How to implement EPBD - IEQ and primary energy requirements

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How to set national requirements in line with revised EPBD?

- EPBD 2002-2010-2018-2022 has developed to be a comprehensive and technically complex document
- Energy is used in buildings to provide IEQ – as the quality level of IEQ remarkably affects energy use, it is highly important to specify IEQ when setting energy performance requirements
- Healthy indoor environment, healthy indoor climate, comfort, indoor air quality and ventilation are addressed in many places in EPBD, but explicit requirements are left on the responsibility of MS
- Primary energy is the main energy performance indicator and it is important for MS to understand calculation principles and for instance when non-renewable and/or total primary energy factors should be used

Indoor environmental quality and ventilation

- Most important change in EPBD regarding IEQ, is a new requirement to equip non-residential ZEB with **measuring and control devices for the regulation of indoor air quality** (Art 11)
- Applies for existing buildings too, where technically and economically feasible, when a building undergoes a major renovation

- Can be understood as demand controlled ventilation system (mechanical or hybrid with CO_2&T controls); pays attention to the need to have ventilation requirements – if not available how to design and commission such systems?
- Regular inspection of heating and air conditioning systems is extended to stand alone ventilation systems (Art 20)
- The inspections scheme shall include the assessment of the **sizing of the ventilation system compared with the requirements of the building**

Indoor environmental quality and ventilation

- When setting minimum energy performance requirements, taking into account indoor climate conditions, in order to avoid possible **negative effects such as inadequate ventilation**, was already included in the existing EPBD (Art 5) – no change

- Indoor environmental quality is now stressed for both new buildings and major renovations by mentioning that **the issues of healthy indoor climate conditions shall be addressed** (Art 7 and 8) – may be interpreted so that national regulation on IEQ/ventilation should be present

- Ventilation requirements are most crucial in major/deep/MEPS renovation of residential buildings – Art 7 and 8 implementation in MS is worth to be monitored (additional insulation and replacement of windows will block air change if ventilation system would not be installed – mould and other IAQ problems)

EPBD application to set national primary energy requirements and EPC scale

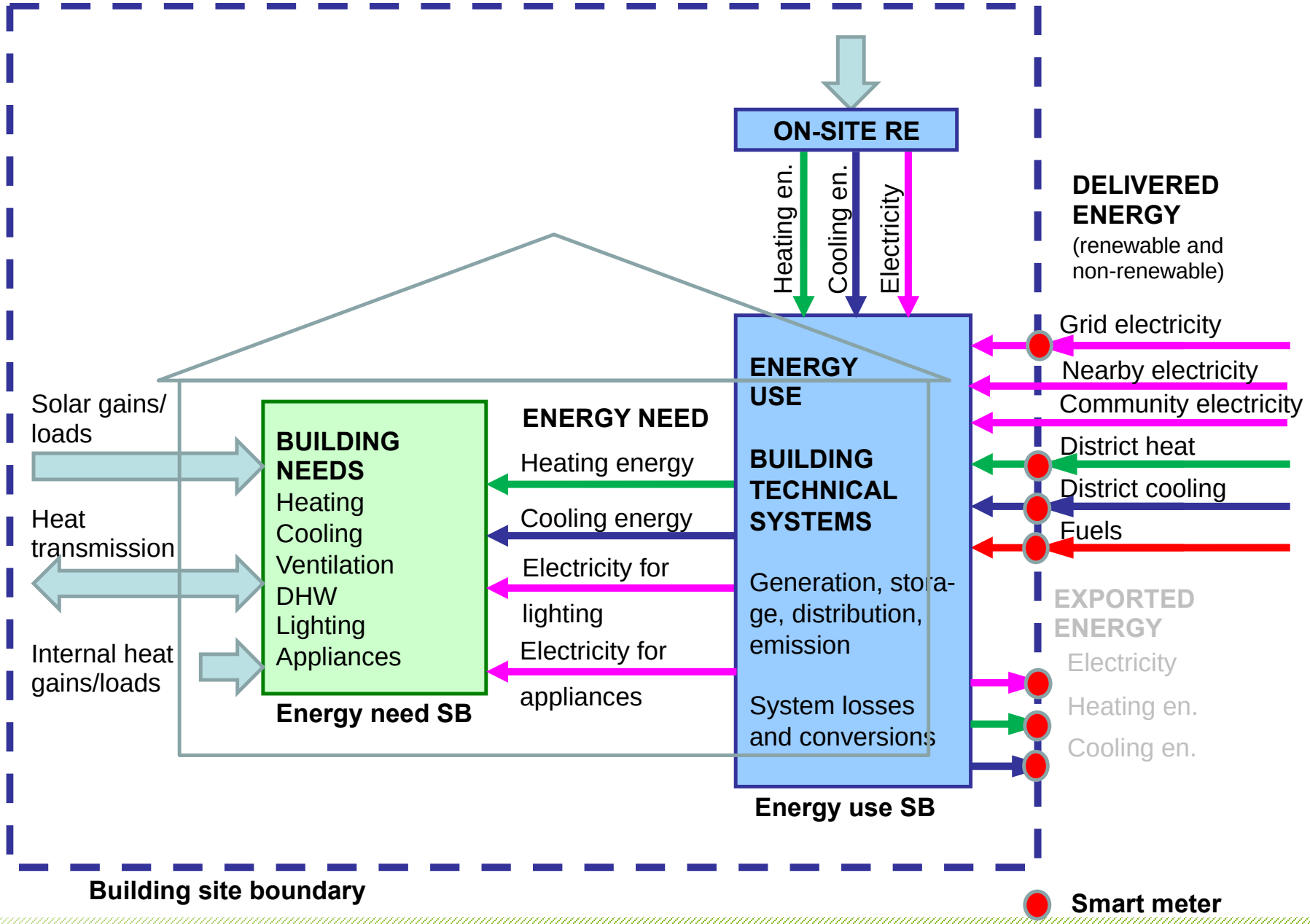
- EPBD proposal 21 October 2022
- Non-renewable primary energy or total primary energy? In many places EPBD uses unspecific expression of “primary energy” (PE) – so, which primary energy factor (PEF) should be used?
- Minimum requirements for ZEB/NZEB and EPC classes

Step 1 – assessment boundary

- 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 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.

- Defining assessment boundary according to the location of energy meters
- On-site RE is not delivered energy with this assessment boundary definition



Calculating total and non-ren PE

- Def 10 and 11 say that primary energy is calculated from delivered energy
- Calculation of non-renewable PE is straightforward, but total PE may include or not include ambient heat and on site renewable energy generation

- Assessment boundary definition will determine would on-site RE generation be delivered energy or not (and will it be accounted or not accounted to the total PE)
- Definition in the previous slide **excludes on-site RE from delivered energy** (because this is not supplied through the assessment boundary)
- **Art 16 says that total PE excludes ambient heat**
- Total PE calculation withoud on-site PV and ambient heat (conflicts with EN ISO 52000-1) is justified also with EED directive energy and primary energy consumption definitions which refer to energy products and exclude ambient heat

Calculating total primary energy

PE covering requirement (Art 9b):

- The total annual primary energy use of a new or renovated ZEB is to be covered, where technically and economically feasible, by:
  - On-site, nearby, renewable energy community generated renewable energy
  - Effective district heating and cooling
  - Energy from carbon free sources (refers to grid electricity)

- The logic of this requirement supports excluding on-site RE from total primary energy, because otherwise it would be on both sides of the equation with equal amounts and would not help to cover total PE
- With inclusion of on-site RE and ambient heat, it would be also practically impossible to fulfil this requirement

Step 2 – cost optimal calculation and ZEB/NZEB requirements

- Non-renewable primary energy is needed for meaningful cost optimal calculations to distinguish the use of fossil fuels and energy from renewable sources
- Non-renewable primary energy is in line with Art 9b stating that ZEB "***energy use***" requirement is "***maximum threshold established at the Member State level***". Here each MS has a freedom to define ZEB by following cost optimality and ANNEX I principles (referred to in Art 2 ZEB definition)
- According to ANNEX I, ZEB should use "***a numeric indicator of primary energy use***" and "***The calculation of primary energy shall be based on primary energy factors, (distinguishing non-renewable, renewable and total) or weighting factors***"
- ANNEX I also requires recognising the **benefits of district heating and cooling**, and **positive influence of renewable energy** which support the use of non-renewable primary energy indicator

EP-value calculation example

- Input data from https://www.rehva.eu/rehva-journal/chapter/how-to-set-primary-energy-requirements-so-that-poor-building-envelope-cannot-be-compensated-with-extensive-pv
- Heat generation options:
  - DH – district heat
  - AWHP – air to water heat pump
  - Gas boiler

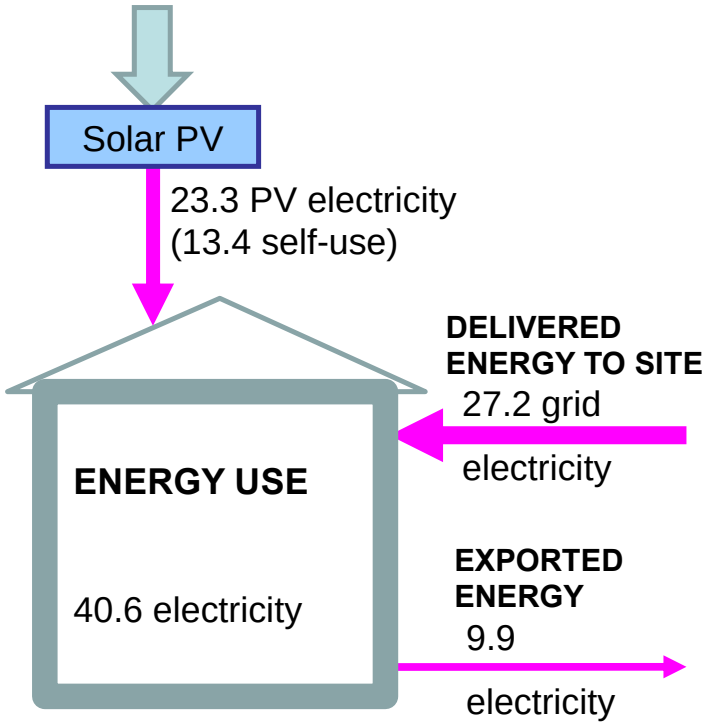
Energy balance	Energy need kWh/m^2 a	Energy use kWh/m^2 a		
		DH	**Gas**	**AWHP**
space heating	38.5	43.9	43.9	16.6
DHW	25.0	26.3	26.3	13.5
supply air heating (electric)	5.0	5.0	5.0	5.0
fans and pumps	5.5	7.5	7.5	5.5
PV self use		10.7	10.7	13.4
PV export		12.6	12.6	9.9
Non-ren. primary energy, self-use only		**46.2**	**81.3**	**62.4**
Non-ren. primary energy, export included		17.3	52.4	39.7
Total primary energy, self-use only		**88.7**	**81.7**	**67.9**
Total primary energy, exported included		57.2	50.2	43.1
Renewable energy		**65.8**	**23.7**	**62.2**
CO_2 emissions, kgCO_2/m^2 a		3.9	10.9	7.2

Primary energy factors & CO_2 emission coefficients	non-ren.	renewable	total	kgCO_2/kWh
grid electricity & PV export	2.3	0.2	2.5	0.42
natural gas	1.1	0	1.1	0.22
DH (district heat)	0.6	0.6	1.2	0.12
RE (solar, geo, ambient)	0	1	1	0

EP-value calculation example

- Assume that this data represent cost-optimal solutions (in a cold climate) and use exactly the same generation efficiency for district heating and gas boiler for illustrative purposes
- Self-used and used in other on-site uses PV is included
- Total primary energy is calculated from the delivered energy to the site (ambient heat and on-site PV are excluded) = total primary energy of the delivered energy to the site
- Exported energy is not accounted

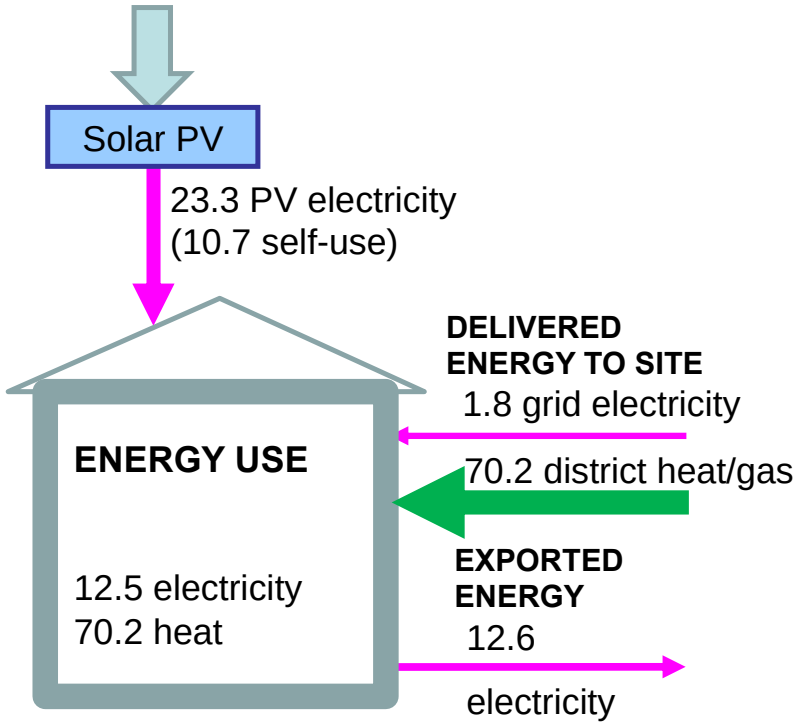
Air to water heat pump



EP_{nren} = 27.2 x 2.3 = 62.4

EP_{tot} = 27.2 x 2.5 = 68.0

District heating or gas boiler



EP_{nren} = 1.8 x 2.3 + 70.2 x 0.6 = 46.3 for district heat

EP_{nren} = 1.8 x 2.3 + 70.2 x 1.1 = 81.3 for gas

EP_{tot} = 1.8 x 2.5 + 70.2 x 1.2 = 88.7 for district heat

EP_{tot} = 1.8 x 2.5 + 70.2 x 1.1 = 81.7 for gas

Step 3 – primary energy requirement

- To set cost-optimal requirement in terms of the **total primary energy**:
  - to enable the use the of effective district heat, the cost-optimal value cannot be smaller than EP_{tot} = 89 (gas boiler and AWHP easily comply with this value)
- By setting the EP_{tot} cost-optimal value we did not follow ANNEX I requirements to take into account the positive influence of renewable energy and benefits of district heating because we account renewable energy with the total PEF which makes no difference to fossil fuels
- To follow ANNEX I, an additional numeric indicator must be set:
  - In this case, additional **non-renewable primary energy indicator** EP_{nren} = 63 can be set to enable the use of AWHP and district heat
- In conclusion, the threshold EP_{tot} = 89 enables to use all three systems studied, but EP_{nren} = 63 only AWHP and district heat. **Therefore, it can be concluded that EP_{tot} threshold is redundant, and it is enough to use EP_{nren}**

Step 4 – PE covering requirement (Art 9b)

- Another factor needed to account carbon free electricity (does not equal to renewable PEF, because nuclear energy is carbon free). If no nuclear electricity, carbon free factor = renewable PEF = 0.2 in this example

- AWHP case: 23.3 + 27.2x0.2 = 28.7 < 27.2x2.5 = 68.0, where 23.3 is PV and 27.2 grid electricity – **not satisfied**
- Effective DH case: 23.3 + 70.2 + 1.8x0.2 = 93.4 > 88.7 – **satisfied**

- AWHP case would be satisfied with 2030 EU electricity PEF (1.6, 1.0 and 0.6 total, non-ren and ren PEF) and slightly increased PV

Step 5 - EPC classes

- To calculate EPC classes/scale Art 9 (MEPS) clarifies that by unspecific expression of “primary energy”, the total primary energy is meant
- Art 16 EPC A+ class uses explicitly total primary energy and excludes ambient heat
- Therefore, while **non-renewable PEF can be applied for the requirements, EPC classes should be calculated with total PEF**

Conclusions

- IEQ is addressed in EPBD so that explicit requirements are on the responsibility of MS
- To equip non-residential ZEB with measuring and control devices for the regulation of indoor air quality can make real improvement in construction
- Non-renewable primary energy indicator can be used for ZEB/NZEB requirements
- For EPC scale, EPBD uses total primary energy
- In all, the following factors are needed to follow EPBD:
  - Non-renewable PEF for the requirements (= current practise in most MS)
  - Biomass factor to be used with non-renewable PE requirement (= current practise)
  - Total PEF for EPC classes
  - Carbon free electricity factor for the PE covering requirement
  - CO_2 emission coefficients for operational CO_2 emissions (= current practise)
- Alternatively, Annex I allows to use weighting factors for numeric indicator of primary energy, which provide more flexibility