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PHOTOVOLTAICS

Agri-PV: Synergies between Renewable Energy and Agriculture

What is Agri-PV?

Agri-PV (Agrivoltaics) is a technology where solar panels are installed on agricultural land to generate renewable electricity while also engaging in farming. The technical and conceptual variations of Agri-PV are already diverse and are continually being refined and optimized through innovations. Unlike conventional ground-mounted PV systems, Agri-PV integrates both crop cultivation and livestock farming on the same land.

Figure 1: High elevated system with continuous row of modules - Experimental station for fruit and vine cultivation in Haidegg.

Potential of Agri-PV

Agri-PV has the potential to increase land use efficiency, based on a high theoretical area potential. In Europe, France, Italy, and the Netherlands are particularly leading in the use of Agri-PV. France has promoted projects with a capacity of up to 5 MWp early on and extensively. The changing climatic conditions are expected to drive the demand for Agri-PV in Austria as well. With rising temperatures, some plants increasingly need protection from heat, making the shading from PV modules, as in Agri-PV, more significant. Outside of Europe, markets like Japan, China, and some US states are leading in the development of Agri-PV.

Synergies of Agri-PV

The multiple use of the same areas significantly contributes to solving the perceived competition for land use among energy production, agriculture, biodiversity, open spaces, and building land. Agri-PV offers farmers and the region numerous advantages for strengthening local value creation.[3]

- Protection of crops from extreme weather events such as hail, heavy rainfall, and heatwaves
- Protection of certain crops from increased direct sunlight
- Reduced risk of late frost
- Decreased use of pesticides due to shorter leaf wetness periods
- Diversification of income sources for farmers
- More efficient electricity generation due to the cooling effect of evapotranspiration

Additional Benefits for Agriculture

Depending on the specific installation concept, 85 to 90% of the area can continue to be used for the production of food or fodder. This simultaneously benefits agricultural production by reducing evaporation, protecting against erosion, shielding from extreme weather, and aiding in climate change adaptation. Researchers at the University of Hohenheim evaluated 58 studies to examine the response of various plant species to reduced light in Agri-PV systems. Fodder plants, leafy vegetables, and root/tuber crops show lower yield losses under slight shading, while berry bushes, fruit/vine crops, and fruit vegetables can even benefit from moderate shading. Based on these findings, berry bushes, fruit, and leafy vegetables are better suited for cultivation in Agri-PV systems compared to maize or grain legumes. They found that significant shading leads to yield losses in certain plants, with grain legumes like soybeans and maize being the most affected.

Technology

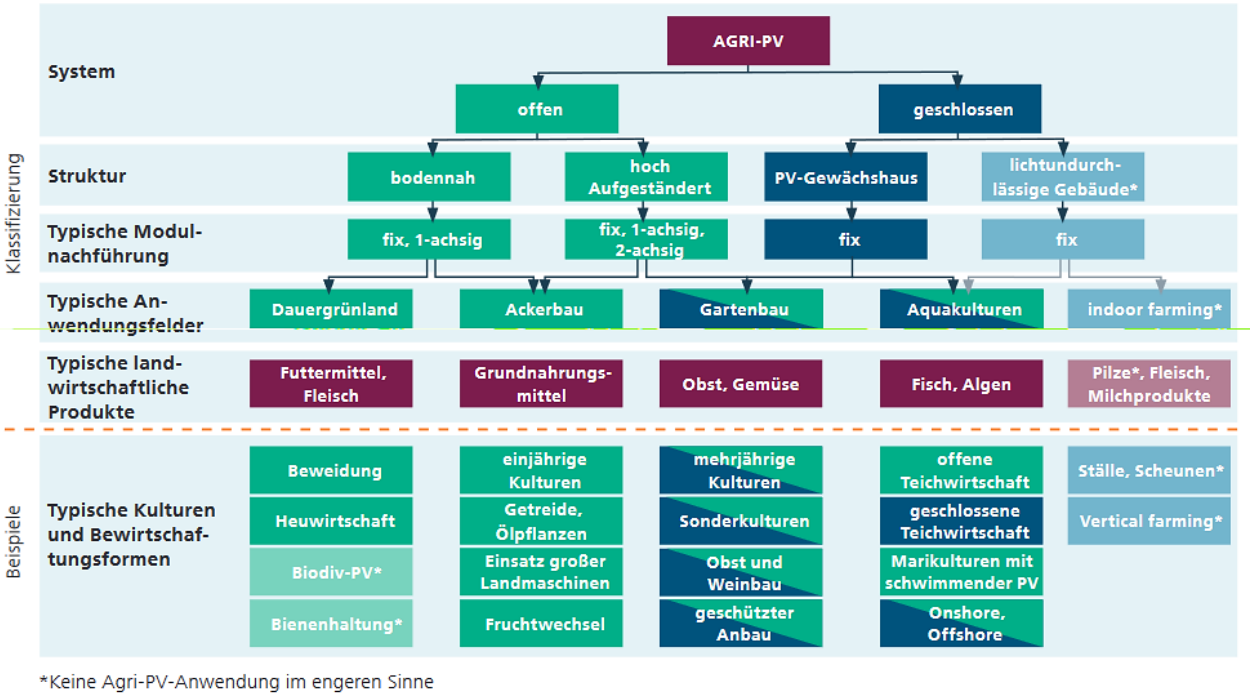

Figure 2: Classification of Agri-PV Systems. Source: ©Fraunhofer ISE [2], no translation

Examples of Technology Deployment in Agri-PV

There are various options for the orientation of PV modules, classified by the type of mounting into ground-mounted, elevated, and high-clearance systems. In the latter, the height or number of installed PV modules can be adjusted as needed, allowing for the use of conventional agricultural equipment beneath the modules. A rough classification is as follows:[2]

Bifacial modules: Receive light from both sides and provide increased safety in case of glass breakage. They are more cost-effective to install but have limited light management options.
High-elevated systems: Solar modules are installed 3-5 meters [3] or higher above the ground, providing protection from environmental influences. Semi-transparent bifacial panels enable synergy effects in certain crops.
Foundation and substructure: Adapting the foundation and substructure to agricultural needs influences the performance of the systems. Construction heights vary depending on the application area.
Light and water management are crucial for the protection of crops. PV modules can direct rainwater away or collect it, while irrigation systems ensure water availability.

Challenges

- Financing: Compared to conventional ground-mounted PV systems, the investment costs for optimizing the design of AgriPV systems tend to be higher and are strongly dependent on the location and system. However, with subsidies, AgriPV is often more economically attractive compared to pure groundmounted systems.
- Definition and Standardization
- Reevaluation in Spatial and Regional Planning: Sustainable spatial planning addresses potential land use conflicts as early as possible. In this context, generation and consumption, as well as existing and future infrastructure, must be considered together in regional planning areas to enable the efficient integration of renewable energies.
- Further research is needed to optimize the synergy potential inherent in the combined use of PV and agriculture.

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TECHNOLOGIE PLATTFORM PHOTOVOLTAIK

Links

[1] Deutsche Energie-Agentur GmbH (dena): "Welche Mehrwerte kann die Agri-PV für die Energie-und Agrarwende bieten?" Verfügbar unter: [https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2023/IMPULSPAPIER_Welche_Mehrwerte_kann_die_Agri-PV_fuer_die_Energie-_und_Agrarwende_bieten.pdf]
[2] Trommsdorff, Max (2022): "Agri-Photovoltaik: Chance für Landwirtschaft und Energiewende." Fraunhofer ISE, 2. Ausgabe. Verfügbar online unter: [https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/agri-photovoltaik-chance-fuer-landwirtschaft-und-energiewende.html]
[3] Leitfaden Agri-Photovoltaik: "Landwirtschaft trifft Energiewende," BMK und klimaaktiv. Verfügbar unter: [https://www.klimaaktiv.at/erneuerbare/photovoltaik/agri-pv.html]
[4] Landesbetrieb Landwirtschaft Hessen: "Agri-Photovoltaik – Potenzial für Landwirtschaft und Energiewende?" Verfügbar unter: [https://llh.hessen.de/unternehmen/technik-energie-und-bauen/verfahrenstechnik-und-energie/agri-photovoltaik-potenzial-fuer-landwirtschaft-und-energiewende/]
[5] Versuchsstation Obst- und Weinbau Haidegg https://www.agrar.steiermark.at/cms/beitrag/12945362/13888112/