Development of nearly zero energy buildings in Europe and related European standards

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Towards nZEB:
• Roadmap of some countries towards nearly zero energy buildings to improve energy performance of new buildings
• Many countries have prepared long term roadmaps with detailed targets
• Helps industry to prepare/commit to the targets
Finland: FInZEB project

- FInZEB represents a major stakeholders in Finland working with EPB
- Aims to prepare a proposal on nZEB national application (2014–2015) regarding:
  - methodology (system boundaries)
  - numeric values of primary energy indicators for major building types

- [www.finzeb.fi](http://www.finzeb.fi)
Making the EPBD pieces fit together
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.

Other services may or may not be included in the rating – included in the REHVA definition.
EPBD recast – Nearly zero energy buildings nZEB

• 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
Energy flows to be covered by nZEB definition for $EP_p$ calculation

For thermal and electrical energy it applies:

\[ \text{Delivered} - \text{exported energy} = \text{energy use} - \text{on site renewable} \]
nZEB definitions

- **European definitions based on EPBD recast:**
  - REHVA 2013 – has revised its 2011 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
  - Overarching EPBD standard FprEN 15603:2014, which will include calculation bases for primary energy and RER, and guidance for nZEB, available in 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
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
**REHVA nZEB definition 2013**

**net zero energy building (net ZEB)**
Non-renewable primary energy of 0 kWh/(m$^2$ 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/(m$^2$ 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/(m$^2$ 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 follows the building site/energy network connection points.
- Demand reduction measures can be distinguished from RE solutions in the energy use SB, not in the delivered/exported energy SB.
FprEN 15603:2014 defines energy balance of a building (a), on site perimeter (b), nearby (c) and distant energy production (d).

- Includes informative annex for setting nZEB rating
Definition of nearly Zero-Energy Buildings (nZEB)

- **G.1 General principles**
  - The use of only one requirement, e.g. the numeric indicator of primary energy use, is misleading. Different requirements are combined to a coherent assessment of a nearly Zero-Energy Building (nZEB).

- **G.2 First requirement: The building fabric (Energy needs)**
- **G.3 Second requirement: The total primary energy use**
- **G.4 Third requirement: Non-renewable primary energy use without compensation between energy carriers**
- **G.5 Final nZEB rating: Numerical indicator of non-renewable primary energy use with compensation**
The CEN proposal for nZEB: a hurdle race

**Start**
- **Hurdle 1:** Building needs
  - Conditioned space

**Hurdle 2:** Building use
- Total primary energy
- Technical building systems

**Hurdle 3:** Building use
- Non-renewable prim. energy
- Energy carriers

**Arrival**
- nZEB rating
  - Primary energy balance
  - Delivered - Exported

Evolution of assessment boundaries
Delivered - Exported

At this stage, the compensation between energy carriers and the effect of exported energy is taken into account.

The numerical indicator of non-renewable primary energy is calculated according to 7.6 (step B).
EPBD standards 2015-2016

- The set of second generation CEN-EPBD standards under development (about 40 standards, mostly new numbers)
- CEN TC 371 ‘Energy performance of building project group’ coordinates the work with five committees:
  - TC 89, Thermal performance of buildings and building components
  - TC 228, Heating systems in buildings
  - TC 156, Ventilation for buildings
  - TC 247, Building automation, controls, and building management
  - TC 169, Light and lighting
- FprEN 15603:2014 is already in formal vote (FV-date Oct 7)
- Other standards are coming to public enquiry (Oct-Nov 2014)
- Standards will include a format for national annexes where MS have to report national options and input data
A complex OA structure is needed
Because:... this is what we are calculating
Small existing building?

You just calculate it as one single piece

...as you would eat a small pastry in one single bite..

= no partitioning required
Big building, arcade + office + residential?

... but what if there is a big cake on the table?
You have to eat it slice by slice ...

\[\text{Partitioning required for complex buildings!}\]
High performance

• Hourly method as the main method
• Monthly methods also included
• In general, many options – only way to achieve European consensus

The amount of energy involved is so small that any interaction may be relevant. Example domestic hot water losses and cooling...

Also localization of gains is relevant.

Will Solar gains of the big window in the living facing south effectively heat upstairs north rooms?

Thermal zones or even room by room calculation may be required...
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**
Map of European climatic zones

Legend
- Zones 1&2
- Zone 3
- Zone 4
- Zone 5
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>nZEB Energy performance</th>
<th>RES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Values</td>
<td>Unit</td>
</tr>
<tr>
<td>Zone 1-2</td>
<td>Cyprus</td>
<td>180</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>(Catania, Athens)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>Slovakia</td>
<td>54</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td>(Budapest, Bratislava, Ljubjana)</td>
<td></td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belgium BXL</td>
<td>45</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>95</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-2,5*(V/S)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belgium Walloon</td>
<td>60</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Belgium Flemish</td>
<td>30</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td></td>
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<td></td>
<td>France</td>
<td>50</td>
<td>kWh/m²/y</td>
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<td>70</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ireland</td>
<td>45</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Netherlands</td>
<td>0</td>
<td>[-]</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td>Country</td>
<td>nZEB Energy performance</td>
<td>RES</td>
</tr>
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<td>--------</td>
<td>---------</td>
<td>-------------------------</td>
<td>-----</td>
</tr>
<tr>
<td></td>
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<td>Values</td>
<td>Unit</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Denmark</td>
<td>20</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>kWh/m²/y</td>
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<tr>
<td></td>
<td>Estonia</td>
<td>50</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>kWh/m²/y</td>
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<td></td>
<td>100</td>
<td>kWh/m²/y</td>
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<tr>
<td></td>
<td></td>
<td>130</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Latvia</td>
<td>95</td>
<td>kWh/m²/y</td>
</tr>
<tr>
<td></td>
<td>Lithuania</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.

<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>
</tbody>
</table>

For all buildings the following primary energy factors were applied:

- 0.7 for heating (district heat or biomass);
- 2.0 for electricity.
## Towards nearly zero energy buildings

### Denmark

<table>
<thead>
<tr>
<th>Indicator</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></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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Non-residential buildings (offices, schools, institutions and other buildings)</th>
<th>Energy frame 2010</th>
<th>Energy frame 2015</th>
<th>Energy frame 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion factors</td>
<td>Electricity</td>
<td>2.5</td>
<td>2.5</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>District heating</td>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Conversion factors:
- **Electricity**: 2.5, 2.5, 1.8
- **District heating**: 1.0, 0.8, 0.6
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
Estonian nZEB

Hoone energiaõhususarv: 90 kWh/m²a

Hoone adresse:
Kehtib kuni:
nZEB requirements up today

• National nZEB applications show 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 2 in Denmark compared to current EP minimum requirements of office buildings (reduction of 40-50%)

• European EPBD standards are seen as a tool for harmonization