BuoyEnergy – A Mobile, Autonomous, and Energy-Self-Sufficient Research Buoy

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Monitoring inland waters such as rivers, lakes, and coastal regions is essential for understanding environmental processes and detecting pollution. Conventional measurement buoys are stationary and limited in spatial coverage, while drifting buoys are unsuitable for confined or coastal waters due to the risk of stranding. This project addresses these limitations by developing a mobile, autonomous research buoy capable of navigating inland waters without external power infrastructure. The buoy combines solar, wind, and wave energy harvesting for long-term autonomous operation. Available energy sources on water surfaces were analyzed theoretically with respect to energy density and seasonal variability. Solar and wind were identified as the primary sources, while wave energy was examined as a supplementary option. Several energy-harvesting prototypes were designed and tested, including photovoltaic modules, wind turbine concepts, and a mechanical wave energy system. A modular, boat-like hull reduces hydrodynamic resistance and allows flexible integration of components. Autonomous navigation uses GPS and an electronic compass. To manage limited energy, an automated anchoring system allows the buoy to remain stationary and enter a low-power mode when required. Results show that solar energy provides the highest average power output, particularly in summer, while wind energy is crucial during low solar radiation. Navigation and anchoring operated reliably in tests. The project demonstrates that energy-autonomous mobile monitoring of inland waters is feasible, while highlighting remaining challenges in propulsion efficiency and winter energy availability.

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