

Review

# A Systematic Literature Review of Physics-Based Urban Building Energy Modeling (UBEM) Tools, Data Sources, and Challenges for Energy Conservation

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**Abstract:** Urban building energy modeling (UBEM) is a practical approach in large-scale building energy modeling for stakeholders in the energy industry to predict energy use in the building sector under different design and retrofit scenarios. UBEM is a relatively new large-scale building energy modeling (BEM) approach which raises different challenges and requires more in-depth study to facilitate its application. This paper performs a systematic literature review on physics-based modeling techniques, focusing on assessing energy conservation measures. Different UBEM case studies are examined based on the number and type of buildings, building systems, occupancy schedule modeling, archetype development, weather data type, and model calibration methods. Outcomes show that the existing tools and techniques can successfully simulate and assess different energy conservation measures for a large number of buildings. It is also concluded that standard UBEM data acquisition and model development, high-resolution energy use data for calibration, and open-access data, especially in heating and cooling systems and occupancy schedules, are among the biggest challenges in UBEM adoption. UBEM research studies focused on developing auto-calibration routines, adding feedback loops for real-time updates, future climate data, and sensitivity analysis on the most impactful modeling inputs should be prioritized for future research.

**Keywords:** urban building energy modeling; physics-based; bottom-up; energy conservation measures



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## 1. Introduction

Urban building energy modeling (UBEM) is a term used in the literature to refer to different types of simulations that are not necessarily related to the buildings in the “urban” area. Urban-scale, large-scale, and district-scale building energy modeling have been used in the literature interchangeably, but they all refer to the modeling and simulation of a group of buildings to study their energy use and behavior. The large-scale building energy modeling (herein UBEM) has been trending for the past decade (Figure 1) due to its effectiveness in providing a significant amount of data on a large group of buildings that could be used by different stakeholders in the energy sector such as energy policymakers, energy companies, building portfolio managers, and researchers. Making the modeling and simulation process more efficient in speed, flexibility, cost, and accuracy is critical, and this requires a thorough understanding of the current state of and future trends in UBEM tools and techniques.

UBEM models are developed for different purposes, such as identifying the buildings with high energy use intensity (EUI), regions with high energy consumption, microclimate impact on building energy use, and studying the energy saving of different energy conservation measures (ECMs) on a large scale. Finding the most effective ECMs is one of the essential end goals in energy modeling projects; however, not all the UBEM approaches are suitable for this purpose. This highlights the importance of such systematic literature reviews.

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