SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
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Water Storage for Agrophotovoltaic Systems

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Objective

A novel experimental photovoltaic system has been installed on Purdue's ACRE Research Farm that aims to

- Provide food, energy and water
- Minimize external inputs
- Answer the question: **How can the needs of current and future generations be sustainably met?**

The experimental farm lacks a water storage system. Indiana experiences high precipitation in winter/spring but low amounts during the growing season. Collecting runoff from the solar panels provides the opportunity to store supplemental irrigation water and prevent erosion. The proposed solution collects, conveys and stores water onsite, offering a reliable, sustainable water source to address a "full-Earth" scenario.


Research & Design Context

Common water conveyance methods include drainage systems, gutters, and vegetated channels while storage techniques involve tanks and ponds. The research on runoff quality from solar panels is limited but their impervious nature alters rainfall patterns and accelerates runoff. These insights guided solution brainstorming and development of final design.

Constraints & Criteria

Constraints	Criteria
• Not interfere with farming operations • Not take up productive land • Not require external inputs • Meet applicable standards for water and conveyance/storage systems	• Affordability • Simplicity • Storage Capacity • Scalability • Lifespan

Methods, Tools, & Principles

The final deliverables for this project include a complete set of design calculations, drawings and specifications of the proposed solution. The design processes began with brainstorming ideas for collecting, conveying and storing the water. Through a decision matrix, the final proposed design was determined and then tested on.

Design

- ACRE weather data
- Irrigation requirement calculation utilizing the National Engineering Handbook Temperature Method for evapotranspiration
- Research gutter materials and shapes
- Research tank sizes and materials for weather resistance

Solutions

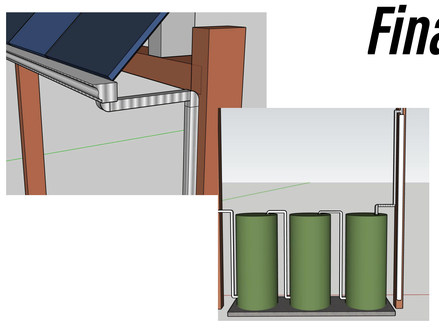
The top 4 most feasible brainstormed solutions were scored 1-5 for each project criterium though a decision matrix.

1. Rigid tank in between
2. Bladder tank in between
3. Closed aqueduct system
4. Underground pipe storage

Testing

- Settlement calculations
- Hydraulic head calculations & small-scale replica
- First flush diverter

Final Design



SketchUp drawing of final design showing the gutter system, first flush diverter and overall system

Quantities

- Runoff available: 10,688 gallons
- Storage available: 10,800 gallons
- Irrigation Requirement: 137,152 gallons in July

Specifications

- Conveyance: 5" Galvanized steel, K-style gutter and downspout
- Storage: 36 300-gallon tanks
- Outlet-Inlet: 1.5" x 2" PVC DWV adapter coupling & 1.5" PVC pipe
- Base Support: 119" x 43" x 3.5" concrete pads
- First Flush Diverter: 13' of 4" PVC pipe

Prototyping

- Settlement: 1.88 in
- First Flush: 1.5 mm/row totaling 8 gallons diverted/row
- Hydraulic Head: verified flow direction throughout tank system

Value Proposition

Economic

- Total costs for labor and materials such as tanks, concrete, gutters is about $20,118
- Total savings/profit is about $227/year from replacing municipally sourced water, increasing yield and selling energy back to grid

Functional & Psychological

- Farmers/consumers can feel good about their choices
- Mitigates climate change by reducing fossil fuel use
- Prevents further degradation of the environment

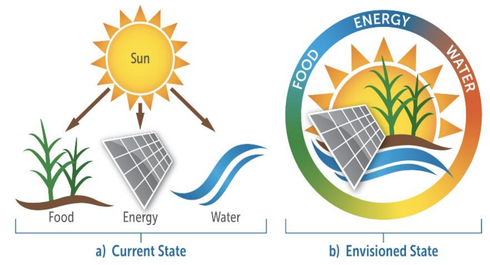
The initial cost is high, but the long-term benefits are worth much more when it comes to the future of our planet.

Impact & Future Work

Impact: This design propels the ACRE experimental farm towards a fully self-sustaining system. Collecting runoff for supplemental irrigation boosts crop production and profits. The experimental farm lays the groundwork for a sustainable food, energy, and water system. The farm's innovative concepts can be adapted globally to enhance sustainability. The aim is to co-produce food, energy and water with minimal environment impact, meeting present and future needs in anticipation of a "full Earth" scenario.

Future Work

- Conduct more precise irrigation requirement calculations
- Perform proper geotechnical analysis to obtain more accurate settlement calculations



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