Doctoral Dissertation
Doctoral Program in Energy Engineering (38th Cycle)

# Energy Performance Assessment of Building Stocks

Enhancing Quality Data Flows for Urban Energy Analysis

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# Abstract

The National Building Renovation Plan established under the newly approved Energy Performance of Buildings Directive (EU 2024/1275) can be effectively supported by combining Urban Building Energy Modelling (UBEM) with building archetyping. However, the limited availability and accuracy of city-wide energy consumption data, together with the high computational cost of large-scale simulations, hinder the validation and calibration of most UBEM applications.

To address these challenges, this Ph.D. research develops a comprehensive methodology to assess and improve the reliability of the entire UBEM workflow, from input data to model outputs.

The research first establishes a theoretical comparison between Building Energy Models (BEMs) and UBEMs, illustrating how simplifications inherited from single-building modelling affect geometry, envelope characterisation, zoning, internal gains, and technical building systems definition. It then examines the limitations of input data, focusing on a very common data source in UBEM as the Energy Performance Certificates (EPCs). Despite their widespread use, data quality issues arise. A dedicated data quality-checking procedure was developed and applied to regional EPC datasets, demonstrating the benefit of automated rules to detect unreliable or non-representative entries.

Reliable EPCs were subsequently used to generate representative buildings according to key segmentation criteria, emphasising the importance of non-geometric attributes in archetype-based UBEM approaches. The work also introduces a shift from representative buildings to representative urban blocks, which were identified and analysed under different climate scenarios.

Finally, the methodology integrates validation and calibration procedures tailored to data availability and modelling goals. This includes a workflow for assessing archetype reliability and an evolutionary optimisation approach for

calibrating in an UBEM environment single-building and multi-building energy demands.

Overall, this Ph.D. delivers an integrated framework that strengthens the credibility and practical applicability of UBEMs. By combining data quality assessment, representative building modelling, and scalable validation and calibration techniques, the work is aimed at supporting energy planners and policymakers in capturing the actual energy performance of the building stock and in designing effective renovation strategies and climate mitigation actions.