Sustainable Wave Energy: Harnessing Ocean Power With a Novel Linear Generator

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As global energy demand rises, ocean waves remain an underutilized renewable energy source that carries significantly more energy per unit area than wind or solar and provides a more consistent power supply. In this project, I investigated whether a linear wave energy converter could improve efficiency, durability, and maintenance requirements compared to traditional rotary-based systems. I designed and built a buoy-driven permanent magnet linear generator to directly convert vertical wave motion into electricity using a tethered stator, alternating neodymium magnets with soft iron flux concentrators, and three-phase copper coils. I designed the system to maximize energy capture while minimizing mechanical complexity, friction, and environmental impact through direct power transmission to shore. I constructed and tested multiple prototypes using motor-driven mechanisms to simulate various wave conditions, and I evaluated different magnet wire sizes, coil turn counts, and soft iron thicknesses. The results showed that my linear wave energy converter produced electricity more efficiently than rotary-based systems by reducing mechanical losses. Increasing the number of coil turns increased the induced voltage due to greater magnetic flux linkage, consistent with Faraday's law of electromagnetic induction. A soft iron thickness of 0.5 inches optimized magnetic flux concentration without saturation and improved generator output. These results demonstrated that my compact linear wave energy converter efficiently generated electricity while improving durability and reducing maintenance, which illustrates its potential for sustainable and practical wave energy applications.

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