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Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project



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HIGHLIGHTS

- European building stocks need retrofit actions to improve the energy performance.
- Necessity to define “reference buildings” in order to perform cost-optimal analyses.
- Definition of a National “Building Typology” according to IEE-TABULA project.
- Methodology to identify reference buildings for assessing energy saving potentials.

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ABSTRACT

Retrofit actions applied to the existent building stock aim at increasing the energy performance, considering the optimal trade-off between energy savings and costs, according to the Directive 2010/31/EU. To select effective refurbishment measures and to quantify the energy saving potentials of the existent building stock, the analysis should be performed on “reference buildings”.

This article presents a methodology for the identification of reference buildings, according to the IEE-TABULA project (2009–12) aimed at creating a harmonised structure for “European Building Typologies”. Among the possible applications of the building typology, this work focuses on the potentialities of energy savings and CO₂ emission reductions for the European residential building stock. In particular, the Italian approach to model the energy balance of a subset of the national building stock is described; the results show the enormous potentialities of energy savings even with basic energy retrofit actions. Cost analyses were not in the scope of the project, but the results of this study are the basis for further investigations aimed at assessing the cost effectiveness of sets of measures. In this regard, the TABULA building-types are being applied by the Italian government for calculating cost-optimal levels of energy performance, complying with the Directive 2010/31/EU objectives.

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1. Introduction

The interest in the analysis of the energy performance of large existing building stocks is highly increased all over the world. In fact, the most effective way to achieve significant reduction of energy consumptions in the building sector is to improve the energy quality of existing buildings. To do this, it is crucial to assess as clearly as possible the actual energy performance of buildings and, after that, apply suitable retrofit measures, both from a technological and from an economical point of view. Many studies have been carried out on this topic, starting from the knowledge of the condition of the existing building stock (Ravetz,

2008), applying statistical data analysis (Theodoridou et al., 2011a), collecting and organising data (Dascalaki et al., 2010) and identifying methodologies for assessing the building stock energy performance (Fracastoro and Serraino, 2011; Corgnati et al., 2008).

The existing building stock is wide, heterogeneous and composed, for the great amount, of buildings with poor energy characteristics. In Europe, according to Loga et al. (2012) and Dascalaki et al. (2011), a large amount of the existing building stocks in all the Member States show annual energy demands for space heating and domestic hot water ranging between 150 kWh m⁻² and 300 kWh m⁻². In this scenario, even basic energy retrofit actions may reduce significantly the building energy demand of a large number of buildings (Desideri et al., 2012). Basic actions on a large scale can determine significant energy savings, as stated in several works (Balaras et al., 2007; Ahern et al., 2013). However, retrofit actions have to be chosen accurately; many studies focus on the identification of the best

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Nomenclature		W	domestic hot water
<i>Symbols</i>		<i>Abbreviations and acronyms</i>	
EP	energy performance indicator [kWh m ⁻²]	AB	apartment block
Q	energy [J, Wh]	BS	building stock
S	surface (heat transfer) [m ²]	DHW	domestic hot water
U	thermal transmittance [Wm ⁻² K ⁻¹]	MFH	multi-family house
V	volume [m ³]	RB	reference building
<i>Subscripts</i>		ReAv	real average
H	space heating	ReEx	real example
nd	need (energy)	SFH	single-family house
p	primary (energy)	SyAv	synthetical average

refurbishment measures to be applied to existing buildings (Brecha et al., 2011; Roberts, 2008), considering economic viability (Galvin and Sunikka-Blank, 2013; Ouyang et al., 2009), market and political context influence (Atkinson et al., 2009; Weiss et al., 2012), societal economic perspective (Joelsson and Gustavsson, 2008), environmental aspects (Ardente et al., 2011), theoretical vs. actual energy consumption (Majcen et al., 2013), and applying systematic methods and tools (Mechri et al., 2010).

The interest on this topic raised a lot in Europe in the last years: in particular, the European Directive 2010/31/EU (European Union, 2010) introduced some remarkable concepts to address the energy retrofit measures of existing buildings in the right direction. This Directive introduces the concept of “cost-optimal”, defined as the energy performance that leads to the lowest cost during the estimated economic lifecycle. At the same time, it enlarges the concept from cost optimal to cost effectiveness, as graphically shown in Fig. 1. This concept has to be adopted by the European Member States in order to set energy performance requirements, for new and especially for existing building, “with a view to achieving cost optimal levels”.

According to the Commission Delegated Regulation No. 244/2012 (European Commission, 2012a) and to its accompanying Guidelines (European Commission, 2012b), Member States are required to define “reference buildings” that should represent the typical and average building stock in each Member State, in order to obtain general results consistent with the characteristics of the analysed building stock.

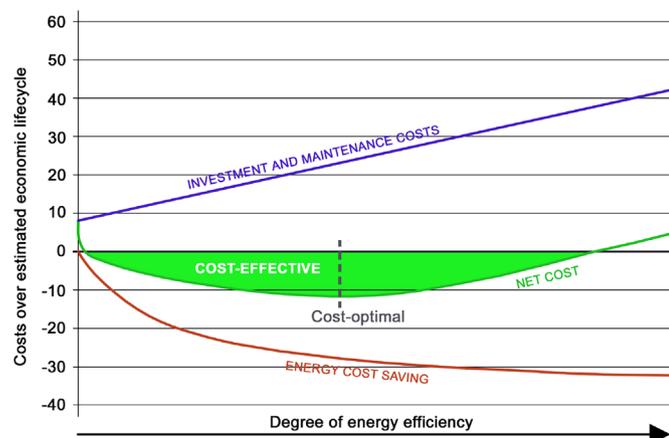


Fig. 1. Cost-optimal point and cost-effective range.

As a consequence, the “cost optimal analysis” requires the preliminary definition of reference buildings. When these are available, the investigation procedure can include the following steps:

1. energy performance calculation of the reference buildings to assess the baseline of the energy performance;
2. definition of sets of energy retrofit measures to be applied to the reference buildings;
3. energy performance calculations to evaluate the energy performance after the retrofit measures;
4. calculation of the life cycle costs using net present valuation; and
5. finally, assessment of the cost optimal (and cost-effective) set of measures to optimise (and increase) the energy performance of the reference buildings.

According to the Commission Guidelines, it is recommended that reference buildings are established in one of the two following ways: (1) selection of a real example, representing the most typical building in a specific category (e.g. type of use and reference occupancy pattern, floor area, compactness of the building expressed as envelope area/volume ratio, building envelope constructions with corresponding *U*-value, technical systems and energy carriers together with their share of energy use) and (2) creation of a “virtual building” which, for each relevant parameter, includes the most commonly used materials and systems.

The choice between these options should depend on expert enquiries and statistical data availability. It is possible to use different approaches for different building categories, to have (real or virtual) reference buildings able to represent the characteristics (geometry, envelope, systems, etc.) of each specific building category.

In the following sections, a new procedure to create a harmonised structure for “reference building” definition at European level, according to the goals of the European Project *TABULA*, is described. The project focused on residential building types and, in this article, the results concerning the Italian reference buildings are presented in detail.

In *TABULA* the building typologies are a basis for analysing the national housing sector (Loga et al., 2012). The national approach for modelling the energy balance of the residential building stock applied to an Italian region (Piedmont) is described. The energy saving potentials on the existing residential building stock are investigated by applying two sets of retrofit measures (two levels, “standard” and “advanced”, as defined in the *TABULA* project) to the reference buildings.

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