Dr Max Trommsdorff

Agrivoltaics Workshop for Lightsource bp

May 22/23, 2024

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Introduction

Introduction

Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft based in Germany is the world's leading organization for applied research.

- **76 institutes and research facilities** with over **30 800 employees,** predominantly scientists and engineers
- Annual research budget of **3.0 billion euros**, of which **2.6 billion euros** is generated through **contract research**
- Around **two thirds** of Fraunhofer's contract research revenue is derived from contracts with **industry and publicly funded research projects**. The federal and state governments contribute around another **third as base funding**.
- **International collaborative partnerships** with outstanding research partners and businesses worldwide provide direct dialogue with the most prominent scientific communities and dominant economic regions.

Fraunhofer international

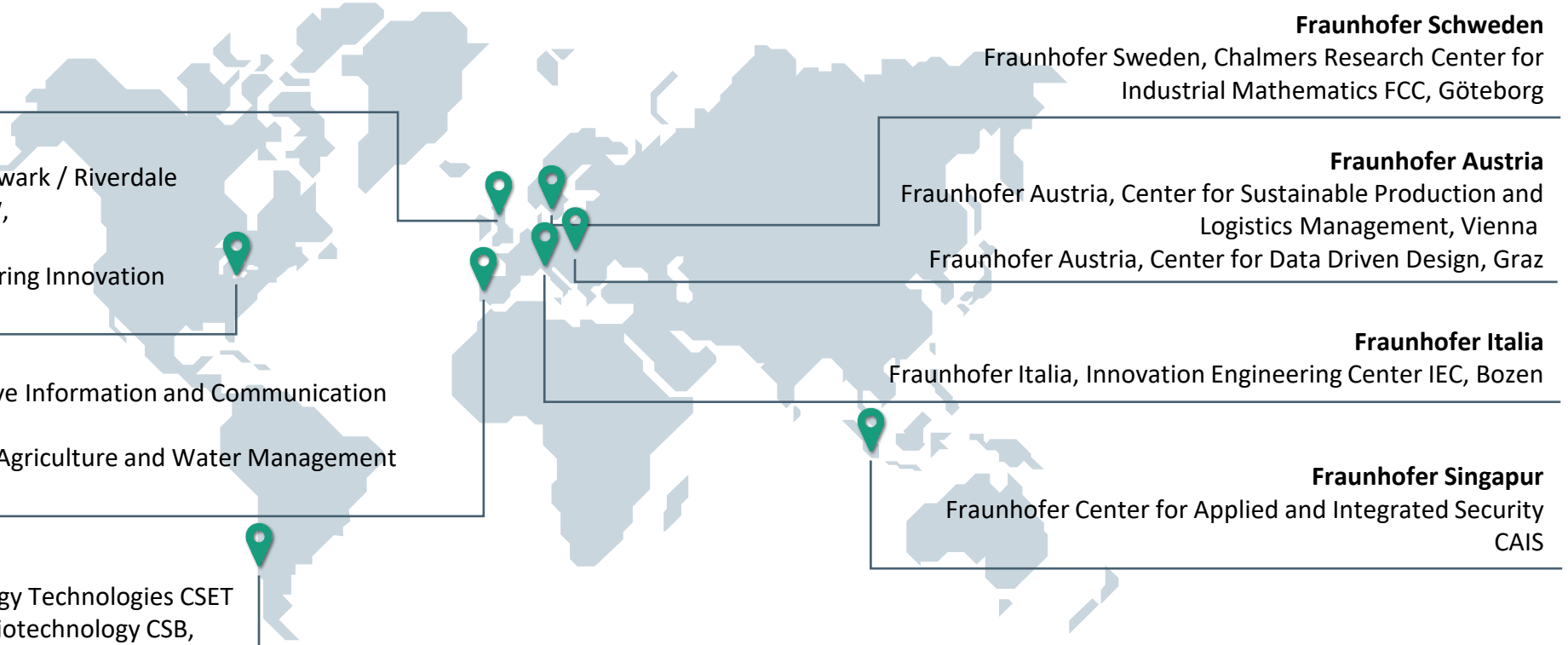
Fraunhofer Centers Worldwide

Fraunhofer UK
Fraunhofer UK, Centre for Applied Photonics CAP, Glasgow

Fraunhofer USA
Fraunhofer USA, Mid Atlantic CMA, Newark / Riverdale
Fraunhofer USA, Center Midwest CMW, East Lansing / Plymouth
Fraunhofer USA, Center for Manufacturing Innovation CMI, Brookline

Fraunhofer Portugal
Fraunhofer Portugal, Center for Assistive Information and Communication Solutions AICOS, Porto
Fraunhofer Portugal, Center for Smart Agriculture and Water Management AWAM, Vila Real / Évora

Fraunhofer Chile
Fraunhofer Chile, Center for Solar Energy Technologies CSET
Fraunhofer Chile, Center for Systems Biotechnology CSB, Santiago de Chile



Fraunhofer Schweden
Fraunhofer Sweden, Chalmers Research Center for Industrial Mathematics FCC, Göteborg

Fraunhofer Austria
Fraunhofer Austria, Center for Sustainable Production and Logistics Management, Vienna
Fraunhofer Austria, Center for Data Driven Design, Graz

Fraunhofer Italia
Fraunhofer Italia, Innovation Engineering Center IEC, Bozen

Fraunhofer Singapur
Fraunhofer Center for Applied and Integrated Security CAIS

Fraunhofer Institute for Solar Energy Systems ISE

Carrying out Research for the Energy Transition since 1981

The Institute in Numbers

Institute Directors
Prof. Dr. Hans-Martin Henning
Prof. Dr. Andreas Bett

Staff around 1500

Budget 2022

Operation	€111.5 million
Investment	€ 9.1 million
Total	€120.6 million

Fraunhofer ISE

Fraunhofer Institute for Solar Energy Systems ISE

Vision

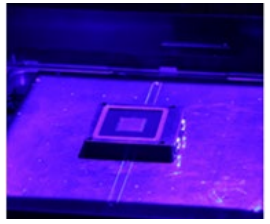
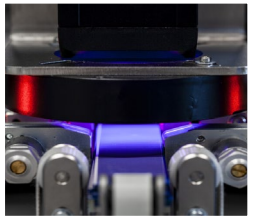
Our driving motivation is to secure the livelihood of present and future generations and protect our natural resources.

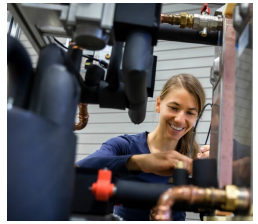
Fraunhofer ISE

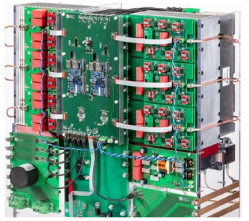
Fraunhofer Institut for Solare Energy Systems ISE

Our Business Areas

Photovoltaics – Materials, Cells, Modules	Solar Power Plants and Integrated Photovoltaics	Electrical Energy Storage	Power Electronics and Grids
Photovoltaics – Production Technology and Transfer	Climate-Neutral Heat and Buildings	Hydrogen Technologies	System Integration

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Solar Power Plants and Integrated Photovoltaics

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Research Topics

- Module Analysis and Reliability
- Photovoltaic Solar Power Plants
- **Integrated Photovoltaics**
- Solar Thermal Power Plants
- Solar Energy Meteorology

Group Agrivoltaics at Fraunhofer ISE

Quick facts

- Originator of the idea of agrivoltaics in 1981
- Research on agrivoltaics since 2010
- 60 researchers from 10+ disciplines
- More than 130 R&D projects in 33 countries
- Agrivoltaics lab with currently 3 different system designs

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Overview, Definition and Techno-Ecological Synergies of Agrivoltaics

Diversity of Agrivoltaics

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Overview, Definition and Techno-Ecological Synergies of Agrivoltaics

Diversity of Agrivoltaics

Source: REM


Source: BayWa r.e.

Overview, Definition and Techno-Ecological Synergies of Agrivoltaics

Diversity of Agrivoltaics

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Overview, Definition and Techno-Ecological Synergies of Agrivoltaics

Diversity of Agrivoltaics


Source: Oregon State Universtiy, Mark Floyd


Source: Next2Sun

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Overview, Definition and Techno-Ecological Synergies of Agrivoltaics

Diversity of Agrivoltaics


Source: Agrithermic


Source: CVE

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Definition of agrivoltaics

Why a common understanding matters

- Novelty of the technology
- Diversity of agriculture and agrivoltaics concepts and applications
- High number of involved stakeholders -> intersectoral communication
- Essential for creating legal framework

➢AGREEvoltaics!

Definition of agrivoltaics

Definition criteria

- How can we define agrivoltaics?
- Definition criteria in literature and in guidelines
  - Collocation of agriculture and PV power production
  - Specification of what is considered as agriculture and PV in the context of agrivoltaics
  - Principle of photon sharing between agriculture and PV power production (solar sharing)
  - Primary agricultural land use
  - Increase of land use efficiency
  - Synergies between agriculture and PV
  - Interactions between agriculture and PV

Definition of agrivoltaics

Definition criteria

Collocation of agriculture and PV power production

- Overhead and interspace agrivoltaics
- Maximum of allowed spatial distribution of interspace systems
- Difficult to set a general distance
  - Interactions between agriculture and PV as requirement?
  - Land use efficiency?

Definition of agrivoltaics

Definition criteria

What is considered as agriculture (and PV) in the context of agrivoltaics

- “Agriculture is the science, art and practice of cultivating plants and livestock.” (International Labour Organization)
- Narrow definition for agrivoltaics: “Agriculture in agrivoltaics is the ~~science, art and~~ practice of cultivating plants and livestock.”
- PV -> only photovoltaics?

Definition of agrivoltaics

Definition criteria

What is considered as agriculture (and PV) in the context of agrivoltaics

- Cultivating plants
  - Arable farming / staple food
  - Horticulture / fruits, vegetables, ornamentals
  - Vertical farming / mushrooms
- Livestock
  - Dairy, meat, poultry
  - Aquaculture, Insects
  - Bee-keeping
  - Barns and stables

Definition of agrivoltaics

Definition criteria

What is considered as agriculture (and PV) in the context of agrivoltaics

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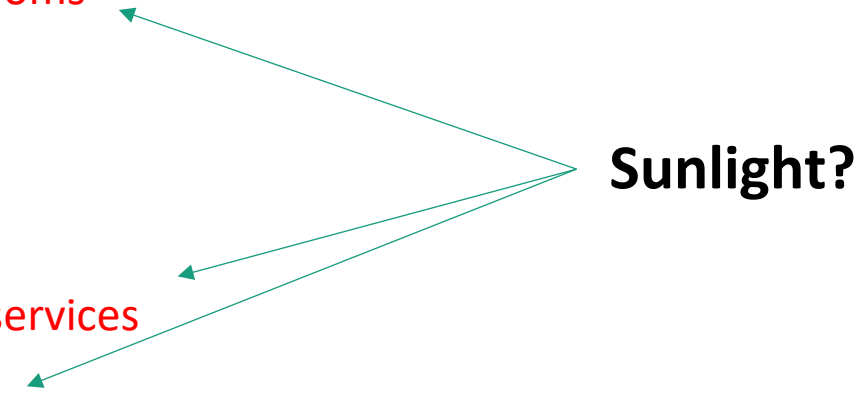


Definition of agrivoltaics

Definition criteria

Principle of photon sharing between agriculture and PV power production (solar sharing)

- Cultivating plants
  - Arable farming / staple food ✓
  - Horticulture / fruits, vegetables, ornamentals ✓
  - Grassland, hay production ✓
  - Vertical farming ?
  - mushrooms ✗
- Livestock
  - Dairy, meat, poultry ?
  - Aquaculture, Insects ?
  - Bee-keeping, ecosystem services ?
  - Barns and stables ✗

Definition of agrivoltaics

Definition criteria

Primary agricultural land use

How to define the primary use of land?

- Political goals
- Official (administrative) land use
- Intensity of agricultural land use
- Intensity of PV land use?
- Involvement of agricultural stakeholders

Definition of agrivoltaics

Definition criteria

Primary agricultural land use

How to define the primary use of land?

- Political goals
- Official (administrative) land use
- **Intensity of agricultural land use**
- **Intensity of PV land use**
- Involvement of agricultural stakeholders

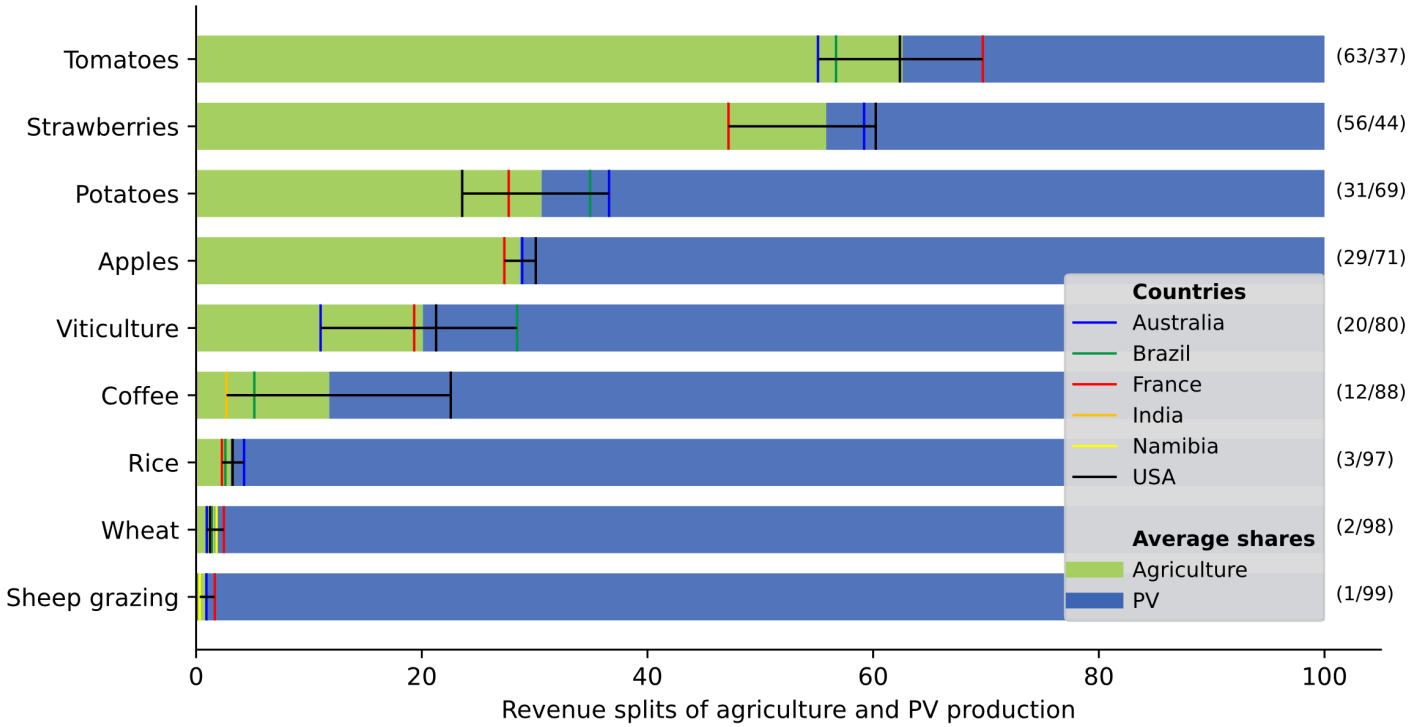
Definition of agrivoltaics

Definition criteria

Primary agricultural land use

- Setting criteria for sufficiently intense agriculture
  - Minimum agricultural yield
  - Minimum land available for cultivation
  - Added agricultural value
  - …

➢ **Is this enough?**



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Definition of agrivoltaics

Definition criteria

Primary agricultural land use

- Setting criteria for sufficiently intense agriculture
- + Setting criteria for maximum PV intensity?
  - Maximum ground cover ratio (GCR)
  - Maximum land losses
  - ….

Definition of agrivoltaics

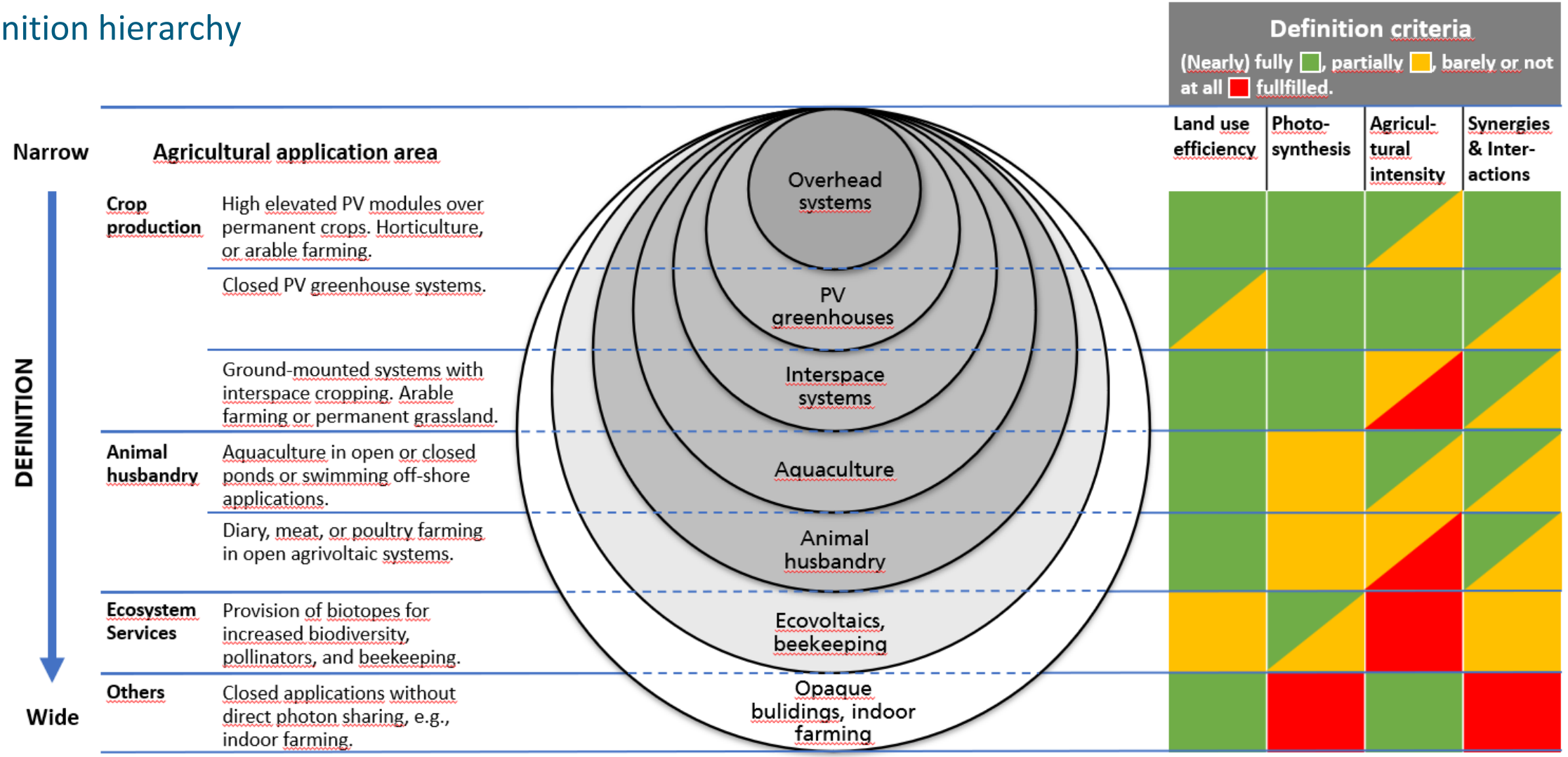
Definition criteria

Increase of land use efficiency

- Much depending on synergies and interactions between agriculture and PV
- Synergies & interactions are hard to measure -> task for R&D

Definition of agrivoltaics

Definition hierarchy



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Definition of agrivoltaics

Definition criteria

- There is no one and only agrivoltaics
- Considering narrow and broader definitions is complex
- But it’s also a strength

Thank you for your attention





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