Italian local codes for energy efficiency of buildings: Theoretical definition and experimental application to a residential case study

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Abbreviations and acronyms:
EE, energy efficiency
IPCC, International Panel Climate Change
EPBD, directive on energy performance of buildings
BERC, building energy regulation code
LR, Lombardia region
EMS, European Member States
GHG, green house gas
EC, European Commission
EPH, primary energy consumption for heating
EMS, European Member States

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1. Introduction

Energy efficiency (EE) in buildings is an important objective of energy policy and strategy in Europe. National and international bodies recognize the threat from human-induced climate change as a major concern [1–3]. The IPCC's Fourth Assessment Report [4] confirms that "warming of the climate system is unequivocal", with the primary concern being that greenhouse gas emissions from human activity have risen "by 70% between 1970 and 2004".

According to the European Energy Efficiency Plan (2011) [5], buildings are one of the greatest potentials for energy saving and moreover the implementation of adequately energy policies in construction sector could promote: drastic reductions of energy consumption and the common use of renewable sources as stated in a series of researches on the topic [6–8].

At European level, legislation has been already set out a cross sectional framework of ambitious targets for achieving high-energy performance in buildings. Key parts of this European regulatory framework are the Energy Performance of Buildings Directive 2002/91/EC (EPBD) [9] and its recast [10]. There is significant potential for reducing consumption in building sector with cost-effective measures [11], and in this scenario, the energy efficiency is clearly the "first fuel" in the delivery of energy services in the coming low-carbon energy future. The majority of the energy consumption of building sector could be simply avoided by providing mandatory energy standards, which are an effective means to reduce greenhouse gas emissions and slow down depletion of non-renewable energy resources. Higher stan-dards for buildings have the highest potential to lower the related primary energy consumption and greenhouse gas emissions [12]. With reference to the mitigation of carbon dioxide emission from buildings, at the global scale, Levin et al. [13] highlight there is a risk, with no strict regulation, that carbon dioxide emissions will nearly double. Lee and Yik [14] present the importance of such norms and regulations promoting energy efficiency in buildings on a voluntary basis. Beerepoot and Beerepoot [15] conduct an analysis evaluating the necessity, as a next step of improvement on government regulation on energy efficiency, of promoting innovation in building technology. Summarizing, EE is increasingly recognized as a tool to decouple economic growth from the increase in energy consumption and thus to reduce greenhouse gas (GHG) emissions by cutting the amount of energy required to accomplish a particular amount of genuine energy service and moreover EE improvement is by nature a decentralized activity; so "municipal authorities" (term used interchangeably with municipalities, local authorities, and local governments) have an essential role to play in ensuring appropriate conditions and applying measures for EE improvements. In this scenario, municipalities must become leading actors for implementing sustainable energy policies throughout building energy regulations code (BERC) providing mandatory rules in term of energy efficiency in buildings couplet with subsidize measures. Moreover, BERCs are proving to be an excellent key to describe the evolution towards sustainable construction and valuable tools to sustain building innovation practices.

1.1. Aim and research setting

The paper aims to investigate current state of the art of EE policies and EE improvements for building sectors in Italy starting from European level, passing thorough Italian scale to a local municipality level. In recent years, extensive literature has been devoted to the subject of the energy policies to implement the EPBD into the EMS [16–19], but regarding the Italian implementation, no consistent literature has been produced: only few researches [20–47] have already described examples of BERC in Italy. The main two questions addressed in this paper are:

(1) How the municipality can design local building energy regulation code; which are the concrete measures to encourage energy efficiency?
(2) Does the BERC have impact on designing and diffuse building practices towards nZEB?

In order to reply to the first question the building energy regulation code of 9 municipalities of Lombardia region (LR) was analyzed. The study carried out an analysis on a sample of BERCs in nine Italian municipalities of LR to highlight the geographical distribution of these local regulations and their potentialities to drive the market and sustain the improvement of EE practices in the construction sector. The second question is argued considering a case study building as example of building energy regulation code application towards nZEB. This paper is structured as follows: Section 2 presents a EE policies framework at European and Italian scale, providing also a Geocluster Italian distribution of BERCs in order to show an overview on their application and their influences on the sector; Section 3 focuses on LR highlighting the policies in force for EE building sectors and the energy consumptions for the existing building stock; Section 4 describes the methodology fol-lowed for the definition of BERCs in nine municipalities in LR with a practical application of the BERC of Selvino (Bergamo, Italy) to a residential case study and Section 5 provides conclusions and policy implications, and offers some directions for future research.

2. EE policies framework at European level: An overview

At European level a significant number of directives and laws related to energy efficiency have emerged in EU, among these the main policy driver related to the energy use in buildings is the Energy Performance of Buildings Directive (EPBD, 2002/91/EC), implemented in 2002 and updated in 2010 (EPBD recast, 2010/31/EU) with more ambitious provisions. The main two mechanism identified to articulate the participation of energy assessment in the building sector are energy regulation (e.g. building codes) and energy certification [22]. Under the EPBD the energy certification of build-ings become compulsory in Member State and thus has a vital role in energy saving [23]. The use of mandatory codes for controlling energy use in buildings emerged in the mid-70s [24]. It is by far the most widely adopted means to enhance building energy effi-ciency, and a large number of countries and regions in Europe has adopted it. Increasing the energy performance of buildings is the key to secure the transition to a low-carbon economy and to achieve the EU Climate and Energy objectives, specifically a 20% reduction in GHG emissions by 2020, 20% energy savings by 2020, and a 20%renewable energy share in the EU gross final consumption. The European policy framework for buildings has been evolving since the early 1990s, but it did not truly gain momentum until the Directive on the Energy Performance of Buildings (EPBD). Particularly, several studies have looked into its implementation in different European countries showing characteristics and potential in increasing the energy efficiency e.g. the study performed by Dascalacki et al. [25] in Greece, by Tronkin and Fabbri [26] in Italy, by Ekins and Lees [27] in UK or Araùjo et al. [28] in Portugal. As stated by Andaloro et al. [32], the EMS adopted the Directive at various times and with differences between EMS, so that the situation became quite fragmented even if there is a common frame [33]. An analysis of current barriers and instruments for the improvement of energy efficiency in European buildings also shows significant differences in terms of commitment, financial potential and market conditions [34]. The commitment of each EMS should be supported not only by some isolated policy instruments, but also by a wider holistic regulatory and policy framework, which composes energy efficiency governance [36] and the support of local governments in order to have a more direct control to reach the overarching goal. Since all policy instruments have limitations and only help overcome some barriers, they are most effective if combined into policy packages designed for the respective location, economy and culture [37]. A comprehensive status of the EPBD implementation in the different EMS is reported in Table 1 in order to clearly outline the actual status.

The EPBD recast has established several new or strengthened requirements such as the new buildings should be nearly zero-energy by the end of 2020 for private building and by 2018 for public building. The Directive aims at improving the energy efficiency performance of both new and existing buildings with resulting savings estimated to be equivalent to 60–70 Mtoe/year in 2020. To reach this target, Member States shall draw up national plans for increasing the number of NZEBs. According to the report published by Buildings Performance Institute Europe (BPIE) ("Principles for

Table 1
Status of the EPBD implementation in the EMS [32].

	Energy efficiency rating	Obligation to certify
AT	7 Classes from A to G. A class is divided in A+ and A++	Since 01/01/2008 for new buildings; since 01/01/2009 for existing buildings for sale or rent.
BE	Capital region: from A to G. A, B, C, D, and E are subdivided in sub-classes (totally 15)	Capital region: July 2008 for private buildings, July 2010 for office and sport building, July 2011 for Buildings of parliament, judicial courts and administrative courts Schools and for Culture and entertainment.
	Walloon region: from A++ to G	Walloon region: September 2009 for new buildings (dwellings, offices and schools); January 2010 will be mandatory for existing residential buildings for selling and at a later date for renting; 2010 for existing non-residential buildings and for public buildings.
	Flemish region: continuous scale with benchmarks to new buildings and colors expressing the quality of the energy performance	Flemish region: since January 2006 for new buildings; since autumn 2008 for residential buildings for sale or rent.
BG	7 Classes from A to G	All buildings in operation with a floor area above 1000 m^2 are subject to obligatory certification.
CY	7 Classes from A to G	January 2010 for residential buildings, September 2010 for non-residential buildings, it became mandatory that every new building or building unit and every existing building above 1000 m^2 that undergoes major renovation must have an EPC in order to get a building permit before construction starts. As part of the minimum requirements, the buildings that apply for a building permit have to be at least class B.
CZ	7 Classes from A to G	January 2009 for new buildings (larger than 50 m^2) and existing renovated buildings (larger than 1000 m^2). For multifamily apartment building is mandatory for each apartment. Public buildings (larger than 1000 m^2, in the case of a new construction or a major renovation of a public building) must display the certificate in a prominent place clearly visible to the public before the 01/01/2008. Other buildings, when rented or sold, will be provided with the energy performance certificate only if they are new or renovated after 1 January 2008.
DK	7 Classes from A to G	The energy certification is required for the buildings when they are new constructed or undergo a major renovation; when they are sold if rented out. As of February 2011, all public buildings with more than 250 m^2 of useful floor area are required to have a valid EPC, even if the owner/tenant has not changed. Since July 2012, this affects all buildings owned or used by the public.
EE	7 Classes from A to G	For public buildings, and when the buildings are rented or sold from 01/01/2009.
FI	7 Classes from A to G	Since 01/01/2008 for all new buildings; since 01/01/2009 for existing buildings when rented or sold.
FR	7 Classes from A to G	Since 01/11/2006, when dwellings or buildings (residential or non-residential) are sold in except for overseas areas; since 01/07/2007, when dwellings or buildings (only residential) are rented, for all new buildings with a building permit required after the 01/07/2007; since 02/01/2008 the certificates have to be displayed in public buildings over 1000 m^2.
DE	Labelling base on chart from green (very efficient) to red (very inefficient)	Since 2002 for all new buildings and in case of major refurbishments; since 01/2009 for all residential buildings; since 07/2009 for all non-residential buildings; since 07/2008 for the oldest residential buildings (up to build age 1965).
EL	7 Classes from A to G. Sub-classes in A and B (A+, A, A, B+, B, B)	01/01/2009 for new buildings; There is an ongoing debate as to whether the certificate will be obligatory for buildings to be rented or sold.
HU	10 Categories from A+ to I	New buildings January 2009; existing buildings January 2012.
IE	7 Energy classes, from A to G. The classes A, B and C are subdivided in three sub-classes (e.g. A1, A2 and A3), D and E in two (e. g. D1 and D2)	Since 01/2007 for new residential buildings; since 07/2008 for new non-residential buildings; since 01/2009 for existing buildings offered for sale or rent; since 01/2009 the BER "Building Energy Rating" must be displayed in the public service buildings over 1000 m^2
IT	8 Energy classes, ranging from A+ to G	For new buildings started 30 days after the publication of D.lgs. n.311/2006 (01/02/2007); for sale: since 01/07/2007 for buildings above 1000 m^2 useful surface; since 01/07/2008 for buildings below 1000 m^2 (excluding single flats); since 01/07/2009 for all apartments.
LV	7 Classes from A to G	New buildings, renovated or reconstructed for acceptance into operation or selling; part of the building (new, renovated, reconstructed) for selling, if the part has, or is intended to have, individual energy carrier or heat metering; existing buildings that are being sold or rented, if the buyer or tenant is requesting an EPC; existing building parts (with floor area over 50 m^2) that are being sold or rented, if the buyer or tenant is requesting an EPC and if this part of the building has individual energy carrier or heat metering; state or municipality owned existing public buildings with heated floor area over 500 m^2 (after the 9th of July 2015, with heated floor area over 250 m^2); existing buildings, if the owner has decided to obtain energy performance certification.

Table 1 (*continued*)

	Energy efficiency rating	Obligation to certify
LT	9 Energy classes, ranging from A++ to G	Certification requirements for new buildings came into force on the 1st of January 2007. The EP class of new buildings (building units) must be at least C. This requirement is valid for all new buildings for which the set of the design terms (references) was issued after the regulation came into force on the 4th of January 2006. The new EP requirements for new buildings in relation to the recast EPBD (article 6) are in force since the 9th of January 2013.
LU	9 Class (A/I) scale	New buildings; extension and modification of existing buildings; renovation or replacement of the technical installations which influences the energy consumption demands; change of ownership or tenancy.
MT	7 Classes from A to G	02/01/2009 for dwellings; 01/06/2009 for all other buildings.
NL	7 Energy classes: from A to G. A class is dived A++, A+ and A	January 2008 for all flats or houses rented or sold. January 2009 permanent certification for public buildings (RICS, 2008).
PL	No defined classes	Since 01/01/2009 for new buildings, for existing buildings for sale or rental, and for refurbished buildings when the renovation influences the energy consumption.
PT	7 Energy classes (A/G), where A and B are subdivided in A+ and A, and B and B	In the first phase, certification is only required for all new residential and non-residential buildings with a floor area larger than 1000 m^2 and requesting a construction permit after 1 July 2007. The second phase includes all new buildings, regardless of their floor area, when they request a construction permit after 1 July 2008.
RO	7 Classes from A to G	Since 01/01/2007 for new buildings (residential and non-residential) and for existing non-residential buildings when sold or rented. For existing buildings with a total useful floor area over 1000 m^2, the certification is mandatory when major renovation is carried out. Since 01/01/2010 an energy certificate will be compulsory for dwellings and apartments in residential buildings when are sold or rented. Since 01/01/2007 for buildings with a total useful floor area over 1000 m^2 occupied by public authorities and institutions providing public services an energy certificate must be placed in a prominent place clearly visible to the public.
SK	7 Classes from A to G	The energy certification is mandatory for new and major building renovations, for sold and rented buildings (not apartments or parts of buildings), for residential and non-residential buildings.
SL	7 Classes A–G. Classes A and B are further split into two sub-classes each	Since 01/01/2008 for new buildings and public buildings.
ES	7 Classes from A to G	For all new buildings when the application for a building permit was made to the Local Authorities after the 31/10/2007. Buildings or parts of buildings of a public authority, occupying a total useful floor area over 500 m^2 and frequently visited by the public, have currently the obligation to possess the EPC.
SE	6 Classes from 1 to 6	31/12/2008 for public buildings and multifamily houses; 01/01/2009 for new buildings and other buildings when rented or sold.
UK	7 Classes from A to G	In England and Wales. Since 01/01/2008 for new residential buildings; since 06/04/2008 for new commercial buildings; since 01/10/2008 for all other residential buildings for rent; since 06/04/2008 for commercial buildings with a floor area larger than 500 m^2 in case of rental (since 01/10/2008 for all other buildings); since 01/10/2008 for all existing buildings in case of sale (except the commercial buildings with a floor area larger than 500 m^2, for them it is compulsory since 01/04/2008). In Scotland. EPCs need to be displayed in a prominent place in all public buildings greater than 1000 m^2 by 04/01/2009. In Northen Ireland. All newly completed buildings required EPCs from 30/09/2008 (all rentals and sales of non-domestic properties by 30/12/2008).

nZEB", 2012 [35]) and the report of the EU Commission [concerned actions], only nine EMS (BE, DK, CY, LT, IE, NL, SE and UK) had reported their NZEB national plans to the Commision. As regards the practical definition of NZEBs [36,37], only five EMS (BE, CY, DK, IE and LT) presented a definition (differ from country to country) that contains both a numerical target and a share of renewable energy sources. Moreover according to Art. 10 of the EPBD recast the EMS must implement a range of economic incentives mainly for building retrofitting: fiscal incentives (tax credit, VAT exemption, etc.), finan-cial incentives (such as investment subsidies or soft loans) and market instruments (e.g. white certificates). Some EMS have developed a package of financial incentive measures has been set (subsidy, reduced VAT and soft loans) to increase the stock of dwellings equipped with solar thermal systems photovoltaic or heat pump technology for new or renovated building. These include third party financing, support to investments based on the level of insulation, or very long term financing schemes. The economic incentives are the key driver for implementing energy efficiency measures through building energy codes and need to be implemented seriously by the EMS. Table 2 is based on information contained in the national plans for NZEBS submitted by eight Member State. According to Article 2 (2) of the EPBD ab NZEB "meansabuildingthathasaveryhigh energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sourced produced on-site".The EPBD set the framework, the final detail application in practice of that definition (what is "very high energy performance")isthe responsibility of the EMS. In this respect the table xx shows a comprehensive analysis of the NZEB implementation by the EMS (Table 2).

The review of available national nZEB definitions shows remarkably high variation in nZEB primary energy values being between 20 and 200 kW h/m^2/y in ten countries. The high variation applied even within the same building type in countries with similar climate. It is partly due to different energy uses included and partly due to different level of ambition in the definitions. It can be concluded that Member States need more guidance in

Table 2
Status of the implementation of the Art. 9 of the EPBD recast in the EMS.

Country	Description of the application in practice Art. 9 (3a)	Numerical indicator for energy demand Art. 9 (3a)	Share of renewable energy sources Art. 9 (3c)
AT	OIB Guidelines.	–	–
BE	Capital region: Brussels air, climate and energy code uses the definition given by the EPBD recast.	Capital region. Residential buildings: 45 kW h/m^{2}yr including heating, hot water and appliances. - Offices, services and educational units: 95–2.5 *C* kW h/m^2/yr with *C* defined as the compactness, ratio between the volume enclosed and the area (including heating, cooling, hot water lighting and appliances).	Capital region. The calculation method of primary energy includes the input of renewable energy sources.
		- -	Wallon region. In addition to the energy performance level of the building envelope, part of the residual consumption ofheat/cold and electricity may be covered by sources of production of renewable energies, with the wholecharacterising all NZEB.
	Walloon region: Regional policy statement. A NZEB is characterised by the energy performance close to the passive house standards.		
	Flemish region: Flemish Action Plan NZEB.		Flemish region. For singular residential buildings are 6 options foreseen: Thermal solar energy systems, photovoltaic solar energy systems, biomass (boiler, stove or qualitative CHP), heat pumps, connection with district heating or cooling, participation in a RE project.
		Walloon region. Residential and non-residential buildings: 60 kW h/m^2/yr by 2014. The value includes energy for heating, hot water and appliances.	
		Flemish region. Residential: 30 kW h/m^2/yr. - Non-residential buildings: 40 kW h/m^2/yr.	
BG	National Plan for Nearly zero-energy buildings.	Primary energy consumption conforming with class A on the national scale. Under the current requirements, class A energy consumption is less than ½ of class B, with the latter regulating the mandatory requirement for making new buildings operational.	Group A – At least 50% of the energy needed for heating, hot water, ventilation and cooling is from renewables. Group B – At least 30% of the energy needed for heating, hot water, ventilation and cooling is from renewables. The share of the electricity in the building's annual primary energy consumption balance is no more than 30%. Group C – At least 20% of the energy needed for heating, hot water, ventilation and cooling is from renewables. The share of the electricity in the building's annual primary energy consumption balance is no more than 30%.
CY	NZEB Action plans.	Residential buildings: 180 kW h/m^2/yr Non-residential building: 210 kW h/m^2/yr (including heating, cooling, hot water and lighting)	25% of the primary energy.
CZ	Act n. 406/2000.	Required average U-value of envelope (having coefficient of 0.7 for NZEB instead of 0.8 for cost-optimal level when comparing to a reference building).	Required non-renewable primary energy (deducting 10–25% from reference values depending on type of building for NZEB compared to 8–10% for cost-optimal one).
DK	Building Regulation 2010 – BR10. Requirements on NZEBs are contained in the building regulations as progressive performance classes; "class 2015" and "class 2020".	Residential buildings: 20 kW h/m^2/yr (including heating, cooling, ventilation hot water) Non-residential buildings: 25 kW h/m^2/yr (including heating, cooling, ventilation hot water and lighting)	Between 44% and 51% in 2015 Between 51% and 56% in 2020
EE	VV no. 68:2012.	Residential buildings.-Small residential building: 50 –Apartment buildings: 100, Non-residential buildings.–Office: 100, Hotel-restaurant: 130, Public buildings: 120, Shopping malls: 130, Schools: 90, Day care centers: 100, Hospitals: 270. The values are in kW h/m^{2}yr and includes energy for heating, cooling, ventilation, hot water and lighting.	–
FI	National Building Code of Finland. No official definition of a nZEB.	In 2015, it is the intention of the Ministry of the Environment to issue the technical descriptions regarding nearly zero-energy construction as recommendations.	–
FR	Réglementation Thermique 2012 (RT2012).	Residential buildings including heating, cooling, ventilation hot water and auxiliary systems): 50 kW h/m^2/yr.	Production of domestic hot water using solar thermal panels.- Connecting to a district heat with more than 50% of energy produced by renewable energy or recovered energy.- Demonstrate that the contribution of renewable energy is greater than or equal to 5 kW h/m^2/yr.
		Offices without a/c: 70, with a/c:110 . Retrofit: 80.	

Table 2 (*continued*)

Country	Description of the application in practice Art. 9 (3a)	Numerical indicator for energy demand Art. 9 (3a)	Share of renewable energy sources Art. 9 (3c)
DE	Federal Government Acts.	New buildings: KfW Efficiency House 40, 55 and 70.- Refurbishments: KfW Efficiency House 55, 70, 85, 100 and 115. The numbers indicate the amount of annual primary energy consumption (QP) in relation (%) to a comparable new building (reference building) according to the requirements of the Energy Saving Ordinance 2009.	Renewable Energies Heat Act sets requirements for a quota of renewable energies to use in new buildings for the purpose of heating and cooling. The annex to the Law gives values depending on the type of renewable energies. The law is foreseen for an amendment, so no detailed information for the future application is possible.
EL	No official definition of a nZEB.	–	–
HU	7/2006 (V. 24.) TNM degree.	Dwelling: from 50 to 75 kW h/m^2/yr depending on the numbers of the floors. - Office: 102 kW h/m^2/yr for one floor and 85 kW h/m^2/yr for more than one floor. - Educational buildings: 60 kW h/m^2/yr for one floor and 50 kW h/m^2/yr for more than one floor.	At least 25% of renewable energy.
IE	The definition is set with a numerical indicator for primary energy use and a building energy rating (BER).	Residential buildings: 45 kW h/m^2/yr (including heating, ventilation, hot water and lighting).	A reasonable proportion of energy will be harnessed from renewable energy sources on site or nearby.
IT	DL. 63/2013. No official definition of a nZEB.	–	Energy for heating, cooling and hot water:- 35% since 1/1/2014 from 31/12/2016.-50% since 1/1/2017.Power from renewable depending on the dimension of the roof area projected to the ground.
LT	Construction Technical Regulation STR 2.01.09:2012 'Energy Performance of Buildings.	The nearly zero-energy buildings are those that comply with the requirements of this Construction Technical Regulation for buildings of class A++ energy performance. Energy performance indicator "C" < 0,25.	Amount, share or type of renewable energy resources is not further specified in the national report.
LV	Cabinet regulation no. 383.	Residential and non-residential buildings: 95 kW h/m^2/yr (including heating, cooling, ventilation, hot water and lighting).	At least 75% of ventilation heat recovery during the heating period,- at least partial use of renewable energy.
LU	RGD 2007 and the RGD 2010.	A+ - A+ being the nZEB-standard.	-
MT	LN 376/2012.No official definition of a nZEB.	A 'nearly zero-energy building' is a building with an energy performance not exceeding 40 kW h/m^2/yr for dwellings and 60 kW h/m^2/yr for all other buildings.	15-25% of the energy demand.
NL	EPG 2012.	Energy Performance Coefficient (EPC)=0.	Not quantified but necessary.
PL	No definition in place yet for nZEB.	–	–
PT	Decreee-Law 118/2013. No definition in place yet for nZEB.	–	–
RO	No definition in place yet for nZEB.	–	–
SK	Act No. 300/2012. No definition in place yet for nZEB.	–	–
SL	Energy Act no. 300/2012.	Apartment buildings: 32, Family house: 54, Offices: 60, Schools: 34 kW h/m^2/yr.	At least 25% of the primary energy must be covered by RE.
ES	No definition in place yet for nZEB.	–	–
SE	Building regulations BBR 2012. The requirements on nZEB are, at present, equal to the requirements in the current building regulations.	The requirements for specific (final) energy use for dwellings are between 55 and 130 kW h/m^2/yr (55–120 kW h/m^2/yr for non-residential buildings).	62% of the total end energy at 2020.
UK	Building Regulations Energy Efficiency Requirements: England (Part L); Wales (Part L); Scotland (Section 6); Northern Ireland (Technical Booklet F). No definition in place yet for nZEB.	–	–

order to set consistent and comparable nZEB values with equal ambition levels. For some reason, the European cost optimal methodology seems not utilized in all countries when defining nZEB it could be speculated that existing energy calculation frames and methodologies are too different to enable easy implementation of those calculation principles.

2.1. EE policies for buildings in Italy: State of the art and EPBD implementation

The implementation of the EPBD in Italy is a shared task between the State, the Regions and the Autonomous Provinces. The Energy Performance Building Regulation in Italy is applied in three levels: National Level: Monitoring of the energy policy, Regional Level: Technical guidelines, rules and general inspections, Local level (province, municipality): Inspections. Implementation started in 2005, with the national transposition Decree no. 192/ 2005 [38], then there was an integration with Decree no. 311/2006 [39] and finally with Decree n. 59/2009 [40], which indicates Technical Specifications UNI/TS 11300 Part 1 to 4 [41,42] as the reference for the energy certification of buildings, in acknowledgment of the European Standard EN ISO 13790 [43] for the envelope and EN 15316 [44] for the heating system. The most significant advancement in the new national regulations was adopted in July 2009, when a new ministerial decree with the National Guidelines on Energy Certification on Buildings [45] entered into force. The National Guidelines specify the procedures, the performance classes and the basic elements for certification, which have legal value in all the Italian regions that have not yet produced their own legislation or until new regional laws come into force. The path of the Italian EPBD implementation is summarized in Fig. 1 with the indication of the milestones for each regulation and the points that are still missing.

With the publication in the Gazzetta Ufficiale Dl. 63 of 4 June 2013 “Urgent provisions for the implementation of EU obligations and for the transposition of Directive 2010/31/EU on the energy performance of buildings” enters into force immediately, even pushing Italy towards “Nearly Zero Energy Buildings”. The primary objective of Directive 2010/31/EU and then Dl.63/2013 is the transformation of the buildings in “Nearly Zero Energy Building”

(NZEB), requiring that all member states set minimum energy performance requirements for new and existing buildings, ensure the energy certification and disciplinary controls on the implants. Among the innovations introduced by Dl.63/2013 are also more precise information on the evolution of Certificate in Energy Performance Certificate (APE). The APE must be prepared by qualified professionals and will be mandatory in the case of construction, sale or lease and for all properties of the Public Administration. To arrive to a shared definition of Nearly Zero Energy Buildings, Article 5 of the new Dl.63/2013 states that by the end of 2014 must be prepared the National Action Plan, which is essential for the definition of clear NZEB, for setting intermediate targets for improving the energy performance of new buildings by 2015, for defining policies and financial measures necessary for the transformation of the architectural heritage in NZEB.

From the technical point of view the EPBD is implemented univocally, by the UNI TS 11300. The technical specifications was developed to define the national calculation method for determining energy performance of buildings and is divided into four parts:

(1) Determination of the thermal energy demand of the building in summer and winter;
(2) Determination of the primary energy requirements for winter heating and domestic hot water production;
(3) Determination of primary energy requirements for summer air conditioning;
(4) Use of renewable energies and alternative methods of generation for space heating and domestic hot water preparation.

A simplified reference calculation tool, DOCET, was developed by ENEA (the Italian National Agency for New Technologies, Energy and the Sustainable Economic Development) together with ITC-CNR (Construction Technologies Institute—The Italian National Research Council) as a reference energy performance calculation method for residential buildings. This tool was further developed in 2010 by ITC-CNR into DOCET PRO, software is based on the simplified monthly method. Implementation due to the regional autonomy mentioned earlier, there were a total of ten defined regional systems in 2010, with over two million energy performance certificates (EPCs) issued. When designing their local EPBD implementation, regional governments and autonomous Provinces are allowed to set stricter minimum requirements. The following table shows the state of the art of the EPBD implementation among Regions and Autonomous Provinces. Some region have moreover adopted a public database with all the data related to the certificated buildings as shown in Table 3.

Table 3
Status of the Italian regional EPBD implementation.

Regions and autonomous provinces	Regional EPBD regulation	Regional EPBD recast regulation	EPC issued	On line EPC database
Abruzzo	-	-	1.151	■
Basilicata	-	-	-	-
Bolzano	■	■	6.364	-
Calabria	-	-	334	-
Campania	-	-	4.000	-
Emila Romagna	■	■	260.000	■
Friuli Venezia-Giulia	■	-	12.400	■
Lazio	-	-	29.700	■
Liguria	■	■	66.329	■
Lombardia	■	■	1.380.000	■
Marche	-	-	49031	■
Molise	-	-	-	-
Piemonte	■	-	233.931	■
Puglia	■	-	2.300	-
Sardegna	-	-	2.500	-
Sicilia	■	-	3.181	-
Toscana	■	■	16.000	-
Trento	■	-	1.644	-
Umbria	-	-	3.255	-
Valle d'Aosta	■	■	2.854	■
Veneto	-	-	19.080	■

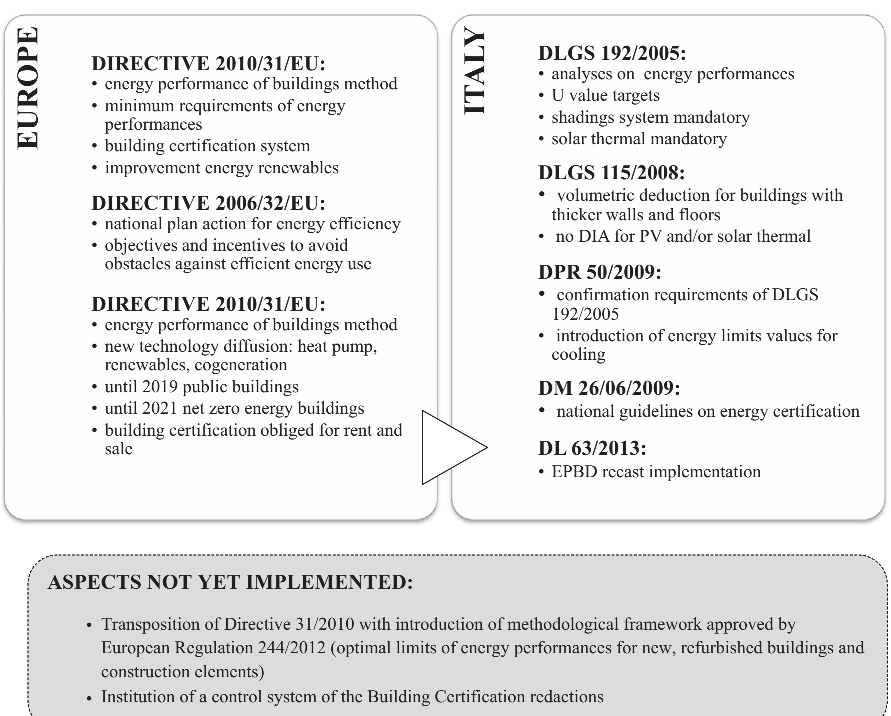

Fig. 1. EPBD structure and its implementation in Italy.

2.2. Geocluster distribution and main energy saving measures of BERCs in Italy

The ONRE Report 2013 [47] counts 1003 BERCs introduced in 2012 in Italian municipalities, which correspond to 12.4% of total Italian municipalities for a total population of over 21 million people. Fig. 2 clearly highlights the fast increase of adopted BERCs in the last years. The chronological subdivision of the analyzed BERCs reflects the introduction of both EU and national legislation and the increasing awareness about environmental issues among administrations, technicians and citizens. A statistical survey of CRESME 2009 [48] reveals that, according to 79% of the interviewed citizen, Municipalities are the main responsible for the regulation of energy efficiency in buildings.

From the geographic point of view, at least one BERC was introduced in every Italian region, with 679 BERCs enforced in the North of Italy – the higher concentration – 247 in the Centre and 77 in the South (Fig. 3). These data reflect the relevance of the instrument also in the areas where cooling consumption is more relevant compared to heating.

Focusing on the energy saving measures introduced with BERCs, the most diffuse are related to the thermal insulation of the envelope, and in particular the *U*-value target to be met in 782 of 1003 BERCs, and the photovoltaic integration in 785 of 1003 BERCs. Strategies related to solar thermal integration for domestic hot water production (in 737 BERCs) and the water conservation for garden and land irrigation (in 571 BERC) are other common items. The parameter that is currently less adopted, and recently introduced only in the latest BERCs, regards the accounting of the actual energy consumption for each single unit (in 267 of 1003 municipalities) and the promotion of the heat pump systems, both for heating and cooling (in 202 BERC). Fig. 4 represents the summary of all the strategies adopted in the existing BERCs.

3. Focus on Lombardia region (LR)

This section presents a state of the art on the EE of the construction sector focusing on LR; in particular, the first section deals the regulation aspects, while the second presents an overview on the existing building stock and its energy consumption.

3.1. EE policies for buildings in LR: State of the art

Lombardy is the first Italian region imposing building energy certification (for new and refurbished buildings) on all of its territory as mandatory, anticipating to 1st January 2008 the minimum energy requirements defined by the national law for January 2010.

This followed the first Italian implementation of an energy rating system for building, which was the "CasaClima/Klima-Haus" scheme developed by the Bolzano Autonomous Province. This certification scheme started in 2001 with the intent of improving the energy performance of the building

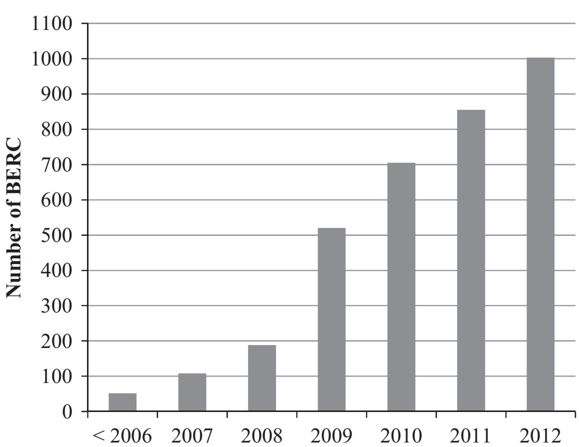

Fig. 2. Increasing number of BERCs adopted in Italy.

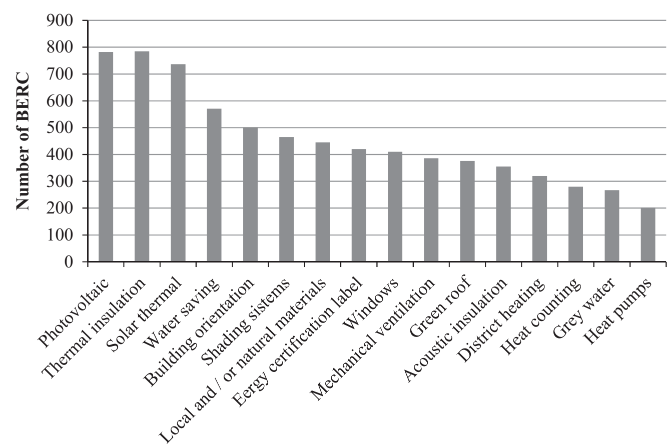

Fig. 4. Summary of strategies adopted by BERCs.

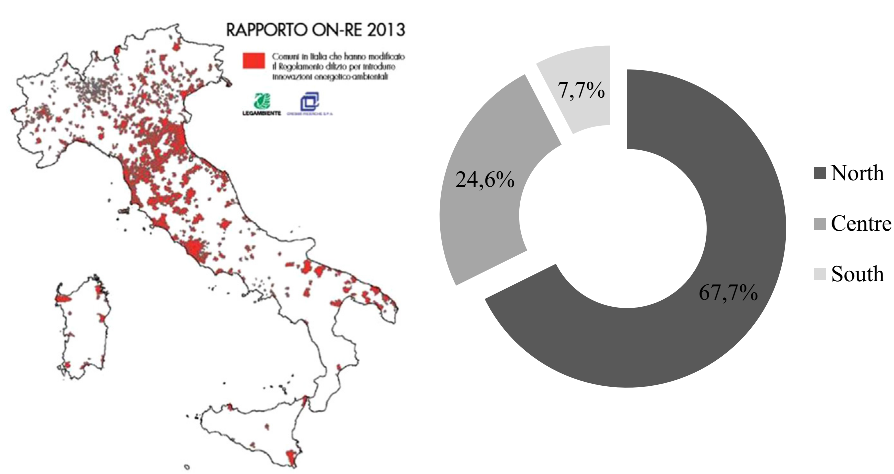

Fig. 3. On the left: Geocluster Italian distribution of BERC adoption according to the ONRE report 2013 [47]. On the right: number of BERCs for the North, Centre and South of Italy.

stock in the area of Bolzano and it led, on the one hand, to the introduction of a building labelling system; on the other, to reduced energy consumption limits for new and refurbished buildings. Moreover, a stringent set of controls on the construction process guarantees clients about the quality of finished buildings.

Lombardy was also the first region to introduce economic incentives in order to promote energy efficiency in buildings: the entire thickness of the building envelope (walls, floors, roofs) does not constitute either volume or surface area, if the heating need calculated is lower than 90% of the statutory limit provided in the DGR VIII/5018 of June 26, 2007. Moreover, an increased limit on the allowable volume can be granted by municipalities for buildings that show a very good energy or environmental performance; the definition of minimum performance levels is left to local authorities, which can use BERCs as a tool to control these incentives.

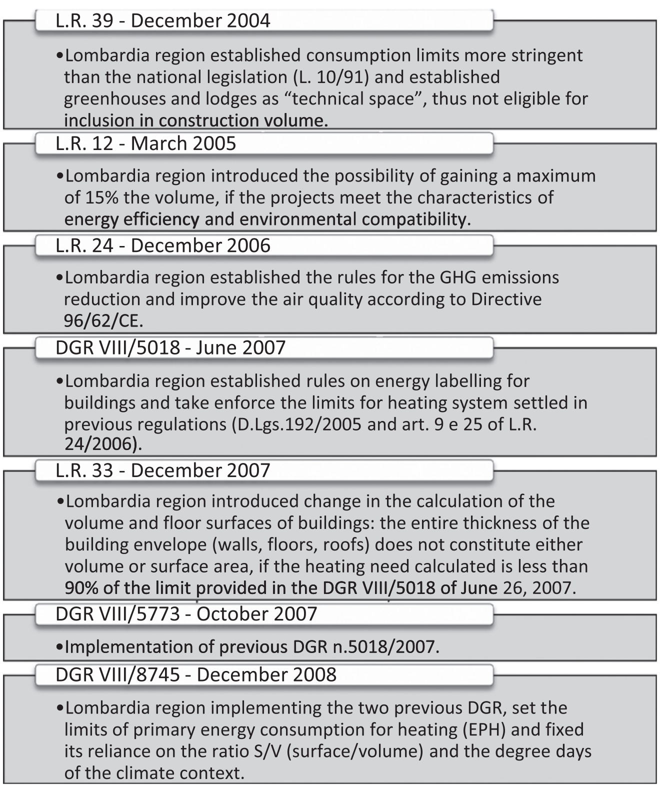

Fig. 5. Scheme of the main Lombardy region regulations for energy efficiency in buildings update in 2008.

Fig. 5 provides a state of the art of the rules enforced in Lombardy for energy efficiency in the building sector.

The authors highlight in this work the important role of the municipalities to apply and promote the energy efficiency regional regulations through BERCs to:

- ensure the correct application of the rules;
- ensure that the constructed buildings respond fully to the project as a first step to guarantee that the delivered performance does not deviate from the expectations (this is a critical issue, as energy efficiency affects the price of the building). This is also a form of protection for users;
- “dose” incentives to allow increases of the allowable building volume only in cases where high performance levels are guaranteed.

3.2. Overview on the existing building stock and its energy consumption

Considering the building consistence in LR, and consequently the energy impact of the construction sector, it emerges that more than 90% of buildings, equal to 1.339.468 units, were built before the first significant Italian energy saving act, no. 10 of 1991 [49] and consequently with very low efficiency and high energy needs. This scenario is also confirmed by data analyses elaborated from the performance building characteristics collected by Finlombarda Spa [50] for energy rating purposes: the average value of primary energy need for heating ($EP_{H\text{-}medium}$) is equal to 202.20 kW h/m^2/y for 941.921.0 buildings registered into the energy efficiency [51] register of the Lombardy region.

The building sector accounts in fact in the Lombardy region to about 41% of the global energy consumption, of which 29% due to the residential sector and 12% to the tertiary sector [52].

Fig. 6 In a typical small town in Northern Italy such as Selvino, near Bergamo, the building sector accounts for around 80% of the local energy consumption of the municipal area (Fig. 7a), 68% of which due to the residential sector. Considering the energy vectors of the residential sector, the chart of Fig. 7b shows that more than 80% of the total energy derives from fossil fuels: natural as accounts for the largest part of the energy needs (42%), followed by gas oil (22%) and biomass (mainly wood) with about 18% of the total. This scenario highlights the impact of the building sector on CO_2 emission and confirms the key role of energy efficiency of buildings to achieve the EU 2020 targets. As recommend by the EU and as shown by the authors, the building energy codes are the main tool to reduce building energy consumption through the control of the design and construction phases.

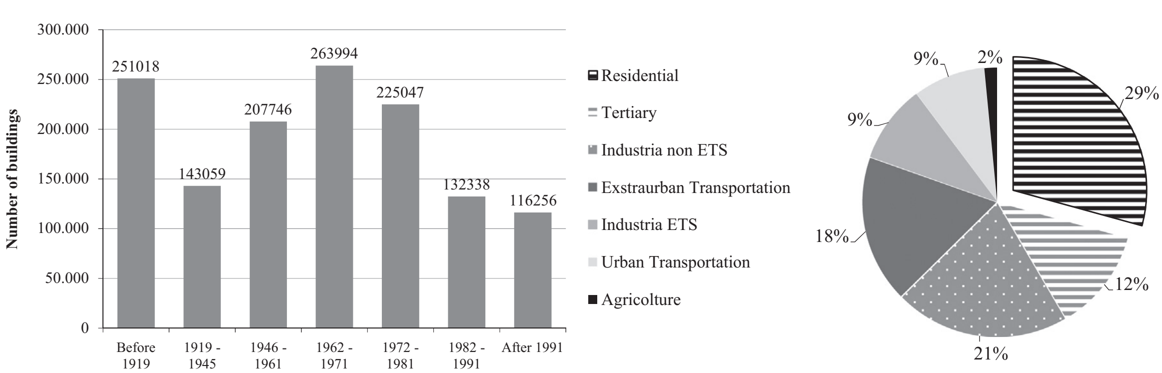

Fig. 6. Residential buildings in the Lombardy region: (a) number of buildings for the different decades; (b) percentage of final energy employed in different sectors.

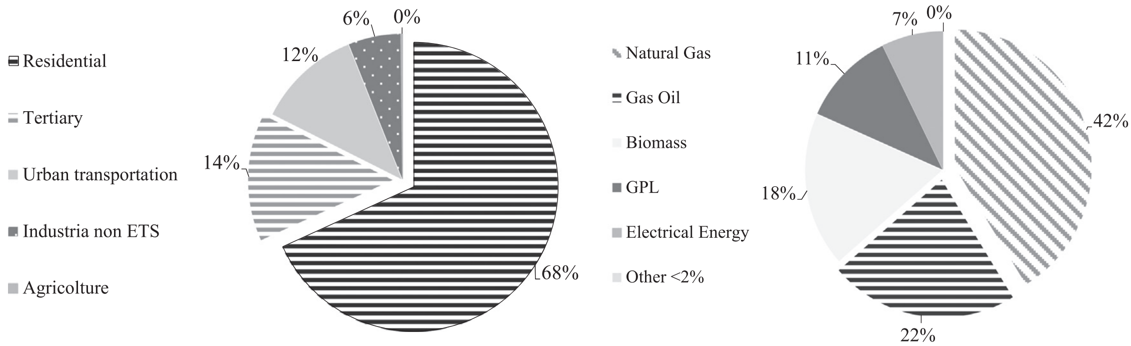

Fig. 7. Left side (a): percentage of the final energy used by the different sectors in a typical small town in Northern Italy. (*Source*: Sirena database [52]). Right side (b): breakdown of the energy flow for the residential sector.

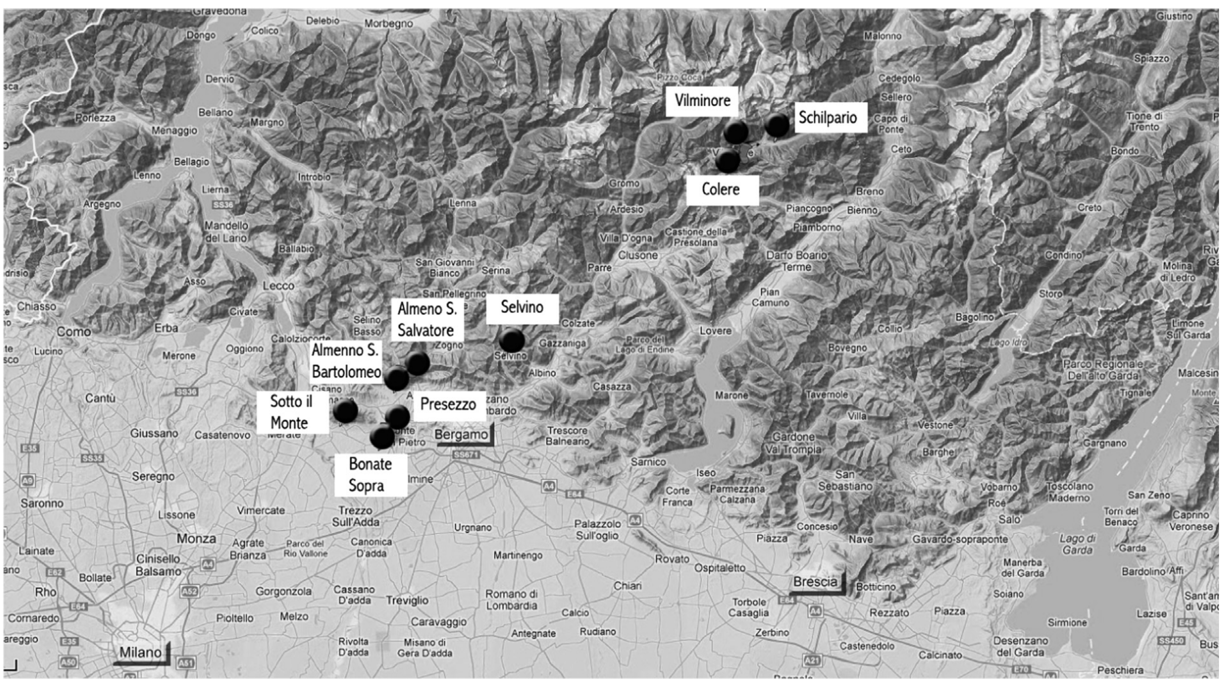

Fig. 8. Map showing the nine municipalities that adopted BERCs developed by Politecnico di Milano.

4. Method, structure and results of BERC definition in nine municipalities of the Lombardy region

In this section the approach and the structure of some BERCs, developed in the framework of a research activity by the ABC Department of Politecnico di Milano for some municipalities of Lombardia region (Fig. 8), are presented. The work involved nine municipalities located in the area between the Po valley and the Alps; in chronological order, the municipalities that implemented a new BERC are: Selvino (Bergamo) in 2005; Colere, Schilpario and Vilminore (municipalities which belong to Valle di Scalve, Bergamo) and Almenno S. Bartolomeo, Almenno S. Salvatore, Sotto il Monte, Bonate Sopra and Presezzo (municipalities which belong to Valle Imagna, Bergamo) in 2007. Most of them are characterized by a population between 500 and 6000 inhabitants, with the peculiarity of Selvino that has normally 2000 inhabitants, becoming 20,000 in summer because of a large number of tourists from the neighbouring larger cities. The BERCs for different towns were developed separately, although in a single line of development, and this article provides a systematic view of the experience looking for indicators of general interest.

The aim of the BERCs designed for these municipalities is to promote energy saving strategies supported by economic feasibility, such as thermal insulation and renewable energy integration. The requirements included in the BERCs are intended to push designers to think of buildings in a holistic way and in general to:

– improve the quality and energy efficiency of buildings;
– assure the correspondence of buildings to the original project;
– improve the current construction practice, pushing the market beyond its actual limits.

The typical BERC structure is articulated into two different types of requirements – mandatory and voluntary – grouped into five families:

(A) impact on the building site,
(B) climate and energy resources,
(C) water saving measures,
(D) air quality,
(E) additional environmental quality.

The first ones are common and valid for all typologies of buildings, while the second are suggested as measures of best practice which contribute to obtaining financial and volumetric space incentives.

Table 4 summarizes the mandatory requirements introduced by the BERCs: most are related to the building envelope, this being, at the time of the BERCs development, the area with the largest margin of improvement in terms of energy efficiency and economic advantage, but other aspects are considered equally important for the overall environmental performance of buildings.

Table 4
Summary of the mandatory requirements of BERCs.

A. Impact on the building site	
1	Conservation of existing vegetation
2	Permeability of the ground
3	Building orientation
4	Right to solar access
5	Shielding of the waste collection areas
B. Climate and energy resources	
1	Energy efficient housing: all buildings that are new or subject to deep refurbishment must be at least in C Class (primary energy demand for heating <86 kW h/m^2 or <26 kW h/m³ per year, respectively for residential and non-residential buildings)
2	Define a clear rule for the construction of the sunspaces and loggias: the reduction of the heating energy demand for heating deriving from the sunspace or the loggia must be greater than 5%.
3	Efficiency of heating systems
4	Accounting systems for individual energy consumption
5	Control of internal air temperature in every room
6	Hot water production by solar energy
7	Mechanical ventilation with heat recovery
8	Reduction of light pollution and use of external light with low power consumption
C. Water saving measures	
1	Accounting systems for individual consumption of water
2	Use of dual-flush water systems
D. Air quality	
1	Control of pollutants by means of suitable indoor air change rates and appropriate choice of materials

Table 5
Summary of the voluntary requirements included in BERCs for the “ECO” label.

A. Additional environmental quality	
1	Timber from certified production (FSC or PEFC certification)
2	Use of renewable energy sources (solar, geothermal, etc.) for at least 25% of winter demand for space heating and domestic hot water
3	Installation of photovoltaic panels for electricity generation: at least 1.5 kWp
4	Rainwater harvesting for irrigation or other uses
5	Green roofs for heat island effect mitigation
6	Accessibility for disabled users
7	Healthy indoor environment (no pollution from VOC etc.)

Table 5 presents the voluntary requirements, derived from best practice examples, that improve the environmental quality of buildings. The implementation of 4 out of 6 requirements permits to obtain the “ECO” label, in addition to the energy classification, defined by the municipalities for those buildings that also meet the energy classes A+, A or B. The combination of these two elements (energy rating and “ECO” label) gives direct access to additional incentives in terms of volume or, where planning restrictions such as minimum distance between buildings, max-imum heights, etc. do not allow, discounts on taxes related to planning permissions. The quantification of these incentives varies from one municipality to the other, being linked also to political decisions about priorities.

One of the most important aspects that were introduced in the BERCs regard the process and in particular the structure of the procedure, the timing and the person in charge for the control over the application of BERC requirements, both during the design and the construction phase. Referring to the regional regulations in force at the time of the development of BERCs (under the DGR VIII/5773 of October 31, 2007), the responsibility for the correctness of calculations and the compliance of the building to the law are responsibility of the certifying body and the site supervisor.

The BERC of Selvino municipality was developed in 2006, under a very uncertain normative framework where no energy rating procedure was defined yet. It was therefore decided, in that specific occasion, to sign an agreement with the CasaClima/Klimahouse Agency of the Province of Bolzano to adopt their the calculation and control procedure. Essentially, the municipality delegated to a third party, no-profit and with proven experience and reliability, the verification of the energy performance of those buildings requiring the volume incentives. The regulations drawn up later, when instead a regional regulatory framework about energy certification was in force, define a strengthening of controls through a closer contact between the energy certifica-tion body and the municipal offices—particularly during the construction phase.

Analysing the data available in the energy land register of Lombardy region the combined effect of both the BERCs and the regional energy legislation, demonstrate the high potential of such tools to push the market towards more efficient practices, bringing a potential reduction of GHG emissions as well. The data of Table 6 shows, for each municipality, the energy performance certifications registered from 2006 to 2012 under the BERC operation, while Fig. 9 highlights the number of energy certifications in relation to the different energy classes. It is important to stress that the upper limit for primary energy consumption, as per the law, stands between classes C and D (depending on heating degree days and shape factor of the building). The table clearly shows a significant improvement over the minimum energy performance in the number of B class buildings.

At Regional level the percentage of the buildings in Class A+, A and B is equal to 6.8% (dot black line in Fig. 9). As shown by

Table 6
Number of building energy certifications, for the classes A+, A, B and C register from September 2006 up to July 2013. The data includes the certifications for rent apartments and real estate market.

Building Energy performance Class	**Case 1 Bonate Sopra**	**Case 2 Selvino**	**Case 3 Almenno S.B.**	**Case 4 Almenno S.S.**	**Case 5 Presezzo**	**Case 6 Sotto il Monte**	**Case 7 Schilpario**	**Case 8 Colere**	**Case 9 Vilminore**
A+	0	0	13	0	0	0	0	0	0
A	13	8	10	4	2	2	4	5	2
B	164	40	51	25	34	47	9	50	12
Total A +, A and B	**177**	**48**	**74**	**29**	**36**	**49**	**13**	**56**	**13**
% Respect to the total	**23.8%**	**5.4%**	**14.4%**	**7.9%**	**8.9%**	**18.1%**	**6.3%**	**42.4%**	**11.6%**
Δ% Respect to the regional value	**17.0%**	**−1.4%**	**7.6%**	**1.1%**	**2.1%**	**11.3%**	**−0.5%**	**35.6%**	**4.8%**

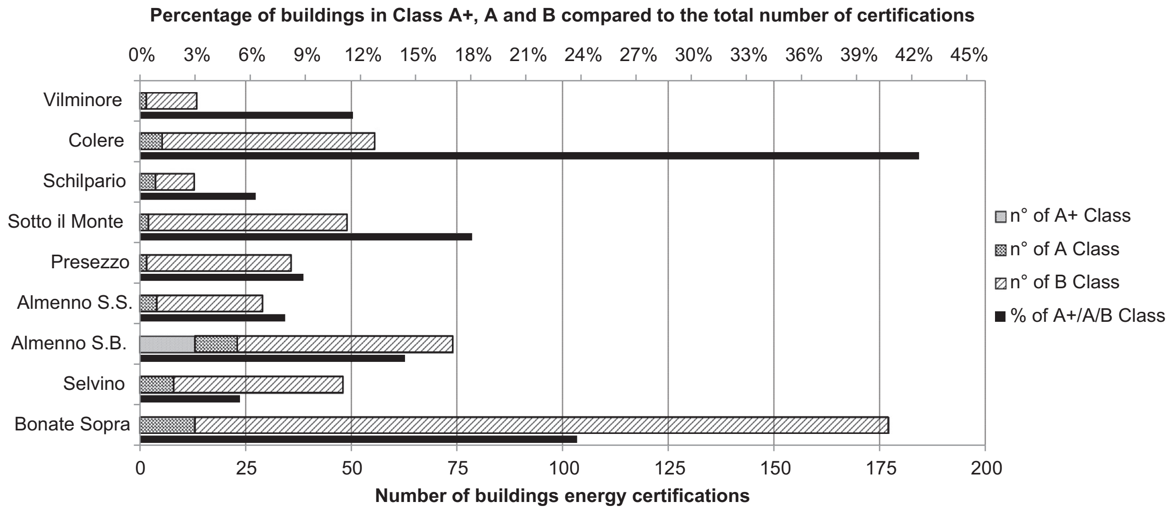

Fig. 9. Chart with the number of energy certificates in the different energy classes and the percentage of the Classes A+, A, B related to the all number of energy certificates. The black dot line represent the regional mean values of building energy certification, Classes A+, A, B, in Lombardy.

Table 6, the percentage of buildings in the three above mentioned classes are for almost all of the analyzed municipality higher than the regional mean value: Only Selvino and Schilpario shows lover values (respectively 5.4% and 6.3%). These revers trend, are due to high number of apartments for rent (Selvino and Schilpario are holyday resorts) that are mainly classified as F or G. (the regional law forced, since July 2010, the owner that rent the apartment to draw up the energy certifications).

Governments implement incentives to encourage investors to consider more and more efficient constructions, with performances higher than what is required by building codes.

New buildings receiving such incentives are the benchmarks for the future minimum energy building requirements (towards higher levels), and will become the future standard. Financial incentives aimed at encouraging investment in energy efficient equipment and processes by reducing the investment cost, either directly (economic incentives) or indirectly (fiscal incentives); the most common one being direct subsidies and fiscal incentives.

Since many barriers hamper energy efficiency in new buildings, there is a strong request for policies, which address energy efficiency in new buildings. Energy efficiency requirements for new buildings effectively reduce energy consumption in buildings. Building codes or standards for energy efficiency regulate on the efficiency of the building envelope, including the structures around heated or cooled parts of the building, but often they also regulate the efficiency of different part of the heating, cooling and ventilation system and maybe even other energy using equipment,. The energy efficiency requirements of the building shell or envelope have historically been the first to be regulated and they are today an essential part of nearly all regulations for energy efficiency in new buildings. The other segments of constructions and installations that influence a building's energy performance 20 can be addressed in the regulation of energy efficiency, but these parts are more rarely included in the requirements.

4.1. A practical application of the Selvino BERC: A residential case study towards nZEB definition

In this section a residential case study in Selvino (Bergamo) is described, as an example of application of BERC requirements to a real project towards ZEB target. The project CasaSelvino [53,54] is a settlement deriving from a holistic design process with a strong integration between architectural, technological and energy issues. The result is a group of low-energy buildings with heating energy demand equal to 26 kW h/m^2/a.

Table 7
Building energy efficiency parametersof the case study.

Building energy efficiency parameters	
Area of building envelope	204 m^2
Ratio surface envelope/volume	1.17 m^2/m^3
U_{value} mean	0.20 W/m^2 K
Transmission heat losses	26.6 kW h/a
Ventilation heat losses	0.23 kW h/a
Internal heat gains	0.28 kW h/a
Solar heat gains	1.60 kW h/a

The aim of the project was to establish morphologically innovative buildings in the framework of the new BERC regulations, showing the potential of their application on building energy conservation. The buildings have very low heating energy needs and they also reach the ECO label thanks to the quality of materials, the use of renewable energy sources and its limited environmental impact. From the architectural point of view, the buildings are characterized by large windows facing south, with a sunspace maximizing solar gains in winter and reducing the heating energy demand of about 5 kWh/m^2/a. The sunspace has an important function in terms of spatial distribution, allowing the extension of the living room to the south-facing garden. The north and east façades are opaque to minimize the transmission losses and improve privacy. The internal distribution optimizes the use of space through a living room-cum-kitchen (20 m^2) that can be extended to the sunspace through sliding windows (4.5 m^2), a bedroom (14 m^2) and a bathroom (4 m^2). Laundry and storage facilities are located in the basement, connected to the rest of the house by external stairs. The sloping roof (Fig. 5), required because of the mountain setting, is designed after the sun path, in order to maximize the solar gains and the generation of energy. It is treated with an extensive green layer on the north surface, in order to increase the thermal insulation and protect the structure from ultraviolet radiation, while on the south surface integrates solar thermal collectors and photovoltaic panels. Table 7 summarizes the energy efficiency features of the buildings.

4.1.1. Building envelope

The main design strategy was to build the houses to very high levels of insulation and to follow very accurately the construction process. This allowed to reduce as much as possible the heat loss due to the envelope transmission and infiltrations. More specifically, the buildings are assembled using prefabricated panels based on a solid wood substructure, wood sheathing, thermal insulation in polystyrene (EPS) and an external concrete layer as finishing. This concrete layer works structurally together with the wood structure thanks to several small connectors. Thanks to this system, it is possible to save time during the installation phase; no additional systems are required for the rigidity of the structure (with consequently less use of building material). The combination of polystyrene (thermally resistive layer) and concrete (thermally capacitive layer) guarantees high levels of thermal insulation and minimizes thermal bridges. This off-site industrialized system guarantees very strict quality levels, limiting operations on site to connections and finishing. Depend-ing on the wall orientation and on its surface, the building envelopes are designed with a minimum of 200 mm EPS insula-tion and additional thin reflective insulation layer when required. The technological solutions reaches an U-value of 0.1 W/m^2 K for the wall and 0.12 for the roof (values are lower than those fixed at the regional level) (Table 8).

4.1.2. Building services strategies

Considering the ambitious targets of the project, characterized by long unused periods (the settlement is planned to be used for vacation and holidays), the heating system was designed with the following elements (Table 9) an electrical radiant heating system placed in the floor, a high-efficiency electric boiler producing domestic hot water, mechanical ventilation with heat recovery (90% efficiency) to reduce ventilation losses and improve the air quality, and solar photovoltaic panels installed on the south-facing roof with an energy peak production of 2.2 kW; this energy will offset most of the electricity required by the other systems. With this strategy it is possible to use directly the electrical energy when users are at home, or sell it to the grid (about 0.40 €/kW h) when it is not needed or there is over-production (mainly in summertime).

Table 8
Thermal characteristic of the building.

Building envelope subsystem	U_{value} target [W/m^2 K] (Lombardy region-regulation)	U_{value} case study [W/m^2 K]	U_{value} reduction [%] (respect to the target)
Wall	0.26	0.10	61%
Roof	0.23	0.12	48%
Basement	0.28	0.20	28%
Windows	1.6	1.40 South orientation, 1.20 west and north orientation	12–25%

Table 9
Energy strategies for the case study.

Energy use	Electric radiant floor heating	Mechanical ventilation with heat recovery	Photovoltaic panels	Electric boiler
Heating	■			
Cooling				
Hot water				■
Ventilation		Efficiency 90%		
Electricity			2.2 kWp	

4.1.3. Step-by-step procedure for BERCs application

Fig. 10 The correct application of BERCs is based on a detailed procedure that must be followed rigorously in order to deliver high-quality buildings that make a significant difference from the current practice. This section summarizes the procedure, presenting its application to the case study in Selvino (Fig. 11) which included the ECO label.

5. Conclusions and outlook for future work

BERCs play a significant role in reducing building energy consumption and diffusing "green construction" practices. The aim of this paper is to describe e and analyse current approaches to encourage energy efficiency in building codes for new buildings. Based on this analysis the paper enumerates policy recommendations for enhancing how energy efficiency is addressed in building codes and other policies for new buildings.

In that respect, the paper describes the method and structure of some BERCs developed by the authors and applied to nine municipalities in the Lombardy region, Italy. These experiences show that: (i) even within an uncertain normative framework, the municipalities have a large potential for guiding the current practices towards buildings with high energy efficiency and limited environmental impact; (ii) the BERC have a positive effect on diffusing low energy practices, (iii) the mandatory measures and the incentives play a key role for building energy saving.

The financial concerns about the investment cost in using energy efficient technologies are a major barrier, while one of the main challenges is to make the public aware of their real use and potential. There still is a general lack of awareness on two fronts:

- amount of energy that users are currently consuming in the building, which makes it difficult for them to understand the benefit of energy efficiency measures [55,56];
- availability of energy efficiency measures and renewable technology opportunities [57,58].

Fig. 10. Views of CasAselvino house.

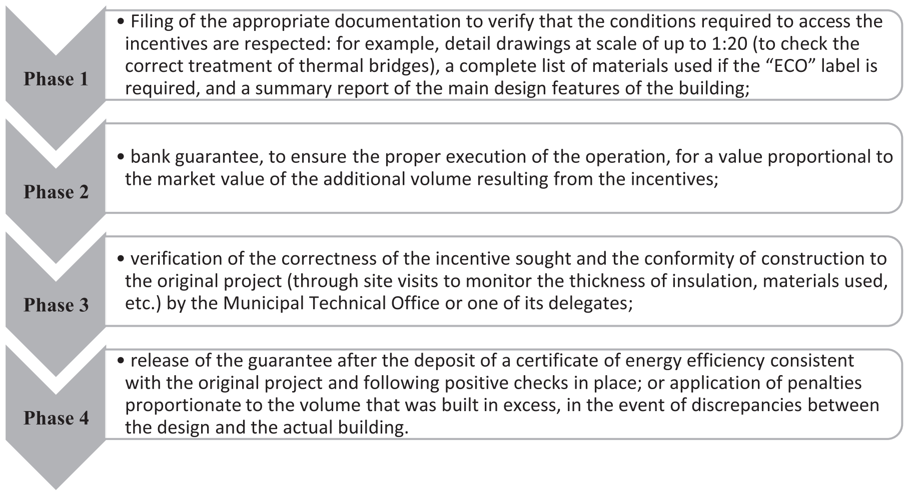

Fig. 11. Scheme of the procedure for the application of BERCs.

The interest generated by the local administrations and by the operators of the construction sector demonstrate that the application of BERC requirements can deliver important energy saving and very good energy labels (e.g. A class for the CasaSelvino settlement presented here as a case study).

In conclusion, the presented work offers practical guidelines for the design of a BERC and it provides general advices for public administrations to guide their work and to be more active in the field of energy and environmental safeguard. The BERC at the municipal lever is a really promising and concrete implementation mechanism for EPBD implementation.

The authors are confident that the contents of the BERCs and the experience acquired up to now will certainly be instrumental to reduce CO_2 emissions through the implementation of more and more similar tools in other municipalities. However, more significant incentives and specific procedures, regarding the energy upgrade of the existing building stock are needed to significantly reduce the energy consumption of the building sector before 2050.

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