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## A Framework for Delivering Targeted Occupancy Interventions to Reduce Energy Usage in Buildings

Aslihan KARATAS<sup>1\*</sup>, Carol C. MENASSA<sup>2</sup>, and Allisandra Stoiko<sup>3</sup>

<sup>1</sup>Postdoctoral Research Fellow, Dept. of Civil and Environmental Engineering, University of Michigan, MI, 48109; email: [karatas@umich.edu](mailto:karatas@umich.edu)

<sup>2</sup>Assistant Professor, Dept. of Civil and Environmental Engineering, University of Michigan, MI, 48109; email: [menassa@umich.edu](mailto:menassa@umich.edu)

<sup>3</sup>Undergraduate Student, Dept. of Civil and Environmental Engineering, University of Michigan, MI, 48109; email: [astoiko@umich.edu](mailto:astoiko@umich.edu)

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### Abstract

Policies aimed at reducing building energy use have often resulted in inefficiencies due to their higher costs, requirements to comply with regulations, incentives, and/or sanctions; and neglecting the impact of occupants on building energy use. To overcome these challenges, energy policy measures can be designed and implemented by identifying occupants' behavior that significantly impact building energy use and relevant factors that may lead to sustainable behavior pattern. Therefore, this study presents a conceptual framework that proposes a multi-level intervention strategy that is tailored to varying occupants' characteristics to produce and maintain energy use reduction in buildings over time. The framework is designed in two main steps: (1) identifying the occupants' energy use and behavioral characteristics before and after the exposure of any energy efficiency intervention (e.g., education, persuasion); and (2) delivering targeted occupancy interventions based on occupants' energy use and behavioral characteristics. This framework will assist decision-makers in formulating and designing effective energy policy tools at lower costs to deliver occupancy-focused interventions for reducing building energy use.

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\* Corresponding author. Tel.: +1-217-721-3621.  
E-mail address: [karatas@umich.edu](mailto:karatas@umich.edu)

## Introduction

The existing building sector in the US accounts for 40 percent of the total energy consumption by the built environment [11]. Moreover, UNEP [31] reported that this sector needs to achieve large-scale energy use reductions cost effectively through efficiency and conservation strategies to alleviate economic, environmental and social problems associated with diminishing natural resources and global warming. To maintain large-scale energy use reduction in existing building sector, energy policy tools can be designed as (i) regulatory tools that are intended to change behavior and often referred to as government command and control systems; (ii) inducement tools that aim to motivate an individual through the promise of a reward or penalty to behave in a certain way without the level of government coercion inherent in regulations; and (iii) capacity tools that are intended to change individual behavior based on providing information in the desired manner [14].

Even if capacity tools are suggested as a starting point for designing energy policy tools [14], they are often designed as either regulatory tools (e.g., occupancy-focused interventions that implement technological solutions such as retrofitting and replacing electrical components) [3,28,36]; or inducement tools (e.g., occupancy-focused interventions that implement reward/penalty systems such as varying energy costs with on- and off-peak consumption) [8,19]. Therefore, this approach leads to several challenges for policy makers such as inefficient results, due to (i) higher costs of policy tools to comply with the regulations and incentives [14,37]; and (ii) ignoring the significant impact of occupants and their energy use characteristics in buildings [6,21,30]. To address these challenges in the development of energy policy tools, this study develops a conceptual framework that proposes a multi-level intervention strategy targeted towards the diverse human characteristics to produce and maintain energy use reduction in buildings over time. This framework assists decision-makers in designing cost-effective energy policy tools to deliver effective energy efficiency occupancy-focused interventions.

## Objectives

The aim of this paper is to present a conceptual framework for assisting policy makers in designing effective energy policy tools at lower costs. This framework proposes multi-level building energy use intervention strategies focused on targeting occupants' energy use characteristics. To accomplish this, the study is designed in three main stages: (1) reviewing energy efficiency intervention strategies; (2) identifying the role of occupants' characteristics in building energy use; and (3) developing a conceptual framework that links the occupants energy use characteristics to the multi-level energy efficiency intervention strategies, and accordingly energy policy tools.

## Energy Efficiency Intervention Strategies Review

To engage occupants in reducing energy use in buildings, several studies in literature analyzed four main levels of interventions: education, persuasion, penalties, and technology. A detailed description of each intervention level is provided below.

*Education* consists of presenting informative messages to invoke voluntary behavior change. Several research studies were conducted of education methods to reduce energy use in buildings by information distribution outlets (e.g., posters, videos, brochures) to convey information to influence consumers [2,16,22]; interactive programs (e.g., site-specific video programs) with more personalized approaches to information delivery [12,23]; feedback methodology that is based on presenting information comparing current energy use with historical use that provides consumers with personalized evaluation and a means to monitor progress [10,32]; and peer-comparison by allowing occupants to acknowledge their energy consumption compared to their peers [17]. Among these education methods, studies showed that information distribution of energy consumption facts and reduction guidelines don't appear to effectively influence consumers. While information distribution is a widely tested form of education, it appears to be largely ineffective on its own [2,16,22]. When it comes to interactive programs, studies highlighted that extended interactive programs may yield a better results compared to the short-term ones [12,23]. Finally, feedback and peer-comparison appear to be the most effective education methods to single-handedly influence consumers' energy consumption [10,17,32].

*Persuasion* involves providing rewards to encourage a favorable behavior. Several studies have been conducted regarding incentives such as monetary incentives [4,15], and pledging campaigns as incentives to encourage sustainable energy conservation behavior [7,35]. Monetary incentives appear to be effective, particularly persuasion

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