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Gravity-Based Energy Storage for Wind Power: Addressing Renewable Intermittency with Sustainable Infrastructure

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Abstract: *The rapid growth of wind power has outpaced the ability of traditional grids to absorb its variability, making large-scale energy storage increasingly essential. Gravity-based energy storage (GBES) systems address this need by converting excess electricity into gravitational potential energy: for example, surplus power is used to hoist heavy masses (such as concrete blocks or water) to an elevated position and later release them to generate electricity. The most mature form of GBES is pumped hydro storage, which accounts for over 90% of global electricity storage, but emerging "solid" gravity systems (tower, rail or shaft designs) enable similar physics without large reservoirs. Recent commercial deployments demonstrate GBES viability: in 2023 China commissioned a 25 MW/100 MWh gravity system (Energy Vault's EVx™) adjacent to a wind farm, marking the first utility-scale, non-pumped-hydro GESS. Multiple projects totaling ~3.7 GWh are underway worldwide, and underground "gravity batteries" using sand in mine shafts have been proposed for ultra-long-duration storage. These implementations show high round-trip efficiency (80–90%), long lifetimes (30–50 years) and zero degradation. In summary, GBES offers a durable, low-maintenance complement to batteries for stabilizing wind-rich grids, though its low energy density and land requirements remain challenges to address.*

Keywords: traditional grids

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