Some building models for (solar) heating and cooling systems

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Introduction

- Results of 2 PhD theses
- Trnsys for buildings
- EES for heat pumps for simultaneous heating and cooling

Engineering Equation Solver
Heat pump for simultaneous heating and cooling

Simultaneous mode

- Evaporator
- Expansion valve
- Compressor
- Condenser
- Heating needs

! NO Cooling needs
Heating mode

Evaporator

Condenser

Expansion valve

Outside AIR as SOURCE

Compressor

Heating needs

Evaporator

Cooling needs
Cooling mode
Modelled buildings

1. Hotel

2. Low-energy residential collective building

3. Office building

4. Retail store
1. Hotel description

- Campanile Hotel nearby University

- 45 bedrooms

- [Hotel.doc](#)
Hourly and annual evolutions

Besoins de chaud (chauffage + production d’ECS) et de froid (rafraîchissement) d’un hôtel de 45 chambres assez fortement vitré à Paris

Production de chaud 68640 kWh/an
Production de froid 30146 kWh/an
Température extérieure moyenne

Besoins de chaud (chauffage + production d’ECS) et de froid (rafraîchissement) d’un hôtel de 45 chambres assez fortement vitré à Marseille

Production de chaud 65621 kWh/an
Production de froid 55172 kWh/an
Température extérieure moyenne

Besoins de chaud (chauffage + production d’ECS) et de froid (rafraîchissement) d’un hôtel de 45 chambres assez fortement vitré à Strasbourg

Production de chaud 119145 kWh/an
Production de froid 17417 kWh/an
Température extérieure moyenne

Besoins de chaud (chauffage + production d’ECS) et de froid (rafraîchissement) d’un hôtel de 45 chambres assez fortement vitré à Rennes

Production de chaud 81635 kWh/an
Production de froid 15800 kWh/an
Température extérieure moyenne
Annual thermal demands

[Bar chart showing annual thermal demands for DHW production, Heating, and Cooling for Rennes, Marseille, and Brussels.]
Seasonal heating and/or cooling COPs
2. Low-energy residential

- 15 apartments
3. Office building

- 12 thermal zones
- With server room
4. Retail store

- 5 thermal zones
- Without cooling → with cooling
### Characteristics and boundary conditions

- **DHW demand**
  \[ q_{DHW} = 1.163 \cdot V_{DHW} \cdot (T_{DHW} - T_{cw}) \]

- Retail store: 10 litres per day and per person at 45 °C
- Office building: 5 litres per day and per employee at 60 °C
- Low-energy residential building: 40 litres per day and per resident at 60 °C

<table>
<thead>
<tr>
<th>Building type</th>
<th>Floor area (m²)</th>
<th>Number of thermal zones</th>
<th>Number of people</th>
<th>Occupation Week days</th>
<th>Scenario</th>
<th>Lighting (W/m²)</th>
<th>Number of pieces of equipment of 230 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Energy Building</td>
<td>675</td>
<td>15</td>
<td>24</td>
<td>6h-9h, 18h-24h</td>
<td>6h-24h</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Office building</td>
<td>792</td>
<td>12</td>
<td>123</td>
<td>8h-20h</td>
<td>No occupation</td>
<td>10</td>
<td>141</td>
</tr>
<tr>
<td>Retail store</td>
<td>1467</td>
<td>5</td>
<td>134</td>
<td>8h-21h</td>
<td>Saturday 8h-21h</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>
Coupling buildings / heat pumps

• Co-solving technique

Indicator: Ratio of Simultaneous Needs

\[ RSN = \min \left( \frac{\sum_{24\ h} q_c}{\sum_{24\ h} q_h + q_{DHW}}, \frac{\sum_{24\ h} q_h + q_{DHW}}{\sum_{24\ h} q_c} \right) \]
In practice
RSN results

Retail store

Office

Residential

<table>
<thead>
<tr>
<th>City (type of climate)</th>
<th>Low-energy building (%)</th>
<th>Office building (%)</th>
<th>Retail store (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rennes (oceanic)</td>
<td>28.00</td>
<td>28.17</td>
<td>10.17</td>
</tr>
<tr>
<td>Marseille (Mediterranean)</td>
<td>30.52</td>
<td>24.37</td>
<td>10.26</td>
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<tr>
<td>Strasbourg (continental)</td>
<td>22.50</td>
<td>22.57</td>
<td>6.86</td>
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</tbody>
</table>
Apportionment of electric consumptions

- With a low-energy residential building
Impact of hot water temperature
3 refrigerants

![Chart showing SCOP (seasonal performance coefficient) for R407C, R290, and R1243yf with and without DHW.](chart)
Conclusion

- Models based on realistic assumptions for Rennes
- A series of simulation results available for subtask B
- Need to calibrate our models and results to the standard form of the deliverables

References

- PhD thesis P. Byrne
- PhD thesis R. Ghoubali