# Low Head Ocean Energy Storage

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## Background

Last year, a wave resonance device was designed to tap into the energy of the ocean's waves. the energy supplied by this device is intermittent and needs a form of energy storage so that it can provide a constant supply of energy when needed. Thus, a compatible water reservoir to store energy needs to be made.

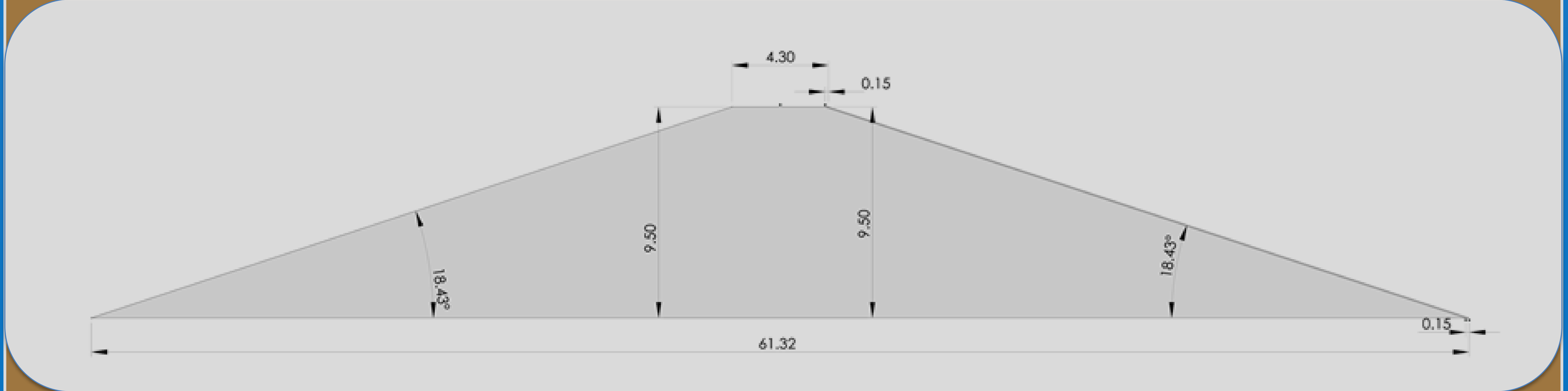
## Design Objectives

- **Reservoir must be built around the resonance device's maximum head of 8 meters above sea level**
- **Reservoir must hold enough potential energy in its water to power 1000 homes for a single day (36.4 MWh of energy)**
- **Design must be long lasting and eco friendly, else the benefits of this renewable source of energy will be diminished**
- **Design must be versatile enough to work in multiple locations**
- **Must be able to compete with other forms of energy storage**

## Full Scale Design

Because the reservoir is limited to 8 meters of head, the footprint of the reservoir has to be quite large. This large footprint means that if the walls of the reservoir were made of anything but dirt, the cost of the reservoir would become too large. Since dredging was found to have a large impact on nature, the only option was to build a reservoir out of dirt on land.

In order to store 36.4 MWh of energy, a footprint of 0.507 km$^2$ is needed. An extra 1.5 meters would be added to the height of the dirt berm to prevent spillage, and a thin layer of bentonite clay would be applied to the interior of the reservoir to prevent leakage.

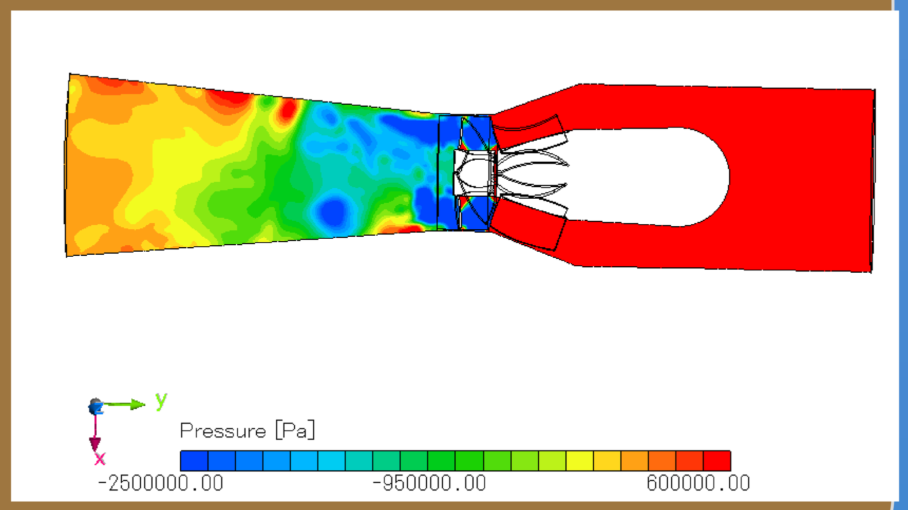



The dirt berm that makes up the walls of the reservoir requires a shallow 1:3 slope to ensure that it lasts a long time.

## Additional Details

The reservoir needs the ability to transform its stored potential energy into electrical energy used in everyday life. Turbines were the natural choice for this task, so a CFD analysis was run to get an idea of which turbine should be used.

It was decided that 6 turbines would be needed for this reservoir totaling at around $25,000,000 when adjusted for inflation.




## Full Scale Summary

- **The total cost of the reservoir is $36,929,000 with the primary costs being the turbines, the bentonite clay, the land, and the cost to move the dirt.**
- **Compared to high head power storage, our design is 5 times the cost per kilowatt hour ($1014 vs $220), and takes up far more space.**
- **Given the high differences in costs it was determined that low head energy storage is currently not cost efficient**

## Model Design

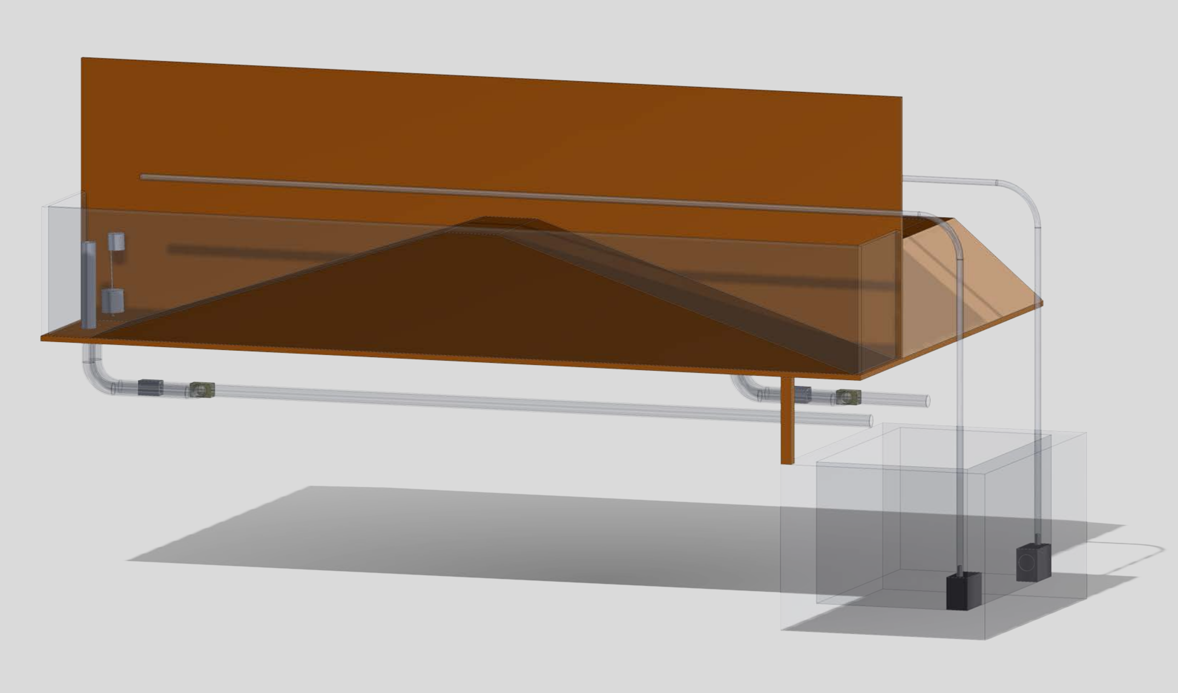
A model was built to see how well a low-head water reservoir would handle. Since a perfect scale model would end up rather flat if set on a table, thus some design changes were necessary to create something more observable. Thus, the top of the table was divided into two portions; one to show an accurate scaled down cross section, and the other to show half of a working low-head reservoir with walls built at an adjusted scale.

## Model Additional Details

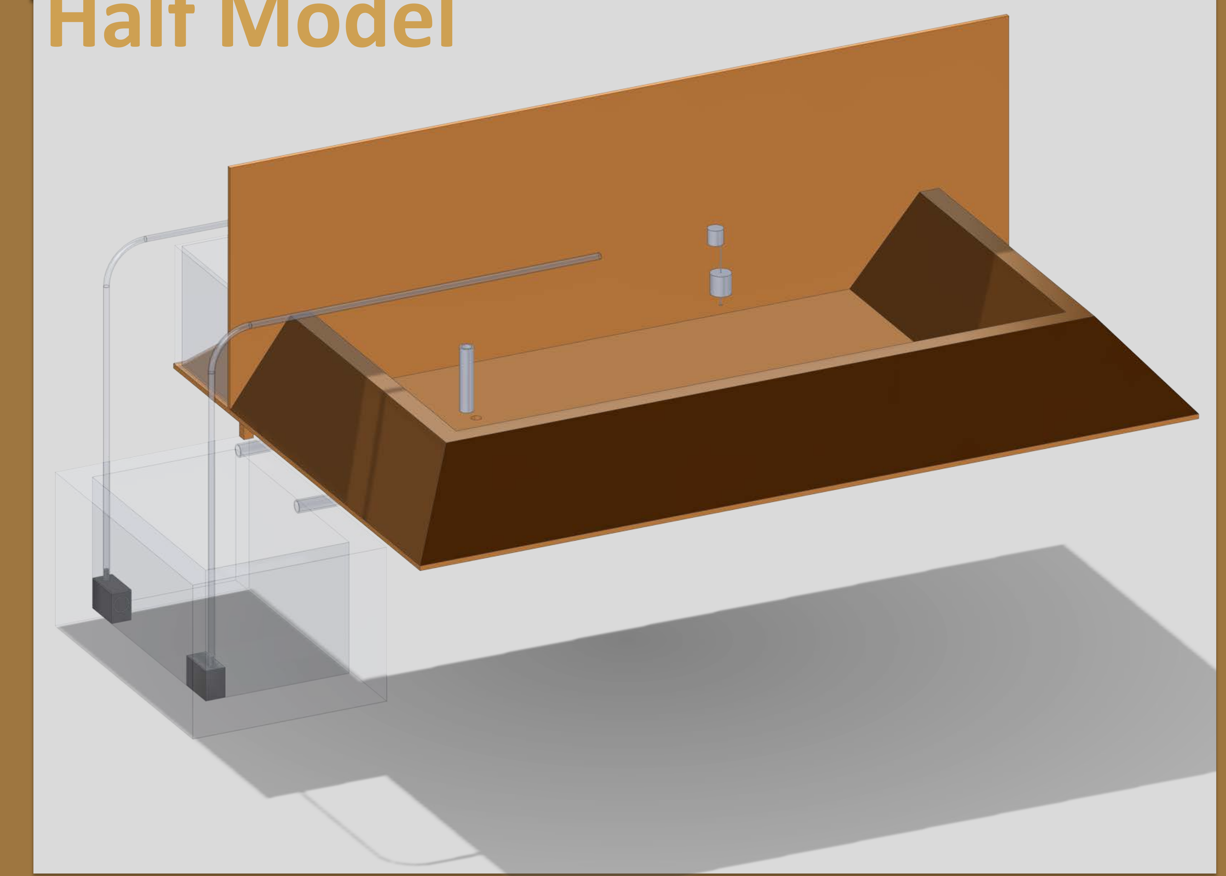
An automatic refill system was implemented so that the model would start emptying when filled all the way. When the water level is low, not much power is provided to the turbine, so the goal was to create a system that shows the power provided to the turbine from the max water level to the minimum. There is also a system to pump water into the reservoir which aims to represent the input from the wave resonance devices.

## Digital Scale Model

### Cross section Model



### Half Model



## Real Scale Model