UNDERSTANDING THE GAPS BETWEEN OPERATIONAL ENERGY USE AND MODELLING

“How Realistic is it to Predict the Operational End Energy Use of a School Using Advanced Computational Modelling?”

Hershil Patel MEng (Hons)

Yianni Spannos
Associate Director

CIBSE Building Simulation Group
Friday 27th April 2012
London South Bank University
Introduction
Why Use Simulation Modelling for Operational End Energy Use Prediction?

- Financial Budgeting
- Legislation Requirements
- General Interest and Public Knowledge
- Performance Funding
The partnership for school issued a BSF Standard Document: PFI Agreement Payment Mechanism in February 2008:

- **KEY POINT:** Carbon Emissions to be below 27kg CO$_2$/m$^2$/Annum for all Private Finance Initiative (PFI) New Build Secondary Schools
Medium to Evaluating Actual Operational Loads

Assumptions

Input

Computational Simulation Modelling

Predicted Operational Energy End
Relationship Between Modelling, Construction and Operation

- **Modelling**
  - Pre Construction & Pre Occupancy
  - Design/ Prediction

- **Construction**
  - Pre Occupancy
  - Workmanship

- **Operation**
  - Post Construction & Post Occupancy
  - Actual

- Regulated
- Unregulated
Comparative Study
Modelling and Operation

Actual Operational Data Available

- Step 1a: Confidence in Data provided
- Step 1b: Comparing Gas and Electric Loads
- Step 2: Modelling and Actual Comparison
- Step 3: Evaluating Variations
Graph indicates a similar distribution in energy consumption of the data sets. Therefore, comfortable with the sample (data set 1) considered in this study.
Energy Consumption and Carbon Emissions of Data Set 1 (Secondary Schools) Actual

Correlation of Energy Emissions and Carbon Emission followed a trend

Illustrates the ratio of power to heat was similar for Data Set 1 (Modelled Schools) Only
Energy Consumption Breakdown of Examined Population Data Set 1

- Actual Gas kWh/m²
- Actual Electric kWh/m²
- Modelled Gas Max
- Modelled Gas Min
- Modelled Electric Max
- Modelled Electric Min
Variation Between Modeled and Actual Operational Values (Maximum) of Schools A-D

- Electrical: -27%
- Thermal: -6%
- Electrical: 35%
- Thermal: 30%
Influential Variables
Simulation Modelling

Building Energy Simulation in Practice : 30th September 2009
Rokia Raslan - An Analysis of Results Variability in Energy Performance Compliance Verification Tools

<table>
<thead>
<tr>
<th>Building Emissions Rate (KgCO₂/m²/annum)</th>
<th>DSM Tool I</th>
<th>DSM Tool II</th>
<th>Variance (Difference / Average) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Type 1</td>
<td>32.6</td>
<td>33.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Building Type 2</td>
<td>26.1</td>
<td>19.5</td>
<td>28.9</td>
</tr>
<tr>
<td>Building Type 3</td>
<td>52.8</td>
<td>39.4</td>
<td>29.1</td>
</tr>
</tbody>
</table>

The figures above are not based on any specific buildings and were for compliance proposes only.

The research evidence indicated that there may be up to a 30% variation in the 2 widely used DSM software’s available.
## Modelling Simulation Inputs

<table>
<thead>
<tr>
<th>Fixed</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Elements</td>
<td>External Weather Profiles</td>
</tr>
<tr>
<td>Air Permeability</td>
<td>Window Operation Strategy</td>
</tr>
<tr>
<td>Thermal Set Points</td>
<td>Controls and Controls Strategy Implementation</td>
</tr>
<tr>
<td>Equipment Types and Loads</td>
<td>BMS Operation</td>
</tr>
<tr>
<td>School Time Table</td>
<td>Plant Room Heating Control</td>
</tr>
<tr>
<td>Building Services Plant and Equipment</td>
<td>Human Behaviour</td>
</tr>
</tbody>
</table>
Simulated Carbon Emissions - Change in Influential Variable Inputs

0.0  Initial Simulation Model

1.0  Window open at Reduced Pollutant Levels?

2.0  Infiltration Rate Coefficient Increased to 1.0

3.0  Out of Hours ICT Equipment Control

4.0  Dynamic Summer Year Weather File Used over Test Reference Year
Simulated Carbon Emissions - Change in Variable Inputs

- Window Open at Reduced Pollutant Levels: 115%
- Infiltration Rate Coefficient Increased: 105%
- Out of Hours ICT Equipment Control: 100%
- Dynamic Summer Year weather File: 97%
- Gas Consumption Variance Over Initial Model
- Electrical Consumption Variance Over Initial Model
Approach
Predicting Energy End Use

BEFORE

Assumptions

Input

Computational Simulation Modelling

Predicted Operational Energy End

AFTER

Assumptions

Input

Benchmarking Exercise

Computational Simulation Modelling

Predicted Operational Energy End
Predicting Energy End Use – Simplified Example

<table>
<thead>
<tr>
<th>School A: Actual</th>
<th>School B: As Designed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered Gas Loads of West Cluster: <strong>50 Units</strong></td>
<td></td>
</tr>
<tr>
<td>Modelled Gas Loads of West Cluster Schools A: <strong>60 Units</strong></td>
<td>Modelled Gas Loads of West Cluster School B: <strong>40 Units</strong></td>
</tr>
<tr>
<td><strong>Ratio = 40/60 = 0.67</strong></td>
<td>Predicted Gas Loads of West Cluster: <strong>33 Units</strong></td>
</tr>
</tbody>
</table>

2006 Building Regulation U – Values

2006 Enhanced Building Regulation U – Values
Thank You for Your Time

Hershil Patel