Refurbishment of public buildings for nZEB in Hungary

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EPBD „recast” 2010/31/EU directive

» The requirements of energy performance should be on cost optimal level.

» All the public buildings built after 31. December 2018 and all the buildings built after 31th December 2020 should be on nearly zero energy level.
EPBD definitions

› The number of definitions in the directive is low, and they are not exact definitions.

› The exact definitions should be formulated by a Member States according to the local conditions.

› There are (or can be) **big differences** between the Member States!
EPBD definition: nZEB

- ‘Nearly zero-energy building’ means a building that has a **very high energy performance**, as determined in accordance with Annex I. 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 **produced on-site or nearby**.
An example: nZEB in Hungary

› Modification of 7/2006. TNM statue in force from 1st January 2016:
  • U values on cost optimal level
  • Specific heat loss depends on A/V
  • Total energy performance:
    Residential 100 kWh/m²,a
    Office 90 kWh/m²,a
    Educational 85 kWh/m²,a
    Cooling + 10 kWh/m²,a
  • Renewable energy ratio: 25 %
RePublic_ZEB

http://www.republiczeb.org/

REFURBISHMENT OF THE PUBLIC BUILDING STOCK TOWARDS NZEB

› Aims:
  • Analysis of the public building stock, defining reference buildings
  • Evaluation of the current state, analysis of possibilities to renovate public buildings towards nZEB
  • Cost-benefit analysis of packages of measures for renovations towards nZEB
  • Strategies and guidelines for nZEB public buildings
  • Communication
Participating countries:

- Italy (CTI - coordinator, POLITO)
- Portugal (LNEG)
- Spain (IREC)
- Slovenia (ZRMK)
- Hungary (BME)
- Romania (URBAN-INCERC)
- Bulgaria (BRES)
- Croatia (EIHP)
- Macedonia (MACEF)
- Greece (CRES)
- UK (BRE)
OFFICE BUILDINGS - primary energy consumption according to nZEB requirement

- Croatia, coastal: 25 kWh/m²a
- Croatia, continental: 30 kWh/m²a
- Romania I climatic zone: 45 kWh/m²a
- Italy, C climatic zone: 54 kWh/m²a
- Italy, D climatic zone: 57 kWh/m²a
- Romania II climatic zone: 57 kWh/m²a
- Italy, F climatic zone: 59 kWh/m²a
- Italy, E climatic zone: 60 kWh/m²a
- Italy, A and B climatic zone: 60 kWh/m²a
- Romania III climatic zone: 69 kWh/m²a
- Bulgaria, class A, lower limit: 70 kWh/m²a
- Slovenia: 80 kWh/m²a
- Romania IV climatic zone: 83 kWh/m²a
- Romania V climatic zone: 89 kWh/m²a
- Hungary: 90 kWh/m²a
- Bulgaria, class A, upper limit: 140 kWh/m²a

Primary energy, [kWh/m²a]
RePublic definition for nZEB

› Refurbishment on nZEB level is:
  – Refurbishment of structures and HVAC systems with materials and technologies, whereby:
    › Lower energy consumption, than on cost optimal level
    › Minimum renewable energy ratio
  – The refurbishment must be cost effective

› Life cycle costs have to be analysed:
  – Investment costs (including change of parts in the future!)
  – Energy costs
  – Operational and maintenance costs
RePublic definition for nZEB
Major outputs: the optimised packages of measures

The project has defined more than 100 a cost-optimal and low-risk technological packages of measures to refurbish public buildings towards nZEB. Here a selection of 12 cases.
### Reference building: student hostel

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross volume</td>
<td>$V_g$</td>
</tr>
<tr>
<td>No. floors</td>
<td>$n$</td>
</tr>
<tr>
<td>Net floor area</td>
<td>$A_{f,n}$</td>
</tr>
<tr>
<td>Area of building envelope</td>
<td>$A_{env}$</td>
</tr>
<tr>
<td>$A_{env}/V_g$</td>
<td></td>
</tr>
</tbody>
</table>
Energy consumption before refurbishment

![Graph showing energy consumption in various categories for a student hostel.](image-url)
Technical details

› Walls: $U = 1,12 - 1,86 \text{ W/m}^2\text{K}$
› Windows: $U = 2,6 - 3,0 \text{ W/m}^2\text{K}$
› Roof: $U = 0,5 \text{ W/m}^2\text{K}$
› Heating and DHW: old gas boiler
› Lighting: fluorescent lamps
# Packages of measures

<table>
<thead>
<tr>
<th>Structures</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall</td>
<td>$U_{wl}$ [W/m²K]</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td>$U_{w}$ [W/m²K]</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$g$ [-]</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof</td>
<td>$U_{r}$ [W/m²K]</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HVAC</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>Heat pump</td>
</tr>
<tr>
<td></td>
<td>Biomass boiler</td>
</tr>
<tr>
<td></td>
<td>District heating</td>
</tr>
<tr>
<td></td>
<td>Condensing gas boiler</td>
</tr>
<tr>
<td>Lighting</td>
<td>New fluorescent lighting</td>
</tr>
<tr>
<td></td>
<td>LED lighting</td>
</tr>
<tr>
<td></td>
<td>With / without modern control</td>
</tr>
<tr>
<td>Renewables</td>
<td>Different amount of PV system</td>
</tr>
</tbody>
</table>
Optimisation tool

Student hostel

Global Cost [€/m²]

Energy Performance $EP_{gl,nren}$ [kWh/m²]

20 40 60 80 100 120 140 160 180

50 100 150 200 250 300 350
Optimisation tool

Student hostel

\[ \Delta GC \text{ [€/m}^2\text{]} \]

\[ EP_{gl,nren} \text{ [kWh/m}^2\text{ a]} \]

- BEFORE REFURB.
- COST-OPTIMAL
- nZEB1
- nZEB2
- nZEB3
- nZEB4
**Optimisation tool**

<table>
<thead>
<tr>
<th>Structure / HVAC</th>
<th>Cost optimal</th>
<th>nZEB 1.</th>
<th>nZEB 2.</th>
<th>nZEB 3.</th>
<th>nZEB4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>-</td>
<td>U = 0,23 W/m²K</td>
<td>U = 0,19 W/m²K</td>
<td>U = 0,23 W/m²K</td>
<td>U = 0,19 W/m²K</td>
</tr>
<tr>
<td>Windows</td>
<td>-</td>
<td>U = 1,1 W/m²K</td>
<td>U = 1,0 W/m²K</td>
<td>U = 1,15 W/m²K</td>
<td>U = 1,0 W/m²K</td>
</tr>
<tr>
<td>Roof</td>
<td>-</td>
<td>U = 0,17 W/m²K</td>
<td>U = 0,14 W/m²K</td>
<td>U = 0,17 W/m²K</td>
<td>U = 0,14 W/m²K</td>
</tr>
<tr>
<td>Heating</td>
<td>Heat pump</td>
<td>Heat pump</td>
<td>Heat pump</td>
<td>Biomass boiler</td>
<td>Biomass boiler</td>
</tr>
<tr>
<td>DHW</td>
<td>Cond. gas boiler</td>
<td>Cond. gas boiler</td>
<td>Cond. gas boiler</td>
<td>Biomass boiler</td>
<td>Biomass boiler</td>
</tr>
<tr>
<td>Lighting</td>
<td>LED with control</td>
<td>LED with control</td>
<td>LED with control</td>
<td>LED with control</td>
<td>LED with control</td>
</tr>
<tr>
<td>Renewable</td>
<td>-</td>
<td>-</td>
<td>PV</td>
<td>-</td>
<td>PV</td>
</tr>
</tbody>
</table>
Primary energy performance

Student hostel

EP\(_g\) [kWh/m\(^2\).a]

- BEFORE REFURB.
- COST-OPTIMAL
- nZEB1
- nZEB2
- nZEB3
- nZEB4

EP\(_{g,\text{ren}}\)

EP\(_{g,\text{nren}}\)
Global cost

Student hostel

<table>
<thead>
<tr>
<th>Case</th>
<th>Operating &amp; Maintenance</th>
<th>Investment</th>
<th>Energy</th>
<th>Global Cost [€/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEFORE REFURB.</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>COST-OPTIMAL</td>
<td>150</td>
<td>150</td>
<td>50</td>
<td>350</td>
</tr>
<tr>
<td>nZEB1</td>
<td>200</td>
<td>50</td>
<td>100</td>
<td>350</td>
</tr>
<tr>
<td>nZEB2</td>
<td>250</td>
<td>100</td>
<td>100</td>
<td>450</td>
</tr>
<tr>
<td>nZEB3</td>
<td>300</td>
<td>150</td>
<td>50</td>
<td>500</td>
</tr>
<tr>
<td>nZEB4</td>
<td>350</td>
<td>200</td>
<td>50</td>
<td>600</td>
</tr>
</tbody>
</table>
Pay-back time

Student hostel

ACTUALIZED Pay-Back Period [a]

- COST OPTIMAL CASE
- nZEB1
- nZEB2
- nZEB3
- nZEB4
Sensitivity analysis
Global cost

nZEB 1.
Sensitivity analysis
Global cost

nZEB 2.
Sensitivity analysis
Global cost

nZEB 3.

nZEB 4.
Sensitivity analysis
Pay-back time

nZEB 1.
Sensitivity analysis
Pay-back time

nZEB 2.
Sensitivity analysis
Pay-back time

nZEB 3.

nZEB 4.
Conclusions

› Requirement called „cost optimal” is not always cost optimal
› Refurbishment according to the nZEB requirements can be NOT cost effective
› Optimisation is always necessary while designing a refurbishment
› Pay-back time can change a lot, if some parameters vary
Thank you for your attention!

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