



# 2024 ASHRAE WINTER CONFERENCE

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**SMNR 31 - Zero Emission Buildings (ZEB), Rolling out the Revised Energy Performance Buildings Directive (EPBD) in Europe**

## **Primary Energy Calculation and New Zero Emission Building Requirements in the EPBD**

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# Learning objectives

- Describe the main indicator used in Europe to assess the Building Global Warming Potential
- Explain the main indicators used in Europe to measure energy performance of buildings
- Compare and contrast the outcomes of three common primary energy indicator calculation approach
- Explain the meaning of on-site renewable energy generation and ambient heat in the primary energy calculation
- Explain the basic requirements for zero emission buildings

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# EPBD 2002-2010-2018-2024

The third revision of EPBD, Energy Performance of Buildings Directive, was provisionally agreed on Dec 7, 2023 and it is expected to be in force in March-April 2024.

Main outcomes of EPBD:

- 2006-2008 energy frames and requirements based on the primary energy & energy performance certificates
- 2012-2013 cost optimal calculations – next rounds 2018&2023 – progress easy to measure
- NZEB 12/2018 and 12/2020, NZEB level finally at least the 2021 cost-optimal level
- 2018 revised EPBD: long term renovation strategies & smart readiness

<https://www.consilium.europa.eu/en/press/press-releases/2023/12/07/fit-for-55-council-and-parliament-reach-deal-on-proposal-to-revise-energy-performance-of-buildings-directive/>

Text of the provisional agreement:

<https://data.consilium.europa.eu/doc/document/ST-16655-2023-INIT/en/pdf>

# Many new items

- Zero-emission buildings
- Deep renovation (and major renovation)
- Minimum energy performance standards MEPS
- Harmonised EPC scale
- ~~Hourly energy calculation method~~
- Non-res. ZEBs to be equipped with measuring and control devices for the regulation of IAQ
- Inspection of stand-alone ventilation systems

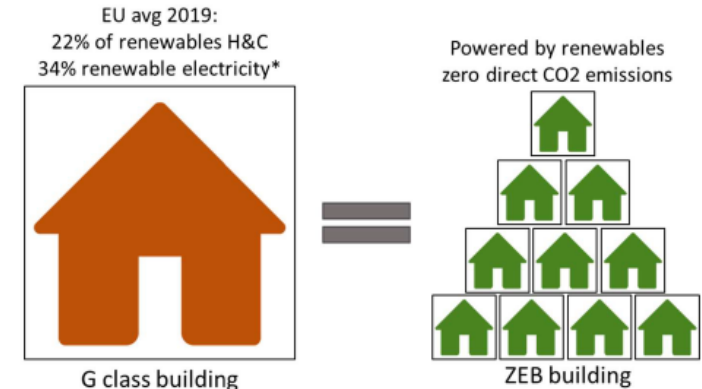
## Main changes compared to 2018 EPBD



- A new vision to transform EU building stock into zero-emission buildings by 2050
- The main new instrument to realize the ambition are National Building Renovation Plans that are next step from long term renovation strategies

# Transforming EU building stock into ZEB

- Existing major renovation is complemented with deep renovation, intending to ZEB level (NZEB before 2030)
- In national building renovation plans, MS must set targets for 2030, 2040 and 2050, including renovation rates, primary and final energy consumption, GHG emissions and to assure finance for renovation
- It is said that the necessary decarbonisation of EU building stock requires energy renovation at a large scale: almost 75% of today's building stock is inefficient according to current building standards, and 85-95% of the buildings that exist today will still be standing in 2050



- **Climate Target Plan** by 2030
  - reduce GHG emissions by 55%
  - integrate 32% RES
  - reduce final energy consumption by 14%
- **Renovation Wave** by 2030
  - renovate 35 million units
  - double and deepen renovation
  - establish minimum standards
  - harmonise EPC classes

# Primary energy and ZEB

- Primary energy (source energy) is the main energy performance indicator in EPBD
- Complemented with operational GHG indicator
- Efficiency first principle = total primary energy (of energy products)

Outline of the presentation:

- EPBD ZEB definitions and requirements
- Common approaches to calculate primary energy indicator (EP-value)
- Primary energy calculation in revised EPBD

# Zero-emission buildings ZEB

- New public buildings shall be ZEB from 01.01.2028 and all new buildings from 01.01.2030
- For existing buildings, major renovation and Minimum Energy Performance Standards (MEPS) requirements
- Efficiency first principle = total primary energy (of energy products)

ZEB definition (Art 2):

‘zero-emission building’ means a building with a very high energy performance, 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**

# Primary energy calculation example

## Primary energy factors and CO<sub>2</sub> coefficients

- EU average factors for electricity
- Electricity total PEF = 1.9 (EC PEF review 2022), nren PEF estimated
- Efficient district heat: fulfils the minimum requirement of 50% of renewable energy sources, CO<sub>2</sub> coefficient calculated with natural gas (50%)

Primary energy factors and CO <sub>2</sub> coefficients	nren PEF	ren PEF	tot PEF	CO <sub>2</sub> coefficient gCO <sub>2</sub> e/kWh
Grid electricity	1.4	0.5	1.9	251
District heating	0.6	0.6	1.2	133
Natural gas	1	0	1	220



# Current practice in EU: common approaches to calculate EP-value

2/3 of MS took into account only PV self-use and the use in other on-site uses (many MS include both EPBD and non-EPBD services)

1/3 of MS account exported energy, which may result in negative values of EP

Three common approaches to calculate primary energy indicator (PEF=1.9):

1. PV self-use and used in other on-site uses, both EPBD and non-EPBD services included

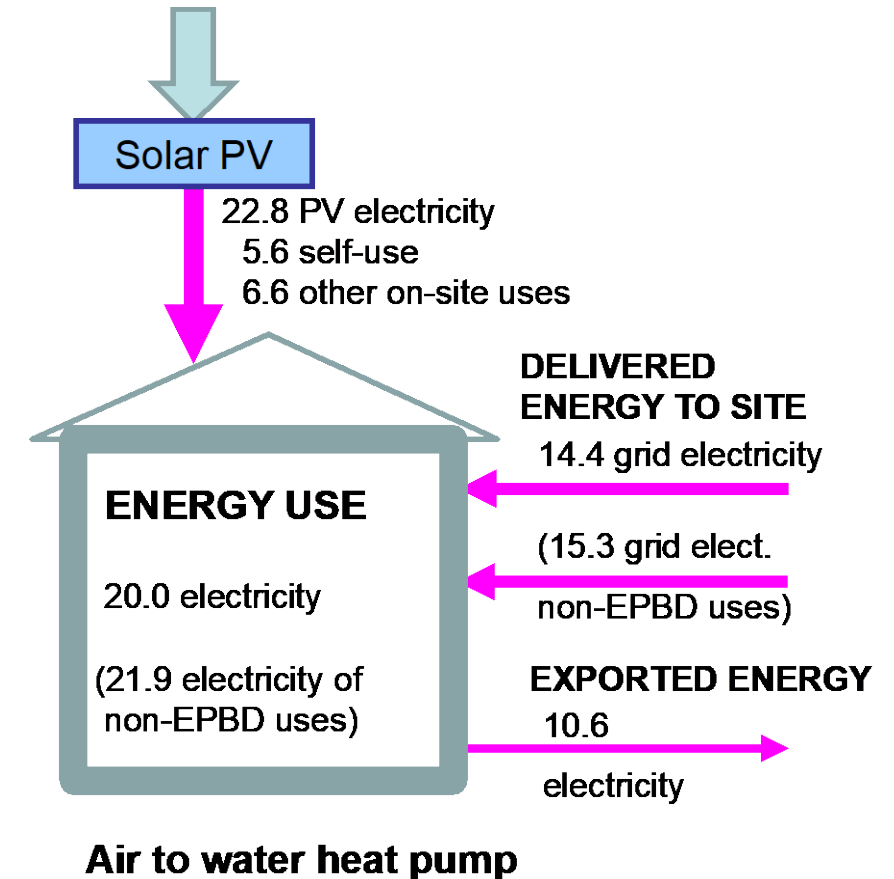
$$EP = (20 - 5.6) \times 1.9 + (21.9 - 6.6) \times 1.9 = 56.2 \text{ kWh/m}^2 \text{ a}$$

2. PV self-use and EPBD services

$$EP = (20 - 5.6) \times 1.9 = 27.3 \text{ kWh/m}^2 \text{ a}$$

3. PV export and EPBD services

$$EP = (20 - 22.8) \times 1.9 = -5.4 \text{ kWh/m}^2 \text{ a}$$



# EP calculation with 3 common methods

- Non-ren PE calculation is in line with EPB overarching standard EN ISO 52000-1:2017
- Total PE calculation does not follow EN ISO 52000-1:2017, because PV electricity and ambient heat of a heat pump are not included in EP-value
- Total PE is calculated from delivered energy to site, = imported/purchased energy that is not clearly defined in EN ISO 52000-1:2017 (possible option in EPBD)
- Total PE: highest value with DH
- nren PE and CO<sub>2</sub>: highest value with gas

Energy balance (input data for PE calculation)	Continental/Oceanic climate			
	Energy need kWh/m <sup>2</sup> a	Energy use and generation, kWh/m <sup>2</sup> a		
		AWHP	DH	Gas
Space heating	9.9	3.3	11.6	11.6
Domestic hot water	25.0	10.0	32.6	32.6
Supply air heating (electric)	0.5	0.5	0.5	0.5
Cooling	4.2	1.1	1.1	1.1
Fans, pumps, fixed lighting	5.2	5.2	5.2	5.2
Lighting (non-EPBD)	6.8	6.8	6.8	6.8
Appliances (non-EPBD)	15.1	15.1	15.1	15.1
PV self use		-5.6	-2.6	-2.6
PV use in other on-site uses		-6.6	-7.3	-7.3
PV exported to grid		-10.6	-12.9	-12.9
<b>Non-ren. primary energy</b>				
self-use EPBD + non-EPBD		41.4	52.6	70.3
self-use EPBD		20.1	32.3	50.0
exported included EPBD		-4.0	4.0	21.6
<b>Total primary energy</b>				
self-use EPBD + non-EPBD		56.2	88.5	79.7
self-use EPBD		27.3	60.9	52.1
exported included EPBD		-5.4	22.4	13.6
<b>Operational kgCO<sub>2</sub>e/m<sup>2</sup> a</b>				
self-use EPBD + non-EPBD		7.4	10.6	14.4
self-use EPBD		3.6	6.9	10.8
exported included EPBD		-0.7	1.8	5.7

Common calculation practices = how it is calculated today

Calculation in revised EPBD = how it should be calculated

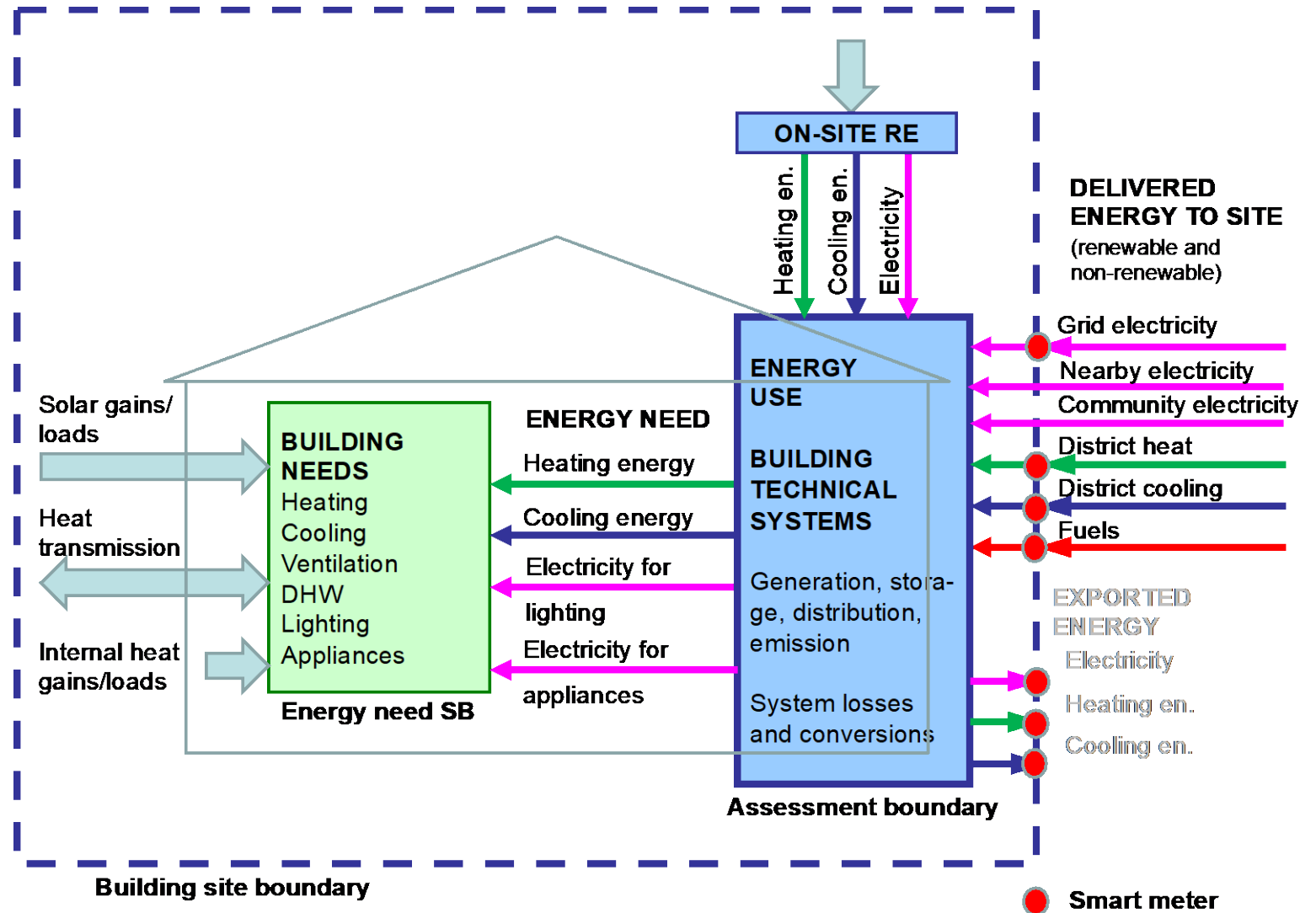
# Primary energy calculation in revised EPBD

## EPBD definitions:

- Art 2 definition 47 '**assessment boundary**' means the boundary where the delivered and exported energy are measured or calculated; (*May depend on **national practices where energy meters are installed***)
- Def 52 '**energy use**' means energy input to a technical building system providing a EPB-service intended to satisfy an energy need;
- Def 56 '**delivered energy**' means energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the uses taken into account or to produce the exported energy;
- Def 57 '**exported energy**' means, 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.

# Site boundary definition following the location of smart energy meters

- Follows connection points to energy supply networks such as grid electricity, district heating and cooling
- On-site renewable energy is inside the system boundary (the self-use of PV electricity reduces the amount of the delivered energy that is the case in all MS)
- Nearby and community renewable electricity depend on technical and contractual arrangements and are distinguished by different PEF



# Calculation of non-ren and total PE

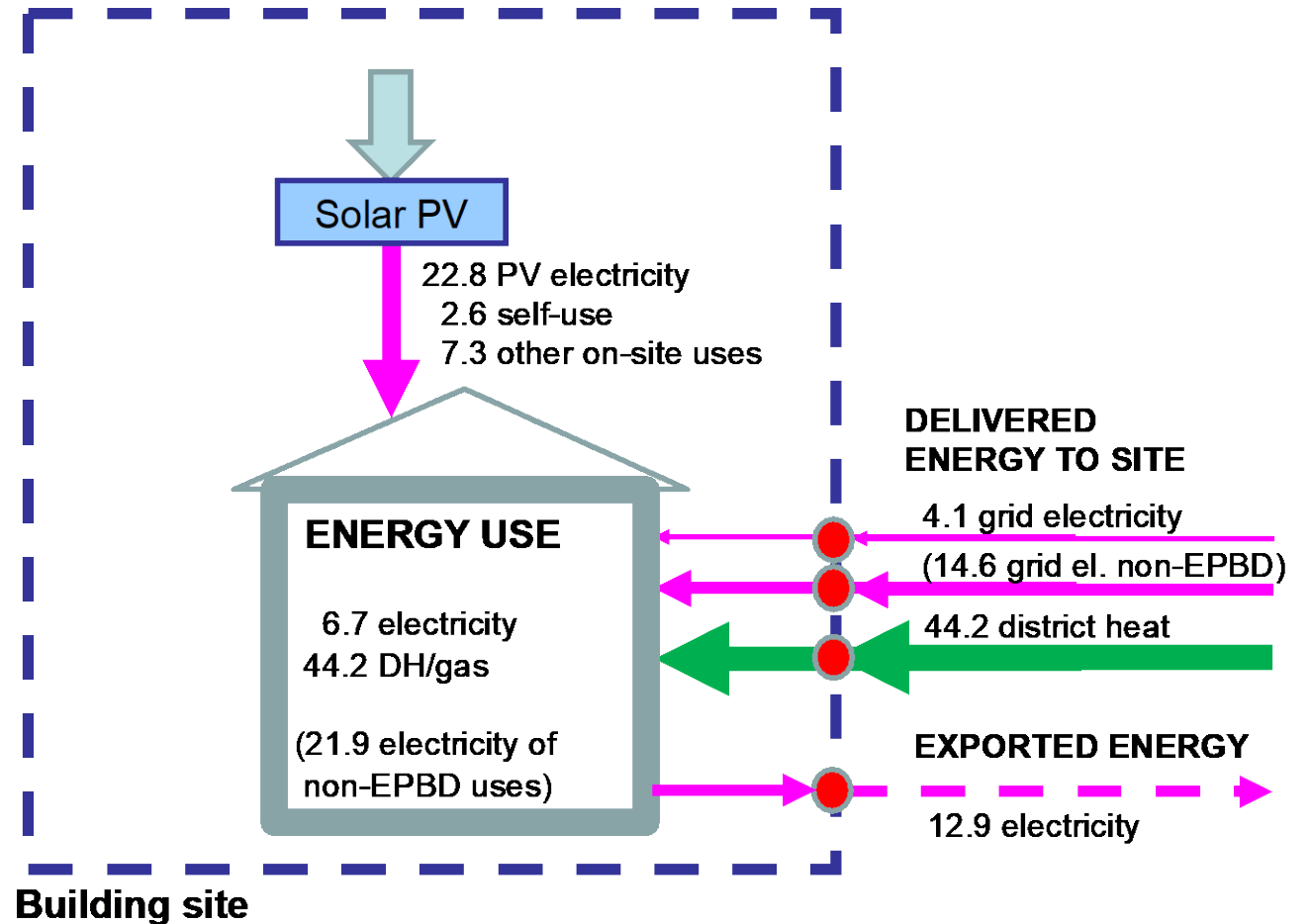
- Total PE may include or not include ambient heat and on-site renewable energy generation – not defined in EPBD
- Assessment boundary definition will determine **would on-site renewable energy generation be delivered energy or not**
- Total PE calculation without on-site PV and ambient heat (conflicts with EN ISO 52000-1) is justified by EED directive energy and primary energy consumption definitions which refer to energy products and exclude ambient heat
- **With exclusion of ambient heat, the same assessment boundary can be used for total and non-renewable energy calculation and the only difference in the calculation will be in primary energy factors** (=common practice today)

# Recommended total PE calculation

Recommended assessment boundary and total PE calculation with exclusion of ambient heat:

- avoids that on-site produced and used renewable energy increases the EP-value
- solar radiation and ambient air are an infinite sources which use should not be punished

It is expected that EC will prepare guidelines for total PE calculation



$$EP_{\text{tot}} = 4.1 \times 1.9 + 44.2 \times 1.2 = 60.9 \text{ kWh/m}^2 \text{ a}$$

$$EP_{\text{CO}_2} = 4.1 \times 0.25 + 44.2 \times 0.13 = 6.9 \text{ kgCO}_2\text{e/m}^2 \text{ a}$$

# EPBD ZEB requirements (Art 9b)

- On-site fossil fuels cannot be used in ZEB
- ZEB energy threshold at least 10% lower than the total primary energy of NZEB
- ZEB operational CO<sub>2</sub> threshold
- The total annual primary energy use of a new or renovated ZEB is to be covered on annual bases, where technically and economically feasible, by:
  - on-site, nearby or renewable energy community generated renewable energy
  - energy from efficient district heating and cooling
  - energy from carbon free sources
- ZEB shall offer the capacity to react to external signals and adapt its energy use, generation or storage, where economically and technically feasible



# Primary energy covering requirement

This requirement is set on annual bases, thus all PV generation is taken into account

PE covering requirement	Nordic			Continental/Oceanic climate			Mediterranean		
	AWHP	DH	Gas	AWHP	DH	Gas	AWHP	DH	Gas
Total primary energy	37.7	72.0	61.9	27.3	60.9	52.1	24.8	58.2	50.1
Covering by PV	-22.7	-22.7	-22.7	-22.8	-22.8	-22.8	-30.0	-30.1	-30.1
Covering by efficient DH		-50.4			-44.2			-40.6	
Covering by ren. grid electr	-9.9	-3.0	-3.0	-7.2	-2.1	-2.1	-6.5	-2.5	-2.5
<b>Total PE - covering</b>	<b>5.0</b>	<b>-4.2</b>	<b>36.2</b>	<b>-2.7</b>	<b>-8.2</b>	<b>27.2</b>	<b>-11.8</b>	<b>-15.0</b>	<b>17.5</b>
Requirement fulfilled	No	Yes	No	Yes	Yes	No	Yes	Yes	No

More challenging for Nordic climate, because the requirement is not fulfilled in the case of air to water heat pump

# Conclusion

- EPBD follows efficiency first principle = total primary energy
- Primary energy calculation is not explicitly defined, many national interpretations possible
- It is possible to calculate EP-value based on the total primary energy from delivered energy to building site, resulting in the the same calculation for both **non-renewable, total primary energy and operational CO<sub>2</sub>, just with different factors:**
  - this excludes ambient heat and treats on-site renewable energy generation inside the site boundary – conflicts with EN ISO 52000-1:2017
  - total PE is calculated from delivered energy to site, =imported/purchased final energy that is not clearly defined in EN ISO 52000-1:2017
- Currently MS use either non-ren PEF, total PEF or weighting factors, EPBD refers to total PEF and weighting factors

# Questions

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