Asia Engine for Net Zero

[Pre-Read]

Agrivoltaics Feasibility Study Report Launch and Press Conference

Context

Leveraging the synergies between agriculture and solar energy through an emerging but proven technology like “Agrivoltaics” enables a country like the Philippines to enhance its food security, achieve its renewable electricity (RE) targets, and contribute to sustainable development. The Asia Engine for Net-Zero Institute (AENZ), a policy acceleration and capacity enhancement non-profit based in Manila, is hosting a first-of-its-kind roundtable discussion to catalyze the development of agrivoltaics in the Philippines by bringing together diverse stakeholders to share insights, discuss challenges, and identify actionable steps. Working with partners in the United States and China in the topic of Agrivoltaics, AENZ is a uniquely positioned, newly established organization at the forefront, and at the intersection of, RE finance and corporate decarbonization.

AENZ's Asia Agrivoltaics Initiative (AAI) [read more here], stems from the recognition of the interconnected challenges in the agriculture and energy sectors. The objectives of the Asia Agrivoltaics Initiative are multifaceted, focusing on environmental, social, and economic impacts. Environmentally, the initiative aims to reduce carbon emissions by increasing the adoption of RE and improving land use efficiency and soil health through sustainable agrivoltaic practices. Socially, it seeks to create job opportunities in the RE and agriculture sectors, enhancing food security, and increasing access to clean energy, especially in rural communities. Economically, the initiative intends to attract both domestic and international investments in agrivoltaic projects, thereby fostering economic growth through the development of a new, sustainable industry. This holistic approach is designed to generate significant and lasting positive impacts across multiple domains.

Agrivoltaics recently featured prominently at the 28th Conference of Parties (COP28) in Dubai and at the 2024 Asia Clean Energy Forum (ACEF) hosted by the Asian Development Bank in Manila. With land use and food systems impacts of the tripling of RE goals emerging as an urgent, multi-stakeholder concern, Agrivoltaics emerges as a solution that has benefits to both agriculture and energy. **The question is: how can Agrivoltaics be a bankable, financially attractive asset class that can be deployed at scale in the Philippines?**

China, the United States, and Europe have become global pioneers in agrivoltaics, showcasing diverse applications and transformative benefits. China leads with over 560 projects totaling more than 30 GW of solar capacity. In the U.S., the National Renewable Energy Laboratory (NREL) monitors over 500 projects with 10 GW capacity, optimizing installations for agricultural practices such as sheep and cattle grazing and crop cultivation. Europe, with 200+ projects exceeding 15 GW across 10 countries, employs innovative technologies like interrow

PV and solar greenhouses. Several lessons can be gleaned that can be applied to the unique country context of the Philippines.

AENZ's work on Agrivoltaics is anchored on goals that promote the scaled deployment of Agrivoltaics as a bankable, financially attractive asset class:

1. **Establishing a collaborative consortium** with stakeholders including high-quality local developers, investing FIs, local governments, farming community and if possible, RE off-taker
2. **Envisaging a blended finance or fund-of-funds facility** to lower project costs and accelerate the scaled deployment of agrivoltaic systems in the Philippines.

Through this work, AENZ aims to make Agrivoltaics a bankable, financially attractive asset class that can provide a myriad of co-benefits for the people and the planet.

Highlights of AENZ's Feasibility Study

AENZ, with support from philanthropic partners, carried out the industry-first technical and financial feasibility study on agrivoltaics in the Philippines. The feasibility study shall be used as a means to jump-start conversations on the opportunities for agrivoltaics in the Philippines.

Agrivoltaics, also known as dual-use solar or solar sharing, integrates agricultural practices with photovoltaic (PV) solar energy generation on the same land. This approach allows for the simultaneous production of crops and RE, addressing the historically competing demands for land resources between agriculture and solar energy installations.

Key Differences from Typical Ground-Mounted Solar PV Projects

- **Dual-Use Nature:** Agrivoltaics allows both crop cultivation and solar energy production on the same parcel of land, unlike traditional PV systems that require large, open fields solely for energy production.
- **Elevated Design of Solar PV over Farmland:** PV panels in agrivoltaic systems are typically mounted on stilts or elevated structures, creating a canopy above the agricultural area. This permits farming activities to continue beneath the panels, preserving the land's primary agricultural function.
- **Agronomic and Ecological Benefits:** The partial shading from solar panels can reduce crop water stress, enhance water use efficiency, and create beneficial microclimates, potentially leading to improved crop yields and increased PV panel energy generation efficiency.
- **Economic Diversification:** Farmers can generate and sell solar energy to supplement their revenue from crop sales, improving the financial sustainability of agricultural operations.

The study includes a Review of Related Literature (RRL) which plays a critical role in establishing the foundation and context for the research. The RRL includes a detailed analysis of global experiences and case studies from countries like China, Japan, the USA, France, Germany, and others. The RRL also discusses various policies and legislative frameworks supporting agrivoltaics across different countries. This includes specific bills and programs in the USA, Japan's strategic energy plans, Germany's renewable energy policies, and China's governmental directives promoting dual-use solar projects. These insights are crucial for understanding the policy environment and identifying potential regulatory pathways for implementing agrivoltaics in the Philippines.

Locations and Crops Considered for the Financial Feasibility Study:

The feasibility study identifies four potential areas for agrivoltaic projects in the Philippines: Negros, Iloilo, Bohol and Quezon Province. Each area selected grows different crops from ampalaya and eggplant in Negros, palay in Iloilo, white potato in Bohol, and tilapia in Quezon. Varying crops were chosen to observe the potential of agrivoltaics in different agricultural configurations.

Results of the Financial Feasibility Study:

The financial feasibility is grounded in a detailed analysis of technical potential, land costs, and crop pricing. The list below are the considerations used in conducting the financial analysis. The list lays out the difference between typical ground mounted PV and agrivoltaics.

1. **Increased efficiency of solar energy generation:** For agrivoltaics financial model, solar yields are adjusted from the generation calculated in the system advisory model to account for the potential efficiency gains due to the cooling effects of the crops and reduced dust accumulation. Multiple studies have shown that agricultural crops help keep the solar panel cool thus enabling them to produce up to 10% more electricity.

2. **Increased Engineering, Procurement, and Construction (EPC) cost due to mounting requirements:** The technical design of the Agrivoltaics scenarios laid out in this analysis are computed from the costs and generation capacity of ground mount solar PV. It is assumed that due to higher mounting requirements the EPC cost of Agrivoltaics would be a set percentage higher than that of ground mount solar PV.

3. **Increased PV spacing for an equivalent electricity production:** The density of panels per unit area is lower to allow adequate sunlight to reach the crops. This reduces the total energy output per unit area compared to traditional installations. Rows of panels are spaced further apart to ensure sufficient sunlight reaches the crops below. This spacing is determined by the type of crops, their light requirements, and the angle of the sun.

4. **CAPEX and OPEX cost differences:** The financial model incorporates various cost factors, including capital and operational expenses. The costs assumed for the CAPEX and OPEX are derived from the Energy Regulatory Commission (ERC) published numbers from the Green Energy Auction 2 (GEA2) serving as a standard reference for the financial analysis. Adjustments have been made to accommodate the specific needs

of Agrivoltaics such as the need for elevated structures for vegetation to grow and to accommodate agricultural activities in Agrivoltaics setups.

5. **Basis of electricity sales for agrivoltaics is similar to Green Energy Auction Program (GEAP):** The financial model uses the lowest yearly average tariff from the supply agreements of the electric cooperative that services the selected project sites. Electricity would be sold at a fixed rate for 20 years, similar to the GEA.

6. **Agrivoltaics system size is smaller compared to Business-as-Usual (BAU):** The installation size of agrivoltaics considered in the study were limited to 5MW as this would allow the project to sell electricity to the distribution utility as an embedded generator which grants it exemption from the competitive selection process.

7. **Upfront-fee for farmers during construction:** The initial phase of the project, which involves construction and setting up the solar infrastructure, will disrupt farming activities. Recognizing the income void this creates for the farming community, the project developer will provide the farmers with an upfront fee.

8. **Revenue sharing with the farming community:** The model envisages a shared profit between the farmers and developers. While the project developer would be the landowner, a predetermined fraction of the income generated from agricultural activities will be redirected to them. This serves as an incentive for the developer to support and possibly enhance farming activities, as their revenue is directly tied to agricultural productivity.

9. **Compensation to farmers for reduced arable land:** Acknowledging that the installation of solar panels will inevitably lead to a reduction in arable land, the model includes a compensation mechanism. Farmers will receive a fixed annual fee to offset the potential loss in income due to the reduced land available for cultivation. This arrangement ensures that farmers' earnings are not adversely affected by the solar installation.

The study assumes assumes the following in all the cases:

	UNIT	Values
Interest Rate	%	8.5
Loan Period	Years	10
Cost of Equity	%	10
WACC	%	9.4
Tariff Escalation Rate	%	0
FOREX	PHP-USD	55.6
O&M (PV)	PHP/kW/yr	472
Fixed Fee to Farmer	PHP/sqm/year	5
Share from Agri	%	10

Comparing the negros case with 10% generation increase with a business-as-usual project in the same site shows that agrivoltaic projects, despite higher upfront costs, yield a slightly higher financial outcome due to the additional revenue from agricultural activities.

Metric	BAU (Solar PV Only)	Agrivoltaics Case	Difference
EPC Cost (USD/Wp)	0.89	0.98	+10%
Specific Yield (kWh/kWp)	1,435.27	1,579	+10%
Energy Generation (MWh)	7,171	7,888	+717
IRR (%)	11.7%	11.9%	+0.2%
NPV (PHP million)	40.8	47.9	+7.1
Payback Period (Years)	8	8	No change

The increase in the efficiency of the solar panels due to the cooling effects provided by the crops more than compensates for the increased EPC cost. Assuming that agrivoltaic configuration indeed increases energy generation by 10% from BAU the IRR for the 4 sites, as seen in Annex 1, is between 9.77%,-11.88% indicating a healthy return on investment that exceeds the WACC, suggesting the project's profitability. However, taking a more conservative approach and assuming only a 3% increase in energy generation shows that only projects with high solar panel coverage remain financially feasible, such as those grown in vegetables (i.e. eggplant and ampalaya) and those above in-land fishponds.

The financial model reflects a sustainable and economically viable approach, integrating agriculture and RE production while supporting the local farming community through innovative compensation and revenue-sharing mechanisms.

While greenfield agrivoltaics is still not a commercially viable opportunity due to the current lack of regulations, the potential for rapid development is significant. Stakeholders have indicated interest to explore brownfield agrivoltaic projects or expanding existing solar projects to accommodate agricultural activities. With the appropriate policy support and collaborative efforts, we can anticipate an accelerated timeline for the first agrivoltaics projects to be implemented in the Philippines.

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Annex:

A. 10% energy generation increase

	Negros	Iloilo	Bohol	Quezon
Crop	Ampalaya and Eggplant	Palay	White Potato	Tilapia
Agriculture Net-Returns per Hectare (PHP/ha)	178,042	10,836	344,017	220,032
Land Cost per sqm	82	73	80	150
Land Area (sqm)	70,000 (64% shaded)	150,000 (30% shaded)	60,000 (75% shaded)	50,000 (100% shaded)
Specific Yield	1,579	1,666	1,680	1,628
Tariff (PHP/kWh)	5.97	5.24	4.93	5.80
Upfront Fee (PHP)	1,250,000	162,540	1,070,000	1,100,000
EPC Cost [USD/kWp]	0.98	0.98	0.98	1.02
IRR	**11.80%**	**10.12%**	**9.77%**	**11.13%**
NPV	**46,384.566**	**13,848.827**	**6,886.639**	**34,833.791**

B. 5% energy generation increase

	Negros	Iloilo	Bohol	Quezon
Crop	Ampalaya and Eggplant	Palay	White Potato	Tilapia
Agriculture Net-Returns per Hectare (PHP/ha)	178,042	10,836	344,017	220,032
Land Cost per sqm	82	73	80	150
Land Area (sqm)	70,000 (64% shaded)	150,000 (30% shaded)	60,000 (75% shaded)	50,000 (100% shaded)
Specific Yield	1,507	1,590	1604	1,547
Tariff (PHP/kWh)	5.97	5.24	4.93	5.80
Upfront Fee (PHP)	1,250,000	162,540	1,070,000	1,100,000
EPC Cost [USD/Wp]	0.98	0.98	0.98	1.02
PIRR	**11.03%**	**9.39%**	**8.99%**	**10.29%**
NPV [PHP 000]	**31,122.104**	**(268.323)**	**(7,661.930)**	**17,687.194**

C. 3% energy generation increase

	Negros	**Quezon**
Crop	Ampalaya and Eggplant	Tilapia
Agriculture Net-Returns per Hectare (PHP/ha)	178,042	220,032
Land Cost per sqm	82	150
Land Area (sqm)	70,000 (64% shaded)	50,000 (100% shaded)
Specific Yield	1,478	1,518
Tariff (PHP/kWh)	5.97	5.80
Upfront Fee (PHP)	1,250,000	1,100,000
EPC Cost [USD/Wp]	0.98	1.02
PIRR	**10.86%**	**10.08%**
NPV [PHP 000]	**27,844.886**	**13,588.963**