Positive effects of a PED: the Italian case in the city of Rome

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Abstract This study explores the feasibility and replicability of Positive Energy Districts (PEDs) within existing urban environments, focusing on two morphologically distinct districts in Rome: Testaccio and Valco San Paolo. The research applies a dynamic, simulation-based methodology using the City Energy Analyst (CEA) tool to evaluate energy retrofit scenarios at the district scale. The approach integrates building envelope insulation, high-performance glazing, HVAC system upgrades, efficient lighting (LED relamping), and large-scale deployment of rooftop photovoltaic (PV) systems. The study also investigates the optimal sizing and implementation of lithium-ion battery storage systems to enhance self-consumption and reduce reliance on the electrical grid.

Buildings were grouped into archetypes based on thermophysical properties, HVAC configurations, and occupancy patterns. Real consumption data were used to calibrate the simulation models, ensuring high accuracy and transferability. Key performance indicators, such as the Load Cover Factor (LCF) and the Grid Interaction Index (GII), were applied to assess the alignment between energy generation and demand, as well as interactions with the grid under various retrofit scenarios.

The results demonstrate that, in the final integrated scenario which includes full electrification, thermal and transparent envelope renovation, system upgrades, and PV integration, electricity demand in the Testaccio district is reduced by over 24 percent, while natural gas consumption is entirely eliminated. Similar outcomes are observed in Valco San Paolo, despite its larger and more recent building stock. Photovoltaic systems covering between 55 and 61 percent of available roof surfaces deliver peak capacities of over 14 megawatts per district. When combined with appropriately sized storage systems, these interventions bring both districts close to achieving energy positivity.

This research provides a replicable methodological framework for evaluating PED potential in dense urban contexts. It supports decision-making processes for urban planners, local authorities, and energy policymakers who aim to promote decarbonisation, resilience, and energy autonomy at the neighbourhood level. Future developments will focus on the environmental life-cycle impact of battery technologies and the integration of PEDs within broader urban energy ecosystems.