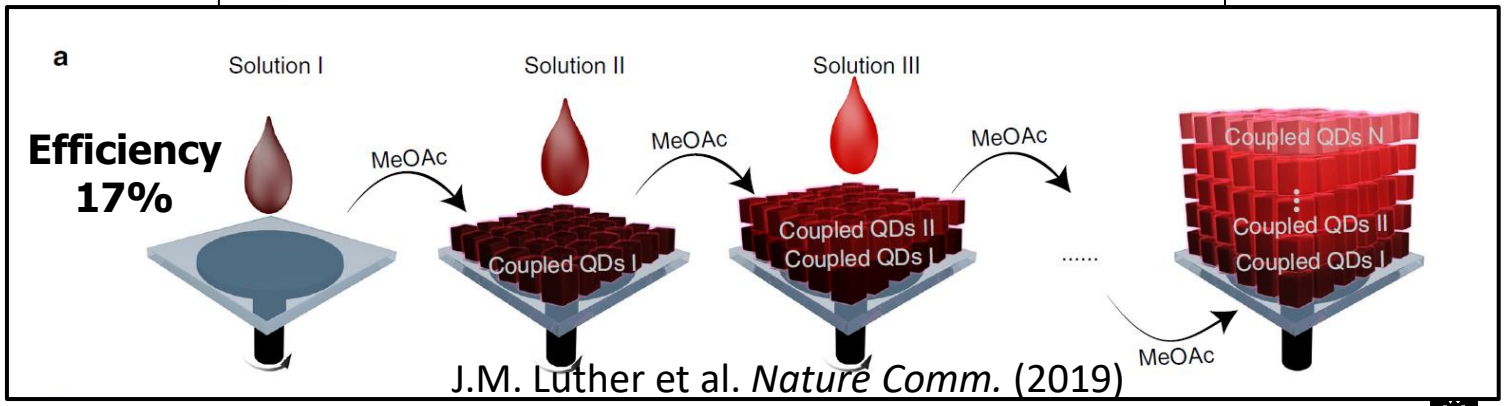
Assembled Nanoc



“Solar cell paint” → Cover large areas

Nanocrystal-based PV films

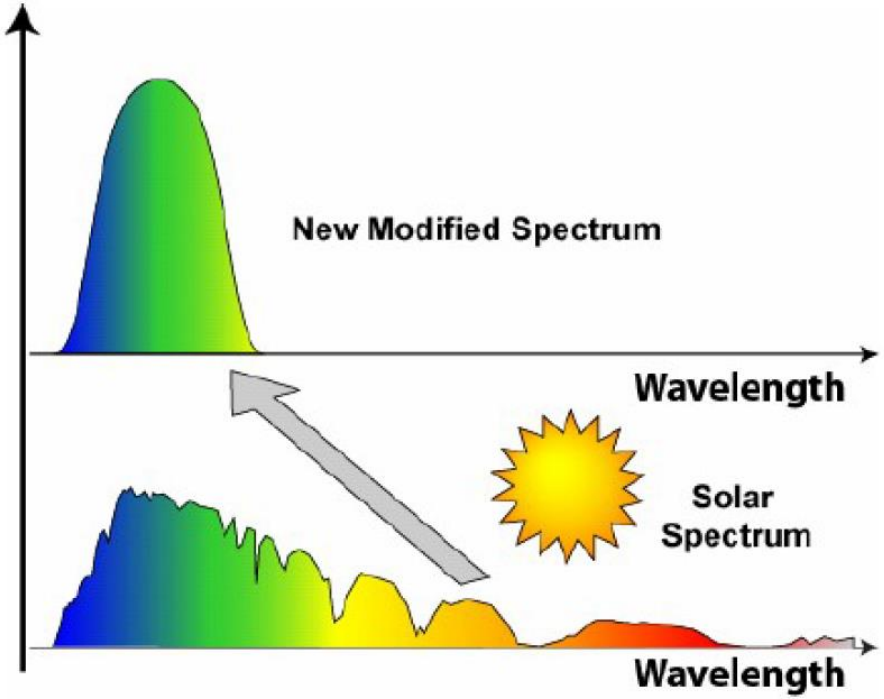


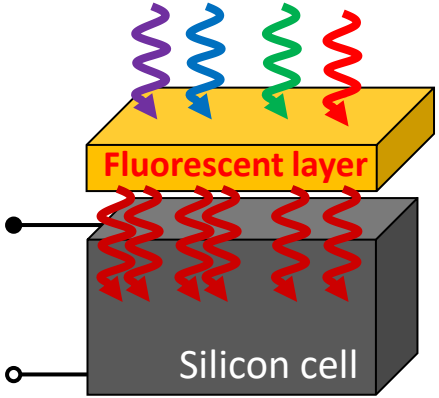


J.M. Luther et al. *Nature Comm.* (2019)

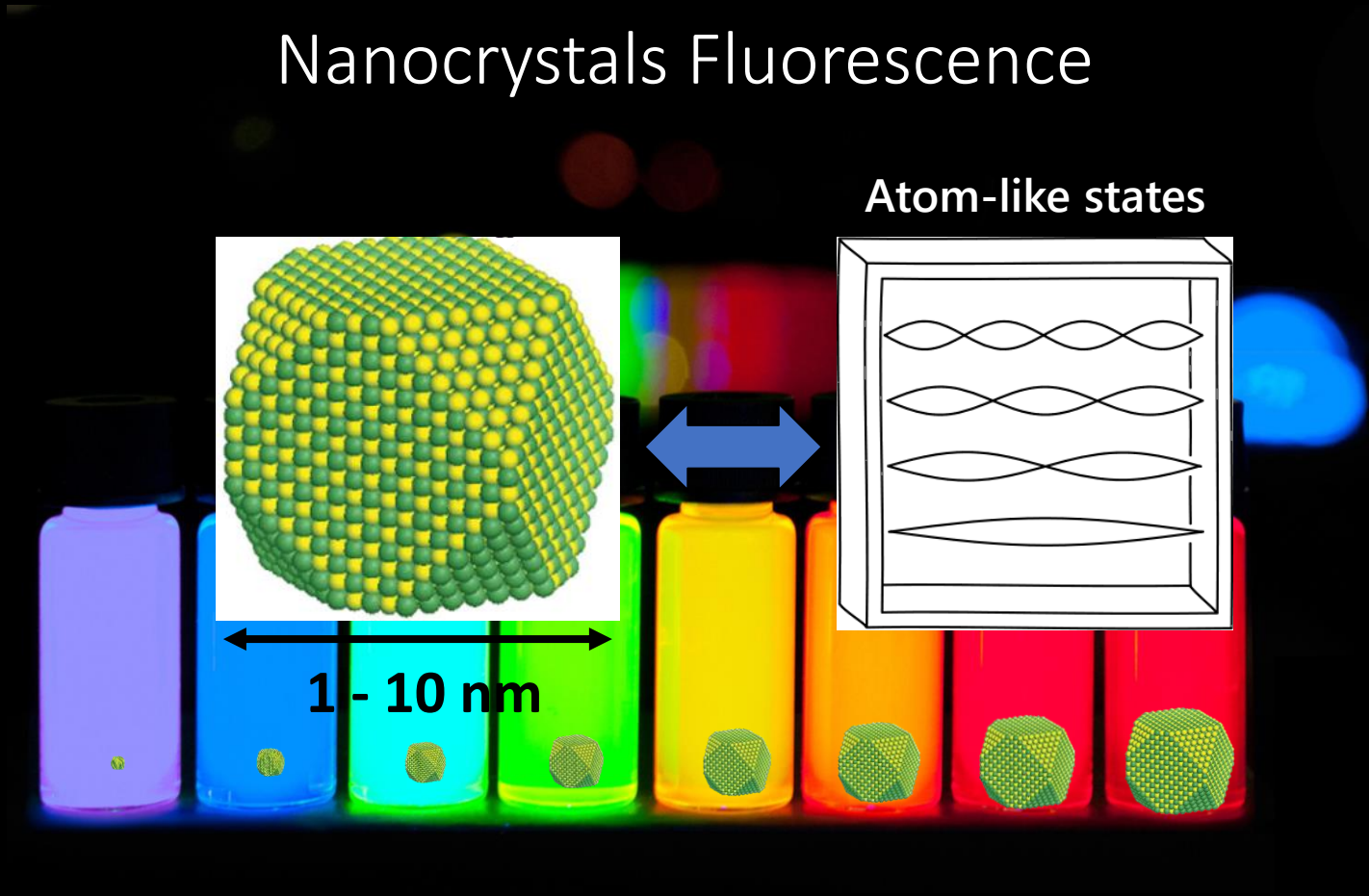
Spectral Shaping

Adjust solar spectrum



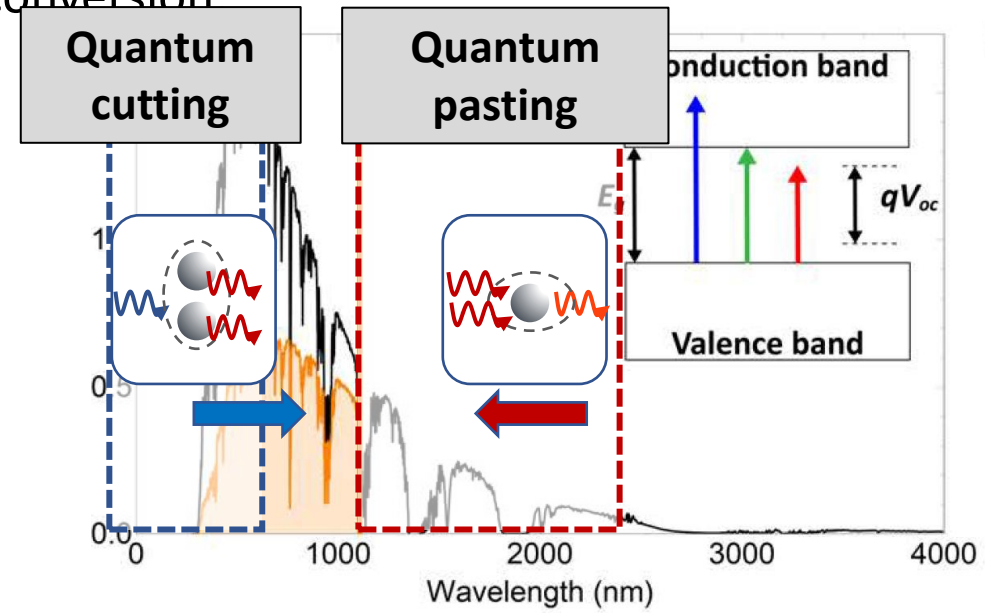


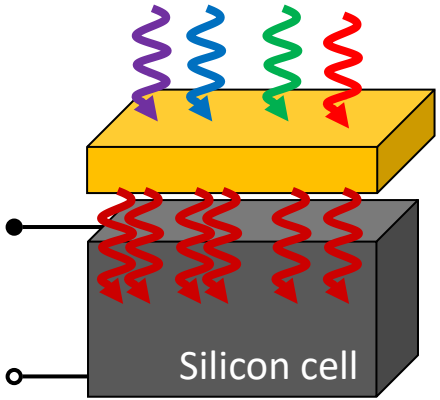
Nanocrystals Fluorescence



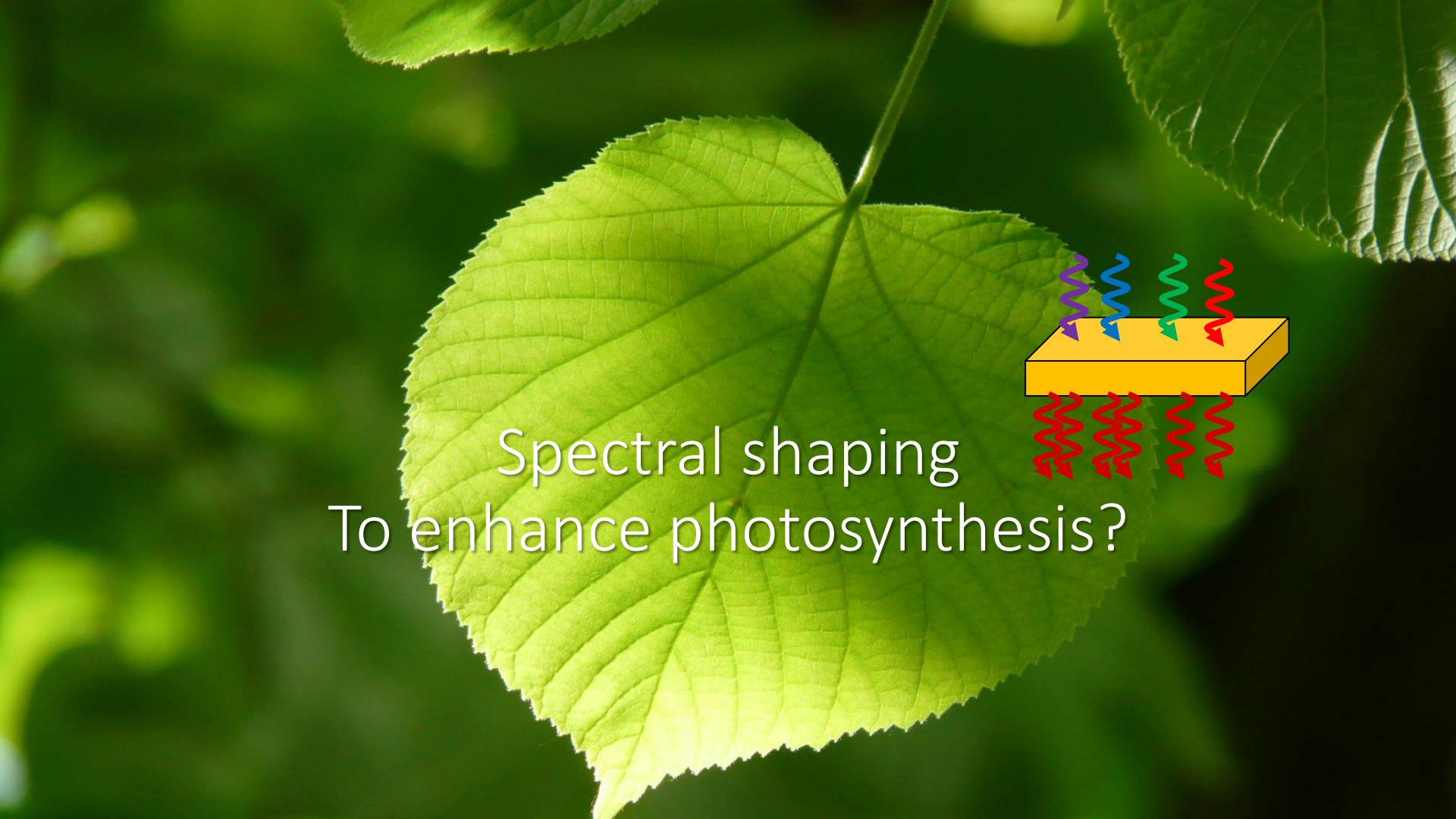
Spectral shaping

Light conversion:

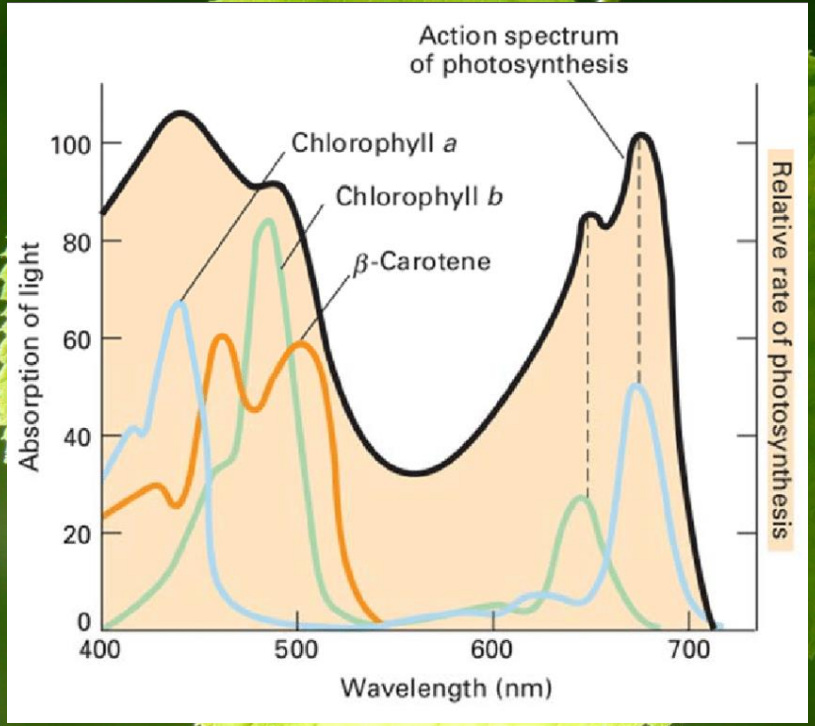


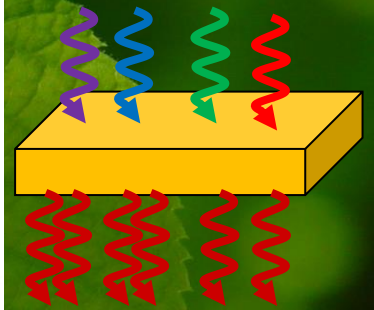


Gain outweighed by losses


Spectral shaping
To enhance photosynthesis?

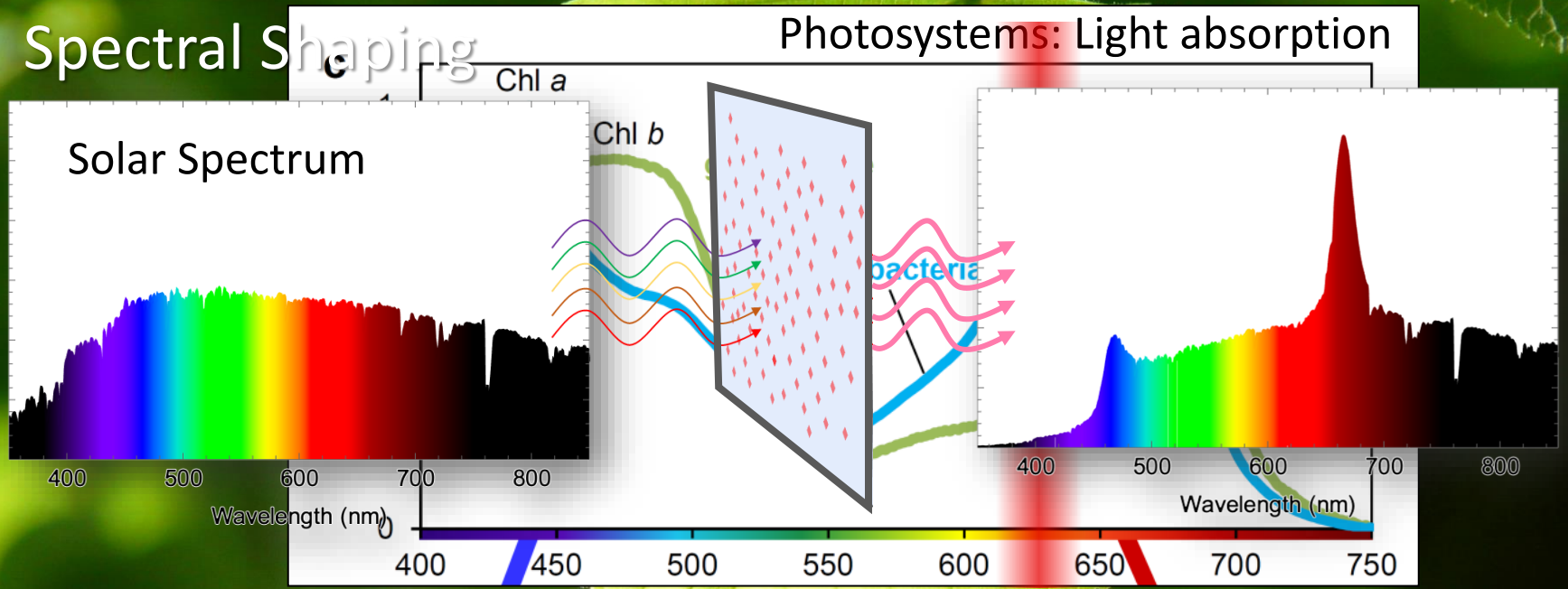
Photosynthetic rate and pigments





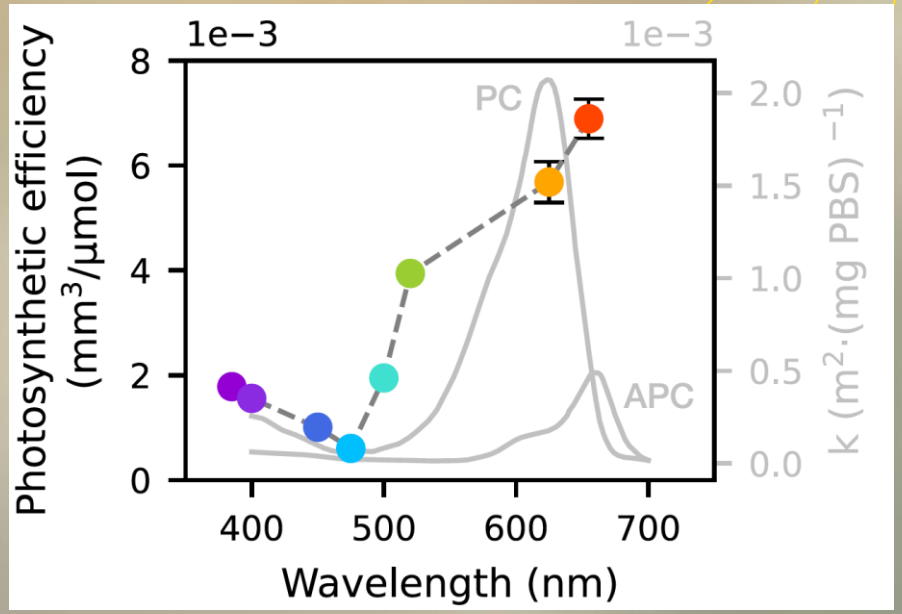
Photosynthetic efficiency: Algae

Spectral Shaping

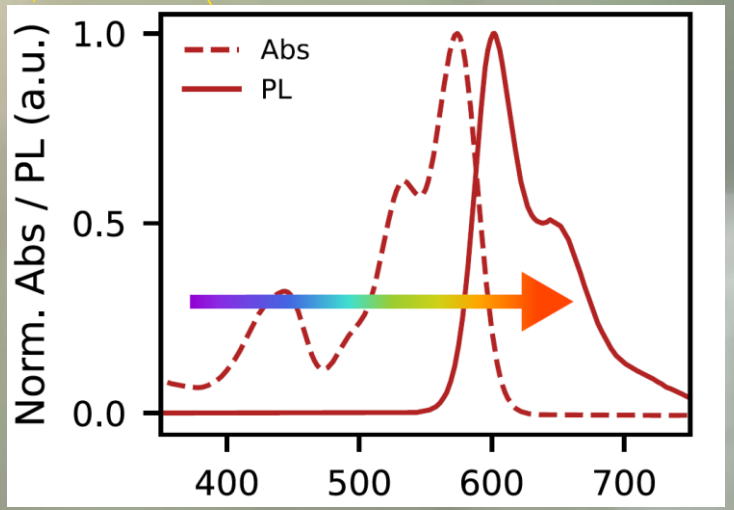


Cyanobacteria

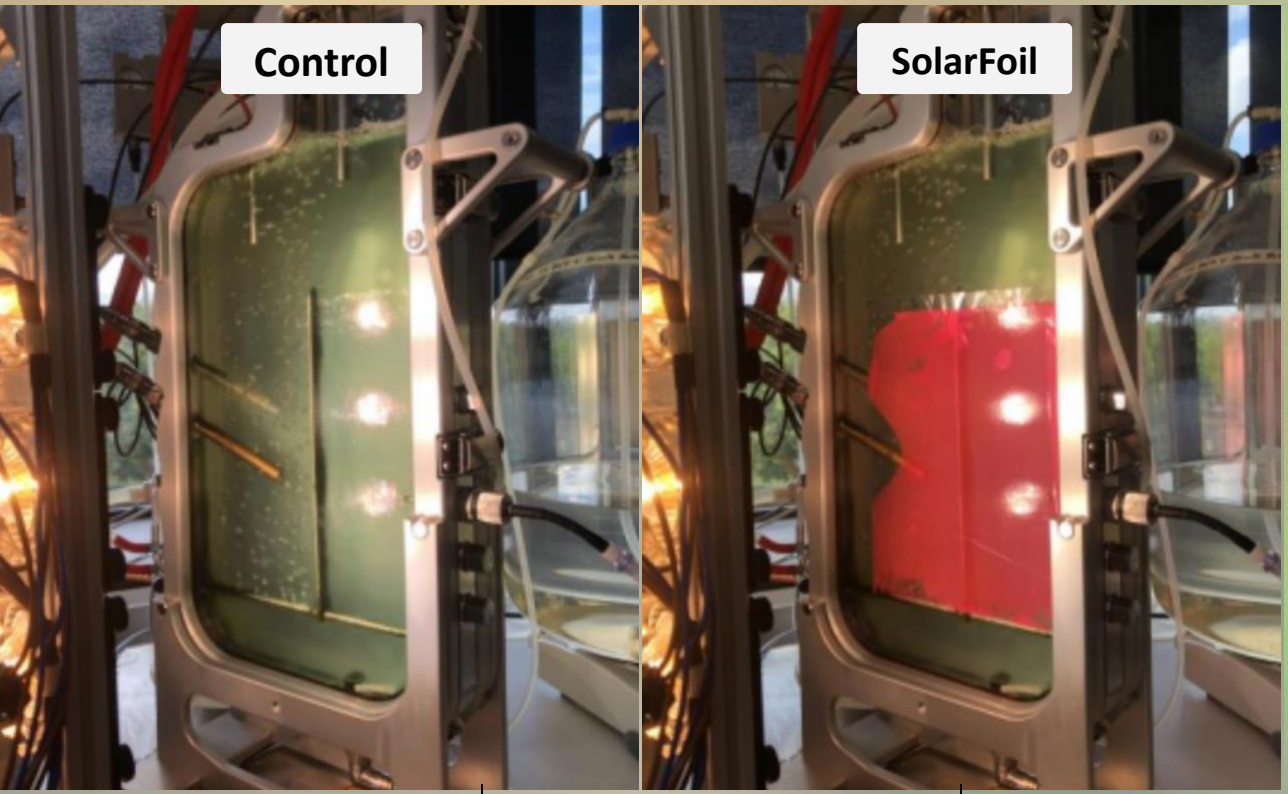
Photosynthetic efficiency



Spectral shaping



Cyanobacteria – growth tests



Growers
"A few % more production is significant"

Lab-Trial
45% more Yield!

For 1 ha facility

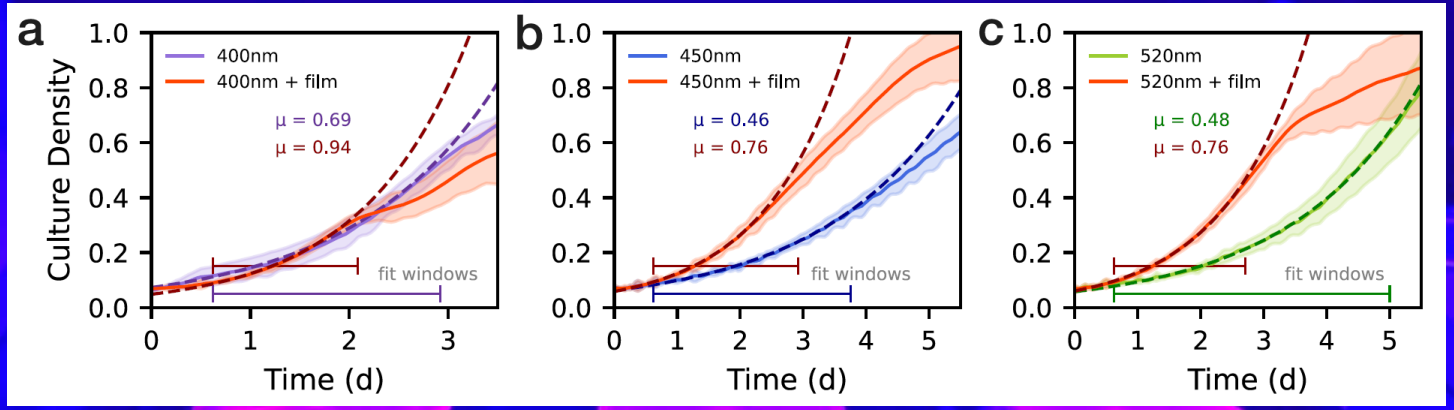
Production increases by 4.5ton

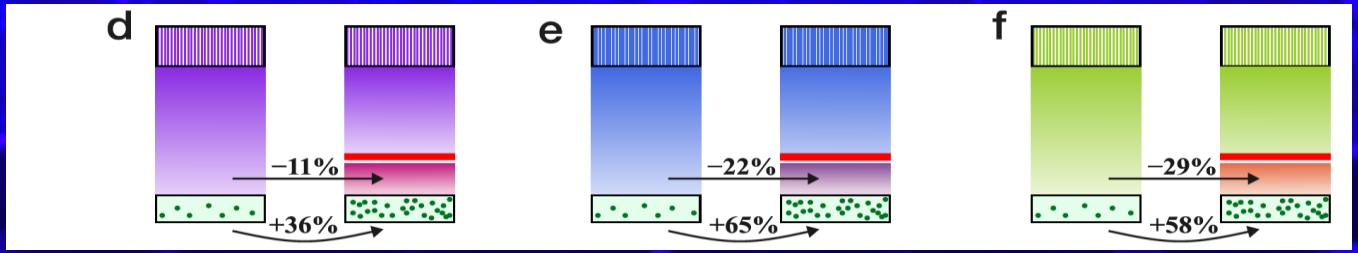
added value of €450k

31% less costs per kg product

Cyanobacteria – growth tests

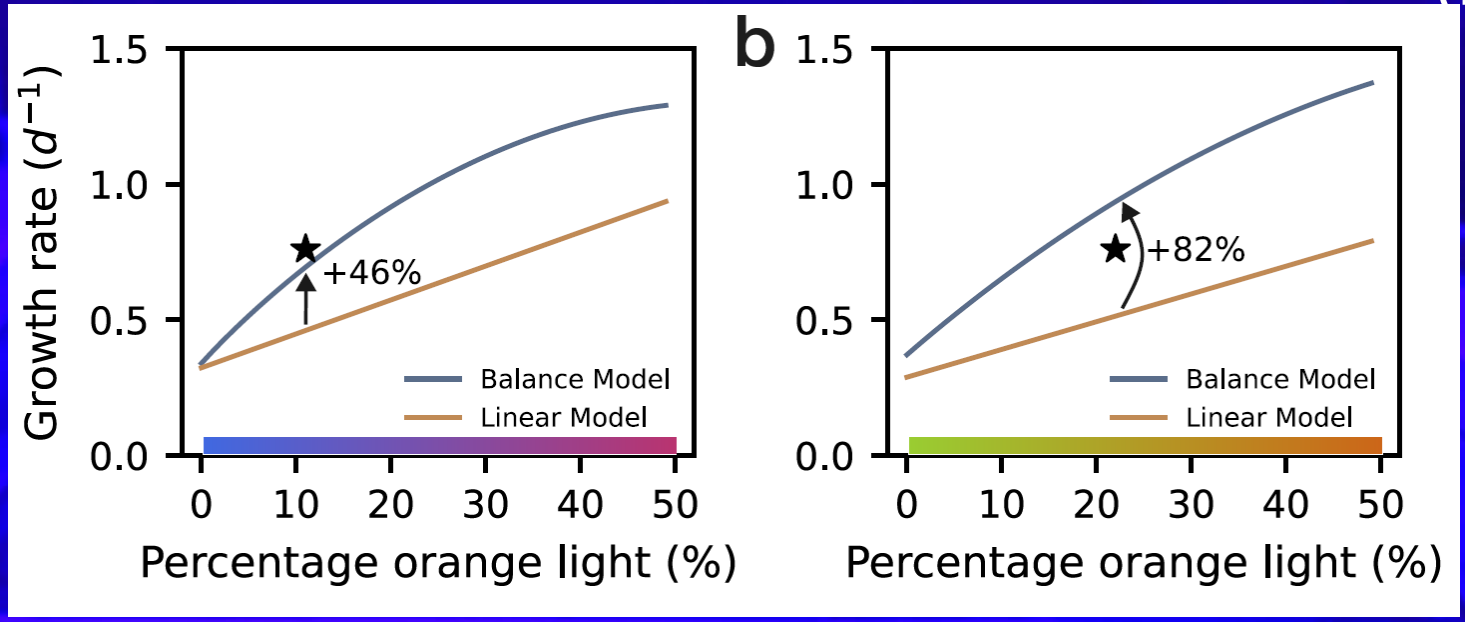
Algae incubator
Jef Huisman Lab
(IBED)





Nonlinear Growth model

Algae incubator
Jef Huisman Lab
(IBED)



Application: Green economy



Nutrient recycling



CO_2 fixation

Algae for Circular economy



Biofuels

Bioplastics



Animal feed



Nutrition



Feedstock

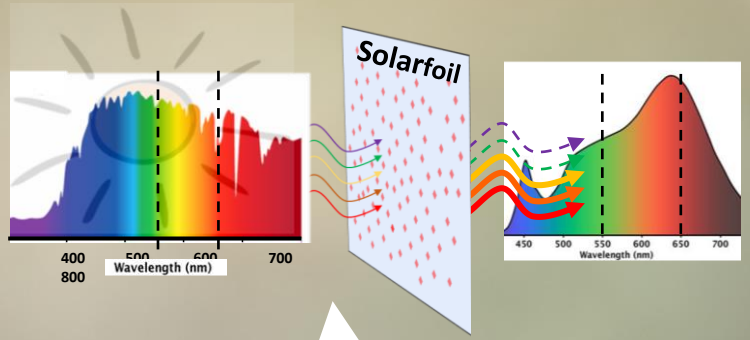


Waste reducer

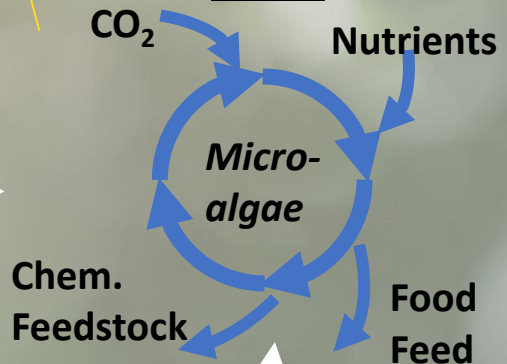
Feedstock provider

UvA USP Project

1. Yield enhancement (*FNWI*)



2. Business modelling (*FEB*)



Result presentation:
SEVEN Brown Bag Lunch, May 18

Feed Food

Application: Green economy



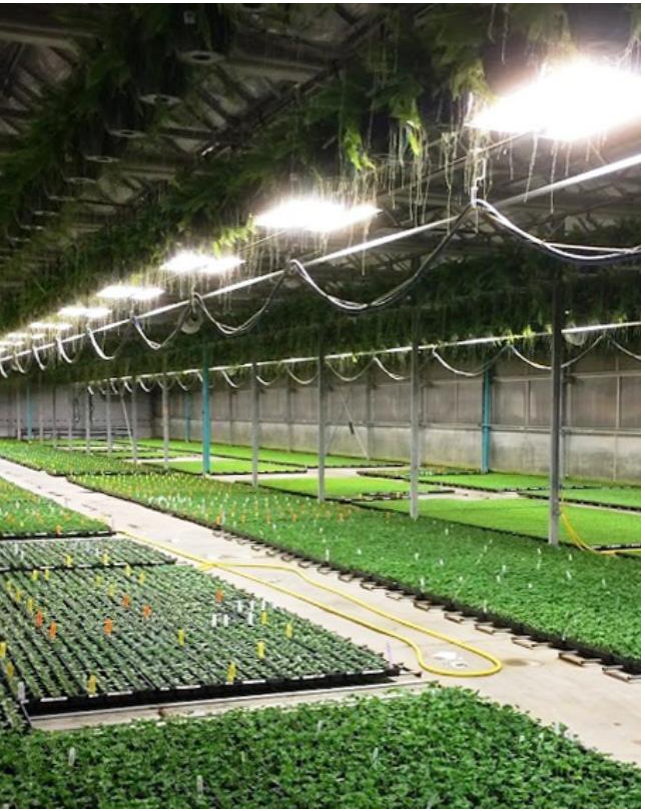
Bioreactors



Polytunnels



Greenhouses



Artificial Lighting has
high energy consumption



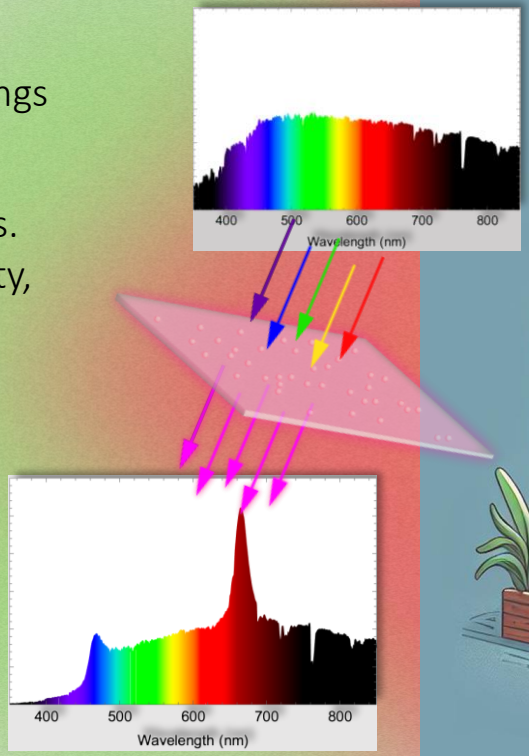
Artificial Lighting already sees the importance of the light spectrum.

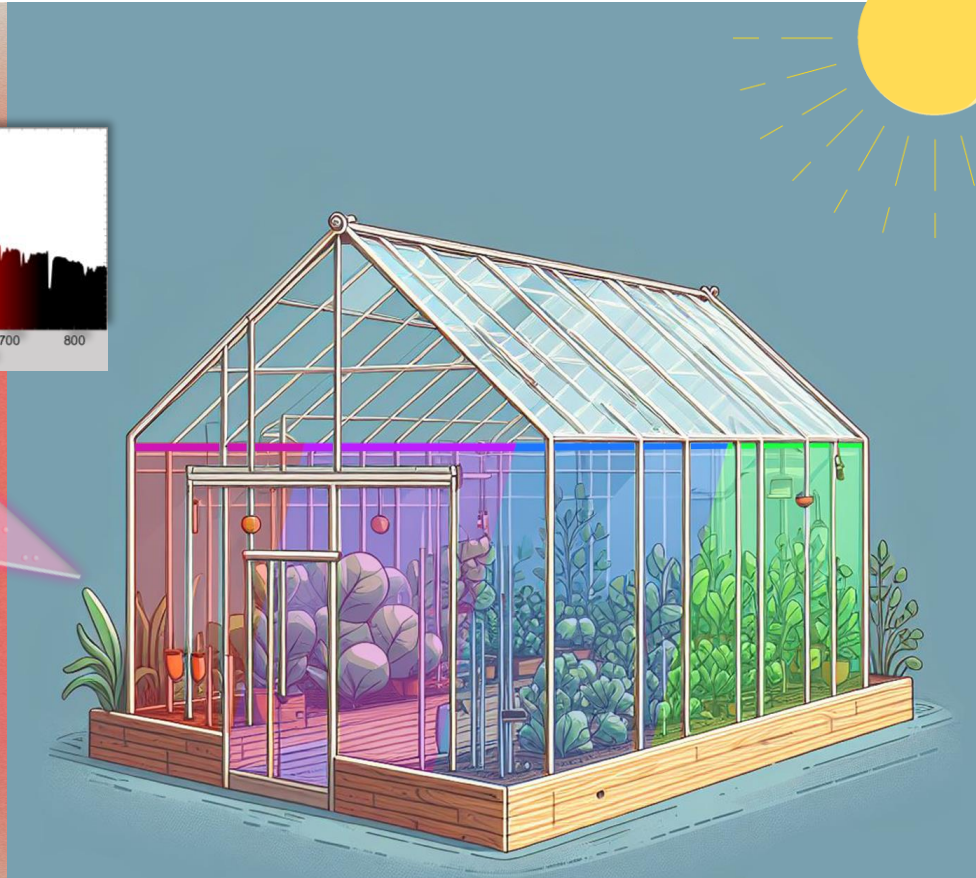
Only possible Since 10-15 years

LED & sun intensity are very different

SOLARFOIL

- Translate Algae learnings into Agriculture.
- Find effective emitters. Consider price, stability, toxicity, industrial compatibility.
- Validate Technology.
- Validate Market.





Conclusions

- Nanoscience:
  Light management, new generation of flexible PV
- Way towards higher efficiencies &
  Building-integrated PV
- Light shaping
  Convert broad sunlight spectrum using nanocrystals
- Not only for PV, but also for agriculture &
  green economy

