

Sustainability and Resilience-Based Framework for Waste-Derived Microgrids

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Abstract

India faces interconnected challenges of increasing waste generation, agricultural-residue burning, and unreliable electricity access, particularly in rural and peri-urban communities. Waste-derived microgrids can address these challenges by converting locally available biomass and organic waste into decentralized electricity. However, existing assessments often emphasize techno-economic performance while overlooking environmental impacts, social consequences, feedstock-seasonality risks, and resilience. This study conceptualizes a Waste-Biomass Microgrid Sustainability and Resilience Index (WBMSRI) for evaluating waste-derived microgrids in the Indian context. The proposed framework integrates technical, economic, environmental, social life-cycle, and resilience dimensions. It considers alternative conversion pathways, including anaerobic digestion, biomass gasification, and combustion, coupled with photovoltaic generation, battery storage, and backup systems. Key indicators include renewable-energy fraction, energy not served, levelized cost of electricity, net present cost, greenhouse-gas emissions, avoided open burning, occupational safety, local employment, energy affordability, community acceptance, and critical-load supply. Indicators are normalized and aggregated using multi-criteria weighting, while sensitivity analysis evaluates the influence of feedstock availability, technology selection, economic assumptions, and indicator weights. The framework is expected to demonstrate that the most suitable configuration is not necessarily the least-cost option, but one that balances reliable waste supply, affordable electricity, environmental benefits, social equity, and operational resilience. The proposed WBMSRI can support technology comparison and planning of circular, inclusive, and resilient decentralized energy systems in India.

Keywords: *electricity generation; index; microgrids; rural system; sustainability*