Development of a Portable Wireless Sensor Network to Enhance Post-Occupancy Commissioning

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ICEBO, 15-16 Sept 2014
Content overview

1. Research motivation and post occupancy commissioning (PO-Cx)
2. Pop-up monitoring™ system requirements
3. Initial experimental validation
4. Conclusions and further work
RESEARCH MOTIVATION AND PO-CX
There is a performance gap between as designed and as operated energy consumption.

Source: www.carbonbuzz.org
Commissioning scope

Question: Could commissioning for energy performance contribute to close the performance gap?

Design

Construction

**Level 1**
Is it there?

**Level 2**
Does it work?

**Level 3**
Is it connected?

**Level 4**
Does it deliver?

**Level 5**
Is it optimised?

Source: Noye et al., CIBSE technical symposium, 2013
**Problem: There is often not enough time during on site Cx for performance evaluation**

<table>
<thead>
<tr>
<th>Design</th>
<th>Construction</th>
<th>Handover</th>
<th>Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State of practice</strong></td>
<td></td>
<td></td>
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<td></td>
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<td>One-off commissioning</td>
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**Optimum energy performance**

<table>
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<tr>
<th>Initial commissioning</th>
<th>Post occupancy Cx</th>
<th>Ongoing commissioning</th>
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Proceedings of the 14th International Conference for Enhanced Building Operations, Beijing, China, September 14-17, 2014
Post occupancy commissioning (POCx)

On-site Commissioning

- Balancing
- Setting to work
- Compliance
- Health and safety

Systems deliver flow rates and temperatures
Post occupancy commissioning (POCx)

- Improved comfort
- Reduced energy wastage
- Client’s brief compliance
- Better referencing for the contractor

Systems deliver comfort at low energy cost

Performance check
- Controls in use
- Seasonal Cx
- Occupants comfort

PWSN deployment → Diagnostic → Intervention → PWSN removal → Ongoing Cx

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POP-UP MONITORING™ REQUIREMENTS
All those data need to be available to evaluate building performance.
Wireless sensor network

Pop-up monitoring™ system

- Affordable
- Wireless
- Self powered
- Easily deployable
- Scalable and flexible
- Non disruptive

Source: Noye et al., CIBSE technical symposium, 2013
Wireless sensor network

Pop-up monitoring™ system

Cost
~ $150 x number of nodes (reusable on several projects) + installation + removal

Source: Noye et al., CIBSE technical symposium, 2013
Wireless sensor network

Pop-up monitoring™ system

Battery life

- Up to 3 years depending on acquisition frequency
- Future: self harvesting sensor nodes

Source: Noye et al., CIBSE technical symposium, 2013
Ventilation feasibility study
# Ventilation feasibility study

<table>
<thead>
<tr>
<th>Sensors</th>
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<tr>
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<td>Temperature</td>
<td>Room</td>
</tr>
<tr>
<td>2 CO$_2$, Temperature, Humidity</td>
<td>CO$_2$ level, Temperature, Humidity</td>
<td>Room</td>
</tr>
<tr>
<td>3 Radiant temp.</td>
<td>Radiant temp.</td>
<td>Room</td>
</tr>
<tr>
<td>4 Passive infra-red</td>
<td>Occupancy</td>
<td>Room</td>
</tr>
<tr>
<td>5 Temperature, CO$_2$, Humidity, Air flow</td>
<td>Air temp., In/out CO$_2$, Air humidity, Air flow</td>
<td>System</td>
</tr>
<tr>
<td>6 Current Voltage</td>
<td>Electric power</td>
<td>System</td>
</tr>
<tr>
<td>7 Pipe temp.</td>
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Off the shelf sensors complemented with self developed sensors
# Ventilation feasibility study

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Off the shelf sensors complemented with self developed sensors
Ventilation feasibility study
INITIAL EXPERIMENTAL VALIDATION
Sensors characterisation - Temperature

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<th>Thermocouple</th>
<th>Capacitive</th>
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<tbody>
<tr>
<td>Range</td>
<td>-40 to 70 °C</td>
<td>-40 to 125 °C</td>
</tr>
<tr>
<td>Resolution</td>
<td>6 10-6 °C</td>
<td>0.04 °C</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.5 °C</td>
<td>± 0.3 to 0.8 °C</td>
</tr>
<tr>
<td>Power consumption</td>
<td>3.5 mW</td>
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Variability of sensor readings at a set temperature in a controlled environment
Sensors characterisation - Temperature

25 °C set point

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Office monitoring set up

Diagram showing a small office setup with a fan, radiator, desk, and meeting table. Markings indicate locations for temperature, humidity, and CO2 sensors.
Controlled activity

Controlled human activities related to thermal comfort

- Window open
- Radiator on
- Fan on
Office monitoring

CO$_2$ levels and occupancy are closely related
Further steps

- Fault simulation
  - E.g.: FCUs fighting each other
- Real case deployments
  - E.g.: Teaching and research building
- Strategies for PO-Cx using pop-up monitoring™
Conclusion

• Truncated commissioning may contribute to the energy performance gap
• BMS might not have sufficient data for PO-Cx
• Rapid development of wireless sensor network technologies can provide low-cost data for pop-up monitoring™
• Initial characterisation test on low power sensors show suitable accuracy and the ability to detect relevant building properties for commissioning
• Deployment on major project this autumn

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