Validating simulation tools for local energy transitions: A methodology to assess accuracy and support municipal planning.

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Abstract Positive Energy Districts (PEDs) are defined as urban areas that achieve a positive annual energy balance and net-zero greenhouse gas emissions. Their development plays a key role in supporting cities' decarbonization goals and promoting sustainable urban transformation. However, implementing PEDs represents a complex challenge for municipalities, as it requires tools that allow evaluation and planning based on local needs and resources. This research proposes a simulation-driven methodology to facilitate the identification and implementation of PED scenarios adapted to the specific characteristics of each city. By relying on simulation-based analysis, the approach provides municipalities with a practical framework to decision-making and refine the simulated environment. This will provide a basis for evaluating different technical and operational strategies before deployment.

The proposed methodology is structured in three stages. The first stage focuses on identifying the most widely used energy simulation tools in existing literature and assessing their suitability for municipal use. This evaluation considers the Key Performance Indicators (KPIs) generated by each tool, analysing their relevance to local authorities' priorities.

The second stage focuses on assessing the accuracy and reliability of the simulated KPIs with measured real-world data. First, the required inputs and outputs for each simulation tool are identified. Then, a monitoring framework is defined, detailing sensor specifications and data-collection protocols, to systematically capture real-world performance for comparison with the simulation results.

The third stage establishes a systematic validation process, comparing simulated KPIs against monitored field data. This comparison will enable performance verification and model calibration, improving the predictive accuracy of the simulations and ensuring greater reliability for decision-making processes.

The complete methodology has been applied in a feasibility study conducted in a district of Alcorcón, Spain, serving as a practical case to refine the approach. Results demonstrate the potential of simulation-driven methodologies to support municipalities in the planning and implementation of Positive Energy Districts aligned with their climate and energy objectives.