

# Solar Energy in Agriculture: High Performance Systems Based on Spectral Beam Splitting



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# Agrivoltaics (first farm 2011)

### **Currently:**

- □ "Hot" topic, PV market \$100 B
- 70% increase of land productivity State level: land resource Farmers: electricity and crops

## **Future prospects:**

- Own consumption
- □ Local residential and industrial estates
- Dever grid food-in

### Commercial facilities:



Monticelli D'Ongina, Italy (source: www.remtec.energy)



Castelvetro, Italy (source: www.remtec.energy)



Virgilio, Italy (source: www.remtec.energy)



Campo D'eco, Abruzzo, Italy (source: www.corditec.it)



Jinzhai plant, Anhui province, China (source: www.remtec.energy)



Changshan plant, Zhejiang province, China (source: www.tonkingtech.com)

## Research facilities:



Biosphere 2, Arizona, USA (source: Kinney et al., 2016)



Montpellier, France (source: www.agrophotvoltaik.de)



Heggelbach, Germany (source: University of Hohenheim)



Santiago de Chile, Chile (source: Fraunhofer ISE)



Chiba Prefecture, Japan (source: www.renewableenergyworld.com)

Weselek et al. Agronomy for Sustainable Development (2019) 39: 35



**<u>Challenge</u>**: PV and crops are competing on the same waveband: Visible (PAR)

Significant decrease in crop yield (and/or in PV potential output)

## Example: Lettuce

Valle et al., 2017







# **Spectral Beam Splitting**



**Our concept:** Splitting the spectrum and optimizing the conversion mechanism of each waveband  $\rightarrow$  Significant increase in the efficiency



## Light experiments with plants underneath the agriculture photovoltaic system



Wen Liu et al., Solar Energy, 2018



DLR, 2018

Solar spectrum separation: light for plant growth is transmitted (red and blue light), all other light is being reflected on concentrator solar cells for solar power generation



# LER



Mittelman et al., EU-PVSEC, 2018

Reference







# Wanted: Spectral Splitters

Task 1: optical mirrors from catalog:

- Hot Mirror, Red-Blue filter
- large scale (0.5 m<sup>2</sup>)
- specular reflectance at IR for a 45° AOI



## Task 2: Dedicated design







Optical tests, Optics Ray Tracing



Agricultural Research Organization (ARO)



