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A scalable and flexible solution to evaluate the effects of the integration of photovoltaic distributed generation systems within the electrical grid

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Abstract-

This study introduces a novel methodological approach for evaluating the impacts of distributed photovoltaic (PV) generation systems within Urban Energy Systems (UES) on the distribution grid at an infrastructural level by generating synthetic electricity networks. The methodology integrates Geographic Information System (GIS)-based procedures, simulation techniques, and energy models to provide a comprehensive tool for analyzing electricity power flows at a high spatio-temporal resolution.

The study emphasizes the potential for localized energy sharing and the formation of Energy Communities. The adaptable platform supports operational and planning activities, offering detailed analyses for various urban settings. The methodology provides a valuable tool for identifying and mitigating the challenges posed by distributed PV systems, such as reverse power flow, line congestion, and over-voltage problems.

A case study focusing on the city of Turin was conducted, wherein a synthetic network of a specific urban area was created and analyzed. This detailed examination revealed critical network vulnerabilities triggered by the simulated integration of photovoltaic (PV) power, highlighting specific points that require attention to be effectively adressed. Furthermore, the study explores potential interventions to enhance the network’s resilience and efficiency in accommodating distributed renewable energy sources.

The proposed methodology can be used by Energy Communities, Distribution System Operators, and other stakeholders to evaluate different scenarios, test different aggregations, and design effective control strategies to ensure the stability and reliability of the distribution grid.

Index Terms- Urban Planning; PV Integration; Synthetic Electricity Network

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