Progress with national nZEB applications in the EU

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REHVA nZEB Task Force

- TF prepared nZEB technical definition and set of system boundaries for primary energy indicator and RER calculation in 2011
- In 2013 it was revised in cooperation with CEN, resulting in REHVA Report No:4
- TF is following nZEB technical, regulatory and policy progress
- Latest, ongoing analyses on RE contribution and RER indicator based on data from 8 nZEB office and school buildings across the EU
Screening of energy frames and nZEB in 2013

• **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 uses 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 or is accounted differently**
Map of European climatic zones
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>nZEB Energy performance</th>
<th>RES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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Data from CA EPBD Oct 2013 (Kurnitski et al. REHVA Journal 2/2014)
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>nZEB Energy performance</th>
<th>RES</th>
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<tbody>
<tr>
<td></td>
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<td>kWh/m²/y</td>
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<td>130</td>
<td>kWh/m²/y</td>
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<tr>
<td>Latvia</td>
<td></td>
<td></td>
<td>kWh/m²/y</td>
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<tr>
<td>Lithuania</td>
<td></td>
<td>&lt;0,25</td>
<td>[-]</td>
</tr>
</tbody>
</table>

Data from CA EPBD Oct 2013 (Kurnitski et al. REHVA Journal 2/2014)
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>Fans&amp;pumps</th>
<th>Lighting</th>
<th>Appliances</th>
<th>On site electricity</th>
<th>Primary energy</th>
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<tbody>
<tr>
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<td>2.4</td>
<td>6.5</td>
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<td>12.5</td>
<td>19.3</td>
<td>-7.1</td>
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</table>

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

Appliances may be largest component in energy balance of nZEB buildings.
<table>
<thead>
<tr>
<th>Country</th>
<th>Status of the definition</th>
<th>Main reference(s)</th>
<th>Year of enforcement</th>
<th>EPBD scope of nZEB definition</th>
<th>Numerical indicator</th>
<th>Maximum primary energy [kWh/m(^2)]</th>
<th>Share of renewable energy</th>
<th>Other indicators</th>
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<td></td>
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## BPIE factsheet on nZEB definitions 2015 www.bpie.eu

<table>
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<th>Country</th>
<th>Status of the definition</th>
<th>Main reference(s)</th>
<th>Year of enforcement</th>
<th>EPBD scope of nZEB definition</th>
<th>Numerical indicator</th>
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<th>Share of renewable energy</th>
<th>Other indicators</th>
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<td>EP, TS</td>
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<td>1/01/2021</td>
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<td>EP</td>
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<td>Included in the calculation; building needs to comply with class A++</td>
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Federation of European Heating, Ventilation and Air-conditioning Associations
RES in energy frames and nZEB applications (2015 data)

• In 2013 RES was not yet implemented in present calculation frames in 5 out of 10 countries with nZEB application

• Most of energy frames were 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, …

• 8 out of 13 countries have set specific indicator for RES in nZEB application (2015 data)

• There is no information that nearby RES has implemented in any country, however ongoing in DK, FI … – but mostly a future issue to be solved with RES inclusion and exported energy
nZEB requirements 4/2015

- Primary energy and % of minimum EP requirements are used as nZEB EP indicator in most of countries
- The range of values varies remarkably from positive energy buildings up to 270 kWh/m²/y primary energy:
  - from 20 kWh/m²/y to 160 kWh/m²/y in residential buildings, but usually targets aim at 45 kWh/m²/y or 50 kWh/m²/y
  - Values from 25 kWh/m²/y to 270 kWh/m²/y are reported for non-residential buildings with higher values given for hospitals.
  - Remarkable differences caused mostly due to different energy uses included, but the methodologies/input data have an effect and evidently there are differences in the ambition level
- nZEB primary energy values show 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%)
Open nZEB issues

1. Energy uses accounted:
   – major difference if accounting or not appliances & lighting

2. System boundary
   – onsite and nearby RES accounting (follows or not energy meters)

3. Time step: hourly vs. monthly calculation

4. Period and type of balance when accounting RES export
   – Annual or limitations for instance on monthly level

5. Numerical indicators of energy performance
   – Primary energy not yet fully established
   – Qualitative/quantitative RES accounting

6. Building categories
   – Standard uses and requirements for non-residential buildings
Main arguments around nZEBs to be established in definitions:

Energy uses accounted

- 7 countries out of 13 account appliances (AT, BG, EE, FI, LV, LT, NL), the rest do not
- 6 countries account lighting in residential buildings (EE, FI, FR, LT, SE, UK)
- Appliances and lighting correspond to 50-60 kWh/m²y primary energy in residential buildings
Inclusion of appliances and lighting – EE

- VV No 68: 2012 – Minimum requirements for energy performance
- Minimum requirements are given for 9 building types, for new buildings and for major renovation
- nZEB and low energy building requirements officially given together with cost optimal minimum requirements

Primary energy factors:
- Electricity 2.0, Fossil fuels 1.0, District heat 0.9 and Renewable fuels 0.75

<table>
<thead>
<tr>
<th>EPC class</th>
<th>nZEB [kWh/m²y]</th>
<th>Low energy [kWh/m²y]</th>
<th>Min. req. NEW [kWh/m²y]</th>
<th>Min. req. Major REN [kWh/m²y]</th>
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</thead>
<tbody>
<tr>
<td>Detached houses</td>
<td>50 (0&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>120</td>
<td>160 (110&lt;sup&gt;a&lt;/sup&gt;)</td>
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<tr>
<td>Apartment buildings</td>
<td>100 (41&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>120</td>
<td>150 (101&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>180</td>
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<tr>
<td>Office buildings</td>
<td>100 (62&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>130</td>
<td>160 (128&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>210</td>
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</table>

<sup>a</sup> without lighting and appliances, <sup>b</sup> without appliances
Building categories

- Steering to optimal design solutions: define standard use/ nZEB requirement for each building category
- Usages, intensities and operation times vary a lot between different building categories – optimal EE and RES measures differ accordingly
- EPBD Annex I building categories are relevant except hospitals
- Hospitals (EE nZEB=270) could be replaced with clinics/health-care centers (12/24 and 5/7 operation instead of 24/24 and 7/7 operation with high loads from hospital equipment)
- Industrial buildings (very often without significant heat gains from the process) will deserve a separate category
- Grocery stores another specific category because EP depends mostly on the refrigeration condensation heat utilization
### The effect of building categories – EE

**VV No 68: 2012 – Full set of EP requirements/standard use input data**

<table>
<thead>
<tr>
<th>Building category</th>
<th>EPC class</th>
<th>nZEB kWh/(m² y)</th>
<th>Low energy kWh/(m² y)</th>
<th>Minimum req. NEW kWh/(m² y)</th>
<th>Minimum req. Major REN kWh/(m² y)</th>
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<tr>
<td>Detached houses</td>
<td>A</td>
<td>50</td>
<td>120</td>
<td>160</td>
<td>210</td>
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<tr>
<td>Apartment buildings</td>
<td>B</td>
<td>100</td>
<td>120</td>
<td>150</td>
<td>180</td>
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<td>Office buildings</td>
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<tr>
<td>Hotels and restaurants</td>
<td>D</td>
<td>130</td>
<td>160</td>
<td>210</td>
<td>270</td>
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<tr>
<td>Public buildings (theatres, sport halls, museums etc.)</td>
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<td>120</td>
<td>150</td>
<td>200</td>
<td>250</td>
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<tr>
<td>Shopping malls</td>
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<td>130</td>
<td>160</td>
<td>230</td>
<td>280</td>
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<tr>
<td>Schools</td>
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<td>90</td>
<td>120</td>
<td>160</td>
<td>200</td>
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<tr>
<td>Day care centres</td>
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<tr>
<td>Hospitals</td>
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<td>270</td>
<td>300</td>
<td>380</td>
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nZEB system boundaries

4-level system boundary needed to enable transparent calculation:

1. Energy need
2. Energy use
3. Delivered and exported on-site
4. Nearby RE
FInZEB: Inside/outside energy meters system boundary incl. nearby RES with physical connection

1. TILOJEN ENERGIANTARVE
   - Lämmitys
   - Jäähdytys
   - Ilmanvaihto
   - Käyttövesi
   - Valaistus
   - Kuluttajalaitteet

2. ENERGIANKULUTUS
   - Nettotarpeet
     - Lämmitysenergia
     - Jäähdytysenergia
     - Valaistussähkö
     - Kuluttajalaitesähkö

3. Uusiutuvan energian tuottojärjestelmät
   - Lämpöenergiat
   - Jäähdysenergiat
   - Sähköenergiat

4. OSTOENERGIA
   - Kaukolämpö
   - Kaukojäähdys
   - Polttoaine
   - Muunnelmavaraisenergia

Tontin raja = kokonaisenergiankulutuksen taseraja
Selected NZEB Examples in MS
### Selected NZEB Examples in MS Analysis

**Costs:** 52% Total costs available, 33% Additional costs available

<table>
<thead>
<tr>
<th>Additional costs of the selected examples of NZEBs compared to the energy level according to the current national requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total costs</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>€/m²</td>
</tr>
</tbody>
</table>
## nZEB Task Force latest buildings (5-8 in the Table)

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Country</th>
<th>Construction Year</th>
<th>Floor Area (m²)</th>
<th>Extra nZEB Cost (€/m²)</th>
<th>General Description</th>
<th>Energy Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSK-II school, Haarlem, the Netherlands</td>
<td>Netherlands</td>
<td>2014</td>
<td>3,900</td>
<td>250</td>
<td>Primary school with zero energy consumption, meaning the total amount of energy used for the building itself on an annual basis is roughly equal to the amount of renewable energy produced on site.</td>
<td>Net-zero energy building without accounting small power equipment loads, achieved with large on-site PV, heat pumps and energy wells.</td>
</tr>
<tr>
<td>Väla Gård office building, Sweden</td>
<td>Sweden</td>
<td>2013</td>
<td>1,750</td>
<td>230</td>
<td>Skanska head office, Nordea office nZEB building, energy consumption 55% less than code requirement, building demonstrates low speed ventilation and Skanska Deep Green Cooling, a ground cooling system without heat pump or chiller. Tripple Leed Platinum.</td>
<td>Nearly zero energy building if the share of wind farm is not accounted.</td>
</tr>
<tr>
<td>Entré Lindhagen office building, Sweden</td>
<td>Sweden</td>
<td>2014</td>
<td>65,000</td>
<td>55</td>
<td>Skanska office in Helsingborg. A nZEB office building, energy consumption is nearly zero or plus including tenant power over the year. LEED certified Platinum.</td>
<td>Net zero energy building (small power equipment loads accounted) or plus energy building w/o small power, achieved with extensive on-site PV, ground source heat pump and boreholes.</td>
</tr>
<tr>
<td>Rakvere Smart Building Competence Centre office building, Estonia</td>
<td>Estonia</td>
<td>2014-2015</td>
<td>2,170</td>
<td>200-300</td>
<td>Estonian first nZEB office building, primary energy consumption 60% less than code requirement, building demonstrates smart building automation systems.</td>
<td>Nearly zero energy building (small power equipment loads accounted), achieved with on-site PV, district heating and energy wells.</td>
</tr>
</tbody>
</table>
### Delivered, on-site and nearby generated, and primary energy

<table>
<thead>
<tr>
<th></th>
<th>FRA</th>
<th>SUI</th>
<th>NL1</th>
<th>FIN</th>
<th>NL2</th>
<th>SWE1</th>
<th>SWE2</th>
<th>EST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>10.5</td>
<td>6.0</td>
<td>13.3</td>
<td>38.3</td>
<td>20.5</td>
<td>32.2</td>
<td>10.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Cooling</td>
<td>2.4</td>
<td>6.7</td>
<td>3.3</td>
<td>0.3</td>
<td>3.2</td>
<td>1.3</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Fans &amp; pumps</td>
<td>6.5</td>
<td>8.1</td>
<td>17.5</td>
<td>9.4</td>
<td>11.8</td>
<td>13.2</td>
<td>3.0</td>
<td>9.7</td>
</tr>
<tr>
<td>Lighting</td>
<td>3.7</td>
<td>16.3</td>
<td>21.1</td>
<td>12.5</td>
<td>12.5</td>
<td>16.5</td>
<td>12.6</td>
<td>11.3</td>
</tr>
<tr>
<td>Appliances</td>
<td>21.2</td>
<td>26.8</td>
<td>19.2</td>
<td>19.3</td>
<td>5.0</td>
<td>16.9</td>
<td>12.6</td>
<td>18.5</td>
</tr>
<tr>
<td>On site electricity</td>
<td>-15.6</td>
<td>-30.9</td>
<td>-73.8</td>
<td>-7.1</td>
<td>-36.5</td>
<td>-39.0</td>
<td>-19.6</td>
<td></td>
</tr>
<tr>
<td>Nearby electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-47.9</td>
</tr>
<tr>
<td>BioCHP fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>184</td>
</tr>
<tr>
<td>Exported heat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-50.0</td>
</tr>
<tr>
<td><strong>Primary energy</strong></td>
<td><strong>42</strong></td>
<td><strong>66</strong></td>
<td><strong>68</strong></td>
<td><strong>96</strong></td>
<td><strong>33</strong></td>
<td><strong>23</strong></td>
<td><strong>-1</strong></td>
<td><strong>61</strong></td>
</tr>
</tbody>
</table>
Conclusions

• To date, an official definition with numeric indicators is available in 15 MS (+ Brussels Capital Region and Flanders)
  – In 3 countries implementation in the legislation is in progress
  – In the remaining 9 MS (plus Norway and the Belgian Region of Wallonia), the definition is still under discussion

• The most urgent open nZEB issues to be harmonized are energy uses included (to be comparable), system boundaries and RES inclusion (to be transparent) and building categories (to be meaningful for design choices):
  – Exclusion of the energy uses may lead to situations where calculated energy use represents only a small fraction of measured energy use in real buildings
  – Requirements set only for residential and non-residential show that majority of countries cannot tackle the eight building categories specified in EPBD recast Annex I

• nZEB extra cost of about +200 €/m² remains a challenge, however some examples of 55-100 €/m² do exist