Application of Sustainable and Innovative FPV to Optimizes Reservoir Designs Generate Power & Reduce Evaporation Water Losses

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Abstract

This project evaluates the feasibility of integrating a floating photovoltaic (FPV) system with the proposed Valenciano Reservoir in Juncos, Puerto Rico, to improve both water and energy resilience. The study combines hydrologic analysis for reservoir design with an assessment of FPV technology as a dual-purpose solution for renewable power generation and evaporation reduction. Runoff hydrographs were developed for major design storms, including the 100-year and Probable Maximum Precipitation (PMP) events, to estimate inflows, reservoir behavior, and operating water levels. Results were used to assess the available water surface for FPV deployment. The analysis shows the reservoir can support an FPV installation.

Introduction

Juncos, Puerto Rico, is one of the municipalities on the island that has experienced persistent problems and inconsistencies with both water and electrical utility services. In response, the Government of Puerto Rico has pursued the design and construction of a new reservoir intended to provide residents with a more reliable and resilient water supply system. The proposed reservoir will capture water from the Valenciano river and is expected to address long-standing service deficiencies affecting the community.

In addition to its water-supply function, the reservoir provides an opportunity to incorporate floating photovoltaic technology as a sustainable infrastructure component that supports Puerto Rico's transition toward more resilient utility systems.

This study develops the hydrologic basis for reservoir design. Results are then used to evaluate the feasibility of installing an FPV system capable of producing renewable energy, reducing evaporation, and improving overall reservoir performance.

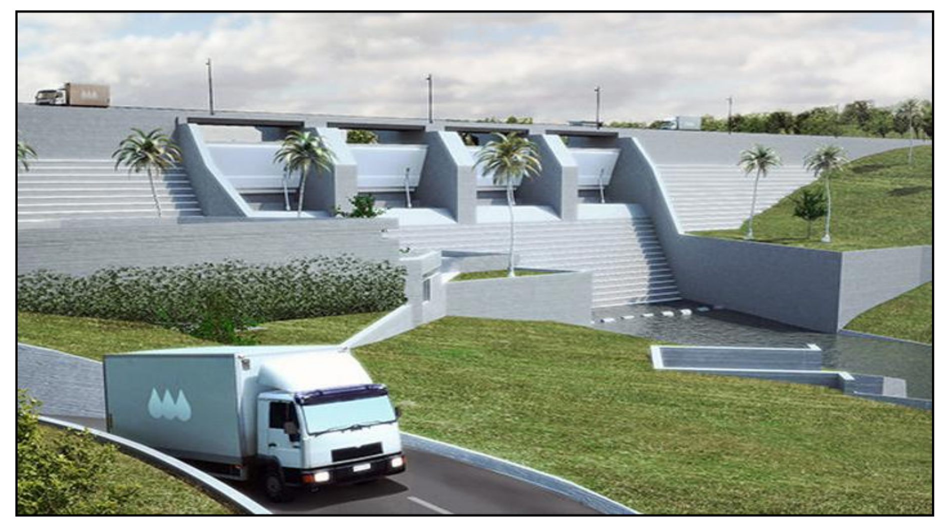
Background

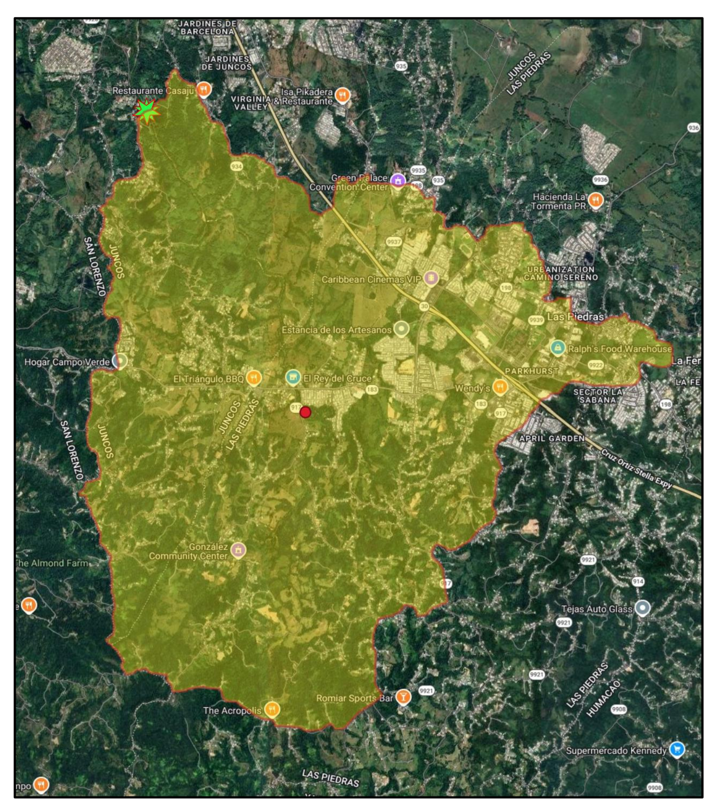
Puerto Rico continues to face recurring interruptions in water and electrical service due to aging infrastructure, extreme weather, and limited system resilience. In Juncos municipality, these challenges support the need for a new reservoir on the Valenciano River that can provide a more reliable water source while also creating an opportunity for renewable energy generation microgrid. Integrating an FPV system on the reservoir is a practical dual benefit: it uses water surface area to generate clean power and reduces evaporation losses and improve water quality.

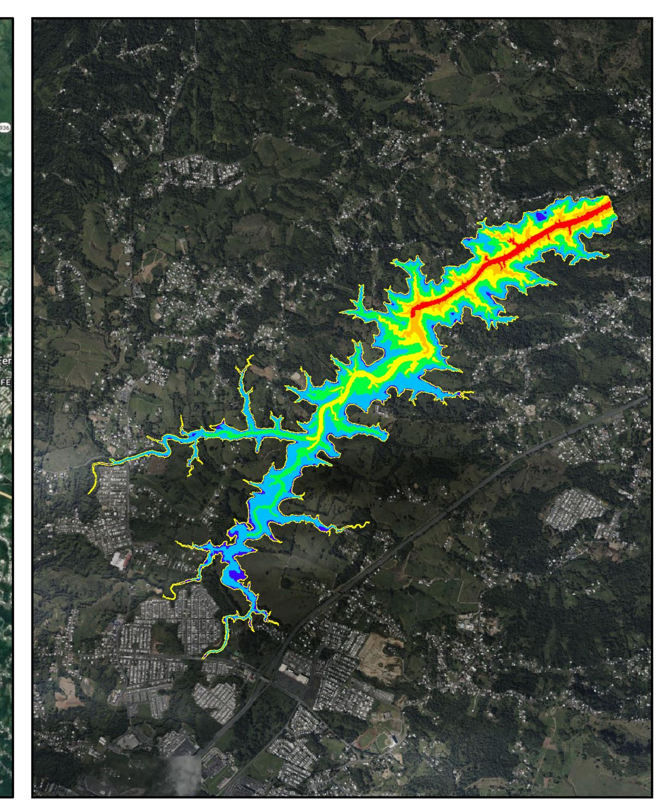
Methodology

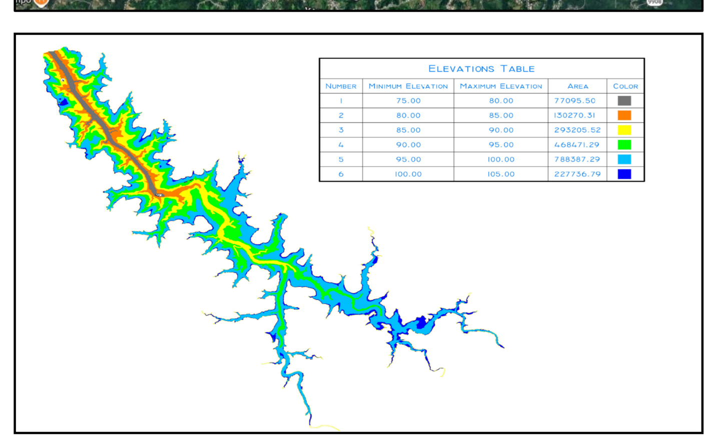
The evaluation process is divided into the following:

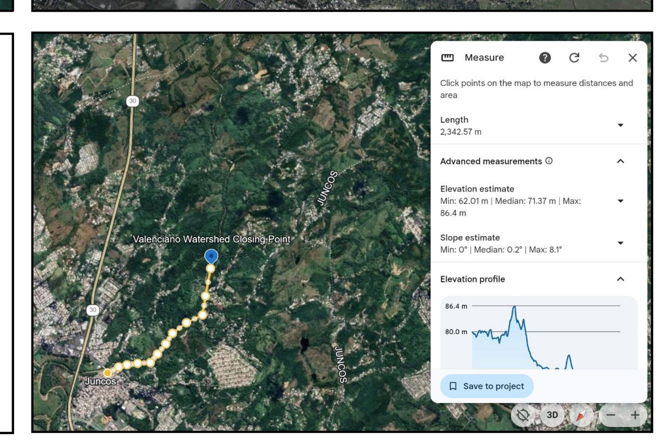
- Statistical Precipitation Data Analysis (Juncos SE Station S1)
- Develop Hydrologic Analysis and Reservoir Design
- Determine Area Available for FPV Installation

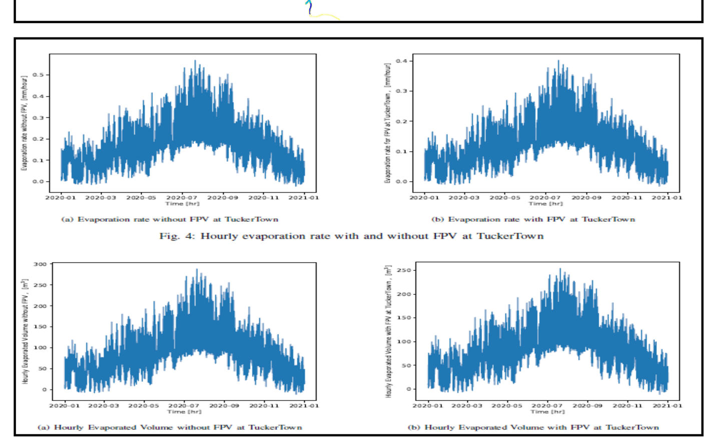


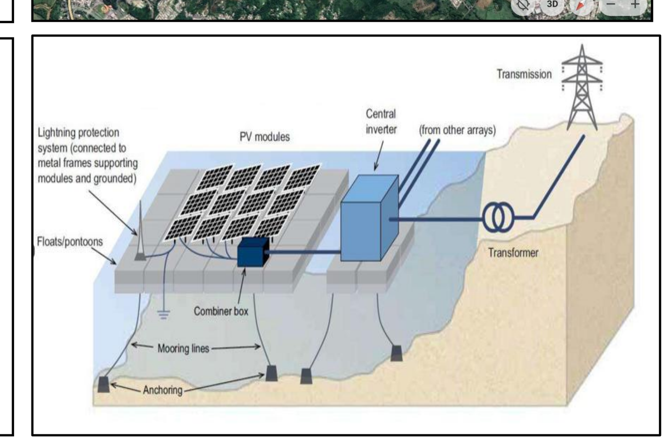












Problem

The chronic instability in both water and electrical service due to aging infrastructure, extreme weather, and limited system resilience. The Valenciano Reservoir will help stabilize potable-water supply while is looking to better serve the people from Juncos, Puerto Rico with a more reliable power generation system. FPV system on the reservoir can simultaneously generate renewable energy, reduce evaporation, improve water quality.

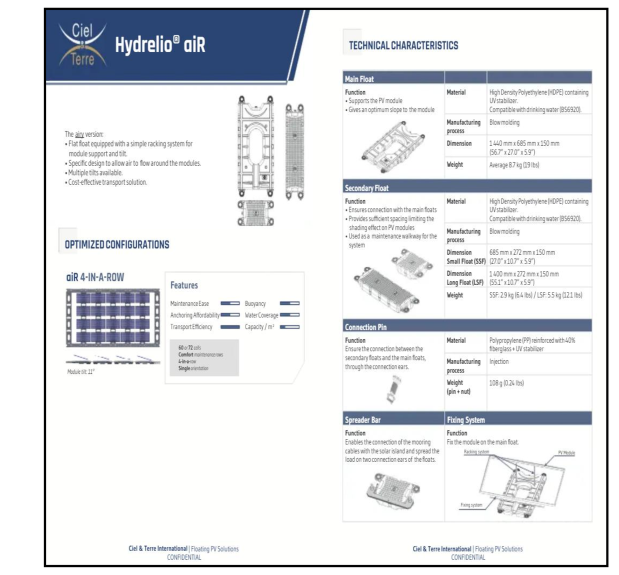
Results and Discussion

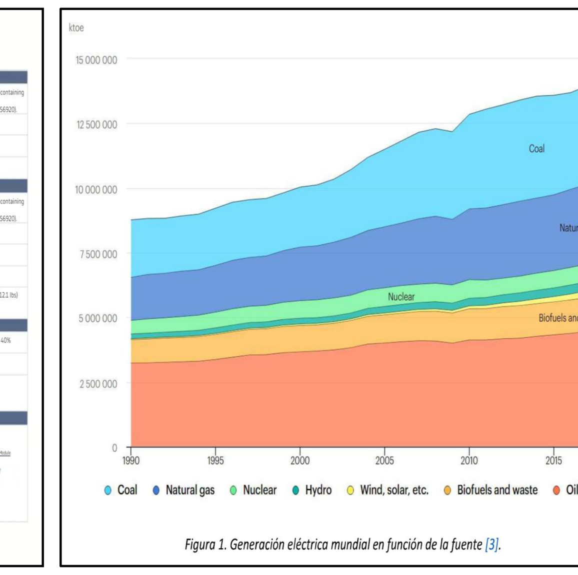
There are many factors to consider when planning a reservoir design; hydrological, geological/geotechnical, environmental, social, water demand, engineering and financial factors. Our project main objective is to design a reservoir taking into consideration the community needs and a sustainable project for a green approach.

Hydrologic Data and Result: The Valenciano watershed covers approximately 15 square miles and is characterized by mountainous, vegetated terrain with scattered rural areas and low-density development. Hydrologic Soil Group C was adopted as representative of the basin, since the watershed is characterized with low to moderate infiltration capacity. A weighted CN for the watershed was developed based on land use, HSG and AMC. The CN weighted is 77, this mean is a watershed mostly forest cover with a high level of drainage. Precipitation data used was 6-Hour, 100-Year = 12.1 in, 24-Hour, 100-Year = 19.9 in and 24 Hour PMP = 52.8 in, for precipitation data we are using the NOAA Atlas 14, station S1 in Juncos, PR. Safe yield demand, safe amount of water we can take from the reservoir is 17.1 MGD and maximum storage = 3370 MG.

Model Discussion: For modeling was used HEC-HMS & HEC-RAS. QGIS was used to delimite the watershed using USGS StreamStat data. The closing point coordinates are 18.20926, -65.92391, calculed with QGIS. Once we have precipitation data, CN, Q (Runoff Caudal), S and Tc, it is used for the modeling to generate the Peak Inflow,WSE and Peak Outflow in Valenciano Reservoir.

FPV Discussion: Floating Photovoltaic (FPV) Solar system offers a practical alternative by placing solar generation on reservoir surfaces, thereby avoiding land-use conflicts while supporting cleaner and more resilient energy supply. This system can reduce evaporation, limit algae-promoting sunlight penetration and increased energy efficiency due to natural cooling from water. A reduction in evaporation between 30-70% of water can be experienced. A typical FPV plant includes PV modules mounted on floating structures, electrical equipment, and anchoring or mooring systems. For 1000 houses A 3.5 MWDC HYDRELIO floating PV system typically needs 17,500–23,300 m² of water surface based on standard FPV power density value of 150 - 200 W/m². For planning and feasibility studies, a conservative allowance of 20,000–25,000 m² (about 2.0–2.5 ha) is used to include buffers and layout constraints.





Conclusions

This study evaluated the hydraulic behavior of the proposed Valenciano Reservoir to identify operating water levels and the available surface area for a floating photovoltaic system. The results indicate that integrating FPV with the reservoir is technically feasible and offers clear benefits, including renewable energy generation, reduced evaporation, and added value to the overall water infrastructure investment. Overall, the project demonstrates a practical approach to combining reservoir design with sustainable energy generation in Puerto Rico. By linking hydrologic analysis with FPV implementation

Future Work

As a next step for this research, it would be great to implement FPV in a pilot project to prove is duable and change midset while make more reliable of power generation system in Puerto Rico.

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