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# Data-driven location–allocation for clean cooking LPG supply chains: A mixed-integer programming approach for Rwanda

Z.G. Gurkan; P. Dueñas Martínez; A.S. Kocaman

**Abstract-**

**Liquefied Petroleum Gas (LPG) is a key clean cooking alternative to biomass, especially in developing countries where household air pollution remains a major concern. This study proposes a scalable decision-making framework for the design of LPG distribution networks, using Rwanda as a case study. We formulate a hierarchical location–allocation model as a Mixed-Integer Linear Program (MILP), leveraging a large-scale dataset with rooftop-level LPG demand for over 3.3 million households across Rwanda. To enable tractable, country-scale optimization, we adopt two complementary strategies: (i) a time-aggregated formulation assuming stable seasonal demand, and (ii) a spatial aggregation method based on agglomerative hierarchical clustering, which places retailers at distance-constrained geomedian points of rooftop clusters. We compare this clustering-based approach against a benchmark that uses village centroids for retailer siting, demonstrating cost savings and improved spatial fairness. Additionally, we assess the scalability of the system under projected demand growth and evaluate infrastructure–transportation trade-offs under fluctuating diesel prices. Our findings underscore the potential of data-driven planning tools in advancing equitable access to clean cooking solutions.**

**Index Terms- Clean cooking; Mixed-integer linear programming; Location–allocation; Agglomerative clustering; Energy access planning; Supply chain optimization; Sustainable development goal 7**



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