Business and Technical Concepts of Deep Energy Retrofit of Public Buildings
IEA EBC Annex 61
Subtask A Modelling Exercise from Estonia

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Studied building

• Public housing (dormitory)
• Prefabricated concrete large panel elements

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of floors</td>
<td>5</td>
</tr>
<tr>
<td>Net area, m²</td>
<td>3519</td>
</tr>
<tr>
<td>Heated area, m²</td>
<td>2968</td>
</tr>
<tr>
<td>Number of apartments</td>
<td>60</td>
</tr>
<tr>
<td>Compactness: Building envelope, m² / volume, m³ / m⁻¹</td>
<td>0.35</td>
</tr>
</tbody>
</table>

• Natural passive stack ventilation
• District heating and one-pipe radiator heating systems
• The thermal transmittances of the building envelope of studied building types are:
  - External walls: \( U_{\text{wall}} \approx 0.8–1.2 \text{ W/(m}^2\text{K)}; \)
  - Roof-ceilings: \( U_{\text{roof}} \approx 0.7–1.1 \text{ W/(m}^2\text{K)}; \)
  - Windows: \( U_{\text{window}} \approx 2.9 \text{ W/ (m}^2\text{K)} \) designed to be air leaky
  - The building envelope contains structural thermal brides.
Simulation methods

• Energy and indoor climate multi-zone modelling
• Climate zone, 6A: design temperature -21 °C, annual heating degree days at \( t = 17^\circ C \): 4160 °C·d
• Internal heat gains were as follows:
  – People: 15.8 kWh/(m²·a). Heat from people is counted from 3.0 W/m² and 80W/person using ISO 7730 standard (1.2 met, 0.7 clo);
  – Appliances, equipment: 15.8 kWh/(m²·a). Heat from appliances and equipment is counted using 3.0 W/m² and the usage rate is 0.6;
  – Lighting: 7.0 kWh/(m²·a).
    Heat from lighting is counted using 8 W/m² and the usage rate is 0.1.
• Ventilation airflow is 0.35 l/(s·m²) (indoor climate category III)
• Domestic hot water: 520 l/(m²·a) / 30 kWh/(m²·a), approximately 35–45 l/(pers.×day) depending on the density of living

Economic calculations

• Energy cost:
  – district heating 0.075 €/kWh;
  – electricity 0.14 €/kWh.
• The global cost of 20 years
  \[ C_p(\tau) = \frac{C_i + \sum_{j=1}^{20}(C_e(j) \times R_e(i))}{A_{low}} - \frac{C_{new}}{A_{low}} \]
• Construction costs (2012…2013 year’s data)
  – additional insulation for external walls, €/m²
  – additional insulation for flat roof, €/m²
  – additional insulation for basement ceiling, €/m²
  – replacement of windows, €/m²
  – renovation of heating system, €/m²
  – renovation of ventilation system, €/m²
  – renewable energy systems, €/MWh
Renovation scenarios

- Scenario 1: Baseline (current state):
  - some minor energy saving measures,
  - 2/3 of windows replaced (\(U_{\text{window}}\) (glass/frame), 1.8/2.0 \(W/(m^2 \cdot K)\))
  - some walls have been insulated (50…100mm)

  - Building envelope
    - roof: 20 cm insulation \(U_{\text{roof}} = 0.18 \ W/(m^2 \cdot K)\), \(\Phi_{\text{eave}} = 0.29 \ W/(m \cdot K)\)
    - external wall (ETICS/EIFS): 15 cm EPS \(U_{\text{wall}} = 0.21 \ W/(m^2 \cdot K)\), \(\Phi_{\text{wall/wall}} = 0.16 \ W/(m \cdot K)\), \(\Phi_{\text{wall/balcony}} = 0.44 \ W/(m \cdot K)\)
    - replacing of old windows: \(U_{\text{old window}} = 1.8 \ W/(m^2 \cdot K)\), \(U_{\text{new window}} = 1.1 \ W/(m^2 \cdot K)\), \(\Phi_{\text{wall/window}} = 0.08 \ W/(m \cdot K)\)
    - basement wall: 10 cm EPS \(U_{\text{basement wall}} = 0.36 \ W/(m^2 \cdot K)\)
  - Ventilation: exhaust ventilation without heat recovery
  - Heating system: new 2-pipe system with thermostats

- Scenario 3: major renovation (2010)
  - Energy Certification Class “D”: \(\text{PE} \leq 180 \ \text{kWh}/(m^2 \cdot a)\)
  - Decrease of delivered energy \(\approx 33\%\)

- Scenario 4:
  - New building: ECC „C“
    \(\text{PE} \leq 150 \ \text{kWh}/(m^2 \cdot a) \ - 50\%\)
  - Low-energy building: ECC „B“
    \(\text{PE} \leq 120 \ \text{kWh}/(m^2 \cdot a) \ - 60\%\)

Individual measures
### Renovation packages

<table>
<thead>
<tr>
<th>Energy saving level, and renovation package</th>
<th>NPV, €/m² (20 year)</th>
<th>Investment, €/m²</th>
<th>Delivered energy, kWh/m² a</th>
<th>Primary energy, kWh/(m²·a)</th>
<th>Primary renovation package</th>
<th>Windows</th>
<th>External walls</th>
<th>Roof</th>
<th>Base floor</th>
<th>Ventilation</th>
<th>DH W</th>
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<tbody>
<tr>
<td>Current state</td>
<td>288</td>
<td>233</td>
<td>242</td>
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<td></td>
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<tr>
<td>Vers. 3.1</td>
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<td>109</td>
<td>156 / -33%</td>
<td>178 / -26%</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
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<td>167 / -31%</td>
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<td>159 / -34%</td>
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<td>x x</td>
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<td>149 / -39%</td>
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<td>122 / -50%</td>
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<td>163</td>
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<td>x x x</td>
<td></td>
<td></td>
<td></td>
<td>x x</td>
</tr>
</tbody>
</table>

### Current state

- **Windows**:
  - Vers. 1: +100 mm
  - Vers. 2: +150 mm +200 mm
  - Vers. 3: +300 mm
  - Vers. 4: +400 mm
  - Vers. 5: +500 mm

- **External walls**:
  - Vers. 1: +100 mm
  - Vers. 2: +150 mm +200 mm
  - Vers. 3: +300 mm
  - Vers. 4: +400 mm
  - Vers. 5: +500 mm

- **Roof**:
  - Vers. 1: +100 mm
  - Vers. 2: +150 mm +200 mm
  - Vers. 3: +300 mm
  - Vers. 4: +400 mm
  - Vers. 5: +500 mm

- **Base floor**:
  - Vers. 1: +100 mm
  - Vers. 2: +150 mm +200 mm
  - Vers. 3: +300 mm
  - Vers. 4: +400 mm
  - Vers. 5: +500 mm

- **Ventilation system**:
  - Vers. 1: +100 mm
  - Vers. 2: +150 mm +200 mm
  - Vers. 3: +300 mm
  - Vers. 4: +400 mm
  - Vers. 5: +500 mm

- **Solar collectors**:
  - Vers. 1: +100 mm
  - Vers. 2: +150 mm +200 mm
  - Vers. 3: +300 mm
  - Vers. 4: +400 mm
  - Vers. 5: +500 mm

### Primary energy: ECC

- **Change of global cost, €/m²**
- **Primary energy, kWh/(m²·a)**
- **Optimal packages**
- **Current state**
Delivered energy

Investments