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A multi-criteria framework for decision process in retrofit optioneering through interactive data flow

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Abstract

Aim of this research is to deliver a system of procedures and instruments that allows comparing different scenarios of restoration and retrofit of existing buildings applicable each time a relevant decision about the asset has to be made. The system developed takes advantages of Building Information Modeling (BIM) and Analytical Hierarchy Process (AHP), thus to focus on main clients' needs. Decisions about real estate assets are frequently made by managers with incomplete and scattered data, not sufficient to fully support the decision making process. Using a BIM model as a central repository of information could strongly support to compare objectively different scenarios and consequently to decide the application of a multi-criteria matrix involving management, energy, economic and social issues. BIM and BEM (Building Energy Modelling) techniques have a wide potential and analysis capabilities; however, they are often adopted without an integrated framework, causing missing performances and costs overrun. The result is a system enabling to analyze the asset, to produce BIM and BEM models ready to include life cycle data, to evaluate feasible alternatives and scenarios and to extract relevant performance indicators for decision makers' support. An existing office building in Milan representing an awkward field for intervention is the case study for the system application. While the tools and software adopted are commonly used, the system of procedures developed by the authors can be considered as an ensemble of workflows otherwise typically used independently. Using them together enhance the decision process providing data on which to set up a strategic plan of the refurbishment considering costs, continuity in occupancy and energy efficiency.

Keywords: Refurbishment; multi-criteria decision making; LCC; BIM; BEM.

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1. Introduction

In Europe around 40% of energy consumption, approximately 11,530 TWh is attributable to the residential and commercial sector [1]. The total primary energy consumption of the buildings belonging to these sectors in Italy shows, in comparison with other EU Countries, one of the higher values. Considering the buildings distribution by intended use, at national level, the average percentage of residential buildings is 87% of the total, while different uses (e.g. hotels, offices, commerce and industry, communications and transport and other uses) represent 6% and the unused buildings represent a further 6%.

Based on National Census data, in Italy there are over twelve million buildings (Fig. 1). More than 50% dates before 1970, which means before the first National Law [2] on energy efficiency was ever adopted. The first Italian law about energy efficiency in buildings dates 1976 although it was mainly ignored as similarly occurred with the most famous L.10/91 [3]. Italy is not an exception, in other country of the European Union most of the buildings are old and characterized by low energy performance and lacking by the comfort and indoor quality [4].
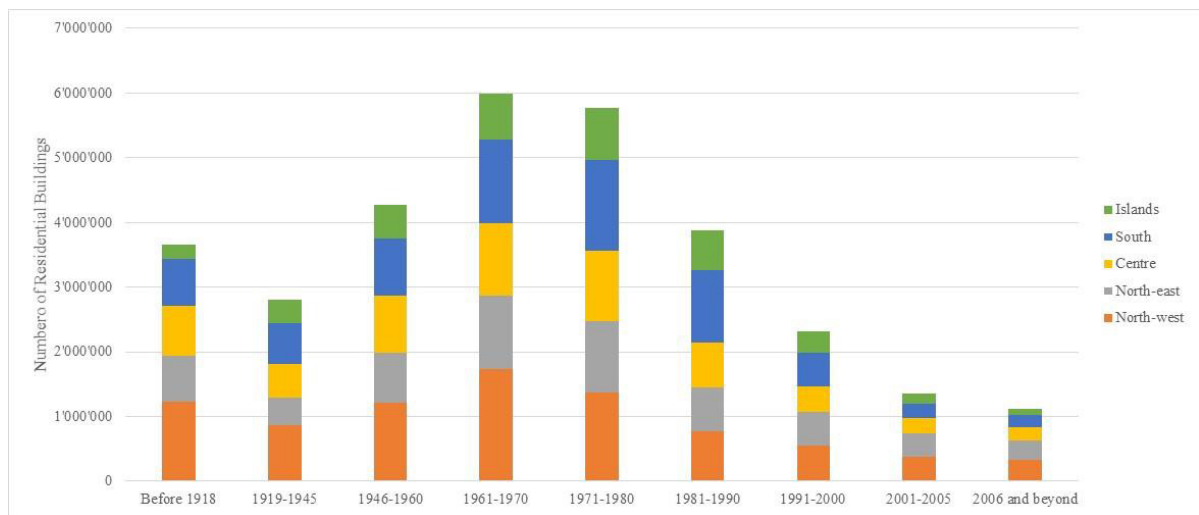

Fig. 1. Construction years of residential building in Italy (data from 2011 National Census).

Old building stocks are facing with regulatory practices shifting toward reductions in energy use, with new users' needs and, most of the times, with the request for improved economic performance. These building stocks are rarely replaced with new and more efficient buildings; in fact, the replacement rate of existing buildings by new buildings is only around 1.0–3.0% per annum [5], thus energy retrofit of existing building is more or less the privileged way to enhance energy efficiency of high-energy consumer assets.

Among existing buildings, office ones have one of the peak levels of energy consumption, which can vary between 100 and 1000 kWh/m^2 year. At national level, an energy audit performed on office buildings in different climatic zones of the territory [6] identified the average values of the total specific consumption of electrical energy and primary energy for heating only.

Cross-checking consumption data for each climate area with the percentages of office buildings per location can be identified a national average consumption for heating of around 80 kWh/m^2 per year. The average specific fuel consumption of 72% of the office buildings, which are located in climatic zones D and E, is about 95 kWh/m^2 year, excluding the quota of electricity required for air treatment. The average energy consumption for buildings located in the North of the country and in other cold climates is about 100 kWh/m^2 (referred to heating only).

The specific primary energy consumption for electricity and heating for offices located in Italy in the different climate zone [7] are reported in the following Table 1. The climate zones are related to the value of Degree Days (HDD') defined as the integral of the differences of the outdoor air temperature and a base temperature (commonly 18°C) above which a building needs no heating.