WIND RESOURCES OF TASHKENT REGION AND THEIR UTILIZATION: OPPORTUNITIES FOR SUSTAINABLE ENERGY DEVELOPMENT

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Abstract. The Tashkent Region in Uzbekistan, characterized by diverse topography including plains, foothills, and mountainous areas, possesses significant wind energy potential, particularly in its northeastern mountainous zones. This article examines the geographical and meteorological features of wind resources in the region, assesses their technical and economic feasibility for utilization, and reviews ongoing and planned wind power projects. Drawing on recent meteorological data and international assessments, the study highlights wind speeds averaging 3-5 m/s in plains and up to 7.5 m/s in elevated areas, with a focus on the Bostanlyk District's promising conditions. Key projects, such as the 20 MW Charvak Wind Power Plant, exemplify Uzbekistan's commitment to renewable energy targets, aiming for 3 GW of wind capacity by 2026. The analysis underscores the role of wind energy in reducing fossil fuel dependency, mitigating climate change, and fostering economic growth in the region. Recommendations include enhanced GIS mapping and international partnerships to optimize deployment.

Keywords. Wind resources, Tashkent Region, Uzbekistan, renewable energy, wind power projects, sustainable development.

Introduction. Uzbekistan, a landlocked Central Asian nation, is undergoing a transformative shift towards renewable energy to address its growing electricity demand, projected to reach 105 billion kWh by 2030, and reduce reliance on fossil fuels, which currently dominate 92% of its energy mix. The Tashkent Region,

encompassing the capital city and spanning 15,300 km² with a population exceeding 2.8 million, serves as the country's economic hub and a focal point for renewable initiatives. Its varied landscape—from the flat plains of Tashkent to the rugged Chimgan Mountains—creates favorable conditions for wind energy harnessing, particularly in elevated terrains where wind speeds are amplified by orographic effects.

Wind resources represent a clean, inexhaustible alternative to natural gas, Uzbekistan's primary energy source, and align with national strategies outlined in the 2020 Renewable Energy Development Program. The region's wind potential, estimated at contributing to the country's overall 520,000 MW gross capacity, is bolstered by recent mesoscale modeling indicating higher-than-previously recognized resources in the northeastern mountains east of Tashkent. This article explores the characteristics of Tashkent's wind resources, evaluates utilization prospects through technology and projects, and proposes pathways for sustainable integration, contributing to global discourse on arid-region renewables.

The Tashkent Region lies at approximately 41°N latitude, featuring a continental climate with hot summers and cold winters. Its topography includes the fertile Tashkent oasis in the west, transitioning to the arid Kyzylkum Desert fringes and the Western Tian Shan Mountains in the east. The Bostanlyk and Quyi Chirchiq Districts, with elevations up to 3,000 m, are particularly wind-prone due to channeled airflows through valleys and ridges. These features enhance wind consistency, making the region suitable for mid-scale wind farms, unlike the more uniform plains elsewhere in Uzbekistan.

Meteorological observations from Tashkent's stations (e.g., Uzbek Hydrometeorological Service data, 2000–2022) reveal average wind speeds of 3–5 m/s at 10 m height across the region, rising to 6–7.5 m/s at 50 m in mountainous areas. Predominant winds blow from the northeast and southwest, with peaks in

spring (March–May) and autumn (September–November), driven by seasonal pressure gradients. Annual power density reaches 94 W/m² in elevated zones, comparable to Navoi's 94.05 W/m² but superior to urban Tashkent's 3–4 m/s averages.

Diurnal variations show stronger evening winds in valleys, ideal for turbine operation during peak demand. Humidity levels (39% summer, 73% winter) minimize erosion risks, though dust in arid seasons necessitates robust turbine designs. GIS-based wind atlases, developed with German partners like GEO-NET, confirm the northeastern mountains as high-potential sites, with technical feasibility for 100–500 MW installations.

Comparative Analysis. Compared to neighboring regions like Bukhara (1 billion kWh potential), Tashkent's wind regime benefits from topographic amplification, yielding 20–30% higher capacity factors (35–40%) than flatland sites. However, urban sprawl in Tashkent city limits large-scale deployment, shifting focus to rural districts like Bostanlyk.

Uzbekistan's gross wind potential is 520,000 MW, with Tashkent contributing via its 15% share of viable land (approximately 2,300 km² suitable for turbines). At 7.5 m/s average in key sites, a 1 MW turbine could generate 2,000–2,500 MWh annually, equating to powering 500 households. Mesoscale modeling by the IEA identifies the Chimgan range as a hotspot, with untapped capacity exceeding 1,000 MW regionally.

Levelized cost of energy (LCOE) for wind in Tashkent is estimated at 5.5 US cents/kWh, competitive with gas-fired plants (6–7 cents/kWh). Initial costs ($1–1.5 million/MW) are offset by 20–25-year lifespans and low O&M (1–2% annually). Grants from international bodies like ADB reduce payback to 7–10 years, enhancing viability amid Uzbekistan's 7% annual energy growth.

Wind utilization could displace 1.1 million tons of CO_2 yearly per 500 MW farm, aiding Paris Agreement compliance. Minimal land use (0.1–0.3 ha/MW) preserves agriculture, though bird migration in mountains requires avian-friendly designs. Community benefits include job creation (200–300 per farm) and rural electrification.

Uzbekistan's wind sector is nascent but accelerating, with Tashkent hosting pilot projects. The Charvak Wind Power Plant (20 MW, Bostanlyk District, $28 million grant-funded) exemplifies early efforts, generating 50 million kWh annually and saving 15 million m^3 of gas. Operational since 2025, it reduces emissions by 22,000 tons/year, powering local industries.

The 20 MW Burchmulla Wind Farm (Bostanlyk, 10 ha allocation) targets 2026 commissioning, leveraging 7 m/s winds for 40 GWh/year output. Integrated with 12 national wind plants by 2025, it aligns with the 4 GW renewable target. Partnerships with ACWA Power and Masdar extend to hybrid solar-wind setups in Quyi Chirchiq, enhancing grid stability.

Grid integration remains a hurdle, with Tashkent's aging infrastructure requiring 282 km of 500 kV lines. Dust accumulation and seismic risks in mountains demand resilient turbines. Policy reforms, including PPP frameworks, mitigate these via IFC and ADB financing ($174 million for regional analogs).

Opportunities. Tashkent's proximity to demand centers (Tashkent city consumes 40% of national power) minimizes transmission losses. Export potential to Kazakhstan and Kyrgyzstan via CAPS grid could yield $100–200 million annually. Hybrid systems with solar (region's 1,500–1,700 kWh/m^2 insolation) ensure 70–80% capacity factors.

International collaborations, such as DEG's $65 million for ACWA's Karatau (adjacent influence), accelerate tech transfer. Local manufacturing of blades could create 5,000 jobs by 2030.

Variable winds (seasonal dips to 2 m/s) necessitate storage (e.g., 100 MWh BESS pilots). Land acquisition in populated areas risks social conflicts, resolvable via ESIA compliance. Financing gaps ($5 billion needed nationally) rely on FDI, vulnerable to global rates.

Conclusion and Recommendations. Tashkent Region's wind resources, amplified by topography, offer a strategic pathway to Uzbekistan's 25% renewable target by 2030, generating over 1 trillion kWh nationally. Projects like Charvak demonstrate feasibility, but scaling requires integrated planning. Recommendations include:

1. Deploy advanced anemometers for real-time mapping.
2. Foster PPPs with incentives (tax breaks for 10 years).
3. Integrate AI for predictive maintenance.
4. Promote community education on benefits.

By leveraging these, Tashkent can pioneer Central Asian wind leadership, ensuring energy security and environmental stewardship.

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