Exploring Business Models for Agrivoltaics in India

Karnataka: A Case Study

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Introduction

As of January 2023, India has an installed solar PV capacity of ~63 GW, of which ~53 GW is attributed to ground-mounted photovoltaic (PV) plants. However, recent trends indicate that it is becoming increasingly difficult to obtain land parcels for large solar projects. Novel and viable alternatives are warranted to achieve the 500 GW renewable energy target for 2030. Agrivoltaics (agriPV) is one such promising technology for optimising land usage by combining agriculture with PV. AgriPV promotes RE growth and leads to the economic development of farmers and rural areas. Hence, this technology is linked to multiple sustainable development goals (SDGs), viz. 1: No poverty, 2: Zero hunger, 3: Good health and well-being, 7: Affordable and clean energy, 8: Decent work and economic growth, and 10: Reduced inequalities. AgriPV has become popular in countries such as Germany, Japan, and Italy and is being actively explored in India.

As per the initial estimates by industry experts, India has an agriPV potential greater than 1.2 TW, emphasising the wide scope of this technology. AgriPV can provide improved conditions for the growth of specific shade-loving crops, including leafy greens, tomatoes, root vegetables, and tubers. However, for most Indian crops such as rice, wheat, and oilseeds, agriPV may result in yield reduction. Hence, in an agrarian economy such as ours, regulations on agriPV should be established. In Germany, yield reduction is restricted to 33% compared with the baseline scenario to qualify as agriPV. For India, such parameters need to be developed scientifically and from an economic standpoint. Deliberations with stakeholders, including policymakers, decision-makers, farmers, agricultural universities, and economists, need to be conducted, and concerns regarding food security or food–energy nexus imbalance need to be prioritised to ensure a holistic implementation plan for agriPV.

One of the major challenges in terms of the implementation of agriPV is the development of suitable business models. This is because of the involvement of farmers as the primary stakeholders. Previously, in the event of any deviation from normal farming patterns, the country has witnessed disturbances and even government bills being repealed. This policy brief explores various business models for agriPV in India and highlights the pros and cons of each model.

Karnataka has been taken as a case study for quantification purposes. Agricultural consumption accounts for ~22,337 million units (MU) of the state's total electricity demand of ~62,000 MU. The finance department pays ~INR 14,000 crores annually to distribution companies (DISCOMs) as compensation for free power being supplied to the agricultural sector.

Business Model 1: State government owned

Salient features:

- The state government (Finance and Energy Departments) forms a special purpose vehicle (SPV) to channel the aforementioned annual compensation towards agriPV investments.
- About 13 GW is needed to offset the entire electricity consumption in the agricultural sector.
- About INR 81,000 crores is needed to set up agriPV for the state of Karnataka.
- Karnataka Power Corporation Limited (KPCL) can assume the role of a developer.
- The government bears the annual operation and maintenance (O&M) costs.
- Farmers are compensated with a land lease agreement (LLA), which includes reparation for revenue loss in case of decreased productivity along with the lease amount.
- The compensation factors in crop type, average annual revenue generated, market price, etc.
- A robust methodology that enables a fair assessment of compensation for both the farmer and exchequer needs to be introduced.
- Free power continues to be supplied to farmers along with a stable additional income.
- The government has cumulative savings of INR 3,41,815 crores, with a payback period of 6 years and an internal rate of return (IRR) of 22%.

Business Model 2: Developer owned

Salient features:

- An agriPV developer invests capital for installation and O&M backed by financial institutions.
- Developers are selected via a tender process conducted by DISCOMs/energy department.
- A power purchase agreement (PPA) is enforced between the developer and DISCOM.
- To ensure due process, the state revenue/agricultural department acts as the administrator.
- Demand and land aggregation is performed upon consensus of farmer unions, local panchayats, and farmer producer organisations (FPOs).
- The developer proposes an LLA with farmers wherein the lease and compensation in case of decreased productivity are considered for the mutually agreed land parcel.
- To address the issues related to legal concerns and scepticism from farmers, a detailed risk mitigation process is conducted by the financial institutions.
- Free power continues to be supplied to farmers along with a stable additional income.
- The government accrues savings as the agriPV PPA will be lower than the average cost of electricity (ACoS).

- Over the lifetime of the agriPV system (25 years), the government has cumulative savings of INR 14.21 crores/MW, whereas a developer has an 11-year payback period and an IRR of 15%.

Business Model 3: Farmer/FPO owned

Salient features:

- The model is financed with equity from farmers and credit borrowed from financial institutions.
- Engineering, procurement, and construction (EPC) contractors enlisted by the DISCOMs/energy department install and maintain the agriPV system at the behest of farmers.
- Farmer collectives such as farmer producer organizations (FPOs), Joint Liability Groups (JLGs), or self-help groups (SHGs) can be utilised or constituted to secure funding.
- The Credit Guarantee Fund set up by National Bank for Agriculture and Rural Development (NABARD) or National Cooperative Development Corporation (NCDC) can be utilised by FPOs[1]. This fund covers 75% of project costs up to INR 1.5 crore for projects exceeding INR 1 crore.
- Farmers can generate their own power and sell the surplus to DISCOMs.
- With a feed-in tariff > INR 5.9/kWh, the farmer will have a payback period of 11 years and an IRR of 17%.
- The government saves revenue as the agriPV PPA will be lower than the ACoS.
- Over the lifetime of the agriPV system (25 years), the government has cumulative savings of INR 13.38 crores/MW.

Business Model 4: Shared ownership (Farmer/FPO + Developer)

Salient features:

- The farmer and developer (private or state owned) collectively work together to install, operate, and maintain the agriPV system, thereby minimizing the associated risks.
- The stakes in the project are mutually decided by both parties.
- The agricultural land is leased to the developer, and the associated costs (including O&M and inverter replacement) are shared by the respective parties based on the agreed stake.

[1] https://www.nabard.org/pdf/cgsfpo.pdf

- De-risking mechanisms such as first loss default guarantee (FLDG) funds can be established to reduce the capital risk.
- With a lease rate of INR 30,000/acre/year, a feed-in-tariff of >INR 6.0/kWh is needed for payback periods of 6 and 11 years for the farmer and developer, respectively, with corresponding IRRs of 30% and 20%, respectively.

SWOT analysis of the business models

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
BUSINESS MODEL 1: STATE GOVERNMENT OWNED	• Savings on annual agricultural subsidies • Ease of operations (allocation of funds/administrative work/signing LLAs) • Secondary income for farmers from the land lease • State generation companies can diversify their RE portfolio • Low-cost financing available from multilateral institutions	• Linkage to KUSUM • Sustainable power supply to farmers • Meeting Renewable Purchase Obligation and renewable energy targets • Reduction in capital costs due to economies of scale	• Use new technologies to reach consumers • Create more personalised messages • Take advantage of opportunities to create viral content.	• Farmers' indifference and inaction to onsite faults • Inaccurate accounting practices due to perceived delays • Renegade farmers wanting to renegotiate lease/compensation rates • Repercussions in political scenarios/regimes • Farmers not receiving timely payment
BUSINESS MODEL 2: DEVELOPER OWNED	• Highest performance as developer is the primary stakeholder • Secondary income for the farmer from land lease • DISCOMs can purchase electricity at prices less than ACoS • Reduced risks for the financial institution due to developer involvement	• Requires proactive interventions from revenue/agricultural department to maintain consistency in lease/compensation rates • More complicated LLA, PPA, and tenders due to multiple stakeholder involvement • More expensive than ground-mounted PV; requires subsidies for financial viability	• DISCOMs can meet Renewable Purchase Obligation targets • Reduction in capital costs due to economies of scale • Offers more business opportunities for PV developers	• ·Acceptance of third-party developers by farmers, causing project delays • ·Difficulty for small developers to secure funding • ·Renegade farmers wanting to renegotiate lease/compensation rates
BUSINESS MODEL 3: FARMER/FPO OWNED	• Increase in income of farmers/FPOs • Self-sufficiency of farmers for agricultural power	• Majority of farmers lack the access to equity and affordable finance • Lack of financial and technical literacy for devising PPAs, preparing documentation, and interacting with banks • Farmers dependent on EPC for maintenance • More expensive than ground-mounted PV; requires subsidies for financial viability	• Promotes entrepreneurship and reduces dependency on volatile agricultural revenue • Creates new business avenues for EPC • Financial institutions can diversify their portfolio by adding agriPV • ·Upskilling/capacity-building opportunities for farmers	• Possibility of imbalance in the food–energy nexus due to a shift towards PV • Poor awareness and comprehension resulting in PV performance concerns • Achieving and maintaining cooperation among FPO members • Repercussions in political scenarios/regimes
BUSINESS MODEL 4: SHARED OWNERSHIP	• Strong business case for farmers/FPOs because of additional income from lease and electricity sales • Easier access to formal financing as the developer has a stake in the project • Reduced risks for farmers/FPOs • Reduced overall risks for the developer as the farmer is a part stakeholder	• Requires a slightly higher feed-in tariff for viable business cases • Requires government oversight to ensure fair percentage stake • Requires capacity building and awareness creation among farmers • More expensive than ground-mounted PV; requires subsidies for financial viability	• Promotes entrepreneurship and reduces dependency on volatile agricultural revenue • Creates new business avenues for EPC • Financial institutions can diversify their portfolio by adding agriPV • Upskilling/capacity building opportunities for farmers • Linkage to KUSUM • De-risking mechanisms can be explored for agriPV	• Exploitation of farmers by developers (developer-centric PPA, LLA) • Renegade farmers wanting to renegotiate lease/compensation rates

Conclusion

Of the four business models proposed, Business Model 4 poses more opportunities and fewer weaknesses and is the most profitable model for farmers. This business case, however, requires a higher feed-in tariff (approximately INR 6.2/kWh) than the other business cases. Business Model 3 promotes entrepreneurship but requires buy-in from financial institutions. Owing to the high amount of risk involved, de-risking mechanisms in the form of FLDGs and credit guarantees are needed for financing farmers.

Business Model 2 allows for a lower feed-in tariff (approximately INR 5.7/kWh) because the total electricity generated is sold to DISCOMs. The amount of electricity that is being used to cater to the farmers' needs plays an important role in making the business case profitable. Business Models 2 and 4 are relatively easier to finance owing to the involvement of a developer. The land lease rate in Business Models 2 and 4 and the feed-in tariff in all four models are important deciding factors for the viability of the business models. Land lease rates and feed-in tariffs should be determined in a way that the business case becomes profitable for both farmers and developers. Business Model 1 may provide savings amounting to about INR 3.42 lakh crores for the state government. However, farmers would continue to get free electricity and thus would not become self-sufficient.

Further, agriPV systems may reduce the productivity of shade-intolerant crops. For such cases, the rent component is crucial and higher feed-in tariffs are required. However, the productivity of certain shade-loving crops may increase with an agriPV system. The rent component in such cases can be eliminated, and profitable business cases can be feasible for every stakeholder. Hence, for Business Models 1, 2, and 4, wherein farmers lease out land to developers/government, nuanced agreements are needed. Legally binding documents should indicate the percentage of land used for setting up PV systems, farming, protecting farmer rights, settling disputes, etc. To prevent socio-political unrest during the implementation of agriPV projects, it is crucial to prioritise early negotiations for the equitable allocation of risks and benefits among stakeholders.

Appendix

Assumptions

The following assumptions were used to achieve an internal rate of return (IRR) of minimum 15% for each stakeholder:

<table>
<tr>
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AgriPV capex = INR 6 crores/MW
O&M costs = 1.25% of CapEx with an annual escalation of 5.72%
Debt equity ratio = 0.85
Loan term = 10 years
Loan rate = 8%
Inverter replacement once in a lifetime in the 13th year

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Capacity utilisation factor = 0.19
Degradation rate of PV modules = 0.92%/annum
Self-consumption of farmers = 5% of generation
1 MW agriPV needs 2 hectares of land
Height of elevated PV = 10 feet
Orientation = South facing

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<tr>
<th>Government owned</th>
<th>Developer owned</th>
<th>Farmer owned</th>
<th>Shared ownership</th>
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Electricity consumed by the agricultural sector = 22,337 Million units (MU)
CapEx required for an overall capacity of agrivoltaics = INR 81,000 Cr
Government power subsidy for the agricultural sector = INR 14,000 Cr
Percentage increase in yearly subsidy = 2.5%

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System size = 1 MW
Feed-in tariff Karnataka = INR 5.7/kWh
Amount generated by selling electricity = INR 94,87,080
ACoS = INR 6.25/kWh[2] with an annual escalation of 3%
Land lease rate for farmer = INR 40,000/acre/year

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Feed-in tariff Karnataka = INR 5.9/kWh
Amount generated by selling electricity= INR 98,19,960

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Farmer’s stake = 25%
Developer’s stake =75%
Feed-in tariff= INR 6.0/kWh
Revenue generated form electricity sales = INR 94,87,080
Land lease rate for farmer = INR 30,000/acre/year

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[2] https://kerc.karnataka.gov.in/uploads/80951657190356.pdf

Graphs

Business Model 1: State government owned

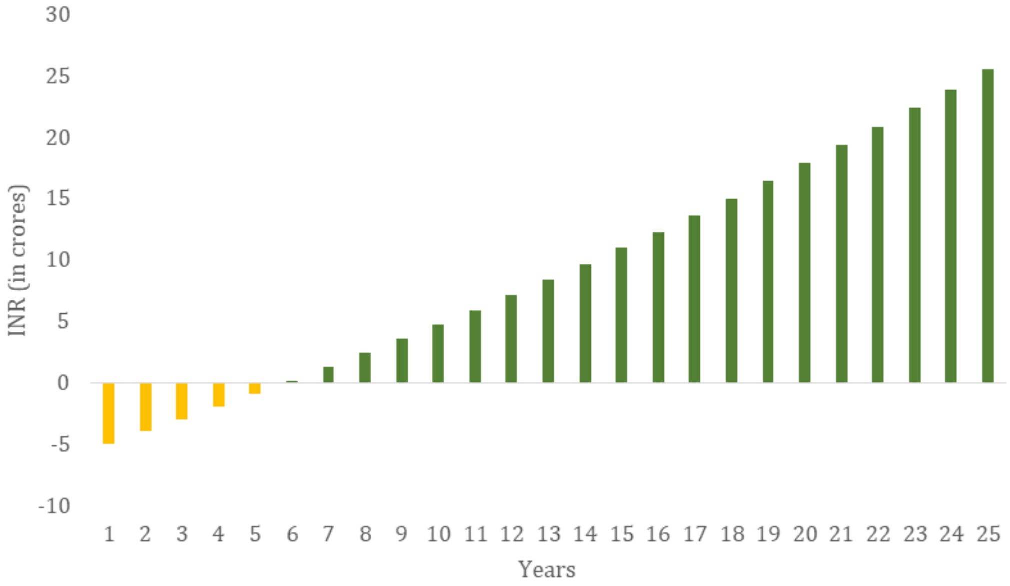

Figure 1: Cumulative savings for the government per MW

Business Model 2: Developer owned

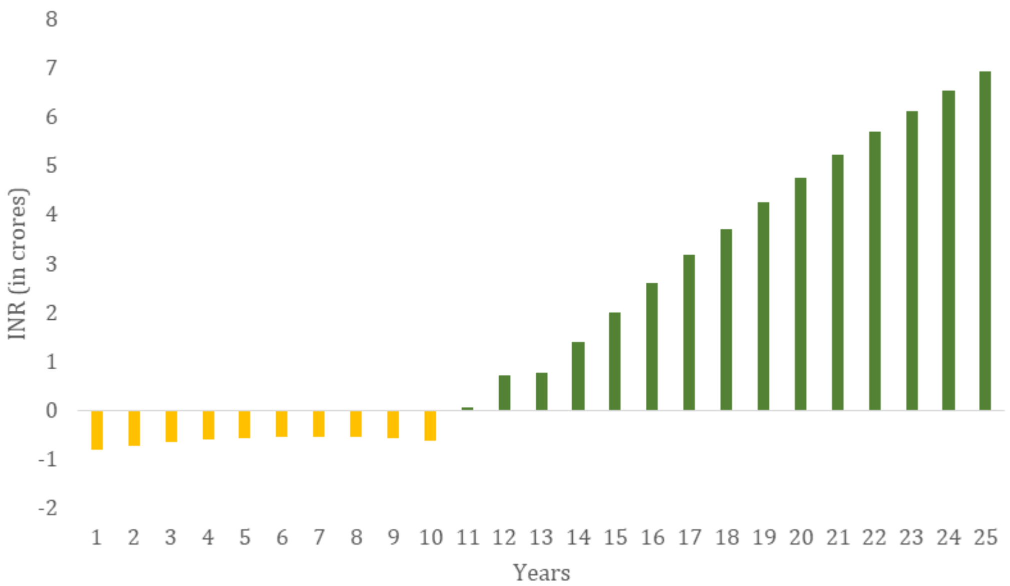

Figure 2: Cumulative savings generated by a developer per MW

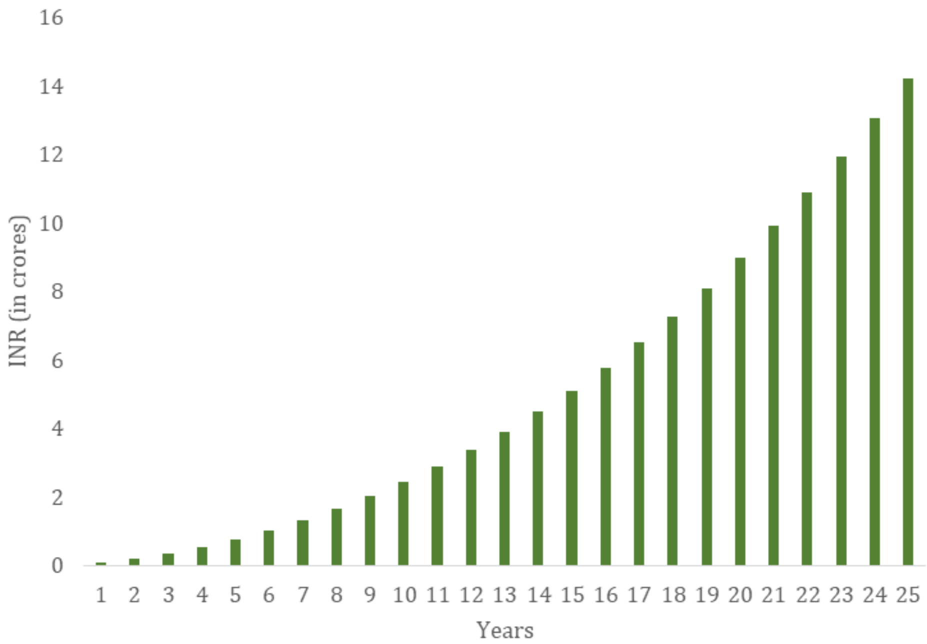

Figure 3: Cumulative savings for the government per MW

Business Model 3: Farmer/FPO owned

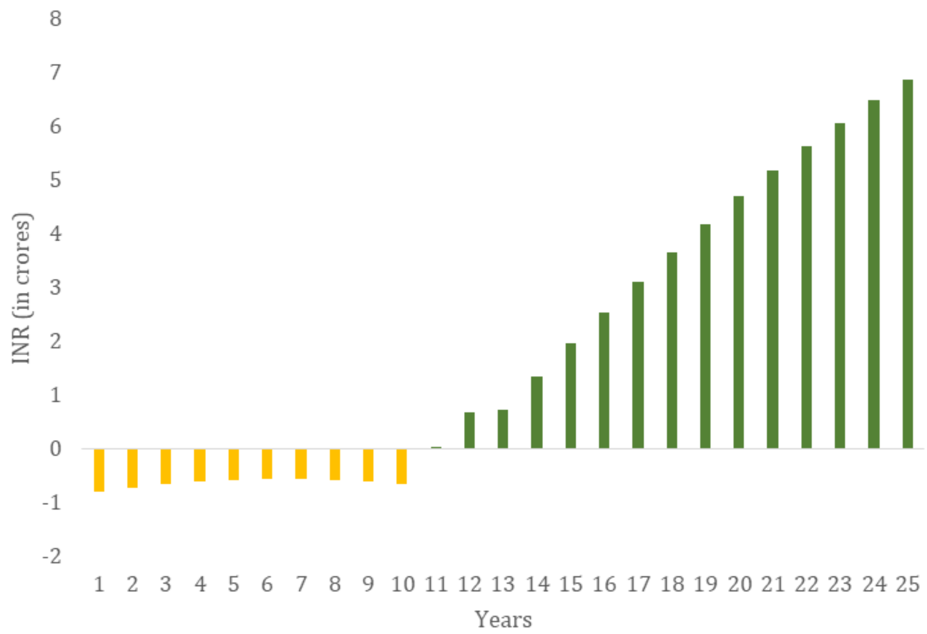

Figure 4: Cumulative earnings for a farmer per MW

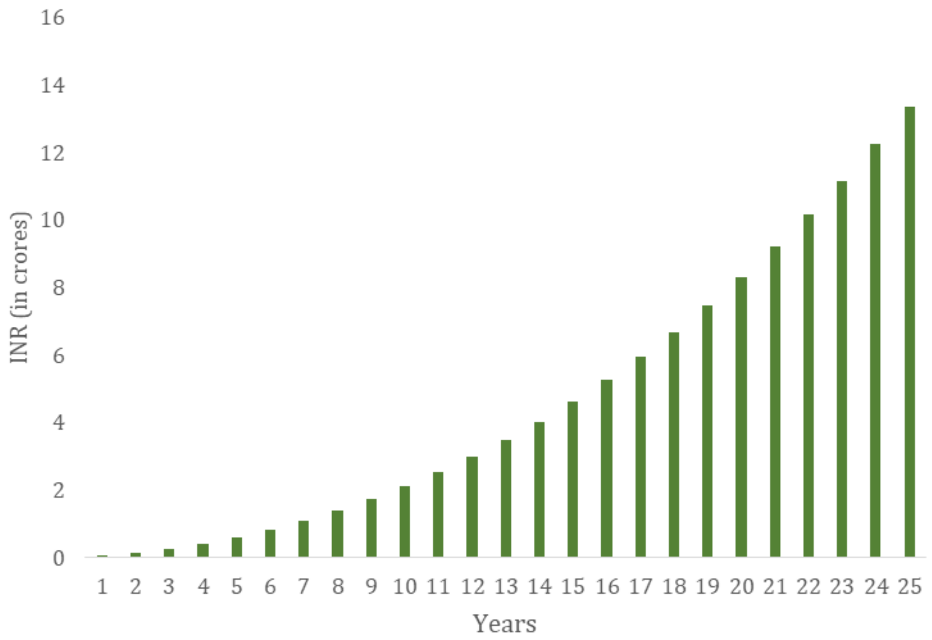

Figure 5: Cumulative savings for the government per MW

Business Model 4: Shared ownership

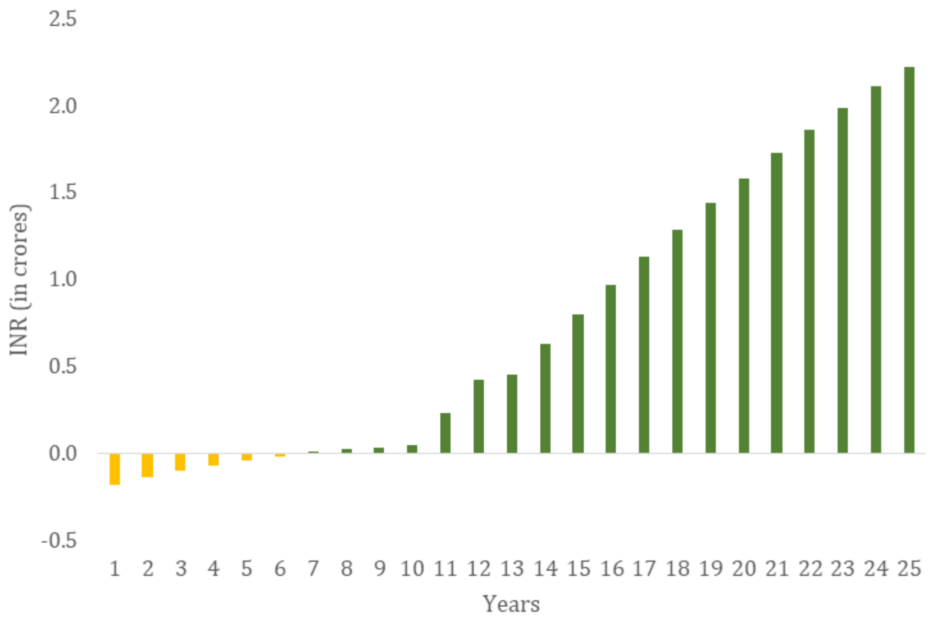

Figure 6: Cumulative earnings for a developer per MW

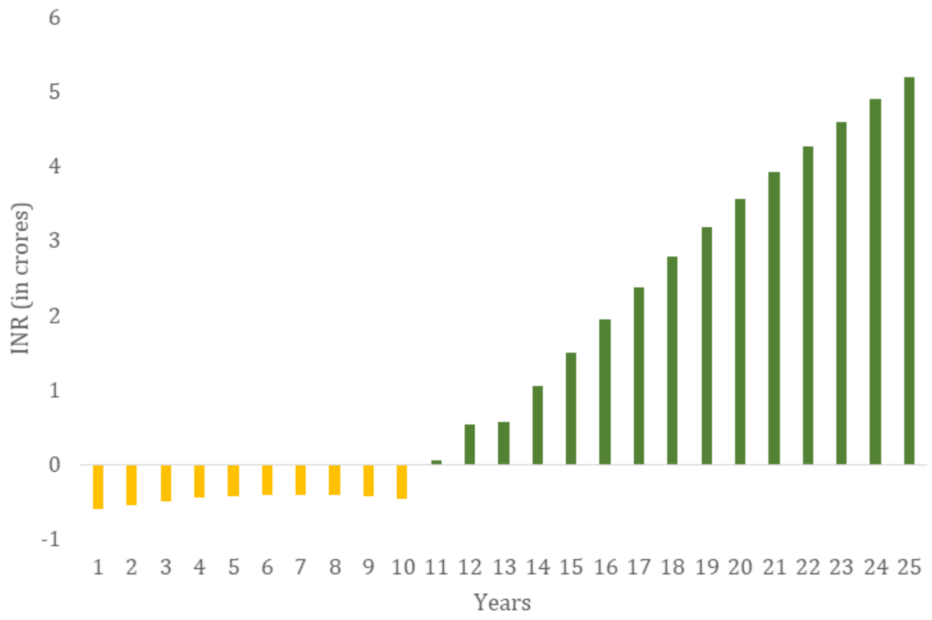

Figure 7: Cumulative earnings for a farmer per MW

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