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Progress towards EPBD recast targets in Turkey: Application of cost optimality calculations to a residential building

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Abstract

In this paper, the latest progress in Turkey towards Recast Directive on Energy Performance of Buildings (EPBD Recast) targets is explained. In addition, sample calculations oriented at cost optimal retrofit analysis of an existing apartment building are also presented. In order to give an initial point of view about cost optimality concept and retrofit strategies in Mediterranean climate, an apartment building is analyzed for hot humid and mild climatic regions. The scenarios which are able to represent cost optimal level are highlighted and key aspects are derived for the nZEB approach in Mediterranean climate.

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Keywords: Residential Building Retrofit; Cost Optimal Levels; Nearly Zero Energy Building (nZEB); Mediterranean nZEB.

1. Introduction

Recast Directive on Energy Performance of Buildings (Directive 2010/31/EC, EPBD Recast) obliges Member States (MS) to set minimum requirements for energy performance of buildings "with a view to achieving cost-optimal levels"[1]. In order to guide cost optimality calculations, a framework methodology was published within EU Regulation no 244/2012 and MS are required to adapt this framework methodology at national or regional level [2]. In accordance with EPBD Recast targets, it is aimed to move towards Nearly Zero Energy Buildings (nZEB) through cost optimal concept until 2020 and to transform existing buildings into nZEB cost effectively.

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As an EU candidate, national legislation in compliance with EPBD (repealed) was enacted in Turkey and the next procedure is the definition of cost optimal and nZEB levels at national context according to EPBD Recast [3].

In this paper, progress of related national research activities in Turkey is explained. In order to display a basic perspective on cost optimality concept in Mediterranean climate, sample calculations are also presented for retrofits of a residential building considering the hot humid and mild climatic regions of Turkey.

2. Cost optimal level and nZEB concepts introduced with EPBD Recast

Cost optimal level and nZEB are new concepts introduced with EPBD Recast. The Directive defines cost optimal level as "the energy performance level which leads to the lowest cost during the estimated economic lifecycle". MS are required to calculate this level by adopting the methodology framework that involves following six stages [1,2]:

- Establishment of reference buildings representing national building stock,
- Identification of energy efficiency measures to analyze on established reference buildings,
- Calculation of the primary energy demand of the reference buildings with energy efficiency measures,
- Calculation of the global cost of the energy efficiency measures,
- Undertaking a sensitivity analysis for input data,
- Derivation of cost-optimal levels of energy performance requirements.

nZEB is defined as "a building that has a very high energy performance" and this definition is expected to be clarified at national level [1]. Also for nZEB calculations, use of the cost optimal methodology is recommended [4].

3. Progress in Turkey towards EPBD Recast targets

In compliance with EPBD, Energy Efficiency Law and Building Energy Performance Regulation were enacted respectively in 2007 and 2008 in Turkey and a national building energy performance calculation methodology was developed for energy certification [5,6,7]. Accordingly, requirements of EPBD Recast are on the national agenda.

The ongoing research project entitled "Determination of Turkish Reference Buildings and National Method for Defining Cost Optimum Energy Efficiency Level of Buildings" is conducted in Istanbul Technical University and funded by The Scientific and Technological Research Council of Turkey. This project aims to develop a legislation compatible framework for national cost optimal analysis. In this respect, establishment of the reference buildings is the first main goal and the required procedure is applied on residential buildings as the pilot typology. Within the research, reference buildings were established for the pilot city Istanbul which contains many different alternatives of buildings and user profiles. The residential reference buildings are classified in three categories: single family houses, apartment buildings and luxury residential blocks within multifunctional high-rise buildings. In addition to these three categories, residential buildings are also categorized in 3 groups according to their construction years.

In order to consider internal heat gains, reference user profile was also determined within the national project using the information gathered from surveys of Turkish Statistical Institute and Ministry of Family and Social Policies [8,9,10,11]. The determined user profile consists of a family with parents and two children. The research is currently moving towards the national cost optimal methodology which is coherent with national context. After this research, it is needed to have further researches focusing on other building typologies and nZEB concept in Turkey.

4. Sample cost optimal analysis in Mediterranean climate

In this study, cost optimal methodology is applied on a reference building which is defined in the national project explained in Section 3. The building is an existing apartment building and constructed between 1985-1999 years. It consists of an unconditioned basement and 12 standard floors with 4 flats in each as displayed in Figure 1.

Heat transfer coefficients (U) of the opaque envelope are explained in Table 1. For the whole building, glazing's heat transfer coefficient is 2,9 W/m^2K, solar heat gain coefficient is 75% and visible transmittance is 80%. The air change rate is assumed as $0,3h^{-1}$. The building has a central hot water boiler with 80% efficiency and hot water radiators for heating. In each flat, the cooling energy demand is met by spilt air conditioners which have 3 COP.

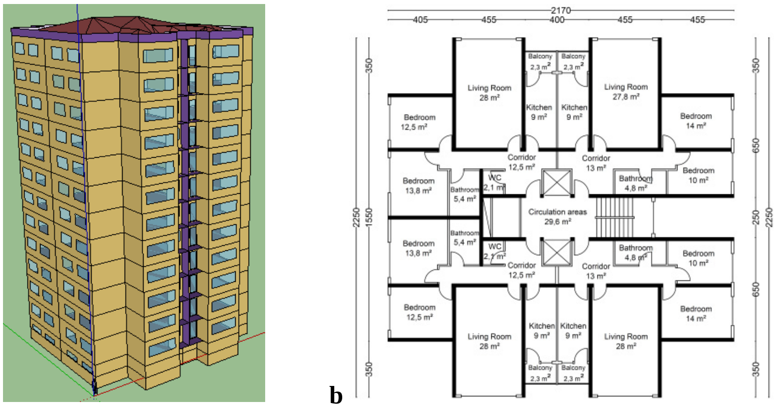
a b


Fig. 1. (a) Geometry of the reference building; (b) Floor plan of the reference building.

Table 1. Heat transfer coefficients of opaque .building components.

Building Component	Heat Transfer Coefficient (U)	Building Component	Heat Transfer Coefficient (U)
External Wall (Concrete)	1,04 W/m^{2}K	Roofspace (Floor of Attic)	1,25 W/m^{2}K
External Wall (Panel)	1,09 W/m^{2}K	Ground Floor (Basement Ceiling)	0,71 W/m^{2}K

The building is analyzed for two different cities, Izmir and Istanbul, which are respectively representatives of hot humid and mild climatic regions of Turkey. Investigated retrofit measures refer to building envelope, heating and cooling systems. Heat insulation retrofit is analyzed for external walls (W), roof (R) and ground floor (F) in three different levels. INS 1 represents the limit values in current national mandatory heat insulation standard in Turkey (TS 825-2013) [12]. Boundaries of U values for Izmir and Istanbul are different according to TS825 since these cities are in different climatic regions. INS 2 is the heat insulation level where U values are 25% lower than TS825 limits and INS 3 is the insulation level which represents the U values 50% lower in comparison to TS825. U values for these three insulation levels are given in Table 2. Another measure analyzed for the building envelope is the renovation of the existing window glasses with different glazing types explained in Table 3.

Table 2. Heat transfer coefficients provided by heat insulation retrofits.

	U value - Istanbul	U value - Izmir		U value - Istanbul	U value - Izmir
INS 1-W (wall)	0,57 W/m^{2}K	0,66 W/m^{2}K	INS 2-F	0,43 W/m^{2}K	0,50 W/m^{2}K
INS 1-R (roof)	0,38 W/m^{2}K	0,43 W/m^{2}K	INS 2-All	INS 2 level for the whole envelope	
INS 1-F (floor)	0,57 W/m^{2}K	0,66 W/m^{2}K	INS 3-W	0,29 W/m^{2}K	0,33 W/m^{2}K
INS 1-All	INS 1 level for the whole envelope		INS 3-R	0,19 W/m^{2}K	0,21 W/m^{2}K
INS 2-W	0,43 W/m^{2}K	0,50 W/m^{2}K	INS 3-F	0,29 W/m^{2}K	0,33 W/m^{2}K
INS 2-R	0,29 W/m^{2}K	0,32 W/m^{2}K	INS 3-All	INS 3 level for the whole envelope	

Table 3. Thermal and optical properties of analyzed glazings.

	Heat Transfer Coefficient (U)	Solar Heat Gain Coefficient (SHGC)	Visible Transmittance (T_{vis})
Glazing (GLZ) 1	1,6 W/m^{2}K	0,56	0,79
GLZ 2	1,6 W/m^{2}K	0,44	0,71
GLZ 3	1,1 W/m^{2}K	0,44	0,71
GLZ 4	1,6 W/m^{2}K	0,30	0,44

In addition to heat insulation and glazing retrofits, the effect of external aluminum blinds which are fixed horizontally at the south façade of the building (specified as "SHADING" in the graphs expressing results) are analyzed as well. The retrofit measure that refers to heating system is replacement of the existing old boiler with a new one which has 95% efficiency (EFFICIENT BOILER retrofit). Similarly, cooling system retrofit refers to replacement of existing split air conditioners with more efficient split air conditioners which have a COP value of 5 (EFFICIENT AIR COND. retrofit).

For the retrofit measures, primary energy consumptions and global costs are calculated in accordance with the cost optimal methodology. In order to define primary energy consumptions for both cities, end use energy consumptions are calculated using EnergyPlus which is a detailed dynamic simulation tool [13]. Primary energy conversion factors, that are used to calculate primary energy, are 2,36 for electricity and 1 for natural gas in Turkey. The results for Istanbul are presented in the graph given with Figure 2 and for Izmir results are given with Figure 3.

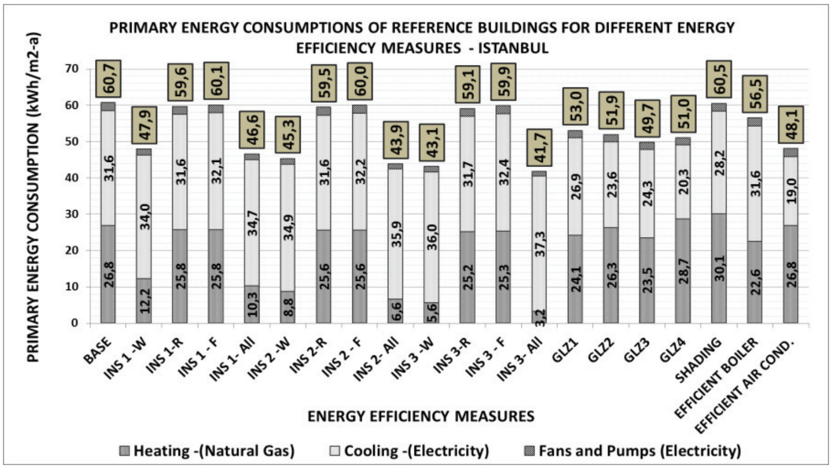


Fig. 2. Energy consumption results of the retrofits applied on reference building in Istanbul.

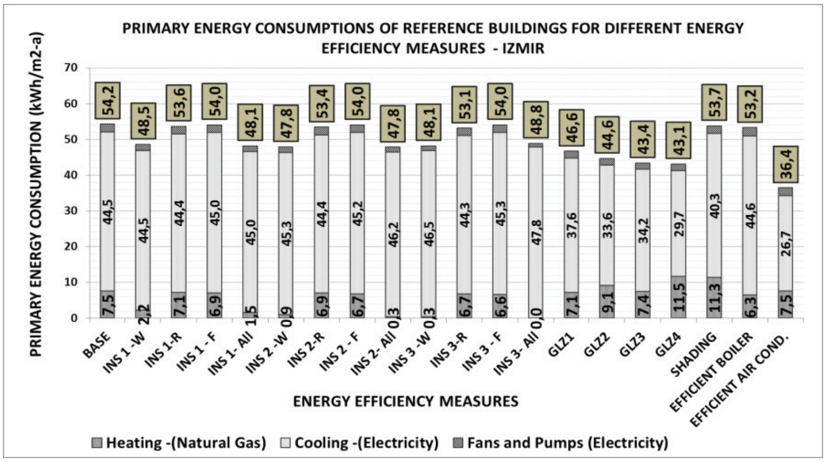


Fig. 3. Energy consumption results of the retrofits applied on reference building in Izmir.

As seen from the graphs, total energy consumption of the reference building is higher in Istanbul. In both cities, cooling energy consumptions are higher than heating energy consumptions for most of the scenarios, however, for

Izmir cooling loads are more effective since the climate is hot humid. Due to the same reason, the most energy efficient retrofits refer to heat insulation in Istanbul while glazing retrofits give the efficient results for Izmir.

As required by cost optimal methodology, global costs are calculated for each retrofit measure using net present value method. In these calculations, only energy and investment costs of the measures are considered and global costs are calculated in Turkish Lira (TL). It is considered that starting year is 2014 and calculation period is 30 years for the cost calculations. The unit costs are gathered from unit price book published by Turkish Ministry of Environment and Urbanization [14]. Inflation rate is assumed as equal to five years' average (%7,72) and market interest rate is %11 [15]. Results of these calculations are coupled with energy performance analysis and presented in Figure 4 and 5. Sensitivity analyzes are not considered within the scope of this sample calculations.

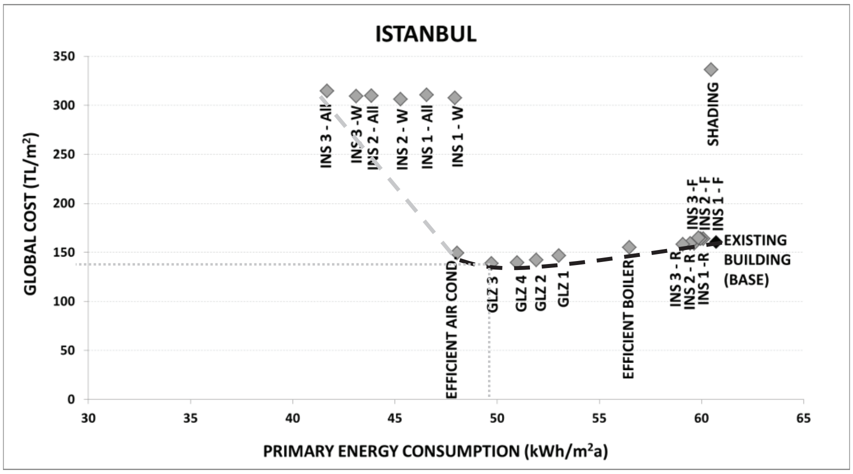


Fig. 4. Global cost-primary energy consumption results of analyzes in Istanbul.

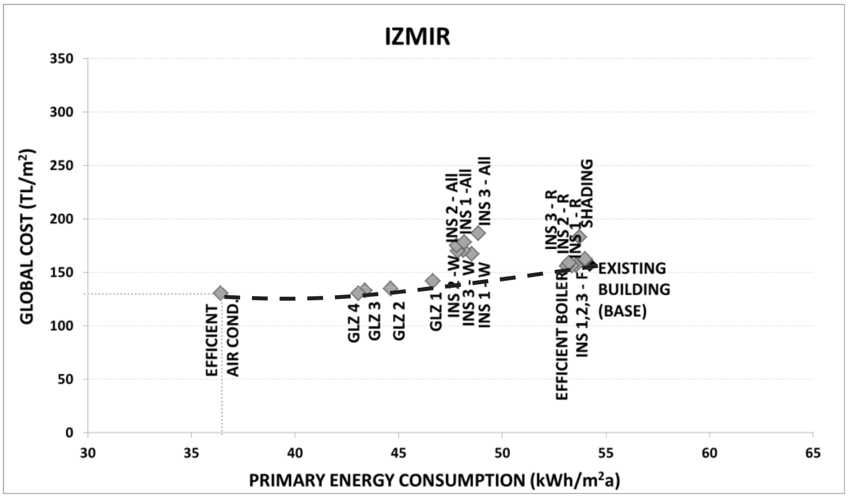


Fig. 5. Global cost-primary energy consumption results of analyzes in Istanbul.

According to Figure 4, the cost optimal scenario, among the retrofits applied to the reference building in this study, is GLZ 3 in Istanbul. In accordance with Figure 5, the cost optimal measure is EFFICIENT AIR COND. In Izmir since cooling energy consumptions are dominant in this climate. In addition, although the heat insulation retrofits result with relatively low energy consumptions, these retrofits are far from optimal point with their costs in both cities. However, TS 825, the mandatory heat insulation standard of Turkey involves requirements for only heating degree-day regions and assesses buildings according to their heating energy needs. Therefore, towards nZEB definitions, it is very important to include cooling energy evaluations into the national standards of Turkey especially for hot climatic regions.

According to results, energy costs are the main driver to achieve lower global costs. However, retrofits that analyzed in this study are basic and sample measures and the entire study is being developed including additional measures. It is expected to observe different tendency when other advanced retrofits with higher initial costs are investigated.

In addition, this paper presents individual analyzes of retrofit measures. However, the research is going to be involve cost optimal analysis of packages of measures since they affect energy performance of a building interactively.

5. Conclusion

This paper indicates that, up to date EPBD Recast related researches in Turkey are mostly concentrated on residential buildings and further investigations on other building typologies should be the further stage.

As shown in this study, cost optimal and nZEB levels are required to be investigated considering the climatic context. Unlike Northern European countries, in Mediterranean countries, cooling energy consumptions are considerably high especially in hot climatic regions. Therefore, it is very important to address energy performance for cooling within national legislation. The strategy development to reach cost optimal and nZEB levels in Mediterranean climate is a critical issue to be considered for Turkey as well.

In conclusion, all national studies aimed at EPBD Recast targets are required to be examined in multidimensional perspective to achieve feasible and reasonable results for all building typologies and for every climatic region.

Acknowledgements

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References

[1] EPBD recast (2010), Directive 2010/31/EU of the European Parliament and of Council of 19 May 2010 on the energy performance of buildings (recast); Official Journal of the European Union.

[2] Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council, Official Journal of the European Union.

[3] EPBD (2002), Directive 2002/91/EC, Directive of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings, Official Journal of the European Union, 2002.

[4] Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA). REHVA nZEB technical definition and system boundaries for nearly zero energy buildings -2013 revision for uniformed national implementation of EPBD recast prepared in cooperation with European standardization organization CEN. Kurnitsky J, editor, 2013.

[5] Energy Efficiency Law, Law Number: 5627, 18.04.2007. Republic of Turkey Official Gazette, 26510, Ankara, 2007 [in Turkish].

[6] Energy Performance of Buildings Regulation, Ministry of Public Works and Settlements, Republic of Turkey Official Gazette, 27075, Ankara, 2008 [in Turkish].

[7] Building Energy Performance Calculation Method, Republic of Turkey Official Gazette, 27778, Ankara, 2010.

[8] Population and Housing Census, 2011, Turkish Statistical Institute (TURKSTAT), No:15843, 2013.

[9] Income and Living Conditions Survey 2012, Turkish Statistical Institute (TURKSTAT), Publication Number 4143, 2014.

[10] Family Structure Survey 2011, Turkish Republic Ministry of Family and Social Policies, 2011, Ankara.

[11] Family Structure Survey 2013, Turkish Republic Ministry of Family and Social Policies, 2013, Ankara.

[12] Turkish Standards Institution, TS 825: Thermal Insulation Requirements for Buildings, Ankara, 2013.

[13] U.S. Department of Energy, <http://www.energy.gov/> data retrieved on July 2014.

[14] 2014 Unit Prices of Construction and Installations, (2014) Turkish Ministry of Environment and Urbanization, Ankara.

[15] The Central Bank of the Republic of Turkey <www.tcmb.gov.tr>, data retrieved on January 2015.