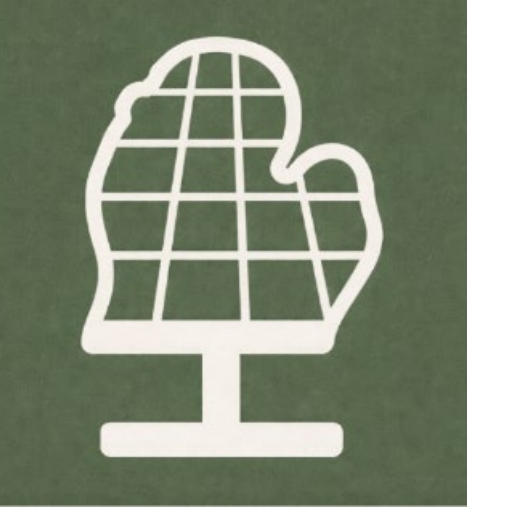


# Optimizing Agrivoltaic System Design for Michigan Farmer Income

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## Background

Recent shifts in global energy supply systems have introduced photovoltaics (PV) as a new competitor with Michigan's agricultural areas. Agrivoltaics work to integrate agricultural production with PV energy generation to operate on the same land area. This project examines agrivoltaic potential in Districts 7, 8, and 13.

- Agrivoltaics offers Michigan farmers a way to host solar arrays on active farmland without removing land from production
- Co-locating crops and solar panels can increase total land productivity, generating both food and renewable energy
- Farmers can gain multiple revenue streams, including crop sales and solar lease payments or energy generation income
- Agrivoltaics can preserve long-term agricultural function while providing a stable but diverse income source tied to renewable energy production



Figure 1. Map of Michigan Districts

Mitten Solar aims to design a tool that determines the most profitable allocation of farm acres between crop production and solar energy for Michigan specialty crop farmers.

## Objectives

**Target Farm Profile:** Develop a clear understanding of specialty crop farming, geographic locations, and management practices to identify and define a representative target farm profile.

**Solar Technology:** Gain a comprehensive understanding of fixed tilt, vertical bifacial, and single axis tracking solar arrays through collaboration with contract manufacturers, solar producers, and simulation tools such as SAMs or PVWatts.

**System Design:** Design a model that aligns with the target farm profile and optimal solar array configuration.

**Validation:** Test the developed model in a real-world application, validating with coefficients and parameters before verifying results from Michigan solar installer data.

**Incentives:** Identify and evaluate federal and state incentives or specific funding (USDA, NRCS, etc.) programs for Michigan farmers to implement agrivoltaics.

## Constraints

**Infrastructure:** Array height, array layout, space availability

**Environmental:** Weather and soil conditions in Michigan

**Financial:** Cost-benefit analysis and long-term economic viability

**Time:** Construction timeline and post-installation site stabilization

**Crop Selection:** Suitability of crops for farm conditions

## Design Alternatives

### Fixed Tilt

- Strengths: Adaptable heights, lower cost, manually adjustable tilt
- Limitations: Low energy generation

### Vertical Bifacial

- Strengths: Good energy production in varying seasons, and can maximize land use efficiency
- Limitations: Lower energy production overall, work best at latitudes of 50 and above

### Single Axis Tracking

- Strengths: Algorithmic tracking, high energy generation
- Limitations: High cost of implementation and maintenance

## Selected Design

### Single Axis Tracking

Scoring high across four metrics in the decision matrix: energy output, land use efficiency, maintenance cost, and environmental impact. The system rotates from east to west allowing panels to follow sun throughout the day. They can be programmed with smart tracking algorithms that adjust panel movement to balance energy production with crop needs. Reduces shading, supports crop growth beneath the arrays, enables electricity generation across seasons. Increases energy yield and long-term revenue potential for farmers.



Figure 2. Example of a single axis tracking system in Grembergen, Belgium.

## Design Parameters

The tool architecture of the program is divided into a three-part structure. The first part includes identifying where the agrivoltaic system could be built.

- Users begin by selecting a county and township within Michigan
- The tool then displays high-resolution satellite imagery, allowing users to zoom in, outline potential project boundaries, and label candidate sites
- This step ensures all subsequent calculations are grounded in real, site-specific conditions

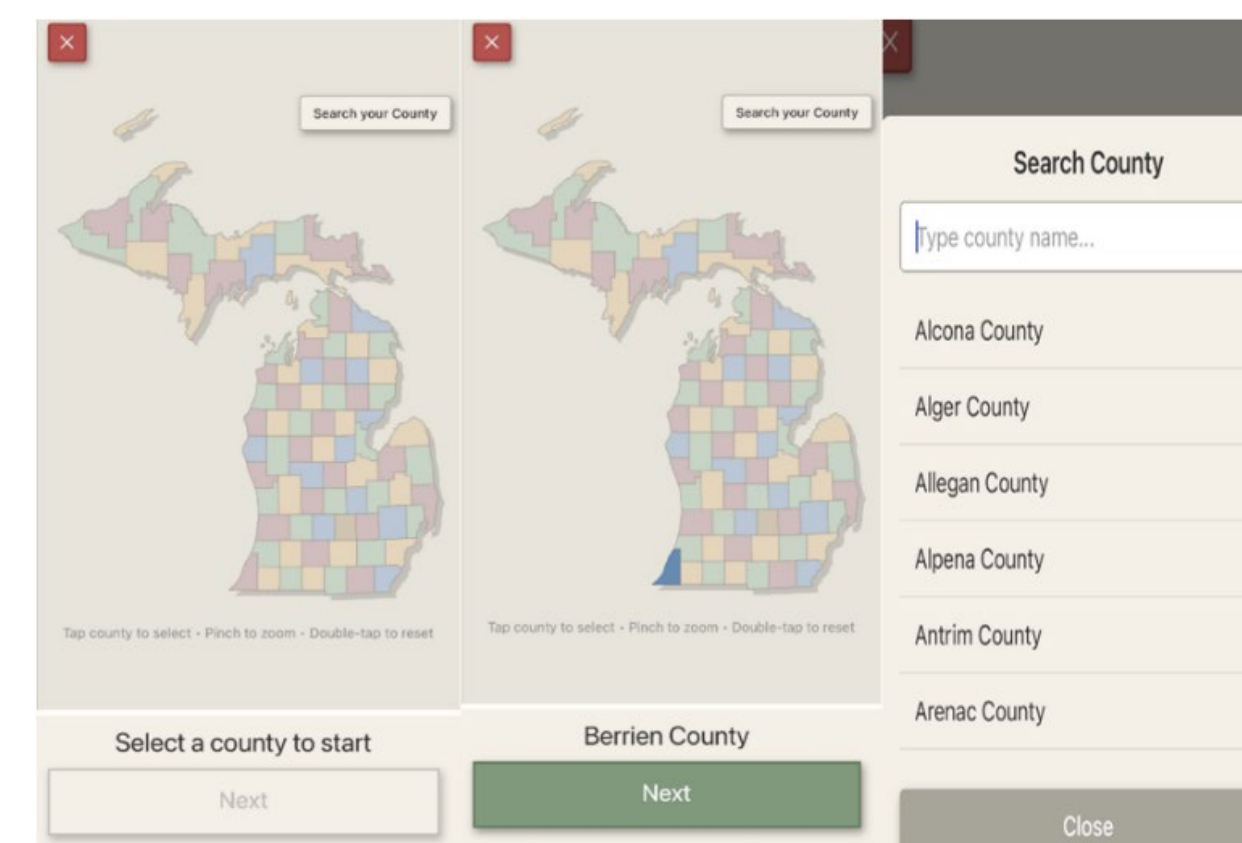


Figure 3. County selection interface

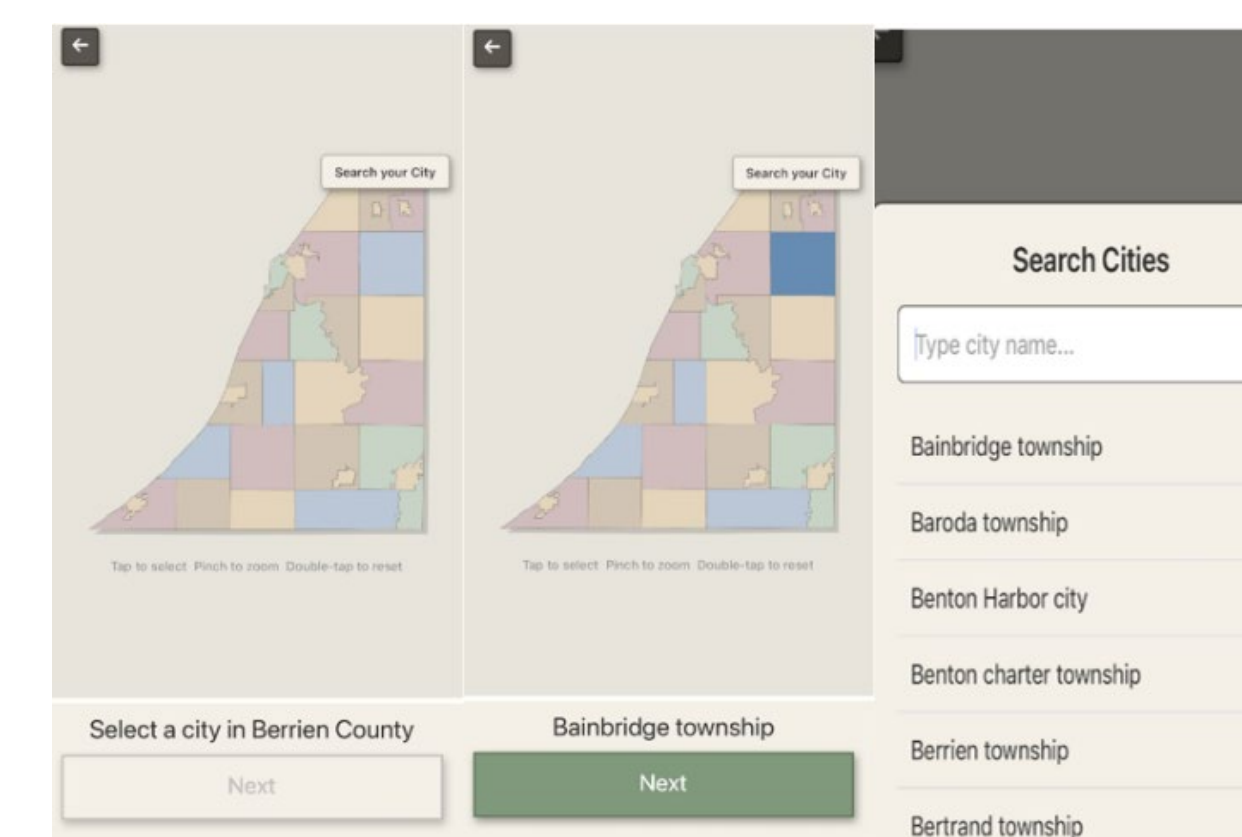


Figure 4. Township selection interface

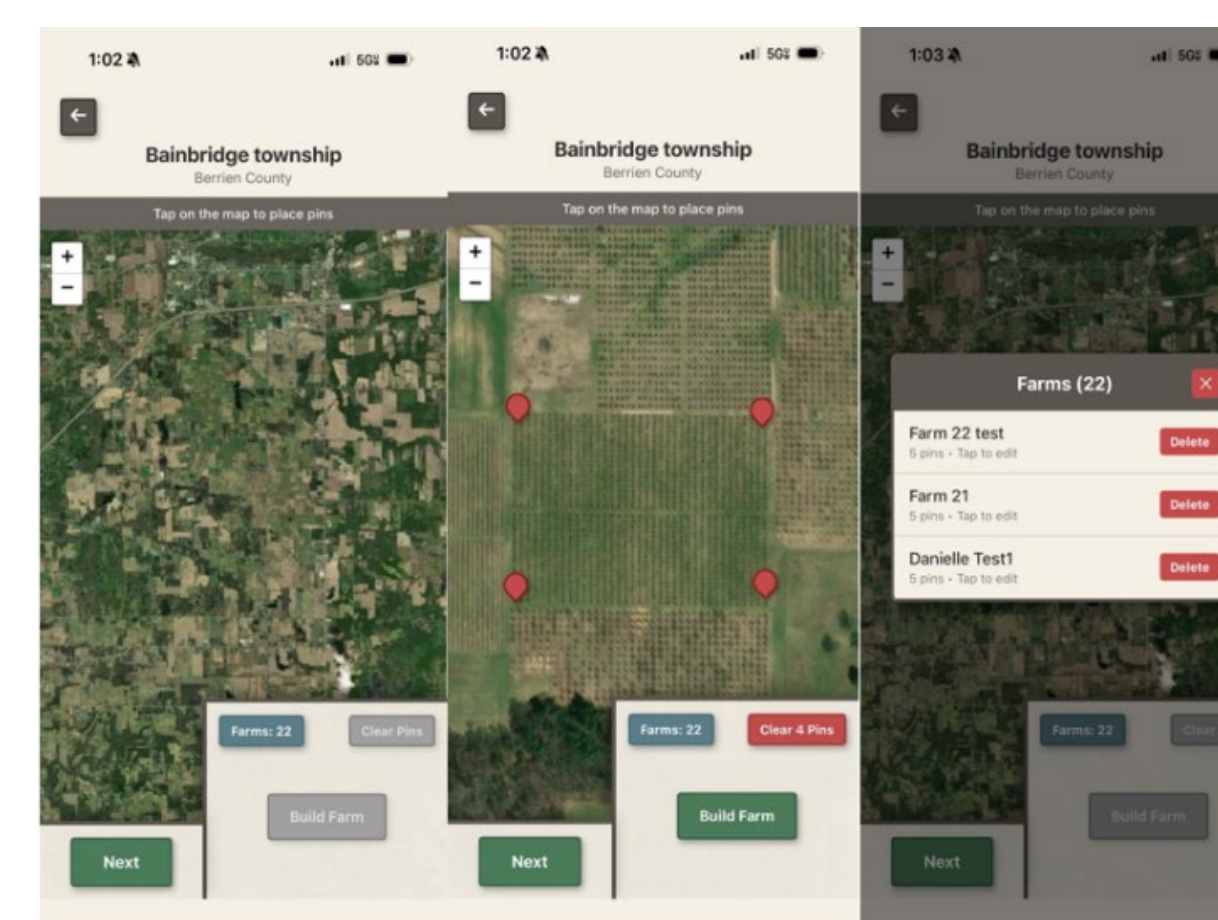


Figure 5. Satellite imaging and site boundary creation

After the site is mapped, the tool estimates the solar energy potential of the selected area. This converts geographic information into quantitative performance metrics.

- The tool uses NLR PVWatts API to model expected energy output based on system size, tilt, azimuth, module type, and system losses
- Users can view solar suitability layers, elevation data, and other spatial characteristics that influence the system
- These energy estimates form the technical basis for the economic model, since energy production directly affects revenue and lease feasibility

## Design Parameters (Continued)

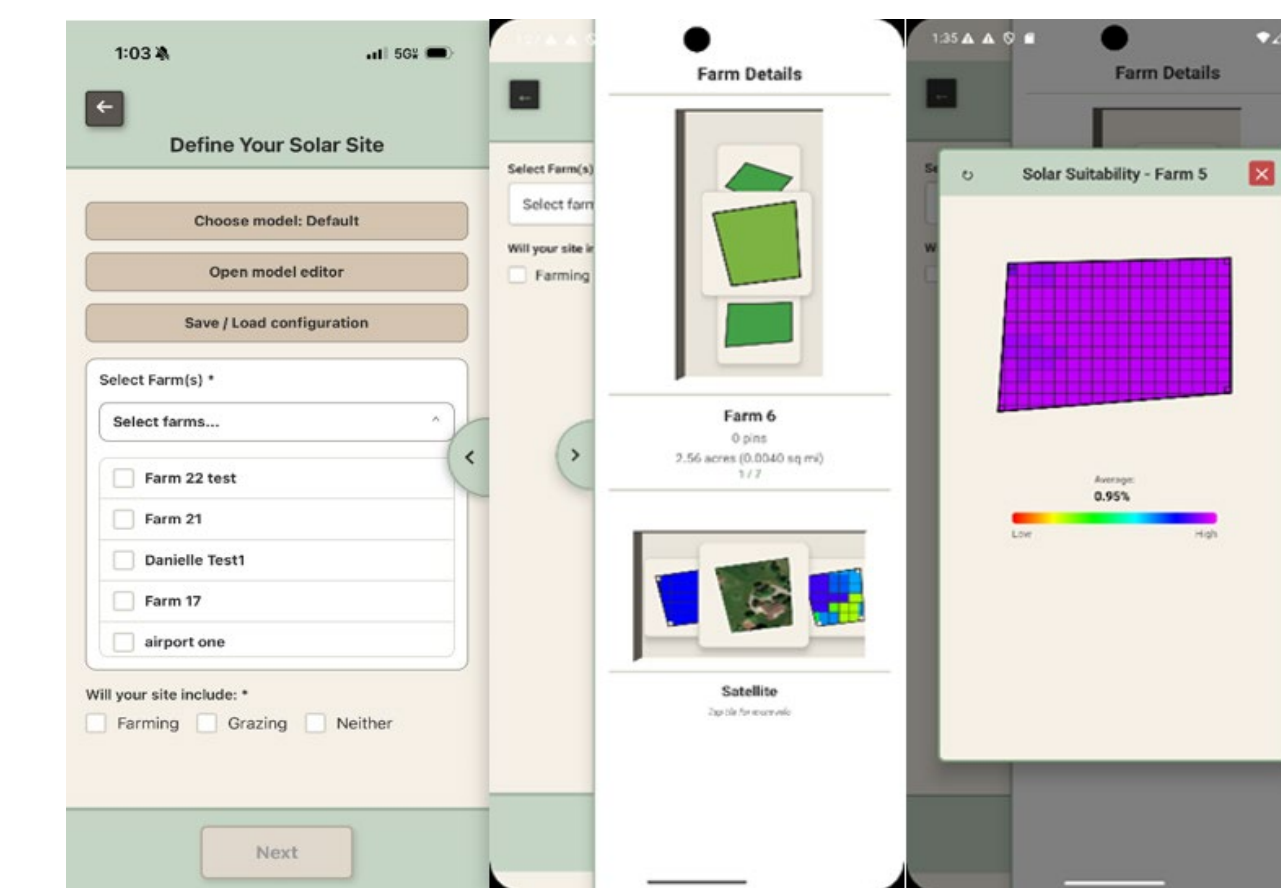


Figure 6. Satellite imagery with solar suitability and elevation layers

The final stage combines land availability, energy production, and financial constraints into a linear programming (LP) model that identifies the most profitable agrivoltaic configuration.

- Users input site-specific values such as crop type, tax incentives, and solar configuration
- The LP model evaluates construction costs, crop revenue, and the maximum lease rate a solar developer could pay while maintaining a positive NPV
- The model then determines the optimal allocation of acres between solar and crops
- The output includes the NPV-maximizing solution, the feasible lease rate range, and the recommended land-use split

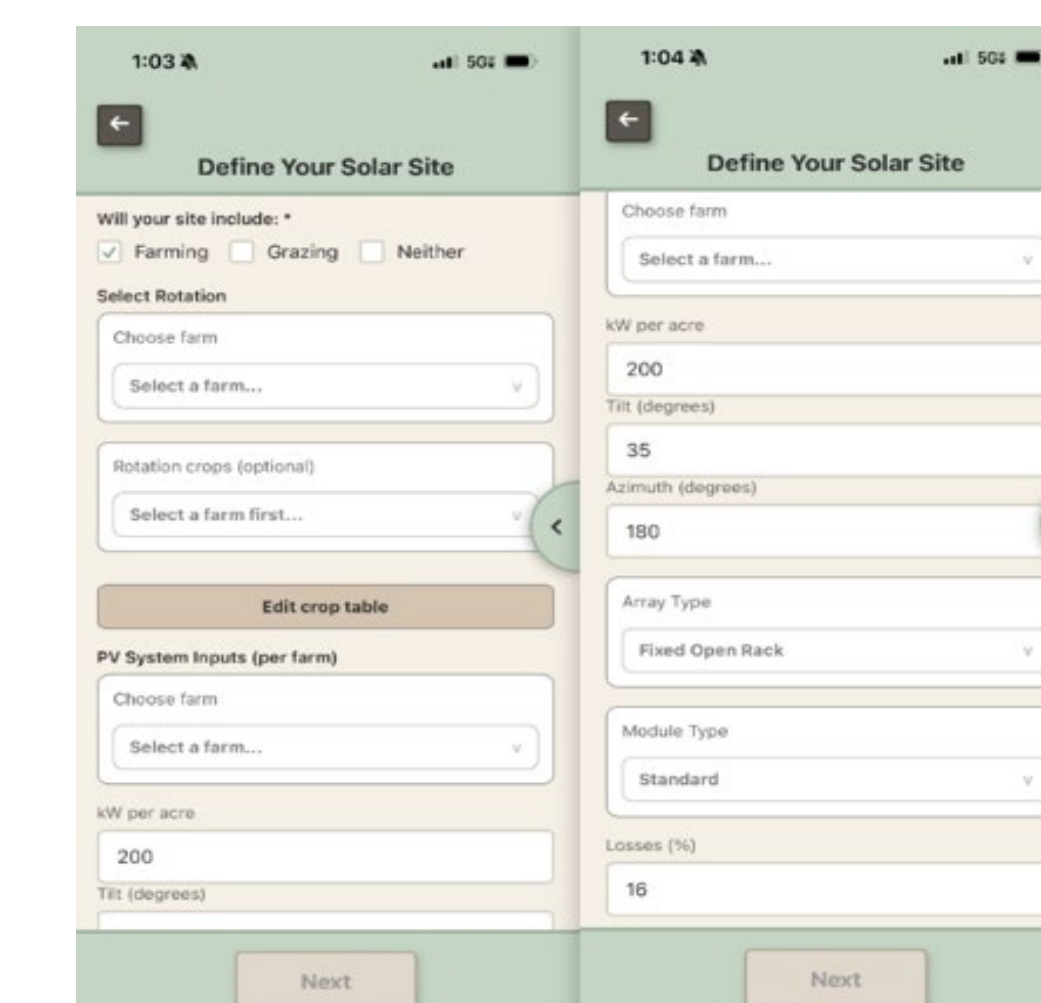


Figure 7. Site definition and scenario selection.

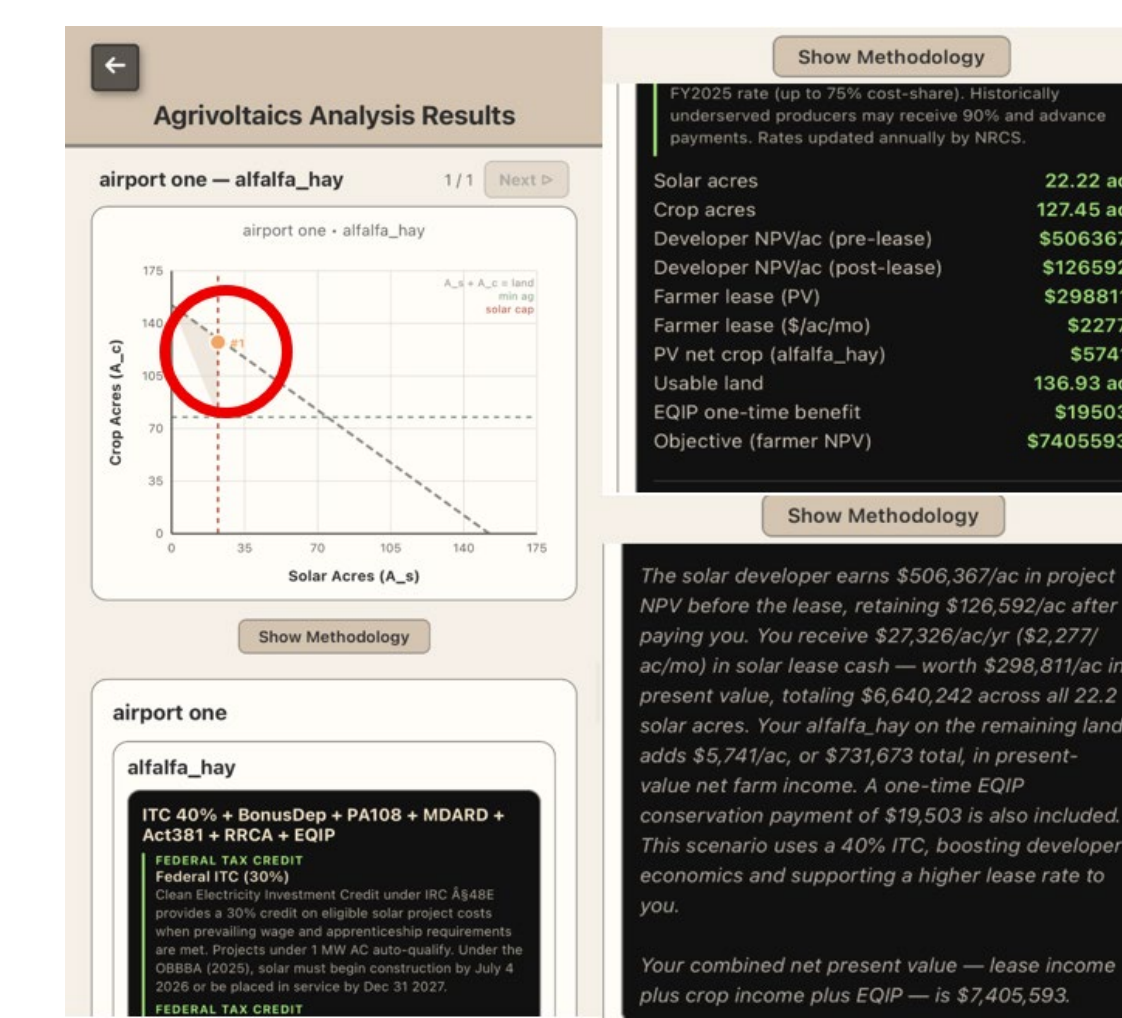


Figure 8. LP model and optimal allocation.

Together these components form a workflow that helps Michigan farmers evaluate agrivoltaic opportunities on their land.

## Economics

Michigan's agrivoltaic economics are shaped by a narrowing incentive landscape and several key Michigan-specific programs:

- **PA 108 Solar Exemption:** Replaces standard property taxes with a fixed solar-specific tax for 20 years, with lower rates for qualifying community-benefit project
- **EGLE Brownfield Grants & Loans:** Funds environmental investigation, cleanup, tank removal, and demolition on contaminated site
- **Act 381 Brownfield TIF:** Reimburses eligible cleanup, demolition, and infrastructure costs through tax-increment financing
- **NRCS EQIP:** Offers high cost-share funding for conservation practices
- **NRCS CSP:** Provides annual payments for multi-year conservation practices

These incentives interact directly with the project's financial model to evaluate system costs, energy production, and lease-rate feasibility. Baseline capital costs range from roughly \$0.95/Wdc for fixed-tilt systems to \$1.06/Wdc for single-axis tracking, with panel density capped at around 350 kW per acre and total system size limited to 10 MW to maintain agrivoltaics scale. PVWatts energy outputs feed into revenue projections, allowing the model to calculate the maximum lease rate a solar developer can pay while maintaining a positive NPV. The optimization framework then identifies the acreage split that maximizes farmer income by balancing crop revenue, solar lease payments, and incentive value within the project's constraints. Together, these economic factors demonstrate that agrivoltaics can provide diversified stable revenue streams for Michigan farmers when supported by appropriate incentives and cost structures.

## Select References

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- [2] Riaz, M.H., Imran, H., Butt, N. Z. (2020) Optimization of PV Array Density for Fixed Tilt Bifacial Solar Panels for Efficient Agrivoltaic Systems: *IEEE Photovoltaic Specialists Conference (PVSC) 47*, 0160-8317 10.1109/PVSC45281.2020.9300670
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