HVAC Systems Modelling

Darren Coppins BEng CEng MCIBSE BEMP
CIBSE Building Simulation Group Vice Chair
CIBSE BSG Certification Group Chair
HVAC Systems Modelling

What is it, why is it important and are we competent to do it

by Darren Coppins
HVAC Systems

Systems which include all the components necessary to deliver comfort conditions to the occupier

- Boilers
- Chillers
- Pumps
- Air Handling Units
- Ducts
- Pipes
- Chilled beams
- Fan coils
- Etc…
Most larger commercial buildings in the UK have some form of energy intensive HVAC system.
HVAC Systems

Current Modelling

Majority of modelling in the UK is dynamic for thermal loads, applying a formula for plant efficiency.

<table>
<thead>
<tr>
<th>LOAD</th>
<th>SCOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>3.4</td>
</tr>
<tr>
<td>50%</td>
<td>5.0</td>
</tr>
<tr>
<td>75%</td>
<td>4.3</td>
</tr>
<tr>
<td>100%</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Load \( \times \) Seasonal Efficiency = Chiller Load

Flow \( \times \) W/l.s flow = Fan Load

Flow \( \times \) W/l.s flow = Pump Load
Current Modelling
When modelling for SBEM & Part L, plant loads can be even more simplistic.

Heating:

\[ \text{Heating energy consumption} = \frac{\text{Zones annual heating load}}{\text{SCoP}} \]

Cooling:

\[ \text{Cooling energy consumption} = \frac{\text{Zones annual cooling load}}{\text{SSEER}} \]

Equations:

\begin{align*}
\text{Equation 8} & \quad F_{PS1} = F_{AR} \times S_{FP_{central}} + S_{CR} \times S_{FP_{terminal}} \\
\text{Equation 9} & \quad F_{PS2} = \text{Greater of} \ (F_{AR} \times S_{CR}) \times S_{FP_{central}} \\
\text{Equation 10} & \quad F_{PS3} = \text{Greater of} \ (S_{CR}/S_{f} \times F_{AR}) \times S_{FP_{central}} \\
\text{Equation 11} & \quad F_{PS4} = F_{AR} \times S_{FP_{central}} \\
\end{align*}

Table 12: Pump power density for Actual building (W/m²)

<table>
<thead>
<tr>
<th>Pump configuration</th>
<th>LTHW only</th>
<th>Both LTHW and CHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant speed pumping</td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Variable speed pumping with differential sensor across pump</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Variable speed pumping with differential sensor in the system</td>
<td>0.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Variable speed pumping with multiple pressure sensors in the system</td>
<td>0.3</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: NCM
Actual performance can be significantly more complex
(Source – IES Chiller Efficiency Database)

Source: IES Chiller Database
We model thermal loads in detail, with little consideration to how plant responds to the building load.
HVAC Simulation

Constructing the HVAC and Controls systems within simulation packages permits much greater analysis of plant loads and energy consumption, part load analysis and plant suitability.
Controls philosophy can be tested and optimised
HVAC Systems

HVAC Simulation

Plant items can be entered with much greater accuracy.
HVAC Simulation

Data is available to the engineer to see conditions at any point on the network at any time step.

This data can be used to evaluate model accuracy and understand the suitability of the plant to serve the combination of simultaneous building loads.
Detailed HVAC Simulation provides more realistic building loads that can result in smaller, more accurately sized plant & systems*

* Smaller plant & systems sizing doesn’t always equal more efficiency in operation
HVAC Simulation

Energy meters can be configured as proposed in the actual building to permit more accurate prediction of energy loads and assist building management to understand where problems may be present once operational.
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HVAC Simulation
Example of how simple changes to control strategy can impact building energy use
Finally,
An answer to the performance gap
Maybe Not
Still many factors impacting our ability to predict building energy use
HVAC Systems

Unmodelled loads
i.e.
- Vertical Transportation
- Domestic Water
- Auxiliary Electricals (CCTV, Entry Systems, Fire systems etc)
- Process loads

Unknowns
i.e.
- Predicting occupancy patterns
- Quality of installation
- Quality of Commissioning
- Tenant Changes

Software Limitations
The software typically doesn’t model everything as you might expect

Competency
HVAC Systems Modelling in the UK is rare, as are experienced modellers who are able to fully configure mechanical and controls systems
HVAC Systems
Full HVAC Modelling is a vital next step for the UK in improving complex building systems.
HVAC Modelling will lead to better skills in the understanding of HVAC systems, their optimisation as well as software limitations & their impact.
To achieve better design the modeller will need to adopt responsibility for interpreting model accuracy, assessing unmodelled loads & the ability for a building to meet the modelled results
HVAC Systems
Thank you for listening

Any Questions?