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Ain Shams University
Faculty of Engineering
Department of Architecture

Retrofitting Residential Gated communities for Net Zero Energy Housing in Greater Cairo

A Thesis Presented in Partial Fulfillment of the Requirements for Master of Science Degree in Architecture Engineering

Presented by
Passent Alaa El Deen Adly Mostafa

BSc in Architecture 2005 – Ain Shams University

Under Supervision of

Prof. Dr. Hanan Mostafa Kamal Sabry
Professor of Architecture, Faculty of Engineering, Ain Shams University

Prof. Dr. Ahmed Atef El Dessoqy Faggal
Professor of Architecture, Faculty of Engineering, Ain Shams University

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Board of Examiners

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Board	Signature
Professor Dr. Mohamad Moamen Afify Professor of Architecture and Environmental Control, Department of Architecture - Faculty of Engineering, Cairo University.	
Professor Dr.Morad Abdelkader Abdelmohsen Professor of Architecture and Environmental Control, Department of Architecture - Faculty of Engineering, Ain Shams University.	
Professor Dr. Hanan Mostafa Kamal Sabry Professor of Architecture and Environmental Control, Department of Architecture - Faculty of Engineering, Ain Shams University.	
Professor Dr. Ahmed Atef El Dessoqy Faggal Professor of Architecture and Environmental Control, Department of Architecture - Faculty of Engineering, Ain Shams University.	

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Statement

This thesis is submitted to Ain Shams University for the M.Sc. degree in Architecture.

The work included in this thesis was carried out by the researcher at the Department of Architecture, Faculty of Engineering, Ain Shams University, and During the Period from May 2017 to August 2019.

No Part of this thesis has been submitted for a degree of a qualification at any other university or institute.

Name	Passent Alaa El Deen Adly Mostafa
Signature	
Date	

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Abstract

Net Zero Energy Building (NZEB) concept is the future international goal for saving energy. NZEB concept has risen in many countries policies and worldwide discussions targeting efficient built environment.

In Egypt, the built environment consumes more than 70.1% of the total sold energy; the residential sector alone consumes 54.9%. According to the Egyptian annual electricity and renewable energy consumption report, "the increase in the rate of sold energy of the residential sector, in comparison with industry and other purposes, is a result of the expansion of residential compounds and new communities". In this regards, this research aims at introducing the concept of retrofitting existing gated communities in order to achieve zero-energy community (ZEC). The research discusses the integration of two strategies: energy efficiency retrofitting techniques to reduce energy demand, and renewable energy systems to generate sufficient energy, which would result in an annual net zero energy consumption.

Design Builder simulation software is used to analyze the feasibility of integrating these two strategies in a single family house, as a part of a residential gated community located in the east of Greater Cairo. The simulation goes through two stages, the first stage concludes three phases, in which the first phase the actual energy performance and the user's electric consumption patterns were determined in four main orientations in the community layout, to identify the maximum annual energy consumption . Three energy efficiency retrofitting techniques such as; insulation and glazing in the building envelope, and retrofitting of lighting systems, are investigated in the second phase aiming to reach the maximum energy reduction. In phase three renewable energy sources such as PV panels and solar thermal techniques are integrated to generate enough energy to cover the remaining energy from phase two. For the second stage, the simulation results of the first stage are implemented on the whole gated community (the community scales) aiming to reach zero energy consumption. The comparative analysis of simulation is used to determine how specific techniques lead to energy reductions in the second phase and energy production in the third phase.

The results achieved a reduction of 88.68% in energy consumption for the whole gated community, and prove that Net Zero Energy Building (NZEB) could be met by applying the appropriate energy efficiency retrofitting techniques, and the use of renewable energy systems. Moreover, a significant reduction in energy is shown when applying (NZEB) retrofit on a community scale (ZEC) than on a building scale. The previous strategies and methodology can be applied on other gated communities, in order to enhance the energy performance of existing buildings.

Keywords: Retrofitting Gated Community-Net Zero Energy Building (NZEB) - Zero Energy Community (ZEC) - Energy Efficiency- Renewable Energy.

Acronyms

EERBC: Egyptian energy efficiency building code

EOSQ: Organization for standards and quality

HBRC: Housing and building national research center

NZEB: Net zero energy building

RE: Renewable energy

SHGC: Solar heat gain coefficient

U-value: Total heat transfer coefficient

VL: Visible light transmittance coefficient

WWR: Window to wall ratio

ZEB: Zero energy building

ZEC: Zero energy community