

# Zero-emission Building: What could be?



**LIVIO MAZZARELLA**

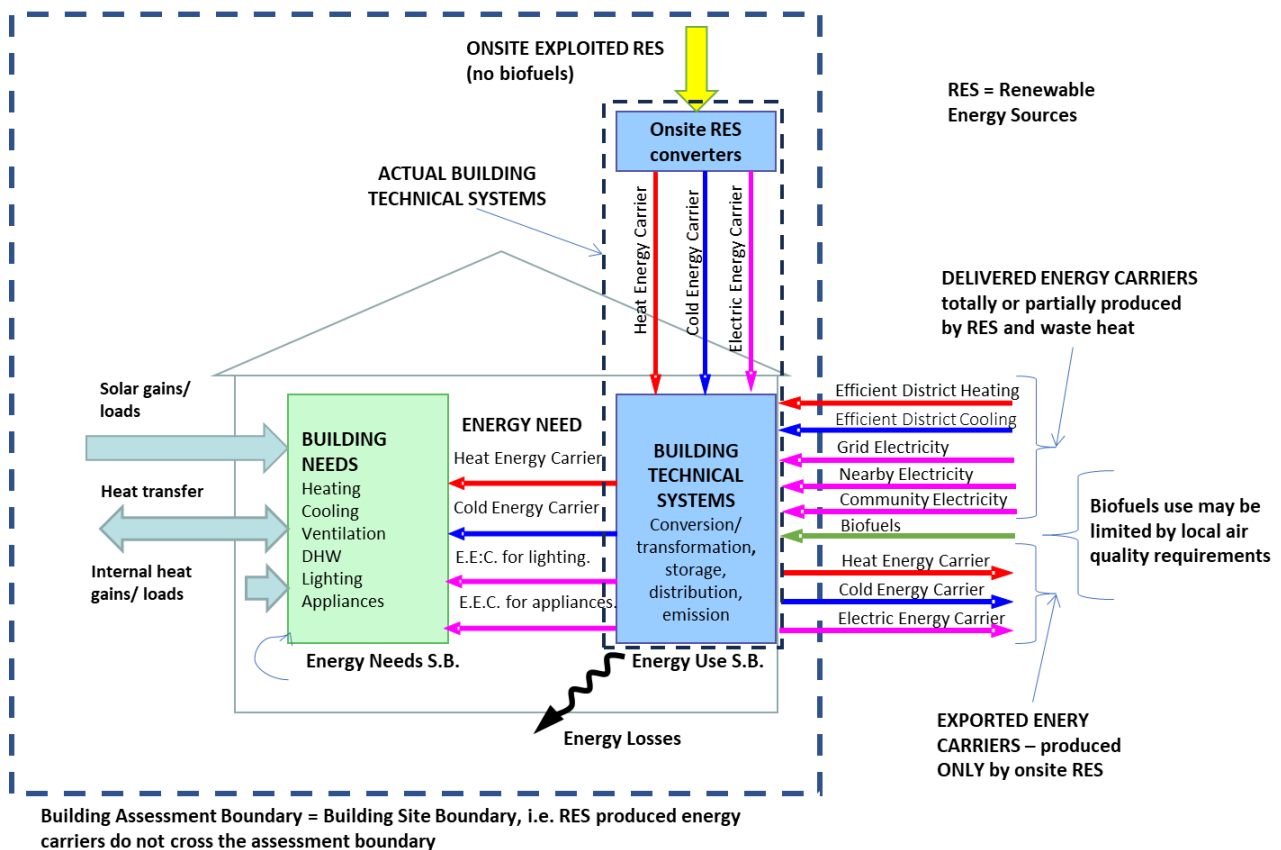
Department of Energy,  
Politecnico di Milano, Milan  
livio.mazzarella@polimi.it

Keywords: EPBD, ZEB, NZEB, renewable energy, primary energy, GWP

With the publication of the “Renovation Wave” strategy in October 2020, the European Union set itself the challenging goal of doubling the annual rate of renovation of existing buildings by 2030, while increasing the share of deep renovations. In order to achieve these objectives, the European Commission has deemed it necessary to revise the current EPBD, 2018/844/EU (European Commission, 2018). The review activity is part of the

Commission’s “Fit for 55” plan proposed in July 2021, which provides for the reduction of CO<sub>2</sub> emissions by 55% by 2030, and then reach climate neutrality by 2050. 13 documents have already been published, including proposals to revise the Renewables and Energy Efficiency Directives and the extension of the Emission Trading Scheme (ETS) to the transport and buildings sectors; in particular, the EPBD was published in December, together with the gas market reform one.

## ZERO EMISSION BUILDING



In the EU, buildings are responsible for 40% of total energy consumption and 36% of direct and indirect energy-related greenhouse gas emissions. In addition, heating, cooling and domestic hot water production services account for 80% of the energy consumed by households.

The decarbonisation of the construction sector is therefore key to achieving the climate and energy targets set for 2030 and 2050 by Europe from the Green Deal. In fact, the plan for the climate target identifies the need to reduce greenhouse gas emissions in buildings by about 60% in order to achieve the overall emission reduction target of 55% by 2030 and all this involves at least a doubling of the renovation rates of the existing building stock.

### The complexity of the European legislative procedure: the trilogue

In the context of the ordinary legislative procedure of the European Union, the *trilogue* is an informal interinstitutional negotiation bringing together representatives of the European Parliament, the Council of the European Union and the European Commission. Each new directive or its revision is subject to this formal procedure, which begins with a proposal from the European Commission and continues with a collection of views on this proposal by the various advisory bodies of the European Union, such as the European Economic and Social Committee (EESC), which represents the economic categories expressing economic interests, social and cultural issues in the respective EU countries, and the European Committee of the Regions (CoR), which brings together local and regional representatives of the European Union (regions, provinces, municipalities, etc.). Subsequently, the proposal and opinions are forwarded to both the Council and Parliament, which make changes and amendments, independently. In fact, for Parliament, the preparatory work is carried out by its specific permanent body, which in the case of the revision of the EPBD is the Committee on Industry, Research and Energy (ITRE), and only when this activity is finished, the resulting text is brought to Parliament for first reading. For the Council, it is the secretariat of the Presidency that is responsible for managing the internal discussion between the governments of the member countries in order to arrive at the formulation of an amended text, which is labeled as a “compromise proposal by the President of the Council”.

Any provisional agreement reached in trilogues as mentioned above is informal and must therefore be

approved in accordance with the formal procedures applicable within each of the two institutions.

### The Commission’s proposal

On 15 December 2021, the European Commission released its proposal to revise the Energy Efficiency of Buildings Directive. One of the most important innovations is present in the amendment of Article 1 Object, where the increase in the energy performance of buildings is accompanied by “the *reduction of greenhouse gases*”... “*to achieve a zero-emission building stock in 2050*”. To achieve this new goal, in Article 2 “Definitions” the definition of the **zero-emission building (ZEB)** is introduced:

*“very high energy performance building, as determined in accordance with Annex I, where the very low amount of energy still required is fully covered by energy from renewable sources generated on-site, from a renewable energy community within the meaning of Directive (EU) 2018/2001 [Amended RED] or from a district heating and cooling system, in accordance with the requirements set out in Annex III; “*

definition that complements a slightly modified definition of the **nearly zero energy building (NZEB)**:

*“very high energy performance building, as determined in accordance with Annex I, which cannot not be below the 2023 cost-optimal level reported by Member States in accordance with Article 6(2) and where the nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby; “*

whose reference article, art. 9 of the EPBD of 2010 (European Commission. 2010), however, is deleted to avoid having a double performance verification in respect to both the ZEB and the NZEB.

Three other definitions are also introduced to quantify the level of atmospheric pollution emissions of a building; specifically:

**operational greenhouse gas emissions:** “*greenhouse gas emissions associated with the energy consumption of the technical building systems during the use and operation of the building*”;

**whole life-cycle greenhouse gas emissions:** “*combined greenhouse gas emissions associated with the building at all stages of the life-cycle, starting from the “cradle” (the*

extraction of raw materials that are used in the construction of the building) over the material production and processing, and the building's operation stage, to the "grave" (the deconstruction of the building and reuse, recycling, other recovery and disposal of its materials)";

**Life-cycle Global Warming Potential (GWP):** "an indicator which quantifies the global warming potential contributions of a building along its full life-cycle".

As reported in the definition of the ZEB (zero emission building), the technical specifications identifying this building can be found in Annex III, which states:

- I. Requirements for zero-emission buildings
- II. Calculation of life-cycle global warming potential (GWP) of new buildings pursuant to Article 7(2) [1]

In the requirements is reported that "the *total annual primary energy use of a new zero-emission building shall comply with the maximum thresholds indicated in the table below [2]*", i.e., for example, for the Mediterranean climate zone, less than 60 kWh/(m<sup>2</sup>y) for residential buildings, less than 70 kWh/(m<sup>2</sup>y) for office buildings, and for all other buildings lower than the total primary energy use established at the Member State level for the nearly zero-energy building.

It is also specified that, this "*total annual primary energy use of a zero-emission building, new or renovated, shall be fully covered, on a net annual basis, by*":

- *energy from renewable sources generated on-site and fulfilling the criteria of Article 7 of Directive (EU) 2018/2001 [amended RED],*
- *renewable energy provided from a renewable energy community within the meaning of Article 22 of Directive (EU) 2018/2001 [amended RED], or*
- *renewable energy and waste heat from an efficient district heating and cooling system in accordance with Article 24(1) of Directive (EU).../... [recast of the EED].*

*A zero-emission building shall not cause any on-site carbon emissions from fossil fuels.*

*Only where, due to the nature of the building or lack of access to renewable energy communities or eligible district heating and cooling systems, it is technically not feasible to fulfil the requirements under the first paragraph, the total annual primary energy use may also be covered by energy from the grid complying with criteria established at national level.*

Synthetically, it can therefore be said that the zero-emission building defined here is a building that has:

- a) a total annual primary energy demand below a predetermined threshold value;
- b) covered by energy (better, energy carriers) produced from renewable sources, either on site or nearby (energy communities and district heating/cooling);
- c) no on-site production of CO and CO<sub>2</sub> emissions from fossil fuels.

If, for reasons of technical impossibility, requirement (b) cannot be met, it is then permitted to be met by using energy "*from the grid complying with criteria established at national level*".

These requirements are not free from ambiguities and inconsistencies, the main one being:

- **which primary energy?** total, non-renewable or renewable; having been assigned a numerical value it is necessary that it is clear to which quantity reference is made! This ambiguity is never clarified throughout the text. To date, all European states have adopted non-renewable primary energy to define the energy performance of the building with the exception of Italy, but by deduction from what is reported in Annex III it emerges that here reference is made to total primary energy or renewable primary energy, if we consider the total exclusion of non-renewable energy sources.

In addition, it seems that the technical impossibility clause may be satisfied only by off-site produced electricity, being the term "grid" usually used for the electric network only (excluding then district heating or cooling).

Finally, it would be necessary to clarify what is meant by annual consumption "*on a net annual basis*": balance between import and export of energy carriers?

1 The "trilogue" agrees that the GWP over the life cycle of buildings of new construction is an indicative LCA analysis, to be reported in the performance energy certificate of a building and not a binding threshold.

2 It should be noted that the term "use" refers to an energy carrier supplied and measured.

## Efficient district heating and cooling

The proposal to revise the EED directive approved in September 2022 by Parliament, the subject of the trilogue with the Council and the Commission, provides the following definition:

- a) until 31 December 2027, a system using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat going into the network;
- b) from 1 January 2028, a system using at least 50% renewable energy, 50% waste heat, 80% of high-efficiency cogenerated heat or at least a combination of such thermal energy going into the network where the share of renewable energy is at least 5% and the total share of renewable energy, waste heat or high-efficiency cogenerated heat is at least 50%;
- c) from 1 January 2035, a system that uses at least 50% renewable energy and waste heat, where the share of renewable energy is at least 20%;
- d) from 1 January 2045, a system using at least 75 % renewable energy and waste heat, where the share of renewable energy is at least 40 %;
- e) from 1 January 2050, a system that uses only renewable energy and waste heat, in which the share of renewable energy is at least 60%.
- f) in line with the energy efficiency first principle, where the share of waste heat exceeds the criteria in points (c), (d) and (e), and where the waste heat would otherwise be lost, waste heat may replace any of the other energy sources;
- g) an assessment has been made of the maximum needed temperatures in distribution grid.

## The EU Council President's compromise proposal

On 21/10/2022 the European Council gave birth to its final version of the amended text compared to the Commission's proposal, after five revisions, with a small revision addition published on 24/10/2022.

The changes introduced by the Council's amendments are relevant even if they do not change the basic principles; in particular, the definition of the **zero-emission building** becomes:

*“Very high energy performance building, as determined in accordance with Annex I, requiring zero or a very low amount of energy, producing zero on-site carbon emissions from fossil fuels and producing zero or a very low amount of operational greenhouse gas emissions in accordance with the requirements set out in Article 9b.”*

In Annex III the part relating to the requirements for zero-emission buildings disappears completely, which is partly replaced by the new art. 9b where, however, it is left to the Member States to individually set the minimum performance thresholds, no longer established in the Directive. This Article reproduces almost entirely what is in part I of Annex III of the Commission proposal through the following paragraphs 1a and 2:

- 1a. *Member States shall ensure that the total annual primary energy use of a new or renovated zero-emission building is covered, where technically and economically feasible, by:*
  - a) *energy from renewable sources generated on-site or nearby, fulfilling the criteria of Article 7 of Directive (EU) 2018/2001 [amended RED];*
  - b) *energy from renewable sources provided by a renewable energy community within the meaning of Article 22 of Directive (EU) 2018/2001 [amended RED]; or*
  - c) *energy from an efficient district heating and cooling system in accordance with Article 24(1) of Directive (EU).../... [recast of EED];*
  - d) *energy from carbon-free sources*
2. *Member States shall ensure that a zero-emission building does not cause any on-site carbon emissions from fossil fuels.*

As it can be seen, the requirements in the Council document are practically identical to those formulated in the Commission proposal, except point (c) which is amended deleting the **condition that district heating and cooling systems be powered exclusively by renewable energy sources and waste heat** disappears, *regardless of the technical feasibility clause*. And except the additional point (d), which introduces the requirement that the used primary energy shall be provided by carbon-free sources (e.g. not only energy from renewable sources but also atomic energy from uranium fission). Since points a), b), c) and d) are

alternative, point d), as well as paragraph 2 below, do not prevent the current use of district heating and district cooling food partially from non-renewable primary energy produced by combustion of energy carriers from fossil sources.

All this explains the change in the definition of ZEB, in which the reference to the obligation to cover energy needs with primary energy from renewable sources has disappeared.

In the revision proposal, as amended by the Council, there is also a new article, 9.bis “Solar energy in buildings”, which commits member states “to ensure that all new buildings are designed to optimise their solar energy generation potential on the basis of the solar irradiance of the site, enabling the later cost-effective installation of solar technologies.”

Some of the inconsistencies already present in the Commission’s proposal remain present, such as ambiguity about which primary energy to consider for performance assessment (although in this case it could be said to be the total) and what is meant by annual consumption “on a net annual basis”.

### The Parliament amendments

In March 2023, the European Parliament discussed and approved in plenary session the ITRE proposed amendments with modifications.

A first amendment, which concerns the zero-emission building, definition has been quite modified and becomes:

*“a building with a very high energy performance, as determined in accordance with Annexes I and III, which contributes to the optimization of the energy system through demand-side flexibility, where any very low residual amount of energy still required is fully covered by energy from:*

- (a) *renewable sources generated or stored on-site;*
- (b) *renewable sources generated nearby off-site and delivered through the grid in accordance with Directive (EU) 2018/2001 [amended RED];*
- (c) *a renewable energy community within the meaning of Directive (EU) 2018/2001 [amended RED]; or*
- (d) *renewable energy and waste heat from an efficient district heating and cooling system within the meaning of Directive (EU).../... [recast EED], in accordance with the requirements set out in Annex III; “*

A new Article 9.a ‘Solar energy in buildings’ appears in the amendments tabled, which follows what is contained in the Council’s proposal for revision.

Annex III is then amended in the table showing the primary energy limit values to be respected in order to be able to consider the building as a ZEB, attributing to existing buildings the values of the table of the Commission proposal (new buildings), while the threshold for new buildings is deferred to a subsequent delegated act the Commission shall adopt by 1 January 2025.

Annex III is also amended in the sentence “total annual primary energy use of a zero-emission building, new or renovated, shall be fully covered, on a net annual or seasonal basis, by”:

- *energy from renewable sources generated or stored on-site and fulfilling the criteria of Article 7 of Directive (EU) 2018/2001 [amended RED],*
- *energy for self-consumption and joined self-consumption within the meaning of Directive (EU) 2018/2001 [amended RED] or local sharing of renewable energy production, including through a third-party market actor, or from a renewable energy community within the meaning of Article 22 of Directive (EU) 2018/2001 [amended RED], or*
- *renewable energy from district heating and cooling system or waste heat.”*

Where the two new items with respect to the Commission proposal are the **seasonal basis** and the **energy for self-consumption and joined self-consumption**.

Finally, the amended technical impossibility clause is maintained and expanded as follows:

*Where, due to the nature of the building or lack of access to renewable energy communities or renewable energy from district heating and cooling systems or waste heat, it is technically or economically not feasible to fully comply with the requirements under the first paragraph, the remaining share or all of the total annual primary energy use may also be covered by renewable energy from the grid, documented with power purchase agreements and renewable heating and cooling purchase agreements as referred to in Directive (EU) 2018/2001 [amended RED], or energy from an efficient district heating and cooling system in accordance with Article 24(1) of Directive (EU) .../... [recast EED]. The Commission shall issue guidance on how to implement and verify the above criteria with special attention to technical and economical feasibility. [Am. 67].*

Therefore, the current position held by the European Parliament is to consider the zero-emission building **as a building powered exclusively by energy carriers produced from renewable energy sources**, exploited on site or in other sites through distribution networks with a documented guarantee of origin, with the only exception introduced by the **efficient district heating and cooling system**.

### What will be the zero-emission building

It is currently difficult to predict what will be the outcome of the negotiations between the Commission,

the Council and the European Parliament to reach a text shared and approved by Parliament, since the positions on the definition of the zero-emission building are similar but different, as shown in the comparative table. A common negative element is however the absence of a clear definition of which primary energy must be used for the calculation of the performance of the building, even if, reasonably, the one that could meet the various requirements is the total, whose use alone is however not advisable because it prevents discriminating between systems that exploit more or less renewable sources with the same total. ■

ZERO EMISSION BUILDING REQUIREMENTS	Commission	Council	Parliament
Annual total primary energy requirements below a predetermined threshold value:	Directive	Member States	Directive
• New Buildings: values fixed by	YES		YES, but later
• Renovated Buildings: values fixed by	NO		YES
Annual total primary energy demand covered exclusively by renewable sources	Yes, if technically feasible.	NO	YES, always
Total annual primary energy requirement covered partially covered by fossil fuels	YES, if not T.F.	YES	NO
No on-site production of CO and CO <sub>2</sub> emissions from fossil fuels	YES	YES	YES
Is it clearly expressed that the primary energy for performance evaluation is total?	NO	NO	NO
Guarantee of origin	YES	YES	YES

### Bibliography

European Commission, 2018. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 - Son the energy performance of buildings (recast). Official Journal of the EU Brussels.

European Commission, 2018. Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. Official Journal of the EU Brussels.

European Parliament – Committee on Industry, Research and Energy, 2022. DRAFT REPORT on the proposal for a directive of the European Parliament and of the Council on the energy performance of buildings (recast). Brussels, 6.6.2022, [https://www.europarl.europa.eu/doceo/document/ITRE-PR-732742\\_EN.pdf](https://www.europarl.europa.eu/doceo/document/ITRE-PR-732742_EN.pdf).

European Commission, 2021. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast). Brussels, 15.12.2021, <https://eur-lex.europa.eu/legal-content/IT/ALL/?uri=CELEX:52021PC0802>.

Council of the European Union, 2022. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) - General approach. Doc. 13280/22, Brussels, 21.10.2022, <https://data.consilium.europa.eu/doc/document/ST-13280-2022-INIT/it/pdf>.

Council of the European Union, 2022. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) - General approach. Doc. 13280/22 corrigenda, Brussels, 24.10.2022, <https://data.consilium.europa.eu/doc/document/ST-13280-2022-COR-1/it/pdf>.

European Parliament, 2022. European Parliament amendments, adopted on 14 September 2022, to the proposal for a directive of the European Parliament and of the Council on energy efficiency (recast). Brussels, 14.09.2022, [https://www.europarl.europa.eu/doceo/document/TA-9-2022-0315\\_IT.pdf](https://www.europarl.europa.eu/doceo/document/TA-9-2022-0315_IT.pdf).