Tent Mountain Pumped Hydro Energy Storage (TM-PHES) Capstone

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PHASE I

Background

- Tent Mountain, formerly a coal mine in southwest Alberta, is undergoing evaluation for transformation into a **320 MW** pumped hydro energy storage (PHES) facility with a continuous generation duration of up to **16 hours**, jointly pursued by TransAlta and Evolve Power.
- The goal of this project is to transform the former pit mine into a **renewable energy storage facility**, effectively acting as a large battery, managing the equilibrium between supply and demand and supporting the stability of the electricity grid.

Reduced Power Prices for Albertans

Potential to simultaneously power up to **400,000** Albertan homes, providing further grid stability and lowering power prices [1].

Job Creation and Economic Growth

Creating up to **200** construction jobs and **30** long-term local operational positions [1].

Supporting the Energy Transition

Abating up to **500,000 tonnes of CO_2** emissions/year, assuming one cycle per day powered by renewable electricity [1].

Reservoir Sizing and Characteristics

- The Upper Reservoir's seepage losses were analyzed and quantified using SEEP/W within GeoStudio. Based on this analysis, strategies to mitigate these losses, such as implementing a **vertical cutoff wall** and **exterior curtain grouting**, were recommended.
- Three alternative types of **rockfill embankment** dams for the North and South Dams were examined, each with distinct core materials: sheet pile, asphalt, and concrete-faced. The **asphalt core** was selected due to its ease of construction, lower environmental footprint, and cost-effectiveness.

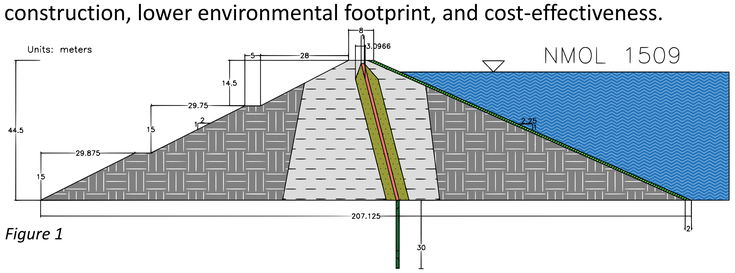

Figure 1

- A 15 m **wide broad-crested spillway**, with a crest height of 0.3 m above the normal maximum operating level (NMOL) was selected to safely route the Probable Maximum Flood (PMF). The peak outflow rate during a PMF was calculated at **29.6 m^3/s**.
- The riparian outlet flow range was determined to be between **0.0 and 1.0 m^3/s**, depending on seasonality.

PHASE II

Water Balance and Hydrological Analysis

- **Ensemble Meteorological Dataset for North America** (EMDNA) forcing data was used to simulate a historical streamflow record, confirm the hydrological feasibility of the project, and establish an average annual water balance for the site.

$$R = P - ET - \Delta S - GW =$$
$$1149\ mm - 861\ mm - 1.9\ mm - 7.9\ mm =$$
278 mm

- For the total watershed area of 5.557 km^2, this result corresponds to an **average outflow** of approximately **0.05 m^3/s**.

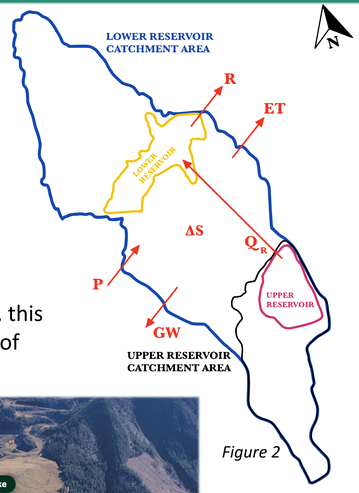

Figure 2

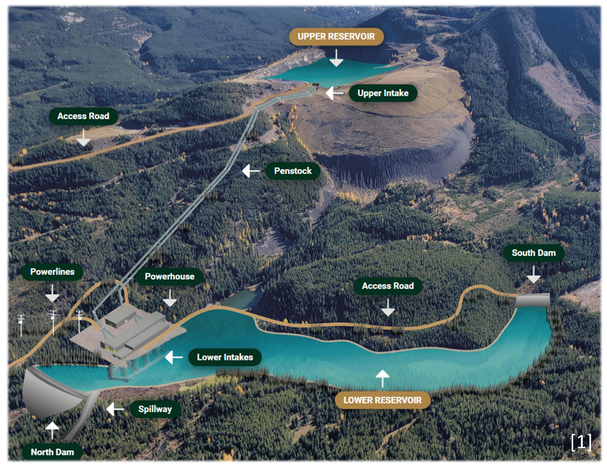

Figure 3

Operational Plan

- Operating the facility on a cycle of **8 hours** of generating to **10 hours** of pumping was the most effective amongst the tested scenarios. Based on 2022 pool prices in Alberta, the facility could expect to have a net revenue approximately between **$70-155 million per year**; translating to an annual percentage variance of 12.03% and 29.28%, respectively.

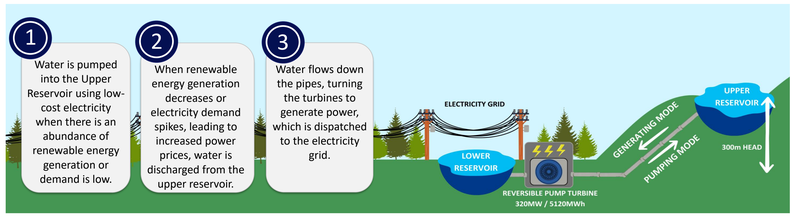

Figure 4

PHASE III

Long-Term Climate Change Impact Analysis

- Projected future meteorological forcing data from **four climate change scenarios**, over the next 75 years, was used to simulate an ensemble of possible future streamflow records and assess the potential impacts of climate change on the project.

Scenario 1
Least extreme climate change scenario due to sustainability investment.

Scenario 2
Climate change scenario based on current trends; most likely to occur at Tent Mountain.

Scenario 3
Regional conflict scenario – wealth disparity and conflict leads countries to focus internally.

Scenario 4
Most extreme climate change scenario due to resource exploitation.

- Scenario 2 was chosen due to its ability to replicate **storage and outflow** values, which resembled those of more extreme climate scenarios.

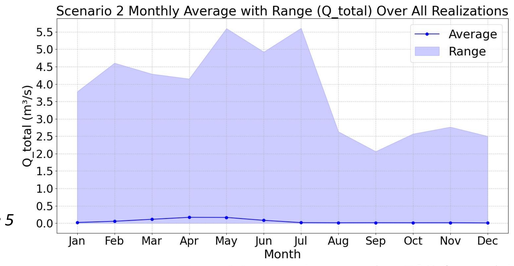

Figure 5

- The average temperature at Tent Mountain rose by 5°C from historical records to Scenario 4, with precipitation values showing a slight increase on average as climate change intensified, characterized by wet months becoming slightly wetter and dry months slightly drier.

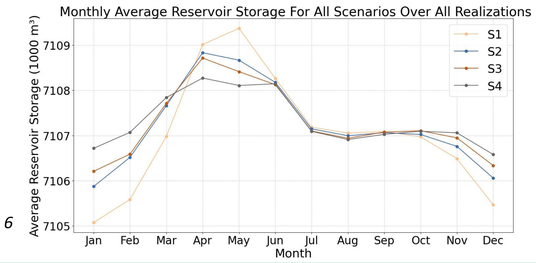

Figure 6

Mitigation and Adaptation Plan

- **Extreme drought** events are likely to increase with each of the scenario, so reducing the effects of evaporation is key to minimizing the impacts. Surface cover options such as **Aquacaps** and **Shade Balls** are the most effective solution to reduce evaporation by creating a **floating barrier** between the water surface and atmosphere.
- **Spillway management** will be utilized during periods of **high precipitation** and **flood occurrences** to safely discharge excess water. These measures can be supplemented with emergency response plans and investment in infrastructure to increase reservoir storage capacity.

References

1. Evolve Power. "Tent Mountain Pumped Hydro Energy Storage." [Online]. Available: https://evolvepower.ca/what-we-do/tent-mountain-pumped-hydro-energy-storage/. [March 23, 2024].

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