

Renewable Marine Energy Applications Improving Coastal Economic Stability Worldwide

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DESCRIPTION

The growing demand for energy has encouraged researchers, industries, and public institutions to explore diverse sources capable of supporting economic activity while reducing dependence on finite resources. Coastal regions occupy a unique position within this discussion because they possess access to extensive marine environments that contain significant energy potential. Oceans continuously generate movement through tides, waves, currents, and thermal differences. These natural processes represent valuable opportunities for electricity production and related economic activities. As interest in sustainable energy development expands, renewable marine energy applications have attracted increasing attention due to their capacity to contribute to energy diversification, employment creation, industrial growth, and regional development in coastal communities around the world. Marine energy refers to electricity generated from ocean-based resources. Unlike conventional fossil fuel systems, marine energy technologies utilize naturally occurring ocean dynamics to produce power. These technologies include tidal stream generators, tidal range facilities, wave energy converters, ocean current systems, and ocean thermal energy conversion installations. Although marine energy currently represents a smaller portion of global electricity generation compared with solar and wind sources, continued research and technological improvements have enhanced its viability and attracted investment from both public and private sectors.

Coastal economies often depend on industries such as fishing, tourism, transportation, shipping, and maritime services. While these sectors provide employment and income, they may also face vulnerability due to environmental changes, fluctuating market conditions, and seasonal variations. Renewable marine energy introduces additional economic opportunities that can complement existing industries. The construction, operation, maintenance, and monitoring of marine energy facilities create employment opportunities requiring a variety of technical and professional skills. Engineers, technicians, environmental specialists, construction workers, data analysts, and project managers all contribute to the implementation of marine energy

projects. Tidal energy represents one of the most predictable forms of renewable electricity generation. Tides occur due to gravitational interactions involving the Earth, Moon, and Sun. Because tidal patterns can be forecasted with considerable accuracy, electricity generation schedules can be planned more effectively than some weather-dependent energy sources. Tidal stream technologies capture kinetic energy from moving water through underwater turbines positioned in locations where tidal currents are particularly strong. As water flows through the turbines, rotational movement generates electricity that can be transmitted to onshore grids.

Wave energy systems utilize the motion of ocean surface waves to produce power. Different technological designs have been developed to capture wave movement and convert it into electrical energy. Some devices float on the water surface, while others are partially submerged or attached to coastal structures. Continuous advances in materials science, engineering design, and monitoring systems have improved the durability and efficiency of wave energy technologies operating in challenging marine environments. These improvements contribute to the growing interest in commercial-scale deployment. Ocean thermal energy conversion offers another approach to marine power generation. This method utilizes temperature differences between warmer surface waters and colder deep-water layers. In tropical and subtropical regions, these temperature variations can support electricity production through specialized thermodynamic systems. In addition to generating electricity, such facilities may support desalination processes and cooling applications that provide additional economic value to coastal communities.

Energy security represents another important consideration for coastal regions. Communities located on islands or remote coastlines often rely on imported fuels for electricity generation. Transportation expenses and supply disruptions can significantly affect energy costs and reliability. Marine energy systems installed near consumption centers can reduce dependence on imported fuels while supporting local energy production. Increased energy independence may improve long-term planning and reduce exposure to fluctuations in global fuel markets. The

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integration of marine energy into existing electricity systems requires careful planning. Energy storage technologies, smart grid infrastructure, and coordinated management systems can support efficient utilization of marine-generated electricity. Combining marine energy with other renewable sources such as wind and solar power may improve overall system reliability by diversifying generation profiles. Integrated energy strategies can enhance resilience and support balanced electricity supply throughout varying environmental conditions.

The role of research and development remains particularly significant as marine energy technologies continue evolving. Investigations into improved turbine designs, advanced materials, predictive maintenance systems, and environmental monitoring techniques contribute to ongoing progress. Research efforts also examine methods for reducing installation costs, increasing electricity output, and improving operational efficiency. Continuous innovation supports the gradual transition from experimental projects to broader commercial deployment. Many coastal regions face economic uncertainties associated with changing environmental conditions, resource availability, and global market dynamics. Renewable marine energy offers opportunities to diversify economic activity while

supporting local employment and energy production. The combination of technological advancement, environmental considerations, and economic development objectives positions marine energy as an important area of investigation within contemporary energy research.

CONCLUSION

Renewable marine energy applications contribute to coastal economic stability through electricity generation, employment creation, industrial development, and energy diversification. Tidal, wave, and ocean thermal technologies provide opportunities for utilizing naturally occurring marine resources while reducing dependence on conventional fuel sources. Although technical, environmental, and financial challenges remain important considerations, continued research and development support ongoing improvements in performance and feasibility. As coastal communities seek sustainable approaches to economic growth and energy management, marine energy is expected to remain a significant area of academic inquiry and practical implementation in the years ahead.