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Refurbishment trends of the residential building stock: Analysis of a regional pilot case in Italy

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ABSTRACT

The article illustrates the Italian pilot action in the IEE-EPISCOPE project, focussing on the analysis of energy refurbishment trends of the Piedmont region residential building stock.

The methodology follows three steps: (1) definition of a knowledge-base on the current state of the building stock, (2) investigation of refurbishment scenarios considering energy efficiency measures and retrofit rates, and (3) comparison of the achievable CO_2 reductions with the climate protection targets in short and middle term. The results are addressed to local authorities to enable them to set up corrective actions to achieve the targets.

Three realistic scenarios are investigated. The first one considers the annual current refurbishment trend and the most common energy efficiency measures. The second scenario applies the measures resulting from a cost-optimal analysis. The third scenario considers the mean annual refurbished floor area necessary to meet the climate protection targets. The results of the scenario analyses emphasise the need of implementing major refurbishments, rather than fixing stricter requirements.

The building stock energy performance is assessed through the building typology approach defined in the IEE-TABULA project. It allows the models of building stock energy refurbishment to be presented in an effective way, easily understandable and manageable by non-energy experts.

1. Introduction

1.1. Policies and strategies for reducing the CO_2 emissions in the building sector

In the recent years, the European Union has taken a role of global leadership in reducing greenhouse gas emissions. The first important step in this direction was the definition of ambitious targets already by 2020. In 2008, the EU launched the "Climate and Energy Package" (the so-called "package 20-20-20") [1], with the following goals for 2020: to reduce at least 20% greenhouse gas emissions compared to 1990 levels, to increase the share of renewable energy to at least 20% of overall energy consumption, to reduce at least 20% final energy uses. The latter objective can be achieved through energy efficiency measures, as foreseen by the Directive 2012/27/EU on energy efficiency issued in October 2012 [2]. In 2014, a new "2030 Framework for climate and energy" [3] highlighted successes and limits of the "package 20-20-20". The main goals of the framework in 2030 are: to reduce greenhouse gas emissions by 40% compared to 1990 levels, to increase the share of renewable energy to at least 27% of overall energy consumption, to achieve at least 27% energy savings compared with the business-as-usual scenario. The European Union has begun to discuss the scenarios and goals for long term horizons, beyond 2020: in the study called "Energy Roadmap 2050" [4], it provides a reduction of greenhouse gas emissions by 80–95% in 2050 compared to 1990 levels.

Italy has fully complied with the "Climate and Energy Package" for the objectives expected by 2020. As regards the reduction of greenhouse gas emissions, the Italian commitment is based on the emissions reduction by 18% overall, 21% for the ETS sectors (*Emissions Trading System*, in particular the generation of electricity) and 13% in the sectors not covered by the ETS, compared to 2005 [5]. The Italian National Energy Strategy (SEN, 2013) [6], approved by the inter-ministerial Decree 8 March 2013, sets more ambitious targets in 2020 compared to those of the "Climate and Energy Package" of the European Commission. The objective of the SEN is to primarily direct the efforts of the country towards a substantial improvement in the competitiveness of the national energy system along with the pursuit of environmental sustainability. Four main objectives

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Nomenclature

Symbols

A	Area [m^2]
COP	Coefficient of performance [–]
f	Factor [–]
g	Total solar energy transmittance [–]
m	Mass [kg]
P	Power [W]
Q	Energy [Wh]
RA	Mean annual refurbished housing stock floor area [m^2]
U	Thermal transmittance [$W\,m^{-2}\,K^{-1}$]
V	Volume [m^3]
η	Efficiency [–]

Subscripts

del	Delivered (energy)
dh	District heating
e	Envelope
el	Electricity
em	Heat emission (subsystem)
f	Floor
g, gn	Heat generation (subsystem)
gas	Natural gas
gl	Glass
H	Space heating
n	Normal
nd	Need (energy)
nren	Non-renewable (energy)
op	Opaque (wall)
P	Primary (energy)
PV	Photovoltaic (system)
rc	Heat recovery
rg	Heat control (subsystem)
sh	Shading
v	Ventilation
W	Domestic hot water
w	Windows

Abbreviations and acronyms

AB	Apartment block
DH	District heating
DHW	Domestic hot water
EC	European Commission
EHP	Electric heat pump
EL	Electricity
ENEA	National Agency for New Technologies, Energy and Sustainable Economic Development
EPBD	Energy performance buildings directive
EPC	Energy performance certificate
EPISCOPE	Energy performance indicator tracking schemes for the continuous optimisation of refurbishment processes in European housing stocks
ETS	Emission Trading System
EU	European Union
GAS	Natural gas
GB	Gas boiler
GCB	Gas condensing boiler
GL	Global refurbishment
GSB	Gas standard boiler
HG	Heat generator replacement
IEE	Intelligent Energy Europe
MFH	Multi-family house
nZEB	Nearly zero-energy building
OP.H	Upper floor insulation
OP.V	Walls insulation
PAEE	Action plan for the energy efficiency
RBS	Residential building stock
SEN	National Energy Strategy
SFH	Single-family house
STREPIN	Strategy for energy refurbishment of the national building stock
TABULA	Typology approach for building stock energy assessment
TR	Windows replacement
TS	Thermal solar system

are foreseen in 2020: (a) to reduce the energy costs by aligning the prices to European levels, (b) to exceed the targets set by the "package 20-20-20", (c) to increase the security of energy supply, and (d) to boost growth and jobs through new investments, both in traditional sectors and in the green and white economy.

The Italian National Energy Strategy (SEN) reports a study from the "National Agency for New Technologies, Energy and Sustainable Economic Development" (ENEA) [7], which explores the conditions for reducing the greenhouse gas emissions at national level. ENEA has investigated two main scenarios, a *reference scenario* and a *roadmap scenario*, by focusing on the carbon dioxide as the main greenhouse gas. The *reference scenario* projects the evolution of the national energy system starting from the existing legislation and the actual trends in demography, technology and economy. It describes a neutral development without new policies beyond those already implemented, although considering the European objectives for 2020. This scenario shows how, due to the recent economic crisis and the policies in force, it is actually possible to achieve and exceed the target of 18% of emissions reduction in 2020 compared to 2005, as indicated by the Decision No. 406/2009/EC [5]. Then the trend of CO_2 emissions decrease will continue until 2030, with a stabilization in the long run. However, such an outcome is not sufficient to ensure the decarbonisation of the "Energy Roadmap 2050" [4]. The *roadmap scenario* starts from the current trends in demography, technology and economy, and highlights the different options and paths to achieve a decarbonised Italian energy system. The scenario assumes a path of CO_2 emissions reduction of 80% compared to 1990 in 2050, and milestones of CO_2 emissions reduction of 40% and 60% in 2030 and 2040, respectively.

The Italian National Energy Strategy (SEN) places the energy efficiency among the priorities in the action. At this regard, the Italian "Action Plan for the Energy Efficiency" (PAEE, 2014) [8] identifies the building sector as a key element for achieving the objectives set by the country in 2020. The PAEE, among other things, establishes: (1) the strengthening of minimum energy performance requirements for new buildings and for the refurbishment of existing buildings, leading progressively to the increase of nearly zero-energy buildings (nZEBs), in line with the Directive 2010/31/EU (*EPBD recast*) [9]; (2) the consolidation of the tax deduction system for the energy refurbishment of the existing buildings.

An effective way to reduce the CO_2 emissions by means of the decrease of the energy consumption is the energy refurbishment of the existing building stocks, which present a high potential for energy savings in the European countries. Several research works deal with this topic, presenting the impact of different energy conservation measures carried out on building stocks on the reduction of greenhouse gas emissions, as for instance in Spain [10], Greece

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