Case Study

Review of control strategy for a primary school built to PassivHaus standard

Chryssa Thoua¹
Mark Lumley¹
Jonathan Hines¹
Azadeh Montazami²
Mark Gaterell²
Anna Mavrogianni³
Nick Grant⁴

¹ Architype, ² Coventry University, ³ UCL, ⁴ E3
Aim and methodology

This case study reports on an ongoing post occupancy Soft Landings project led by Architects

Aim
To investigate whether the Control and Environmental strategies perform as expected and are simple or well-explained for the building users and the facilities manager to use and manage.

Objectives
• Evaluating commissioning of components,
• seasonal adjustment of strategies,
• Review and evaluation of BMS settings and interface, usability of controls

Methodology
• Interdisciplinary workshops in the school after the first year of occupancy
• Interviews with the facilities manager (FM)
• Monitoring
• Questionnaire survey
The case study building

Location
Bilston, Wolverhampton, West-midlands, UK

Timescale
On site October 2012, complete December 2013

Client
Wolverhampton City Council

Value
£5,000,000

South view and playground
Capacity
420 pupils

Gross floor area
2610 m²

Annual energy demand for heating
11 kWh / m² (actual)

Annual electricity usage
50 kWh / m² (actual)
Construction type
Timber frame structure, externally insulated
Ventilated rain-screen cladding (walls)
Blown cellulose insulation, 18 mm OSB for airtightness

Blower door test
0.34 ac / h @ 50 Pa

U-values
External Wall
0.1333 W/ m² K
Flat roof
0.153 W/ m² K
Ground floor slab
0.152 W/ m² K
Pitched roof
0.103 W/ m² K
Argon filled, Triple glazing,
Ug value: 0.54 W/ m² K
Aluminium-clad spruce frame
Uf value 0.77 W/ m² K
First floor plan
Ventilation strategy

A cascade strategy for the mechanical ventilation was possible because of the nature of the occupancy patterns of the classrooms and the hall.

Winter
Mechanical Ventilation with Heat Recovery (MVHR)
Cascade strategy

Summer
Natural ventilation & night ventilation

Heating
Radiators, gas boiler (BMS)

BMS controls
Fan speed (CO₂ modulated)
Heat recovery and heating
Natural ventilation set-points
(average building air temperature)
1 | Fresh air is supplied in the classrooms.

2 | Overflow air from the classrooms transfers to the hub spaces.
1 | A shunt fan supplies air from the hub space to the Hall.

2 | Overflow air from the Hall transfers to the hub.

3 | Air is extracted from the hub space.
1 | A shunt fan supplies air from the hub space to the Hall.

2 | Overflow air from the Hall transfers to the hub.
Summer ventilation strategy in classrooms

**Mixed mode**
- Controls: Simple to change between seasonal modes
- Indoor conditions: Lower CO$_2$ levels
- Conflict: Windows may remain closed when required (cold draughts, noise, outdoor pollutants) without compromising IAQ
- Less reliant on occupant preferences

**Natural mode**
- Typically Higher CO$_2$ levels
- Requires training: e.g. CO$_2$ alarms to raise awareness
- Marginally reduced energy consumption
- Controls: Problematic seasonal transition: switching between MV winter and NV summer
Summer ventilation strategy in classrooms

**Mixed mode**
- Controls: Simple to change between seasonal modes
- Indoor conditions: Lower CO\(_2\) levels
- Conflict: Windows may remain closed when required (cold draughts, noise, outdoor pollutants) without compromising IAQ
- Less reliant on occupant preferences

**Natural mode**
- Typically Higher CO\(_2\) levels
- Requires training: e.g. CO\(_2\) alarms to raise awareness
- Marginally reduced energy consumption
- Controls: Problematic seasonal transition: switching between MV winter and NV summer
BMS settings

CO₂ modulated air supply in the classrooms

Problem
The location of the CO₂ sensor was not the one specified in the duct

Investigation
The CO₂ levels in the classroom in winter were satisfactory.

Result
There is no need to change the location of the sensor
**Problem**
The location of the \( \text{CO}_2 \) sensor was not the one specified in the duct.

**Investigation**
The \( \text{CO}_2 \) levels in the classroom in winter were satisfactory.

**Result**
There is no need to change the location of the sensor.
Natural ventilation controls

Automated natural ventilation controls:

- BMS operated high-level windows in the hub space and the hall
- BMS operated roof-lights over circulation spaces
Manual natural ventilation controls
- Windows and ventilation panels in the classrooms

Benefits
- Sense of full / local control
- Direct response to requirement for thermal comfort
- Not distracted by actuators
- Not relying to commissioning of complex components and systems

Risks
- Requires awareness of indoor air quality
- Depends on personal preferences
- Possibly not optimal, e.g. forgetting to leave ventilation panel open for night cooling

Image source: Architype
Automatic control of natural ventilation

Problem

a) Users complaints that the high-level windows of the hub space open when they shouldn’t.

b) The ground floor hub space can get uncomfortably cold mainly at lunch time. This was attributed to shunt fan operation when the Hall is occupied (lunch). Draught can be caused in classrooms especially when high level windows are closed.
Automatic control of natural ventilation

Investigation
The BMS natural ventilation setpoint

Where is the building average temperature measured?
(Sensors on the first floor)

Method
Monitoring air temperature in 3 different locations in the Hub space and in 2 classrooms

BMS air temperature sensor

Ground floor, sensor ‘Tair 3’

First floor, sensor ‘Tair 1’ and ‘Tair 2’
Air temperature loggings via BMS in winter 2014

**Average daily peak:**

- First floor west (Tair 1) **22.7 °C**
- First floor east (Tair 2) **22.9 °C**
- Ground floor west (Tair 3) **21.9 °C**
Findings
Peaks between sensors id different floor levels of the hub space can have up to 2 °C difference.
Proposed improvements

- Increase natural ventilation setpoint temperature
- Ensure actuators are functioning
- Override switches are functioning and self-explanatory
Training for building users

**Explain controls**
Local explanation of how window override switches work
E.g. how to open a window and for how long before it goes back to BMS control

**Explain strategies**
Includes a better understanding of automatic controls and impact of actions on indoor conditions
E.g. when to open high level windows but also MV features

**Raise awareness**
Teachers should be aware of the impact of CO₂ levels on learning
Incorporate CO₂ alarms to guide occupant window opening behaviour for summer mode

Override switches in the hub (above) to control high level windows (right)

Further benefits of training: timely and effective communication of issues
Training for building facilities manager

Explain controls
The BMS interface are preferably adjusted taking into consideration feedback from facilities and school management.

Explain systems
This includes components that were not properly commissioned: e.g. connections for meters and communicating any adjustments.

Protocol for maintenance and troubleshooting
Including access to technical support.

Method
Workshops and training sessions
Building User Guide
(The process of producing a building user guide was significant in initiating a dialog between the design team, the school management and users and led to adjustments of control and environmental strategy.)
Conclusions

Is the use of BMS suitable for PH primary schools in the UK?

To answer this we need to consider:

• The ability to provide relevant training for the Facilities Manager and building users

• The **cost** and length of the training and complexity of maintenance and troubleshooting protocols with BMS compared to that without BMS

• The **risk** of components and systems not properly **commissioned**/installed: likelihood of not commissioning properly, impact on indoor conditions, occupant satisfaction and energy consumption.

• Is there a feasible alternative that would not compromise the effectiveness of the environmental strategy?
Any questions?

Thank you!

Acknowledgements
Part of the data were obtained thanks to the Knowledge Exchange and Enterprise Network (KEEN) project between Architype and Coventry University, led by the University of Wolverhampton and funded by European Regional Development Fund (ERDF) and Architype.
Special thanks to Tina Gibbon, headteacher of the Wilkinson Primary School.
The design team and soft landings team.