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Old or new occupants of energy rehabilitated buildings. Two different approaches for hierarchizing group of buildings

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ABSTRACT

Public Administrations are frequently entitled to intervene in building stocks with energy rehabilitation actions. Unfortunately, the monetary budget at their disposal is generally limited and, consequently, a prioritization criterion is needed to optimize its allocation. The classification of the building energy performance is increasingly used by Public Administrations for this purpose.

Here we argue that a proper prioritization criterion should depend upon the potential subjects to which the rehabilitated buildings are given back. If the energy rehabilitation is conducted on buildings that will be assigned to new dwellers, it would be preferable to use the energy class – which is based on a standardized energy consumption – because a change of the building users will occur with a consequent plausible change of the building energy usage profile. Instead, if same dwellers will occupy the retrofitted building, a criterion based on a usage profile – that is actually the one established by these occupants – seems to be more appropriate.

The priority orders of 23 buildings of the Sicilian stock, obtained using their energy class and real energy consumption, are presented and compared. Results show at which extent these two rankings differ, thus warning Public Administrations about prioritization criteria to adopt.

1. Introduction

The European Union (EU) is strongly committed to reducing the greenhouse gases emissions, and for this purpose adopted an environmental plan that sets a reduction of 20% of pollutant emissions, a reduction of 20% of energy consumption and the use of at least 20% of renewable energy, within the year 2020 (European Commission, 2010). The great amount of energy required by buildings (they are, in fact, responsible for approximately 40% of total final energy consumption in the EU – 28 ODYSSEE and MURE, 2015) has focused a great attention on this sector. To support the reduction of the energy consumption in the sector and improve its energy efficiency, many Directives were issued by the EU. Among these directives, three of the most important are the followings: the 2002/91/EU (European Parliament and the Council, 2002), the 2010/31/EU EPBD *recast* (European Parliament and the Council, 2010) on the energy performance of buildings and the 2012/27/EU EED European Parliament and the Council, 2012) on the energy efficiency.

The institution of an energy performance certification system of buildings, which was firstly introduced by Directive 2002/91/EU (European Parliament and the Council, 2002), represents a key policy tool to allow each Member State to achieve their own national CO_2 reduction targets in accordance with the EU goals. In line with this Directive, an energy performance certificate (EPC) must be attributed to buildings, when constructed, sold or rent out, and made available to the future owner or by the owner for the buyer or tenant, respectively. In accordance with the in force Italian guidelines for the energy certification (D.M. of 26/06/2015) the energy class of a given building depends on the so-called global energy performance index, $EP_{gl,nren}$, that is determined by dividing the yearly amount of non-renewable primary energy – needed to satisfy the needs related to a "standard use profile" of the building – by the net surface area of the building. $EP_{gl,nren}$ is expressed in kWh/(m^2 year) and accounts for the energy needs for winter (EP_H) and summer seasons (EP_C) climatization, ventilation (EP_V), Domestic Hot Water production (EP_W), lighting (EP_L) and carrying of people or goods (EP_T) as well as for auxiliary energy of equipment.

As it is well known, the EPC is currently used in economic transactions involving buildings (*i.e.* when a building or a building unit is sold or rented out) and, for instance, in Italy has been acknowledged. In fact, the energy class indicated on the EPC, is assumed as a useful indicator of the energy performance of the given building that, in turn, affects its market value (Abela, Hoxley, McGrath, & Goodhew, 2016; Nunes, Lerer, & da Graca, 2013). The EPCs are also used within the

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European research project IEE-EPISCOPE (IEE-Energy Performance Indicator Tracking Schemes for the Continuous Optimization of Refurbishment Processes in European Housing Stocks, 2013–2016) (Loga et al., 2016) (www.episcope.eu) to assess the energy performance of the EU housing stocks, at different scales (national, regional, or local) (Ballarini and Corrado, 2017).

On the other hand, apart some concerns about the appropriateness of current methodologies for building energy certification pointed out in literature (Abela et al., 2016), it is worth reminding here that, nowadays many Public Institutions (*i.e.* Municipalities) have decided to set incentives (in the form of moneys or tax reductions) for building owners who intend to energy rehabilitate their construction (Dall'O, Galante, & Pasetti, 2012; Valdiserri and Biserni, 2016). In this context, because of the obvious limitations of their monetary budget and in order of optimizing its allocation, the highest priority for economic incentives should be given by Public Administrations to those buildings that are recognized to be the most energy consumer.

To establish a hierarchical order of the buildings that have to undergo an energy retrofit process (Ferrante et al., 2016; Filogamo, Peri, Rizzo, Giaccone, 2014), the practice to use energy indicators, especially the energy class, is becoming more and more common among Public Institutions. An example of such way of proceeding is provided by the Municipality of Palermo, which is using the EPC as its policy tool within the Covenant of Majors for Climate & Energy (http://www.covenantofmayors.eu/index_en.html).

However, when singling out a possible prioritization criterion of the buildings belonging to a given stock, we do believe that a distinction between the two following circumstances should be made: 1) if the energy rehabilitation is conducted on buildings that will be assigned to new dwellers, and 2) if the energy rehabilitation is conducted on buildings that will be assigned to the previous dwellers. In fact, we argue that based on the potential subjects to which the retrofitted buildings will be given back, different approaches for the establishment of an order of priority of the buildings should be applied. Specifically, in the first case it is preferable to use the energy class that is based on a standardized energy consumption as the prioritization criterion (that is the in force practice) because, since a change of the building users will occur, a consequent change of the energy usage profile is also plausible. In this case a hierarchy of the buildings that is established on the basis of their real energy consumption would indeed turn out meaningless in order of representing the rehabilitation rank because new dwellers will occupy the enhanced buildings with their own energy use-related habits that are obviously un-known at the time of the rehabilitation interventions.

On the contrary, in the case that previous dwellers will occupy again the enhanced building the "true" behaviour (and not a "standardized" one) matters for the definition of the rehabilitation rank. Therefore, it is preferable a prioritization criterion that is as much close as possible to the usage profile that is actually established by these occupants. A hierarchy of the buildings that is founded on the basis of their "standardized" energy consumption would indeed turn out to be not fairly representative of the rehabilitation ranking because in this case same dwellers will occupy the enhanced buildings with a similar energy use-related habits as before. Consequently, a ranking criterion for energy retrofitting building stocks that is alternative to the energy class needs to be identified in this latter case.

The main goal of this paper is to show the importance of using a different ranking criterion in the case that the final users of the retrofitted buildings will remain the same. To accomplish this task, a suitable sample comprised of 23 residential buildings located in Sicily (Southern of Italy) was considered. Given their construction age, they represent a good example of buildings for which owners could be motivated to implement energy retrofit measures. The energy classes possibly attainable by the selected buildings were determined according to the in force Italian regulation scheme and referring to a standard usage profile. Afterwards, using the energy bills that were collected directly in the field for all the 23 buildings, we evaluated their "alternative" energy class, this time, based on their real energy consumption. The two generated orders of priority with respect to the energy class and to the real energy consumption were compared in order of pointing out the possible differences. Based on the large extent of discrepancies found for the two ranking orders the need of two different criteria seems confirmed.

The structure of the paper is as follows. Section 2 reports a description of the energy calculation method selected for assigning the energy class to buildings on the basis of their standard energy consumption; Section 3 describes the considered group of buildings along with their actual energy consumption; Sections 4 and 5 illustrate and discuss the outcomes of the analysis, respectively.

2. The energy calculation method used: UNI TS 11300 – the Italian technical standard for the evaluation of the building energy use

In order of determining the energy class of the buildings, the current Italian standard for the evaluation of the energy requirements of building, that is the UNI TS 11300, was used. This technical standard was developed with the aim of providing a unique calculation methodology to assess the energy performance of buildings especially their thermal energy need and primary energy consumption. It consists of the following parts:

- Part 1: determination of the building thermal energy demand for climatization in winter and summer season (released in 2008, revised in 2014) (UNI/TS 11300-1: 2014);
- Part 2: determination of primary energy need and efficiency for climatization in winter season, DHW production, ventilation and lighting in non-residential buildings (released in 2008, revised in 2014) (UNI/TS 11300-2: 2014);
- Part 3: determination of primary energy need and efficiency for climatization in summer season (released in 2010, currently under revision) (UNI/TS 11300-3: 2010)
- Part 4: use of renewable energy sources or other generation systems for the winter climatization and DHW production (released in 2012, revised in 2016) (UNI/TS 11300-4: 2012);
- Part 5: calculation of the primary energy and of the amount of energy obtained by renewable energy sources (released in 2016) (UNI/TS 11300-5: 2016);
- Part 6: determination of the electric energy need for elevators, escalators, and mobile sidewalks (released in 2016) (UNI/TS 11300-6: 2016).

The part 1 of the UNI TS 11300 defines the manner in which applying, at the Italian country level, the ISO 13790 (ISO 13790: 2008) with respect to the monthly-balanced method for the calculation of the thermal energy demand for space heating.

Once 1) the "building-plant" system is defined together with its thermal zones (*i.e.* calculation zones), 2) both the internal (temperature and relative humidity) and external (average monthly temperature of the average daily air temperature and average monthly total solar irradiance) conditions are defined, and 3) the length of the heating season is singled out (determined on the basis of the climatic zone where the building is located), then the calculation of the thermal energy demand for the space heating of a single thermal zone during a given month (indicated in the standard with the symbol $Q_{H,nd}$) can be done using the following equation:

$$Q_{H,nd} = Q_{H,ht} - \eta_{H,gn}\, Q_{gn} \tag{1}$$

where $Q_{H,ht}$ represents the total thermal exchange of the thermal zone during one month for the space heating; Q_{gn} represents the total thermal gains of the thermal zone during one month for the space heating; and $\eta_{H,gn}$ is the utilization factor of the thermal gains of the thermal zone