Development of a Data-Driven Regulatory Framework for Measuring and Monitoring Off-Grid Electricity Access in East Africa

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Abstract

Off-grid electrification is integral to universal electricity access in Sub-Saharan Africa, yet regulation and measurement emphasise installations and connections rather than sustained service. This research examines how data-driven approaches strengthen the measurement, monitoring, planning and regulation of off-grid electrification in East Africa, focusing on Uganda and Rwanda. Methods combined a systematic, PRISMA-style review and policy analysis with fieldwork involving 405 households and 37 key informants in four Ugandan districts. Big data analysis covered twelve months of PAYG transactions from 120,665 accounts. These strands informed modelling of the Available Energy (AE) metric and the development and piloting of the Energy Market Access Portal (EMAP). The findings show that off-grid systems are a differentiated access pathway, and their sustainability depends on affordability, reliability, after-sales support, consumer protection and regulatory visibility. In Uganda, off-grid sources serve 28% of the households, compared with 25% served by the national grid, yet 68% of off-grid users reported a technical fault during the preceding year. PAYG data revealed customer attrition, product concentration and repayment stress that periodic reports would obscure. AE simulations showed that degradation, interruptions and supply timing can cause realised energy service to diverge from tier classifications. The EMAP pilot demonstrated that heterogeneous operator records can be standardised into role-based analytics for providers, regulators, planners and investors without exposing customer-level data. The research concludes that off-grid access should be governed as a continuing electricity service. It recommends field-based performance verification, minimum reporting standards, privacy-preserving data sharing, further empirical validation of AE and phased expansion of EMAP across providers, technologies and institutional settings.