CTI report for CRIF

Percentage distribution of primary energy (Ep) values in the Italian national building stock

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CTI & CRIF

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0. Foreword

The European Union (EU) has set itself ambitious climate change targets further to the conclusion in 2015 of landmark international agreements with the adoption of the UN 2030 agenda and sustainable development goals and the Paris climate agreement. The scale of investment needed to meet these targets is estimated at hundreds of billions of euros, a large proportion of which is accounted for by energy efficiency in buildings. Against a background of very low annual rates of renovation of the building stock across Member States, significant emphasis is being placed on the need to boost renovation in order to meet the EU's energy efficiency and climate objectives.

The scale of investment needed to achieve the EU's energy savings targets cannot be met by the public sector alone and therefore the issue of private finance in the context of the transition to a more sustainable economy and future has taken centre stage in recent years. Indeed, it is widely recognised that the EU financial sector will play a central role in the climate transition, with positive knock-on effects for economic growth and job creation. This has led to the development in the EU since 2018 of a comprehensive regulatory and supervisory agenda on Sustainable Finance, which is evolving rapidly and significantly with the objective of ensuring that the EU meets its international environmental commitments and targets.

At the heart of the Sustainable Finance agenda is the EU Taxonomy and its technical screening criteria (TSC) contained in the April 2021 Delegated Act on Sustainable Activities for Climate Change & Mitigation Objectives . These are and will remain the benchmark for much of the regulatory and supervisory landscape in the area of Sustainable Finance and will therefore necessarily be very relevant standards for energy efficient financing, including energy efficient mortgages.

With regard to the latter, the TSC for buildings - focussed on (1) construction of new buildings, (2) renovation of existing buildings and (3) acquisition and ownership of buildings - are fundamental, as they will ultimately determine Taxonomy compliance of the underlying mortgage (or consumer) loans used to finance the acquisition, construction or renovation of buildings, as well as the covered bond or securitisation issued to fund mortgage loans.

For many months, the Energy Efficient Mortgage (EEM) Label , through its Market Committee and Taxonomy Task Force, as well as various Energy Efficient Mortgage Initiative (EEMI) National Hubs, have been analysing the TSC to understand the full extent of their implications for the financing of construction and real estate and how to ensure and evidence compliance. At the time of writing in the summer of 2022, there are currently more questions than answers on exactly how the EU Taxonomy should be interpreted from this perspective and discussions with the European Commission in this respect are ongoing.

A key challenge which emerged in the context of the Italian EEMI national hub was the identification of the top 15% of the existing building stock using Primary Energy Demand (PED) as required by the TSC for the acquisition and ownership of existing buildings. In Italy, a continuous function assigning a specific interval of PED to an EPC class does not exist. Accordingly, it is not possible to identify a threshold at 15% of the distribution when considering only the EPC label. The result is that the introduction of PED in the context of the EPC embeds uncertainty in the Italian market, giving rise to incoherence and rendering communication of these considerations to the market difficult.

This was the starting point for the mandate from the EEMI to the Comitato Termotecnico Italiano (CTI), which brings together leading experts in the standardisation of energy and thermotechnical-related activities, for the present Report. Through the CTI's analysis of the Italian building stock and available EPCs, which takes account of the comparative reliability of aggregated and disaggregated data and draws on expert knowledge, it has been possible to identify a threshold for different building types and climate zones at 15% of the distribution to comply with the 15% best in class requirement of the EU Taxonomy. At the same time, the CTI has also designed a methodology for identifying buildings with a performance 10% better than nearly zero energy (nZEB) buildings. This has delivered a threshold again for different building types and climate zones, albeit outside of the regulatory framework given the current absence of a national PED threshold for these buildings which currently represent less than 0.1% of the entire Italian building stock at the time of writing.

These results are expected to serve as extremely valuable guidance in the Italian market to support banks in: (1) accurately benchmarking the energy efficiency of their existing loan books, (2) originating new EEM and progressively 'greening' their loan books and therefore balance sheets (3) developing EEM covered bonds or securitisation programmes. In fact, at the time of writing, the analysis and resulting thresholds are being used by a number of banks in Italy to link and adjust their bond frameworks to the EU Taxonomy, starting with the 15% best in class criterion. This will help banks in issuing EU Taxonomy-aligned bonds.

As a concrete example of the use of the thresholds when applying the new EU Taxonomy eligibility criteria for buildings to a given bank's mortgage/buildings portfolio:

In 2020, CRIF identified green buildings for the issuance of green bonds and green covered bonds[1]. Buildings with an EPC class better than C were considered eligible, representing the top 15% in terms of the EPC label. Comparing the results using the old eligibility criteria and those of the EU Taxonomy delivers the following results:

Year of construction < 2020	Brown (PED > threshold)	Green (PED < threshold)	Grand Total
Brown (labeled as D, …, G)	95,5% (41,967)	4,5% (1,961)	43,928
Green (label A, B, C)	21% (2,022)	**79% (7,733)**	9,755
Grand Total	43,989	9,694	**53,683**

[1] Using official data from SIAPE - Sistema Informativo sugli Attestati di Prestazione Energetica (enea.it)

The example is focused on buildings constructed before 2020. The 9,755 buildings with an EPC equal to C or better were eligible under the old criteria. However, 2,022 (21%) have a PED higher than the relative threshold compliant with the EU Taxonomy. On the contrary, 1,961 (79%) buildings have a PED lower than the threshold with a label equal to D or less. Based on the new criteria, the green portfolio has 9,694 buildings. 533 building with EPC B and 1,489 with EPC C are no longer classified as 'green', while 1,151 buildings with EPC D, 581 with EPC E, 128 with EPC F, and 101 with EPC G do meet the necessary criteria.

In the spirit of the EEMI, it is also intended that, in turn, this Report and its underlying methodology be shared and adapted across other jurisdictions and EEM national market hubs with a view to supporting the identification of appropriate thresholds in these jurisdictions as necessary and supporting banks in achieving EU Taxonomy compliance.

1. Introduction

This report comes from the need to look in detail at the application of the EU Taxonomy to the Italian context in the specific sector of buildings and related performance.
Reference is made to the legislative framework provided by Regulation (EU) 2020/852 and related Delegated Acts of 4.6.2021 [c(2021) 2800 final] on the establishment of a framework to facilitate sustainable investment in the European Union. In particular, technical screening criteria are established to determine the conditions under which a specific economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and as an activity that does not significantly harm any environmental or social objective.
The criteria for determining the degree of environmental sustainability of an investment in a given economic sector apply to:

a) the measures adopted by Member States or by the Union that set out communication and reporting requirements for financial market participants or issuers of financial products or bonds that are made available as "green" or "environmentally sustainable" financial products;
b) financial market participants that make available financial products;
c) undertakings which are subject to the obligation to publish a non-financial statement or a consolidated non-financial statement[2].

The aim of the Taxonomy is to define a set of rules, indicators and threshold values according to which the financial investment market can be considered to be aligned with the climate change mitigation and adaptation objectives that the EU has set itself.
By verifying the conformity of investments with the criteria defined by the Taxonomy, an economic activity is considered environmentally sustainable and therefore "green" if:

a) it contributes substantially to one or more of the following environmental objectives:
    - climate change mitigation;
    - climate change adaptation;
    - the sustainable use and protection of water and marine resources;
    - the transition to a circular economy;
    - pollution prevention and control; and
    - the protection and restoration of biodiversity and ecosystems.
b) it does not significantly harm any environmental or social objective as set out in the Regulation;
c) it is carried out in accordance with the minimum safeguards, meaning procedures implemented by an undertaking that is carrying out an economic activity to ensure the alignment with the OECD Guidelines for Multinational Enterprises and the UN Guiding Principles on Business and Human Rights, including the principles and rights set out in the eight fundamental conventions identified in the Declaration of the International

[2] These obligations are defined by Directive 2014/95/EU (Non-Financial Reporting Directive - NFRD), which defines the disclosure of non-financial and diversity information by certain large undertakings and groups, and by the future Corporate Sustainability Reporting Directive (CSRD).

Labour Organisation on Fundamental Principles and Rights at Work and the International Bill of Human Rights;

d) it complies with technical screening criteria that have been established by the Commission and reported in the Delegated Acts to Regulation 852 of 4.6.2021.

The technical screening criteria referred to in point d) are the most technical aspect of Regulation 2020/852. These were issued with EU Delegated Regulation 2021/2139 of 4 June 2021, which supplements the regulatory framework of the Taxonomy for both climate change mitigation and adaptation actions. The reference document for this study is Annex I "Mitigation" - C(2021) 2800 final, 4.6.2021 - to the aforementioned Delegate Regulation 2139 which, under point 7 "Construction and real estate activities", sets out the reference thresholds for the construction of new buildings (point 7.1), the renovation of existing buildings (point 7.2) and the acquisition and ownership of buildings (point 7.7).

2. Aims and methods

The **aim** of the project is to analyse the publicly available data on the SIAPE portal operated by ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development)[3] and any data provided on Energy Performance Certificates (EPCs) for residential and non-residential buildings, with particular reference to energy performance indexes in order to identify a methodology for the identification of the threshold values defined by the EU Taxonomy. The same analysis has been performed using data from Trento. In fact, the Autonomous Province of Trento provided an open database with EPCs.

The **purpose** is therefore to develop a proposed methodology for identifying the threshold values provided for in the Delegated Acts of Regulation (EU) 2020/852, in relation to the establishment of a framework to facilitate sustainable investment, regarding the technical screening criteria for the purchase and ownership of buildings contributing to climate change mitigation.

In particular, the project will analyse the requirement relating to the threshold of "**the top 15% of the national or regional building stock expressed as operational Primary Energy Demand (PED)** and demonstrated by adequate evidence, which at least compares the performance of the relevant asset to the performance of the national or regional stock built before 31 December 2020 and at least distinguishes between residential and non-residential buildings" referred to in Delegated Act C(2021) 2800 final, 4.6.2021 - Annex 1.

In addition, the same approach will be used to analyse and examine the requirements of Annex 1 for the construction of new high-performance buildings and, in particular, the following compliance criterion: *"The Primary Energy Demand (PED), defining the energy performance of the building resulting from the construction, is **at least 10 % lower than the threshold set***

[3] The findings published in this report use the latest data available at January 2022

for the nearly zero-energy building (NZEB) *requirements in national measures implementing Directive 2010/31/EU of the European Parliament and of the Council."*

A general overview of some of the secondary indicators used with respect to primary energy (Ep) will also be provided to give a better understanding of the energy performance of buildings.

3. Glossary

This glossary is intended to give a better understanding of the technical terminology contained in this report. For additional terms and definitions, please refer directly to the directives, legislative provisions and technical regulations in the bibliography.

Energy Performance Certificate (EPC) - ***APE*** **in the Figures in Italian:** "a document, drawn up in accordance with the rules contained in this decree and issued by qualified independent experts, which certifies the energy performance of a building through the use of specific descriptors and provides energy efficiency improvement recommendations" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Energy Attribute Certificate[4] (EAC): "a document prepared and certified by a qualified professional, not necessarily unrelated to the property, on the design or construction of the building, in which the calculated primary energy demand, and the category of building or building unit are reported in relation to the energy certification system in force, as well as the corresponding maximum permitted values set by the legislation in force for the specific case or, where there are no limits set, for an identical building of new construction" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Nearly Zero Energy Building (nZEB) - ***Edificio a energia quasi zero*** **in the Figures in Italian:** "a building that has a very high energy performance, calculated in accordance with the provisions of this decree, which meets the requirements defined in the decree in Article 4(1). The nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, produced on-site" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Reference or target building for a building subject to design review, diagnosis, or other energy assessment: "identical building in terms of geometry (shape, volumes, floor area, areas of building elements and components), orientation, location, intended use and surrounding area, and having predetermined thermal

[4] The definition of an Energy Attribute Certificate (EAC) is provided to clarify the distinction with the Energy Performance Certificate (EPC).

characteristics and energy parameters" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Building: "a system comprising the external building structures which enclose a space of a defined volume, the internal structures which divide this volume, and all the technical systems and devices permanently located within it; the external area enclosing a building may be adjacent to all or some of these elements: the external environment, the land, and other buildings; the term may refer to an entire building and its systems or to parts of the building and its systems designed or renovated to be used as separate building units" (source: translated from UNI/TS 11300-1 **[10]**).

Energy from renewable sources: "energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases" (source: Directive 2010/31/EU as transposed in Italian Legislative Decree 192/05, as amended **[3]**).

Primary energy: "energy from renewable and non-renewable sources which has not undergone any conversion or transformation process" (source: Directive 2010/31/EU as transposed in Italian Legislative Decree 192/05, as amended **[3]**).

Building excluding technical systems: "a system consisting of the external building structures forming the building envelope, which enclose a defined volume and the internal structures which divide this volume. The internal technical systems and devices are excluded from this definition" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Heating system: "permanent technical system intended for the winter or summer climate control of rooms, with or without the production of domestic hot water, or intended only for the production of domestic hot water, irrespective of the energy carrier used, including any heat production, distribution, storage and use systems, as well as adjustment and control elements, potentially combined with ventilation systems. Systems dedicated exclusively to the production of domestic hot water for individual residential building units and similar are not considered as heating systems" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Building envelope: "integrated components and elements of a building that separate the interior from the outdoor environment (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Energy performance of a building: "an annual amount of primary energy actually consumed or expected to be required to meet, with standard use of the building, the various energy requirements of the building, heating, cooling, domestic hot water, ventilation and, for the tertiary sector, lighting, lifts and escalators. This quantity is expressed by one or more descriptors which take into account the level of insulation of the building and the technical and installation characteristics of the technical systems. Energy performance may be expressed as non-renewable primary energy, renewable primary energy, or total primary energy as the sum of the previous two" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

Major renovation of a building: "an existing building is subject to major renovation when works of any description (e.g. routine and non-routine maintenance, renovation and restoration) involve more than 25% of the surface of the building envelope, including all the building units that make up the building and consisting of, but not limited to, the restoration of external walls, external rendering, roofing or roof waterproofing" (source: translated from Italian Legislative Decree 192/05, as amended **[3]**).

SIAPE Italian Energy Performance Certificate Information System. This is the national database of EPCs, managed by ENEA, which is fed by all the data collected in the first instance by the regional information systems.

Building unit: "a section, floor or apartment within a building which is designed or altered to be used separately"[5] (source: Directive 2010/31/EU as transposed in Italian Legislative Decree 192/05, as amended **[3]**).

4. General

4.1. Introduction

Before explaining the methodologies referred to in this report, it is useful to introduce and describe some of the concepts related to energy performance certificates (EPCs), which will help give a better understanding of the analyses that will be carried out on national and regional databases. This chapter explains these concepts.

4.2. Buildings which require an EPC

An EPC is issued by qualified independent experts and, according to the law, is required under certain specific circumstances. The most common situations are when a building is to be sold

[5] Not directly reported: when assessing the energy performance of buildings, for residential buildings the concept of the building unit is generally associated with subdivision. For other types of buildings, the concept of functional independence applies.

or rented out or undergo major renovations. However, it is also possible for a citizen or other parties who want information on the energy status of their property to freely request an EPC.

According to Italian law (Italian Legislative Decree 192/05, as amended) **[3]**, an EPC is required for all types (categories) of buildings, except:

a) buildings falling within the framework of the regulations of part two and Article 136(1)(b) [6] and (c)[7] of Italian Legislative Decree no. 42 of 22 January 2004, concerning the Italian cultural and landscape heritage code, without prejudice to the provisions of paragraph 3-*bis* and paragraph 3-*bis*(1);
b) industrial and workshop buildings where the areas are heated for production process requirements[8] or using waste energy from the production process which cannot otherwise be used;
c) non-residential agricultural buildings without air conditioning;

c-*bis*) buildings declared as unfit for use or in a state of collapse;

d) stand-alone buildings with total useful floor space of less than 50 square metres;

e) buildings which are not included in the categories of buildings classified on the basis of intended use referred to in the article of Italian Presidential Decree no. 412 of 26 August 1993, such as cellars, garages, multi-story car parks, storage facilities, and seasonal structures for the protection of sports facilities, the standard use of which does not include the installation and use of technical air conditioning systems;

f) buildings used as places of worship and for religious activities.

Therefore, the national SIAPE database or the regional databases contain details for all types of buildings except those listed above.

4.3. EPC: purpose and information provided

In order to understand the information contained in an EPC, we must first consider the **main purpose** of the certificate, namely that of providing information. An EPC is drawn up with the aim of informing the future user of a building about the energy performance of that building, excluding management aspects related to, for example, the number of occupants and the actual way it is used. For this reason, it is requested as part of the sale or rental of a building, and is updated in the case of major renovations. As an information tool, the EPC can also be a useful guide for the real estate market in relation to energy aspects, as part of a wider assessment of a building as a whole.

The EPC therefore contains a series of information and indicators that is useful to the buyer or tenant. The main features relevant to this report are presented below. The EPC format

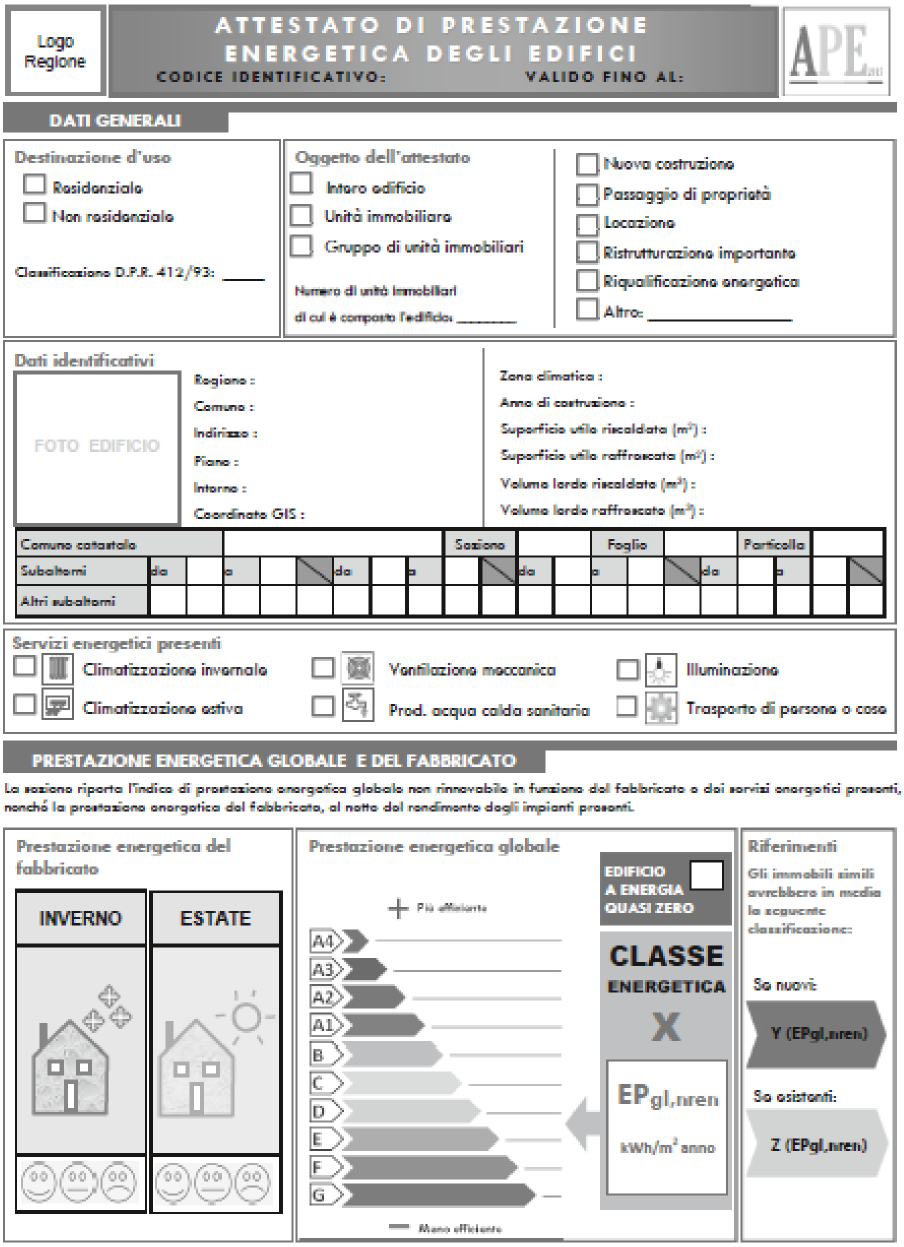
[6] Villas, gardens and parks [...] that are notable for their outstanding beauty.

[7] Real estate complexes that have a characteristic aspect having aesthetic and traditional value, including historical centers and districts.

[8] These are the cases in which the temperature inside the areas is maintained at a certain level mainly due to process requirements and not for the well-being of people. The setpoint may therefore be different from the standard value for the well-being of people (Italian Presidential Decree 74/13 [11]).

referred to in this report is contained in Italian Ministerial Decree of 26 June 2015, known as the “Guidelines” **[6]**.

Figure 1 – First page of the EPC (Italian format)



Logo Regione

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE IDENTIFICATIVO: VALIDO FINO AL:

APE

DATI GENERALI

Destinazione d'uso
- Residenziale
- Non residenziale

Classificazione D.P.R. 412/93: ____

Oggetto dell'attestato
- Intero edificio
- Unità immobiliare
- Gruppo di unità immobiliari

Numero di unità immobiliari di cui è composto l'edificio: ______

- Nuova costruzione
- Passaggio di proprietà
- Locazione
- Ristrutturazione importante
- Riqualificazione energetica
- Altro: ______________

Dati identificativi

FOTO EDIFICIO

Regione :
Comune :
Indirizzo :
Piano :
Interno :
Coordinate GIS :

Zona climatica :
Anno di costruzione :
Superficie utile riscaldata (m²) :
Superficie utile raffrescata (m²) :
Volume lordo riscaldato (m³) :
Volume lordo raffrescato (m³) :

Comune catastale		Sezione		Foglio		Particella	
Subalterni	da … a	da … a	da … a	da … a			
Altri subalterni							

Servizi energetici presenti
- Climatizzazione invernale
- Climatizzazione estiva
- Ventilazione meccanica
- Prod. acqua calda sanitaria
- Illuminazione
- Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

La sezione riporta l'indice di prestazione energetica globale non rinnovabile in funzione del fabbricato e dei servizi energetici presenti, nonché la prestazione energetica del fabbricato, al netto del rendimento degli impianti presenti.

Prestazione energetica del fabbricato

INVERNO | ESTATE

Prestazione energetica globale

+ Più efficiente

A4, A3, A2, A1, B, C, D, E, F, G

— Meno efficiente

EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA X

EP gl,nren kWh/m² anno

Riferimenti

Gli immobili simili avrebbero in media la seguente classificazione:

Se nuovi: Y (EPgl,nren)

Se esistenti: Z (EPgl,nren)

Energy information and indicators are divided into sections. First of all there is a section with the **general details** (*dati generali*), useful for uniquely identifying the property being certified. On the first page, there is an indication of the overall energy performance and that of the building excluding technical systems (*prestazione energetica globale e del fabbricato*). As far as the **performance of the building** is concerned, to be understood as the performance of the structural components alone (*prestazioni energetica del fabbricato*), without therefore considering the systems, there is a division between winter (heating - *inverno*) and summer (cooling - *estate*). The indicators, expressed in the form of a smiley face scale, therefore summarise the performance; a smiling face indicates a good performance. The conditions for the determination of the scale, as indicated in Italian Ministerial Decree of 26 June 2015 “Guidelines” **[6]**, are as follows[9].

Figure 2 - Indicator of winter energy performance of the envelope, excluding the efficiency of the systems present (the formulas remain in Italian)

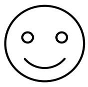
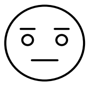
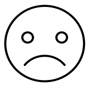
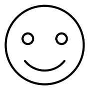
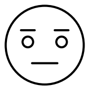
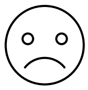
Building envelope winter performance	Quality	Indicator
$EP_{H,nd} \leq 1^* EP_{H,nd,limite\ (2019/21)}$	high	
$1^* EP_{H,nd,limite\ (2019/21)} < EP_{H,nd} \leq 1{,}7^* EP_{H,nd,limite\ (2019/21)}$	medium	
$EP_{H,nd} > 1{,}7^* EP_{H,nd,limite\ (2019/21)}$	low	

Figure 3 - Indicator of summer energy performance of the envelope, excluding the efficiency of the systems present[10] (the formulas remain in Italian)

Building envelope summer performance		Quality	Indicator
$A_{sol,est}/A_{sup\ utile} \leq 0{,}03$	$Y_{IE} \leq 0{,}14$	high	
$A_{sol,est}/A_{sup\ utile} \leq 0{,}03$	$Y_{IE} > 0{,}14$	medium	
$A_{sol,est}/A_{sup\ utile} > 0{,}03$	$Y_{IE} \leq 0{,}14$		
$A_{sol,est}/A_{sup\ utile} > 0{,}03$	$Y_{IE} > 0{,}14$	low	

The **overall energy performance** (*prestazione energetica globale*), on the other hand, includes the systems and is expressed by the energy class (from A4, very efficient, to G, inefficient) and the indicator $EP_{gl,nren}$ (non-renewable overall energy performance) expressed in kWh/m^2 year. It should be noted that both pieces of information (energy class and EP) are useful and complement each other. In fact, the energy class expresses the relative energy quality of a property, where the classes are calculated using a so-called “reference building”. The EP value, on the other hand, provides an absolute estimate of the consumption of non-

[9] The indicators and formulas in this report are taken directly from the Italian legislation and are not translated.

[10] The two indicators are respectively the solar area of the envelope, which takes into account how much of the building is glazed and the screening present, and the periodic thermal transmittance, which takes into account, among other things, the mass of the components. A better summer performance is achieved by using solar screens and increasing the mass of building components.

renewable primary energy. Therefore, given the same EP value, it is quite normal that two buildings that are different in terms of type, geographical context, and services present, can fall into different energy classes.

The previous information also includes whether the building is an **nZEB** (nearly zero-energy building - *edificio a energia quasi zero*) and the **performance benchmarks for similar buildings**[11] (*riferimenti*).

With regard to the **building services present** (*servizi energetici presenti*), this information should be interpreted as existing building services and considered in the assessment (on the EPC) according to the legislation in force. It should be noted that, for example, lighting, present in all buildings, is considered only for buildings in the tertiary sector (non-residential).

There is more detailed information on the EP value on the second page of the EPC: the indicator for **renewable primary energy** (*energia primaria rinnovabile*) is specified, which, in addition to the indicator for non-renewable primary energy (*energia primaria non rinnovabile*), allows the calculation of total primary energy. There is also an indicator for **CO_2 emissions**[12] (*emissioni di CO_2*) and an estimation of the **"physical" quantities** (e.g. Scm[13] of gas, kWh of electricity, kg of biomass, etc.) of the energy carriers used/consumed (*fonti energetici utilizzati*).

[11] Currently, the benchmark for similar new buildings is calculated by software, taking into account the minimum energy requirements in force at the time the EPC was prepared. As regards the benchmark for existing buildings, this should be provided in future by ENEA, which will calculate it on a statistical basis.

[12] Currently only CO_2 emissions are assessed and not all gases responsible for climate change (GHG, greenhouse gases).

[13] Standard cubic metres.

Figure 4 – Second page of the EPC (Italian format)

Logo Regione	ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI CODICE IDENTIFICATIVO: VALIDO FINO AL:	APE

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonché una stima dell'energia consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard (specificare unità di misura)	Indici di prestazione energetica globali ed emissioni
☐	Energia elettrica da rete		Indice della prestazione energetica non rinnovabile EPgl,nren kWh/m² anno
☐	Gas naturale		
☐	GPL		
☐	Carbone		
☐	Gasolio e Olio combustibile		
☐	Biomasse solide		Indice della prestazione energetica rinnovabile EPgl,ren kWh/m² anno
☐	Biomasse liquide		
☐	Biomasse gassose		
☐	Solare fotovoltaico		
☐	Solare termico		
☐	Eolico		Emissioni di CO_2 kg/m² anno
☐	Teleriscaldamento		
☐	Teleraffrescamento		
☐	Altro (specificare)		

RACCOMANDAZIONI

La sezione riporta gli interventi raccomandati e la stima dei risultati conseguibili, con il singolo intervento o con la realizzazione dell'insieme di essi, esprimendo una valutazione di massima del potenziale di miglioramento dell'edificio o immobile oggetto dell'attestato di prestazione energetica.

RIQUALIFICAZIONE ENERGETICA E RISTRUTTURAZIONE IMPORTANTE
INTERVENTI RACCOMANDATI E RISULTATI CONSEGUIBILI

Codice	TIPO DI INTERVENTO RACCOMANDATO	Comporta una Ristrutturazione importante	Tempo di ritorno dell'investimento anni	Classe Energetica raggiungibile con l'intervento ($EP_{gl,nren}$ kWh/m² anno)	CLASSE ENERGETICA raggiungibile se si realizzano tutti gli interventi raccomandati
REN1		Si /No		Es: X (YYY kWh/m² anno)	X YYY kWh/m² anno
REN2					
REN3					
REN4					
REN5					
REN6					

A crucial part of the EPC is the **recommendations** on any improvements that can be made to the building. With regard to the recommendations, it should be considered first of all that they represent indicative assessments that may not be exhaustive and have not taken into account the whole range of feasible interventions. In addition, it should be noted that, although quantitative information, such as the time for return on investment, is reported, this could be subject to assessment errors linked to the complexity of a comprehensive and robust technical-financial assessment of energy efficiency interventions[14] in the context of EPC preparation.

[14] Such a technical-financial assessment can only be considered robust and reliable in a more detailed context and with a more in-depth examination, for example, in the context of an energy audit.

Figure 5 – Third page of the EPC (Italian format)

Logo Regione	ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI CODICE IDENTIFICATIVO: VALIDO FINO AL:	APE

ALTRI DATI ENERGETICI GENERALI

Energia esportata	____________ kWh/anno	Vettore energetico: ____________

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V – Volume riscaldato		m³
S – Superficie disperdente		m²
Rapporto S/V		
$EP_{H,nd}$		kWh/m² anno
$A_{sol,est}/A_{sup\ utile}$		-
Y_{IE}		W/m²K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren	EPnren
Climatizzazione invernale	1-						η_H		
	2-								
Climatizzazione estiva	1-						η_C		
	2-								
Prod. acqua calda sanitaria							η_W		
Impianti combinati									
Produzione da fonti rinnovabili	1-								
	2-								
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose	1-								
	2-								

Among the other indicators reported (on page 3 of the EPC), **$EP_{H,nd}$**, expressed in kWh/m² year, is considered particularly important, which is in fact the quantitative specification of the "smiley face" relating to the winter performance of the building. As has already been said, this indicator does not take into account technical systems. Although it is therefore a partial indicator, providing information only on the building envelope, and therefore indirectly on the insulation level of the building, makes it possible to make considerations on the "basic" heating requirements of the building[15].

[15] Considering heating only, this indicator is more significant in cold climate areas, where heating accounts for a significant part of overall energy consumption compared to other building services (cooling, hot water, etc.)

As regards the detailed system data, among the useful information that can be obtained it is worth highlighting the **EP_{ren} (renewable) and EP_{nren} (non-renewable) values divided by system** (*servizio energetico*). This data gives an idea of the relative weight of each system compared to the others and also which systems in particular use renewable energy sources. It should be noted, however, that the approach given by the official format creates some ambiguity because of the fact that it also specifies “combined systems” and “production from renewable sources” among the types of building services.

The final pages of the EPC contain information on opportunities for improving the energy class (specifying any national and local incentives and allowances), the certifying body, inspections, software used, and also the key and compilation notes.

4.4. Difference between calculated and measured performance

It should be noted that all indicators and numerical parameters contained on the EPC relate to **calculated energy performance**. This means, for example, that energy consumption values, in terms of primary energy and also in terms of physical quantities per energy carrier, are not derived from energy bills or other types of energy measurement, but rather are values estimated by modelling the building using software and deriving these energy performance indexes according to defined methodologies and algorithms. Italian Legislative Decree 192/05 **[3]** specifies the technical standards to be adopted as methodologies for the calculation of the energy performance of buildings. These documents are subsequently listed in Italian Ministerial Decree of 26 June 2015 “Application of energy performance calculation methodologies and definition of minimum building requirements and standards” **[5]**. The same decree states that “the calculation tools and commercial software for the application of the methodologies [...] ensure that the values of energy performance indexes, calculated through their use, have a maximum deviation of plus or minus 5% from the corresponding parameters determined by the application of the national reference tool [...]. This guarantee shall be provided by means of a statement issued by the CTI, after verification of compliance with the condition referred to in this paragraph.”

It should also be noted that the above-mentioned performance and indicators are calculated using input data relating to the use of the building and the climate of the standard location. This means, for example, that the occupation profile of the building is not the actual one but rather a standardised profile (unique and possibly differentiated only by type of building). On the one hand, this element ensures greater comparability between buildings in terms of energy performance, removing the effects of causes that are not attributable to the quality of the building envelope and technical systems, but more simply to a greater or lesser use of the building and the building services present. It should be noted that such comparability is an essential aspect of the energy performance certification system, and it is also a guarantee of a certain uniformity in the data collected, minimising what may be the judgement of the professional in attributing data with an impact on energy consumption. On the other hand, however, standardisation may result in the possibility that the consumption calculated in this way differs from the actual consumption of the building under consideration (**measured performance**).

Analysing in more detail the possible differences between calculated and measured performance, the following should be considered:

- calculated performance is obtained using (assuming) a continuous occupation profile[16]. In general, this implies a cautious calculation, in the sense that the actual measured performance is expected to be better (lower energy consumption) than the calculated performance. This would also appear to be demonstrated by simulations currently under way by ENEA and CTI in relation to a refinement of the calculation methodology that is closer to the actual measured consumption;
- the above is all the more true when the building is actually used discontinuously;
- this difference, however, tends to be reduced as the energy performance of the building envelope improves[17]. This is because the smaller losses of the building envelope naturally make the operating profile of the systems more regular and "flat". In other words, the effect of night-time attenuation is, in high-performance buildings, much less significant and impactful on consumption. Consequently, even in the presence of a refined regulation system, there is no substantial difference between a continuous (24 hours a day) and discontinuous (night only or day only) occupation profile.

4.5. Concepts of renewable, non-renewable and total primary energy

As already mentioned in the previous sections, in the context of Italian legislation on the energy performance of buildings and energy performance certificates, when it comes to primary energy, a distinction is always made between:

- renewable primary energy;
- non-renewable primary energy; and
- total primary energy (which is always the sum of renewable + non-renewable).

In this regard, it should be noted that by having a renewable component, in terms of primary energy, depends primarily and solely on the type of energy carriers used. Each energy carrier (e.g. gas, electricity, biomass, etc.) is converted into primary energy via conversion factors, as defined in Table 1 of Italian Ministerial Decree of 26 June 2015 **[5]**, the so-called "Minimum Requirements" as reported below.

[16] Except in some cases, for air conditioning (summer) and ventilation in non-residential buildings.
[17] Components with low thermal transmittance.

Table 1 - Conversion factors of energy carriers into primary energy

Energy carrier	$f_{P,nren}$	$f_{P,ren}$	$f_{P,tot}$
Natural gas (1)	1.05	0	1.05
LPG	1.05	0	1.05
Diesel and fuel oil	1.07	0	1.07
Coal	1.10	0	1.10
Solid biomass (2)	0.20	0.80	1.00
Liquid and gaseous biomass (2)	0.40	0.60	1.00
Mains electricity (3)	1.95	0.47	2.42
District heating (4)	1.5	0	1.5
Solid urban waste	0.2	0.2	0.4
District cooling (4)	0.5	0	0.5
Thermal energy from solar collectors (5)	0	1.00	1.00
Electricity generated from solar panels, small wind turbines and small hydropower (5)	0	1.00	1.00
Thermal energy from the external environment – free cooling (5)	0	1.00	1.00
Heat energy from the outside environment – heat pump (5)	0	1.00	1.00

(1) The values will be updated every two years based on data provided by GSE.
(2) As defined in Annex X to Italian Legislative Decree 2006 no. 152 of 3 April 2006.
(3) The values will be updated every two years based on data provided by GSE.
(4) This factor is assumed in the absence of values declared by the supplier and declared by a third party in accordance with section 3.2.
(5) Conventional values relevant to the calculation system.

Analysing the table, it should be noted that some energy carriers are considered completely non-renewable (e.g. gas, diesel), others as fully renewable (e.g. energy from solar panels, energy from the external environment, etc.) and others as partly renewable.
With regards to the latter category, it should be noted that, for example:

- mains electricity is considered partly renewable and partly non-renewable because it is produced using both renewable sources (hydroelectric power plants, wind farms, solar farms, etc.) and non-renewable sources (fuel oil and gas power plants, etc.);
- biomass is considered only partly renewable, not because part of the carrier is non-renewable, but because the conversion factor into primary energy also takes into account the energy used for conversion (pelletisation, for example), transport, etc. and in the case of biomass, this (process) energy is assumed to be derived partly from fossil fuels and therefore non-renewable sources.

Note: the future use of new “mixed” energy carriers, such as a mixture of natural gas, biomethane and hydrogen, as envisaged by the energy transition targets and related national strategies, will require an update of the table, while the methodology for calculating the energy performance of buildings is ready to implement these changes.

From the point of view of examining the energy performance of a building, consider the fact that if we only look at the EP_{nren} indicator on non-renewable primary energy, it is possible to infer that the building has a higher or lower demand for fossil fuels (makes greater or lesser use of non-renewable energy to meet its needs). However, no information is given as to whether this supposedly low use of non-renewable energy is the result of a building with very low "basic" needs (e.g. considering heating, thanks to a very high-performance building envelope) or with high demand but largely covered by systems using renewable energy sources. To get this information, it is necessary to add another indicator to EP_{nren}, namely EP_{tot}.

If, from the point of view of energy classification, the two situations described do not make any difference, it should be considered that, for the same non-renewable energy, the building with the lowest total energy is certainly better in energy terms. This is because renewable primary energy is not, in general, free of charge[18] and therefore the use of renewable energy sources could still involve significant energy expenditure[19] in some circumstances.

5. Methodology for identifying the top 15% of building stock

5.1. General

The aim of the following methodology is to identify the energy performance "threshold" below which a building can be considered to be part of the **subset of the top 15% most energy-efficient buildings** of a specific set of buildings, which may be, for example, the national or regional building stock.

For this purpose **two possible paths** are considered, depending on the **type of data available**. In fact, the methodology and type of calculations to be carried out are influenced by having a certain level of detail and the best possible data disaggregation available for the chosen sample: this can lead to a more precise definition of the threshold that defines the top 15% most energy-efficient buildings.

Currently, although every EPC contains a lot of detailed information, its transposition into regional/provincial databases and from these to the central database of ENEA (SIAPE), and the subsequent availability of the same information on the public SIAPE portal in a more or less aggregated form, requires a differentiated approach.

Two possibilities (or paths) are therefore considered:

[18] In the case of systems using free renewable energy sources (e.g. solar, solar thermal, etc.) the installation cost of the systems should be considered, which affects any assessment of the building or of the energy interventions that comprise the whole life cycle of the building or in any case until the end of the useful life of the systems or of the interventions analysed.
[19] Consider, for example, biomass, which is widely regarded as renewable, but certainly not free.

a) “**PATH A**” (less reliable): the available data comprises aggregated information and/or data such as, for example, that from the SIAPE public portal;
b) “**PATH B**” (more reliable): the available data comprises disaggregated records (data for individual EPCs) such as those from the Province of Trento database.

Path A therefore starts from the assumption that the data (record) for each individual EPC is not available for analysis, but that the data is available in the form of aggregated information (e.g. number of buildings by energy class, average EP by energy class, etc.).

Path B, on the other hand, starts from the assumption that all the records corresponding to issued EPCs, as archived in the various regional (or national, SIAPE) databases through the use of xml standards for the transmission of data from the EPC preparation software to the databases. In other words, the assumption is that all the data contained in the EPC (property features, energy requirements and indicators, etc.) for each property for which an EPC has been prepared and lodged is available[20].

It should be noted that the paths and methods described below can be generalised. There currently may not be the conditions and the data necessary to apply the more detailed path at a national level (SIAPE), but it is not excluded that in future these conditions may exist and therefore also path B (more detailed and accurate) can be applied. The conclusions of the report will also reflect on the reliability of the results from both paths.

5.2. Path (A) starting from aggregated EPC information

5.2.1. Data available in SIAPE and necessary for the application of path (A)

In order to identify what is stated in the introduction, SIAPE makes the following data available:

- Number of **EPCs lodged by energy class**;

- **Average values of energy performance indexes**, expressed as non-renewable, renewable and total primary energy, **by energy class**. The methodology applies equally to non-renewable, renewable or total primary energy (the sum of the first two). In the examples in this report, thresholds for non-renewable energy alone will be calculated given it is a more significant indicator and in line with the objectives of the relevant European Directives.

[20] As far as SIAPE (the national database) is concerned, the data is currently not public (free access). At the moment there is only one portal (website), which makes some information obtained from the database available.

*Figure 6 – Example: Number of EPCs (*APE*) by energy class (source: ENEA SIAPE portal)*

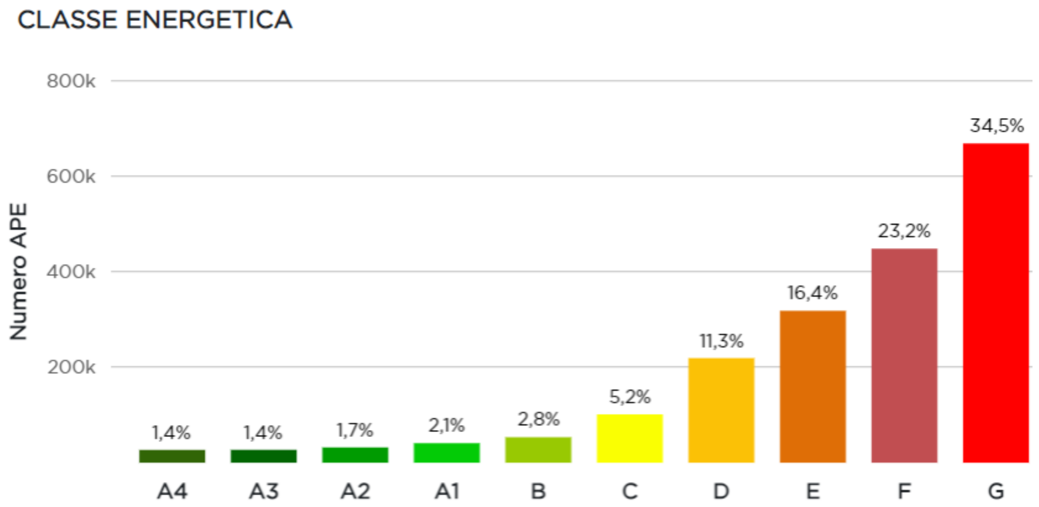
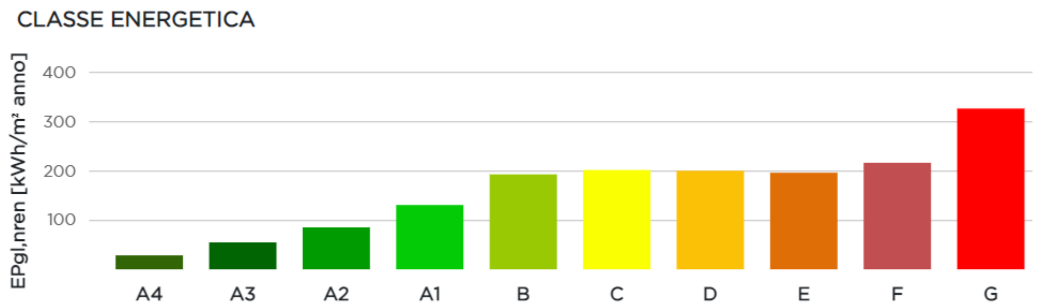


Figure 7 – Example: Performance index $EP_{gl,nren}$ by energy class (source: ENEA SIAPE portal)



This is the necessary and sufficient data to identify the threshold of the top 15%.

5.2.2. Methodology

For the calculation of the threshold value for the identification of the top 15%, it is necessary to:

1) **Calculate the percentage of EPCs that meet the following criteria:**

- the building is in class A4,
- the building is in class A3 or above (A4),
- the building is in class A2 or above (A3 or A4),
- ...
- the building is in class G or above (A3, A4....or F),

and the percentile corresponding to the pre-calculated percentage distribution.

2) Analyse the percentiles, from which it is then possible to **identify the energy class in which the 15% of EPCs fall**.

3) **Identify the average values** for each class. To find the 15% threshold value, the values of the energy performance indexes, expressed as non-renewable, renewable and total primary energy, by energy class, must be taken into consideration.

4) **Identify the boundaries between classes.** These average values can be used to speculate what the boundaries between classes might be, by means of arithmetic averages. In this regard, note that class G is "open ended" (it has no upper limits). This means that the average EP can also be very high. Therefore, using the average EP values of classes F and G for the hypothetical calculation of the boundary between these two classes would make the mistake of overestimating this value. For this reason, only for the boundary between these two classes, the average value of class F and the lower boundary between classes F and E is used, assuming equidistance between the lower boundary-central value and the central value -upper boundary.

5) **Calculate the EP value corresponding to the 15% threshold.** The boundaries between the classes are necessary for the identification of a value of EPgl,nren corresponding to 15%. This threshold can be determined by linear interpolation between values either of the lower boundary and average value or the average value and the upper boundary.

5.2.3. Example of application

Below is an example of the application of the methodology described above. The data sample is that contained in SIAPE on 17 December 2021. The data refers to residential buildings in climate zone E. The procedure consists of the following steps.

1) Calculation of the percentage of EPCs in each energy class and calculation of the percentiles (cumulative distribution).

Table 2 – Number and percentile of EPCs by energy class (example)

Energy class	Number of EPCs	Distribution [%]	Percentile [%]
A4	16939	1.6%	1.6%
A3	18262	1.7%	3.2%
A2	19977	1.8%	5.1%
A1	22952	2.1%	7.2%
B	26557	2.4%	9.6%
C	47323	4.3%	13.9%
D	112596	10.3%	24.3%
E	177937	16.3%	40.6%
F	258935	23.7%	64.3%
G	389450	35.7%	100.0%
Total	**1090928**	**100.0%**	-

2) Identification of the class in which the 15% falls: from analysis of the percentiles it is possible to **identify the energy class in which the 15% of EPCs falls**. In the above example, it can be seen that the 15% threshold falls in **class D**. This means that the following are part of the top 15%:

- all buildings in classes A, B and C;
- only some of the buildings in class D;
- no buildings in classes E, F and G.

3) Identification of average EP values (data provided by SIAPE).

4) Calculation of the boundary EPs (data calculated as a function of the average EP values) for each class, i.e. the boundary EP between the various classes.

Table 3 – Average $EP_{gl,nren}$, lower boundary and upper boundary (example)

Energy class	EP lower boundary [kWh/m^{2}year]	EP average [kWh/m^{2}year]	EP upper boundary [kWh/m^{2}year]
A4	0.0	27.3	38.3
A3	38.3	49.2	59.4
A2	59.4	69.6	78.8
A1	78.8	87.9	99.2
B	99.2	110.5	119.3
C	119.3	128.1	135.2
D	135.2	142.2	155.2
E	155.2	168.2	191.1
F	191.1	213.9	236.8
G	236.8	344.4	452.1

5) **Calculation of the EP value corresponding to the 15% threshold:** not all buildings in class D will belong to the “top 15%” subset, but rather only 1.1% of the total (since 13.9% of the total is the sum of all buildings in classes A, B and C). **Therefore, by**

correlating the two tables above, we can obtain $EP_{gl,nren}$ corresponding to 15% as follows:

$$EP_{gl,nren,top15\%} = EP_{\text{confine inf.}} + (EP_{\text{confine sup.}} - EP_{\text{confine inf.}}) * \%_{\text{Residua del 15\%}} / \%_{\text{APE nella classe}}$$

in numbers, in the example above:

$$EP_{gl,nren,top15\%} = 135.2 + (155.2 - 135.2) * 1.1\% / 10.3\% = 137.3 \text{ kWh/m}^2 \text{ year}$$

In the calculation shown, 137.3 kWh/m^2 year represents the threshold of the “top 15%” of EPCs. As can be seen, this value is very close to the boundary between Class C and Class D, since in this case, only a small part of Class D buildings belongs to this “top 15%” subset (by including all Class D buildings, we would get a threshold corresponding to the percentile of 24.3%).

5.2.4. Critical aspects of application and level of approximation in this procedure

“Path A”, described above, essentially involves using the average EP values per energy class and the percentage distribution of EPCs per class in order to estimate the EP threshold of the top 15% subset. This procedure is considered to be the only one applicable since this is the only information available, i.e. in aggregated form[21].

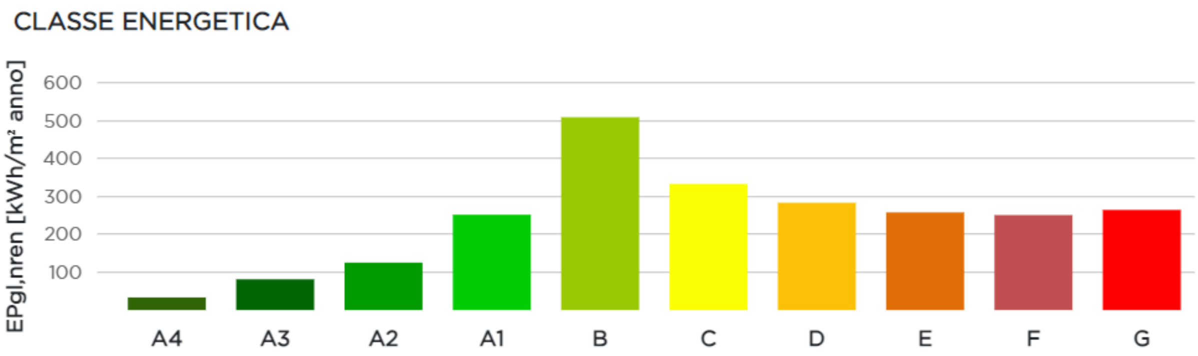
It should be stressed, however, that this procedure has a level of approximation which is not entirely negligible and is affected by the **lack of disaggregation (and selection) of the EPCs for the building services in question**. This section is therefore intended to explain this concept in detail, as it is essential to assessing the reliability of the analysis.

Firstly, it should be considered that there is no direct correlation between the value of $EP_{gl,nren}$ and the energy class. Although the energy classification is based on $EP_{gl,nren}$, the boundaries between the classes and therefore the energy class of a building are established in a relative way using the mechanism of the so-called “**reference building**”. It may therefore be the case that, for the same $EP_{gl,nren}$, two buildings could fall into different energy classes. This happens, for example, for buildings that have different building services (heating and domestic hot water only or also cooling). As can be seen from the data, this is more common for non-residential buildings than for residential buildings (with greater homogeneity of the services present and considered in the calculation).

For non-residential buildings, therefore, a **flattening or decreasing of the average $EP_{gl,nren}$ may occur as the energy class increases** (for more inefficient energy classes). The following figure shows a clear example.

[21] This is the current situation for EPC data at a national level in Italy (ENEA SIAPE portal)

Table 4 – Average EP$_{gl,nren}$ values by energy class - commercial buildings - climate zone D (data source: ENEA SIAPE portal)



Consider that the graph comes from a sample of 33,616 EPCs. As a result, in this case, the number is not considered to be a critical factor.

Since detailed EPC data is not public, it is not possible to carry out an in-depth analysis to identify the cause or causes of this phenomenon. One of the plausible assumptions lies in the significant weight of lighting for non-residential buildings, together with the fact that performance parameters for lighting have not to date been defined in the reference building mechanism[22]. ENEA and CTI have already examined this topic in research conducted in 2016 **[12]**.

What's more, the hypothesis that the anomalous trends found may also be due to the poor reliability (quality) of the EPCs present in the database is not entirely excluded.

Therefore, the impossibility of considering buildings in the analyses for the same building services[23] or selecting only certain services, can therefore lead to results that are not entirely reliable, using average EP values per energy class, since precisely such average EP values are calculated using a heterogeneous subset of buildings.

Taking into account what has been said above with regards to the reliability and robustness of the analysis, in the presence of this phenomenon of flattening or decrease of the average EP$_{gl,nren}$ value as the energy class increases, two possible alternatives are presented below, in order to obtain a result (threshold).

Alternative 1 (priority to energy class):

It is possible to consider that, for the same average EP value, a more efficient energy class building will certainly have better characteristics in terms of the energy quality of the building

[22] In other words, the fact that there are no benchmark performance values for lighting, makes the contribution of the related energy requirement an "invariant" factor as far as classification is concerned.
[23] This impossibility has been verified both for the ENEA SIAPE portal and for the Province of Trento database.

components and systems[24] than a lower energy class building. Where this reversal phenomenon exists, it is therefore possible to consider the most efficient energy classes, in increasing order, in order to determine the threshold of the most efficient buildings.

Alternative 2 (priority to average EP):

It can be considered that, regardless of the energy classification, the aim of the study within the Taxonomy framework is to identify buildings with a better average EP value. Consequently, it is possible to apply the same procedure described in path A with just one difference: in the presence of "reversals" in the trend of average EPs values by class, to reorder the classes by increasing average EP. The threshold will therefore be calculated not necessarily using the best classes (the most efficient ones) but with the classes with the lowest average EP value.

5.3. Path (B) starting from disaggregated data

5.3.1. Data available in the database and necessary for the application of path (B)

An EPC database, populated with data collected through xml transmission standards, contains a significant amount of data and information about each individual property for which an EPC has been prepared and lodged. By having such data, it is therefore possible to identify the 15% threshold much more accurately and quickly.

Starting from disaggregated data, it is necessary and sufficient to have the $EP_{gl,nren}$ value for each building (building unit), or the overall energy performance index, expressed as non-renewable primary energy.

5.3.2. Methodology

For the calculation of the threshold value for the identification of the top 15%, it is necessary to:

1) Sort the records by increasing $EP_{gl,nren}$ values (lowest to highest)
2) Calculate how many EPCs represent 15% of the sample based on the number of records in the database. This number (rounded down) will correspond to the last record that falls within the top 15%
3) Identify the $EP_{gl,nren}$ value corresponding to this last record within the 15%. This $EP_{gl,nren}$ value constitutes the 15% threshold for a certain sample.

[24] Due to greater energy efficiency or the use of renewable energy sources.

6. Methodology for identifying buildings with a performance 10% better than nZEB buildings

6.1. General

The objective of the following methodology is to identify the energy performance "threshold" below which a building can be considered to be part of the **subset of buildings having a performance that is 10% better than the set of so-called "nZEBs" (nearly Zero-Energy Buildings)**, which in turn can be identified as a subset of the national or regional building stock.

With respect to the objectives and methodologies referred to in Chapter 5 of this study, it is necessary, when talking about nZEBs, to make some preliminary remarks to understand the methodology that will be described below. These remarks constitute clarifications concerning:

- the definition of nZEB, required for the identification of buildings classified as an nZEB within the entire building stock;
- the mechanism of construction of certain legal limits, which must be verified in order for a building to be declared as an nZEB.

With regard to the methodology, as for the identification of the top 15% of energy-efficient buildings, it is possible to follow two paths according to the type of data available:

a) data from the public SIAPE or regional database (aggregated EPC data);
b) data from SIAPE or regional database records (data for individual EPCs).

6.2. nZEB definitions

6.2.1. EU Directive definition

The definition of nZEB is contained in European Directive 2010/31/EU **[1]** as subsequently amended and by European Directive 2018/844/EU **[2]**. The definition is as follows:

'nearly zero-energy building' means a building that has a very high 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 sources produced on-site or nearby.

This definition includes two concepts, which correspond to the general requirements that an nZEB must possess:

- very low or nearly zero energy requirements;

- very significant coverage (of this requirement) with renewable sources produced on-site or nearby.

The two conditions must be met at the same time. Therefore, a very low energy requirement or very significant coverage with renewable energy sources (of high demand) are not sufficient on their own.

Another feature of the European Directive 2010/31/EU should be noted **[1]**: it does not provide "threshold" values and does not explicitly quantify the requirements of an nZEB. It is left to the Member States to identify these quantitative values. However, a number of principles (Annex I, referred to in the definition) are provided to which Member States must comply. Annex I therefore provides a general common framework for calculating the energy performance of buildings and specifies, for example:

- in what terms and how energy performance should be expressed;
- which technical systems or services to consider in energy performance;
- the aspects that the calculation methodology must consider.

6.2.2. Italian legislation definition

In Italy, European Directive 2010/31/EU [1], as subsequently amended by European Directive 2018/844/EU [2], has been transposed into national legislation by Italian Legislative Decree 192/05 **[3]**, as amended[25].

Italian Legislative Decree 192/05 **[3]**, as amended, reports the following definition of nZEB (translated from Italian):

nearly Zero-Energy Building: a building that has a very high energy performance, calculated in accordance with the provisions of this decree, which meets the requirements defined in the decree in Article 4 (1). The nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, produced on-site.

There are two differences from the definition in European Directive 2010/31/EU [1]:

- energy from renewable sources must be produced only "on-site" and not nearby;
- general criteria are defined (Article 4(1)) which are additional to those defined in Annex I to European Directive 2010/31/EU [1].

Like European Directive 2010/31/EU [1], Italian Legislative Decree 192/05 **[3]** does not provide values or thresholds, but refers to one or more implementing decrees for the definition of the methods of application[26].

[25] The most recent amendment to Italian Legislative Decree 192/05 took place with Legislative Decree 48/20 [4].

[26] Decrees of the Minister for Economic Development, in agreement with the Minister for Environment, Land and Sea Protection, the Minister for Infrastructure and Transport and, for their areas of

On an application level, the reference for the definition of nZEB is Italian Ministerial Decree of 26 June 2015 **[5]**, known as the "Minimum Requirements". In particular, this decree, in its Annex 1, point 3.4, details the characteristics that a building must fulfil in order to be called an nZEB. Point 3.4 states that:

All buildings, whether new or existing, are "near zero-energy buildings" if the following are respected at the same time:
a) all the requirements set out in paragraph 3.3(2)(b), determined with the values in force from 1 January 2019 for public buildings and from 1 January 2021 for all other buildings;

b) the obligations to integrate renewable sources in accordance with the minimum principles set out in Annex 3(1)(c) to Italian Legislative Decree no. 28 of 3 March 2011.

Therefore, it is necessary to examine these two points in more detail, as each one includes more requirements. The following figure shows paragraph 3.3(2)(b) in detail.

Figure 8 – Extract from Italian Ministerial Decree of 26 June 2015 "Minimum Requirements"

b) verification of compliance with the following conditions with reference to the parameters, indexes and efficiencies defined in letter a) above:

i. the parameter H'_T is lower than the relevant limit value shown in Table 10 of Appendix A;
ii. The $A_{sol,est}/A_{sup\ utile}$ parameter, determined in accordance with section 2.2 of Appendix A, is below the corresponding limit value in Table 11 of Appendix A for category E.1 buildings, except for colleges, convents, prisons, and barracks and category E.1(3) buildings, and all other buildings;
iii. the $EP_{H,nd}$, $EP_{C,nd}$ and $EP_{gl,tot}$ indexes are lower than the corresponding limit values calculated for the reference building ($EP_{H,nd,limite}$, $EP_{C,nd,limite}$ e $EP_{gl,tot,limite}$), as defined in letter l-*novies*) of Article 2(1) of the legislative decree and for which the energy parameters, and the thermal and generation characteristics are given in the relevant tables of Chapter 1 of Appendix A, for the corresponding years of validity. It should be noted that for the limit values of these indicators, marked with the year of the start of their validity, there is a gradual reduction divided into two stages:
   - Stage I - marked (2015): effective from 1 July 2015 with limit values valid for all buildings;
   - Stage II - marked (2019/21): effective from 1 January 2019 for public buildings or buildings for public use, as defined in the letters l-*sexies* and l-*septies* of Article 2(1) of the legislative decree, and from 1 January 2021 for all other buildings;
iv. the efficiencies η_H, η_W and η_C are higher than the values of the corresponding efficiencies specified for the reference building ($\eta_{H,limite}$, $\eta_{W,limite}$, e $\eta_{C,limite}$), as defined in Article 2(1) of the legislative decree and for which the energy parameters and thermal characteristics are given in Tables 7 and 8 of Appendix A.

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responsibility, the Minister for Health and the Minister for Defense, after agreement with the Joint Conference.

With regard to the second point, that is to say the one citing Italian Legislative Decree 28/11 **[7]**, the text of Annex 3(1)(c) is reported first.

Figure 9 – Extract from Italian Legislative Decree 28/11 Ministerial Decree 26 June 2015 "Minimum Requirements"

1. In the case of new buildings or buildings undergoing major renovations, thermal power generation systems must be designed and constructed in such a way as to ensure the simultaneous compliance with the coverage, through the use of energy produced by systems powered by renewable sources, of 50% of the expected consumption for domestic hot water and of the following percentages of the sum of the expected consumption for domestic hot water, heating and cooling:

a) 20% where the application for the relevant building permit is submitted between 31 May 2012 and 31 December 2013;

b) 35% where the application for the relevant building permit is submitted between 1 January 2014 and 31 December 2016;

c) 50% where the application for the relevant building permit is issued from 1 January 2017.

Furthermore, reference should be made to ministerial responses to Frequently Asked Questions (FAQ)[27] on the subject (Document of 21 October 2015 **[8]**), which substantially "extend" the reference to the other paragraphs of Annex 3 in addition to paragraph 1.

Figure 10 – Extract from the first series of ministerial FAQs

2	"Minimum Requirements" Ministerial Decree	Annex 1 point 3.4	Is the obligation to integrate renewable sources into a nearly zero-energy building solely the 50% coverage of the sum of the expected consumption for domestic hot water, heating and cooling (Annex 3(1)(c) to Italian Legislative Decree 28/2011)?	The reference to Annex 3(1)(c) is intended to be indicative of the share from renewable sources to be guaranteed (50% of the sum of domestic hot water, heating and cooling) **irrespective of the start date**; the obligation to integrate, however, applies to **all the requirements in Annex 3** (50% domestic hot water and installed electrical capacity)
3	"Minimum Requirements" Ministerial Decree	Annex 1 point 3.4	For the purpose of identifying a nearly zero-energy building, are the provisions of points 5, 6, 7 and 8 of Annex 3 to Italian Legislative Decree no. 28 of 3 March 2011 still valid?	**Yes**

In conclusion, with regard to the legislative context at a national level in Italy, by reading the following:

- Legislative Decree 192/05 **[3]**
- Ministerial Decree of 26 June 2015 **[5]**
- Legislative Decree 28/11 **[7]**
- FAQs of 21 October 2015 **[8]**

it can be seen that any building that meets the following requirements at the same time can be defined as an nZEB:

- from Ministerial Decree of 26 June 2015 **[5]** as regards the parameters and indicators: H'_T, $A_{sol,est}/A_{sup\ utile}$, $EP_{H,nd}$, $EP_{C,nd}$ and $EP_{gl,tot}$, η_H, η_W and η_C.

27 https://www.mise.gov.it/index.php/it/energia/efficienza-energetica/edifici

- from Annex 3 to Legislative Decree 28/11 **[7]**: 50% of H+W+C consumption, 50% of W consumption, minimum power from installed electric renewable energy sources (RES), exceptions for district heating, increases for public buildings, except in cases of higher performance than the minimum requirement.

Note: during the drafting of this report, Italian Legislative Decree 199/21 was published in the Official Gazette [13], which changes the aforementioned Annex 3 of Italian Legislative Decree 28/11 **[7]** and consequently also the minimum quotas from renewable energy sources and the criteria for identifying an nZEB. However, this change in the criteria is not retroactive, given that EPCs are valid for 10 years.

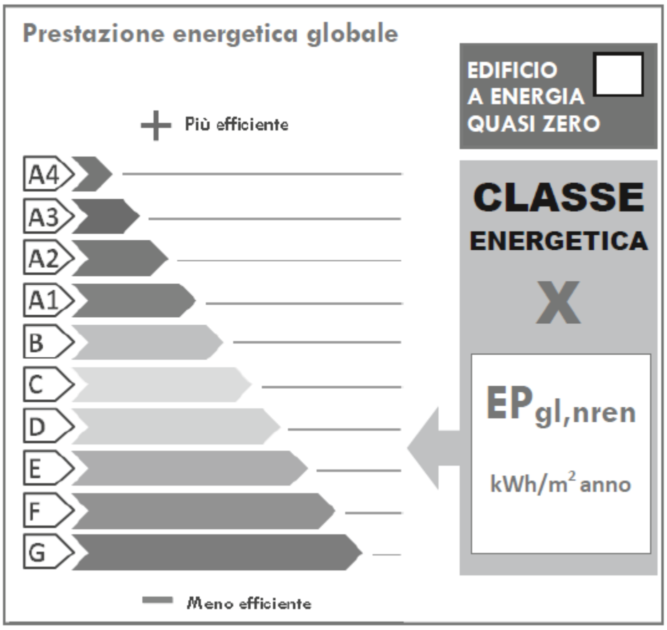
6.3. Path (A) starting from SIAPE information

As explained in the previous points, the verification that a building has all the characteristics defined in the decrees to be called an nZEB is something that requires a series of data in terms of performance parameters and indexes, and possibly other information (in some specific cases) that is not all available and stored in SIAPE. As a result, it is not possible, to date, to establish with certainty retrospectively, i.e. once the EPC has been lodged, whether a given building actually has nZEB characteristics or not[28].

Nevertheless, the EPC clearly and explicitly specifies whether a building is an nZEB or not, through a "cross" marked in the overall energy performance box (*PRESTAZIONE ENERGETICA GLOBALE* box in Figure 1 and Figure 11).

Figure 11 – Extract from the EPC format (Italian format)

[28] However, it is possible to verify the opposite, that is, by checking some parameters, it is possible to establish retrospectively with certainty which buildings definitely do not have the characteristics to be called an nZEB. However, this is not useful for the purpose of this study.

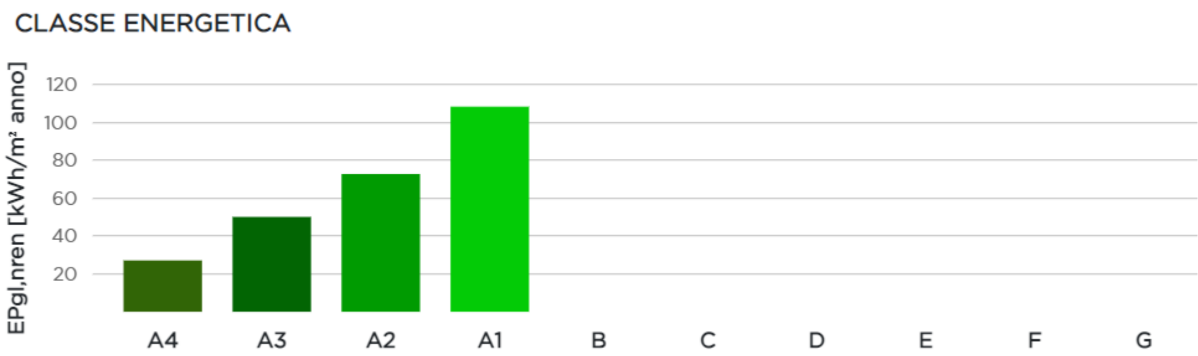


Currently, this cross is in most cases manually marked by the assessor, who, assisted by software, has the task of verifying whether the building is an nZEB or not, based on compliance with the requirements (outlined in the previous points).

This information (the nZEB cross) is stored in SIAPE. By querying public information, it is therefore possible to select only the data relating to nZEBs and then to carry out a review and analysis of the performance characteristics of these buildings.

By way of example, the following figure shows an extract of nZEBs from SIAPE with an indication of the average $EP_{gl,nren}$ value, expressed in [kWh/m^2 year], by energy class.

Figure 12 – Example of an extract of nZEBs from the SIAPE portal



The previous extract leads to a subset of 7,831 nZEBs (residential + non-residential) out of a sample of 1,938,348 EPCs (about 0.4%).

Note that there is no direct correlation between the threshold value of $EP_{gl,nren}$ (non-renewable primary energy) and whether a building is an nZEB or not. This is because the set of requirements for a building to be defined as an nZEB or not does not include $EP_{gl,nren}$ but rather $EP_{gl,tot}$ and quotas from renewable sources (only for certain building services). However, among the nZEB parameters are $EP_{H,nd}$ and $EP_{C,nd}$, which are calculated using the reference building mechanism, and whose resulting limit corresponds to the boundary between class A1 and class B. Therefore, the assumption[29] that nZEBs fall into the most efficient classes (classes A, A1 to A4) is justified.

It is therefore also possible to assume that an nZEB must have an $EP_{gl,nren}$ value equal to at least that representing the boundary between class A1 and class B. This would therefore have to be calculated, in the same way as for the identification of the top 15% threshold in terms of energy performance.
This operation, however, is not feasible in the same ways (procedure) as described above. This is because, as can also be seen from the examples reported, for the nZEB subset there is no average value of $EP_{gl,nren}$ relative to class B (since there are no nZEBs in class B). Neither is it possible to refer to the threshold calculated for the 15%, since it includes both nZEBs and non-nZEBs and it can be shown that the nZEBs in the A classes have better average performance indicators than buildings in the A classes that are not nZEBs; this is due to the higher requirements for nZEBs.

Consequently, only by considering nZEBs, the only way to estimate a hypothetical boundary between classes A1 and B is by using the average values of the A2 and A1 classes. The boundary between classes A1 and B is then calculated, in a similar way to the boundary between classes F and G in the previous procedure, by placing the EP of class A1 as the average value between the lower and upper boundaries of class A1. This upper boundary of class A1 will constitute what can be assumed as the $EP_{gl,nren}$ threshold for nZEBs from which to calculate the required “-10%”.

Note: In addition to the threshold, in the examples given in this report, the weighted average $EP_{gl,nren}$ of the nZEBs, calculated using the available data, will also be specified for information purposes.

With regard to the procedure described above, the following possible critical issue is noted: in a similar way to what happens for the identification of the “top 15%” threshold, it is not necessarily impossible that even among the nZEBs, although they all fall into class A, there may be inversions between the average EP value and the classes. If this is the case, one of the two alternatives presented in the previous chapter can be followed.

6.4. Path (B) starting from disaggregated data

As explained for path (A), the verification that a building has all the characteristics defined in the decrees so that it can be called, with absolute certainty, an nZEB is something that requires

[29] This assumption was a filtering criterion adopted by ENEA for the public presentation of SIAPE data.

a series of data in terms of performance parameters and indexes, and possibly other information (in some specific cases) that is not all available and stored in SIAPE (or in the regional databases).
As a result, it is not possible, to date, to establish with certainty retrospectively, i.e. once the EPC has been lodged, whether a given building actually has nZEB characteristics. This is the case even if the individual records are available.

For path (B), it is therefore appropriate to make use of the direct "nZEB" marking (cross) on the EPC in order to identify the subset of nZEBs that form part of all the buildings for which an EPC has been lodged.

Once nZEB records have been identified and selected, unlike path (A), having the EP data for each individual EPC, it is possible to conduct more accurate statistical analysis and observations.

Before identifying the threshold value, however, it should be remembered that the EP values corresponding to nZEBs with different intended uses may also be very different from each other. This depends on the specific features of each intended use[30], but also on the presence or absence of certain building services[31] or also on the fact that certain services may or may not be considered in the calculations[32]. This requires greater attention in the calculation of the threshold, since, without the application of any further filters, there would be the need to deal with a very heterogeneous sample. It is therefore recommended to apply greater clustering, which involves a further disaggregation of the sample by intended use. Next, it will be possible to identify the performance threshold on which to apply the 10% reduction as follows.

To do this, always bearing in mind that there is no single nZEB threshold value set by law, it is possible to proceed in various ways. For each cluster, it is possible to:

1) refer to the highest EP value among nZEBs;
2) refer to the average among nZEBs;
3) refer to the EP value corresponding to a certain percentile (e.g. excluding the worst 10%) among nZEBs.

In all three cases, a 10% reduction in performance should be applied. The first way, although correct and simple, has the disadvantage of identifying the highest possible threshold value, corresponding to an EPC of a specific building and not representative of the average building. In addition to this, the first method of selection is also more sensitive to mistakes in EPCs[33]. The second selection method is simple, but it could select an EP value corresponding to performances that are too high (this would not represent the "minimum" threshold but an average of the energy performance of the nZEBs). The third way is the one that is recommended, as it is closer to the concept of a minimum threshold, but at the same time

[30] For example: residential buildings, offices, schools, hospitals.
[31] For example: air conditioning may not always be present.
[32] It should be noted that under Italian law, lighting and transport (lifts and escalators) are considered only for non-residential buildings.
[33] EPCs lodged but prepared incorrectly or superficially.

excludes a distribution "tail" in which it is more likely that very specific (non-representative) buildings will fall as well as "off scale" values due to poorly prepared or superficial EPCs.

7. Possible disaggregation (filters)

7.1. General

As discussed, both the national SIAPE database and the various regional databases contain data for all the buildings for which an EPC has been lodged (for sale, rental or other reason). The databases therefore contain EPCs of all categories of building use. Only some specific types of buildings are excluded and therefore are not present in the databases, for which an EPC is not required (see section **Error! Reference source not found.**).

The following points detail the main possible types of disaggregation, i.e. the filters that can be used to obtain subsets of the databases that are uniform for a given property feature. The methodologies described in the previous chapters of this report can therefore be applied not only to the entire database but also to subsets of the database, depending on the type of information to be obtained[34].

At a general level, it should be considered that some types of disaggregation, such as the distinction between residential and non-residential buildings, are strongly recommended since an analysis carried out on the entire database would mean that buildings would be very different from each other in terms of use and characteristics.

On the other hand, it is also necessary to consider that too deep a disaggregation could lead, for example, to certain categories of buildings, such as hospitals, swimming pools and gyms, cinemas and theatres, etc., having an insufficient sample in numerical terms to guarantee an acceptable significance of the results obtained. However, the sample size and significance should increase over the years, as the information uploaded into the databases increases.

The possible types of disaggregation are shown in the following points, distinguishing between those for the SIAPE portal and those for the complete regional databases, if they are public.

7.2. Possible types of disaggregation for the SIAPE portal

7.2.1. Geographical analysis

[34] With a few exceptions (described in the following points), with reference to the geographical analysis, for which certain information is not available from the SIAPE portal.

The first possible type of disaggregation using the SIAPE portal is on a geographical basis. It is possible to select only EPCs for an individual region or autonomous province[35] and, if necessary, go down to the individual province level.

It should be pointed out, however, that this type of filter, although present on the SIAPE portal, does not allow access to EP data for an individual energy class, making it impossible to apply the above methodologies[36]. This limitation, however, is not considered to be significant or have an impact for the purposes of the analysis and this study. In fact, it is considered that the geographical disaggregation by province (or by region) is much less significant from the point of view of energy performance than the disaggregation by climate zone (described below), since the former is a purely administrative subdivision that does not significantly impact[37] energy performance.

7.2.2. Climate zone

The climate zone can be selected either on the "Property features" (*Caratteristiche degli immobili*) page or on the "Emissions and Performance Indexes" (*Indici di prestazione ed emissioni*) page. The latter is the area containing the data of interest for the analysis referred to in the methodologies set out in this report.

Italy is currently divided into six climate zones, ranging from climate zone A (the hottest) to climate zone F (the coldest).

The subdivision into climate zones is carried out on a municipality level, based on degree days. This means that for every Italian municipality, the degree days are calculated and a climate zone assigned. Looking in more detail:

Zone A: municipalities with a number of degree days not exceeding 600;
Zone B: municipalities with a number of degree days greater than 600 and not greater than 900;
Zone C: municipalities with a number of degree days greater than 900 and not exceeding 1,400;
Zone D: municipalities with a number of degree days greater than 1,400 and not exceeding 2,100;

[35] The autonomous provinces of Trento and Bolzano are placed (and selectable) at a regional level.
[36] This is currently a limitation of the portal. However, it was considered appropriate to mention this disaggregation as it is not excluded that in the future the portal may be revised/expanded to include such data.
[37] It is possible that the regulations in force in some regions or autonomous provinces, if more stringent than the national legislation, could lead to different energy performances, since the minimum energy requirements are more stringent. However, given that most EPCs are prepared for existing buildings, which are therefore not subject to any minimum requirement, it is considered that any geographical differences in regulatory terms would not significantly impact such a statistical analysis.

Zone E: municipalities with a number of degree days greater than 2,100 and not exceeding 3,000;

Zone F: municipalities with a number of degree days of greater 3,000.

The list of municipalities and their degree days is contained in Italian Presidential Decree 412/93 **[9]**. Note: it is possible, and has already occurred over the years, that, following geographical aggregation or disaggregation, some municipalities may be merged or divided. In this case, the decree states that the degree days must be recalculated and communicated to ENEA. Such rare cases, however, are not critical to the analyses referred to in this report.

When analysing data by climate zone, it should be borne in mind that currently[38] only certain regions are present in SIAPE. Therefore, considering the relationship between regions and climate zones, it should be borne in mind that some climate zones may not guarantee a sufficient sample for analysis or not have any EPCs at all.

The regions currently present in SIAPE are:

- Abruzzo,
- Calabria,
- Emilia-Romagna,
- Friuli-Venezia Giulia,
- Lazio,
- Liguria,
- Lombardy,
- Piedmont,
- Province of Trento,
- Province of Bolzano,
- Umbria.

The following table shows a matrix of regions and climate zones, with the number of EPCs currently present in SIAPE by region.

Table 5 – EPC distribution (currently in SIAPE) by region and according to climate zone

[38] On 15/12/2021, the SIAPE portal reported the data of the incorporated EPCs until 31/12/2020.

Regions or autonomous provinces	EPCs in SIAPE as of 31/12/2020	Distribution %	Climate zones in regions or autonomous provinces					
			F	E	D	C	B	A
Abruzzo	80425	4.1%	X	X	X	X		
Basilicata	0	0.0%		X	X	X		
Calabria	24133	1.2%	X	X	X	X	X	
Campania	0	0.0%	X	X	X	X		
Emilia Romagna	954	0.0%	X	X	X			
Friuli Venezia Giulia	66641	3.4%	X	X	X			
Lazio	338850	17.5%	X	X	X	X		
Liguria	129886	6.7%	X	X	X	X		
Lombardy	900556	46.5%	X	X	X			
Marche	0	0.0%		X	X	X		
Molise	0	0.0%	X	X	X	X		
Piedmont	281988	14.5%	X	X				
Province of Bolzano	14013	0.7%	X	X				
Province of Trento	29907	1.5%	X	X				
Puglia	1710	0.1%		X	X	X		
Sardinia	0	0.0%		X	X	X	X	
Sicily	0	0.0%	X	X	X	X	X	X
Tuscany	0	0.0%	X	X	X	X		
Umbria	69305	3.6%		X	X			
Aosta Valley	0	0.0%	X	X				
Veneto	0	0.0%	X	X	X			

7.2.3. Intended use (residential and non-residential)

As far as the intended use is concerned, buildings can first be divided into two main categories: residential and non-residential buildings. In this respect, with reference to Italian Presidential Decree 412/93 **[9]**, which provides a general classification of buildings by category, listed in the next section, the following should be specified.

The above mentioned decree identifies category E.1 as "residential buildings and similar". These are in turn divided into three subcategories:

- E.1 (1) dwellings used as permanent residences, including private dwellings and farmhouses, colleges, convents, prisons, and barracks;
- E.1 (2) dwellings used as temporary residences, such as holiday homes, weekend homes and similar;
- E.1 (3) buildings used as hotels, guest houses and similar activities.

As may be expected, for the purposes mentioned in Italian Ministerial Decree of 26 June 2015 **[5]** and also for the statistical purposes of SIAPE and the regional databases, the treatment of a series of buildings such as hotels, prisons, barracks, etc. as residential buildings can create some problems. For this reason, the Ministry of Economic Development (MISE) clarified the matter with a series of FAQs **[8]**, specifying that for the purposes of the EPC and within the framework of Interministerial Decree of 26 June 2015, the following subcategories are considered as "non-residential" buildings:

- E.1.(1) *bis*: colleges, convents, prisons, barracks;

- E.1.(3): buildings used as hotels, guest houses and similar activities.

Only the following subcategories are considered as “residential”:

- E.1 (1) dwellings used as permanent residences, including private dwellings and farmhouses;
- E.1 (2) dwellings used as temporary residences, such as holiday homes, weekend homes and similar.

7.2.4. General classification of buildings by category

As mentioned in the previous point, Italian Presidential Decree 412/93 [8] provides a general classification of buildings by category. The classification is as follows:

- E.1 Residential buildings and similar:
    - E.1 (1) dwellings used as permanent residences, including private dwellings and farmhouses, colleges, convents, prisons, and barracks;
    - E.1 (2) dwellings used as temporary residences, such as holiday homes, weekend homes and similar;
    - E.1 (3) buildings used as hotels, guest houses and similar activities;
- E.2 Buildings used as offices and similar: public or private, detached or adjoining buildings also used for industrial or workshop activities, provided they are separate from such constructions for the purposes of thermal insulation;
- E.3 Buildings used as hospitals, clinics or nursing homes and similar establishments, including those used for the admission or treatment of minors or elderly persons and supported accommodation for the care and rehabilitation of drug addicts and other persons entrusted to public social services;
- E.4 Buildings used for recreational or religious activities and similar:
    - E.4 (1) including cinemas and theatres, conference meeting venues;
    - E.4 (2) including exhibition venues, museums and libraries, places of worship;
    - E.4 (3) including coffee bars, restaurants, dance halls;
- E.5 Buildings used for commercial and similar activities: including shops, wholesale or retail stores, supermarkets, showrooms;
- E.6 Buildings used for sports activities:
    - E.6 (1) swimming pools, saunas and similar;
    - E.6 (2) gyms and similar;
    - E.6 (3) support services for sports activities;
- E.7 Buildings used for all levels of educational activities and similar;
- E.8 Buildings used for industrial and workshop activities and similar.

Apart from what has already been described in the previous point as regards residential and similar buildings, it is appropriate, by looking at the list of categories, to consider that sometimes the **subcategories** can also be important and decisive for energy consumption analysis, since the same category can also include very different buildings. For example, let’s consider category E.4, comprising cinemas and theatres, museums and exhibition venues, as well as coffee bars and restaurants. In this case, the breakdown by category type (recreational and leisure venues) is not sufficient to distinguish between the buildings from an energy performance point of view.

Therefore, it is always advisable to refer to the subcategories for energy analysis. The SIAPE portal allows this disaggregation by subcategory.

The only critical issue that can occur as a result of filtering by subcategory is the **small sample size** of EPCs currently in the databases. Even at a national level, including all the regions currently connected to SIAPE, it is important to consider that few EPCs have been carried out for some types of buildings so far. This is due both to the small number of buildings present in the country, and because buildings belonging to some categories are rarely subject to sale, rental or renovation works, for which an EPC is required.

As an example, the following table shows the number of EPCs currently in the SIAPE database by intended use.

Table 6 – Number of EPCs by subcategory (intended use) [39]

Intended use (DPR 412/93 categories)	Number of EPCs	%
E.1 (1) dwellings used as permanent residences, including private dwellings and farmhouses;	1619339	83.54%
E.1. (1) *bis*: colleges, convents, prisons, barracks;	972	0.05%
E.1 (2) dwellings used as temporary residences, such as holiday homes, weekend homes and similar;	35106	1.81%
E.1 (3) buildings used as hotels, guest houses and similar activities;	4250	0.22%
E.2 Buildings used as offices and similar: public or private, detached or adjoining buildings also used for industrial or workshop activities, provided they are separate from such constructions for the purposes of thermal insulation;	66737	3.44%
E.3 Buildings used as hospitals, clinics or nursing homes and similar, including those used for the admission or treatment of minors or elderly persons and supported accommodation for the care and rehabilitation of drug addicts and other persons entrusted to public social services;	2273	0.12%
E.4 (1) including cinemas and theatres, conference meeting venues;	894	0.05%
E.4 (2) including exhibition venues, museums and libraries, places of worship;	591	0.03%
E.4 (3) including coffee bars, restaurants, dance halls;	14558	0.75%
E.5 Buildings used for commercial and similar activities: including shops, wholesale or retail stores, supermarkets, showrooms;	119606	6.17%
E.6 (1) swimming pools, saunas and similar;	240	0.01%
E.6 (2) gyms and similar;	1608	0.08%
E.6 (3) support services for sports activities;	663	0.03%
E.7 Buildings used for all levels of educational activities and similar;	4209	0.22%
E.8 Buildings used for industrial and workshop activities and similar.	67302	3.47%
TOTAL	**1938348**	**100.00%**

As can be seen from the previous table, the abovementioned issue mainly concerns some non-residential categories. It should also be considered that in the previous extraction no filter was applied in addition to the intended use. Therefore, by applying a further filter, such as the climate zone, this issue is exacerbated.

As a general rule, for energy analysis, regardless of the database examined, it is considered that the minimum number of EPCs (**the sample**) for an analysis with an acceptable degree of significance is **100**. In addition, a necessary condition for applying Path A is that there is at least one EPC per energy class.

7.2.5. New builds

Using the SIAPE portal, it is possible to select and perform analyses on newly constructed buildings. This filter is possible through the parameter "EPC reason" for which the EPC was prepared, as declared by the assessor. Possible reasons include:

- New build;
- Transfer of ownership;

[39] Database query carried out on 03/12/2021.

- Rental;
- Major renovation;
- Energy efficiency upgrading;
- Other.

This distinction/disaggregation is considered to be of some importance for energy analyses and for this reason has been mentioned in this report. However, following an analysis carried out on the SIAPE portal, it is considered that there is currently insufficient reliability for this type of information to allow analysis without further cleaning of the data.

Table 7 – Number of new build EPCs by energy class [40]

Energy class	Number of EPCs	% Distribution
A4	18582	24.6%
A3	16660	22.1%
A2	14385	19.1%
A1	12207	16.2%
B	5475	7.3%
C	2656	3.5%
D	1622	2.2%
E	1130	1.5%
F	1074	1.4%
G	1608	2.1%
Total	75399	100.0%

As can be seen from the previous table, it currently appears that a not inconsiderable number of EPCs are in any case in low-efficiency energy classes, despite being for new builds.

In this respect, while it should be said that there are no direct specific requirements as regards the energy classification of new buildings, it is undoubtedly possible to state that compliance with all the minimum requirements in force at a national level since October 2015 in terms of both energy efficiency and the use of renewable energy sources, should automatically lead a new building to have a high energy class (A and B).

In conclusion, to be able to use this type of filter in the analysis, it is recommended to take into account only the values for buildings in classes A and B.

7.2.6. Year of construction

In addition and complementary to the “EPC reason” filter, it is also possible to disaggregate the SIAPE database by year of construction. The time periods considered by the SIAPE portal are as follows:

- Before 1945
- 1945 – 1972

[40] Database query carried out on 03/12/2021.

- 1973 – 1991
- 1992 – 2005
- 2006 – 2015
- After 2015

These time periods are not random; the chosen dates correspond to the issuing of the most important national laws on energy efficiency in buildings.

The same issue highlighted for the new build filter applies to this disaggregation, i.e. that there is currently a not inconsiderable number of EPCs with a year of construction after 2015 which, despite this, fall into inefficient energy classes. Once again, to be able to use this type of filter in the analysis, it is recommended to consider only the values for buildings in classes A and B.

7.3. Possible disaggregation with disaggregated databases

Starting from a comprehensive, disaggregated database, i.e. containing all the information relating to each individual EPC, it is certainly possible to carry out all the possible types of disaggregation described in the previous chapter as regards the SIAPE portal. It is considered that such filters are also sufficient for the appropriate clustering of buildings in relation to the objectives of this analysis.

With a comprehensive, disaggregated database, it is also possible to make selections (extractions) with greater granularity (e.g. by municipality or for a more limited range of year of construction). Even if this option were to exist, it is nevertheless advisable to maintain the same levels as those shown for the SIAPE portal (e.g. by province, for the geographical analysis). This is because by going to a lower level, the sample would be restricted, with the resulting risk of decreasing the robustness of the result, against a debatable increase in the significance and precision of the analysis.

In conclusion, as shown, the use of a disaggregated database would lead to a more accurate determination of the thresholds that have been targeted for identification, but from the point of view of the clustering of the building stock would be no different from what is possible today with the SIAPE portal.

8. Conclusions

The thresholds that identify the *green* share of the Italian building stock differ according to the year of construction of the property (pre- and post-2021 as per the Taxonomy), the climate zone, and intended use. The results of the analyses carried out with specific reference to climate zones E and F show a significant difference between the thresholds obtained through path A (applied to the data available on the SIAPE portal) and path B (applied to the open data of the Autonomous Province of Trento).

In conclusion, multiple thresholds are defined which differ according to the data used, data quality, and any data quality processes applied. Below are the results for residential buildings (the difference is even more marked for non-residential buildings).

Table 8 – Top 15% threshold comparison – residential buildings

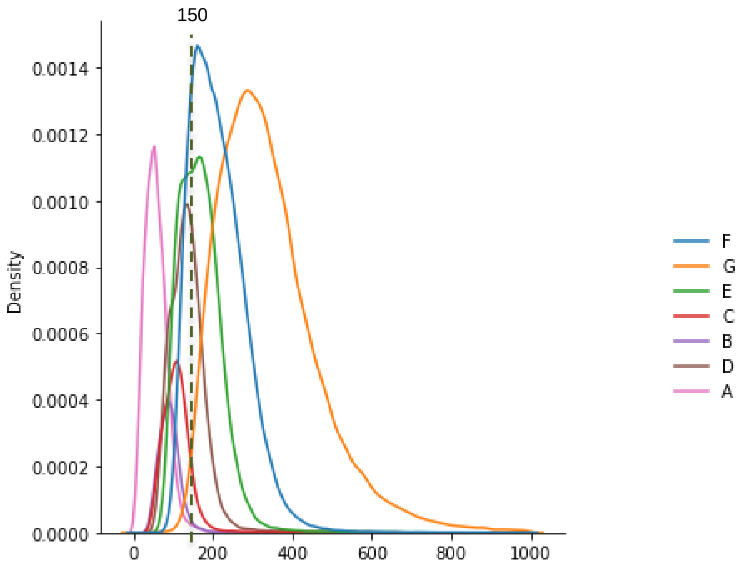
TOP 15% THRESHOLD	from SIAPE Portal	from Trento open data
Climate zone F	151.2 kWh/m^2 year	95.2 kWh/m^2 year
Climate zone E	137.3 kWh/m^2 year	81.9 kWh/m^2 year

Apart from a clear difference in the methodologies adopted, it is also possible that there is a difference linked to the characteristics of the area, as well as to the real estate market and the sensitivity toward energy efficiency issues. For these reasons, and because of the periodic updating of the SIAPE portal, regulatory developments, and the increasing attention towards energy consumption, an annual update of the thresholds is a must in order to redefine the perimeter of energy-efficient and therefore *green* buildings.

Another conclusion regards the methodology: a simple analysis on the SIAPE dashboard and Trento open data do not allow for the identification of threshold values according to the EU Taxonomy and Delegated Acts of Regulation (EU) 2020/852. As an example, identifying the NZEB-10% threshold for hotels, the knowledge of the real estate market, and EPC regulation is crucial. A mere data analysis is not enough because of few data and heterogeneity of the sample. The result of this work has made it possible to identify thresholds for all climate zones thanks to the evaluations of experts in the real estate sector, since the data available, with particular reference to specific building types and/or climate zones, is insufficient for a robust analysis without the above-mentioned expertise. All investigations were carried out on energy performance certificates in accordance with current legislation. However, the thresholds will also be applied to certificates prepared using calculation methods dating back to before 2015 and before the introduction of the new Italian legislation for the energy efficiency of buildings (some of these certificates are valid until 2025).

It is also important to underline how in the Italian real estate market, the increasing attention to the expected consumption (PED) of a property makes communication more complex in terms of energy efficiency (or energy efficiency class) of the building. Indeed, the class shown on the certificate summarises the relative efficiency of a property well (see section 3.3), but that could be contradicted by the assessment and/or analysis of the expected consumption in absolute terms: properties in class ‘B’ could be labelled as *brown* if they are above-threshold with respect to the PED, while properties with label ‘G’ could be below-threshold in terms of PED and therefore considered *green*. As shown in figure 13 a threshold of 100 kWh/m2 would include residential buildings with all possible labels (from 'A' to 'G'), excluding a small portion of buildings in 'A'.

Figure 13 – CRIF’s elaboration on residential EPCs - CENED data – December 2021



For new buildings and the *NZEB-10%* threshold, the lack of a national PED threshold for these buildings makes it necessary to establish one outside the regulatory framework, in a scenario where properties labelled as nearly zero-energy buildings represent less than 0.1% of the entire Italian building stock as of the date of writing of this document.

The identified thresholds are as follows:

Residential properties			Climate zone					
			A	B	C	D	E	F
Type of threshold	Year of construction	Label A						
	<=2020	TOP 15% - PED	65	65	70	75	100	105
	>2020	NZEB – 10%	45	45	50	55	70	70

Commercial properties			Climate zone					
			A	B	C	D	E	F
Type of threshold	Year of construction	Label A						
	<=2020	TOP 15% - PED	250	250	260	260	270	270
	>2020	NZEB – 10%	150	150	160	160	180	180

Properties used as offices			Climate zone					
			A	B	C	D	E	F
Type of threshold	Year of construction	Label A						
	<=2020	TOP 15% - PED	160	160	170	180	180	180
	>2020	NZEB – 10%	105	105	110	115	120	120

Properties for tourist-hotel use			Climate zone					
			A	B	C	D	E	F
Type of threshold	Year of construction	Label A						
	<=2020	TOP 15% - PED	270	270	280	280	290	300
	>2020	NZEB – 10%	180	180	190	190	200	210

Buildings for Workshop-Industrial-Agricultural use			Climate zone					
			A	B	C	D	E	F
Type of threshold	Year of construction	Label A						
	<=2020	TOP 15% - PED	170	170	170	180	180	180
	>2020	NZEB – 10%	110	110	115	115	120	125

Other commercial properties			Climate zone					
			A	B	C	D	E	F
Type of threshold	Year of construction	Label A						
	<=2020	TOP 15% - PED	250	250	270	275	280	300
	>2020	NZEB – 10%	150	150	160	165	170	175

9. Bibliografia e riferimenti normativi

[1] **Direttiva 2010/31/UE** del parlamento europeo e del consiglio del 19/05/2010 sulla prestazione energetica nell'edilizia (rifusione).

[2] **Direttiva 2018/844/UE** del parlamento europeo e del consiglio del 30 maggio 2018 che modifica la direttiva 2010/31/UE sulla prestazione energetica nell'edilizia e la direttiva 2012/27/UE sull'efficienza energetica.

[3] **Decreto Legislativo 19 agosto 2005, n. 192** "Attuazione della direttiva (UE) 2018/ 844, che modifica la direttiva 2010/31/UE sulla prestazione energetica".

[4] **Decreto Legislativo 10 giugno 2020, n, 48** "Attuazione della direttiva (UE) 2018/844 del Parlamento Europeo e del Consiglio, del 30 maggio 2018, che modifica la direttiva 2010/31/UE sulla prestazione energetica nell'edilizia e la direttiva 2012/27/UE sull'efficienza energetica".

[5] **Decreto 26 giugno 2015** del Ministero dello Sviluppo Economico "Applicazione delle metodologie di calcolo delle prestazioni energetiche e definizione delle prescrizioni e dei requisiti minimi degli edifici".

[6] **Decreto 26 giugno 2015** del Ministero dello Sviluppo Economico **"**Adeguamento del decreto del Ministro dello sviluppo economico, 26 giugno 2009 - Linee guida nazionali per la certificazione energetica degli edifici".

[7] **Decreto Legislativo 3 marzo 2011, n 28** "Attuazione della direttiva 2009/28/CE sulla promozione dell'uso dell'energia da fonti rinnovabili, recante modifica e successiva abrogazione delle direttive 2001/77/CE e 2003/30/CE".

[8] **Domande frequenti - Documento del 21 ottobre 2015** (FAQ - APE e requisiti minimi) (n.d.r.: prima serie di Faq).

[9] **Decreto del Presidente della Repubblica 26 agosto 1993, n. 412** "Regolamento recante norme per la progettazione, l'installazione, l'esercizio e la manutenzione degli impianti termici degli edifici ai fini del contenimento dei consumi di energia, in attuazione dell'art. 4, comma 4, della legge 9 gennaio 1991, n. 10".

[10] **UNI/TS 11300-1** “Prestazioni energetiche degli edifici Parte 1: Determinazione del fabbisogno di energia termica dell’edificio per la climatizzazione estiva ed invernale”.

[11] **Decreto del Presidente della Repubblica 16 aprile 2013, n. 74**. Regolamento recante definizione dei criteri generali in materia di esercizio, conduzione, controllo, manutenzione e ispezione degli impianti termici per la climatizzazione invernale ed estiva degli edifici e per la preparazione dell'acqua calda per usi igienici sanitari, a norma dell'articolo 4, comma 1, lettere a) e c), del decreto legislativo 19 agosto 2005, n. 192.

[12] **Ricerca di sistema elettrico - Studio sui parametri tecnici dell’edificio di riferimento e requisiti energetici minimi degli impianti d’illuminazione, degli ascensori e delle scale mobili** - G. Murano, R. Nidasio, A. Panvini, L. Terrinoni, - Report RdS/2016/128 - settembre 2016.

[13] **Decreto Legislativo 8 novembre 2021, n. 199** - Attuazione della direttiva (UE) 2018/2001 del Parlamento europeo e del Consiglio, dell'11 dicembre 2018, sulla promozione dell'uso dell'energia da fonti rinnovabili.