Thamesmead Condensation, Damp and Mould Strategy. The use of smart thermostats to assess ventilation interventions with demand controlled ventilation

Peter Rickaby MA DipArch PhD RIBA [1], Ian Mawditt[*2], Adam Fudakowski[3], Simon Jones[4]

1 Energy and Sustainability Consultant (Buildings and Housing)
50 Vernier Crescent, Medbourne, Milton Keynes
MK5 6FE, UK
Telephone +44 (0)7836 211656,
Email peterrickabyconsultancy@gmail.com

2 Fourwalls
5 Pitchcombe Gardens
Bristol
BS9 2RH
United Kingdom
ian@fourwalls-uk.com

***3** Switchee Ltd*
61-63 Rochester Place, Camden, NW1 9JU
020 7043 2310
info@switchee.co

4 Aereco Ltd
1 Cherrywood Business Park
Courtstown
Little island
Cork
Ireland
Simon.jones@aereco.ie

1. ABSTRACT

An implementation of a Condensation, Damp and Mould (CD&M) Strategy for the Thamesmead estate in south-east London Targeting 2000 homes.

The evidence-based strategy is designed to manage CD&M systematically and focus on homes that will not be refurbished or replaced for some time. CD&M risk assessments and surveys are used to identify homes for a range of interventions, including energy advice, smart heating controllers and demand-controlled mechanical extract ventilation, in various combinations.

Evaluation of the first phase of the programme indicates that it is effective in reducing CD&M and increasing the affordability of heating with the potential to improve health outcomes for residents. Analysis of IAQ has come through innovative use of data from smart thermostats and evaluation of vapour pressure.

2. KEYWORDS

Smart Thermostat, Ventilation, Vapour Pressure

3. INTRODUCTION

The Thamesmead CDM Strategy is an innovative evidence-based approach to a long-standing problem. The use of risk assessments and a comprehensive energy advice programme. The adoption of technologies such as smart heating controllers and demand controlled continuous ventilation. The use of data collected from the smart thermostats to provide for deeper monitoring and analysis of the CDM programme without the need for a specific monitoring project.

By the time of writing, the CDM programme has involved more than 1000 interventions in over 250 homes. The evaluation objectives are:

1. To evaluate the effectiveness of the programme in reducing condensation, damp and mould, draw conclusions and make recommendations about any appropriate improvements as the programme continues to be rolled out across Thamesmead.

2. To consolidate the experience of the initial pilot phase, record the lessons learned, evaluate the efficiency and practicality of the project procedures and identify appropriate improvements.

Thamesmead provides approximately 2500 homes, mostly for rent by low-income households. The estate was built by the Greater London Council in the 1970s and transferred to Gallions Housing Association during the 1990s. More recently, Gallions merged with Peabody, and the estate is now owned by the Peabody Group.

The estate consists of high-rise towers and medium- and low-rise blocks arranged around courtyards. The towers contain one- and two-bedroom flats; the lower blocks contain one-, two-, three- and four-bedroom apartments. There are over twenty different types of homes. Blocks are connected by walkways above ground level, which provide access via lifts and stairways to hallways or access decks at each level.

Most blocks have reinforced concrete floors and flat roofs supported on columns and cross-walls. The towers and some lower blocks are clad with pre-cast reinforced concrete panels. Some blocks have brick cladding. Windows and external doors were originally metal- or timber-framed and single glazed, but in the medium- and low-rise blocks most windows have been replaced with PVCu-framed double-glazed units. Insulation is poor, consistent with standards at the time of construction; little or no insulation has been added.

The original district heating system was replaced by individual gas-fired central heating and hot water systems by Gallions after 2000. Ventilation is provided by 'trickle ventilators' in window heads supplemented by intermittent extract fans in most bathrooms and kitchens. However, many fans are not working or unused, because residents perceive them to be ineffective, noisy and expensive to run.

4. THE THAMESMEAD CDM PROGRAMME

There is widespread fuel poverty in Thamesmead. The poorly insulated homes tend to be under-heated and under-ventilated. Condensation, damp and mould are common. Of twenty-five dwellings surveyed between November 2016 and February 2017 nineteen (76%) had condensation or mould in at least one room; seventeen homes (68%) had condensation or mould in several rooms. This is the problem that the Thamesmead CDM programme seeks to address.

The objective of the CDM programme is to manage condensation and mould and mitigate fuel poverty, in households whose homes may not be improved for several years. The programme has three key features:

1. Risk assessment of the Thamesmead stock, using existing data, to identify the dwellings most at risk of condensation, damp and mould.
2. Detailed surveys of medium- and high-risk dwellings to establish the sources and extent of condensation, damp and mould, the existing provision of ventilation and the patterns of occupancy.
3. Three levels of intervention, based on the risk assessments and survey data:
    a. For low-risk homes: energy advice, which is delivered by Peabody's in-house energy advice service; all households will receive this advice.
    b. For medium-risk homes: energy advice, a smart heating controller, and where appropriate a new heating boiler.
    c. For high-risk homes: energy advice, a smart heating controller and a demand controlled ventilation system.

5. CDM RISK ASSESSMENTS

A sample housing stock condition survey was carried out by Peabody soon after the acquisition of Gallions, and the data have been assimilated into Peabody's housing stock database. At the time that the pilot phase of the CDM Strategy was initiated, data for 1382 homes were available. These data were used for an assessment of the risk of properties suffering from condensation damp and mould. The information available included condition data, occupancy data, Housing Health and Safety Rating System (HHSRS) assessments and SAP energy rating assessments and some EPCs. The risk assessment were based on:

1. Vulnerability (age of occupants)
2. HHSRS Damp and Mould rating
3. HHSRS Excess Cold rating
4. SAP energy rating band
5. Occupancy ratio (occupants per bed-space)

The scores derived from the data are summarised in Table 1, together with the weightings used to calculate an overall CDM risk score for each home.

Table 1: Scores and weightings *used in each risk assessment category*

Age of Occupants	Score
00-04 Years	5
05-14 Years	4
15-24 Years	3
25-34 Years	2
35-44 Years	1
45-54 Years	2
55-64 Years	3
65-74 Years	4
75-84 Years	5
85+ Years	5
Weighting 20%	

Damp & Mould	Score
1 - None	1
2 - Typical	2
3 - Slight	3
4 - Moderate	4
5 - Extreme	5
Weighting	50%

Excess Cold	Score
1 - None	1
2 - Typical	2
3 - Slight	3
4 - Moderate	4
5 - Extreme	5
Weighting 10%	

SAP Band	Score
A	1
B	1
C	2
D	3
E	4
F	5
G	5
Weighting 10%	

Occupancy Ratio	Score
0	5
0.2	4
0.4	3
0.6	2
0.8	1
1.0	1
1.2	1
1.4	2
1.6	3
1.8	4
2.0>	5
Weighting 10%	

For each home, the score in each category was multiplied by the weighting factor (e.g. for 20% weighting the score is multiplied by 2, for 50% weighting the score is multiplied by 5) and the weighted scores were added up and divided by 10; this produced a risk score for each home, between 1 and 5. A score of less than 2.5 is considered 'low risk'; a score between 2.5 and 3.5 is 'medium risk', and a score above 3.5 is 'high risk'.

6. CDM AND VENTILATION SURVEYS

Surveys of medium- and high-risk homes were carried out between November 2016 and February 2017 to establish the actual incidence of condensation, damp and mould and the extent of the existing provision of ventilation. The aim was to validate the risk assessments and allow them to be recalibrated if necessary, and to investigate any relationship between the incidence of CDM and the provision of ventilation.

The CDM and ventilation surveys can be completed in approximately twenty minutes per dwelling. They record the incidence of condensation, damp and mould room-by-room. Existing ventilation is also recorded room-by-room, including extract fans, wall air inlets and window air inlets (trickle ventilators). Photographs were taken to record the extent of CDM.

No significant mould was found in homes with risk scores less than 3.5 (medium risk), except in one case (risk score 3.3), and all the homes where mould was found in several rooms have risk scores above 3.5 (high risk). Overall, the data from the CDM surveys suggest that the risk assessment is a reliable indicator of the likely presence of mould, and can be used to determine appropriate interventions, provided there is a parallel process, using complaints or observations from other surveys, to correct errors.

The presence of intermittent extract fans and trickle ventilators (window air inlets) does not make much difference to the incidence of mould, but the presence of continuous centralised mechanical extract ventilation (communal MEV) systems in homes such as those on The Moorings estate does. This supports the conclusion that intermittent extract ventilation is not an effective remedy for CDM, but the installation of continuous ventilation can be effective.

7. ENERGY ADVICE

All households in Thamesmead should receive energy advice under the CDM programme. Initial and follow-up visits were originally planned. The advice is provided by Peabody's in-house energy advisor, who delivered some advice during the pilot, although it was not initially coordinated with other interventions.

8. MOULD WASHES

Homes with extensive mould are being treated with three-part fungicidal mould washes, then redecorated with emulsion paint. The mould wash kills the mould and permeates into the plaster or plasterboard linings to inhibit further growth.

Mould washes are thought to be effective for between two and five years, so they may mask the effects of other measures such as insulation, more efficient heating and ventilation until the end of that period.

9. SMART HEATING CONTROLLERS

The Switchee heating controller is a new device designed for social housing. It replaces the room thermostat and programmer, and has all the usual 'smart' functions: it senses occupancy and sets back the heating when the home is unoccupied; it 'learns' the occupancy pattern and anticipates the demand for heat; and it controls the internal temperature in the home to the set level. Switchee can operate autonomously, without intervention from residents, or they can adjust the temperature via a touch-screen if they wish. The screen also displays other information, such as whether heat is being called for and how long it will take the home to reach the set temperature.

However, the important feature of Switchee, for the CDM programme, is that it monitors the home and makes data available to the landlord via a GSM connection and an online 'dashboard'. Switchee has sensors that monitor occupancy (movement), temperature, relative humidity (RH), use of the heating system (on or off) and the demand temperature setting. The Switchee software also calculates indicators such as how long a home takes to heat up by 1°C and the background temperature to which the house will fall when the heating is off, and it can flag homes that are underheated or overheated, or which have high RH levels.

The value of Switchee to the CDM programme is its ability to identify homes where there is under-heating, under-ventilation or high RH (indicating condensation and mould risk) so that interventions can be targeted. Switchee also allows homes to be monitored after improvements have been made, to confirm effectiveness; and it allows energy advisors to brief themselves prior to advice visits.

10. VENTILATION

Ventilation systems are only installed in homes with high risk scores, and where surveys or inspections in response to complaints reveal significant mould.

Good ventilation is known to reduce condensation and mould, because it removes moist, stale air 'at source' from kitchens and bathrooms and brings fresh external air into living rooms and bedrooms, thus reducing relative humidity (RH) throughout the home.

However, residents often disable ventilation because they perceive it to be noisy, draughty and expensive to operate. The CDM and ventilation surveys revealed many properties were already provided with extract fans in kitchens and bathrooms, but most were either switched off, not working or noisy; some had never been used. The challenge for the CDM Strategy has been to provide ventilation that is quiet, doesn't cause draught discomfort and is inexpensive to run.

Rickaby Thompson Associates was originally asked to review ventilation options on behalf of the housing provider and to develop a performance specification. A wide range of options was considered.

Since there is no published retrofit ventilation standard, Rickaby Thompson Associates considered the minimum ventilation rates required by Building Regulations Approved Document F (ADF) for new dwellings, and recent ventilation research carried out for the Ministry of Housing, Communities and Local Government (MHCLG), and concluded that the ADF minimum ventilation rates would be inadequate in Thamesmead. The ventilation performance specification recommended to and adopted by the Thamesmead CDM team is as follows:

- Continuous mechanical extract ventilation, centralised (cMEV).
- Minimum whole-house ventilation rates in background and boost modes consistent with ADF, but with:
    - an increase of 20% over the published extract air flow rate values,
    - the additional capacity to deliver rates consistent with ADF with and increase of 50%, if required.
- Calculation of minimum ADF ventilation rates based on occupancy of two persons per bedroom, or three persons in a one-bedroom home.
- Demand controlled ventilation (DCV): ventilation rates controlled by RH sensors so that they are continually matched to the ventilation requirement, eliminating both under-ventilation and over-ventilation.
- In all homes where ventilation has been provided the internal doors have been under-cut to provide 10 mm air gaps, permitting a net flow of air from living spaces and bedroom to kitchens and bathrooms, from where it is extracted.

11. CONCLUSIONS

Table 2 shows the numbers of completed interventions of each type up to the end of June 2018. Many homes have received several measures. The number of homes with completed interventions up to June 2018 is 256; installations continue.

Table 2: Numbers of completed Thamesmead CDM interventions up to June 2018

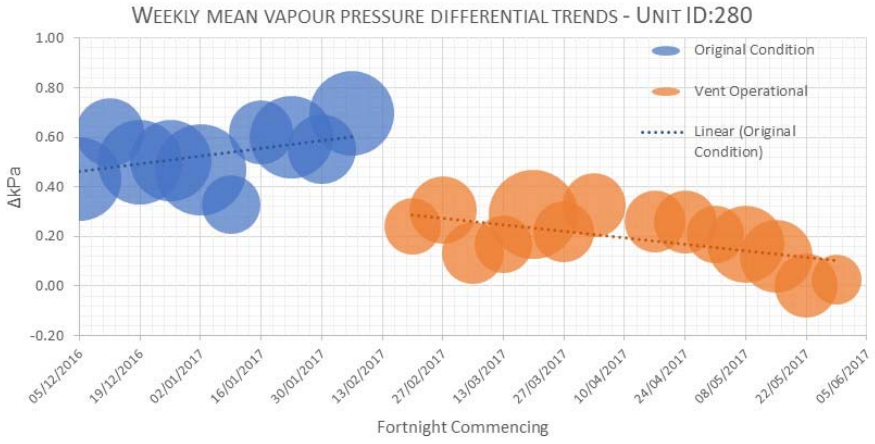
Measure	**Interventions** (to June 2018)
Energy advice visit	186
Switchee smart heating controller	149
Cavity wall insulation	229
Boiler replacement	15
Mould wash	242
New Aereco demand-controlled ventilation system	168
Upgraded ventilation system (The Moorings)	68
Total	**1057**

The initial Switchee data review focussed on the period for one month before and one month after the completion and commissioning of the ventilation system, in each case, All the homes were occupied during these periods and all were heated intermittently (typically at least twice each day) with demand temperatures set between 20ºC and 21ºC (one home was frequently heated to 24ºC). The data reveal that before the installation of ventilation systems internal relative humidity (RH) typically ranged between 40% and 65%, with frequent occupancy-related peaks above 60% RH for 30% of the time (increasing the risk of condensation on cold surfaces) sometimes lasting for long periods. After installation of the continuous demand-controlled ventilation systems RH typically ranged between 40% and 50%, and occupancy-related spikes in RH were reduced not only in size (usually to not more than 55%) but also in duration (typically 3% of the time over a typical month), as the ventilation systems detected the rises in RH and increased the ventilation rates to bring the RH levels down.

Homes in which internal RH is controlled below 60% should not suffer significant condensation and mould. Thus, the initial data review suggested that the risk of condensation and mould in the sample homes has been substantially reduced, if not eliminated. It should be noted that this effect is observed even though very few of the homes in the data sample had yet received energy advice. However, none of the homes were considered to be under-heated.

To better determine the effect of the ventilation intervention, further analysis of the data was performed using differential vapour pressure. In the pilot study two properties were reviewed.

Chart 3 Weekly mean vapour pressure differential trends for one of the properties



The data using weekly averages are given in an example chart 3. The original conditions of the dwellings are indicated in blue, with vapour pressure excess (VPX or ΔVP) plotted on the y-axes, which represents the average for that week. The size of the bubble represents the range between the 10th and 90th percentiles.

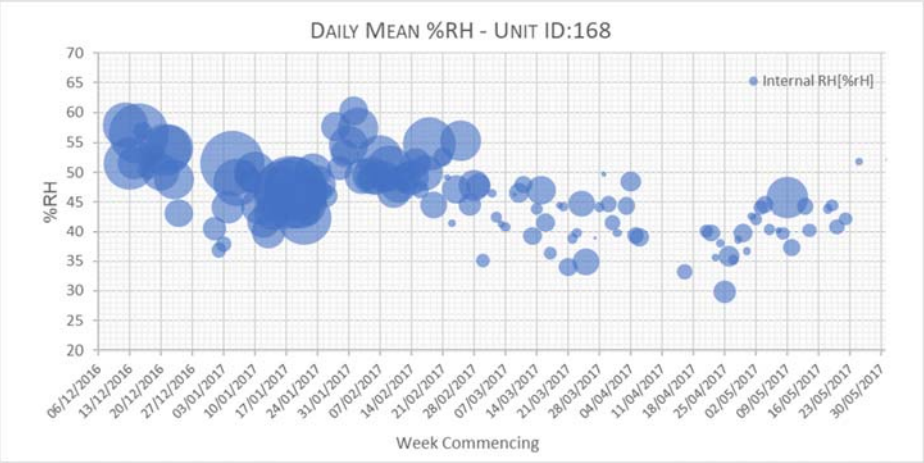
The orange bubbles indicate the period where, from this data, it can be estimated that the ventilation systems would have been commissioned.

The orange dotted line shows how the vapour pressure excess trend decreases, as the ventilation becomes operational. It should be noted that some of this downward trend will relate to seasonal variance, i.e. vapour pressure excess will decrease as the external conditions become warmer.

A data period of approximately two weeks between the 'original condition' and 'vent operational' has been removed from the chart for clarity. The data from these periods contained wider ranges of vapour pressure excess compared to other weeks, and it is possible that these wide variances related to when the ventilation systems were being installed (i.e. external doors being kept open for longer than normal for trade access).

An alternative illustration of the vapour pressure excess conditions is shown in chart 4. The daily mean %RH is now plotted on the vertical axis, and the size of the bubble is for the vapour pressure excess. It can be seen in this property that the size of bubble (VPX) reduces toward the end of February. This is the same period as the ventilation being commissioned. Not only does the VPX reduce, but so also the %RH.

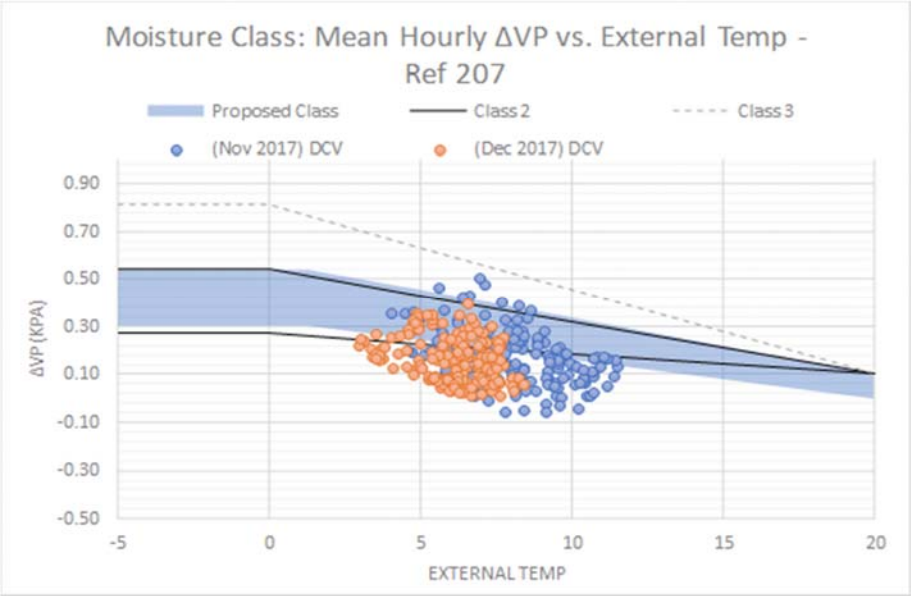
Chart 4: Shows the daily mean %RH with bubble size showing vapour pressure excess for one of the properties



Indoor temperatures, relative humidity, and, therefore, vapour pressure excess, is strongly influenced by external meteorological conditions. In analysing the vapour pressure excess, thresholds need to be applied to determine if the excess conditions internally are likely to be the source of a problem. However, the moisture classifications published in existing standards (e.g. BS 5250: 2011[1]) may be too conservative, i.e. moisture production is lower than the standard assumes. This is illustrated in chart 4, which applies more rigorous thresholds for vapour pressure excess, plotted against the external temperatures. Thresholds for humidity class 2 (offices and shops) and class 3 (dwellings) are taken from BS5250. However, the blue banded area is the average data taken from 1600 English dwellings (Ridley, et al[2]): the blue band is being proposed as an average class for a dwelling, which is more in line with class 2 (offices and shops). Persistent conditions above the blue area (or class 2) , i.e. into and above class 3 will significantly increase the risk of condensation and mould occurrences.

Chart 4 includes 2-months post installation of the ventilation system in another property. These are shown as dots (blue for November 2017 and orange for December 2017).The dots each represent the average VPX per hour per day for the month represented. It is clear from this data that the ventilation system is able to provide a consistent environment (close clustering of data) with the VPX spanning class 2 and the lower class 1 (storage buildings – area below class 2 on chart 4), i.e. moisture conditions being maintained significantly below mould condensation risk.

Chart 4: Shows mean hourly vapour pressure differential against external temperatures for one property



Using the raw data to create chart 4, a regression analysis was additionally performed to understand how, typically the internal conditions would be maintained with the new ventilation and the occupants usual use of heating. This analysis was done by normalising the vapour pressure excess conditions for external winter standard day conditions of 5°C, 80%RH. The regression results show that the internal environment conditions in this property have favourable vapour pressure excess of 0.23 kPa (e.g. upper boundary of class 1), whilst the temperature was at 18.5°C and 51% RH on an average winter's day

The Thamesmead CDM programme is experimental, and some aspects have proved more difficult to implement than others. Based on the data available for the interventions completed-to-date, the programme is effective in eliminating condensation and mould.

The CDM surveys have shown that the risk assessment process is a good method for identifying homes at risk of condensation and mould, using existing data. However, it is not completely accurate, and should continue to be supplemented and validated by surveys. Residents' complaints also identify high-risk homes. The CDM surveys have also shown that intermittent extract ventilation, especially with noisy or poor-quality fans, is not an effective remedy for CDM.

Since condensation risk is related to occupancy and residents' behaviour, it is important that even households in low-risk homes receive energy advice. Boiler replacement and improved heating controls are effective in improving heating efficiency, reducing residents' fuel costs and helping them to avoid under-heating. Demand-controlled continuous ventilation is effective in reducing internal relative humidity (and thus reducing the risk of CDM), but initially it proved expensive and difficult to install in Thamesmead, because of the concrete construction and the presence of asbestos. The installation process has become easier, as standard configurations have been developed for each type of home, and installation processes have been fine-tuned.

The Switchee device is probably a little more effective than any other heating controller, if used properly, in helping to control CDM, but its ability to operate autonomously provides a benefit in homes where the residents are unwilling or unable to engage with the problem. The monitoring facility that the Switchee device provides is a powerful tool for the landlord: it enables homes at risk of CDM to be identified and targeted, energy advice to be customised to households' circumstances and behaviour, and the effectiveness of interventions to be monitored. This facility supports the case for Switchee to be installed across the Thamesmead stock, even in apparently low-risk homes.

12. ACKNOWLEDGEMENTS

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13. REFERENCES

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