Impact of the natural ventilation in a bay of the IW on cooling and ventilation energy requirements for a typical summer in Pittsburgh

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PURPOSE OF THE PROJECT

- Extend the previous studies: validation and improvement of the TRNSYS/COMIS model
- Define control strategies for the window opening
- Predict the system performance to meet the cooling and ventilation requirements
- Determine the most efficient control strategy to maximize energy saving, ensure thermal comfort and avoid condensation in IW
CONTENTS

1 - Presentation of the study

2 - Description of the model TRNSYS-COMIS

3 - Description of the control strategies for window opening

4 - System performance

5 - Further research
1. PRESENTATION OF THE STUDY

Modeling assumptions

Zone:
- One bay (south or north) of IW (Pittsburgh, PA)
- 2 windows on each façade (E&W)
- Adiabatic walls (N&S)

Occupancy
- 6 persons max.
- Zone occupied from 7:00 AM to 8:00 PM (thermal comfort required during this period)

Window opening:
- Two positions: maximum opening / close
- 4 windows opened at the same time

Cooling system:
- Fan coils (T set point: 22°C with a nighttime setback)

Ventilation system:
- Semco unit (T set point: Tin / RH set point: 50%)
2. TRNSYS-COMIS model

- **TRNSYS (TRaNsient energy SYstem Simulation)**
  Flexible tool designed to simulate the transient performance of thermal energy systems
  (developed by SEL, CSTB, TESS, TRANSSOLAR)

- **COMIS (Conjunction Of Multizone Infiltration Specialists)**
  Multizone Air Flow and Contaminant Transport Model
  (developed for IEA Annex 23, maintained by CSTB, EMPA, LBNL)

➤ **TRNSYS-COMIS model**
  dynamic thermal building model with an integrated ventilation model
3. CONTROL STRATEGIES

- Classical controls based on:
  ✓ Temperature (Control A)
  ✓ Temperature & Humidity (Control B)
    *(Several on/off differential controllers with hysteresis)*

- Different thresholds used for the controls

- Programmed in Fortran as a new TRNSYS component
3. CONTROL STRATEGIES

## Summary

<table>
<thead>
<tr>
<th>Control strategy</th>
<th>Schedule</th>
<th>Building loads</th>
<th>Ventilation loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>[O] No natural ventilation</td>
<td>Fan coils</td>
<td>Semco unit</td>
</tr>
</tbody>
</table>
| Control A (T)    | [N] nighttime natural ventilation  
[D&N] daytime and nighttime natural ventilation | Fan coils / opening windows | Semco unit |
| Control B (T&RH) | [N] nighttime natural ventilation  
[D&N] daytime and nighttime natural ventilation | Fan coils / opening windows | Semco unit |

Control A = Influence of the minimum outside air temperature (Tout_limit) on the system performance and thermal comfort

Control B = Influence of the water temperature in the mullions (Tmullions) on the system performance and thermal comfort
4. SYSTEM PERFORMANCE

Bay in South

<table>
<thead>
<tr>
<th>Case</th>
<th>Energy (kWh)</th>
<th>Thermal comfort (% of time in the comfort zone)</th>
<th>Hours of opening windows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensible</td>
<td>Latent</td>
<td>Total</td>
</tr>
<tr>
<td>Base case</td>
<td>4,541</td>
<td>2,137</td>
<td>6,679</td>
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</table>
## 4. SYSTEM PERFORMANCE

### Energy savings (%)

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<th>Latent</th>
<th>Total</th>
<th>Occupied</th>
<th>Unoccupied</th>
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<tr>
<td>Base case</td>
<td>4,541 kWh</td>
<td>2,137 kWh</td>
<td>6,679 kWh</td>
<td>0.88</td>
<td>0.74</td>
</tr>
<tr>
<td>[N], Tout&gt; 17C</td>
<td>15.0</td>
<td>-184</td>
<td>-48.7</td>
<td>0.83</td>
<td>0.38</td>
</tr>
<tr>
<td>[N], Tout&gt; 15C</td>
<td>21.0</td>
<td>-205</td>
<td>-51.5</td>
<td>0.77</td>
<td>0.36</td>
</tr>
<tr>
<td>[N&amp;D], Tout&gt;17/19C</td>
<td>18.0</td>
<td>-219</td>
<td>-57.8</td>
<td>0.77</td>
<td>0.36</td>
</tr>
<tr>
<td>[N&amp;D], Tout&gt;15/19C</td>
<td>23.3</td>
<td>-240</td>
<td>-60.9</td>
<td>0.72</td>
<td>0.29</td>
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## 4. SYSTEM PERFORMANCE

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<td>0.83</td>
<td>525</td>
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<tr>
<td>[N], Tout&gt; 15C</td>
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<td>-205</td>
<td>-51.5</td>
<td>0.77</td>
<td>705</td>
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<td>[N&amp;D], Tout&gt;17/19C</td>
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<td>-219</td>
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<td>0.77</td>
<td>620</td>
</tr>
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<td>[N&amp;D], Tout&gt;15/19C</td>
<td>23.3</td>
<td>-240</td>
<td>-60.9</td>
<td>0.72</td>
<td>787</td>
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<tr>
<td><strong>Control Temperature and Humidity</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[N&amp;D], Tout&gt;17/19C, DP&lt;12C</td>
<td>14.2</td>
<td>-4.8</td>
<td>8.9</td>
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<tr>
<td>[N&amp;D], Tout&gt;17/19C, DP&lt;14C</td>
<td>20.9</td>
<td>-1.0</td>
<td>13.9</td>
<td>0.84</td>
<td>733</td>
</tr>
<tr>
<td>[N&amp;D], Tout&gt;17/19C, DP&lt;15C</td>
<td>26.1</td>
<td>3.3</td>
<td>18.8</td>
<td>0.78</td>
<td>950</td>
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<tr>
<td>[N&amp;D], Tout&gt;17/19C, DP&lt;16C</td>
<td>33.8</td>
<td>11.0</td>
<td>26.5</td>
<td>0.73</td>
<td>1255</td>
</tr>
<tr>
<td>[N&amp;D], Tout&gt;17/19C, DP&lt;18C</td>
<td>45.8</td>
<td>32.6</td>
<td>41.6</td>
<td>0.59</td>
<td>1811</td>
</tr>
</tbody>
</table>
The IW and the climate are not ideal for the natural ventilation:
- light thermal mass
- location of the windows
- not enhanced use of the stack effect
- High humidity in the outside air

Nevertheless, decrease the total energy demand: 14% of energy savings (to maintain the thermal comfort during 84% of the occupied period) both in North and South bays: around 1,000 kWh per bay per summer.

The use of the hybrid ventilation does not impact much the cooling peak (around 3.1kW – South bay / 3.4kW North bay).

The natural ventilation provides required ventilation.
5. FURTHER RESEARCH

**Precision of the previous results can be improved thanks to:**
- Measurement of the pressure coefficient Cp (to characterize the air tightness of the IW façade)
- CFD modeling (to study the air flow pattern in the IW)

**Exercising the model in its current form:**
- Increasing the thermal mass of the building
- Decreasing the time step between two control decisions (from 1 hr to 45 min or 30 min)
- Defining additional opening position of the windows

**Additional extensions of the model:**
- Improving the control strategy to open the windows (optimum or predictive control)
- Using fan assisted natural ventilation
- Implementing the solar shading control with the ventilation control

**Additional research:**
- Economical effect on energy consumption based on the electricity consumption of the fan coils and the Semco.
- Develop a modular model that can be used for the ITEST project
QUESTIONS ?