CO₂ mitigation potential from space and water heating in the Hungarian public buildings

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Overview

- Background – CO₂ emissions and energy consumption
- Methodology
- Preliminary findings
- Conclusions and recommendations
CO₂ emissions & use of primary energy in the Hungarian tertiary sector

In the period 1985-2005 the CO₂ emissions as well as primary fuel consumption increased in total by cca. 30%
While share of the natural gas increased by one third (1985-2005), share of non-gas primary fuels decreased substantially in the same period.
Methodology

- Bottom-up technology-based model
- Modeling framework based on residential model of Novikova (2008) with all input data and assumptions adjusted to public buildings
- Mitigation potential is estimated through the ‘cost curve’ method
- In the study are considered the most cost-efficient abatement options and options with the largest mitigation potential based on the database of Novikova (2008) adjusted and extended for the needs of public sector
- Options for existing buildings:
  - temperature management, hot water demand reduction, high-performance building envelope, boilers with increased efficiency
- Options for new construction:
  - Passive house standard
Methodological steps

1. Building stock 2005-2025
2. Baseline scenario 2005-2025
3. Mitigation scenario 2005-2025
4. Construction of cost curve

Input parameters:
- Population growth (Novikova 2008)
- Trends in building stock development and its factors
- Final energy consumption

External parameters:
- Discount rate
- Heating degree days
- Energy prices
- Physical constants

Database of building types
Database of heating energy requirements based on energy audits in Hungarian public buildings
Database of sector-relevant abatement options (based on Novikova 2008 and extended)
Data sources

- Building typologies: Ürge-Vorsatz et al (2000) and energy audits (below)
- Average heating energy requirements: based on set of audits:
  - UNDP/GEF Hungary Public Sector Energy Efficiency Project,
  - Display campaign (2008),
  - Csoknyai (2008)
First results: Hungarian public buildings
## Classification of public buildings in 2005

<table>
<thead>
<tr>
<th>Category</th>
<th>2005 Number of buildings</th>
<th>2005 Number of buildings</th>
<th>Floor area (m²)</th>
<th>Floor area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kindergartens &amp; nurseries</td>
<td>4,963</td>
<td>9%</td>
<td>2,485</td>
<td>5%</td>
</tr>
<tr>
<td>Primary and secondary schools</td>
<td>8,160</td>
<td>15%</td>
<td>11,137</td>
<td>22%</td>
</tr>
<tr>
<td>Universities</td>
<td>286</td>
<td>1%</td>
<td>1,572</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospitals &amp; Buildings for confined to bed</td>
<td>881</td>
<td>2%</td>
<td>4,228</td>
<td>8%</td>
</tr>
<tr>
<td>Doctor's offices &amp; ambulance stations</td>
<td>2,988</td>
<td>5%</td>
<td>1,970</td>
<td>4%</td>
</tr>
<tr>
<td>Medical centres</td>
<td>1,136</td>
<td>2%</td>
<td>5,453</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Public Administration offices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small public office buildings</td>
<td>4,407</td>
<td>8%</td>
<td>2,297</td>
<td>4%</td>
</tr>
<tr>
<td>Large public office buildings</td>
<td>995</td>
<td>2%</td>
<td>2,781</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Social buildings</strong></td>
<td>2,735</td>
<td>5%</td>
<td>1,747</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Cultural buildings</strong></td>
<td>5,021</td>
<td>9%</td>
<td>10,825</td>
<td>21%</td>
</tr>
<tr>
<td>Other (assumed non-heated)</td>
<td>23,691</td>
<td>43%</td>
<td>7,107</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>55,264</td>
<td></td>
<td>51,601</td>
<td></td>
</tr>
</tbody>
</table>

Note: the floor area of Other is an estimate due to lack of data.
Average heating energy requirements per building type

KWh/m².a

Kindergarten: 300 kWh/m².a (Space heating)
Primary, secondary buildings: 320 kWh/m².a (Space heating)
Doctor's offices: 260 kWh/m².a (Space heating)
Hospitals & medical centres: 400 kWh/m².a (Space heating)
Small public administration: 280 kWh/m².a (Space heating)
Large public administration: 350 kWh/m².a (Space heating)
Social buildings: 450 kWh/m².a (Space heating)
Cultural buildings: 200 kWh/m².a (Space heating)

Other: 50 kWh/m².a
Water heating: 30 kWh/m².a
Space heating: 200 kWh/m².a
**CO₂ mitigation potential in 2025, cumulative investments and saved energy costs**

Total mitigation potential: 761 kt CO₂ (37% of the SWH baseline CO₂ emissions)
Total energy savings: 3.8 TWh

<table>
<thead>
<tr>
<th>Measure</th>
<th>CO₂ savings in 2025</th>
<th>Cumulative CO₂ savings in 2025</th>
<th>Cost of mitigated CO₂ in 2025</th>
<th>Energy savings in 2025</th>
<th>Cumulative energy savings in 2025</th>
<th>CCE in 2025</th>
<th>Cumulative investments 2008-2025</th>
<th>Cumulative saved energy costs 2008-2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching off DHW recirculation at night</td>
<td>7</td>
<td>7</td>
<td>-253</td>
<td>35</td>
<td>35</td>
<td>0.0003</td>
<td>0.12</td>
<td>16</td>
</tr>
<tr>
<td>Temperature management 2C</td>
<td>89</td>
<td>96</td>
<td>-220</td>
<td>446</td>
<td>481</td>
<td>0.01</td>
<td>38</td>
<td>223</td>
</tr>
<tr>
<td>Insulation of wall in large industrialized buildings</td>
<td>65</td>
<td>161</td>
<td>-106</td>
<td>325</td>
<td>806</td>
<td>0.03</td>
<td>171</td>
<td>369</td>
</tr>
<tr>
<td>Insulation of wall in small buildings</td>
<td>30</td>
<td>191</td>
<td>-79</td>
<td>147</td>
<td>953</td>
<td>0.03</td>
<td>249</td>
<td>433</td>
</tr>
<tr>
<td>Exchange of windows</td>
<td>140</td>
<td>331</td>
<td>-56</td>
<td>695</td>
<td>1648</td>
<td>0.04</td>
<td>627</td>
<td>769</td>
</tr>
<tr>
<td>Insulation of roof</td>
<td>53</td>
<td>384</td>
<td>29</td>
<td>264</td>
<td>1912</td>
<td>0.06</td>
<td>832</td>
<td>891</td>
</tr>
<tr>
<td>Insulation of basement</td>
<td>29</td>
<td>413</td>
<td>49</td>
<td>146</td>
<td>2058</td>
<td>0.06</td>
<td>953</td>
<td>958</td>
</tr>
<tr>
<td>Passive building standard</td>
<td>273</td>
<td>686</td>
<td>219</td>
<td>1374</td>
<td>3432</td>
<td>0.09</td>
<td>3114</td>
<td>1629</td>
</tr>
<tr>
<td>Condensing boiler</td>
<td>75</td>
<td>761</td>
<td>236</td>
<td>369</td>
<td>3801</td>
<td>0.1</td>
<td>3530</td>
<td>1859</td>
</tr>
</tbody>
</table>

Note: the table shows aggregated results for technical options in all examined buildings.
### Mitigation potential by cost categories

<table>
<thead>
<tr>
<th>CO₂ mitigation potential in cost categories</th>
<th>CO₂ abatement potential in 2025</th>
<th>Total cumulative investment 2008-2025</th>
<th>Cumulative energy cost savings 2008-2025</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative</td>
<td>By cost category</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% baseline of modeled end-uses</td>
<td>1000 tCO₂/yr.</td>
<td>% baseline of modeled end-uses</td>
</tr>
<tr>
<td>&lt; 0 EURO</td>
<td>18.1%</td>
<td>367</td>
<td>18%</td>
</tr>
<tr>
<td>0 - 20 EURO*</td>
<td>18.4%</td>
<td>374</td>
<td>0.3%</td>
</tr>
<tr>
<td>20-100 EURO*</td>
<td>22.6%</td>
<td>459</td>
<td>4%</td>
</tr>
<tr>
<td>100 - 300 EURO*</td>
<td>35.0%</td>
<td>711</td>
<td>12%</td>
</tr>
<tr>
<td>&gt;300 EURO*</td>
<td>37.4%</td>
<td>761</td>
<td>2%</td>
</tr>
</tbody>
</table>
Aggregated cost curve for Hungarian public buildings

Baseline CO2 emissions in 2025: 2033 kt CO2
Mitigation cost curves for application of passive house standard in new construction

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2
Conclusions & recommendations (1)

- Public buildings offer significant share of cost-effective mitigation potential

- Processing of energy audits in the Hungarian public buildings shows large specific heating energy consumption in Hungarian public buildings and implies possible savings

- The most cost-effective options are:
  - Temperature management
  - Reduction of energy for water heating through switching off hot water recirculation during night
  - External wall insulation & windows replacement
  - Insulation of other building components (basement & roof)
  - Passive house application for new construction
  - Installation of condensing boiler
Conclusions & recommendations (2)

- Nevertheless, the buildings have to be retrofitted holistically, not only via implementing low-cost options.

- Only thorough, complex retrofit, “including the simultaneous insulation of walls, exchange of windows and renovation of heating systems provide better thermal performance and less risk of fabric damages” (Zöld and Csoknyai, 2007).

- Retrofit of the existing buildings to the lowest possible levels should be promoted right from the beginning and thus not leaving room for energy inefficiency trapped in sub-optimal retrofits.

- There are first examples of both passive new construction and passive retrofit in the Hungarian public buildings (e.g. retrofit of the REC centre, plan for “green” governmental district, retrofit of Pecs museum).

- To lower additional costs of passive construction in Hungary, one should support the conditions for passive construction businesses.

- To ensure that low-energy & passive buildings function as designed, commissioning, an overall check of the installed equipment, should be performed both in major retrofits and new constructions.
Acknowledgements

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References

- Workshop “Mitigation potential in the Hungarian buildings”, Budapest, October, 6, 2008.
Background slides
CO$_2$ emissions in Hungarian tertiary sector

Source: ODYSSEE 2009. URL: http://odyssee.enerdata.eu
Final energy by fuel (2005)

Mitigation cost curves for small educational buildings

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2
Mitigation cost curves for large educational buildings

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2
Mitigation cost curves for small health care buildings

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2
Mitigation cost curves for large health care buildings

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2
Mitigation cost curves for small public administration buildings

Temperature management 2°C
External walls insulation
Roof insulation
Basement insulation
Exchange of windows
Condensing boiler

Baseline CO₂ emissions for space and water heating in 2025: 2033 kt CO₂
Mitigation cost curves for large public administration buildings

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2
Mitigation cost curves for social buildings

Baseline CO2 emissions for space and water heating in 2025: 2033 kt CO2