Power Assessment of Mid-Scale (20-30MW) OTEC Plants across US Locations

1.1 Background/Objectives

Ocean Thermal Energy Conversion (OTEC) is a renewable energy technology that can generate continuous baseload electricity by exploiting the temperature difference between warm surface and cold deep seawater. Pilot-scale OTEC plants have demonstrated technical feasibility, with the transition to commercial mid-scale deployment being the next major step for this emerging technology. A comprehensive power assessment using ocean temperature gradient data and realistic design specifications would benefit this progression. Foundational benchmarks for OTEC economics and strategies were established by Ocean Energy Systems (2012) for 10MW, 50 MW, and 100 MW OTEC plants, using amortized annual capital-loan repayment and annual levelized costs to calculate the total Levelized Cost of Electricity (LCOE). An industrial report by Lockheed Martin (2011) described a 2.5 MW Mini-spar floating pilot plant in Hawaii, demonstrating the use of mature, Commercial Off-The-Shelf (COTS) equipment to minimize technical risk and capital expenditure. While these prior studies provided critical technical and economic benchmarks for either small-scale pilot or large-scale utility systems at specific point-locations, a gap remains in evaluating the potential of mid-scale systems across a broader geographic range. This study addresses this gap by documenting an updated power prediction model for a mid-scale plant through detailed analysis.

1.2 Approach/Activities

The presented models are mid-scale OTEC plants with net power ranging from 20 MW to 27 MW, operating between 4.1°C cold deep seawater at a depth of 1000 meters and 28.9°C warm surface seawater at a depth of 15 meters in four diverse U.S. locations. The analysis was applied to multiple distinct tropical and sub-tropical regions: American Samoa, the Gulf of America (GoA), Hawaii, and Puerto Rico. Site-specific net power performance is derived from World Ocean Atlas historical temperature data, both monthly and seasonal, within US waters. This dataset provides standardized, long-term average oceanographic variables. To simulate OTEC performance, temperature values were extracted at two specific depths of 15m and 1000m. Using the thermal gradient and specified flow rates of 120,000 kg/s warm water, 80,000 kg/s cold water, and 1,560 kg/s working fluid, two types of power output were modeled: gross and net power. A closed-cycle ammonia OTEC system with three-pipe bundles of 3.5m diameter is selected for cold-water intakes. It is to compare the effects of oceanographic temperature and seasonal conditions on the stability and magnitude of OTEC power generation. To reflect modern market volatility, the OTEC cost model must apply specialized Federal Reserve Economic Data (FRED), Chemical Engineering Plant Cost Index (CEPCI) indices, along with Bureau of Labor Statistics (BLS), to major component groups.

1.3 Results/Lessons

This research evaluates essential oceanographic variables and analyzes distinct operational profiles for mid-scale OTEC implementation that effectively leverage economies of scale. The results provide monthly average temperature gradient values and net power production across chosen sites. American Samoa provides the most consistent year-round energy profile, with a high average net power of 27.73 MW, peaking at 29.5 MW in March, while the GoA has the most significant seasonal volatility, with peak power of 27.17MW during August. Puerto Rico and Oahu (Hawaii) exhibit a moderate, stable seasonal cycle. This study provides a thorough roadmap for identifying thermally optimal deployment zones across the U.S., demonstrating that mid-scale OTEC can maximize net energy production while using existing and mature COTS infrastructure.