Bodega Marine Laboratory Hydropower Feasibility

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Purpose & Scope

Investigate the viability of using hydropower turbines to harness the mechanical energy of seawater outflow from Bodega Marine Lab (BML) in support of their vision of becoming the first carbon neutral marine research facility

- **Energy**
  - Quantify flow parameters and energy availability
- **Turbine**
  - Select turbine(s) and predict performance
- **Finance**
  - Determine system cost & return on investment
  - Investigate PGE incentives
- **Policy**
  - Identify policy roadblocks
- **Risks**
  - Identify potential risks

Figure 1: Pumps to holding tanks representing sizeable energy use

Figure 2: Effluent outflow location to ocean

System Overview

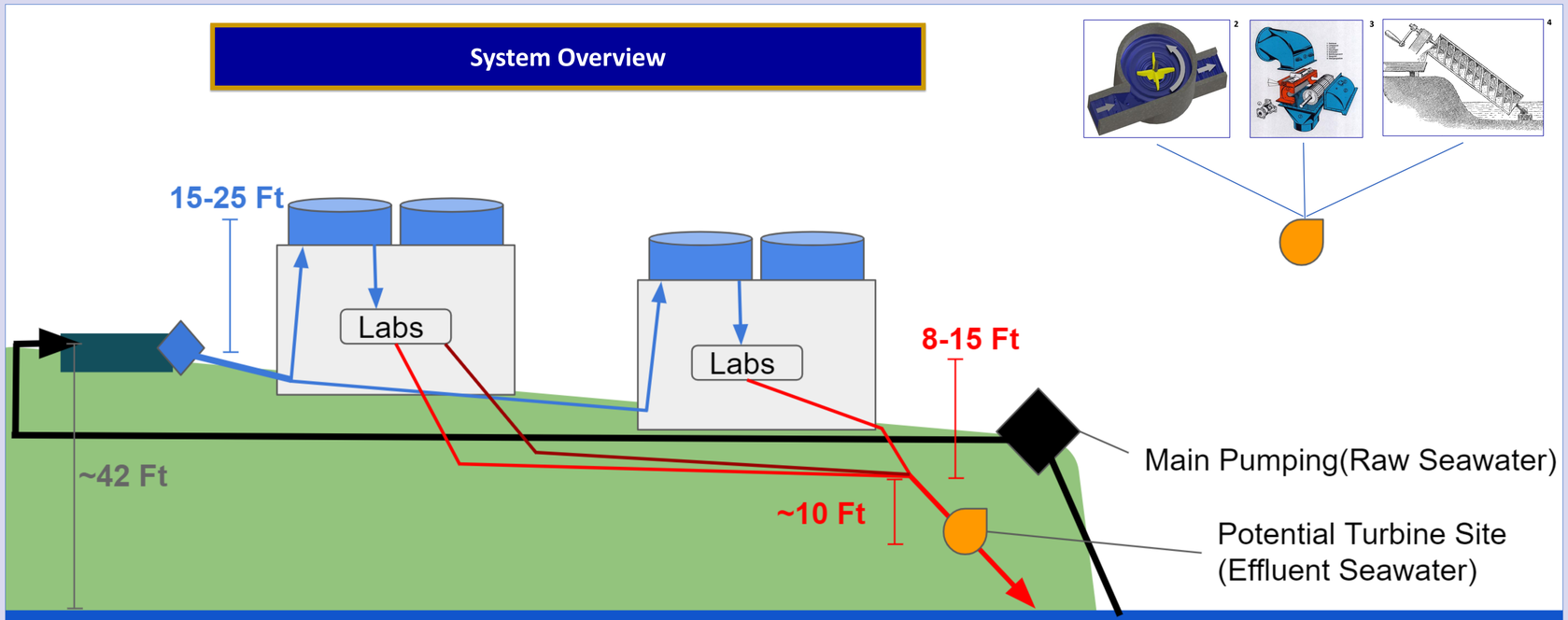

Figure 6: System overview of primary Bodega Marine Laboratory water flows

Methodology

Information Gathering
- Visit the Marine Lab to take pictures and observe facility parameters
- Conduct literature review
- Collect water flow, energy, and billing data

Data Analysis
- Estimate parameters of water flow
- Determine energy potential

Contact Turbine Manufacturers
- Obtain recommendations and specifications
- Collect equipment & installation quotes

Contact PG&E Account Manager
- Determine approximate $/kwh for facility
- Identify potential rebate programs

Perform economic analysis
- Estimate annual energy production
- Estimate payback time

Figure 3: Pumphouse location pulling up to 1,000,000 gal/day of seawater

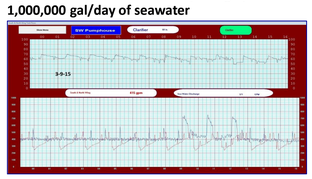

Figure 4: Sample flow data (BML Facilities)[1]

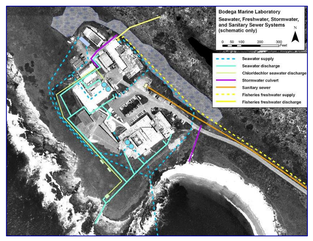

Figure 5: Seawater flow map of facility (Bodega Marine Lab Facilities)[1]

Results

Qualitative Analysis

Turbine	Efficiency	Cost	Maint.	Risk	Manufacturer
Archimedian Screw	+++	-	-	-	Landustrie WORLDWIDE WATER TECHNOLOGY
Gravitational Vortex	++	+	+	+	BARNARD HYDRO SOLUTIONS INC.
Crossflow	+	+++	++	-	SCOTT HYDROELECTRIC

Table 1: Qualitative assessment of turbine alternatives: + = better performance, - = worse performance

Economic Analysis	Archimedian Screw	Gravitational Vortex	Crossflow
Upfront Costs	$210,000	$50,000	$12,000
Annual Costs	$600	$500	$300
Power (kW)	0.95	0.8	0.7
Annual Benefit	$1,243	$1,069	$953
Annual Net	$643	$569	$653
NPV (20 years)	-$191,856	-$41,012	-$4,043
Payback Time	100+ Years	100+ Years	28 Years

Table 2: Economic Analysis of three turbine options at a 3% discount rate, assuming $12/month reduction in demand charges Smaller turbines have better payback due to low costs, despite worse performance

Risks

The Bodega Marine Lab is the center of some of the most important research on coastal ecosystems. In addition to critical research that requires 24/7 flow of fresh seawater, the lab lies on a nature preserve, thus adding to the complexity of any infrastructure project.

- **Technical**: Tying in a hydroturbine may disrupt outflow, requiring diversion control
- **Maintenance**: Additional staff hours to monitor biofouling and power production
- **Permitting**: Compliance likely requires a minimum $20,000 fee

Conclusions & Next Steps

- Hydropower is technically feasible, but not economically competitive
  - However, BML may wish to pursue the project anyway given their goals for carbon neutrality
  - Generation will reduce carbon emissions by 2-3 MT CO_2 per year
- The permitting process can have high costs, but bundling this project into another project will practically eliminate those costs
- Full hydrological system analysis may be required to determine the impact of the turbine on overall system performance

Contact Information

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References

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[3] "Ossberger Crossflow Turbine Water21." [Online]. Available: http://www.water21.org.uk/ hydropower/ossberger-hydroturbines/the-ossberger-turbine/. [Accessed: 03-May-2018].
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