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TEXAS STATE INGRAM SCHOOL OF ENGINEERING

# C1.05 – Pumped Storage Hydropower to Harness Excess Solar


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## Problem Statement

Electrical grid management becomes increasingly challenging as energy sources transition to more renewable and variable options, such as solar power or wind power. Senior Design Team C1.05 aimed to reduce the need for lithium batteries as energy storage and adapted the traditional idea of pumped storage hydropower (PSH) into a variety of alternatives. The main requirement was a minimum of 50 megawatt-hour (MWh) capacity, and there were no other constraints.

The original four alternatives were evaluated for time, environmental impact, complexity, cost, and lifecycle.

## Original Alternatives

- **PSH in Conjunction with Desalination Plant:** Proposes using the H2Oaks desalination plant in San Antonio, TX, as the lower reservoir and routes the treated water to the existing Olmos Reservoir for hydropower.
- **PSH as a Gravity Battery:** In a pressurized, underground system to be constructed by a solar farm in Upton County, TX, a piston is hydraulically lifted when there is excess energy and released to push water through a turbine for hydropower.
- **Optimizing PSH with Tides:** To improve PSH system efficiency, the system will be constructed at a seaside cliff, pumping water for storage at high tide, and releasing water for hydropower as needed. Advocate Harbour in eastern Canada was proposed for its terrain and large elevation changes between high and low tide.
- **Retrofitting Buchanan Dam for PSH:** The Buchanan Dam in Burnet, TX, along the Colorado River is a hydroelectric plant with a current capacity of 54.9 MWh. This alternative proposes retrofitting the existing dam to allow for a PSH system.

## Site Information

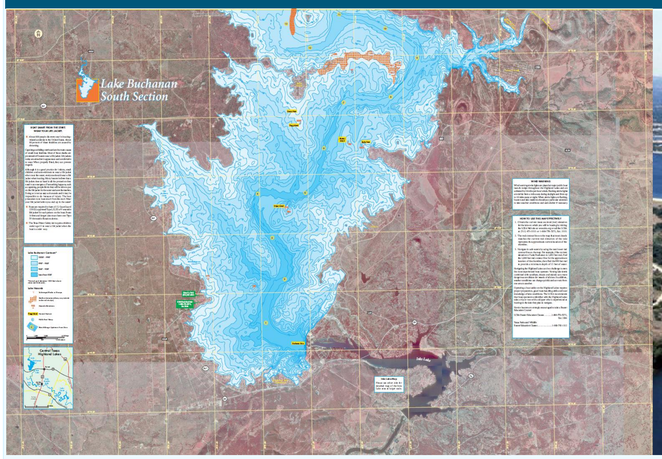



**Figure 1**: Map of Buchanan Lake, Buchanan Dam and Inks Lake ("Lake Buchanan", n.d.)

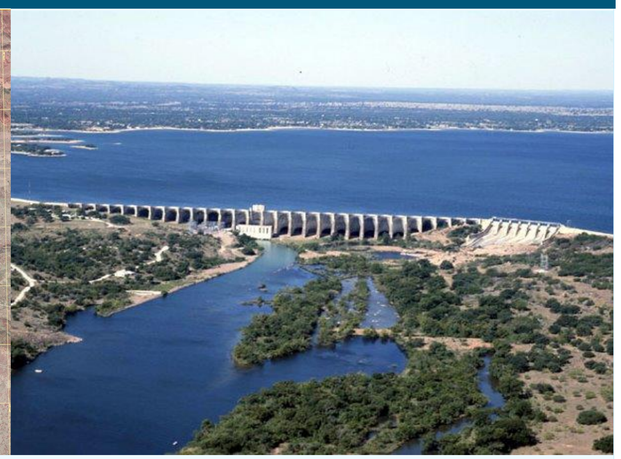


**Figure 2**: Buchanan Dam

## Information

**Why Retrofitting?**

•Retrofitting Buchanan Dam is cost-effective compared to building a new facility, as the dam's infrastructure already exists.
•Recent upgrades worth $51.1 million modernized the floodgates, electrical systems, and safety features, reducing the scope of additional retrofitting needs.

**Key Considerations for Retrofitting**

•*Life Cycle Costs:* Estimated at $350 million, with annual maintenance and periodic upgrades costing $85 million over the system's life.
•*Lifecycle Duration*: Traditional pumped hydro systems last up to 80 years; however, as an existing structure, Buchanan Dam's lifecycle will be shorter.
•*Environmental Impact*: Closed-loop systems like this one exhibit significantly lower lifecycle emissions than other large-scale storage options, such as lithium-ion batteries.
•*Decommissioning Benefits:* Salvageable components (e.g., turbines, generators, pipes) offset end-of-life costs by an estimated $87.5 million.

**Advantages Over Other Systems**

•*Cost-Effectiveness*: Leveraging existing infrastructure reduces costs significantly compared to a new construction project.
•*Sustainability:* Pumped hydro storage systems are more durable, efficient, and environmentally friendly than lithium-ion battery solutions for long-term energy storage.

**Additional Info:**

In the past year, the reservoir has been 44.9-72.7% full.

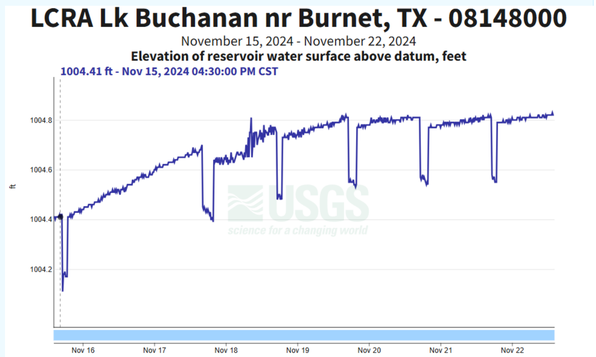


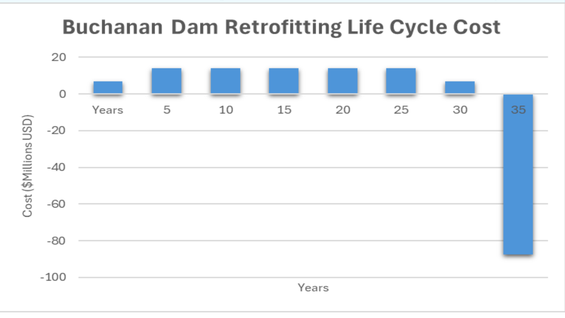

**Figure 3**: Buchanan Dam Elevation of Reservoir Water Datum

## Initial and Life Cycle Costs

**Table 1**: Initial Cost Estimate

| Component: | Cost: |
|---|---|
| **Reservoirs, Dams, and Waterways** | $127,000,000.00 |
| **Water Conductors** | $222,000,000.00 |
| **Powerstation Equipment** | $1,000,000.00 |
| **Total:** | $350,000,000.00 |

**Table 2**: Life Cycle Cost Estimate Graph




## Sustainability

**Table 3:** Envision Evaluation

| Credit Category | Applicable | Submitted | Percentage |
|---|---|---|---|
| Quality of Life | 152 | 35 | 23% |
| Leadership | 0 | 0 | NaN% |
| Resource Allocation | 174 | 73 | 42% |
| Natural World | 182 | 50 | 27% |
| Climate and Resilience | 190 | 68 | 36% |
| Total Points / % | 698 | 226 | 32% |

- Project evaluated with Envision Framework
- *5 categories*: Quality of life, Leadership, Resource Allocation, Natural World, Climate and Resilience
- Irrelevant categories neglected

## Next Steps

Now that a single alternative has been selected, Team C1.05 will be developing a 30% design of the engineering needed for the project.


**Acknowledgements**: Thank you to Dr. Felipe Gutierrez for his guidance through the development of this project.