Agrivoltaics and Biomass = Win-Win Solution

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Frank Radosits

Energy Economics Group (TU Wien)
Gußhausstraße 25-29, Vienna, 1040, Austria

Jiří Bím

Faculty of Electrical Engineering, Czech Technical University in Prague,
Prague, 160 00, Czech Republic

Outline

1. Types of agrivoltaics
2. Benefits in crop production
3. Methodology
4. Results
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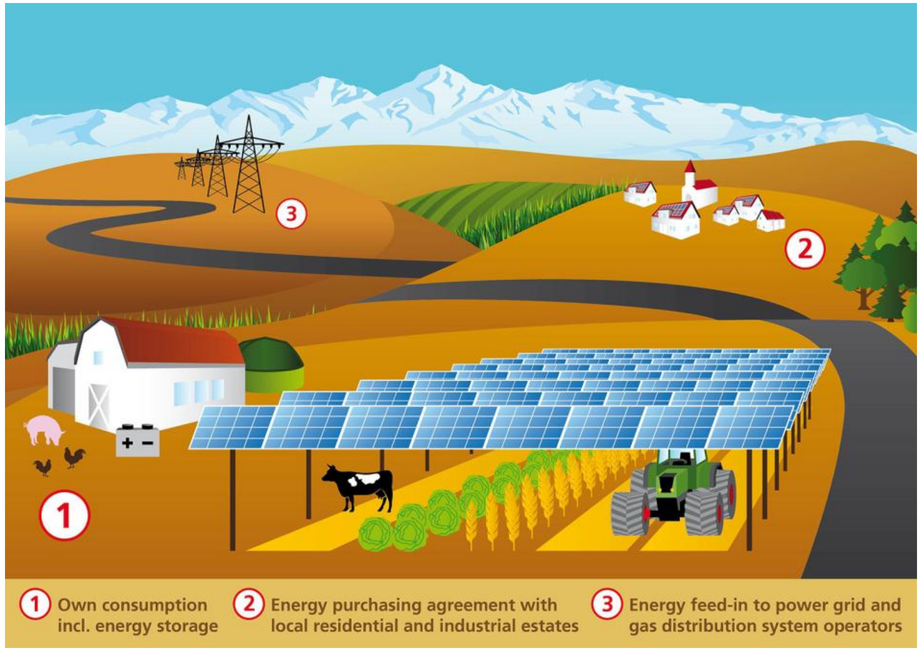
   - -Regulations
5. Conclusions



Types of agrivoltaic systems

- The main division of agrivoltaic installations is in vertical and horizontal forms
- Mainly are used bifacial photovoltaic panels
- Horizontal agrivoltaic system – south oriented panels or east-west “roofs” oriented with panels – protection role
- Vertical agrivoltaic system – east-west oriented “fences” – less then 10 % of land for technology



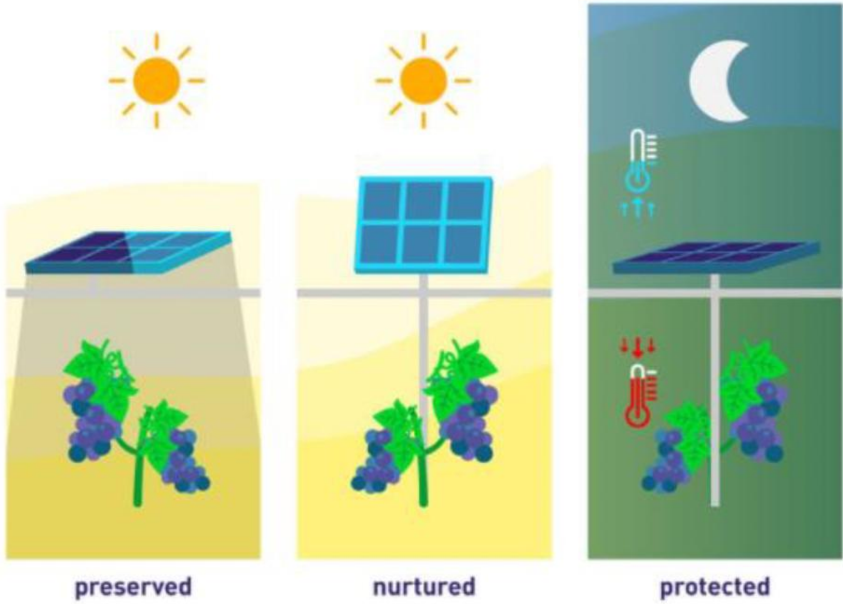
Multiple benefits of agrivoltaic system

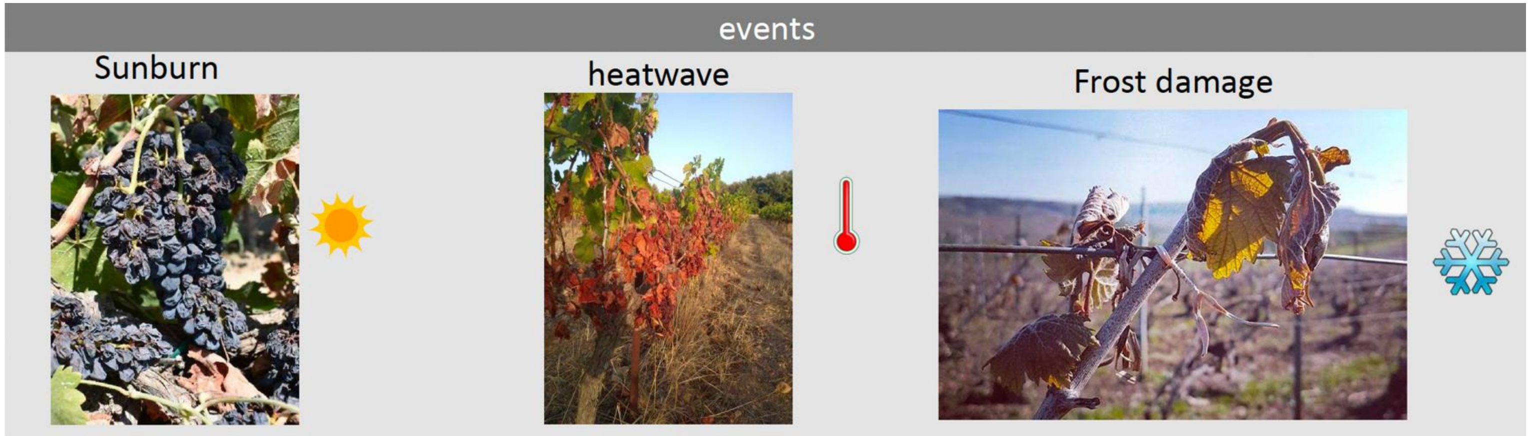
- Technical – e.g. distributed electricity production
- Economic - decrease electricity costs and bring additional economic profit/savings for farmers
- Social - sector development and local employment increase
- Environmental - agrivoltaics systems produce “green” electricity, improve soil conditions,

  improve conditions for planting crops

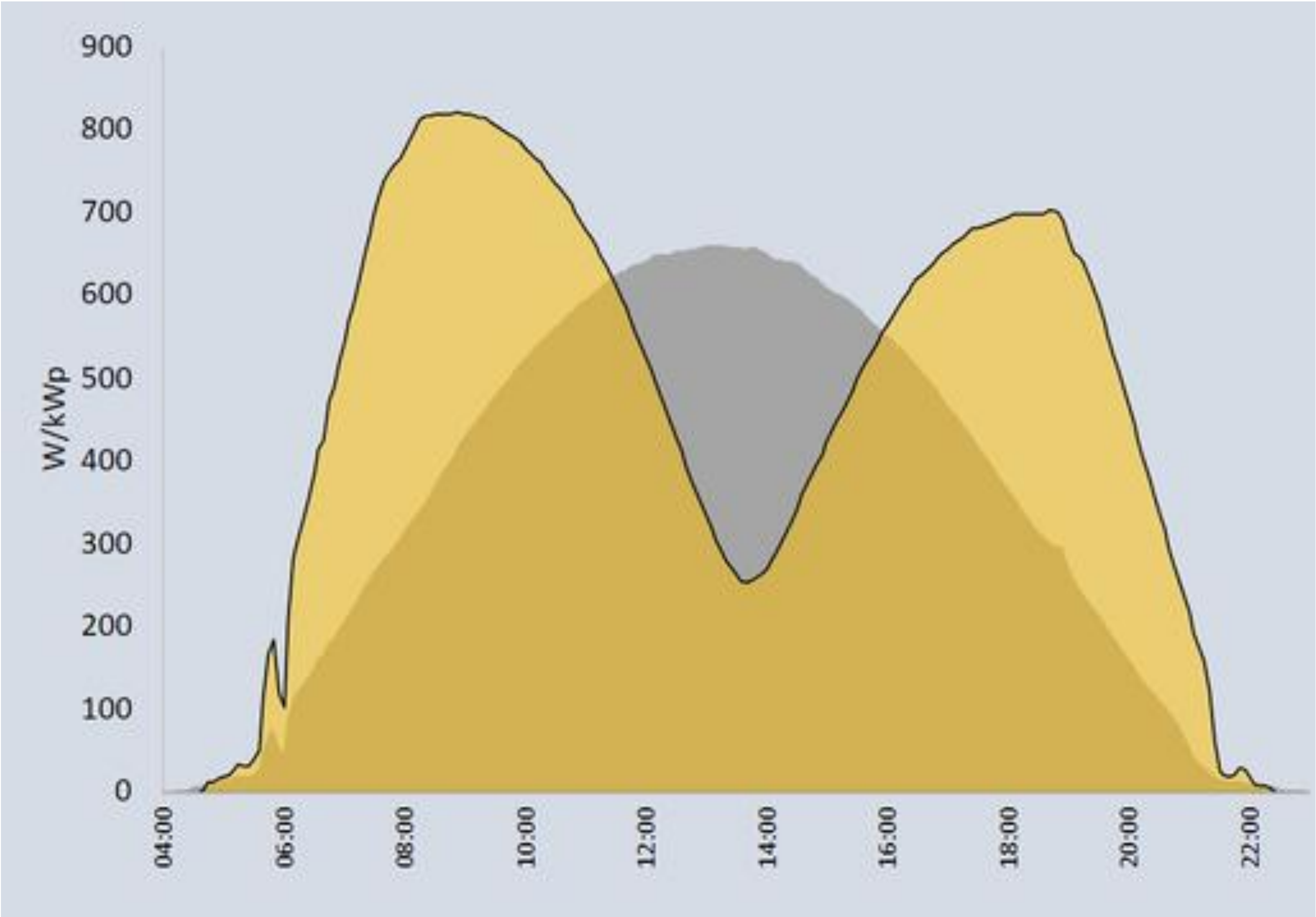
Production protection

- Physical protection of fruit from heavy rain/hail
- Reducing the pressure of fungal diseases
- Protection against damage from strong direct sunlight
- Protection against spring frosts and high temperatures
- Differences between fixed structures and structures with a tracker



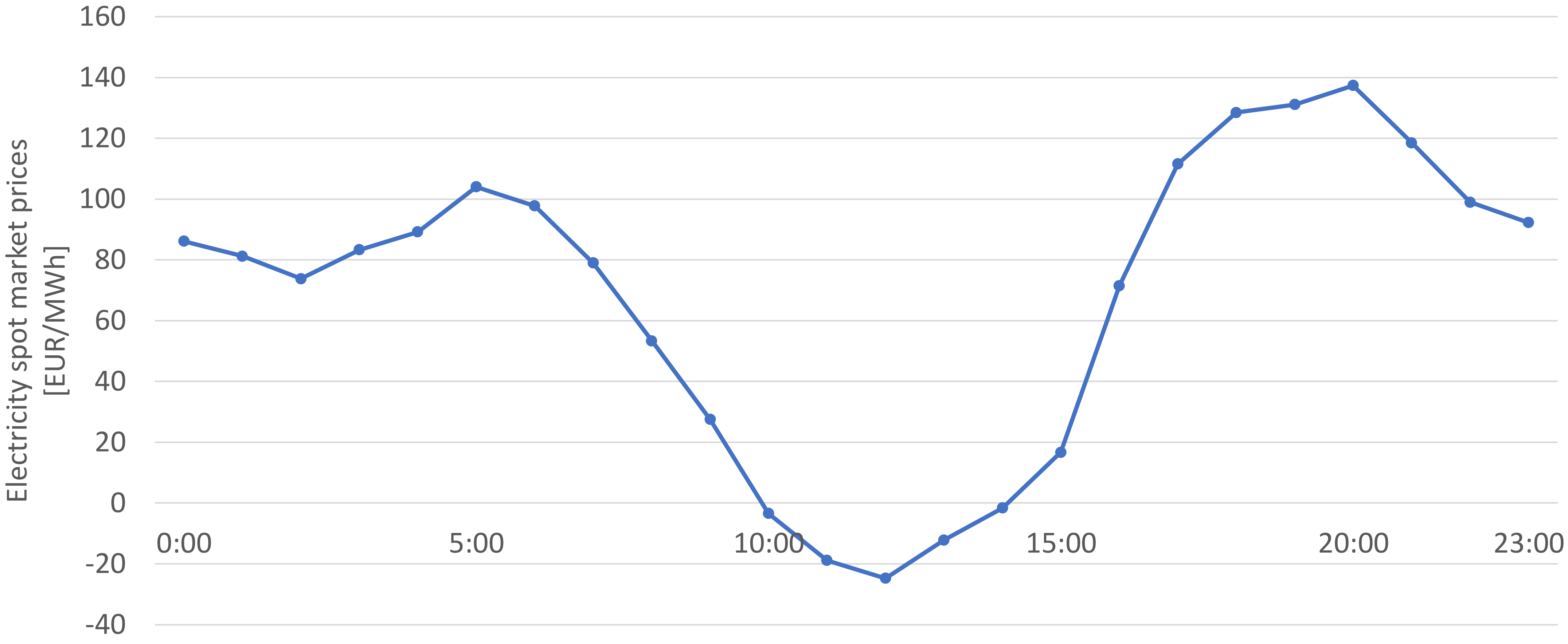


Technical and economic aspects



https://vertical.solar/energy-yield_new

Technical and economic aspects

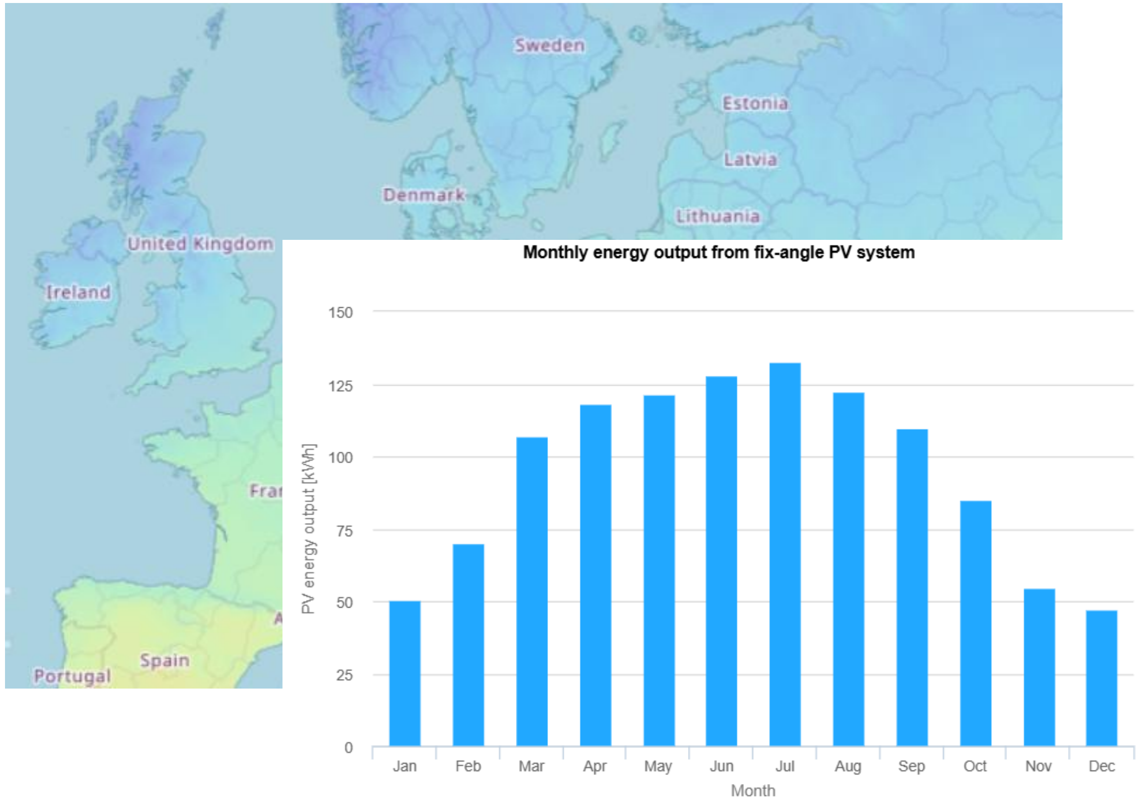


July 5, 2023 - Germany

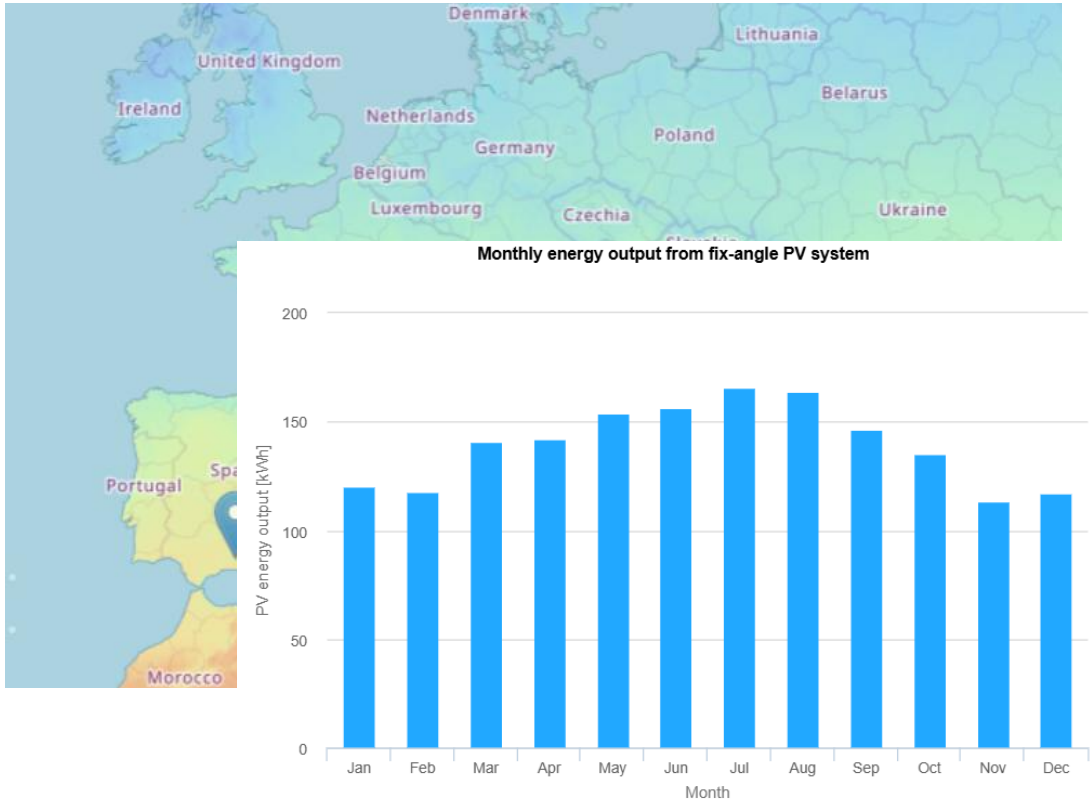
Source: https://transparency.entsoe.eu

Methodology

Aasen, Germany

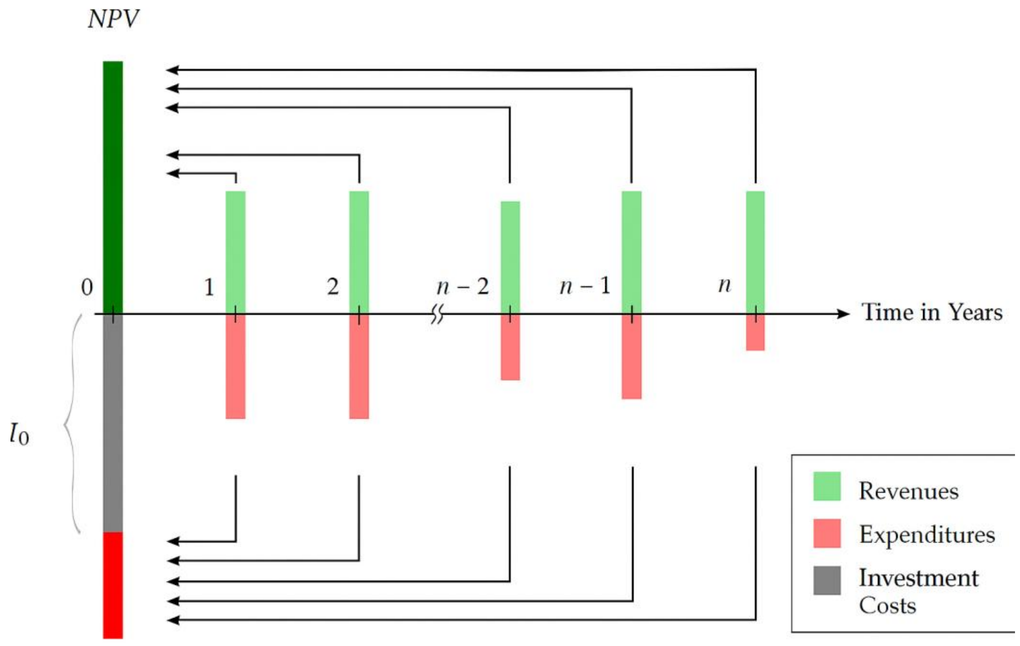


Alhendín, Spain



Methodology

- $NPV = -I_0 + \sum_{i=1}^{n} \frac{CF_i}{(1+r)^i} + \frac{L}{(1+r)^n}$



- Literature analysis on regulations in EU member states

NPV — Net present value (NPV) of the investment in EUR
I_0 — Investment costs at time 0 in EUR
CF_i — Cash flow in period *i* in EUR
r — Selected discount rate for the net present value calculation
L — Residual value of the investment at the end of the analysis period in EUR
n — Analysis period in years

Input data

Table 1. Cost input data for the NPV calculations.

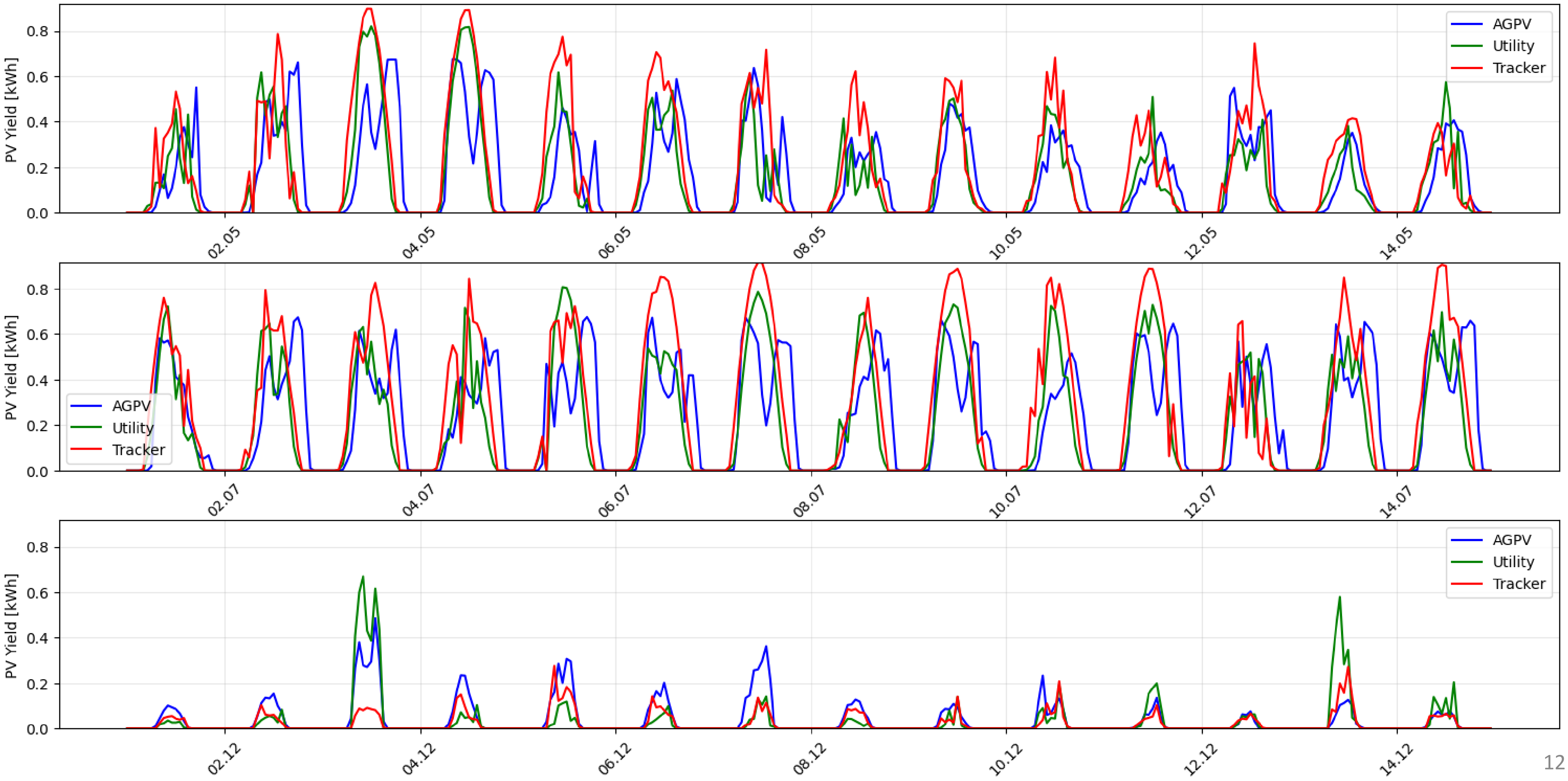
	Agriculture	Agriculture + vertical PV	Agriculture + trackers	Conventional ground mounted solar	
Row distance	-	6 m	8 m	5 m	
Installed capacity	-	620 kWp/ha	1000 kWp/ha	1070 kWp/ha	
Investment costs	-	690 EUR/kWp	759 EUR/kWp	560 EUR/kWp	
Market premium		52 EUR/MWh 45 EUR/MWh	52 EUR/MWh 45 EUR/MWh	52 EUR/MWh 45 EUR/MWh	-Germany -Spain

1 EUR = 24.009 CZK

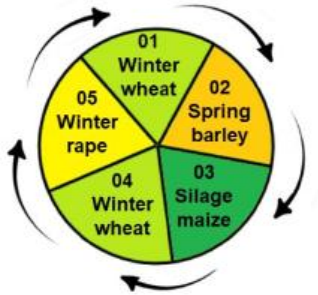
Scenarios

- South FIX
- East-west tracker
- East-west vertical

PV production yield

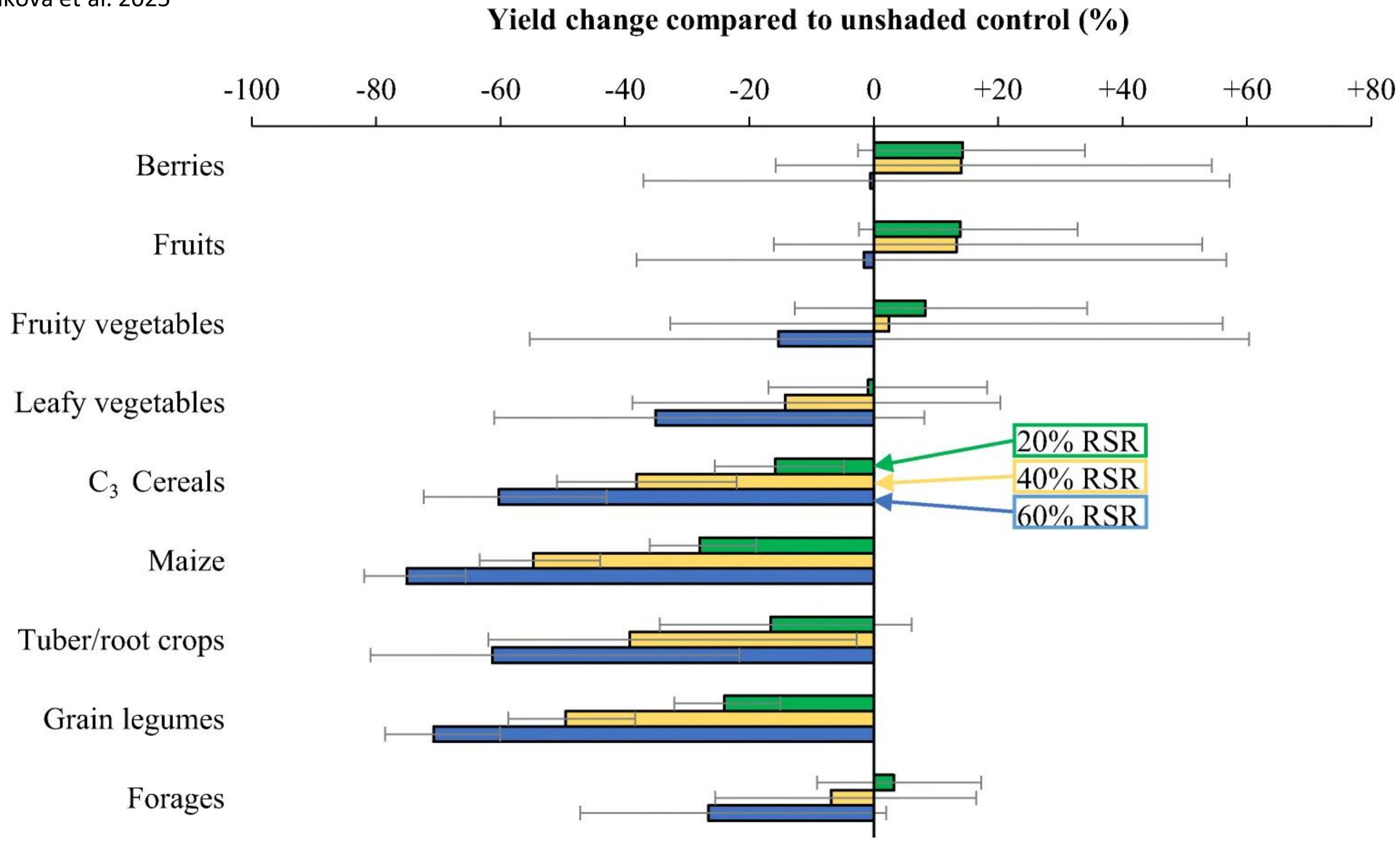


Crop rotations



Pohanková et al. 2025

- Germany
  - 1st rotation: Winter wheat → spring barley → silage maize → winter wheat → winter rapeseed
  - 2nd rotation: Winter wheat → Corn → Winter rapeseed → Sunflower → Beans → Potatos → Forage legumes



Laub et al. 2022

- Spain (Sanchez-Navarro et al. 2021)
  - 1st rotation: Winter wheat → Sunflower → Legume → Cover crops
  - 2nd rotation: Corn → Winter wheat → Legumes → Potatos

Revenues from crops

Table 2. Average revenues and yields per crop type in Germany.

	Revenues [EUR/t]	Yield [t/ ha]
Winter wheat	220.5	6.83
Corn	236.4	8.02
Rapeseed	487.1	3.57
Sunflower	421.4	2.79
Peas	281.6	2.74
Potato	240.8	25.99
Forage legumes	49.03	20.7

Aasen, Germany

Table 3. Average revenues and yields per crop type in Germany.

	Revenues [EUR/t]	Yield [t/ ha]
Winter wheat	220.0	3.22
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Rapeseed	420.0	2.17
Sunflower	410.0	2.79
Peas	310.0	1.98
Potato	240.8	31.97
Forage legumes	49.03	18.75

Alhendín, Spain

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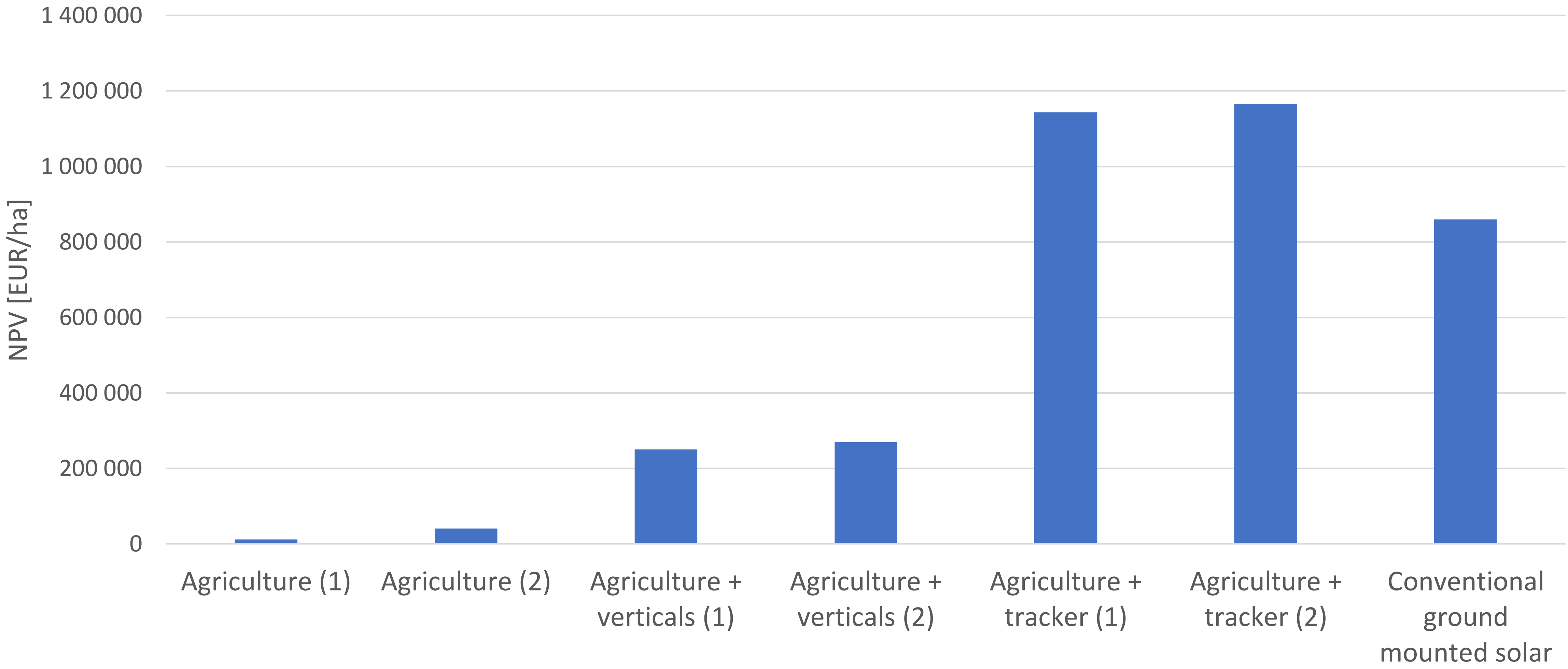
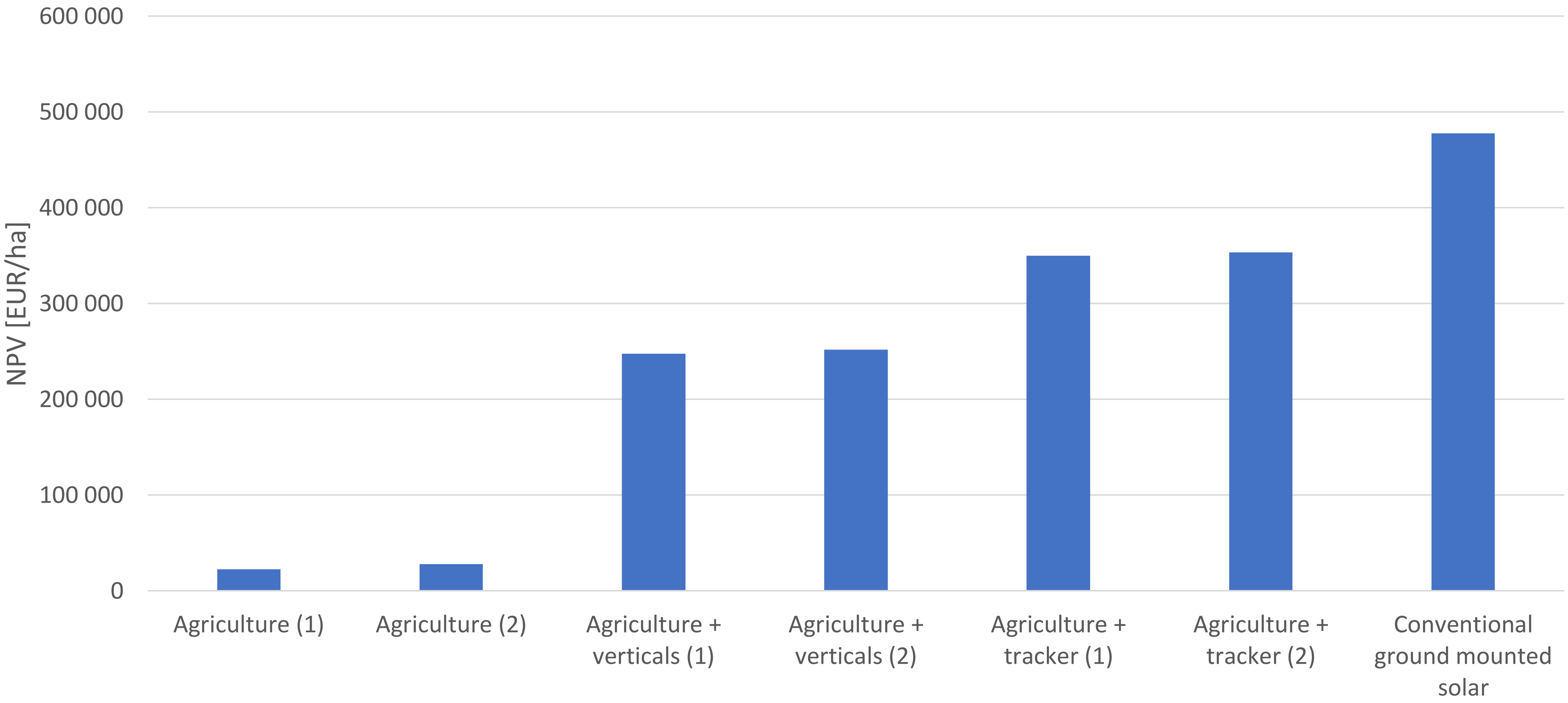
Alhendín, Spain

Average assumed subsidies are 183-289 EUR/ha.

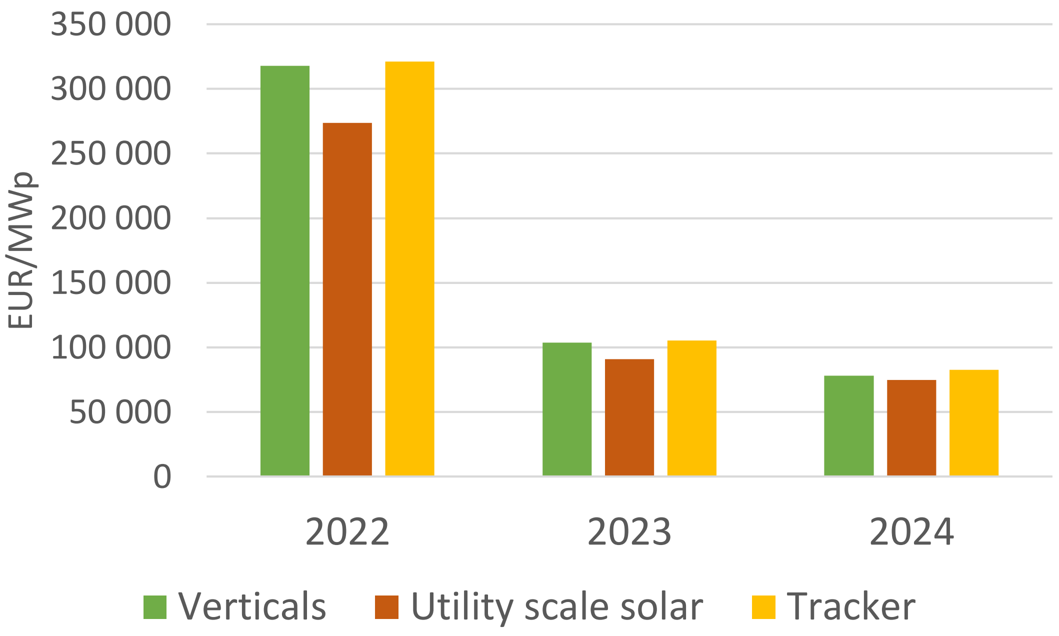
Results – Alhedín, Spain



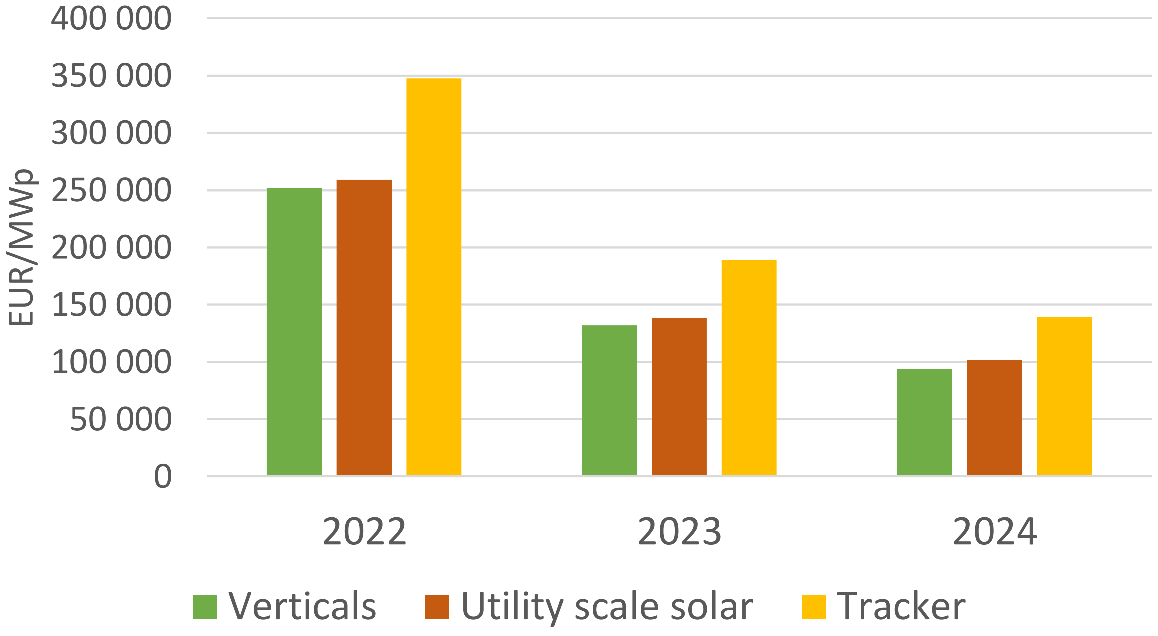
Results – Aasen, Germany



Results – Revenues from electricity sales



Aasen, Germany



Alhendín, Spain

Regulations

Overview of enabling policies for Agri-PV across Member States

		Belgium	Czech Republic	Croatia	Denmark	France	Finland	Germany	Greece	Hungary	Ireland	Italy	Latvia	Netherlands	Poland	Portugal	Slovenia	Spain	Sweden
Legal definition	Clear legal definition of Agri-PV	No	Yes	Yes	No	Yes	No	Yes	No	No	No	No	No	No	No	No	Yes	In progress	No
Land use, zoning & permitting	Agri-PV systems are permitted under the land use & zoning regulations	Yes	Yes	Yes	Yes	Yes	Unknown	Yes	Unknown	No	Yes	In progress	Yes	No	Yes	Yes	In progress	No	No
	Simplified & dedicated permitting process for Agri-PV	No	No	No	No	Yes	No	Under certain circumstances	No	No	No	Under certain circumstances	No	No	No	No	No	No	No
	Clear requirements for EIAs or other type of impact assessments for Agri-PV	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Under certain circumstances	No	Yes	Yes	Yes	Yes	Yes	Yes
Support schemes	Agri-PV systems are eligible for CAP direct payments	No	Yes	No	In progress	Yes	No	Yes	Unknown	In progress	No	Under certain circumstances	No	Yes	No	No	No	In progress	No
	Agri-PV systems are included in the energy suupport schemes (e.g. FiT, auctions, CfDs)	No	In progress	No	No	Yes	No	Yes	Unknown	No	No	Yes	No	No	No	No	No	No	No
Technical Requirements	Clear rules on Ground Coverage Ratio (GCR)	No	No	No	No	Yes	No	No	Unknown	No	No	Yes	No	No	No	No	Yes	In progress	No
	Clear minimum height and spacing requirements	No	Yes	No	No	Yes	No	Yes	Unknown	No	No	Yes	No	No	No	No	Yes	In progress	No

Yes No In progress Under certain circumstances Unknown

Conclusions

- Revenues from electricity production can be higher for agrivoltaics per MWp of installed capacity.
- Revenues from crop sales contribute only a minor share to the NPV.
- The main reasons for differences in NPV per hectare are investment costs and row distances.
- A larger row distance can be advantageous for certain crops.
- Improvements in the regulatory framework are important.

Thank you for your attention!

Jiri Bim

bimjiri@fel.cvut.cz

Frank Radosits

radosits@eeg.tuwien.ac.at