The EPBD recast: *how to come to a transparent and fair ZEB definition*

DICK VAN DIJK
EPB Center expert, convenor of ISO/TC 205 & TC 163 Joint Advisory Group on the et of EPB standards (EN ISO 52000 family)
dick.vandijk@epb.center

JAREK KURNITSKI
REHVA Technology and Research Committee, Tallinn University of Technology

In the discussions on the definition and metrics for zero-emission buildings in the ongoing EPBD revision, several aspects have been covered in recent articles. In this article a new and simple metric is proposed that can be used for threshold values for "the very low energy demand" that is to be "fully covered by energy from renewable sources". It can be used to safeguard a highly energy efficient building and, in combination with the main overall energy performance indicator, to set out trajectories towards a true zero-emission building (ZEB).

Keywords: EPBD recast, zero-emission buildings, threshold values, energy performance indicator, hourly energy performance calculations

Introduction

In [2] Kurnitski addresses a variety of aspects of the EPBD recast proposal [1], including the definition of a zero-emission building (ZEB). More specifically, a series of calculation examples clearly demonstrate that ZEB threshold values should not be based on overall total primary energy (where "total" stands for all non-renewable *plus all renewable* primary energy, but on **overall non-renewable primary energy**.

In [3], Kurnitski and Zirngibl present additional examples that confirm the conclusions of [2] and where they continue with the focus on the impact of compensation of non-renewable primary energy use by export of surplus renewable energy generated on-site, as reward for replacing non-renewable electricity production in the grid. The EPBD proposal [1] states that for the threshold values the energy balance can be calculated on a "net annual basis"; ergo: non-renewable energy delivered to the building in winter can be 'covered' by a surplus of RE generated in summer. Kurnitski and Zirngibl conclude that the EPBD should be clear on this and replace the term "covered by RE" by "**compensated** by RE". At the same time Kurnitski and Zirngibl point to the fact that an **additional requirement** is needed for the quality of the building, to avoid that a bad building quality is masked by compensation with exported renewable energy.

In [4] Kurnitski and Hogeling take the logical next step by addressing the negative impact of this compensation. Their examples prove that due to compensation a poorly insulated building can obtain the same high energy performance as a highly insulated building. They conclude that for the threshold values the primary energy should be calculated as **non-renewable** primary energy with subtracting only the amount of PV that is **self-used and used in other on-site uses**. This implies that also **hidden compensation** for exported renewable energy has to be avoided. With monthly or annual calculation energy balances, due to the averaging over longer periods, **exported energy is disguised as self-use**. Monthly or annual calculation leads to an overoptimistic energy performance and the non-renewable energy that has to be delivered to the building is severely underestimated. They conclude that, as a consequence, hourly calculation methods should eventually be required to be taken into use in all Member States.

Compensation covers up non-renewable energy use

The question is, why **explicit** compensation (by rewarding exported renewable energy in the energy performance of a building) and **hidden** compensation (by monthly or "net annual basis" for the energy balance calculation) is not (yet) banned. Two reasons can be imagined:

(1) When there were only small amounts of renewable energy exported to the grid, these could be easily absorbed by the grid as a welcome renewable contribution, worth compensating by a reduction of the penalty for delivered non-renewable energy. But already nowadays we are faced with congestion in the grid: e.g. sunny hours where the price of electricity becomes even negative because the grid is overloaded with renewable energy from PV and wind.

(2) It is feared that in e.g. Nordic climate ZEB is not reachable in a cost-effective way without resorting to this compensation (see also [3]). For the reason shown under (1) there must be another way to tackle this problem, because compensation:
   - (a) gives the **false impression** that no (or less) non-renewable energy is used,
   - (b) leads to the **wrong incentives,** and
   - (c) does not recognize and appreciate **smart designs**, where supply and demand are better matched by local storage and/or smart control of energy using equipment and appliances.

By the way, expressing the energy performance in terms of CO_2 emission makes no difference, because the same compensation mechanisms apply when using fixed CO_2 weighting factors instead of primary energy ones. So, also for the carbon balance it is important to stress that there should be no implicit or explicit compensation.

Two problems, one solution: the residual energy to be delivered to the building site

So, two problems need to be solved:

- an **additional requirement** to safeguard the quality of the building is needed;
- if **truly ZEB** is not technically feasible, what would be a suitable metric, knowing that a ZEB based on compensation is not the way to proceed, because it obscures the goals and takes away the necessary triggers to progress towards real ZEB.

Let's go back to one of the key goals of the EPBD: "*The enhanced climate and energy ambition of the Union requires a new vision for buildings: the zero-emission building, the very low energy demand of which is fully covered by energy from renewable sources where technically feasible.*" ([1], recital 19).

A solution is to take "*the very low energy demand of the building which is to be fully covered by energy from renewable sources"* literally:

The building itself, as approached from the outside world, is as energy efficient as possible. This can be accomplished by limit values on the performance of the building envelope and technical building systems, complemented with a threshold value on -indeed- "*the very low amount of energy still required"*. This can be translated as the amount of residual energy needed for the EPB services that has **to be delivered 'from elsewhere'**: how much heat and electricity should be delivered to the building from nearby (e.g. district heating/cooling) or distant (e.g. public grid). This is illustrated in **Figure 1**.

A few notes at this point:

Note 1: it leaves open if the delivered energy is renewable or non-renewable: the thermal energy and/or electricity may be (partly) non-renewable **now**, but evolve to more renewable sources **later**, during the lifetime of the building. On the other hand, if not converted to primary energy we are comparing apples and oranges. So primary energy factors have to be assigned. Since dynamic (hourly) primary energy factors are currently not available, we see two alternative options here, either to use primary energy factors 1 (because in the end it should be all renewable), which *de facto* means: take the delivered energy (this would be in favour for on-site heat pumps) or, to use generic non-renewable primary energy factors (to treat district heat and on-site heat pumps on equal basis) or perhaps better: to use weighting factors that are tailored to the national trajectories towards ZEB. This is a subject for (national) fine-tuning.

Note 2: So, it includes (whatever kind of) **energy** that has to be **delivered "from elsewhere":** this strengthens its role as metric for an energy efficient building. Renewable energy needed from elsewhere is not taken for granted; it is not abundantly and freely available. While the optimum use of renewable energy sources available on-site is up to the owner of the building.

Note 3: No compensation for surplus of renewable energy produced on-site and exported to the grid[1]. Note (again) that in this metric, the "*very low amount of energy still required"* is really supposed to be **covered** and **not compensated** by renewable energy from 'elsewhere' (and yes: including the grid).

Note 4: According to EN ISO 52000-1 renewable energy produced on-site is also counted as energy delivered to the building through the assessment boundary[2]. When we take the *boundary for the residual energy still to be delivered*

1 In terms of the choices provided in EN ISO 52000-1 [6]: "$k_{exp}=0$"

2 EN ISO 52000-1 assessment boundary is marked as Energy use System Boundary in **Figure 1** and is still needed for the calculation of the complete energy balance.

to the building site, the RE produced, processed and used on-site is already taken into account. Note that this is in line with the philosophy of EN ISO 52000-1 [6] that states "*Inclusion or exclusion of energy contribution according to the perimeter (origin) depends on the calculation objective.*"

Note 5: A big positive side effect of this proposal is that there is **no need to separately assess how much renewable energy is produced, processed and used on-site**. No discussion on whether and how to take free cooling by night ventilation into account or on what

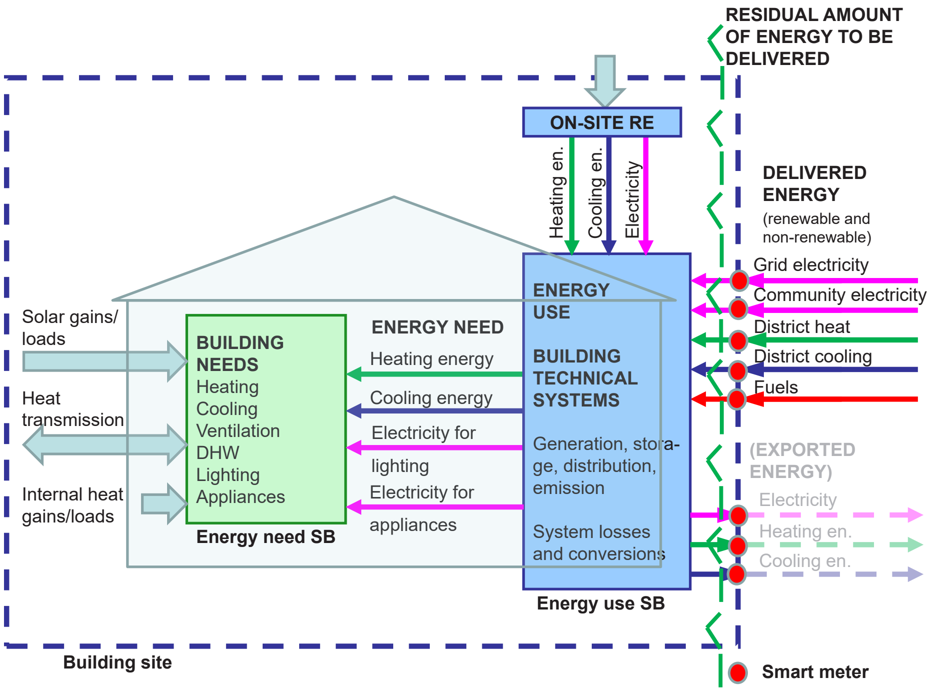
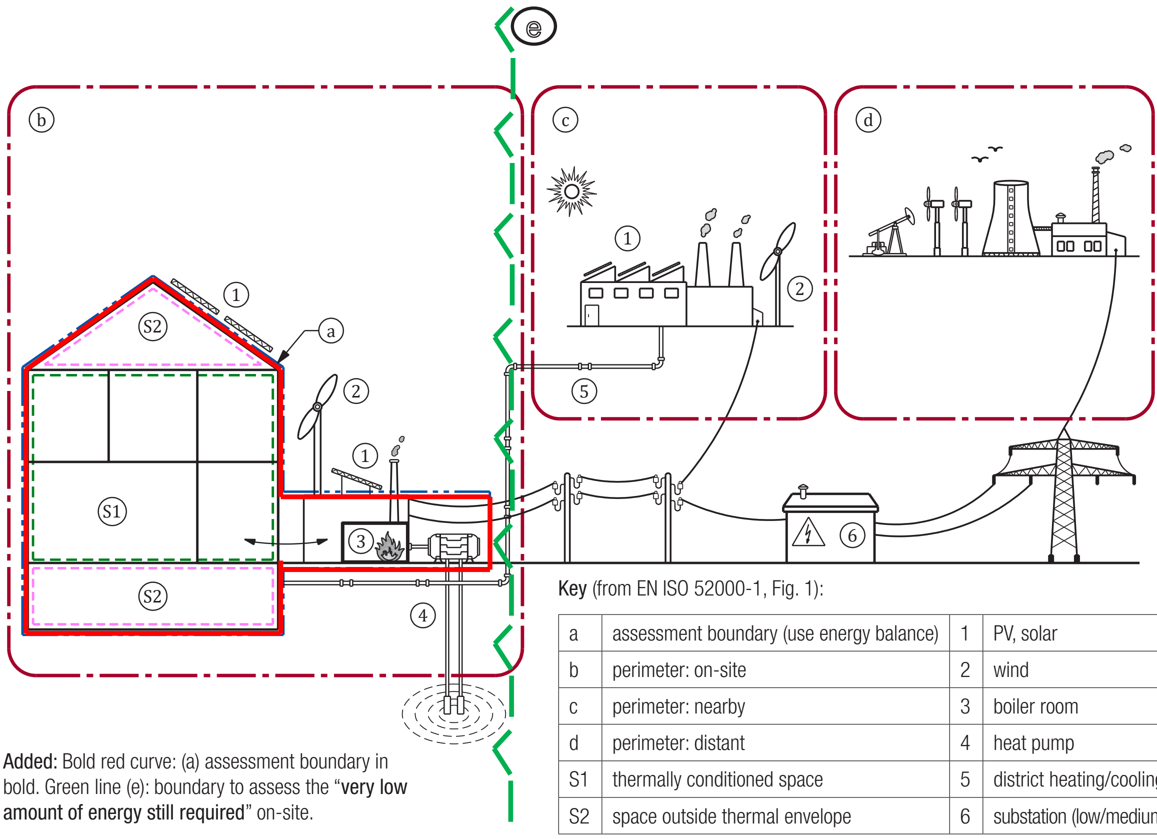


Figure 1. The **boundary** proposed as metric for the very low amount of energy still required, which for a ZEB is to be covered by renewable energy.



Key (from EN ISO 52000-1, Fig. 1):

a	assessment boundary (use energy balance)	1	PV, solar
b	perimeter: on-site	2	wind
c	perimeter: nearby	3	boiler room
d	perimeter: distant	4	heat pump
S1	thermally conditioned space	5	district heating/cooling
S2	space outside thermal envelope	6	substation (low/medium voltage and possible storage)

Added: Bold red curve: (a) assessment boundary in bold. Green line (e): boundary to assess the "**very low amount of energy still required**" on-site.

Figure 2. Assessment boundary for the EP calculation according to EN ISO 52000-1 and the boundary for the residual energy still required.

to do with the heat extracted from ambient air by an air-water heat pump; no need to discuss whether to take the input or the output from a solar collector as renewable energy, etc.[3]: only how much energy is still needed from elsewhere is what counts.

Note 6: It must be stressed again that **(sub-)hourly calculations are necessary** to avoid hidden compensation and overoptimistic results. This is illustrated in **Figure 3**, derived from one of the publicly available **spreadsheets** at the EPB Center website (Laurent Socal, [5]) that, together with a series of extensive **Case study reports** and **short videos** supports the understanding and use of the set of EPB standards.

Figure 3 clearly shows that by averaging over the whole day there seems to be only (9,88 – 7,88) = 2,0 kWh electricity delivered from the grid, while the hourly balance reveals that in fact 9.88 kWh is delivered from the grid during that day. Actually, for a proper appreciation also the PEF and CO_2 values should be dynamic, to distinct summer versus winter and e.g. daytime versus evening; see note 4 in the next section.

Using a monthly energy balance, the underestimation of delivered non-renewable energy due to ignoring the hourly variation in demand and supply could be mitigated by a **generic correction ("matching") factor**. But a generic matching factor does not reward individual designs using smart technologies to better match demand and supply (summer-winter; daytime-evening), and to apply on-site storage.

Note that hourly calculation is also essential for assessing the indoor environment quality. E.g. a **thermal comfort indicator** is important to prevent that a high energy performance is at the cost of the quality of the indoor environment needed for healthy and comfortable living and working conditions.

A short summary is given in **Table 1**.

Main overall EP indicator: the non-renewable primary energy

Compare the indicator introduced above (see **Table 1**) with the main EP indicator: the non-renewable overall primary energy performance, see **Table 2**.

Again a few notes:

Note 1: In the EPBD proposal [1], **renewable energy communities and citizen energy communities** are listed as potential sources of renewable energy. In this context we should distinct between communities that have a physical connection dedicated to specific buildings and communities that are economic / contractual organizations that e.g. invest in renewable

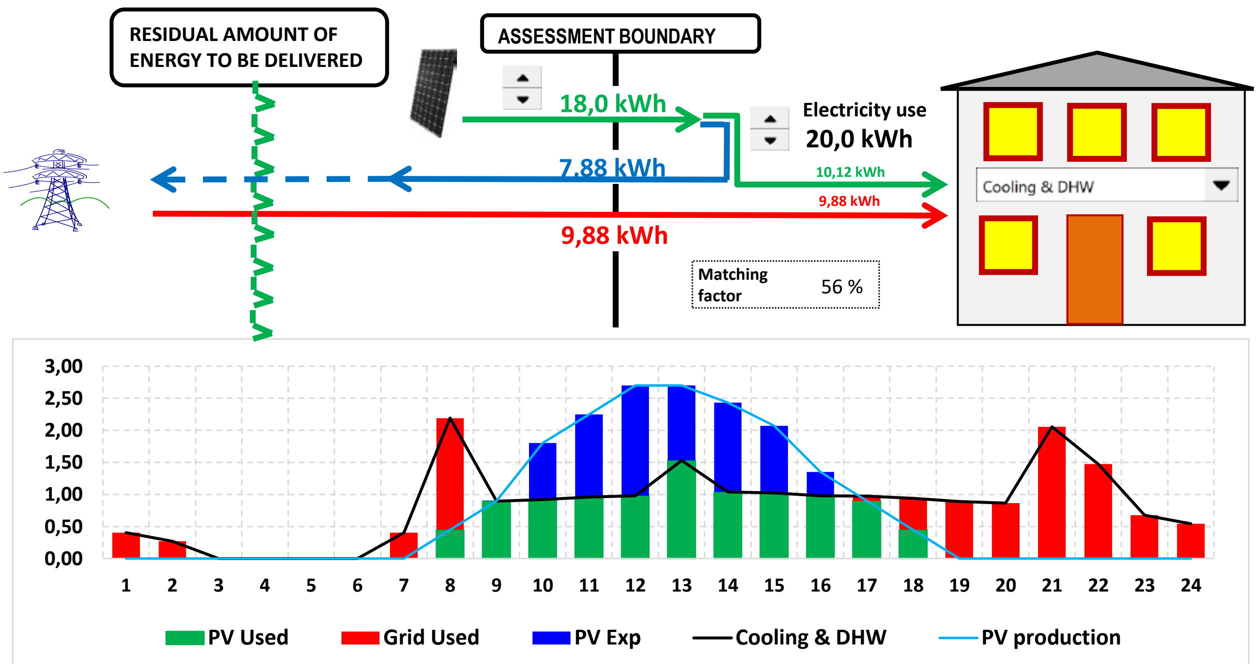


Figure 3. Illustration of hourly PV mismatch (based on [5]) but updated).

3 For the same reason, but also because renewable energy should by priority be used where high energy efficiency is difficult, the Renewable Energy Ratio (RER) is an indicator that can lead to irrational choices.

energy production for the public grid or dedicated to other users (e.g. industry). Only if there is a **permanent and dedicated physical connection**, the energy community can be regarded as a specific source. It is then at the same level as district heating and cooling. Without such connection, it would lead to double counting: as RE source for the specific building and as RE source for the public grid [4].

Note 2: Renewable energy from the electric public grid is an eligible source to assess the EP of the building. In the EPBD proposal [1] only sources on-site and nearby are listed. This seems to be given in by the focus on the improvement of the building and its nearby provisions. But looking from a macro perspective it is evident that autarkic buildings are not the goal, so renewable energy from the grid is included here.

Note 3: Again: **hourly calculation** is necessary to avoid hidden non-renewable energy use, overoptimistic EP and lack of incentives, recognition and appreciation for smart design.

Note 4: For a really proper appreciation the **PEF and CO_2 values should be dynamic**, to distinct summer versus winter and e.g. daytime versus evening: the hourly and monthly variation of supply and demand of the building and the hourly and monthly variation of supply and demand of renewable energy in the grid are all taken into account simultaneously. On-site or nearby energy storage is rewarded as well as smart use of equipment, leading to use of energy from the grid when there is sufficient renewable energy in the grid and export of own produced renewable energy to the grid when the grid has a large demand.

Table 1. *The very low amount of energy to be delivered to the building site.*

The residual energy to be delivered to the site		Comment
Boundary:	The building site	with the building site being zero carbon from fossil fuel
Main purpose:	Metric for "Highly energy efficient building" and indication how much energy still to be delivered from nearby and/or distant	**threshold values** as function of climate and building category (= conditions of use, occupancy pattern, internal gains, ...)
PE factors:	For the primary energy still required and [eventually] to be fully renewable in the future. PEF values to be fine-tuned, see text above (Note 1)	• the sources are not defined at the building site boundary • in the future these should be 100% renewable: see main text

Table 2. *The non-renewable primary energy performance indicator.*

The non-renewable primary energy performance (EP_{Pnren})		Comment
Boundary:	on-site + nearby + distant	Including the public grid
Main purpose:	the main EP indicator	keeping in mind that still several important choices are to be specified to unify this indicator; see e.g. U-CERT project [7]
PE factors:	Heat and electricity, for nearby (physically connected RE energy communities, district heating and cooling) and distant	At policy level trajectories can be given for the transition of nearby and distant sources towards 100% renewable before 2050; see main text below.

4 This is in line with EN ISO 52000-1 Table B.23, ***Specification of nearby perimeter:***
- Biofuels (liquid or gaseous): Connected to the same branch of the distribution network or having a dedicated connection, requiring specific equipment for the assessed object to be connected to it
- Electricity: Connected to the same branch of the distribution network, meaning medium voltage or lower
- District heating/cooling: always nearby

Monthly PEF values, instead of hourly, take away the extra stimulus to optimize the interaction with the grid with respect to hourly peaks and overloads / congestion. Annual PEF values miss the opportunity to boost initiatives aiming at a better distribution of renewable energy production over the seasons.

Note 5: According to the current EPBD proposal '**self-used**' is defined as the part of on-site produced renewable energy used by on-site technical systems for EPB services. While '**other on-site uses**' is defined as the energy used on-site for uses other than EPB services, and may include appliances, lighting in dwellings, miscellaneous and ancillary loads or electro-mobility charging points.

And '**exported energy**' is defined as, expressed per energy carrier and per primary energy factor, the proportion of the renewable energy that is exported to the energy grid instead of being used on site for self-use or for other on-site uses.

It makes sense to make the distinction between 'other on-site uses' and 'exported energy', because **"export"** of a surplus of on-site produced renewable energy **to the 'other on-site uses' does not interfere with the grid**. And because covering (part of) the 'other on-site uses' leads to a **real decrease of the amount of electricity taken from the grid,** it should be deductible from the electricity to be delivered from the grid for the EPB services. In contrast with exported renewable energy to the grid, it is not disguising or compensating delivered non-renewable energy! Of course the maximum that can be deducted is 100% of the amount of 'other on-site uses', at the given (sub-) hourly time interval.

Finally: illustration of the suggested successive steps

A diagram to illustrate the successive steps is given in **Figure 4**.

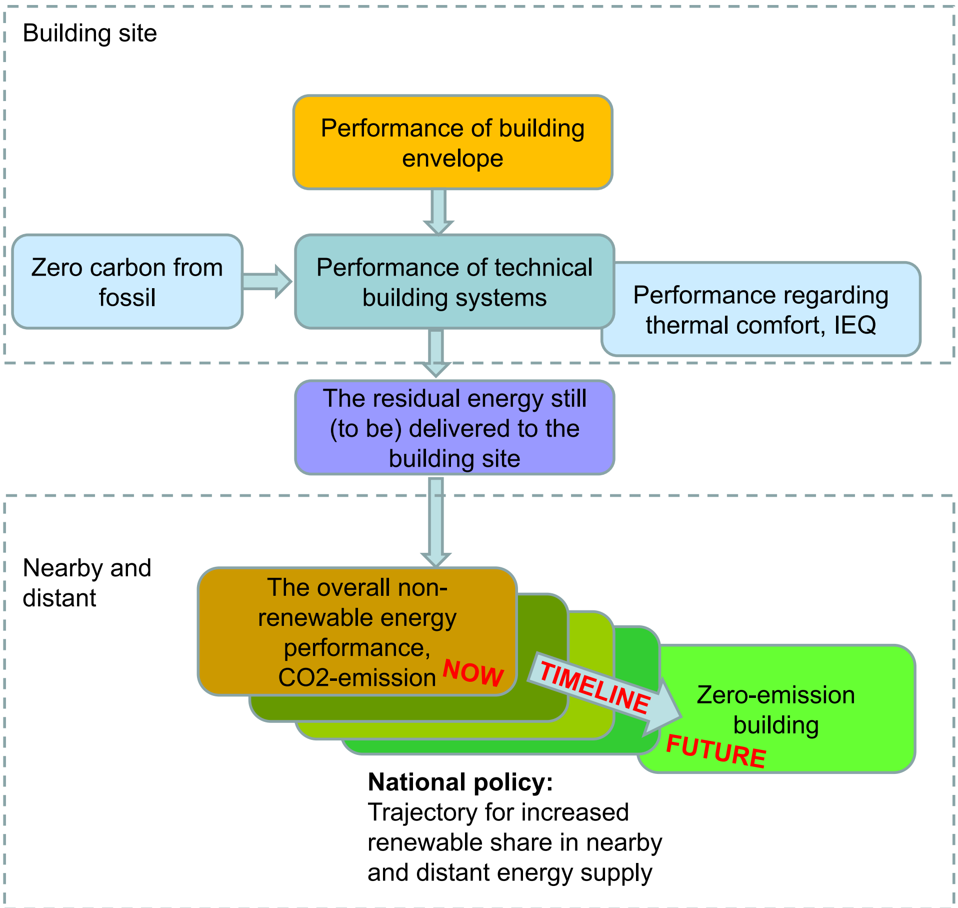


Figure 4. Diagram illustrating the suggested successive steps.

Conclusion

In the discussions on the definition and metrics for zero-emission buildings in the ongoing EPBD revision, several aspects have been covered in recent articles. In this article a new and simple metric has been proposed that can be used for threshold values for "the very low energy demand" that for a zero-emission building (ZEB) is to be "fully covered by energy from renewable sources". It can be used to safeguard a highly energy efficient building and, in combination with the main overall energy performance indicator, to set out trajectories towards a true zero-emission building (ZEB).

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References

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