nZEB definitions in Europe

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In the directive ‘nearly zero-energy building’ means a building that has a very high energy performance (EP). The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources (RES) produced on-site or nearby.

⇒ nZEB = very high EP + on-site or nearby RES

Definition of “a very high EP” and “significant extent of RES” let for Member States (MS), however the cost-optimality principle has been set.

EPBD Article 9 [http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm]:
- By 31 Dec 2020, all new buildings are nearly zero energy buildings
- After 31 Dec 2018, public authorities that occupy and own a new building shall ensure that the building is a nearly zero energy building
EPBD definition for energy performance

EPBD definitions (article 2):
• ‘energy performance of a building’ means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, *inter alia*, energy used for heating, cooling, ventilation, hot water and lighting.
nZEB definitions

• European definitions based on EPBD recast:
  – REHVA 2013 – REHVA has revised its nZEB technical definition and set of system boundaries for primary energy indicator and RER calculation in cooperation with CEN, REHVA Report No:4 www.rehva.eu
  – CEN is working with overarching EPBD standard prEN 15603:2013, which will include calculation bases for primary energy and RER, EN 15603 expected 2014-2015

• National definitions
  – More than 10 MS have already launched national nZEB
    • Progress report by EC, COM(2013) 483 final/2, 7.10.2013: 4 (10) MS provided a definition that comprises both numerical target and a share of RES, included in a legal document
    • Concerted Action CA EPBD Oct 2013 reports that 10 MS have nZEB numerical definitions
EPBD overarching standard

- prEN15603:2013 defines energy balance of a building (a), on site perimeter (b), nearby (c) and distant energy production (d).
- will include some guidance for nZEB definition
REHVA nZEB technical definition – 2013 revision

- ZEB, net ZEB, PEB and nZEB definitions
- A set of system boundaries to calculate:
  - Energy need
  - Energy use
  - Delivered and exported energy
  - Primary energy
  - Renewable energy ratio
  - Nearby energy production
  - Sites with multiple buildings
- Load matching and grid interactions
- Worked examples
- National low energy and nZEB requirements/targets from selected countries
Energy flows to be covered by nZEB definition for $E_{P_p}$ calculation

For thermal and electrical energy it applies:

\[
\text{Delivered} - \text{exported energy} = \text{energy use} - \text{on site renewable}
\]
net zero energy building (net ZEB)
Non-renewable primary energy of 0 kWh/(m² a).

NOTE  A net ZEB is typically a grid connected building with very high energy performance. A net ZEB balances its primary energy use so that the primary energy feed-in to the grid or other energy network equals to the primary energy delivered to ZEB from energy networks. Annual balance of 0 kWh/(m² a) primary energy use typically leads to the situation where significant amount of the on-site energy generation will be exchanged with the grid.

nearly zero energy building (nZEB)
Technically and reasonably achievable national energy use of > 0 kWh/(m² a) but no more than a national limit value of non-renewable primary energy, achieved with a combination of best practice energy efficiency measures and renewable energy technologies which may or may not be cost optimal.

NOTE 1 ‘reasonably achievable’ means by comparison with national energy use benchmarks appropriate to the activities served by the building, or any other metric that is deemed appropriate by each EU Member State. 
NOTE 2. Renewable energy technologies needed in nearly zero energy buildings may or may not be cost-effective, depending on available national financial incentives.
	nZEB depends on national conditions
EP and RER calculation needs detailed system boundaries.

- System boundaries (SB) for energy need, energy use and delivered and exported energy calculation. The last one may be interpreted as the building site boundary.
- Demand reduction measures can be distinguished from RE solutions in the energy use SB, not in the delivered/exported energy SB.
Example: nZEB office – primary energy

Primary energy: \[ EP_p = 4.2 \cdot 1.0 + 33.8 \cdot 2.0 - 9.0 \cdot 2.0 = 53.8 \frac{kWh}{m^2a} \]

- Electricity use of cooling, ventilation, lighting and appliances is 39.8 kWh/(m² a)
- Solar electricity of 6.0 kWh/(m² a) reduces the delivered electricity to 33.8 kWh/(m² a)
- Net delivered fuel energy (caloric value) is 4.2 kWh/(m² a) and primary energy is 54 kWh/(m² a)
RER: Example of nZEB office

Renewable energy ratio:

\[
RER_p = \frac{15.0 + 4.4 + (2.2 - 2.0) \cdot 33.8}{15.0 + 4.4 + 4.2 \cdot 1.0 + 33.8 \cdot 2.2 - 9.0 \cdot 2.2} = \frac{26.2}{78.2} = 0.33
\]

- The same input data as in previous example
System boundary for nearby RE plants contractually linked to the building (a share of the capacity/production can be linked to the building)

National legislation needed to allocate new RE capacity to the building/development with a long term contract
Situation with national energy frames

- Differences in energy frames:
  - Primary energy not yet used in all countries
  - Some countries (Germany, France) use reference building method, fixed values in other countries
  - Both simulation (Estonia, Finland) and monthly methods (Germany, Denmark) used

- Inclusion of energy flows depends on country:
  - Germany/residential – heating energy only (space heating, DHW and heating of ventilation air)
  - Germany/non-residential – cooling and lighting also included (appliances not)
  - Denmark – appliances and in residential also lighting not included
  - Sweden – appliances and user’s lighting not included (facility lighting incl.)
  - Estonia, Finland, Norway – appliances and lighting included (all inclusive)

- RES (on site renewable energy production) is not accounted in all countries
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<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Values</td>
<td>Metric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 1-2 (Catania, Athens)</td>
<td>Cyprus</td>
<td>180 210 kWh/m²/y</td>
<td>Primary energy</td>
<td>Residential</td>
<td>No</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Non-residential</td>
<td>No</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>54 32 60 kWh/m²/y</td>
<td>Primary energy</td>
<td>Heating, hot water, ventilation, cooling (non-res), lighting (non-res)</td>
<td>Detached Apartment Offices</td>
<td>N.a.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3 (Budapest, Bratislava, Ljubjana)</td>
<td>Slovakia</td>
<td>54 32 60 kWh/m²/y</td>
<td>Primary energy</td>
<td>Heating, hot water, ventilation, cooling (non-res), lighting (non-res)</td>
<td>Detached Apartment Offices</td>
<td>N.a.</td>
</tr>
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<td></td>
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<tr>
<td></td>
<td>Belgium BXL</td>
<td>45 95-2,5*(V/S) kWh/m²/y</td>
<td>Primary energy</td>
<td>Heating, cooling (non-res), hot water, lighting (non-res) appliances</td>
<td>Residential Offices, educational</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Belgium Walloon</td>
<td>60 kWh/m²/y</td>
<td>Primary energy</td>
<td>Heating, hot water, appliances</td>
<td>Residential and non-res.</td>
<td>N.a.</td>
</tr>
<tr>
<td></td>
<td>Belgium Flemish</td>
<td>30 40 kWh/m²/y</td>
<td>Energy use</td>
<td>Heating, cooling, hot water, ventilation, auxiliary systems</td>
<td>Residential Office and school</td>
<td>Yes</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>50 70 110 kWh/m²/y</td>
<td>Primary energy</td>
<td>Heating, ventilation, cooling, hot water, lighting, auxiliary systems</td>
<td>Residential Office Office AC</td>
<td>No</td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td>45 kWh/m²/y</td>
<td>Energy load</td>
<td>Heating, ventilation, hot water, lighting</td>
<td>Residential</td>
<td>N.a.</td>
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<tr>
<td>Netherlands</td>
<td></td>
<td>0 [-]</td>
<td>Energy perform. coefficent (EPC)</td>
<td>Heating, ventilation, cooling, hot water, lighting</td>
<td>Residential/ non-residential</td>
<td>Yes</td>
</tr>
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</table>

Federation of European Heating, Ventilation and Air-conditioning Associations
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>nZEB Energy performance</th>
<th>RES</th>
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<tbody>
<tr>
<td>Zone 5</td>
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<td>Values</td>
<td>Unit</td>
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<td></td>
<td></td>
<td>20</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Denmark</td>
<td>50</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Estonia</td>
<td>95</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Latvia</td>
<td>&lt;0,25</td>
<td>[-]</td>
</tr>
</tbody>
</table>

Data from CA EPBD Oct 2013 (Kurnitski et al. REHVA Journal 2/2014)
RES in energy frames and nZEB applications

• RES was not yet implemented in present calculation frames in 5 out of 10 countries with nZEB application

• Most of energy frames are not yet ready to support exported energy:
  – Full utilization on annual bases: Denmark, Estonia, net plus energy program in Germany
  – Monthly bases (limited to the amount of the delivered electricity each month and the rest of exported is not accounted): Germany
  – Not accounted: Finland, Norway, Italy, …

• 5 out of 10 countries have set specific indicator for RES in nZEB application

• None of EU countries have implemented nearby RES – future issue to be solved with RES inclusion and exported energy
REHVA Journal 2/2014: nZEB case studies provide more reliable benchmarks than first national nZEB definitions

Energy data from four nZEB office buildings:
- Delivered heating is in first building a fuel and in last one district heat. Two other buildings have heat pumps, delivered heating is electricity.
- Delivered cooling is in all buildings electricity.
- On site electricity is PV in 3 buildings and bio-CHP in one building.
- All values in the table are in kWh/m²y.

For all buildings the following primary energy factors were applied:
- 0.7 for heating (district heat or biomass);
- 2.0 for electricity.

<table>
<thead>
<tr>
<th>Climate zone</th>
<th>City, country</th>
<th>Heating</th>
<th>Cooling</th>
<th>Delivered energy</th>
<th>Lighting</th>
<th>Appliances</th>
<th>On site electricity</th>
<th>Primary energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Dion France</td>
<td>10.5</td>
<td>2.4</td>
<td>6.5</td>
<td>3.7</td>
<td>21.2</td>
<td>-15.6</td>
<td>44</td>
</tr>
<tr>
<td>4</td>
<td>Gland Switzerland</td>
<td>6</td>
<td>6.7</td>
<td>8.1</td>
<td>16.3</td>
<td>26.8</td>
<td>-30.9</td>
<td>66</td>
</tr>
<tr>
<td>4</td>
<td>Hoofddrop Holland</td>
<td>13.3</td>
<td>3.3</td>
<td>17.5</td>
<td>21.1</td>
<td>19.2</td>
<td>-40.4</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>Helsinki Finland</td>
<td>38.3</td>
<td>0.3</td>
<td>9.4</td>
<td>12.5</td>
<td>19.3</td>
<td>-7.1</td>
<td>96</td>
</tr>
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</table>
### Towards nearly zero energy buildings

Denmark

<table>
<thead>
<tr>
<th>Characteristic values</th>
<th>Residential buildings (houses, hotels, etc.)</th>
<th>Energy frame 2010</th>
<th>Energy frame 2015</th>
<th>Energy frame 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum of primary energy to</td>
<td>52.5 + 1650/A in kWh/m²a</td>
<td>30 + 1000/A in kWh/m²a</td>
<td>20 kWh/m²a</td>
<td></td>
</tr>
<tr>
<td>Non-residential buildings (offices, schools, institutions and other buildings)</td>
<td>71.3 + 1650/A in kWh/m²a</td>
<td>41 + 1000/A in kWh/m²a</td>
<td>25 kWh/m²a</td>
<td></td>
</tr>
<tr>
<td>Conversion factors</td>
<td>Electricity 2.5 in kWh/m²a</td>
<td>2.5 in kWh/m²a</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>District heating 1.0 in kWh/m²a</td>
<td>0.8 in kWh/m²a</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>
Towards nearly zero energy buildings

Estonia

Primary energy requirements for 9 building types (apply from Jan 9, 2013)

<table>
<thead>
<tr>
<th></th>
<th>nZEB A kWh/(m² a)</th>
<th>Low energy B kWh/(m² a)</th>
<th>Min.req. new C kWh/(m² a)</th>
<th>Min.req. maj.ren. D kWh/(m² a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached houses</td>
<td>50</td>
<td>120</td>
<td>160</td>
<td>210</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>100</td>
<td>120</td>
<td>150</td>
<td>180</td>
</tr>
<tr>
<td>Office buildings</td>
<td>100</td>
<td>130</td>
<td>160</td>
<td>210</td>
</tr>
</tbody>
</table>

- nZEB and low energy requirements officially given (not yet mandatory)
- Conversion factors:
  - Electricity 2.0
  - Fossil fuels 1.0
  - District heat 0.9
  - Renewable fuels 0.75
Conclusions

• National nZEB applications showed remarkably high variation between 20 and 200 kWh/m²y primary energy in ten countries:
  – caused partly due to different energy uses included and partly due to different level of ambition in the definitions
  – exclusion of the energy flows leads to situation where calculated energy use could represent only a small fraction of measured energy use in real buildings

• Requirements only for residential and non-residential show that majority of countries cannot tackle the eight building types specified in EPBD recast Annex

• nZEB primary energy values showed a reduction by factor of 1.6 in Estonia and by about 2 in Denmark compared to current EP minimum requirements of office buildings

• Member States need more guidance in order to set consistent and comparable nZEB values with equal ambition levels