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Ocean Wave-Powered Underwater Charging

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Abstract:

Pittsburgh Coastal Energy is an early-stage hardware startup using ocean waves to charge underwater systems while submerged. At-sea systems such as unmanned underwater vehicles (UUVs) rely heavily on battery power for operational energy, which imposes significant limitations on their mission duration, stealth capabilities, and weight and size dimensions. Our mission is to expand undersea capabilities for UUVs and other naval systems by delivering underwater battery charging solutions to enhance long-duration stealth, ensure protection against storms, and offer operational flexibility for unmanned systems, thus providing strategic advantages unobtainable with other energy generation technologies.

Our core innovation - the Polar Ionic Nanogenerator (PING) - directly converts mechanical energy from ocean waves into electricity without relying on bulky mechanical systems. Traditional ocean wave energy converters are large structures restricted to the ocean surface and are prone to single-point failures with high maintenance costs. PINGs, on the other hand, are modular interlinking cells built into scalable metamaterial structures, similar in concept to cells within a solar panel. Their modularity ensures redundancy and adaptability so that even if a single cell fails, the system maintains uninterrupted power generation to enable reliable operation in remote and harsh ocean environments. PING modules are designed to function effectively at depths of up to 20 meters under normal

ocean conditions and over 100 meters during storms. This is because they require only minor wave-induced displacements on the scale of centimeters to harvest sufficient power. Key benchmarks for the technology include achieving watts-per-square-foot power output, a design depth of at least 100 meters, and a maintenance-free lifetime of at least one year.

Our proof-of-concept was successfully demonstrated at the University of Pittsburgh, where we are co-developing a patent for the technology. With over $100,000 in non-dilutive funding secured from the Department of Energy, our next steps include enhancing PING power output, engaging with defense end-users to align with mission-critical needs, and building a prototype to deploy for underwater testing by the end of 2025. We are actively seeking defense partnerships to collaborate on SBIR/STTR funding opportunities to advance PING performance and expedite its deployment in undersea operations.