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Assessment of cost optimal solutions for high performance multi-family buildings in Iran

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Abstract

According to the international benchmarks proposed for the energy demand reduction, the Iranian government, for limiting domestic energy demand growth, has set some energy efficiency policies. In this regard, the present study proposes various solutions to investigate the feasibility of improving the performance of an existing typical multi-family building in Iranian context, to achieve a high performance one with proper cost-optimal levels of energy performance by using the global cost approach defined by EU legislation. Precisely 50 different packages of energy efficiency measures were analyzed in terms of economic and energy performance with consideration on the effects of different envelope thermal insulation, shading system, window types and highly efficient systems in addition to the solar renewable energy source. Then the impact of the selected measures on energy efficiency improvement and global cost were studied and revealed that obtaining high performance building simultaneously with the cost optimal levels can be fulfilled, just when the financial support from the government subsidies exist, otherwise there is still a long way from being economically feasible.

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Keywords: high performance; buildings simulation; energy efficiency measures; cost optimal level; energy performance; multi-family building; Iran

1. Introduction

With regard to the international efforts to reduce the growing energy consumption, it is highly remarkable that the building sector has an important role due to its responsibility for more than 40 % of global energy used, and approximately one third of global greenhouse gas emissions, both in developed and developing countries [1].

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In this context, it is noticeable that Iran was the world's ninth largest emitter of greenhouse gas (GHG) in 2012 [2], the average energy consumption in Iranian residential sector is 2.5 times higher than the European average [3], and the energy consumption in Iran is growing rapidly with an average annual rate of about 8% [4]. Since Iran is one of the biggest owners of oil and gas reserves, energy was not an issue of concern before the international agreement on climate change. However, after the adoption of the Kyoto Protocol on August 2005 by Iran, extensive theoretical and practical research has been carried out for guidelines and standards in this area. These includes efforts to curtail wasteful energy use and to limit domestic demand growth, by implementation of the energy efficiency policies and the energy value increment through the energy subsidy reform, through raising the prices of domestic petroleum, natural gas, and electricity. Khalili Araghi et al. [5] examined the effects of reducing energy subsides in Iran which reveals that a higher energy prices will decrease energy consumption by Iranian households. The first phase of the reform was adopted in 2010, and the second phase was conducted in 2014 [6], with the purpose of reducing the energy consumption in the Iranian construction sector by at least 30% [7]. Tahsildoost et al. [8] studied energy retrofit techniques in Iranian educational building, using two methods based on The International Performance Measurement and Verification Protocol (IPMVP) and ASHRAE Guideline 14. Bagheri et al. [9] started developing an energy performance label for office buildings in Iran, by defining the characteristics of Reference Buildings as the energy efficient buildings, and designing and authorizing the label appearance for implementation as a national standard, using and validating an indigenous software tool (Behsazan) for simulating energy consumption in buildings of Iran. Heravi et al. [10] examined the energy performance of buildings by evaluation of design and construction measures concerning building energy efficiency in Iran.

Sustainability in general, and energy efficiency in particular are key measures for improving building performance [11], therefore a large number of scientific works were conducted in order to determine strategies for energy efficient building by employing various methods considering the construction style and local climate. Since these are new topics for the Iranian context, existing guidelines for other countries, like the recast of the European Energy Performance of Building Directive (EPBD) [13], may be used as a basis for the development of this branch of science and technology in Iran. In particular, the EPBD introduced the concept of cost-optimal level, which is defined in European legislation as "the energy performance level which leads to the lowest cost during the estimated economic lifecycle" and established a comparative methodology framework for its calculation, based on the global cost method.

Many studies performed in other countries demonstrated the effectiveness of the cost optimal methodology in studying cost-effective energy efficiency measures able to reach the nearly Zero Energy objective. Ferrara et al. [14] used a simulation-based optimization method to study cost optimal solutions for a real low-consumption house in France, with a view of obtaining nearly zero energy buildings. Becchio et al. [15] assessed cost optimal levels of a single-family house by presenting guidelines for designing reference building envelope and technical systems solution for nZEB. Ganiç et al. [16] investigated the possibilities of adapting of the cost optimal methodology to the Turkish context and tested the validity of the process under different market conditions. At the Iranian level, some studies were developed on the design of typical zero-energy homes [17], on traditional passive techniques [18] and on the simulation-based optimization of buildings based on genetic algorithms [19].

1.1. Scope and objectives

The present study aims to investigate energy performance and cost optimal solutions for a multi-family building in Iranian context by following the European cost-optimal approach, and at the same time taking into account Iranian legislation [20]. This is done by following different steps, each representing one sub-objective. These are [21]:

- Definition of energy efficiency measures (EEMs) that can be applied to a reference case study building concerning the building envelope, the energy systems and the exploitation of renewable energy sources.
- Assessment of the energy performance of several packages of EEMs and evaluation of the impact of these measures on the energy performance of the reference building;
- Calculation of the global cost of each package of EEMs and definition of the cost optimal level.

Furthermore, the study aims to test the applicability of a European methodology to a context that differs from Europe from both technical and economic points of view.