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Tracking the energy refurbishment processes in residential building stocks. The pilot case of Piedmont region

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Abstract

The objective of the IEE-EPISCOPE project is to make the energy refurbishment processes in the European housing sector more transparent and effective. Each participating country is developing a pilot action, aiming at tracking the refurbishment progress of housing stocks at different scales. In the present article, the monitoring of the Piedmont regional housing stock is concerned. A preliminary analysis on data sources is performed, to identify the current state of the stock and the refurbishment rates. The results are a basis to carry out energy performance calculations and to assess future refurbishment scenarios and quantify the energy saving potentials.

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Keywords: Residential building stock; Building energy refurbishment; Building typology

1. Introduction

1.1. Energy refurbishment of the existing building stock

Over the last years the attention towards energy savings and reduction of CO_2 emissions of building stocks has continuously increased, due to the depletion of fossil energy resources, the climate change and the environment pollution. On the average, the European building stocks display more than 40% of the energy consumption and

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greenhouse gas emissions of all the consuming energy sectors. In particular, the residential sector is responsible for almost 30% of total final energy consumption [1]. Since 2002 the European Union has issued directives encouraging the Member States to adopt strategies to increase the energy efficiency of their existing building stocks.

The European Directive 2012/27/EU establishes a set of binding measures to help the EU to reach 20% energy efficiency target by 2020. Under this Directive, all the EU countries are required to use energy more efficiently at all stages of the energy chain, from its production to its final consumption [2]. The European Directive 2010/31/EU (*EPBD Recast*) [3] aims at improving the energy efficiency of buildings by introducing the "cost-optimal" methodology in order to define minimum energy performance (EP) requirements for the existing buildings and to identify targets towards "nearly zero energy buildings" (NZEB) [4].

In the building sector, various instruments and policies are being applied by the Member States in their effort to comply with the *EPBD Recast*. In this context, many studies analyse the potentialities of the energy refurbishment processes in housing stocks through the evaluation of the energy performance of buildings [5,6] and focus on the improvement of current policy instruments to increase refurbishment rates of the existing buildings [7-9]. In order to identify effective energy efficiency measures and determine reliable energy saving potentials, the building energy performance analyses should start from a clear picture of the current state of the building stock and should be based on representative data. Anyway, available data from energy statistics and census are often limited and need to be elaborated with specific methodologies, even applying some probable assumptions.

1.2. Pilot actions in the IEE-EPISCOPE project

The strategic objective of the IEE-EPISCOPE project (*Energy Performance Indicator Tracking Schemes for the Continuous Optimisation of Refurbishment Processes in European Housing Stocks*, 2013-2016) [10] is to make the energy refurbishment processes in the European housing sector more transparent and effective. This objective can be reached through the following steps: first, determining a clear knowledge of the current state of the existing building stock, then researching suitable scenarios of energy efficiency measures for the building stock, and finally identifying the achievable energy savings and CO_2 emission reductions. The implementation rate of different refurbishment measures will be compared with those activities which are necessary to attain the relevant climate protection targets. This research work will allow to address local policy instruments to achieve high energy efficiency standards and to raise energy efficient retrofitting actions towards NZEBs in short, middle and long term.

In the EPISCOPE project, the tracking of the energy refurbishment progress and the implementation of different refurbishment measures in the participating countries is applied by means of "pilot actions" developed by each project partner. The Italian pilot action focuses on the housing stock of Piedmont region, in the Northwest of Italy.

The aim of the present article is to illustrate the preliminary work conducted in the EPISCOPE project for identifying and processing the main data sources of the Italian pilot action. This is considered a fundamental work as it provides the basis for defining the current state of the housing stock concerning the implementation level of the thermal insulation and the heating system efficiency. Starting from this basis, the subsequent work – out of the scope of this article – will consist of the calculation of the current energy performance of the Piedmont residential building stock and of the application of scenario calculations concerning building stock refurbishment trends.

Nomenclature

U	thermal transmittance (W $m^{-2}K^{-1}$)
η	efficiency (-)
Subscripts	
g	generation (system)
op	opaque (envelope)
w	windows
Acronyms	
EPC	energy performance certificate
RBS	residential building stock

2. Method

2.1. Common principles for tracking the state of the building stock

The EPISCOPE project is intended to define a generally applicable set of quantities, named *monitoring indicators*, which – in case of a regular update – can provide the basic information to observe and understand the development of the energy performance in residential building stocks. An indicator system developed within the project intends to deliver a common language for the exchange of information on international level. It does not provide any limiting rules with respect to the national or regional pilot projects which are carried out autonomously by the partners. Anyway, the results of the individual pilot actions have to be translated into the common indicator system so that a comparison will be possible [11].

According to EPISCOPE, the energy performance analysis of a building stock is a two steps process, concerning:

1. Identification of *monitoring indicators*, which consists in collecting reliable data of the building stock to be regularly updated.
2. Definition of *model assumptions*, to close the information gaps in case of lack or incompleteness of *monitoring indicators*. The *model assumptions* are also meant to describe future development of the building stock.

The combination of *monitoring indicators* and *model assumptions* determinates either the *base case*, which describes the current energy performance of the building stock, or the *scenario*, meant to assess the future energy consumptions. By applying this methodology, the main challenge of the EPISCOPE project consists in overcoming the lack of data by means of the application of model assumptions, provided that these assumptions are chosen in such a way as to represent the most probable conditions and are declared in the analysis.

2.2. Data analysis for the identification of monitoring indicators

The current state of the housing stock in Piedmont region and the trend of building energy refurbishments have been determined by means of statistical data. These data, i.e. the *monitoring indicators*, have been derived either directly or by processing from the following data sources:

- census of population and dwellings by the National Institute of Statistics (ISTAT, census 2011) [12],
- reports from the observatory of the real estate market (OMI) [13],
- database of the building EP certificates of Piedmont Region,
- reports of National Agency for New Technologies, Energy and Sustainable Economic Development(ENEA) [14].

The *monitoring indicators* related to the size of the building stock are provided by the National Institute of Statistics, concerning the number of residential buildings and dwellings (also available split by construction period) in Piedmont region. The residential building stock floor area has been derived both from ISTAT and from the observatory of the real estate market (OMI). Among the above references, the main energy-related data source of *monitoring indicators* for the Piedmont regional pilot action is the database of the building EP certificates (EPC).

In 2009, the Piedmont Region issued an information system for the energy performance certification of buildings (SICEE). The system allows the qualified professionals to compile the certificates and to transmit them to the regional authorities, which in turn analyze and collect the certificates in a database. This database has a limited access and its use is restricted at statistical purposes and research activity. The database includes, for each certified building or dwelling, the following information:

- general data (e.g. building use, year of construction, building typology),
- main geometric data (e.g. conditioned net floor area, conditioned gross volume, compactness ratio),
- main data of the building envelope (e.g. thermal transmittance of external walls and windows),
- main data of the thermal systems (e.g. type of thermal system, mean seasonal global efficiency of the space heating system and of the domestic hot water system, mean seasonal efficiency of the heat generator, type of energy carrier for space heating and for domestic hot water, use of renewable energy sources),
- the energy performance indicators and the energy class.

A statistical analysis was carried out on the EPC database, which includes all the EP certificates delivered from 2010 to 2013. The objective of the analysis has been the identification of the thermal insulation state of the building envelope and the thermal system features of the existing housing stock. A preliminary activity consisted in removing inconsistencies from the database. These may occur both in the main parameters object of analysis (e.g. the wall U-value) and in the normalizing parameters (e.g. the conditioned net floor area). Due to the heterogeneous origin of the data, errors may occur in measurements and evaluations generated by differences in the professionals skills [15].

As the EPISCOPE pilot action will investigate energy refurbishment scenarios of the building stock, the statistical analysis also focused on the identification of the *monitoring indicators* concerning the recent energy refurbishment rates of the regional housing stock. The main information was derived from ENEA reports on the "demands of tax deduction for the energy refurbishment of existing buildings". The average building stock floor area annually refurbished was got from the number of dwellings refurbished in the period ranging from 2008 to 2012 by type of energy efficiency measure.

3. Results and discussion

3.1. Monitoring indicators and model assumptions of the Piedmont regional housing stock

The main *monitoring indicators* concerning the residential building stock (RBS) size are shown in Table 1.

Table 1. Basic data of the residential building stock of Piedmont region (Sources: ISTAT, 2011; OMI, 2012).

Number of buildings	Number of apartments	National reference area [m^2]
944 690	2 443 772	214 332 304

It has to be noted that the EPC database of Piedmont region, as the main energy-related data source for *monitoring indicators* in the pilot action, does not cover all the RBS floor area of Piedmont but only that area for which an energy certificate was issued. The regional housing stock having an energy certificate is the 19% of the total and, as regards the motivation issue, 65% of EPCs was delivered for sale or rent, 16% for building renovation, 7% for new building, 12% for other reason.

The *model assumption* to overcome the information gap between the EPC database and the whole building stock consisted in assigning the *monitoring indicators* got from statistical analysis of the EPCs issued for sale and rent to the residential building stock not having an EPC. Due to the lack of data, the EPCs for sale and rent are considered suitably representative of the average existing building stock.

The results of the statistical analysis carried out on the EPC database are shown in Figs. 1-2. The distribution of the thermal transmittance of the building envelope components with reference to the conditioned net floor area of the current regional housing stock is show in Fig. 1(a), for the vertical opaque enclosures, and in Fig. 1(b), for the transparent components, by construction period and global. Around 63% of the net floor area of the RBS reveals external uninsulated walls and the 42% of the RBS floor area presents single glazing windows. As the first Italian law on the building energy efficiency was issued in 1976, it can be supposed that the percentages of insulated floor area related to periods before 1976 are referred to refurbishment actions occurred to buildings during their lifecycle.

The distribution of the types of space heating systems and of heat generators with reference to the conditioned net floor area of the RBS are shown respectively in Figs. 2(a) and 2(b). In the latter case, the information is also available by construction period even if not reported here. Globally, the 41% of the total regional housing floor area has centralized heating systems, while the 52% is provided with individual heating systems. The most widespread heat generators are the standard non-condensing gas boiler (68.5%) and the condensing gas boiler (18%), followed by the district heating (7.1%), while the biomass heat generators and the heat pumps cover less than 3%.

Some preliminary *monitoring indicators* of the current building energy refurbishment trend are the results of elaborations on the ENEA data concerning the demands of tax deduction for the energy refurbishment of existing buildings; they are shown in Fig. 3. The average annual rate of the retrofitted dwellings in Piedmont is around 2%. The most commonly applied measures are windows replacement and heat generator replacement, while the least applied measures are the insulation of vertical and horizontal building components.

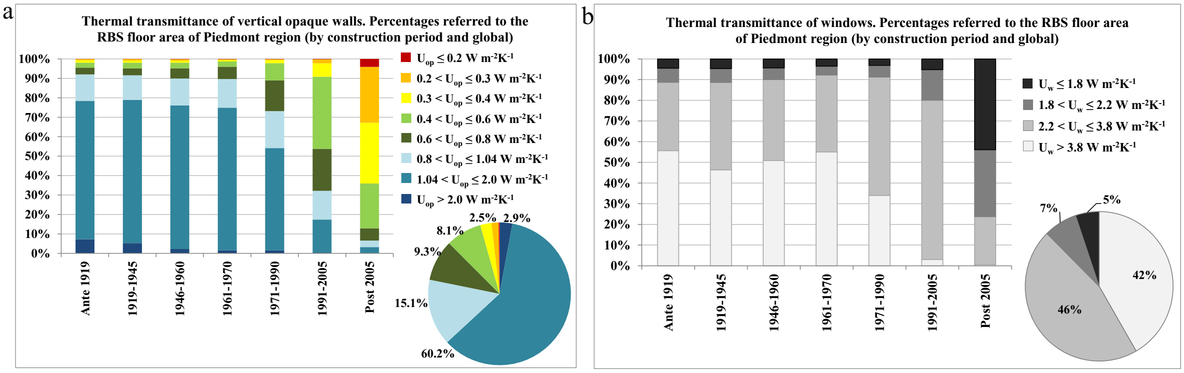
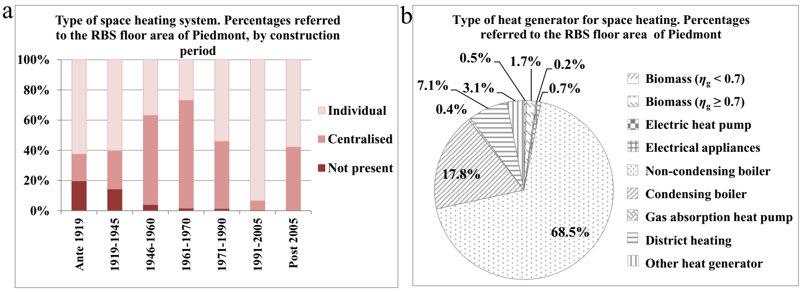


Fig. 1. Thermal transmittance of vertical opaque walls (a) and of windows (b) with reference to the residential building stock (RBS) floor area.



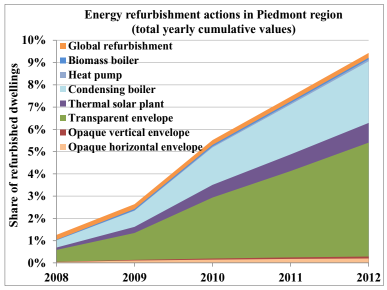


Fig. 2. Type of space heating system (a) and type of heat generator for space heating (b), with reference to the residential building stock (RBS) floor area.

Fig. 3. Energy refurbishment actions in Piedmont region.

3.2. Definition of the base case

According to the principles of the pilot action, the current state of the residential building stock is represented by the so-called *base case*. The Piedmont regional *base case*, got from the set of *monitoring indicators* and *model assumptions*, is shown in Fig. 4. The data provided in Section 3.1 referring to the current state of the housing stock, grouped by construction period, are further split by energy efficiency levels. The RBS floor area was clustered assuming that increasing heating system efficiency corresponds to decreasing U-values of walls and windows. The black segments in Fig. 4 identify, for each construction period and for a different amount of housing stock floor area, from 1 up to 6 different conditions.

The assessment of the energy performance of the *base case* will be carried out in the subsequent phase of the EPISCOPE project through the application of calculation methods on representative building typologies [16]. In addition, *scenario* analyses will be performed considering refurbishment trends, like the trend shown in Fig. 3.

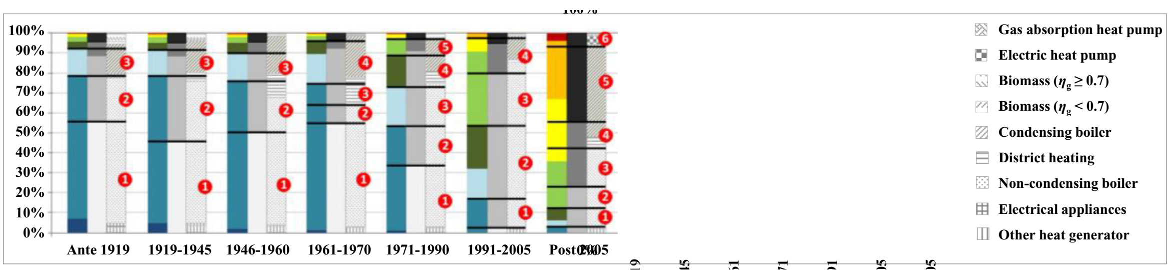


Fig. 4. *Base case* of the Piedmont residential building stock (the percentages are referred to the RBS floor area).

4. Conclusions

The article investigated the preliminary phase of the Italian research activity in the IEE-EPISCOPE project, whose aim is laying a basis for the tracking of the housing stock energy refurbishment progress in the field of thermal protection and heat supply against the background of energy saving and climate protection requirements.

Innovative aspect of the research project is the methodology for collecting and processing the data that characterize the current building stock, by using *monitoring indicators* and *model assumptions*. On this basis, energy performance calculations and scenario analyses will be developed in the forthcoming phase of the project.

The main data source of the Piedmont regional pilot action is the energy performance certificates database, which revealed to be a fundamental reference for monitoring the current state of the housing stock, even if an application of assumptions has been necessary. The statistical analysis performed on the EPC database can be considered a good starting point for providing reliable information on thermal insulation and heating system efficiency.

In this context, as the strategic objective of the EPISCOPE project is to make the energy refurbishment processes in the European housing sector more transparent and effective, recommendations will be given to local administrations for providing a regular monitoring, for instance by requiring more detailed and controlled input data in the building energy certificates, by carrying out representative surveys and censuses, by delivering results from energy audits.

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