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Smart Meter Analytics and Tariff Design for Alleviating Energy Poverty: Evidence from a Clustering-Based Study in Montreal

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Energy poverty, defined as the inability to afford adequate energy services, poses serious health and comfort risks, particularly in regions with extreme climates. Traditional identification methods often rely on static income-based indicators, failing to capture real-time energy deprivation. This study leverages smart meter data from 5,984 households in Montreal to develop a data-driven approach for detecting and alleviating energy poverty. Daily per capita load profiles are first clustered into low-, medium-, and high-load groups using k-means, with low-load households exhibiting consistently lower usage and reduced behavioral flexibility. Integrating per capita living area in a second-stage clustering enhances differentiation between structurally low-demand and affordability-constrained households. Building on these profiles, policy simulations of a three-tier Increasing Block Tariff (IBT) are conducted to assess potential distributional impacts. The results suggest that low-load households would increase annual electricity consumption by 6.3% while reducing expenditures by 12.9%, indicating improved affordability and access. High-load households are projected to face higher unit prices and reduce discretionary use, while system-wide average prices remain stable, ensuring revenue neutrality. This combined profiling–tariff approach demonstrates the potential of smart meter analytics to support equitable electricity pricing. The framework provides a replicable tool for policymakers, highlighting IBT as an effective mechanism to alleviate energy poverty and achieve a fairer distribution of electricity costs without compromising utility stability.

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