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## Modeling Urban Design with Energy Performance

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### Abstract

Traditional urban design methods focus on the form-making process and lack performance dimensions such as energy efficiency. There are inherent differences between *Urban Design* as a model of decision-making for choosing form alternatives and *Energy System Modeling* as a model of evaluating and assessing system functions. To design a high energy performance city, the gap between the two models must be bridged. We propose a research design that combines the Urban Design Computational Model (UDCM) and the Optimization Model of Energy Process (OMEP) to demonstrate how an urban design computation can be integrated with an energy performance process and system. An evidence-based case study of community-level near zero energy districts will be needed for future work.

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*Keywords:* Urban design computational model; Energy process model; Urban energy system; Urban design; Energy performance

### 1. Introduction

Urban design as a creative process projects future patterns and forms of the physical urban structure. Creating an urban design plan sometimes requires an optimistic view that the future urban environment will be better than the current one, and often relies on synthetic knowledge and visualization techniques used by architects and urban designers to determine the footprints of buildings, landscape and infrastructural layout. Design decisions are normally based on a “model” about how the environment ought to be made [1]. In the context of urban design practice, the “model” refers to a three-dimensional representation of the future urban form, normally a non-quantitative one. The model of urban design also

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refers to those concepts and principles for organizing urban spaces, which are normally partially physical, partially social and partially economic.

### **Nomenclature**

UDCM	Urban Design Computational Model
OMEPE	Optimization Model of Energy Process
UES	Urban Energy System
UD	Urban Design

Energy performance modeling for building and urban systems, however, is normally understood as a different kind of “model” and/or “performance analysis process”. It depends on technology, data and algorithms. The model is quantitative and is driven by criteria such as efficiency, low carbon emission and life cycle cost. For example, in the case of EnergyPlus, defining a building energy model requires computations that include building geometry, materials, HVAC systems and occupant data. The output of the model is the system performance, which is used for benchmarking and evaluation.

To what extent can the *Urban Design Model*, a creative process for designing future urban form, be quantified? And if so, can we align urban form with energy performance to create a better understanding of system properties to allow designers to make better design decisions?

On the other hand, how does the *Energy Performance Modeling* go beyond the post facto test of the alternatives that have already been designed in the first place? To what extent can the energy performance modeling process inform design decisions or generate design solutions? Could the research question move from a performance-based question: “how the system functions and performs” to a design-oriented question: “how the system should be altered and changed”, in which design is viewed as a driver for developing an urban energy model and further a high efficient and sustainable urban system?

## **2. Three Keywords: System, Performance and Design**

### *2.1. Discrepancy between urban design and energy engineering on keywords*

To design an energy efficient urban system, both urban designers and energy engineers use keywords such as system, performance and design. Both disciplines have their own intellectual legacy and extensive literatures that define concepts, tools, models and research questions in different ways. In order to integrate models and modeling from both fields, we will need a consistent definition and a set of basic vocabulary, a toolbox and the right research questions. We also advocate integrating urban design and energy engineering at the early-stage planning of an urban system, which requires further evidence to demonstrate the durability of the methodology and also the experience of “best practices”.

### *2.2. System*

The term *System* is used by both urban designers and energy engineers. In the case of energy system modeling, buildings and cities are often seen as an energy system, closed or open, with internal processes as well as energy and/or materials and other interactions cross the system boundary. Energy system

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