Wind and Wave Energy Trends Along Major Indian Ports

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Abstract:

Understanding the spatio-temporal evolution of wind and wave energy is essential for optimizing renewable energy extraction and identifying suitable sites for infrastructure development. This study assesses the combined potential of wind, swell, and wind-sea energy along major Indian ports using 44 years (1979–2022) of ERA5 reanalysis data, validated against buoy and altimeter observations. Extreme value analysis is conducted using the Generalized Extreme Value (GEV) method. Among six major ports, the highest swell and wind-sea power increases are observed at Kandla (1.33 kW/m/decade) and Mumbai (0.1 kW/m/decade) during June–August (JJA) and September–November (SON). The most significant rise in wind energy occurs at Mumbai (2.47 W/m²/decade) and Kochi (2.39 W/m²/decade). Peak swell power at Kandla reaches 66.84 kW/m, while wind-sea power peaks at 62 kW/m during JJA. The extreme wind energy is recorded at Kandla, averaging 0.51 kW/m² (peaking at 3.65 kW/m²). JJA emerges as the most promising season for renewable energy generation, followed by SON. The findings highlight substantial renewable energy potential along the Indian coastline, emphasizing the need to account for seasonal variability and regional climatic influences when planning coastal energy initiatives. This comprehensive analysis provides valuable insights for sustainable energy development and strategic infrastructure placement across India's coastal regions.

Keywords:

Offshore renewable energy. Combined wind-wave energy. Generalized Extreme Value distribution. North Indian Ocean. Port location