The Performance of a Physical Model of a Low-Head Seawater Pumped Hydro Storage System

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Abstract:
The majority of energy produced in Small Island Developing State (SIDS) is from fossil fuels. Therefore, in order for the SIDS to reduce their carbon footprint, there becomes an increasing need for the adoption of variable sources of energy. In this study a low head Seawater Pumped Hydro Storage System (SPHS) was investigated for energy production within the small island state of Trinidad and Tobago (one of the larger SIDS nations by population size). A scaled physical model of the system was then developed and tested using seawater from the north coast of Trinidad. The geometric dimensions of the system were adjusted as required to achieve maximum energy efficiency based on varying flow at limited low head. Experimental validation confirmed the importance of pipe size and configuration for system efficiency, with larger pipes and minimized bends yielding the best performance, emphasizing the practical implications for SPHS implementation in a SIDS. For the proposed scalability aspect, a small diameter pipe connected to the pump should be used to transport the seawater from the sea to the upper reservoir by harassing a combination of solar and wind power during the daytime. Then at night or when energy demand increases, the seawater can be released from the upper reservoir through a substantially larger pipe diameter connecting to the impeller's turbine (at least 4 times that of the pump pipe's diameter). The outcome of this research found that the higher the flow rate from the upper reservoir due to the increase pipe size, would exponentially increase the power generated for a shorter time frame and limit energy losses due to pipe friction, given that the other conditions remain the same.

Keywords:
Hydropower, Scalable, Low head, Seawater, Pumped Hydro storage.