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## Social housing retrofit: Improving energy efficiency and thermal comfort for the housing stock recovery in Mexico

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### Abstract

Social housing in Mexico has been built without considering internal thermal comfort. This situation has forced people to live in adverse conditions, increase the use of air-conditioning systems for those who can afford it, or to abandon the houses looking for a better place. Currently Mexico has nearly five million abandoned dwellings and 40% of built housing deficit requires expansion and/or improvement. Retrofit of existing buildings has been carried out in the world to improve energy efficiency or to reduce green housing emissions; however, in Mexico retrofit is not widely applied and less in social housing. This paper proposes and applies in two case studies with hot, semi-humid climate a method to evaluate the improvement of indoor thermal comfort through enhancing envelope's U value. Finally, an economic analysis is conducted to assess retrofitting social housing with Mexican government programs funds.

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*Keywords:* Social housing retrofit; indoor thermal comfort; energy efficiency; abandoned dwellings; U value.

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## 1. Introduction

Housing is one of the biggest and most complex issues in Mexico. The number of built houses in the country went from 29 million in 2010 to 31 million in 2012, from which almost 5 million are abandoned [1]. This is mainly due to factors such as location, insecurity, lack of public services and poor quality of spaces and construction materials [2], which in turn causes high indoor temperatures and high energy consumption in air conditioning [3].

### 1.1. Energy consumption

Residential sector in Mexico occupies the third place of the total energy consumption (18.8%), where electricity is the second most consumed energy source (30.4%) only behind liquefied petroleum gas [4]. In the same path, air conditioning appears as the third electricity consumption equipment (24%) behind television (26%) and refrigerators (35%) [5]. Data from “Secretaría de Energía” (SENER for its acronym in Spanish) [6], show that electricity consumption increases in the warmer months (Fig. 1), becoming more evident in the electric rates corresponding to the geographical areas with the highest average minimum temperature in the summer.

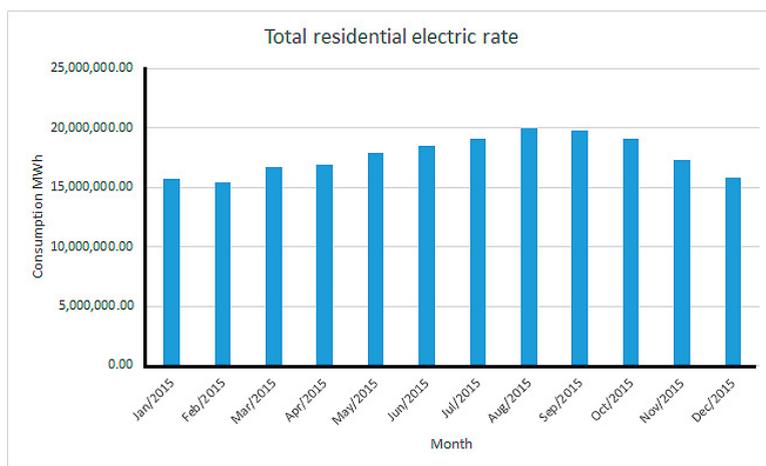


Fig. 1. Total residential electricity consumption (2015)

### 1.2. Indoor air temperatures

For dwellings occupants, indoor temperature is one of the most valuable aspects, even sacrificing others such as indoor air quality to have thermal comfort [7]. The production of social housing prototypes almost identical in design and materials for any region of the country without considering the climate, makes them uncomfortable and forces the occupants to use ventilation and air conditioning systems increasing their energy consumption [8], and in some cases, emigrate in search for better thermal conditions.

### 1.3. Current panorama

Improving energy efficiency and thermal comfort in residential sector are increasingly important topics for Mexico. Government programs for energy efficiency such as “Fideicomiso para el Aislamiento Térmico de la Vivienda” (FIPATERM) and “Ahorro Sistemático Integral” (ASI) have allowed national savings estimated at 3, 410.72 GWh and mitigation of 1, 534, 824 Tons of CO<sub>2</sub> [9]. Mexico has the mandatory standard NOM-020-ENER-2011 which limits heat gains through the envelope for new residential buildings; and the voluntary standard NMX-C-460-ONNCCE-2009 which recommends thermal resistance values (R-value) for envelopes by thermal region.

In recent years, many governments and international organizations have encouraged and supported existing residential buildings retrofit projects around the world [10]. However, much remains to be done in Mexico. Existing

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