



**2024 ASHRAE  
Decarbonization Conference:  
Decarbonizing Existing Tall Buildings**

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# The EU Zero Emission Building requirements

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# Learning Objectives

1. Describe the differences between zero carbon standards and definitions in varied leading regions of the world
2. Explain how the United Kingdom (UK) Net Zero Carbon Building Standard addresses operational and embodied carbon, and compares with other leading zero carbon building standards
3. Describe the cost-optimal energy and operational carbon, and embodied carbon requirements in European Union regulations
4. Describe the differences between different regions' policies and requirements from the perspective of a designer working across regions of the world

Learning objectives of this presentation:

- To understand energy performance regulation in EU
- To know the development from nearly zero energy buildings to zero emission buildings
- To understand new energy performance indicator calculation based on total primary energy
- To understand other ZEB requirements including covering of total PE and ban of fossil fuels

# Introduction

Energy Performance of Buildings Directive EPBD has been revised for the third time: 2002 – 2010 – 2018 – 2024

**(EU) 2024/1275** – can be found easily

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
- Nearly zero energy buildings (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
- 2024 Zero Emission Buildings, MEPS, trajectory of the building stock

# EPBD 2024: Many new items

- Zero Emission Buildings (ZEB)
- 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

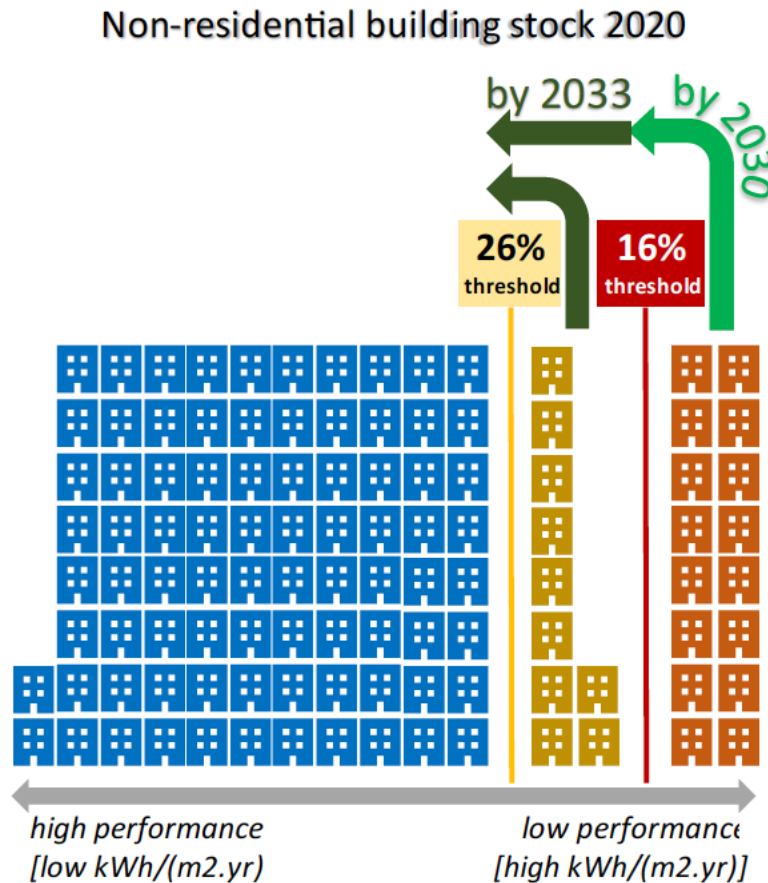
## Main changes compared to 2018 EPBD



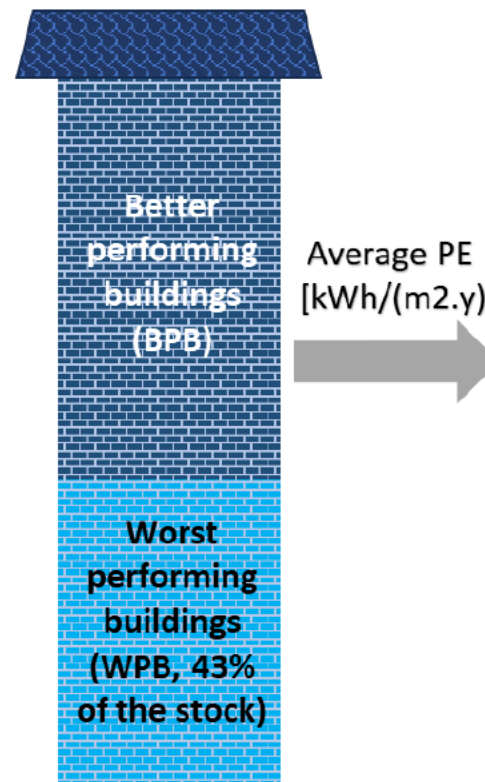
- A new vision to transform EU building stock into zero-emission buildings by 2050
- The main new instrument to realize the ambition are National Building Renovation Plans that are next step from long term renovation strategies

# Existing buildings

**Non-residential:** establish Minimum Energy Performance Standards (MEPS) to improve worst-performing buildings above the thresholds

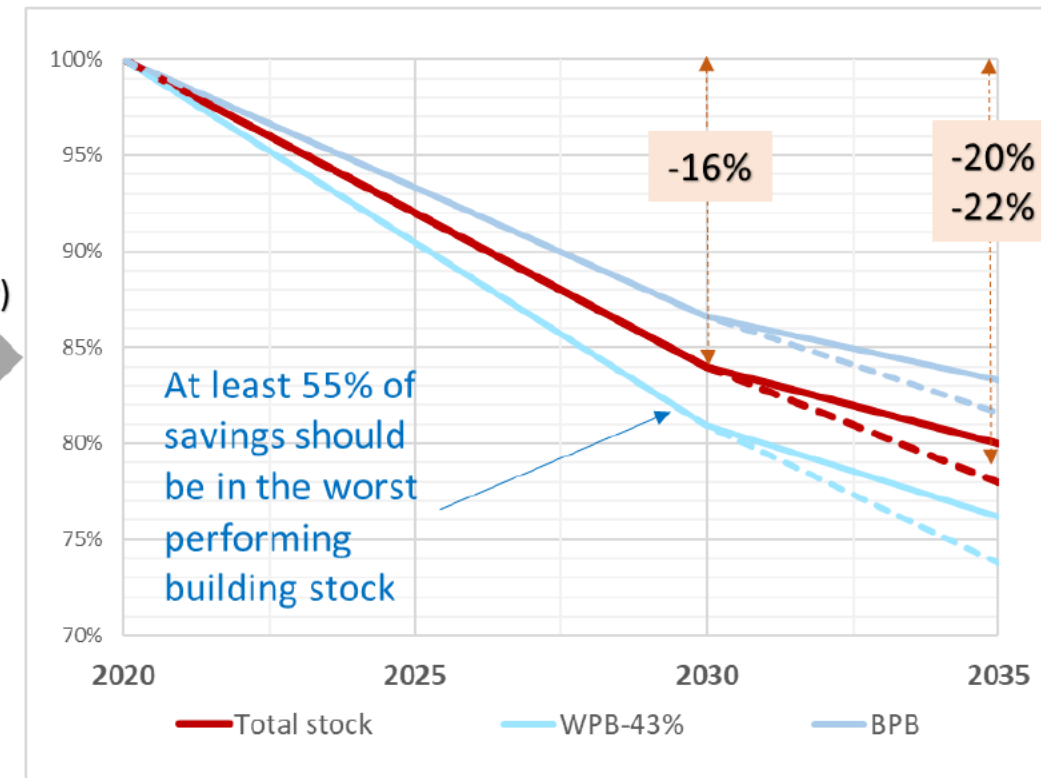


Residential building stock 2020



**Residential:** follow the trajectory to reduce the average primary energy use per m<sup>2</sup> by 16%/2030 and 20-22%/2035

National trajectory for the average primary energy use in kWh/(m2.y)



# 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)

***‘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 Article 11*

# Zero Emission Buildings requirements (Art 11)

- ZEB cannot cause any on-site carbon emissions from **fossil fuels**
- Maximum threshold for the energy demand of a ZEB shall be set with a view to achieving at least the cost-optimal levels. The **maximum threshold for the energy demand** of a ZEB shall be at least 10 % lower than the threshold for total primary energy use established for nearly zero-energy buildings.
- Maximum threshold for the **operational greenhouse gas** emissions of a ZEB shall be set
- The total **annual primary energy** use of a new or renovated ZEB **shall be covered**, where technically and economically feasible, by:
  - energy from renewable sources generated on-site or nearby, fulfilling the criteria laid down in Article 7 of Directive (EU) 2018/2001 (RED);
  - energy from renewable sources provided from a renewable energy community within the meaning of Article 22 of Directive (EU) 2018/2001 (RED);
  - energy from an efficient district heating and cooling system in accordance with Article 26(1) of Directive (EU) 2023/1791 (EED);
  - 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

# Embodied carbon reporting/requirements

Life-cycle GWP is to be calculated and disclosed in the energy performance certificate:

- from 1 January 2028, for all new buildings >1 000 m<sup>2</sup>
- from 1 January 2030, for all new buildings

Life-cycle GWP minimum requirements to be set from 2030:

- By January 2027, Member States shall publish a roadmap detailing the introduction of limit values on the total cumulative life-cycle GWP of all new buildings and set targets for new buildings from 2030, considering a progressive downward trend, as well as maximum limit values

Life-cycle GWP stages (product stage A1-A3, construction A4-A5, use stage B4, B6 and end of life C1-C4) and indicators (GWP total, GWP fossil, GWP biogenic) will be clarified in EU framework for the national calculation of life-cycle GWP prepared by EU Commission by 31 December 2025



# ZEB requirements – main changes

- Energy threshold, energy performance indicator (EP) compared to total primary energy ( $EP_{\text{tot}}$ )
- Covering total primary energy on annual bases
- Capacity to react to external signals and adapt
- (+ no fossil fuels on site, operational  $\text{CO}_2$  threshold  $EP_{\text{CO}_2}$ )

# Total primary energy

- Terminology: primary energy (PE) = source energy
- So far non-renewable primary energy has been commonly used
- Total PE = non-renewable PE + renewable energy
- Will change PE factors (PEF) and calculation principles

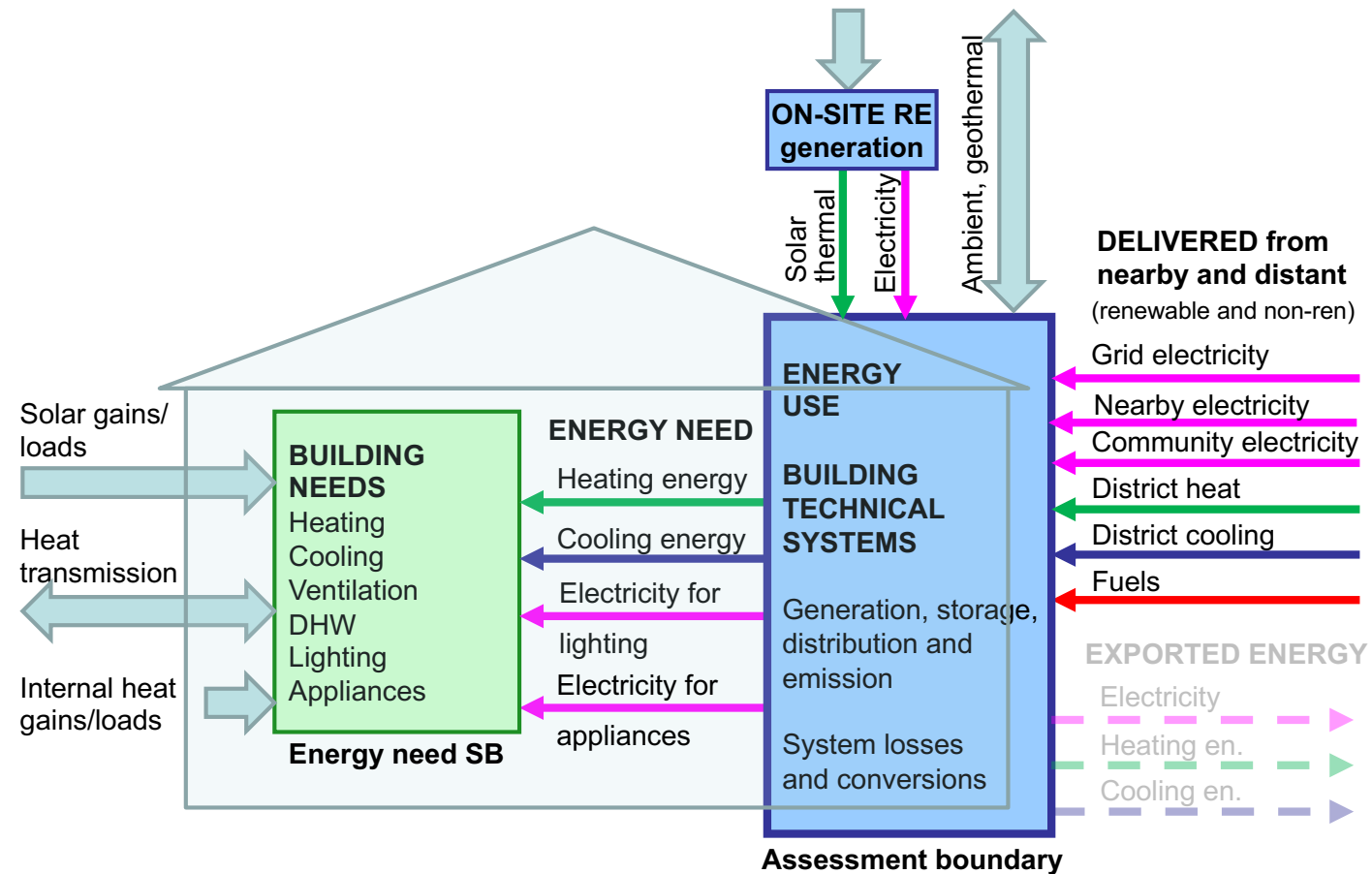
EU average electricity PEF and efficient district heat PEF (50% renewables)

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

<https://data.europa.eu/doi/10.2833/404077>

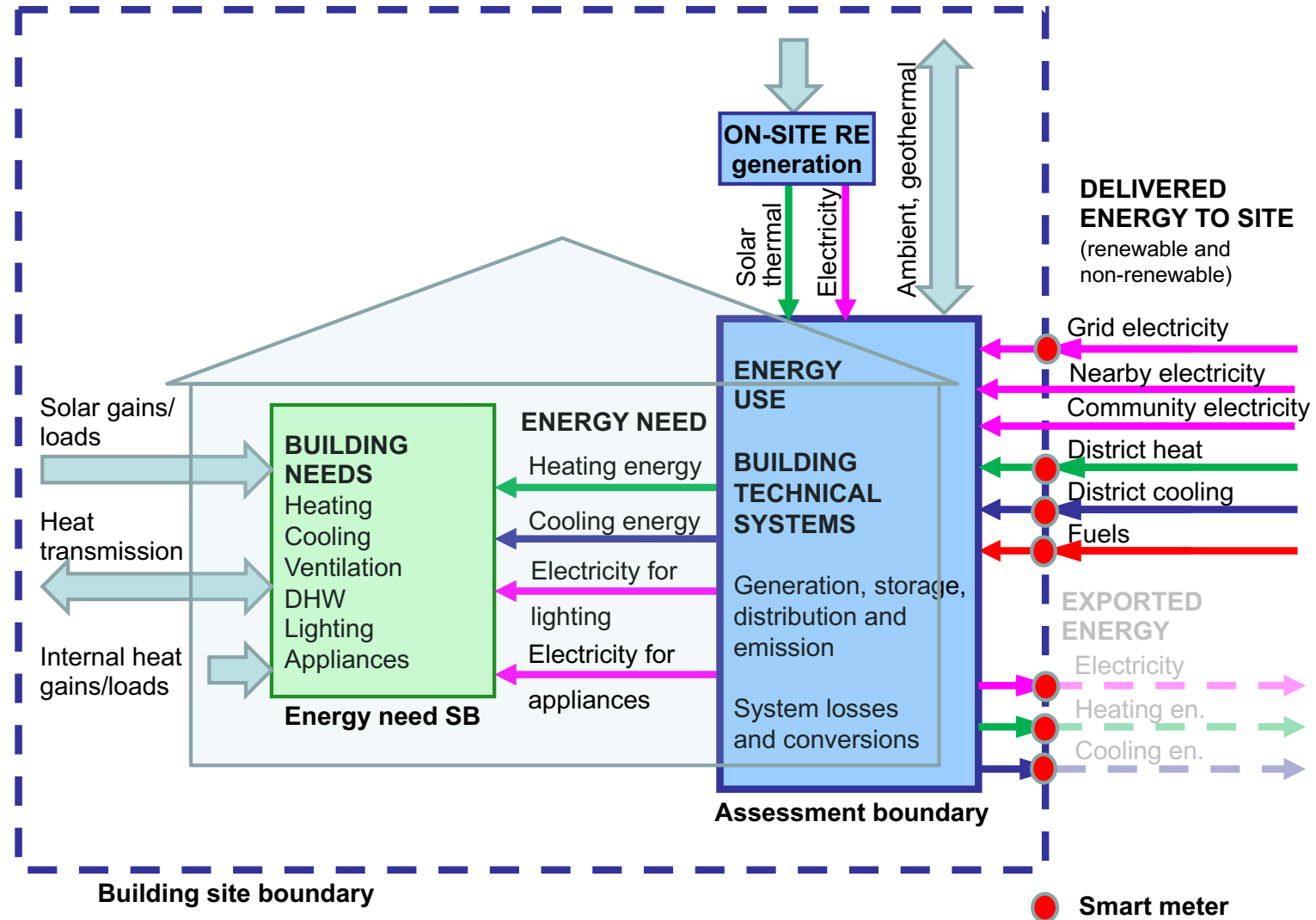
# Total primary energy

- ISO 52000-1:2017 building assessment boundary treats on-site generated PV electricity similar to grid electricity – both of these are supplied/delivered to building
- Total PE calculation results are not meaningful because:
  - non-renewable PEF of PV electricity is 0, but total PEF = 1
  - ambient heat captured by heat pumps from environment has total PEF = 1
  - heat pumps, solar PV and thermal will be punished in EP calculation



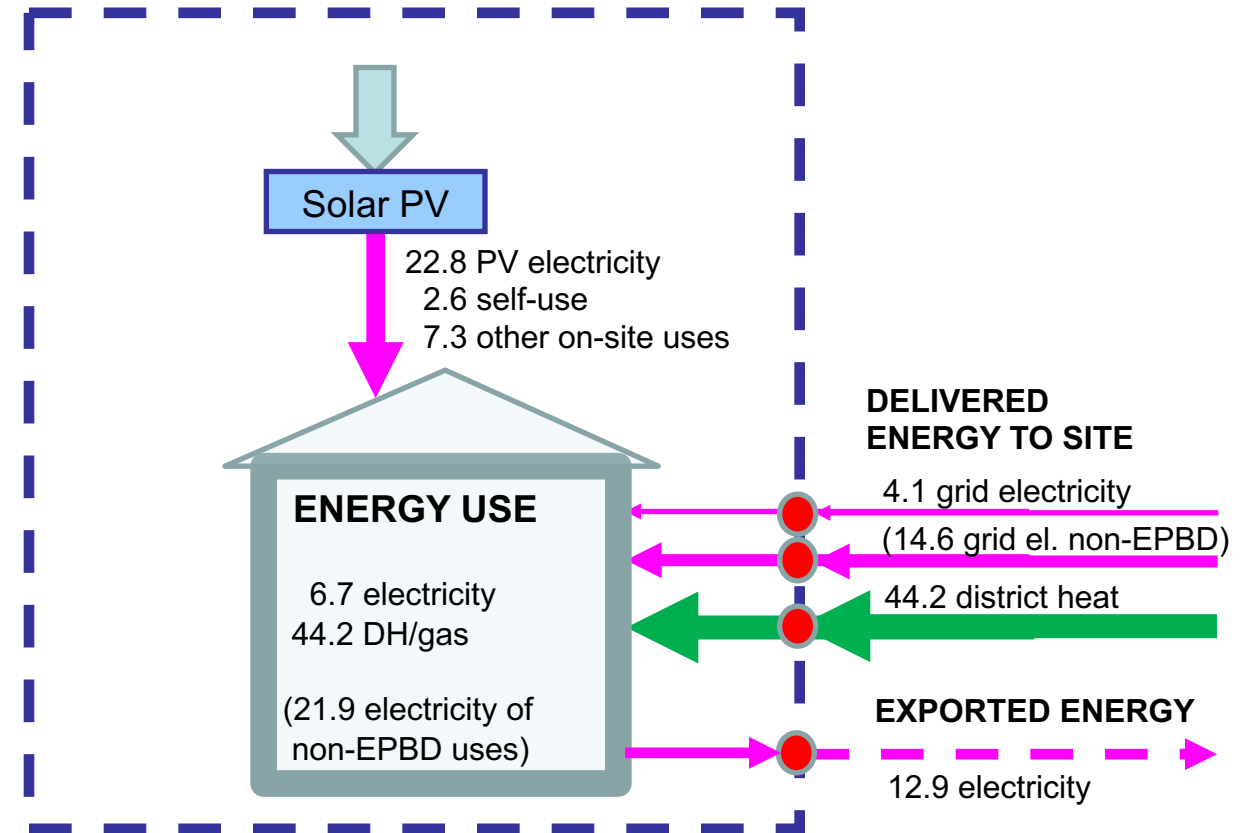
# Site boundary for total primary energy

- Only the energy flows supplied through the assessment boundary are taken into account in PE calculation
- On-site renewable energy generation, ambient and geothermal heat are inside the boundary, thus not added to PE
- May also be interpreted that are considered with a PEF equal to zero
- Complements building assessment boundary of ISO 52000-1



# EP indicators example

- EP indicators, total PE and operational CO<sub>2</sub> according to EPBD
- EPBD scope is limited to HVAC + fixed lighting, plug loads and other lighting are non-EPBD that is not taken into account
- Exported energy may or may not be taken into account; if taken PEF shouldn't be higher than 1 (EPBD guidance recommendation)
- PV self-use needs to be known for EP calculation – hourly calculation recommended for new buildings but not required
- Total PEF challenging for district heat (heat pump in a building and district heat plant does not provide the same result), possibility for weighting factor



Building site

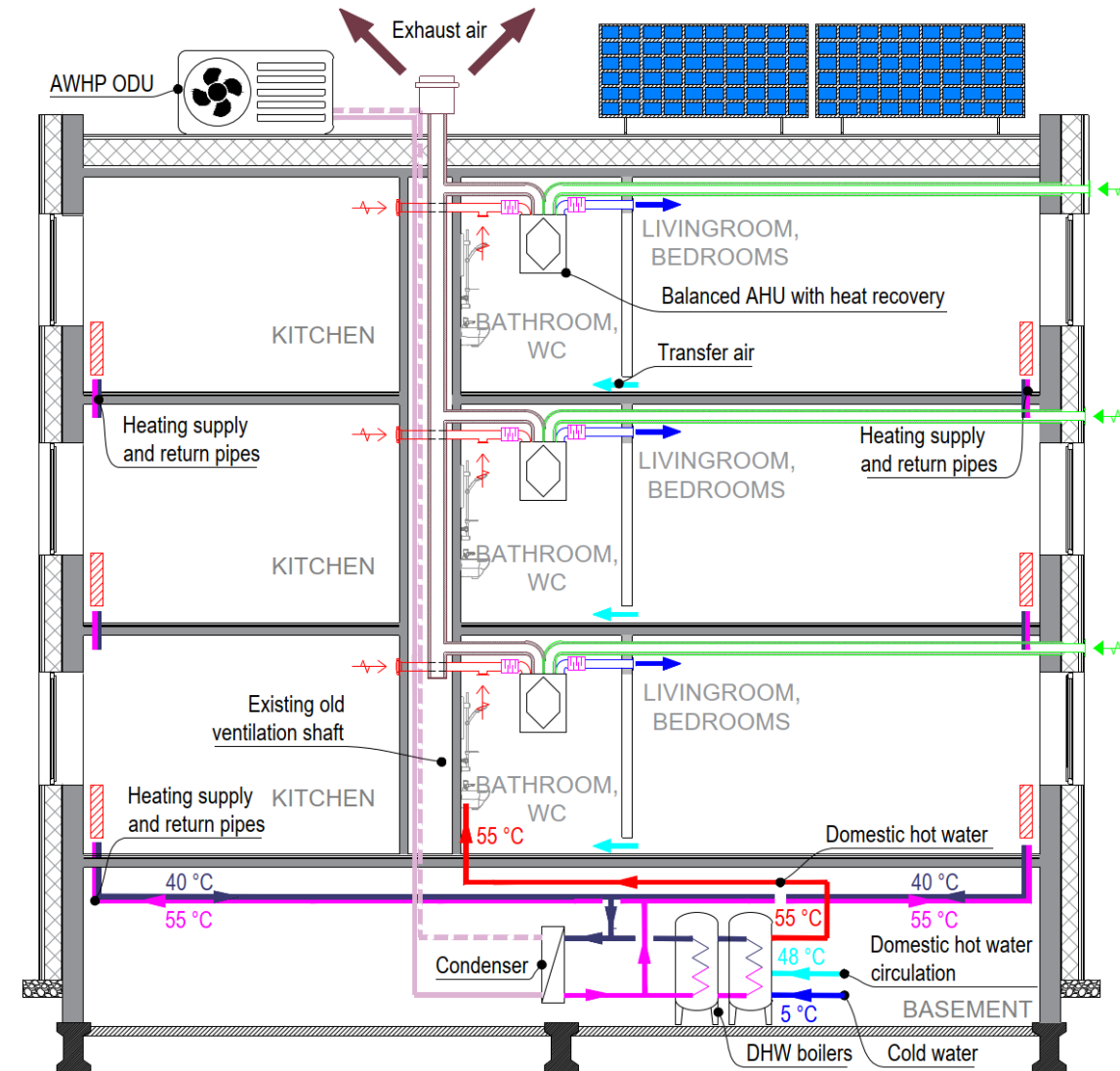
$$EP_{\text{tot}} = 4.1 \times 1.9 + 44.2 \times 1.2 = 60.9 \text{ kWh/m}^2 \text{ a}$$

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

# Model apartment building used for examples

- 3-storey, 12 apartments, 1120 m<sup>2</sup> heated area
- U-values depend on the climate
- Heat recovery ventilation
- 30 kW PV system
- Cooling system
- Air to water heat pump, effective district heating (50% renewables) or gas boiler for heating

U-values W/(m <sup>2</sup> K)	Nordic and Continental	Mediterranean
External walls	0.14	0.23
Cellar wall	0.15	0.23
Windows U <sub>w</sub>	0.80	1.30
g-value	0.50	0.50
Roof (insulated)	0.11	0.20
Attic floor (insulated)	0.10	0.20
Ground floor to cellar	0.18	0.25
Floor on ground	0.49	0.49



# Current practices 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 EP-value:

1. PV self-use and used in other on-site uses, both EPBD and non-EPBD services included
  2. PV self-use and EPBD services
  3. PV export and EPBD services
- ZEB calculation (total PE and CO<sub>2</sub>) may result in values which are not easy to compare

Energy balance (input data for PE calculation)	Energy need kWh/m <sup>2</sup> a	Continental/Oceanic climate		
		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

# Covering total primary energy

- Non-renewable and not carbon neutral fraction of delivered energy has to be covered with exported energy and ambient heat on **annual bases**
- Previous example of multifamily apartment building shows that covering is possible in typical situation in all EU climates, AWHP = air to water heat pump, DH = district heat, Gas = gas boiler (not allowed in ZEB):

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 heat pump	-23.4			-21.6			-20.7		
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>-18.4</b>	<b>-4.2</b>	<b>36.2</b>	<b>-24.3</b>	<b>-8.2</b>	<b>27.2</b>	<b>-32.5</b>	<b>-15.0</b>	<b>17.5</b>
Requirement fulfilled	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No

- EPBD allows exemptions if not technically or economically feasible (for instance if shading blocks PV generation)



# Other ZEB requirements

## **Capacity to react to external signals and adapt:**

- Qualitative requirement in EPBD, many national interpretations possible
- Means a capability to communicate with grid (for instance a price signal) and to control something based on this signal
- Examples fulfilling this requirement: turn-off the heat pump if temperature is within certain acceptable range, bi-directional electric vehicle charger that allows vehicle's battery to temporarily support the electricity grid, on-site battery, price-based water heating, ...

## **No use of on-site fossil fuels:**

- Natural gas network is considered as fossil fuel until renewable/carbon neutral fuels content does not exceed 50%

## **Operational greenhouse gas emissions threshold:**

- A new indicator calculated from delivered energy with CO<sub>2</sub> coefficients

# Conclusions

- EU moves from current nearly zero energy buildings to zero emission buildings 2028/2030 with requirements for new buildings
- Principal change to account both non-renewable and renewable energy – total primary energy in ZEB requirements
- Overarching ISO 52000-1:2017 EPB standard not ready for total PE calculation according to EPBD, EPBD guidance document (under preparation) introduces additional guidance
- ZEB energy requirements will stay to follow a cost-optimality principle, i.e. 30/20 years life cycle calculation with net present value method
- 2028 ZEB must be at least NZEB - 10%, and later will be based on revised cost-optimality methodology which will include monetized additional benefits such as health care cost reduction from improved indoor climate, economic (GDP) impact and carbon cost that justify higher investments to energy performance
- Clear development trend towards hourly calculation/energy simulation in the compliance assessment (recommended for new buildings but not required), majority of EU MS already use or plan to take into use hourly calculation

# Questions

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