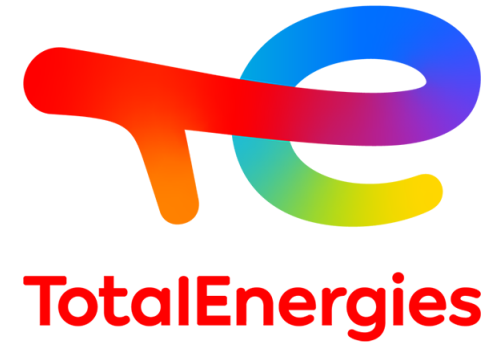




Industrialization and Scale-up of Agrivoltaics Solutions to Support both Agriculture and Energy Transition

EUPVSEC 2025 – Parallel Event

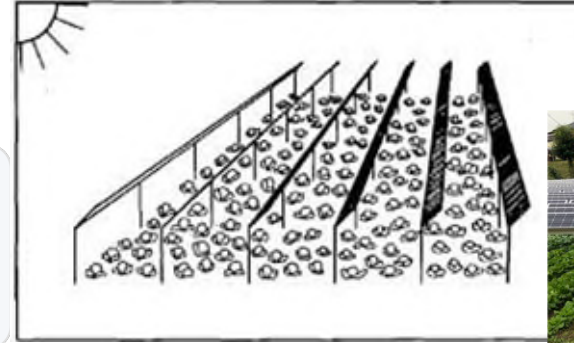
Etienne DRAHI

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From Pilots to Commercial Projects – Global Overview

1981: Concept Introduced

German researcher Adolf Goetzberger proposes the agrivoltaic concept of dual-use solar farming, planting the seed for future development.



2013: Early Adoption in Japan

Japan implements “solar sharing” rules, allowing farmers to install PV above crops under its FIT program. By 2021, Japan has ~200 MW of agrivoltaic capacity in operation.



2020: First Gigawatt-Scale Projects

China commissions a 700 MW agrivoltaic array (berries grown under PV) on the edge of the Gobi Desert – the world’s largest Agri-PV project, expanding to 1 GW. Europe also ramps up pilot projects in France, Germany, Italy.



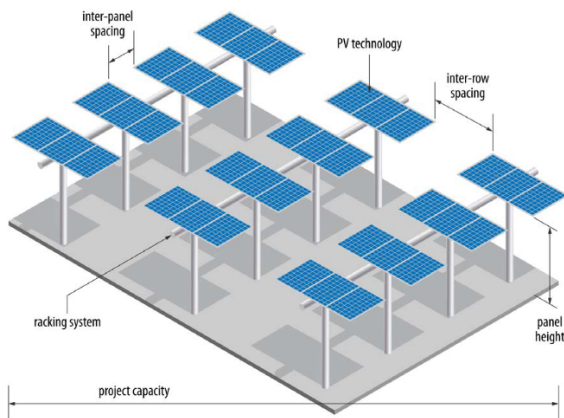
2025: Entering Commercial Scale

Globally, agrivoltaics reaches an estimated ~14 GW installed capacity. Many projects are transitioning from research pilots to full commercial installations, supported by emerging policies and industry investment.

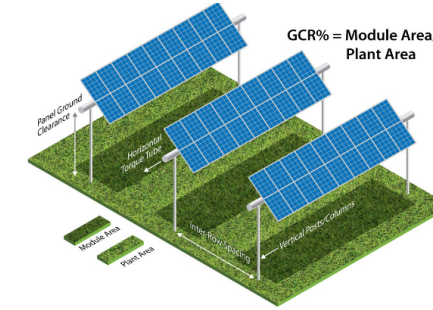
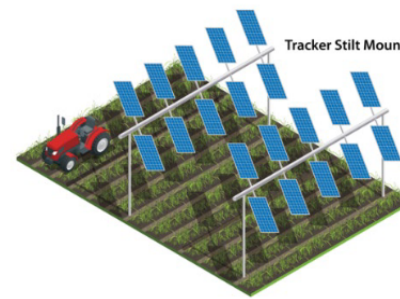
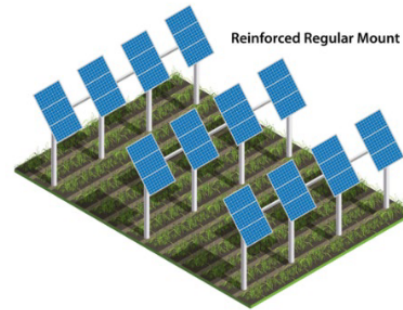


Agrivoltaics Technologies – Types & Pros/Cons

Above head – canopy like system



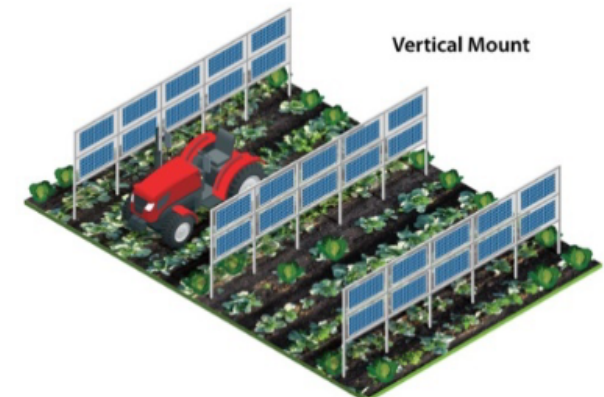
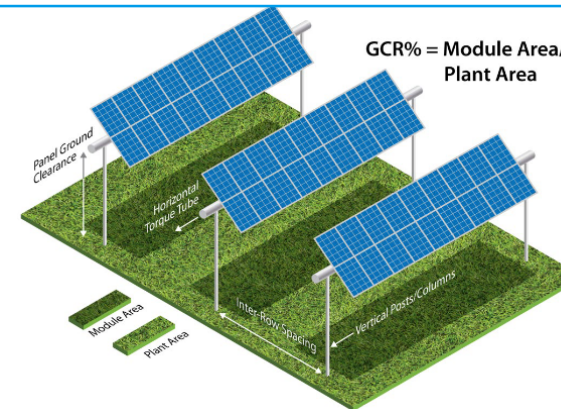
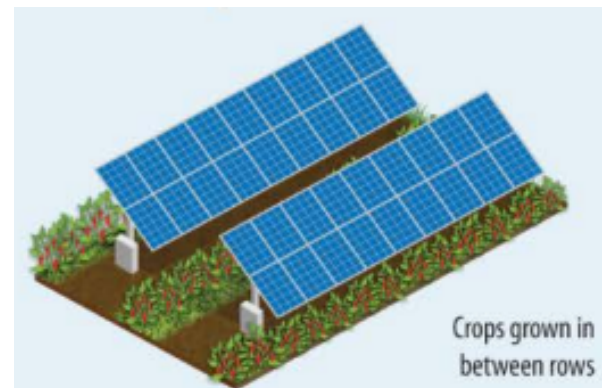
PV system with 5 degrees of freedom
(height, inter-module space, inter-row pitch, module technology, racking system)



Main pro: protection against extreme weather event & climate change

Main con: system to be adapted for each type of culture + machinery → high CAPEX

Inter-culture PV fixed or tracked system



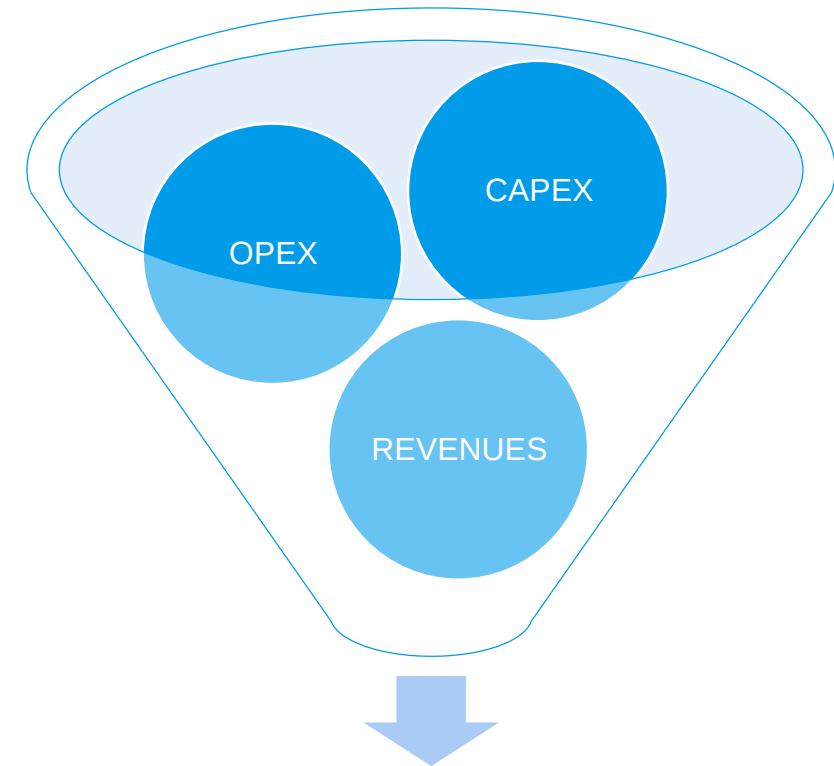
Main pro: easiness to implement = lower CAPEX + ecosystems benefits

Main con: reduced cultivation space + potentially no service against climate change if pitch too wide

PV Project Economics

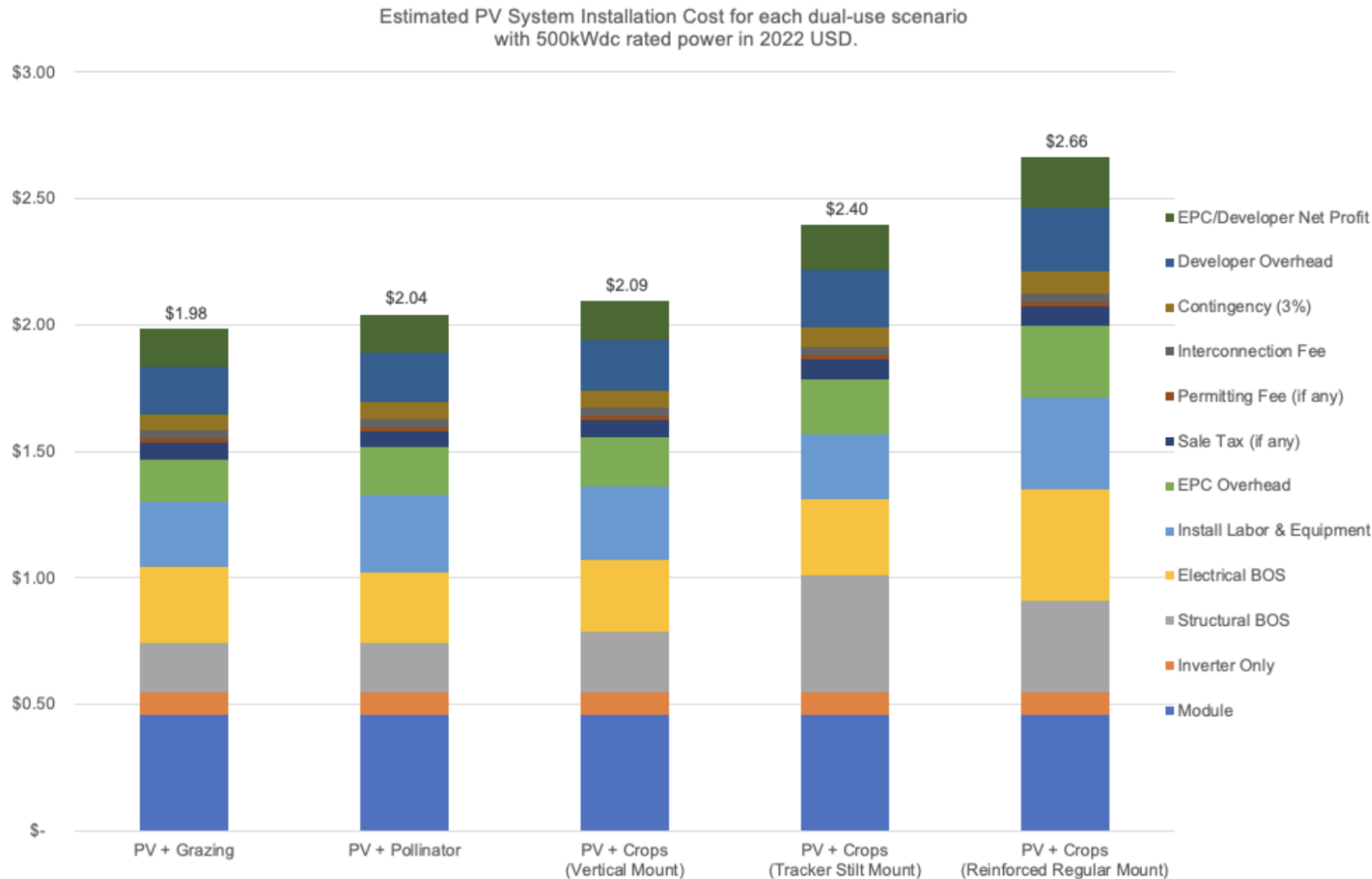
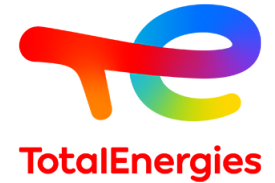
Inputs

- CAPEX: PV Modules, Mounting Structure, Electrical Equipment, Monitoring and Control Systems, *Agricultural Equipment*, Electrical Infrastructure, Land Preparation, Civil Works, Permits & Regulatory Costs, Engineering & Design, Contingency, Installation & Labor Costs, Project Development & Financing Costs
- OPEX: Maintenance and Repairs, Monitoring & Performance Analysis, Insurance, Operations Management, Land Lease or Rent, Utilities, *Crop Management*, System Upgrades and Retrofits, Data Monitoring & Communication, Training & Workforce Development, Regulatory Compliance, Marketing & Outreach, Decommissioning & End-of-Life Costs
- Revenues: sold electricity (FIT, PPA...), subsidies, credits...



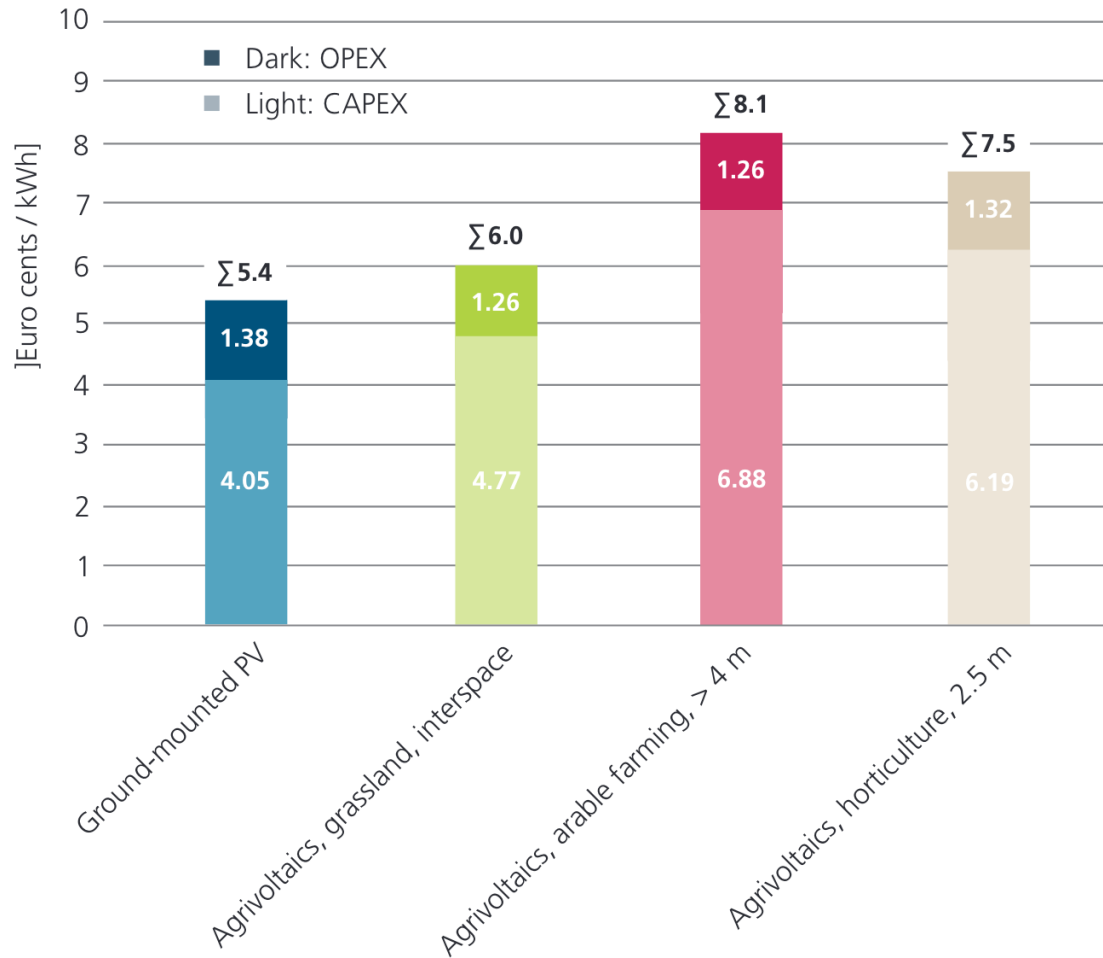
PV Project Economics (IRR, NPV, cashflow, EBITDA, ROACE...)

CAPEX Cost breakdown of each dual-use scenario



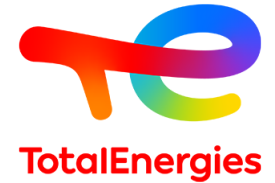
- **Site preparation & labor are the major cost driver** between typical **PV plant** and **grazing or pollinator friendly PV**
- **BOS and Installation Labor are the major drivers** of cost between different **PV + Crop** system types.
- **PV + Crop** systems need more steel in **lbs** because of the atypical support structure.
- Although **PV + tracker stilt mount** require lower amount of steel compared to other PV + crops systems, it has a **higher premium for its tracker technology**.
- **Soft Costs** – 13% EPC Overhead & Profit on Material & Equipment, 12% Developer Overhead & Profit on total cost, 4% contingency on total cost.

OPEX and Uncertainties



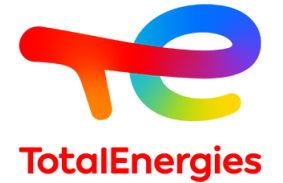
- Estimation done with **lease rates estimated from agriculture**. Should be lower for arable land or grasslands. **Sometimes for free** depending on crops and service provided.
- Regular agricultural use **eliminates the land management costs** that are typically borne by a PV system operator.
- **Cleaning and repairing costs** for PV modules **increase** when work needs to be done **at greater heights**, such as with the use of lifting platforms. In regions with high **likelihood of soiling**, the **additional cleaning costs can be more significant**, depending on the cleaning method employed. Currently, **there is limited knowledge about the long-term effects of fertilizers and crop protection products** on the substructure and PV modules.

Economics – Project Viability (IRR, NPV, LCOE)



- **Higher Costs → Higher LCOE:** Agrivoltaics installations have higher CAPEX and sometimes higher OPEX, leading to higher LCOE compared to standard PV. In Germany, agrivoltaics LCOE ranges from ~5.4 €/kWh to ~6.0–8.1 €/kWh, a 10–50% increase.
- **Revenue Streams:** Agrivoltaics projects generate revenue from electricity sales (via FITs, PPAs, or net metering), agricultural income (crops or livestock), and incentives/subsidies (upfront grants or higher tariffs).
- **Co-benefits:** Potential revenue from carbon credits and ecosystem services (pollination, soil health) is not yet monetized, undervaluing the societal ROI.
- **Achieving Acceptable IRRs:** Strategies include policy support (grants, premium tariffs), cost reduction through scale, value stacking (on-site solar power use), and hybrid business models (profit sharing between energy developers and farmers).
- **Financing and Risk:** Lenders are cautious until performance track records are established. Key finance questions include PV system performance and farming operations' impact on maintenance.
- **Long-term Outlook:** As costs decrease and crop improvements are factored in, agrivoltaics LCOE could approach standard PV LCOE. Most ventures currently need subsidies or high electricity prices to be viable.

Market Potential & Regulation by Region



Market potential

Europe

~944 GW

Technical potential from just **1% of EU farmland**.
(If 5–10% land used: multi-**TeraWatt-scale** potential of 1.5–14 TW.)

Current: ~0.3 GW installed (pilots); **2030 Outlook:** > 10 GW likely with new EU incentives.

USA

20%

of U.S. electricity needs if **~1% of farmland** is used for agrivoltaics (~800 TWh/year, roughly 500–600 GW).

Current: <1 GW (research stage); **2030 Outlook:** 3–5 GW (with USDA support & agrisolar policies).

India

3,200–13,800 GW

Estimated **technical potential** across suitable farmland (min–max scenario).
Policy Target: 20–60 GW by 2040 (**Moderate:** 20 GW; **Optimistic:** 60 GW).
Current: ~<0.1 GW (pilots under KUSUM scheme).

China & Asia

>1,000 GW

Vast land availability suggests **TeraWatt-scale potential** (e.g. desert agrivoltaics, pastoral lands).
China already leads with **~2 GW installed (2020)**, including world's largest 700 MW site.
Japan: ~0.2 GW by 2022; **South Korea & SE Asia:** emerging pilots. **2030 Outlook (Asia excl. India):** 20–50 GW aggregate (driven by China).

Regulation

EU Europe

- 📄 **France:** Legal Agri-PV definition (≥90% crop yield); CRE tenders with tariff bonuses.
- 📄 **Germany:** DIN SPEC 91434 standard (≥66% yield, <15% land use); innovation tenders dedicated to Agri-PV.
- 💰 **Italy:** €1.1B PNRR grants for agrivoltaics; panels max 40% land coverage.
- 📄 **EU-wide:** CAP reform allows dual-use farmland to keep subsidies; Horizon Europe funding for Agri-PV R&D.

us USA

- 💰 **DOE/USDA:** Federal pilot grants and programs expanding **dual-use** farming + solar support.
- 📄 **States:** MA SMART program offers a \$0.06/kWh agrivoltaics adder; states enacting pro-agrivoltaic zoning and commissions to remove barriers.
- 💰 **IRA (2022):** 30% ITC + bonus credits (e.g. energy community, storage) boost on-farm solar economics; encourages community and rural solar projects that include Agri-PV.

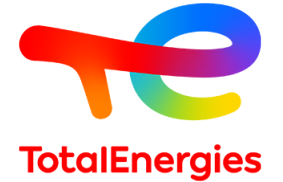
IN India

- 💰 **KUSUM Scheme:** Funds 500 kW–2 MW farm solar plants; farmers earn from selling power while co-cultivating crops under the arrays.
- 📄 **MNRE/GIZ:** Developing national agrivoltaic guidelines and viability gap funding; supporting pilots in multiple states.
- 🌱 **States:** Gujarat, Maharashtra, etc. testing Agri-PV for irrigation (solar pumps) and community farming; exploring tariff incentives for agrivoltaics in state solar tenders.

🌐 Asia (excl. India)

- 🌞 **China:** Large “PV + agriculture” projects (e.g. 700 MW berry farm) on arable land; policy mandates crop cultivation under PV and minimum crop output. Focus on land restoration & farmer income.
- 📄 **Japan:** “Solar sharing” guidelines require ≥80% of normal crop yield; 10-year permits and FIT/FIP incentives for compliant projects.
- 📄 **South Korea & Vietnam:** Early Agri-PV pilots (ginseng, tea); governments drafting dual-use policy frameworks as part of renewable energy and agricultural modernization plans.

Conclusions & Outlooks



- **From Niche to Next Normal:** Agrivoltaics is transitioning from a niche innovation to a mainstream solution in the renewable energy toolkit, reconciling solar capacity expansion with food security. But CAPEX need to be reduced.
- **Scaling Trajectory:** Expect diversification in agrivoltaics applications, from small family farms to utility-scale solar parks. By 2030, 50–100 GW of agrivoltaics could be installed globally, with China, Europe, and possibly India leading.
- **Outlook – Cost Reduction:** Industry learning and R&D are expected to reduce CAPEX premiums, making agrivoltaics competitive with conventional PV. Early commercial projects are identifying cost-saving opportunities.
- **Outlook – Policy Evolution:** As technology matures, direct subsidies may decrease, but agrivoltaics could stand on its own merits. New revenue streams and integration into broader rural development programs are likely. But potential additional costs can appear for permitting
- **Co-Benefits Realized:** Agrivoltaics will enhance local food-energy-water resilience, create rural employment opportunities, and innovate farming practices. It supports agriculture, easing land-use tensions. Increasing its acceptance?
- **Final Thought:** Agrivoltaics aligns with multiple UN SDGs and is becoming an "agrarian solar revolution." It offers farmers supplemental income while accelerating renewable energy generation, making it a key player in sustainable development

THANK YOU

