Highlights of EPBD recast proposal – *aspects related to HVAC*

JAREK KURNITSKI
REHVA Technology and Research Committee, Tallinn University of Technology
jarek.kurnitski@taltech.ee

The proposal introduces zero-emission buildings, deep renovation, minimum energy performance standards, harmonised EPC scale, hourly energy calculation method, monitoring and regulation of indoor air quality, inspection of stand-alone ventilation systems and a new vision to transform European building stock into zero emission buildings by 2050.

Keywords: EPBD recast, zero-emission building, deep renovation, national building renovation plan, minimum energy performance standard, monitoring indoor air quality

Energy Performance of Buildings Directive is in the third revision, the recast proposal (EPBD recast) was published in 15.12.2021, being a part of the "Fit for 55" package. The new directive may be expected by the end of 2022. The main new vision of the recast proposal is to transform all existing buildings into zero emission buildings by 2050. For this purpose, nearly zero energy buildings (NZEB) will be replaced by zero-emission buildings (ZEB) and existing major renovation is complemented with deep renovation, intending to ZEB level. The main new instrument to realize the ambition are *National building renovation plans* that are the next step from the present *long-term renovation strategies*. In these national building renovation plans, Member States (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 the 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.

Deadlines for ZEB and improvement of worst-performing buildings

There are clear deadlines in the recast proposal to target new ZEB and for improvement of worst-performing existing building stock by defining minimum energy performance standards (MEPS). New public buildings shall be ZEB from 2027 and all new buildings from 2030. In ZEB, the very low energy demand shall be fully covered by energy from renewable sources. First time, Annex III of the directive sets threshold primary energy values for ZEB in three climate zones, from which national values cannot be higher. It is also required to move to hourly energy calculation that is set in Annex I.

The energy performance certificate (EPC) scale is planned to be harmonised so that class A is ZEB and worst performing 15% of existing buildings will belong to class G. Other classes are proportionally divided in between of these two and the same scale must be used both for new and existing buildings. This means that the major renovation requirements do not need to be class A. It is expected that MS stimulate class A renovation that is called deep renovation by financial incentives. Deep renovation is defined as NZEB before 2030 and ZEB as of 1 January 2030. There is a full article about financial incentives setting that MS have to provide appropriate financing and support measures to stimulate both deep renovation as well as mandatory renovation of worst performing building stock that is targeted with MEPS. MEPS require that public buildings will achieve EPC class F by 2027 and class E by 2030. The same requirement applies for other non-residential buildings. Residential buildings must achieve EPC class F by 2030 and EPC class E by 2033.

Indoor environmental quality and ventilation

Indoor environmental quality is stressed for both new buildings and major renovations by mentioning that the issues of healthy indoor climate conditions shall be addressed. 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. There is a new requirement to equip zero emission buildings with measuring and control devices for the monitoring and regulation of indoor air quality. In existing buildings, the installation of such devices shall be required, where technically and economically feasible, when a building undergoes a major renovation. Regular inspection of heating and air conditioning systems is extended to stand alone ventilation systems. Ventilation systems are also specified as part of the EPBD measures aimed at addressing indoor air quality.

Methodology development

Energy performance levels for ZEB and as well as for major renovation requirements will stay to be based on the cost-optimality principle. Next cost-optimal levels calculation round in 2023 will be conducted with existing methodology and NZEB requirements that will stay in use until 2027 in public and 2030 in other new buildings cannot have the lower ambition than the 2023 cost-optimal level. By June 2026, the Commission plans to revise the cost-optimal methodology of minimum energy performance requirements in existing buildings undergoing major renovation, and 2028 cost-optimal calculations are to be done with this revised methodology. A review of the methodology should take into account extension of the emissions trading system (ETS), carbon prices and environmental and health externalities.

Life cycle carbon footprint (GWP with the Level(s) framework) is required to be calculated and reported in EPCs from 2027 for new buildings larger than 2 000 m² and from 2030 for all new buildings. This includes carbon footprint of building materials and products as well as operational energy and is for informing on the whole-life cycle emissions of new construction; there is no mention about possible requirements. Smart readiness of buildings is further developed by a mandate to the Commission to publish a delegated and an implementing act on a common Union scheme for rating the smart readiness of non-residential buildings above 290 kW effective rated output by the end of 2025.

Zero-emission building (ZEB) definition

ZEB is perhaps the most fundamental issue defined as "the very low amount of energy still required is fully covered by energy from renewable sources generated on-site, from a renewable energy community or from a district heating and cooling system, in accordance with the requirements set out in Annex III". In Annex III, it is further specified that the energy to be fully covered is the total annual primary energy, for which maximum thresholds are provided in **Figure 1**. So far, the primary energy requirements have been based on non-renewable primary energy, following the cost-optimal regulation (EU) No 244/2012 and Commission Recommendation (EU) 2016/1318. To understand the meaning of the change from non-renewable primary energy to total primary energy, REHVA Technology and Research Committee prepared a calculation example shown in **Figure 1**.

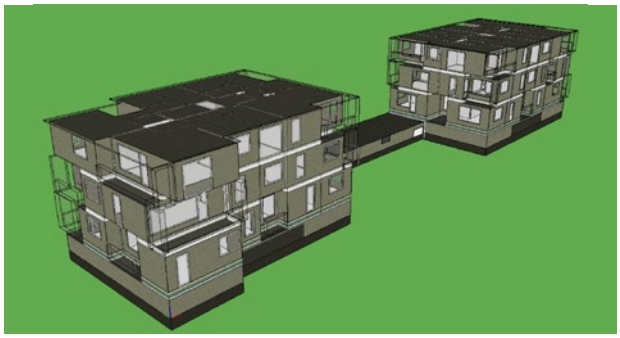
In the example, Annex III ZEB requirements are applied to a NZEB apartment building in Nordic climate to check if and under which conditions these requirements could be fulfilled. The building configuration meets current Estonian NZEB requirements with district heating (DH) and ground source heat pump (GSHP) if PV generation is 16 kWh/(m² a). Air to water heat pump (AWHP) would need some improvement and gas would need major changes. **Figure 1** indicates the primary energy factors and CO_2 emission coefficients of energy carriers and renewable energy from the EN ISO 52000-1 standard, and estimated values for effective district heating.

EPBD Annex III limits the total primary energy in Nordic climate to 75 kWh/(m² a). **Figure 1** line "EPBD No 1" shows that the gas boiler is closest to reach this requirement when calculated without taking PV export into account in the primary energy. Heat pumps show the highest total primary energy values because the heat taken from the environment is included in the total primary energy (EN ISO 52000-1, total primary energy factor 1.0). If the exported PV electricity would be taken into account, the gas boiler total primary energy of 71 kWh/(m² a) will be the only one fulfilling the requirement. This result is not logical and the total primary energy values conflict with CO_2 emissions and non-renewable primary energy which are lower for district heating and heat pumps.

The second requirement in the ZEB definition ask to fully cover, on a net annual basis, the total primary

energy use by renewables (without accounting renewables from the electricity grid). In this case, it is impossible to fulfil this requirement even if the maximum size of 24 kWh/(m² a) of PV that is possible to install to the roof is considered and exported PV is taken into account. At the same time, renewable energy covers non-renewable primary energy in the case of district heating and is very close to that with GSHP.

Apartment building calculation example (Nordic climate)					input data
Primary energy factors & CO_2 emission coefficients					
	non-ren.	renewable	total	$kgCO_2/kWh$	€/kWh
Grid electricity & PV export	2.3	0.2	2.5	0.42	0.2
Natural gas	1.1	0	1.1	0.22	0.1
DH (district heat)	0.6	0.6	1.2	0.12	0.08
RE (solar, geo, ambient)	0	1	1	0	0



Uwall=0.14; Uroof=0.12; Ufloor=0.14; Uwindow=0.9; q50=1.5 m³/hm². Heat recovery ventilation, 80% temp.ratio, electric reheating coil. No cooling (passive measures to control summer thermal comfort). Heat source options: DH (district heating), Gas (gas boiler), GSHP (ground source heat pump) and AWHP (air to water heat pump).

System efficiencies, -	
Boiler efficiency, DH	0.90
Boiler efficiency, gas	0.95
Em&distr. efficiency	0.97

Heat pump, -	GSHP	AWHP
Energy ratio	0.78	0.81
SPF space heating	4.2	2.8
SPF DHW	2.6	2.0

Energy calculation	Energy need kWh/m² a	Energy use kWh/m² a			
		DH	Gas	GSHP	AWHP
Space heating	25.9	29.7	28.1	10.8	12.8
DHW	30	33.3	31.6	11.5	15.0
Supply air heating	4.4	4.4	4.4	4.4	4.4
Fans and pumps	5.5	6	6	5.5	5.5
Fixed lighting	1.4	1.4	1.4	1.4	1.4
PV generation	16				
PV self use,-		0.55	0.55	0.7	0.7
PV self use, kWh/m² a		8.8	8.8	11.2	11.2
PV export[1], 0/1	0	0	0	0	0
Non-ren. primary energy, kWh/m² a		44.7	72.6	51.7	64.2
Total primary energy[2], kWh/m² a		**91.9**	**82.0**	**100.9**	**109.0**
Renewable energy[3], kWh/m² a		**53.8**	**16.0**	**49.5**	**44.1**
CO_2 emissions, $kgCO_2/m^2$ a		8.8	14.4	9.4	11.7
Energy cost[4], €/m² a		5.6	6.6	4.5	5.6

EPBD No 1

EPBD No 2

1) PV export not taken into account =0, is taken into account = 1
2) If PV export=0, only self used PV is accounted in the total primary energy
3) Renewable energy does not include renewable energy from grid electricity as specified in EPBD draft
4) Exported electricity compensation is assumed to be 1/3 of the electricity price

Figure 1. Comparison of NZEB building in Nordic climate and the zero-emission level.

Non-renewable energy and total primary energy calculation

To explain how the values in **Figure 1** were calculated, GSHP case is shown below step by step, all units in kWh/(m² a). Sum of all energy uses (all electrical, blue values in **Figure 1**) is 33.6 and the self-use of PV is 11.2. Delivered energy to the site is thus 33.6-11.2=22.4, **Figure 2**. As exported energy was not accounted, non-renewable primary energy is:

$$EP_{nren} = 22.4 \times 2.3 = 51.5$$

For the total primary energy calculation, also the heat extracted from environment needs to be taken into account, because it has renewable and total primary energy factor of 1.0. This additional energy flow of geothermal energy is shown in **Figure 3**. Because the exported energy was not accounted, only the self-use of PV is calculated in the total primary energy:

$$EP_{tot} = 15.1 + 18.5 + 16.0 - 4.8 + 22.4 \times 2.5 = 100.8$$

Renewable energy in EPBD recast proposal does not include the renewable energy from grid electricity:

$$RE = 15.1 + 18.5 + 16.0 = 49.6$$

It would be logical to account renewable energy from grid electricity, which will increase renewable energy by 22.4 × 0.2=4.5.

This calculation example shows that the details of ZEB definition are either not correctly understood or need some development. The use of total primary energy-based requirements seems not to be sound. Instead, ZEB should be defined based on non-renewable primary energy or CO_2 emissions which provide similar results. Renewable energy compensation calculation works well, but it is unclear why renewable part of grid electricity cannot be taken into account. ■

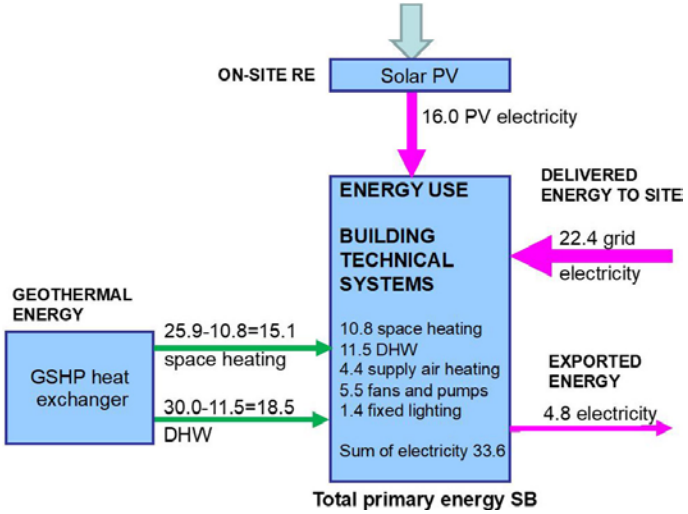


Figure 3. Energy flows for total primary energy calculation.

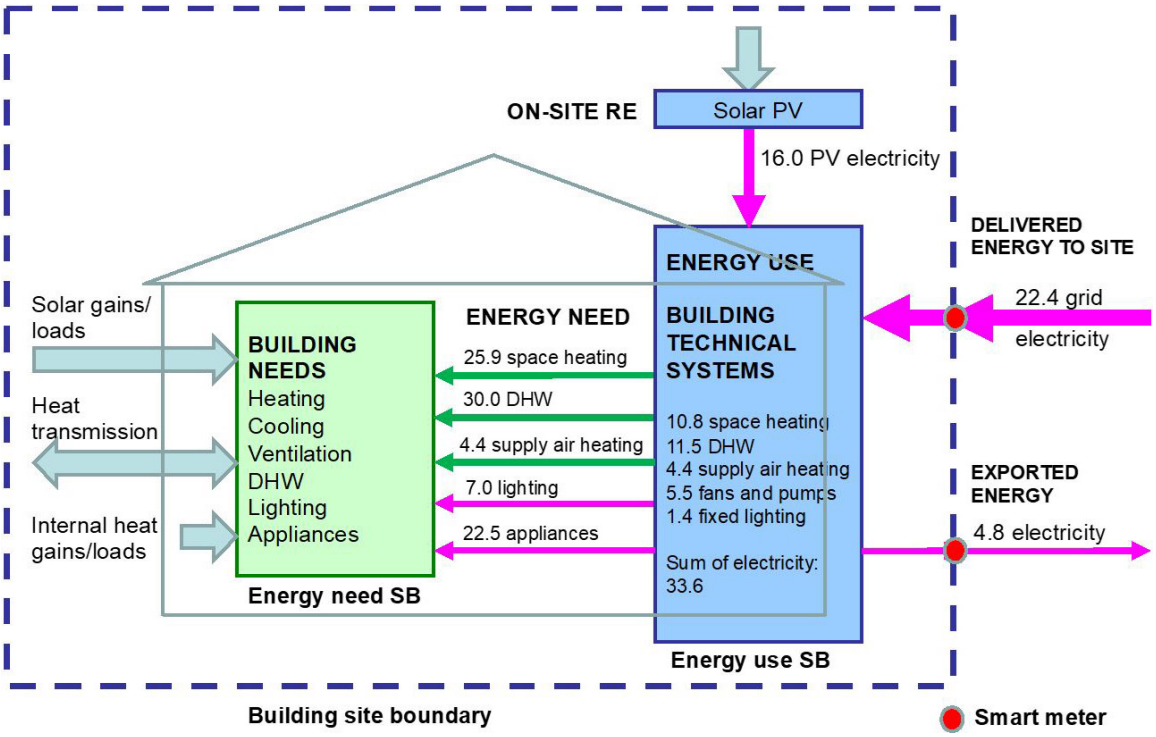


Figure 2. Energy flows for delivered and exported energy calculation. Note that internal heat gains (under energy needs) include the full lighting as well as appliances which are not included in EPB services but are used for PV self-use (otherwise PV self-use of 70% would be impossible).