Project 2: Modeling Energy Storage Systems

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Abstract

A large amount of renewable energy that can be used to support a portion of our energy demands is provided by the sun. However, one main challenge associated with solar energy is how to store that energy so it can be used at a later date.

The team was tasked with creating a model to determine the most efficient configuration of a variety of sites, layouts, and materials for the reservoir.

Project Management

- Eliminate some decisions that the code would have to make
  - Zone 1 was selected using an evidence-based decision matrix
  - Other decisions were made based on the team's choice to prioritize efficiency over cost
- To maximize efficiency of the model, we chose reasonable values to balance cost and efficiency
- The model calculates reservoir surface area, input energy, system efficiency, time to fill, and time to empty

References

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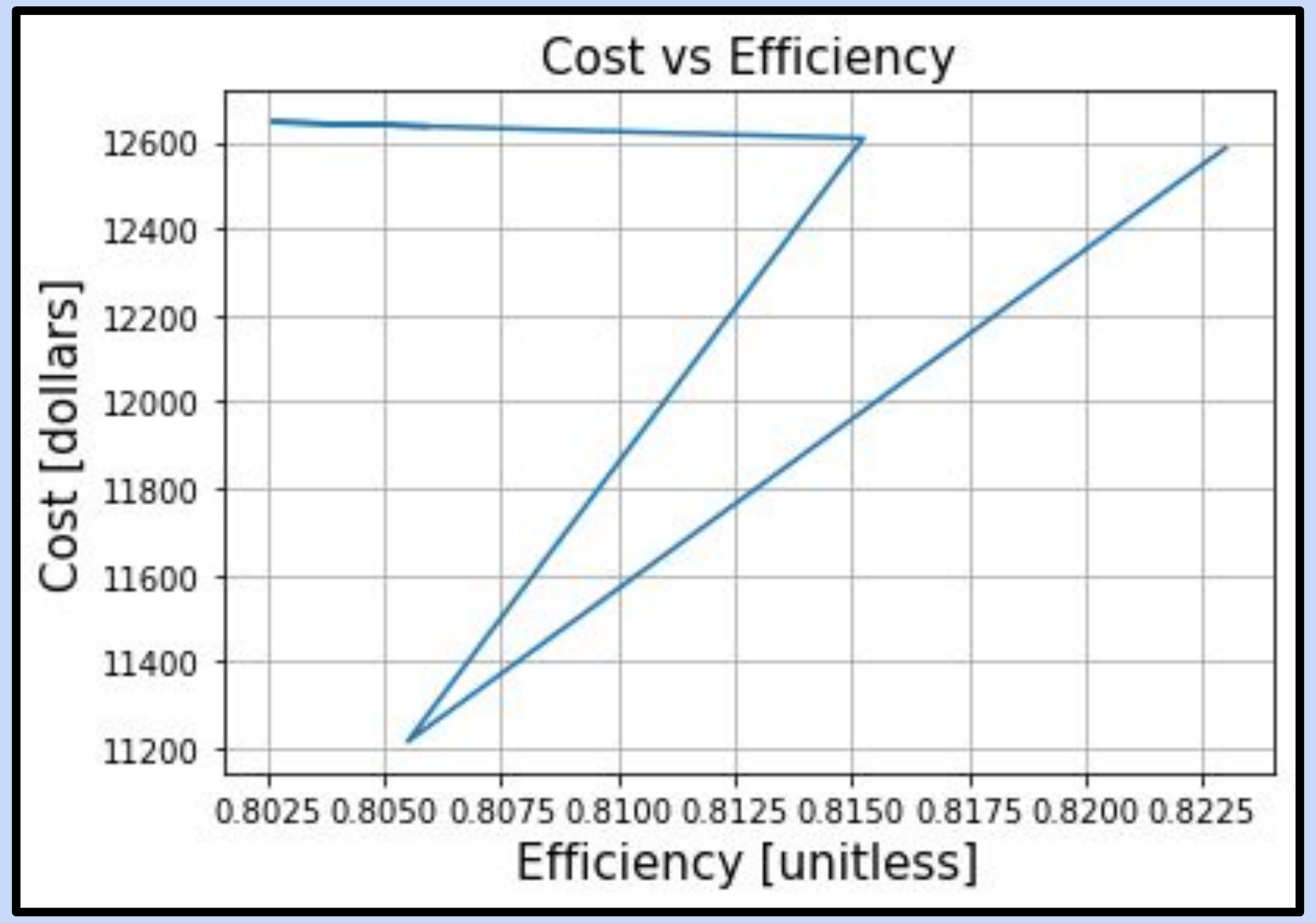
Methods

$$V_{down} = \frac{Q_{turbine}}{Area_{pipe}} \qquad V_{up} = \frac{Q_{pump}}{Area_{pump}}$$

$$M = \frac{\left(E_{out} + E_{in}\left(\frac{1}{\eta_{turbine}}\right) - 1\right)}{g(H + d/2) - f(L/D)(V_{down}^2/2) - \mathcal{E}_1 V_{down}^2/2 - \mathcal{E}_2 V_{down}^2/2}$$

$$E_{in} = m(f(L/D)V_{up}^2/2) + m(\mathcal{E}_1 V_{up}^2/2) + m(\mathcal{E}_2 V_{up}^2/2) + E_{out} + E_{out}\left(\left(\frac{1}{\eta_{turbine}}\right) - 1\right) + m(f(L/D)V_{up}^2/2 + m(\mathcal{E}_1 V_{down}^2/2) + m(\mathcal{E}_2 V_{down}^2/2)$$

Results



Pump Efficiency	0.92
Pipe Diameter	3.0 m
Pipe Friction	0.002
Turbine Efficiency	0.92
Mass	1.3×10^{9} kg
Area of Reservoir	106630 m^2
E_{in}	149.0 J
Efficiency	.8055
Fill Time	5.70 hours
Empty Time	11.94 hours
Overall Estimated Cost	$669,331.18

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Discussion

- Eliminated site 2 due to cultural considerations
- Site 3 was eliminated due to environmental concerns and practical purposes
- Eliminated concerns about people, animals, or objects falling into reservoir

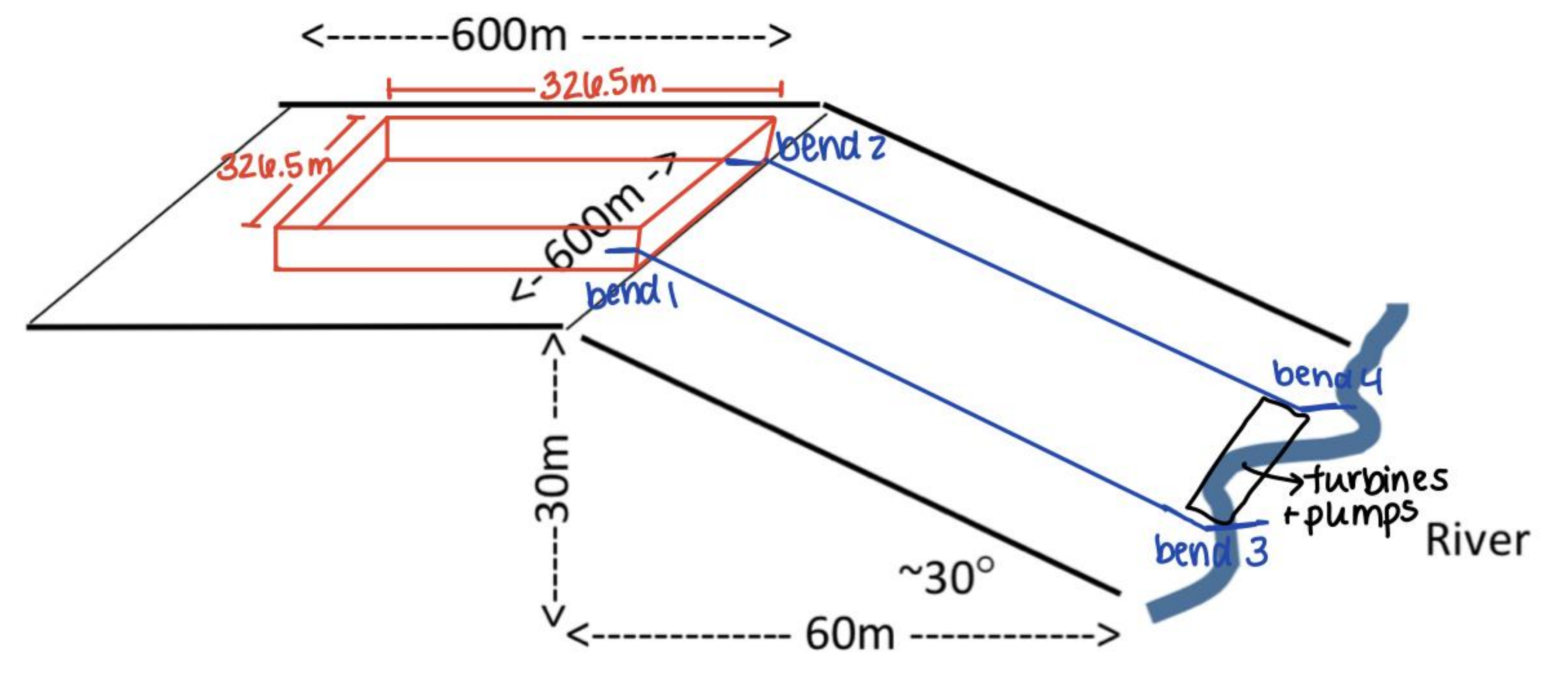

Figure 1: Zone 1 layout

Conclusion

- Final calculated cost: $669,331.18
- Cost to efficiency ratio: $836,664:1
- Model weaknesses: neglects other potentially significant factors, prioritizes cultural and environmental factors over cost and efficiency in site selection
- Model strengths: Cuts down on needed surface area, maximizes efficiency, keeps time to empty under 12 hours
- Criteria: minimum cost among efficiencies above 0.8