Assessing Energy Saving Potential of a Public Building Stock in Relation to the National Implementation of the Energy Performance of Buildings Directive

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ABSTRACT

At present 95% of energy consumption for heating, domestic hot water, air conditioning, lighting and ventilation in Europe are related to buildings built before 1980. Therefore, in order to achieve Kyoto Protocol targets, the immediate priorities could be to improve energy performance of those buildings.
In Italy, based on the Energy Performance of Buildings Directive (EPBD) delivered on 2002, first new national benchmarks for energy efficiencies in buildings are defined and effective from January 2006. The prescriptions of the new standards, as foreseen by EU Directive, are also related to the retrofit actions for existing buildings. In this frame, Public Administrators should promote criteria, methods and tools to verify building energy quality and to define rehabilitation strategies on large scale.
The present study is conducted, defining a methodology for data collection, organisation and elaboration, in order to estimate the energy performance and the potential of improvement of energy savings about existing building stocks. In the frame of the recent national implementation of the EPBD, this study provides a first example of the EU Directive effects in large scale retrofit strategies.

KEYWORDS

EPBD, energy saving, retrofit, building stock, public buildings

INTRODUCTION

The analysis of energy saving potential in the large scale building stocks is complex in nature. Generally, the information available for both the public owner and private buildings are inconsistent, incomplete and approximate because of the old fashioned and inadequate public administration management practices.
In order to verify the feasibility and difficulties for defining scenarios for energy performance and energy rehabilitation priorities on existing buildings, a preliminary analysis of a Public Building stock has been carried out based on the school buildings located in the district of the Municipality of Milan, which represents common typologies of school buildings for the entire north region in Italy.

METHODOLOGY FOR COLLECTING DATA

Data from public offices are generally recorded on administrative criteria, containing information like address, age, volume, total floor area, owner, etc. By consulting

different data sources from several offices of the Municipality, 627 schools have been identified, of which 517 buildings owned by the Municipality.
Fortunately, during years 1980-1984 Municipality of Milan published a collection of 21 books, Comune di Milano – Rip. Dem. e Patr. (1980-84), containing additional data for all its own buildings, such as covered surface areas, number of storeys, construction typologies, photos and plan views. At first, utilizing the books collection, the perimeter of each school building was measured on the related plan. In second step, the dimension of vertical surfaces of the buildings was estimated by multiplying the perimeter to the number of the storeys and to the typical average floor to floor height. The average floor to floor height was estimated according to both the technological construction (checked also on the photos) and the age of the building. The covered surface data has been assigned for both the basements and roofs extension.

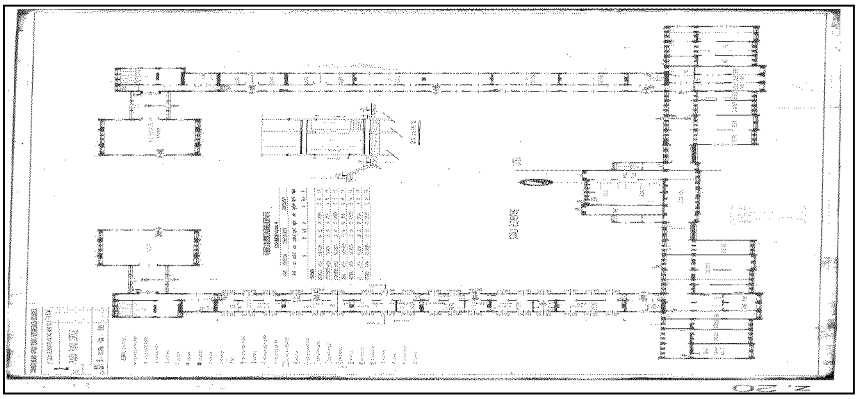

Figure 1: Example of building data collected in Municipality books

The final database (made by an excel sheet) having full information on the building characteristics consists of 458 buildings built before 1984. The upload of the rest of the buildings (not included in the book collection) has been previewed for completing database in the future.

ASSESSMENT OF HEATING ENERGY PERFORMANCE

The building database described above was grouped, on the basis of built age, in three categories: until 1945 (A), from ’45 to ’75 (B), from ‘76 to ’84 (C). These categories are related to the most significant changes in the construction technologies during these periods (before the II World war, between the war and the first Italian standard on envelope energy performance, and after this last date).
According to the built age and the construction typology for each building, Reg. Lombardia-DISET (1989) and Reg. Lombardia-AIP (1981), the U-values (external walls, roofs, basements and windows) and the typical ratio between window and opaque vertical surface were assigned. For example, conventional external wall constructions for groups A, B, and C were considered as made of bricks, with an air gap between hollowed bricks and with thermal insulation materials between hollowed bricks, respectively.

The dimensional and thermo-physical properties, CNR (1982), were used for calculating the actual specific heat loss transmission coefficient for each building, which can be defined as follows:

$$C_d = \Sigma\ U_i \times S_i/Vol\ [W/(m^3 °C)] \qquad (1)$$

where U_i and S_i are the U-value and the area of the external surfaces, and Vol is the gross heated volume.
Assuming an air change of 0.5 Vol/hour, the value of the heat loss ventilation coefficient has been assigned as C_v = 0.175 [W/(m^3°C)], constant for all the buildings.
Then, the total heat loss coefficient has been defined as $C_g = C_d + C_v$.
This value, multiplied to the heated air volume and to the actual Degree Days (depending on the daily use of the building in heating season) results the Useful Energy Demand (UED) of the building:

$$UED = C_g \times V \times DD \times 86,4\ [kJ] \qquad (2)$$

This figure is independent from the heating system efficiency and represents only the useful heat required to maintain the indoor reference temperature. For the assessment of primary energy demand, the data about the systems (e.g. size, type, efficiency of production, distribution and regulation, etc.) are required but not available at the current phase of the study. In fact, the only data source available regarding the heating systems is related to energy management contract, which includes limited information like actual heating Degree Days, type of energy source and specific cost for energy management.
Based on the methodology described above, the estimations of Useful Energy Demand was carried out, Ferrari (2004), for the analyzed building stock. For the entire buildings UED is equal to 859 TJ/y. Figure 2 shows in percentage the useful energy demand for different range of built age of the buildings.

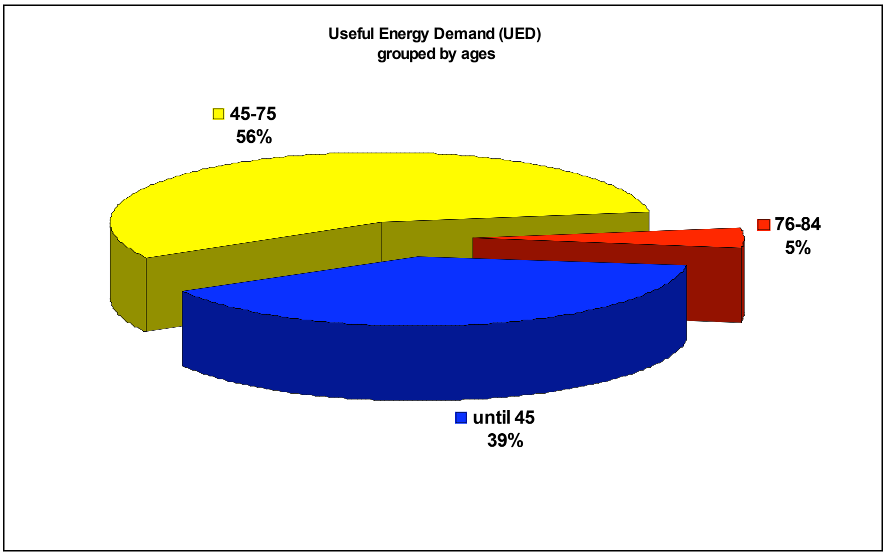

Figure 2: Useful Energy Demand, buildings grouped by ages

We can see that the energy demand, referred to the buildings built on B age is highest. Moreover, it has to be mentioned that the useful energy demand corresponding to the age group A represents less than 40% of total demand, while its volume share is 45%, and, in contrast, the energy demand of the age group B (56% of the total UED) is related to the 48% of the total volume: in fact, also in relation to specific energy demand in MJ/m^3 (Fig.3) buildings of group B is the most significant group of the stock that require retrofit actions.

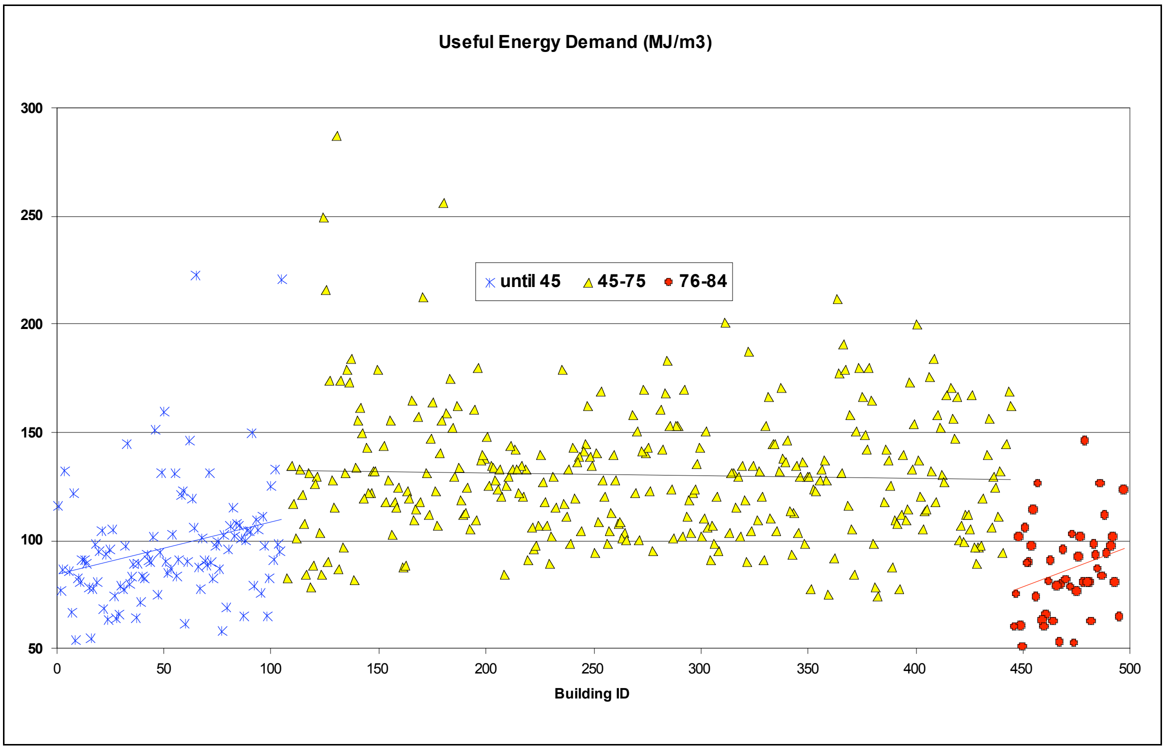

Figure 3: Specific Buildings Useful Energy Demand by ages

EPBD SCENARIOS

The first national implementation of Energy Performance of Buildings Directive was carried out as a new law on August 2005 (D.Lgsl. 192), and basically referred to reduce the heating energy demand in buildings. The new standards, foreseen for both the new and refurbished constructions, are related to the maximum values of building primary energy demand, as a function of national climatic zones (based on standard Degree Days) and the S/V (total external surface to building volume) ratio. The methods to estimate the building primary energy demand are based on well known procedure, as the EN 832 one. Otherwise, in alternative to the calculation of primary energy demand (for verifying the compliance of the pre-defined maximum values), the D.Lgsl. 192 provide also a set of maximum U-values for building envelope respecting which the standards result satisfied. The maximum U-values, referred to opaque external walls, basements, roofs and windows, are defined as a function of the national climatic zone and different for two deadlines of implementation: the current one started from January 2006 and the second one will start from 2009.

TABLE 1
Maximum U-values for Milan (climatic zone E) provided for Italian implementation of EPBD.

Zone E 2101- 3000 DD	Maximum U-values from 2006 (W/m^2K)	Maximum U-values from 2009 (W/m^2K)
Basements and roofs	0.43	0.34
Opaque external walls	0.46	0.37
Windows (glass + frame)	2.8	2.5

Based on the U-values compliance option, the adoption of the maximum U-values constrained by the standard foreseen by EU Directive implementation has been adopted as improved scenarios ("current" and "advanced", depending on the 2006 and 2009 values respectively).
The comparison among the hypotheses of rehabilitations according to current standard (UED_{cur}), according to advanced standards (UED_{adv}) and real status of building stock (UED_{real}) is reported in the Fig. 4.

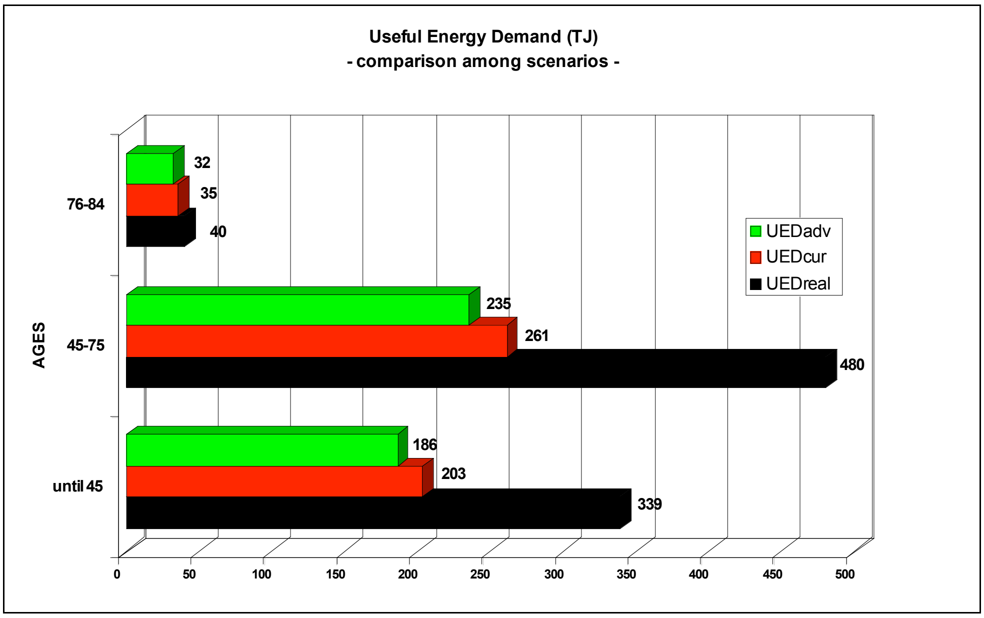

Fig. 4. Comparison among Useful Energy Demand scenarios, grouped by ages

It is obvious from the figure that the refurbishment of the most recent building stock (better quality construction) is less effective: in fact, in case of advanced scenario, this result in 20% reduction in total energy demand, equivalent to 8 TJ/y of energy saving.
For the buildings of the worst period (built age B), energy saving potential is significant also starting from a conventional rehabilitation, with 219 TJ (the 46% of the current demand) and could rise to the 51% in case of advanced insulation strategies (reduction of 245 TJ/y).
The rehabilitation of the older buildings (built age A) could permit a reduction from 40% to 45% i.e. 136 TJ/y in respect of the current standard and 153 TJ/y with the advanced scenario.

CONCLUSIONS

The energy evaluation of the school building stock of Municipality of Milan suggests a first criteria of building selection for the future refurbishment priorities. In fact the UED data are directly linked to the performance of building envelope and identifies its weakness with respect to new targets. In this study, two different scenarios were defined based on the adaptation to the performances required by the national implementation of the EPBD (compulsory also in case of retrofit actions): according to new current thresholds and, respecting more restrictive predicted limits, to the 2009 thresholds. Even if the standards provided for the first national implementation of EPBD are still considered relatively soft, the gap between the current building energy performances and the reachable ones in case of retrofit reveals a substantial potential of energy-environmental (energy savings correspond to a proportional amount of avoided CO_2 emissions) improvement.
In the light of above points and foreseeing future new laws for the implementation of the EPBD, the Italian Public Administrations should focussed intensively on planning and definition of strategies for improving energy efficiency in short and medium terms.

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