



# VENTILATION IN NEW HOMES

A report of site visit findings

# CONTACTS

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# ACKNOWLEDGEMENTS

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# 01. INTRODUCTION AND SUMMARY

The Zero Carbon Hub (“the Hub”) visited 33 dwellings across 6 construction sites in 2015 to see how effectively their mechanical ventilation systems were designed, installed, commissioned and handed over to occupants.

**This report presents the findings from the site visits anonymously.**

**It is intended for organisations with an interest in quality assuring the delivery of ventilation systems, including government policymakers, developers and their advisers.**

In summary, the Hub team found things going wrong at multiple stages of the construction process at every site. The cumulative effect of these issues ultimately outweighed any good practice, as the systems we tested showed significant under-performance. At 5 of the 6 sites, fans were operating at only half the required duty or lower, i.e. flow rates were far too low.

The end result was that nearly all of the 13 occupants interviewed by the team across the sites had turned off their ventilation systems, finding them too noisy, especially at night. If systems are turned off, they are not doing their job. The air quality in the property will be compromised, with potentially serious consequences for the health of occupants.

**An example of a common issue found was flexible ducting being installed in place of rigid ducting, and long duct runs of over 5 metres with multiple bends. This happened either because the drawings used had missed specifying the type of ducting needed, and/or rigid ducting had been specified but the design was not followed on site or was found to be impractical to deliver by the site team.**

Poor installation of flexible ducting leads to fans having to work harder to deliver the minimum ventilation rates required by Approved Document Part F of Building Regulations (ADF), and to systems being noisy.



The need to address such process-related issues is pressing. In highly efficient, airtight homes, reliance on incidental air leakage through leaky walls and windows no longer provides a safety net. It is essential that ventilation systems are designed, installed, commissioned and handed over to occupants in accordance with Building Regulations.

## Definitions

The sites visited during this project had **System 3 or 4 ventilation strategies.**

### System 3 - MEV

Continuous Mechanical Extract Ventilation (centralised or decentralised)

### System 4 - MVHR

Mechanical Ventilation with Heat Recovery

In common with other recent studies, our findings show that despite the availability of good practice guidance and training from Government departments, commercial companies, trade associations and professional bodies, minimum ventilation rates are still not being achieved in practice by the systems reviewed. The critical question is, why?

Our interviews with installers, Site Managers and SAP assessors suggest three key reasons for issues continuing to occur, and therefore three strategic responses:

## 1. Inertia

On a number of sites it was evident that installers were “doing what they’d always done”. This manifested as continuous MEV systems being treated like intermittent systems, and improvisation on site if issues were found with designs. Such practices are more likely to have performance consequences now that ventilation technologies have moved on. Precision and attention to detail is needed when installing and commissioning cutting-edge technology in carefully engineered new dwellings.

## Recommended action

### Industry

Developers should make sure they only use suitably trained and qualified people to deliver their ventilation systems.

### Government

Unlike gas fitters, designers, installers and commissioners of mechanical ventilation systems are not required by law to be trained. Although there are Competent Person Schemes available, anecdotal evidence suggests voluntary membership of ventilation-specific schemes is low. Designers, installers and commissioners should only be allowed to operate if they meet minimum competency standards. Building Control Officers also need to become more familiar with the range of ventilation systems and their importance so they know what issues to look out for. However, relying solely on Building Control for quality assurance (where a Competent Persons Scheme is not used) means that if problems are found, it may be too late to do anything meaningful about them.

## 2. Fragmented delivery

Communication up and down the delivery chain is always vital, but particularly between the architect, the Mechanical and Electrical (M&E) designer, and the installer. Any changes being made on site, such as to duct run lengths, duct type, positioning of inlets and terminals, positioning of controls, or substitution of products, must be checked with the design team as it could affect the overall performance of the system, possibly to the extent that the system would fail compliance checks.

### Recommended action

#### Industry

Project teams should agree at the beginning of the project how communication on changes to the ventilation system between the design team and the team on-site will take place. Other areas of responsibility should also be agreed at the outset, such as who will have responsibility for the maintenance and performance of the system once the property is in use.

#### Government

ADF and the Domestic Ventilation Compliance Guide (DVCG) should be updated to more strongly emphasise the importance of agreeing workable communication processes, roles and responsibilities at the outset of projects, in addition to the technical guidance already provided.

## 3. Inadequate enforcement

At present, if a ventilation system fails to meet the standards in ADF in reality, it is unlikely this outcome would be discovered in any systematic way. Developers and their suppliers are, in effect, trusted to meet Building Regulations. In-depth checks of ventilation systems do not appear to happen routinely. Secondly, even if a problem is discovered once the system is in use, it is unclear how this situation would be resolved, and who would be pushing for resolution. For example, in addition to minimum ventilation rates not being achieved in practice, the Hub team found examples of commissioning testing procedures and checks not being properly carried out and commissioning sheets not being scrutinised with no come back.

Robust inspections, enforcement and sanctions for non-compliance are necessary as, with the exception of noisy systems, many occupants are unlikely to be able tell if their systems are not working properly. Policy and legal frameworks need to protect occupants and be tough enough to incentivise the delivery chain to take seriously the need to get it right.

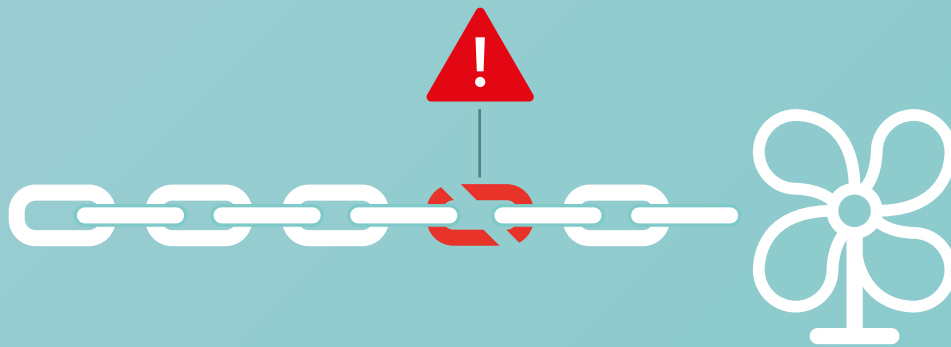
### Recommended action

#### Industry

Developers should ensure appropriate ventilation system-specific quality checks are being made by their teams at each major stage of the construction process. Including visual inspections by the Site Manager or equivalent.

#### Government

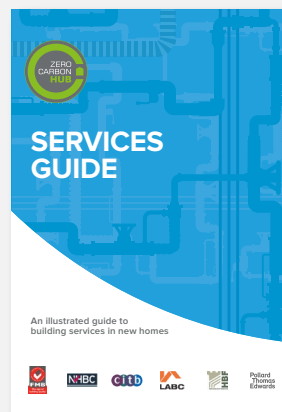
Despite mechanical ventilation installations being “notifiable” work, the framework relies too heavily on trust. The inspection, enforcement and sanctions regime needs to be reviewed, strengthened, and adequately resourced.



Consumers are acutely aware of the consequences of something going wrong with their boiler or with their electrical wiring, for example. The effects can be fatal.

It is time to borrow thinking used to improve issues with gas and electrical safety and apply similarly stringent frameworks in the ventilation sector. Failing ventilation systems may be less noticeably and immediately dangerous, but the effects over time are certainly not benign.

**We are hugely grateful to the developers who provided sites for scrutiny, and to our partners without whom this project would not have been possible.**



The results of this project have fed in the new Services Guide published by the Zero Carbon Hub in March 2016. The Guide highlights the most important “do’s and don’t’s” when delivering ventilation systems.

## 02. WHY IS IT IMPORTANT TO HAVE WORKING VENTILATION SYSTEMS?

Without well thought-out ventilation strategies and properly functioning systems, indoor air quality in dwellings will be compromised, potentially leading to health issues for the occupants and/or damage to the building fabric through condensation and mould.

The links between ventilation and health were summed up well in the quote below from the 2013 report by the Zero Carbon Hub and NHBC Foundation's Ventilation and Indoor Air Quality Task Group, led by Lynne Sullivan, OBE.



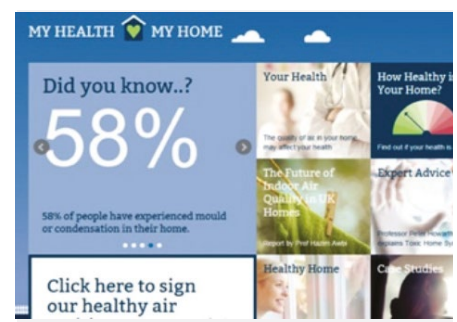
“A variety of airborne pollutants are present in homes and some are associated with serious health effects, including asthma, lung cancer, chronic obstructive pulmonary disease and cardiovascular disease. As new homes become more airtight, adequate ventilation is relied upon increasingly to maintain satisfactory indoor air quality. It is essential that ventilation systems of all types successfully deliver adequate indoor air quality...”

**Mechanical Ventilation with Heat Recovery in New Homes report, July 2013**



More recently, the high-profile report by the RCP and RCPCH “Every Breath we Take: the lifelong impact of air pollution” shared the concerning finding that 40,000 deaths in the UK each year are attributable to exposure to outdoor air pollution. The report also highlighted the “often overlooked issue” of the quality of our indoor space:

“Factors such as kitchen products, faulty boilers, open fires, fly sprays and air fresheners, all...can cause poor air quality in our homes, workspaces and schools... We must strengthen our understanding of the key risk factors and effects of poor air quality in our homes, schools and workplaces. A coordinated effort is required to develop and apply any necessary policy changes.”  
**Royal College of Physicians, February 2016**



Beama’s “My Health, My Home” website also provides a good explanation of the main sources of pollutants in dwellings, the potential health impacts and describes how air quality can be improved by well functioning ventilation systems.

See:

[www.myhealthmyhome.com](http://www.myhealthmyhome.com)



## 03. PROJECT APPROACH

A growing body of research, including the 2016 MVHR Meta Study<sup>7</sup> by the Glasgow School of Art and partners, suggests that problems introduced at each stage of the construction process, including the handover process to occupants and maintenance regimes, are creating a ‘gap’ in the actual performance of ventilation systems compared to the design intent or regulatory requirements.

Such process and delivery-related issues need to be tackled through industry collaboration and with the full support of the Government and the regulatory framework.

With this in mind, the Zero Carbon Hub initiated a project early in 2015 to gather evidence from 6 new developments under construction in England and Wales. Many questions were raised with the construction teams and their advisers to try to understand what was happening on site, how closely the delivery of ventilation systems matched the design intention, and what aspects of delivery went well and not so well.

An adapted version of the “Housebuilder Process Review”, developed by Zero Carbon Hub for the ‘Design vs As Built Performance’ project, was used to identify issues with the:

- Design
- Installation
- Commissioning
- Handover
- Use and maintenance

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1. *Characteristics and performance of MVHR systems - A meta study of MVHR systems used in the Innovate UK Building Performance Evaluation Programme, Sharpe, Gupta and Mawditt (2016)*

The Hub team sought to understand why certain decisions were made and the reasons why good or bad practice was being observed, as far as possible. More information on the Site Review Process can be found on page 9.

### Objectives

**The project aimed to understand:**

- Why the particular ventilation strategy was chosen
- What the design intention was by examining original plans and specifications
- Who had responsibility for each part of the delivery process
- What went well and why
- What problems were found and the reasons for these
- What internal processes developers should change
- What changes to policy and regulatory frameworks would better support the industry

In addition to evaluating how well the process of delivering the systems went, the opportunity was also taken to measure the ventilation and air exchange rates achieved in a sample unit at each site. The purpose was to determine the impact of process-related issues on the final ventilation rates.



*One of the Hub team out on site*

## Site identification

Further details of the 6 sites reviewed can be found on page 11, but overall:

- 4 sites were in Wales
- 2 sites were in England
- All units were built to recent standards in Building Regulations (i.e. ADF 2010 and ADL1A 2006 onwards)
- Across the 6 sites, 33 units were inspected in detail and more were reviewed to see if issues were repeated (which they were). Although this sample size is not representative of the building stock in England and Wales as whole, the sample size was broadly representative for each site.
- The sites utilised either a System 3 (Continuous Mechanical Extract Ventilation – centralised or de-centralised) or System 4 (Mechanical Ventilation with Heat Recovery) ventilation strategy

The team chose to focus on the delivery of MEV and MHVR systems to complement another project being led by Department for Communities and Local Government (DCLG) which is reviewing the performance of System 1 (background ventilators and intermittent extract fans) and System 3 (specifically de-centralised continuous mechanical extract) strategies. The project is called Ventilation and Indoor Air Quality in Naturally Ventilated, Energy Efficient New Homes and is due to report findings later in 2016.

The sites used in this project were all major new developments. This was necessary to allow the project team to review the implementation of the ventilation strategy at each stage of construction process, including at first fix, second fix, at the commissioning stage, and in most cases, once units were occupied.

## Site review process

The site visits involved a combination of pre-checks, a visual inspection, testing, and face-to-face interviews with the project team and occupants. Formal feedback sessions with the developers who provided sites was also carried out or offered. Taken together, these activities provide a solid picture of the performance of the systems and the processes at each site.

Documents requested in advance of the site visits were:

- **Copies of the Energy Performance Certificates (EPC) and final Standard Assessment Procedure (SAP) reports**
- **Copies of Air Leakage test results**
- **Domestic Ventilation Compliance Guide (DVCG) commissioning sheets**
- **Sites designs and drawings**

With the exception of Site 1, the information provided on the detailed design intention was incomplete. ADF ventilation rates, as the minimum standard, are assumed to be intended for the purposes of this study.

## Visual inspection

Approximately 40 questions and checks were made at each site. The list below provides examples of the types of checks made:

- **Inspection of the ducting in the roof void to ascertain the type and quality of connections and ducting runs**
- **Determining whether the ventilation ducting installed is in line with the design layout (location, number of bends etc.)**
- **Determining whether all flexible ducts have been pulled taut, has true radii bends and are trimmed accordingly**
- **Determining whether the total equivalent area of trickle vents meets minimum standards**
- **Checks on whether all doors have been trimmed to achieve a clear gap underneath of 10 mm, or 20 mm where no floor covering has been provided**
- **Noting the location and type of ventilation system controls provided e.g. manual, automatic, humidistats and how well these were labelled**
- **Checking DVCG commissioning sheets, or equivalent, have been fully completed**
- **Checking whether the filters in MVHR units have been replaced or cleaned prior to handover**
- **Checking handover information for clear instructions on how to use and maintain systems**

## Testing

At least one test unit was identified at each site. The following tests were conducted:

- **Supply/extract air flow rates in normal and boost mode**
- **Whole-house air exchange rates using tracer gas decay technique**

For further details on the tests performed see page 23.

## Interviews

Informal face-to-face interviews were conducted with the design team, the SAP assessors, Site Managers and installers, where people were available. The following provides an example of the types of questions asked:

- **Was the ventilation strategy known at the concept stage of the project?**
- **What factors influenced the choice of strategy?**
- **Who designed the ventilation system?**
- **Were the ventilation requirements clear and straightforward to incorporate?**
- **Do you get feedback from the construction team on the buildability of a design? What process was there for this?**

A total of 13 occupants were interviewed (at home) across the 6 sites. They gave feedback on simple questions such as whether they were aware of the ventilation system in their property, whether they knew where it is located, whether they used the trickle vents or window opening, whether they knew how to use the system controls and how to maintain the system.



## 04. SITE INFORMATION

### KEY

FF FIRST FIX

SF SECOND FIX

DMEV DECENTRALISED MEV

CMEV CENTRALISED MEV

### SITE 1

LOCATION	ENGLAND
TOTAL UNITS ON SITE	129
PHASES	FF, SF, COMMISSIONING, IN USE
UNITS INSPECTED	7
UNITS TESTED	1 SHOW HOME
VENTILATION SYSTEM	dMEV (SYSTEM 3)
OCCUPANT INTERVIEWS	1

### SITE 2

LOCATION	WALES
TOTAL UNITS ON SITE	APPROXIMATELY 300
PHASES	FF, SF, COMMISSIONING, IN USE
UNITS INSPECTED	5 (INCLUDING 1 SHOW HOME)
UNITS TESTED	3 + 1 SHOW HOME
VENTILATION SYSTEM	MVHR (SYSTEM 4)
OCCUPANT INTERVIEWS	5

### SITE 3

LOCATION	WALES
TOTAL UNITS ON SITE	144
PHASES	FF, SF, COMMISSIONING
UNITS INSPECTED	6 (INCLUDING 1 SHOW HOME)
UNITS TESTED	1
VENTILATION SYSTEM	dMEV (SYSTEM 3)
OCCUPANT INTERVIEWS	1 (SALES TEAM)

### SITE 4

LOCATION	WALES
TOTAL UNITS ON SITE	87
PHASES	FF, SF, COMMISSIONING
UNITS INSPECTED	5 (INCLUDING 1 SHOW HOME)
UNITS TESTED	2
VENTILATION SYSTEM	dMEV (SYSTEM 3)
OCCUPANT INTERVIEWS	1 (SALES TEAM)

### SITE 5

LOCATION	WALES
TOTAL UNITS ON SITE	128
PHASES	FF, SF, COMMISSIONING, IN USE
UNITS INSPECTED	5
UNITS TESTED	1
VENTILATION SYSTEM	dMEV (SYSTEM 3)
OCCUPANT INTERVIEWS	1

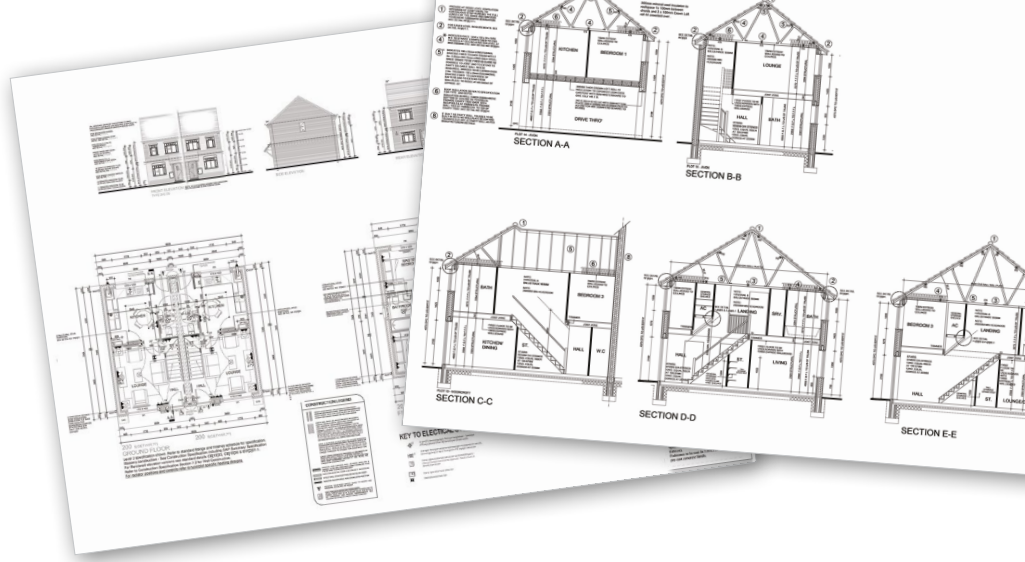
### SITE 6

LOCATION	ENGLAND
TOTAL UNITS ON SITE	400
PHASES	2
UNITS INSPECTED	5
UNITS TESTED	1
VENTILATION SYSTEM	(FLATS) cMEV, (HOUSES) dMEV (SYSTEM 3)
OCCUPANT INTERVIEWS	4

## 05. FINDINGS FROM THE VISUAL INSPECTIONS

The following tables summarise, by theme, the main findings from the visual inspections on site and the interviews carried out. There is some overlap between the themes.

 <b>1. Did the project team have processes in place to enable high quality delivery of the ventilation systems?</b>	
<b>Site 1</b>	Yes. The Site Manager knew what was expected at first and second fix, for example, drawings indicating the ventilation routes were available in the site office. Regular meetings were held between the Site Manager and the design team.
<b>Site 2</b>	Yes. The designs were carried out by an M&E consultant after consultation with the developer and installer. However, planning and discussions did not involve the SAP Assessor which resulted in the SAP assessment being incorrect.
<b>Site 3</b>	Partially. Designs were carried out “in house” without full consultation with the installer. However, two points of contact were assigned to coordinate questions on ventilation system design, installation and commissioning from the site team: the Site Manager and the installer. The same company carried out the installation and commissioning, which has the potential to reduce the risk of poor commissioning.
<b>Site 4</b>	Partially. Designs were carried out “in house” without full consultation with the installer. However, the Site Manager was assigned to handle questions on the ventilation system design, installation and commissioning. The same company carried out the installation and commissioning (the same installer as Site 3) which has the potential to reduce the risk of poor commissioning.
<b>Site 5</b>	No. The main developer designed the systems, providing one point of contact for ventilation system installation and commissioning – this was the electrical sub-contractor. However, the installed system did not match the design and there was no evidence of any processes in place to aid communication and prevent errors being introduced along the delivery chain.
<b>Site 6</b>	Partially. One point of contact was assigned to coordinate the ventilation system design, installation and commissioning, but there was little evidence of systems being checked on site. The same company carried out the installation and commissioning.



## 2. Were the designs/ventilation strategies suitable for the scheme and sufficiently detailed?

<p><b>Site 1</b></p>	<p>No. The designs and working drawings available demonstrated the potential for compliance with ADF. However, some of the ducting and fans were missing from the construction layout drawings for one unit, which was then missed by the installation team at first fix in their attempt to be faithful to the drawings. Remedial works were carried out by the electrician which resulted in flexible ducting being installed instead of specified rigid ducting. The ducting was also not pulled taut, was excessive in length and sagged as a result.</p>
<p><b>Site 2</b></p>	<p>Partially. At the detailed design stage the decision was made to change from a System 1 (background ventilators and intermittent extract) to a System 4 (MVHR) strategy due to the scheme's location next to a busy road/concern about window opening. There was a generous service zone for ducting cross-over, enabling easy access for installation. However, the designs did not take into account fire compartments nor were they co-ordinated with soil vent pipe positions, meaning duct lengths were increased by up to 6 metres compared to the drawings.</p>
<p><b>Site 3</b></p>	<p>Partially. The limited design information and working drawings available suggested the potential for ADF compliance. However, the designs did not specify the duct type (flexible or rigid).</p>
<p><b>Site 4</b></p>	<p>Partially. The limited design information and working drawings available suggested the potential for ADF compliance. However, the design did not specify the duct type (flexible or rigid).</p>
<p><b>Site 5</b></p>	<p>Partially. The limited design information and working drawings available suggested the potential for ADF compliance. However, the design did not specify the duct type (flexible or rigid).</p>
<p><b>Site 6</b></p>	<p>Partially. The limited design information and working drawings available suggested the potential for ADF compliance. The structural timber joist layout was not shown at the design stage so layout of the ducting necessarily changed on site.</p>

### 3. Was information about the ventilation system correctly represented in the SAP assessment?

<b>Site 1</b>	Yes. Including the ducting choice.
<b>Site 2</b>	No. The design-stage SAP reports were not updated to reflect a change from System 1 to System 4. The design team were not aware the assessment had not been updated. The original SAP assessments were based on a traditional build construction with a System 1 ventilation system. Subsequently the designs were changed to a concrete frame construction and the ventilation strategy modified to System 4. The SAP assessor was not informed of this changes and the As-Built SAP reports and EPCs were inaccurate as a result.
<b>Site 3</b>	Partially. Including the ducting choice. However, the Design-Stage SAP calculations were based on rigid ducts to all fans, but flexible ducting was installed in some cases.
<b>Site 4</b>	Partially. Including the ducting choice. However, the Design-Stage SAP calculations were based on rigid ducts to all fans, but flexible ducting was installed in some cases.
<b>Site 5</b>	Partially. Including the ducting choice. However, the Design-Stage SAP calculations were based on rigid ducts to all fans, but flexible ducting was installed in some cases.
<b>Site 6</b>	Yes. Including the ducting choice.

### 4. Were systems and ducting installed in accordance with the designs?

<b>Site 1</b>	Yes. The ducting broadly followed the routes on the design layout. However, as noted above, in the unit where the drawings had missed off the ventilation system, flexible ducting was installed. This ducting was too long and sagged. The other units had rigid ducting installed, as designed.
<b>Site 2</b>	Yes. The ducting was generally installed well and in line with the drawings. Proprietary components were used in the installation, including duct clips and connectors. The installation was well sealed and well insulated. However, the final connection to the MVHR unit used un-insulated flexible ducting. The installation contractor explained that site realities meant it was not practical to install rigid ducting due to physically being able to make the connection once the ceiling plasterboard had been installed.
<b>Site 3</b>	No. The in-house designs were followed and where possible the system was taken through-the-wall to reduce duct lengths. Most flexible ducting was installed with care, e.g. pulled taut. However, rectangular hole-cutting in joists presented some problems which resulted in flexible ducting being used more than intended. Some flexible ducting runs were over 4 metres, increasing the chance of excess system noise. The installer advised that they were following the drawings, but the design had not accounted for the long flexible duct runs. There were also examples of ducting sagging in the roof space and between joists creating a risk of condensation building up. The design did not specify the duct type which resulted in duct selection decisions being made on site.



<p><b>Site 4</b></p>	<p>Yes. In general the installation was good and the in-house designs were followed. However, the design had not specified the duct type needed which resulted in duct selection decisions being made on site. The electrical sub-contractor installed the ducting, which was either through-the-wall (rigid) or flexible in the roof space. Short ducting runs were used, taken through the wall and well sealed. The flexible ducting in the roof space was pulled taut with condensation traps. However, there were issues on site and changes made, for example, taking out soffit vents and taking the duct to a roof tile.</p>
<p><b>Site 5</b></p>	<p>No. Some roof space ducting was sagging/not pulled taut risking condensation build-up and an increase in fan noise. The design was not explicit with respect to the duct type needed which resulted in duct selection decisions being made on site. Installation also differed from the design with fan positions being moved by the installer. The reason was aesthetics – aligning the fans with the lighting grid layout. Where the design specified a ridge vent it had been changed to a tile vent near the ridge due to availability of the ridge vent being an issue.</p>
<p><b>Site 6</b></p>	<p>No. Flexible ducting was poorly installed with many bends and long duct lengths. In some loft spaces the ducting was not connected to the roof vent. A kitchen duct in one unit was 12 metres in length. Ducting was insulated but the insulation was poorly installed, with gaps and no seals. The structural timber joist layout was not shown at the design stage so layout of the ducting necessarily changed on site.</p>



*Ducting at Site 3 – Long looping ducting could cause condensation to build up and increase the required fan power*



*Ducting at Site 2 – Rigid duct installation. Straight duct runs using proprietary bends where needed. Intake/exhaust ductwork is pre-insulated (grey ducting). Ducting mechanically connected and fastened throughout*

## 5. Were trickle vents and background ventilators installed in accordance with ADF?

Guidance published in ADF for System 3, continuous MEV (Table 5.2c), specifies that small background ventilators, having an equivalent area of 2500mm<sup>2</sup>, should be provided in all rooms, except for wet rooms where there are extract fans or terminals. This requirement only applies to homes with a design air permeability of <math><5.0 \text{ (m}^3\text{.hr)/m}^2 \text{ @50Pa}</math>, but it is considered good practice for them to be fitted in all instances.

<b>Site 1</b>	No. All the windows installed had trickle vents, including the wet rooms. This was thought to be an error by the window supplier. There was also more than double the Equivalent Area required (see image below).
<b>Site 2</b>	Yes. The window company provided the correctly specified windows with no trickle vents as these are not required for an MVHR strategy.
<b>Site 3</b>	No. Contrary to the design, all the windows installed had trickle vents, including wet rooms. The units had nearly four times more Equivalent Area than required.
<b>Site 4</b>	Yes. The design of the trickle vent sizing and provision closely followed guidance in ADF.
<b>Site 5</b>	No. All the windows installed had trickle vents, including wet rooms.
<b>Site 6</b>	Partially. Trickle vent sizing and provision closely followed guidance in ADF. However the Equivalent Area size of ventilators selected were larger (4000mm <sup>2</sup> ) and more appropriate for naturally ventilated dwellings.



**Trickle Vents at Site 1 – Over-provision of trickle vents at Site 1. Two ventilators fitted with approximate EQA of 5800mm<sup>2</sup>. One trickle vent with EQA of 2500 mm<sup>2</sup> would meet ADF guidance.**

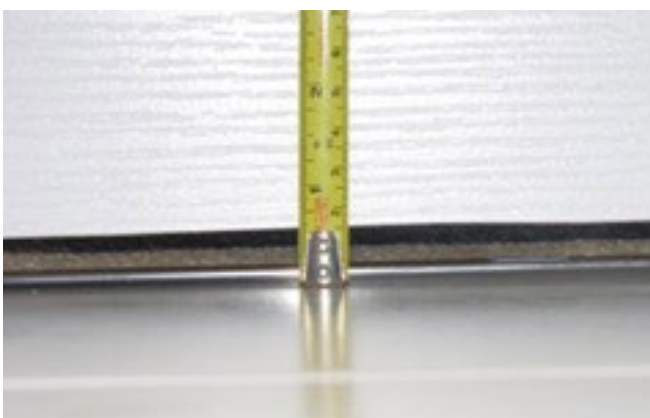


## 6. Were door undercuts provided to the correct height?

“To ensure good transfer of air throughout the dwelling, there should be an undercut of minimum area 7600 mm<sup>2</sup> in all internal doors above the floor finish. This is equivalent to 10 mm for a standard 760 mm width door. This should be achieved by making an undercut of 10 mm above the floor finish if the floor finish is fitted, or by a 20 mm undercut above the floorboards, or other surface, if the finish has not been fitted.”

### ADF 2010, System 3

<b>Site 1</b>	No. Door undercuts were inconsistent. Approximately 20% of internal doors had door undercuts of <10mm in all the dwellings inspected.
<b>Site 2</b>	No. Door undercuts were inconsistent. Many were <10mm in the dwellings visited.
<b>Site 3</b>	No. Door undercuts were inconsistent. The Site Manager was unaware of the requirement for door undercuts. Approximately 35% were <10mm in the dwelling tested.
<b>Site 4</b>	No. Door undercuts were inconsistent. The majority were <10mm in all dwellings visited.
<b>Site 5</b>	No. Door undercuts were inconsistent. The majority were <10mm in all dwellings visited.
<b>Site 6</b>	No. Door undercuts were inconsistent. The majority were <10mm in all dwellings visited.



Site 1 – Example of sufficient door undercut: 15-20mm between carpeted and non-carpeted floor finishes – to allow 10 mm above carpet finish for undercut



Site 1 – Example of inadequate door undercut

## 7. Were ventilation systems commissioned in accordance with the Domestic Ventilation Compliance Guide (DVCG)?

<p><b>Site 1</b></p>	<p>No. Despite commissioning certificates being provided, there was no evidence of full commissioning of air flow rates to meet ADF minimum values in normal or boost setting. i.e. the Site Manager had not seen any checking of air flow rates taking place. The electrical contractor advised that the fan speeds were set ‘audibly’ (based on judgement of acceptable sound levels) and no air flow rate measurements were taken. The installation company carrying out the commissioning had just one commissioner to cover the whole of the region.</p>
<p><b>Site 2</b></p>	<p>Partially. Interviews suggested that full testing and balancing had not been done in every unit and that the commissioning was done by a person who had been informally trained. Commissioning certificates were only available for some units, but of those available, the air flow rates in boost mode matched the design flow rates exactly, which is unusual. Issues with the commissioning were perhaps the reason why gaps in the room terminal valves were found to be too small. These were set between 1 and 2mm, meaning that the fan duty was much greater than required, for both normal and boost speeds. This error was repeated in every dwelling inspected. The consequence was that the systems were noisier than intended. Releasing the valves to increase the air velocity would allow the fans to run at much lower speeds.</p>
<p><b>Site 3</b></p>	<p>No. There was no evidence that full commissioning was routinely performed. The interview with the Site Manager suggested that commissioning was carried out by the electrical contractor, but only if specifically asked by the Building Control Body. This meant there were less than a handful of commissioning certificates available for a large number of units. It was stated that customers (home buyers) are shown how to set up the fans themselves and to alter them to suit their needs. The customers are given a copy of the ventilation manufacturers handbook to assist. The site team were not aware it is a requirement of ADF to follow a specific commissioning procedure.</p>
<p><b>Site 4</b></p>	<p>No. The installation and commissioning company were the same as for Site 3, hence neither the installer nor the on-site team were aware of the ADF requirement for commissioning. There was no evidence that full commissioning was routinely performed. Commissioning was carried out by the electrical contractor, but only if asked by the Building Control Body. The customer (home owner) was provided with the ventilation system manual and shown how to set the fans themselves.</p>

<b>Site 5</b>	No. There was no evidence that full commissioning was routinely performed. Commissioning was carried out by the electrical contractor, but only if asked by the Building Control Body. The home owner was provided with the ventilation system manual and shown how to set the fans up themselves. No commissioning certificates were provided. All fans are set to manufacturer's default setting when installed.
<b>Site 6</b>	No. Commissioning certificates were only available for some of the units inspected, but of those available, the air flow rates in boost mode matched the design flow rates exactly, which is unusual. Where centralised MEV systems were installed, the fan speed was factory set and could not be adjusted for on-site commissioning purposes. Commissioning was only possible via room terminal valve adjustments.

*Measurements of air flow rates being made by a member of the Hub team using a powered automatic compensating volume flow meter*



## ? 8. Were controls in place and labelled?

Overall, ventilation controls were simple, with boost speed being triggered with either the light switches (in bathrooms) or a separate switch (typically just for kitchens). However, labelling was an issue.

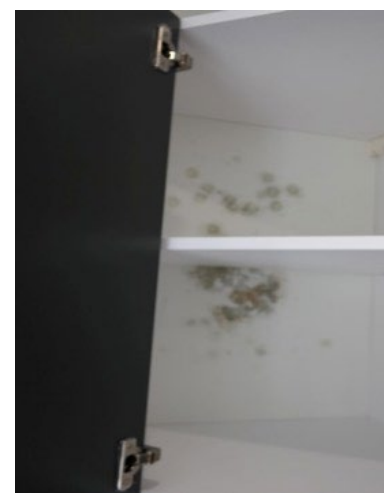
<b>Site 1</b>	No. Fan controls were not labelled apart from the isolator switch.
<b>Site 2</b>	No. Fan controls were not labelled apart from the isolator switch.
<b>Site 3</b>	No. Fan controls were not labelled apart from the isolator switch.
<b>Site 4</b>	No. Fan boost switches were unmarked.
<b>Site 5</b>	No real controls evident. Fan boost switches, where fitted, were unmarked. Some fans had no boost mode at all as they had been incorrectly wired to the light switch.
<b>Site 6</b>	Yes. Fan boost switches were labelled.



*Site 4 – Example of multi-gang switch. One of these is to boost the fan, but there is no labelling to tell the user which one*

## 9. Was a handover process carried out and the ventilation system delivered to the occupant in a good state?

<p><b>Site 1</b></p>	<p>Partially. The handover procedure was very good. There was a full explanation of the ventilation system, controls and trickle vents with a checklist provided for the Site Agent to work through. However, the external ventilation grilles in 40% of dwellings were not cleaned out properly before handover (they contained mortar and debris). The occupier we were able to interview thought the fans were too noisy and chose to turn the system off completely at the isolator switch. The issue was caused by the fan coming on at night due to the humidistat control kicking in.</p>
<p><b>Site 2</b></p>	<p>No. There was a good handover process to the buyers. However, the occupants interviewed did not know they had an MVHR system and were therefore unaware of the need to change the filters. The suspected reason for this was that all apartments were buy-to-let properties. The handover procedure was carried out with the home owner, but not with the renter. Consequently, they had not been informed of the type of ventilation system or the need to maintain it. The filters in the MVHR units had not been changed/cleaned upon handover. The MVHR system was quiet in normal mode and was only noticeable when on boost. The noise was likely down to room air terminal valves being set too tight (see above).</p>
<p><b>Site 3</b></p>	<p>No. The sales team confirmed that homeowners complained of noisy fans and all isolators were switched off. As with Site 1, it is thought the reason systems were switched off was due to humidistats causing the fans to come on late at night. Occupiers were shown how to 'commission' the fans to reduce noise levels. The Show Home also showed signs of mould and condensation in the under-stairs cupboard and kitchen top wall cupboards potentially as a result of under-ventilation due to trickle vents being closed and fans switched off.</p>
<p><b>Site 4</b></p>	<p>According to the sales team, no information was available as the site was not yet occupied.</p>
<p><b>Site 5</b></p>	<p>No. The occupant interviewed had switched off the system at the isolators due to noise.</p>
<p><b>Site 6</b></p>	<p>Yes. The handover procedure was very good. There was a full explanation of the ventilation system carried out as part of the handover procedure. No issues were raised by occupants.</p>



*Mould in a cupboard in the Show Home at Site 3 – Example of the risk of under-ventilation, including during building drying-out phase. Sales staff had closed all the trickle ventilators and switched off fans*

# Overview

	Process	Design	SAP Assessment	Installation	Trickle vents	Door undercuts	Commissioning	Controls	Handover/operation
Site 1	😊	😞	😊	😊	😞	😞	😞	😞	😊
Site 2	😊	😊	😞	😊	😊	😊	😊	😞	😞
Site 3	😊	😊	😊	😞	😞	😞	😞	😞	😞
Site 4	😊	😊	😊	😊	😊	😞	😞	😞	—
Site 5	😞	😊	😊	😞	😞	😞	😞	😞	😞
Site 6	😊	😊	😊	😞	😊	😞	😞	😊	😊



# 06. FINDINGS FROM TESTING IN SAMPLE UNITS

This section presents the results of the measurements taken by the Zero Carbon Hub's project team during the site visits.

## Tests carried out on site

### Air flow rates

Ventilation system air flow rates were measured using the unconditional method (Method A) as described in the BSRIA Guide: Domestic Ventilation Systems BG46/2015. This method is unconditional as it is not influenced by site variables, such as fan type, airflow direction and other characteristics. The instrument used for this method is a powered volume flow meter (Observer DIFF) which eliminates back pressure and turbulent flow characteristics when used to measure a fan or room terminal valve. The test used is similar to the industry standard used for ADF compliance, but more accurate than the typical conditional method (Method B).

### Air exchange measurements

Air exchange measurements were carried out in a test dwelling in all 5 dwellings with MEV. This test is useful for understanding the performance of a ventilation system in a dwelling. The method chosen was a short-term concentration decay measurement in accordance with ISO 12569: 2000 (E), Determination of air change in buildings - Tracer gas dilution method.

This type of test measures the physical air exchange that takes place in a given volume. Air exchange is influenced by the ventilation system, in this case the continuous fans and the background ventilators. The level of infiltration will also play a role in the air exchange rate, as will temperature differentials, exposure and external conditions, e.g. wind. Measurements for air exchange were taken with the fans set to normal speed, and background ventilators were open in all habitable rooms (note if e.g. a bathroom was fitted with a background ventilator, this was closed for the test).

For each test, five air samples were taken to measure the concentration decay of tracer gas (ISO 12569: 2000 (E) requires a minimum of two samples). The accuracy of the tests performed had a quality of regression ( $r^2$ ) of 0.985 to 0.999, which suggests good quality tests were performed. Whilst this test method gives an accurate measure of the air exchange, it is a 'snap shot' test which captures conditions only during the period of the test, e.g. results may differ on, e.g. windy vs still days. Longer term measurements to obtain an average exchange of air, e.g. over a 7-14-day period were not practical. This short-term test is suitable for continuous mechanical ventilation where air exchange rates are likely to be more constant. Longer-term measurements would be more appropriate in naturally-ventilated buildings.

## Sites using MEV (System 3)

In most of the test sites (Sites 1, 3, 4 and 5) the installations were decentralised continuous MEV (dMEV), i.e. individual fans installed in wet rooms. The system in Site 6 was centralised in the apartments (i.e. wet rooms ducted to a central fan unit) but decentralised in the houses. NB: Original air flow commissioning test data was not available for review for any MEV installation at any of these sites.

The first set of results relate to extract flow rate measurements. Chart 1a shows the measurements for the whole-house ventilation rate, i.e. the sum of the individual fan flow rates in normal speed setting. According to ADF, the minimum whole-dwelling extract ventilation should be at least 0.3 l/s per m<sup>2</sup> of internal floor area (or greater depending upon number of bedrooms or occupants as described in Table 5.1b ADF). With the exception to Site 1, design extract flow rates were not available for this review, and therefore the baseline design values in the chart reflect the minimum requirement of 0.3 l/s per m<sup>2</sup>. The review of the design information for Site 1 confirmed that the designed extract flow rates met the minimum air flow guidance given in ADF.



Chart 1a – MEV Measurements – Normal Setting

As chart 1a illustrates, none of the measured extract flow rates in any of the 5 dwellings met the minimum ADF values. The percentage of duty required is shown in the chart (light green stacks). Site 6 only delivered 35% of the required duty, whereas the best site, Site 3, delivered just half (50%) of the required duty.

Some of the reasons for under-commissioning are discussed earlier, but in summary it became apparent that, in most cases, installations were considered too noisy to set to the correct air flow settings, particularly the dMEV systems with a room-side continuously operating fan.

Chart 1b (over the page) shows the extract flow rate measurements for the sum of the extract ventilation high rates, i.e. the sum of the individual room fan flow rates in boost speed setting.

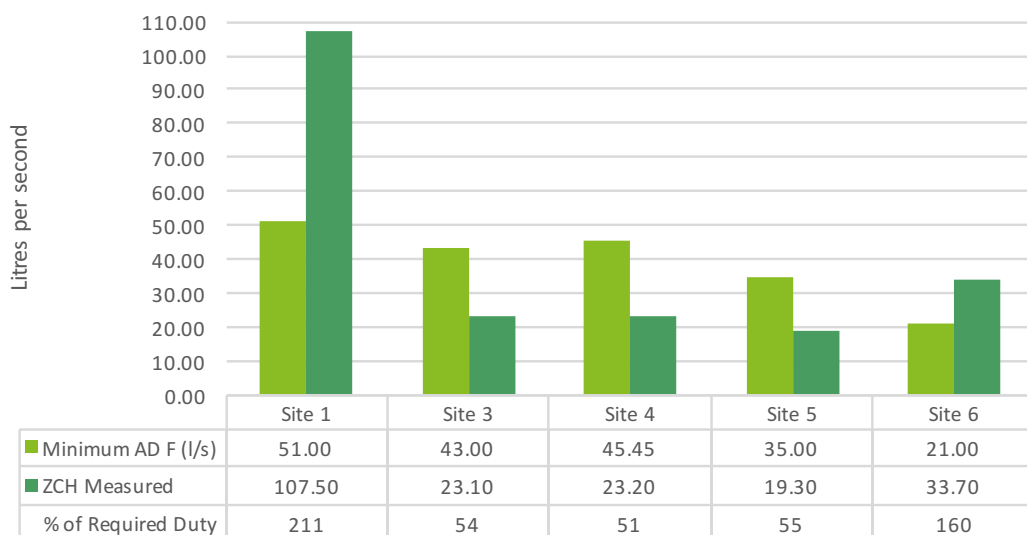


Chart 1b – MEV  
Measurements – Boost  
Setting

Chart 1b gives the minimum whole-dwelling extract flow according to table 5.1a (ADF). The minimum high extract rates for each room should be:

Room	Minimum High Rate (l/s)
Kitchen	13
Bathroom	8
Utility room	8
Sanitary (e.g. W.C. no bath/shower)	6

For example a dwelling with a bathroom and kitchen would be  $8 + 13 \text{ l/s} = 21 \text{ l/s}$  minimum high rate.

Again, design data was only available for Site 1. The review of the design confirmed that the extract flow rates above were used to reach the 51 l/s required for that dwelling.

The measured flow rates suggest that only Site 6 had been commissioned to achieve the minimum high rate specification, albeit over-ventilating fairly significantly (fan duty was 60% higher than necessary).

Site 1 is the only other site that met the minimum high rate specification. However, it was apparent in this dwelling that the installer had set the fans to maximum speed in boost, hence the fan duty is more than double, for which there would be an energy (and noise) penalty. Sites 3 to 5 were only delivering just over half of their duty, and there was little difference between the air flow in normal and boost fan flow rates.

## Background Ventilators

MEV installations induce a small negative pressure inside a dwelling. Air inlets are therefore required to provide fresh air into the dwelling. According to ADF, a provision of 2500 mm<sup>2</sup> is required per habitable room (excluding wet rooms) if the design air permeability of the dwelling is <5.0 m<sup>3</sup>/(h.m<sup>2</sup>) @ 50Pa.

Chart 1c presents the findings relating to background ventilators across the 5 MEV sites in the study.

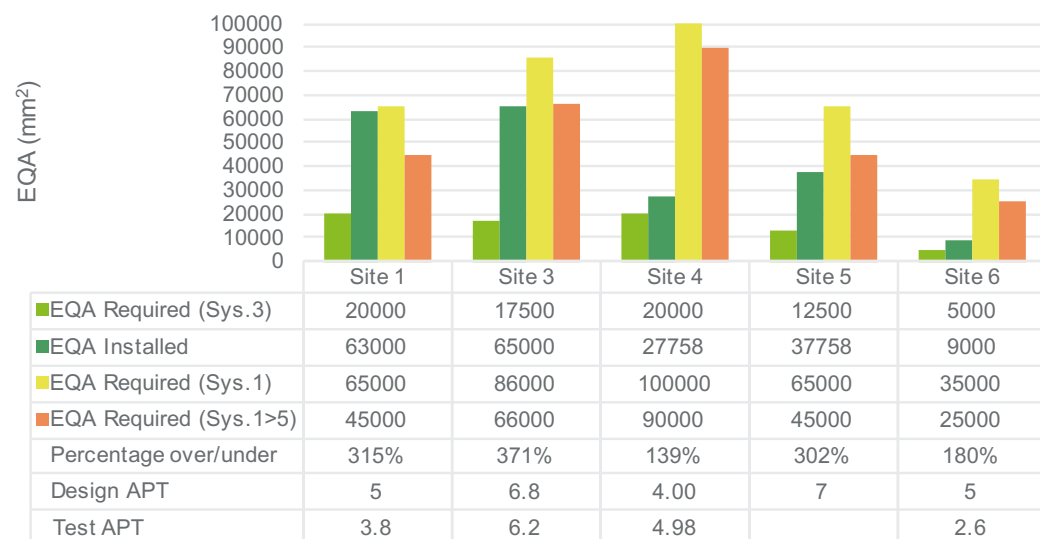


Chart 1c – Background Ventilator Equivalent Areas

The light green stack shows the background ventilator Equivalent Area (EQA) required in each property, based upon the 2500 mm<sup>2</sup> requirement published in ADF. The darker green stack, adjacent, shows the total EQA installed in each dwelling.

Sites 3 and 5 are the only sites that, strictly, do not require background ventilators to meet ADF as they have a design airtightness >5.0 m<sup>3</sup>/(h.m<sup>2</sup>) @ 50Pa (“Design APT”), although it is considered good practice to do so. Airtightness results from sites 1, 3 and 4 were provided by the developer. Test data was not available for the dwelling on Site 5. The Hub team conducted the air permeability test on Site 6.

Site 4 is the only site in our sample that matched, most closely, the correct EQA requirement using correctly sized ventilators, each with an EQA of 2500mm<sup>2</sup>. The slight overshoot relates to roof windows, which are typically supplied with ventilators by default. Site 6 is the next closest, and has the correct amount of ventilators. However, the size of the ventilators used for this site had a larger EQA (4000mm<sup>2</sup>) which is more in line with the size of ventilators required for naturally ventilated homes (e.g. Systems 1 and 2 in ADF).

**Sites 1, 3 and 5 were provided with significantly more background area EQA than required by ADF.**

Chart 1c additionally shows the EQA required (yellow and orange stacks) for these dwellings had they employed System 1 or 2 as their ventilation strategy, i.e. naturally ventilated dwellings. For natural ventilation, there are two different total EQA requirements in ADF, with a greater EQA provision required for more airtight dwellings (<math>5.0 \text{ m}^3/(\text{h}\cdot\text{m}^2)</math> @ 50Pa indicated by the yellow stacks). It can be seen that the total EQA provided in Sites 1, 3 and 5 is more closely aligned with the larger background ventilator requirements for naturally ventilated dwellings. Thus, it is possible that those responsible for window procurement (which would include background ventilators) may not be aware of the continuous mechanical ventilation strategy.

## Air Exchange Measurements

Chart 1d presents the results for the air exchange measurements, shown by the light green stack. Although there is no direct comparison with ADF, the minimum volumetric air exchange can be calculated from the 0.3 l/s per  $\text{m}^2$  requirement and the volume of the dwelling. The calculated 'required ach<sup>-1</sup>' is indicated in the chart for reference (dark green stack).

As can be seen, despite the low performance of the fans demonstrated above, the measured air exchange rate is slightly better than the minimum required in all but Site 5 – this being the most sheltered of the sites, with the lowest wind speed on the day of measurement. Site 4, which had broadly the correct amount of ventilators, had a better than expected air exchange rate, but was also the most exposed (coastal/hilly) of all dwellings tested.

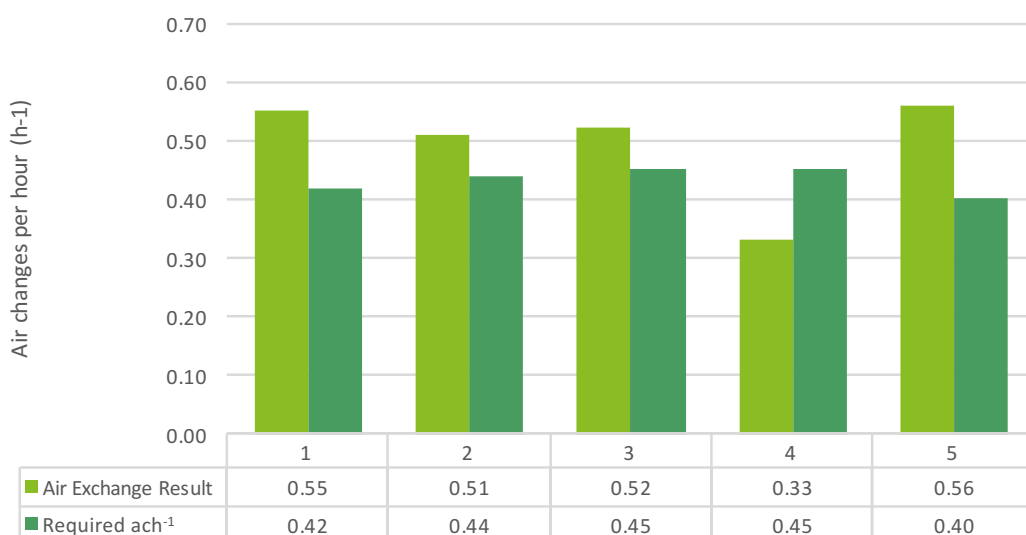


Chart 1d – MEV Air Flow and Air Exchange Measurements

## Mechanical Ventilation with Heat Recovery (MVHR)

This section presents the results from the development (Site 2) that used continuous mechanical ventilation with heat recovery (MVHR) as their chosen ventilation strategy (System 4 as defined in ADF).

As above, the results reported relate to measurements taken by the field team during the respective site visit. Original air flow commissioning data was available only for some of the units visited.

Chart 2a shows the measurements for the whole-house ventilation rates, i.e. the sum of the individual fan flow rates in normal speed setting. As with MEV, ADF specifies that the minimum whole-dwelling extract ventilation should be at least 0.3 l/s per m<sup>2</sup> of internal floor area (or greater depending upon number of bedrooms or occupants as described in Table 5.1b ADF).

Four MVHR-ventilated flats were reviewed, all within one development. The measurements taken during the field visits (dark green stacks) show that the measured air flow rates are less than the minimum recommended by ADF, with the exception of the supply air for flat S2D.

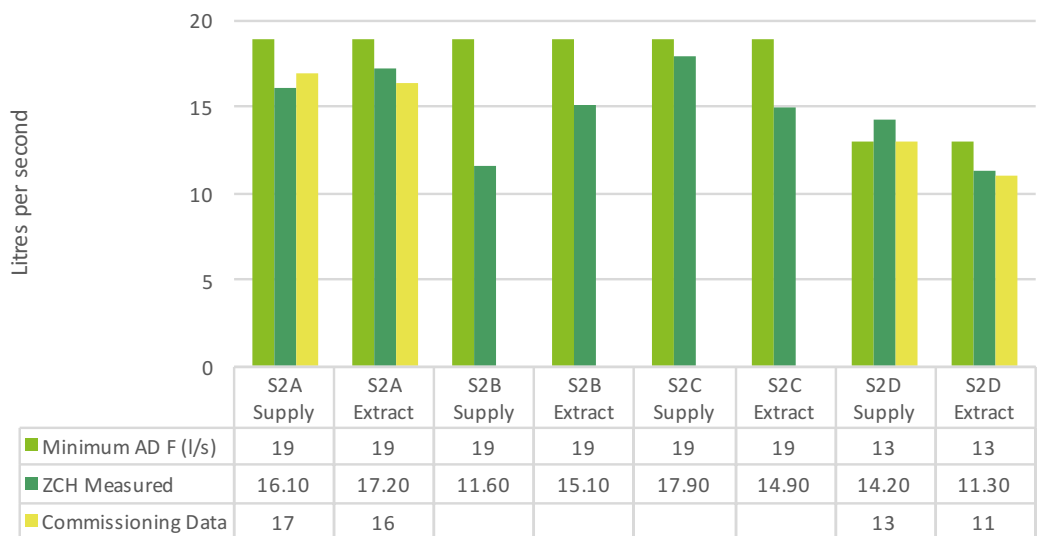


Chart 2a – MVHR Measurements – Normal Setting

Commissioning values were only available for flats S2A and S2D, which showed a correlation with the values observed during the field visit. However, the commissioning data shows that the systems had been set to operate slightly below the minimum ADF requirement.

Visual inspection of each of the systems revealed an uncharacteristic finding in that all of the room air terminals were closed too tightly, with an air gap of between approximately 1-2mm around the valve opening, as the photo over the page indicates.



Site 2 – Example of room extract air terminal with inadequate air gap setting, leading to higher flow resistance and localised air velocity noise

The consequence of this tight setting is that, to achieve the air flow rate values, the fan speeds for both supply and extract needed to be set to higher speeds to overcome this resistance, thus the systems will be using more electrical energy than is necessary. The high fan speeds will likely cause noise nuisance.

### Flow Rate Measurements (boost speed)

Chart 2b shows the measurements for the sum of the supply and extract ventilation high rates, i.e. the sum of the individual room air flow rates in boost speed setting. Extract rates in boost are the same as for MEV (see the table on page 25). Supply air flow rates should be balanced to match the extract air flow rates, although this is not specified in ADF.

The issue of the inadequate air gap setting on the room terminal valves is exacerbated with the increase in fan speed from normal to boost setting. In each flat, the fan settings for the MVHR in boost were set to near maximum capacity (45 l/s), whereas Chart 2b indicates the highest whole-dwelling flow rate (minimum ADF) in boost to be 29 l/s. However, the air flow rates measured by the project team range from as low as 14 l/s to 27.4 l/s, with none of the systems meeting the minimum ADF specification. It was also observed that the sound levels from the systems increased.

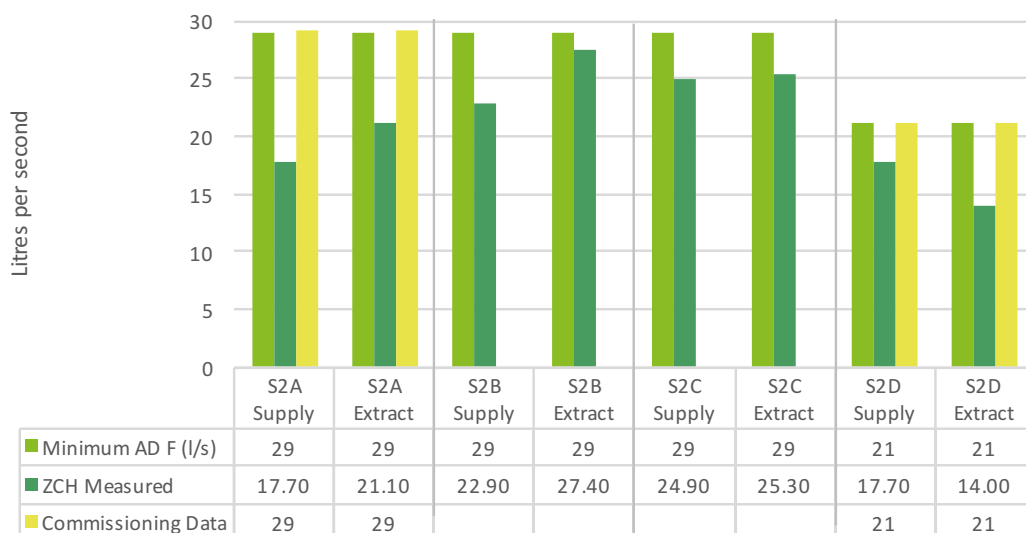


Chart 2b – MVHR Measurements – Boost Setting

From the commissioning data received (flats S2A and S2D), it was noted that the air flow rates matched exactly the design data. The site visit measurements were made within four weeks of the original commissioning process.

## System balance

For the heat recovery component of an MVHR system to operate efficiently, it is important that the dwelling is reasonably airtight, ideally  $<3.0 \text{ m}^3/(\text{h.m}^2) @ 50\text{Pa}$ . Airtightness test data was made available only for flat S2A at the time of the site visit, which achieved  $3.8 \text{ m}^3/(\text{h.m}^2) @ 50\text{Pa}$ , slightly above the ideal of  $<3.0 \text{ m}^3/(\text{h.m}^2) @ 50\text{Pa}$ , but within the SAP target of  $5.0 \text{ m}^3/(\text{h.m}^2) @ 50\text{Pa}$ .

It is also important that the ventilation air for the dwelling exchanges through the ventilation system, thus the sum of the intake air should equal the sum of the exhaust air for the system to be in balance. Intake and exhaust air measurements were not practicable during the site visit. However, the sum of the supply and extract air rates to/from the individual rooms gives a good indication of system balance. Achieving a system balance of  $<10\%$  during commissioning is considered best practice, but up to  $15\%$  is acceptable.

The table shows the balance deviation between the four systems at each available fan speed.

	S2A	S2B	S2C	S2D
Balance deviation (normal) %	6.61	26.2	18.3	22.8
Balance deviation (boost) %	17.5	17.9	1.59	23.3

None of the systems were found to be satisfactorily balanced for both speed settings. It is of greatest importance that the normal speed setting, which is the most dominant, achieves reasonable balance. Only flat S2A achieves a balance of  $<10\%$  in normal speed, although boost is not well balanced for the same system ( $17.5\%$ ). The balance achieved for boost setting is good only in flat S2C ( $1.6\%$ ).



## Air exchange measurements

An air exchange measurement was carried out in one flat on the MVHR development (S2A). The results are shown in Chart 2c, along with the MVHR design (light green stack) and measurement data (dark green stack) which has been converted into air exchange rates for comparison. The orange stack indicates the calculated minimum air change rate, based upon the requirement of 0.3 l/s per m<sup>2</sup> in ADF. The air exchange measurement was performed with the system in normal speed setting.



Chart 2c: Site 2 Plot A: MVHR Air Flow and Air Exchange Measurements

As illustrated, the minimum air exchange rate (0.34 ach<sup>-1</sup>) is met by the MVHR system. However, a further 0.19 ach<sup>-1</sup> was measured, giving a total measured value of 0.53 ach<sup>-1</sup>. The additional air exchange is likely due to the air leakage of the flat (3.8 m<sup>3</sup>/(h.m<sup>2</sup>) @ 50Pa) and the effect of wind on the ventilation system. The flat subject to this test was on the fourth storey and on a coastal location. Thus wind (approx. 1 m.s<sup>-1</sup> during the test) and exposure will influence the total air exchange rate.

## 07. CONCLUSIONS AND RECOMMENDATIONS

In summary, the Hub team found things going wrong at multiple stages of the construction process at every site. The cumulative effect of these issues ultimately outweighed any good practice, as the systems we tested showed significant under-performance. At 5 of the 6 sites, fans were operating at only half the required duty or lower, i.e. flow rates were far too low.

The end result was that nearly all of the 13 occupants interviewed by the team across the sites had turned off their ventilation systems, finding them too noisy, especially at night. If systems are turned off, they are not doing their job. The air quality in the property will be compromised, with potentially serious consequences for the health of occupants.

It is essential that ventilation systems are designed, installed, commissioned and handed over to occupants in accordance with Building Regulations. Our findings show that despite the availability of good practice guidance and training minimum ventilation rates in the units reviewed were not achieved in practice.

### Processes

1. None of the 6 sites visited achieved delivery of ventilation systems in accordance with minimum standards. For example, one of the sites had excellent ducting design and installation, but was let down by poor commissioning. Even when ducting design and installation was broadly in line with guidance, small errors were still made, culminating in problems down the line once the units were occupied, such as noisy fans.
2. Designs and drawings, where available, were in line with ADF ventilation rate requirements, but a lack of detailed specification reduced the chance of these being met in practice. For example, failing to state whether rigid or flexible ducting should be used resulted in installers, in some cases, improvising on site (with no consultation back to the designer). One site missed off the ducting layout in their drawings for one unit altogether, meaning the sub-contracted installer decided to address the mistake as he saw fit, with the result that flexible ducting was installed. This flexible ducting installed was too long and sagged. The other units on site had rigid ducting.
3. On some occasions the designs and drawings asked for something which the site team concluded was not practically deliverable, again leading to improvisation and the use of flexible ducting where rigid had been specified. Another common issue was that drawings underestimated the duct run lengths needed, for example, due to beam or Soil Vent Pipe positions missing from the design drawings. This meant ducting had to be diverted.

4. Although it was evident that installers were attempting to be faithful to designs at most of the sites, the mismatch between the design and the reality of the site meant long duct runs and the use of flexible ducting, which was sometimes not pulled taut, meant the performance of the system was compromised. Some of the flexible ducting measured by the Hub team was well in excess of 5 metres. One site had a flexible duct run of 12 metres.
5. Issues resulting from long, sagging duct and use of room side fans in decentralised MEV systems became obvious when occupiers were interviewed. In most instances they had found systems to be noisy (particularly in boost mode) and had turned them off at 4 of the 5 MEV sites inspected. The occupants at Site 6 were unconcerned by the noise levels.
6. At Site 2 the occupants interviewed were not aware they had an MVHR system at all, which is good in the sense that the system must have been running without obvious noise issues, but may mean the systems would not be maintained over time, leading to performance issues. This was largely due to handover information on the ventilation systems not trickling down to tenants.

## System performance

7. The delivery and process problems found on site resulted in all fans in the 5 MEV sites under-performing significantly when on a normal setting. All fans were operating at half the duty required or lower.
8. In boost mode, only 2 of the 5 sites with MEV had flow rates which met or exceeded the required levels. One of these sites exceeded the design levels so dramatically (due to fans being set at maximum) there would be an energy consumption penalty.
9. However, despite the low performance of the fans, the measured air exchange levels themselves, in all but one of the 5 MEV sites, were better than design air exchange levels calculated by the Hub team. Site 5 fell short of the required standard, but this was one of the most sheltered of the sites, with the lowest wind speed on the day of measurement.

10. The reason for the adequate air exchange rates in the majority of the MEV sites in practice, was almost certainly down to the over provision of background ventilation through trickle vents. The Equivalent Area provided was often much higher than the DVCG advises.
11. One of the reasons for the “mismatch” between fan performance and background ventilation provision, suggested by the installers interviewed, is project teams assuming dMEV system should be delivered in a similar manner to System 1 (background ventilation and intermittent fans). Put another way, the over provision of background ventilation (through trickle vents) appears to be consistent with what would be delivered alongside intermittent extract fans – an accidental hybrid system. This suggests the need to strengthen training on the difference between these two systems and the consequences of deviating from the design for compliance.
12. In the units with MVHR (at Site 2) the measurements taken during the site visits show that the design air flow rates in normal mode were mostly met, with the supply air to flat S2B being the only one to fall short. However, in boost mode, the flow rates for the supply and extract in all units fell considerably short of the design levels. However, like the MEV systems, the actual air exchange rates measured achieved or out-performed the design intention, potentially due to natural air flow through ducts.

## Standards and guidance

13. The commissioning process was, on the whole, weak. The problems found were different at each site. Examples of issue were:
  - A lack of awareness of the need to test and check the performance of the system
  - Checking of systems being done “by ear” using noise levels as the guide to performance, not flow rates
  - Commissioning being done by people who were not officially trained (because there is no requirement to have done such training) and certificates being generated off site
  - On two sites, the fan setup was left to the homeowner, with no official commissioning

## Project teams should ensure

- Systems are designed, installed and commissioned in accordance with ADF and the DVCG
- Any changes found to be necessary on site should be referred back to the designer to check the design still complies with legal requirements and/or the design intention
- SAP assessments should be updated to reflect the reality of what is delivered on site
- Installers working with dMEV systems should be trained on the specific regulatory requirements e.g. the amount of background ventilation needed being different to intermittent extract systems
- When designers specify rigid ducting, checks are made to ensure it will be practically deliverable on site
- Duct run lengths specified in drawings are practically deliverable on site
- If flexible ducting is used, installers know and recognise the importance of it being pulled taut and run lengths kept as short as possible
- Commissioning is done in accordance with approved procedures and by fully trained and competent people
- Handover materials are made available for future occupants as well as the initial occupants or buyers

## Example of how a developer (and their supply chain) is changing internal processes following the site visit

Feedback for Site 1 was carried out with 40 Site Managers and design team members. The ventilation system manufacturer was also present.

The developer has reviewed all the issues highlighted and has changed their procedures to make sure the issues do not continue to happen. For example, more consultation with the designer (manufacturer) has been put into the process.

Site Managers are now aware of the issues found and the implications of not installing the systems correctly. The manufacturer is also aware of the changes that were made on site, due to lack of detail in drawings. For example, a portico missing on the elevation drawings meant a fan outlet needed to be moved.

## What next?

Given the potential risks to the health of occupants in new dwellings if mechanical ventilation systems do not deliver minimum ventilation rates, all possible avenues for ensuring that minimum standards and good practice is routinely achieved should be fully explored and concerted action taken by government and industry.

In 2013 the NHBC Foundation and Zero Carbon Hub Indoor Air Quality Task Group made the following recommendation:

**“Competence within the industry remains a key issue, with the Task Group’s concerns being heightened by overwhelming evidence that good practice is not being adhered to, in respect of design, installation and commissioning.**

Organisations such as Beama point to the many hundreds of installers who have now been trained through the BPEC scheme, regrettably the competency schemes have made little progress.

Members of the MVHR Task Group called on DCLG to consider mandatory competency requirements for new build ventilation systems to drive uptake and standards.”

Progress has been made since the publication of that report. For example, since January 2014, NHBC standards have included a chapter on MVHR systems (Chapter 3.2). The NICEIC Competent Persons Scheme is also now up and running with a new training programme.

However, the findings from this project show there continues to be an urgent and continued need to solve the delivery and process-related issues leading to the under-performance of mechanical ventilation systems. Technical guidance and voluntary certification schemes alone can only take us so far.

**It is essential that ventilation systems work well within a quality building design and reliably deliver the minimum ventilation rates required by Building Regulations.**

Our interviews with installers, Site Managers and SAP assessors suggest three key reasons for issues continuing to occur, and therefore three strategic responses:

## 1. Inertia

On a number of sites it was evident that installers were “doing what they’d always done”. This manifested as continuous MEV systems being treated like intermittent systems, and improvisation on site if issues were found with designs. Such practices are more likely to have performance consequences now that ventilation technologies have moved on. Precision and attention to detail is needed when installing and commissioning cutting-edge technology in carefully engineered new dwellings.

### Recommended action

<b>Industry</b>	Developers should make sure they only use suitably trained and qualified people to deliver their ventilation systems.
<b>Government</b>	Unlike gas fitters, designers, installers and commissioners of mechanical ventilation systems are not required by law to be trained. Although there are Competent Person Schemes available, anecdotal evidence suggests voluntary membership of ventilation-specific schemes is low. Designers, installers and commissioners should only be allowed to operate if they meet minimum competency standards. Building Control Officers also need to become more familiar with the range of ventilation systems and their importance so they know what issues to look out for. However, relying solely on Building Control for quality assurance (where a Competent Persons Scheme is not used) means that if problems are found, it may be too late to do anything meaningful about them.

## 2. Fragmented delivery

Communication up and down the delivery chain is always vital, but particularly between the architect, the Mechanical and Electrical (M&E) designer, and the installer. Any changes being made on site, such as to duct run lengths, duct type, positioning of inlets and terminals, positioning of controls, or substitution of products, must be checked with the design team as it could affect the overall performance of the system, possibly to the extent that the system would fail compliance checks.

### Recommended action

#### Industry

Project teams should agree at the beginning of the project how communication on changes to the ventilation system between the design team and the team on-site will take place. Other areas of responsibility should also be agreed at the outset, such as who will have responsibility for the maintenance and performance of the system once the property is in use.

#### Government

ADF and the Domestic Ventilation Compliance Guide (DVCG) should be updated to more strongly emphasise the importance of agreeing workable communication processes, roles and responsibilities at the outset of projects, in addition to the technical guidance already provided.



### 3. Inadequate enforcement

At present, if a ventilation system fails to meet the standards in ADF in reality, it is unlikely this outcome would be discovered in any systematic way. Developers and their suppliers are, in effect, trusted to meet Building Regulations. In-depth checks of ventilation systems do not appear to happen routinely. Secondly, even if a problem is discovered once the system is in use, it is unclear how this situation would be resolved, and who would be pushing for resolution. For example, in addition to minimum ventilation rates not being achieved in practice, the Hub team found examples of commissioning testing procedures and checks not being properly carried out and commissioning sheets not being scrutinised with no come back.

Robust inspections, enforcement and sanctions for non-compliance are necessary as, with the exception of noisy systems, many occupants are unlikely to be able tell if their systems are not working properly. Policy and legal frameworks need to protect occupants and be tough enough to incentivise the delivery chain to take seriously the need to get it right.

#### Recommended action

<b>Industry</b>	Developers should ensure appropriate ventilation system-specific quality checks are being made by their teams at each major stage of the construction process. Including visual inspections by the Site Manager or equivalent.
<b>Government</b>	Despite mechanical ventilation installations being “notifiable” work, the framework relies too heavily on trust. The inspection, enforcement and sanctions regime needs to be reviewed, strengthened, and adequately resourced.

In conclusion, consumers are acutely aware of the consequences of something going wrong with their boiler or with their electrical wiring, for example. The effects can be fatal.

It is time to borrow thinking used to improve issues with gas and electrical safety and apply similarly stringent frameworks in the ventilation sector. Failing ventilation systems may be less noticeably and immediately dangerous, but the effects over time are certainly not benign.

## 08. NOTES

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NOTE: This Guide is not a legal document and does not form part of a Building Regulations approved specification. It is for information and good practice purposes only. Consult your Building Control Officer for details on approved specification's and policy.

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