ABSTRACT

India has achieved universal village electrification and near-universal household electricity connections; yet, rural electricity remains unreliable, with poor service quality and high AT&C losses, resulting in a financially distressed utility that hinders socio-economic development. This study examines Solar Photovoltaic–based Distributed Generation System (SPV-DGs) as a pathway to sustainable, service-level rural electrification. This system has a transformative solution to achieve sustainable and service-level rural electrification, but it has a critical "sustainability gap" because many installations underperform or fail altogether. This is because the "installation-centric" model puts more emphasis on upfront connections than on long-term operational viability. This sustainability gap also persists because of multi-dimensional barriers, such as technical, economic, regulatory, and socio-institutional. The study employs a qualitative, multi-case approach along with doctrinal and comparative policy analysis to analyze the policy and regulatory framework, state-level implementation models, and systemic barriers. The study develops an operational sustainability assessment framework, the Sustainability Framework for Rural Distributed Generation (SFRDG), as a diagnostic tool. It has indicators across five pillars: Technical & Operational Resilience; Economic Viability & Productive Use; Institutional & Regulatory Certainty; Socio-cultural Equity & Governance; and Environmental Stewardship. The study proposes the DG-SURE (Sustainable, Unified, Resilient, Equitable) regulatory model, which is based on technical solutions and complements SFRDG. It includes standards that are context-specific, lifecycle-oriented standards, asset-transfer protocols, virtual aggregation, and DISCOM incentives. The findings suggest that adapting global sustainability models to local needs and embedding energy justice principles can make investments less risky, promote equity, and unlock $10–15 billion in rural DG investments by 2030. This progress supports 500 GW renewable energy target of India and its aim of net-zero emissions by 2070. The study has limitations that includes case selection and the need for quantitative validation through pilots and Delphi weighting.

Keywords: Rural Electrification; India; Distributed Generation; Solar Photovoltaic Systems; Energy Policy; Electricity Act, 2003; Distribution Companies (DISCOMs); Sustainability Framework; Energy Access; Productive Use of Energy; Renewable Energy Governance; Just Energy Transition; SDG 7