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Envelope retrofit in hot arid climates

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Abstract

This article aims to evaluate envelope retrofit as a tool to decrease reliance on air conditioning units in hot arid climates. Energyplus is used to model an apartment block in Cairo and analyze its energy performance. Retrofit through glazing improvement is evaluated in relation to cooling load and carbon emissions. Results provide guidance for envelope retrofit as a part of a plan to empower energy efficiency in Egypt and hot arid countries.

Peer-review under responsibility of the organizing committee of SBE16.

Keywords: Energy efficiency; Envelope retrofit; Energy policies; Simulation; Hot arid climates

1. Introduction

The residential sector is a major consumer in Egypt. In 2013, it consumed 42.6% of national electrical consumption. In addition, consumption increase is more than 5% annually with rising carbon dioxide emissions [1]. Statistics have shown a sharp rise in the use of mechanical cooling as a solution to climate change and heat waves in summer. In 2015, temperatures in Cairo arrived to 45°*C* due to heat waves and about 20% of energy consumption. Statistics show that between 1996 and 2010, sales of ACUs have increased from 54,000 units per year to 7,66,000 units per year [3]. The existing building stock is informal and compliance with Building Energy Efficiency Building Code is almost inexistent [11, 12]. It is necessary to investigate suitable retrofit strategies that can be adopted and applied within the Egyptian housing context.

Cairo has hot arid climate which very low precipitation and mild winters. 92.5% of Cairene Households are living in one apartment blocks. Just by walking through the streets of Cairo, it would be easy to notice the spread of linear apartment blocks [5]; linear apartment blocks is an internationally widespread typology that appeared in the late 19th century as an urban planning leitmotif of modernism. It promoted lower density housing compared to tower blocks and promoted air, sun & light. However, apartments in linear blocks in Cairo consume more energy compared to long compact towers. Electricity is one of the main energy sources in Egyptian houses; it arrives to 99% of households [8].

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The housing sector in Egypt is dominated by private owners that consider quality aspects as a secondary priority and this had its impact on the construction process and the building envelopes [9,10]. Reinforced concrete column and beam structural system with bricks for walls is the dominant method used for residential construction since the 1950s and it is almost exclusively used with the flat slab for apartment blocks. This is due to material availability, common knowledge, easy application, time efficiency and economic convenience. Glass windows with wooden shutters are mostly common for openings. Windows are single glazed, transparent and usually are formed of very thin glass layer. A recent study has proposed a plan for energy empowerment in the residential sector through Building Energy Efficiency Code enforcement and energy retrofit as an inevitable path for an effective change in consumption patterns. However, it is still necessary to investigate suitable retrofit tools and their applicability [6]. Replacement of existing window glass panes is investigated as an efficient method to decrease summer heat gain towards internal spaces and hence decrease cooling demand. The results will provide guidance for the development of a tool that aids to a successful energy requalification process.

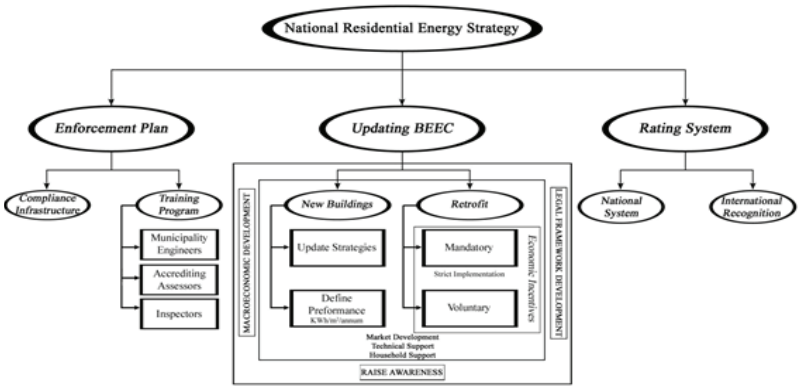

Fig. 1. National residential energy strategy proposed.

2. Aim of work and Methodology

This paper aims to investigate envelope retrofit as a tool to increase comfort levels and decrease cooling loads with consequent energy reductions in the residential sector of Cairo-Egypt as an example of hot arid climates. EnergyPlus is used to model a typical apartment block, evaluate its performance and improvement potentials through envelope retrofit strategies within the Cairene climatic context. It aims to investigate retrofit through glazing improvement as a strategy to decrease heat flows towards inner spaces during summer season and decrease annual cooling load. The study analyzes energetic and environmental aspects through energy consumption and carbon emission analysis. Results provide guidance for envelope improvement as a tool for efficient retrofits to reduce consumption rates and empower energy efficiency in Egypt and hot arid countries.

The first step was to choose a base case that is representative of the residential sector in Egypt and its energy patterns. So revision of previous survey work and studies in Egypt and Cairo was executed. The revised sources included official data by governmental institutions and research work by scholars. The case study for this work was chosen based on statistical confirmation of the presence of the building typology, the repetition of that typology in surveys that focused on or included Cairo and included energy data for audit results confrontation, and the presence of air conditioning units (ACUs) in the chosen base case. A field survey was made after to investigate the validity of the chosen model. Then, building audit and energy performance monitoring –through utility bills- was executed to understand actual performance levels. Audit data were inserted into a simulation model and its energy performance was assessed and calibrated. Retrofit strategies are defined and their impact on the simulated model is investigated through numeric results. Each strategy is evaluated in relation to the cooling load –energy consumption- and carbon emissions. The following sections provide a description of the executed steps.