BAILY
GARNER

Damp and Mould

A Practical Toolkit for Diagnosis and Treatment

Issue 1: 14 November 2023

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FOREWORDS

I am a Chartered Building Surveyor, who has worked with existing residential stock for most of my career.

I have encountered damp and mould on plenty of occasions and dealt with it…. but have I?

The uncomfortable truth is that tragic events relating to housing tend to be the prompt to elicit change in the construction industry and the housing sector. These events affect all of the “cast” from landlords and their advisors, to manufacturers, contractors and the residents themselves.

Which is why, with the help of likeminded people, organisations and institutions, we have produced this toolkit, which not only covers the proper diagnosis of damp, but practical guidance to the application of a long term, value focused resolution.

At the centre of this toolkit is a step-by-step flow chart, taking the user through a process which puts building pathology at its core and it is, without doubt, the most sound basis I have seen to address the issue.

As professionals, it is our collective responsibility to ensure we keep abreast of the latest legislation and thinking, no matter the role we play, which is why we have made the toolkit fully available on our website, in the hope that it will positively impact people’s lives.

You may be familiar with previous Baily Garner toolkits relating to The Future Homes Standards and Retrofitting Existing Stock – both have been well received, particularly the referencing of various archetypes which resonates with the reader, and this toolkit is no different.

Finally, I would like to thank Professor Mike Parrett for sharing his experience, insight and training that he has given our technical staff – which would have been really useful at the start of my career!

Andy Tookey
FRICS, APMP

Managing Partner

BAILY GARNER

I have long since talked about the intangibility of dampness detection by even the most highly trained surveyor using the usual site reconnaissance skills of sight, touch and smell, together with the sole reliance on an electrical moisture meter.

The concept of tangible detection of the source and cause of dampness beyond the mere identification of the symptoms, requires a more pathological and holistic approach using a range of different techniques and equipment as a deliberate process of eliminating what is not the cause, until you are left with what is the cause.

Working in the field of Building Pathology and building failure detection for over 45 years has enabled me to build up a catalogue of inherent defects to buildings over different genres from ancient to modern and to hone the skills required for accurate detection, some of which is reflected in this guidance.

There has arisen over many past decades a growing reliance on commercially driven diagnoses of dampness and mould in buildings with many within the built environment professions, along with homeowners and Landlords alike, relying on so-called long-term damp guarantees that seem to guarantee the products and not the original diagnosis!

The recent tragic death of young toddler Awaab Ishak has highlighted that, at best, damp and mould diagnosis is misdiagnosed and at worst, completely misunderstood. I welcome Awaab's Law which will be embedded into the new Social Housing (Regulation) Bill 2023 and hope that this Toolkit will play a part.

My pioneering work in this field has long since called for a National Assessment Methodology (NAM), that draws parallels to general medical practice, which serves to substantially reduce the reliance on commercially driven diagnoses, by improving the understanding and processes involved in pinpointing cause(s) and source(s) beyond the mere identification and treatment of the symptoms.

This requires a more deliberate pathological procedure to be followed, and is a paradigm shift in professional practice that achieves much more reliable and tangible diagnosis. It is these processes that we have laid out in this Toolkit.

I have often been quoted as saying that there is nothing more sustainable in the maintenance of buildings than correct diagnosis which improves the quality of people's lives in the home.

According to the Office for National Statistics, there are still over 6 million hazards in UK Homes - It is time to get Pathological!

Professor Mike Parrett
CSci FRICS FCIOB FCABE FIMMM

Consultant

MICHAEL PARRETT ASSOCIATES

INTRODUCTION

In the United Kingdom our homes have always been designed and built to cope with the British climate and to suit a lifestyle that existed at the time of their construction. Whilst this was fine in the past, modern lifestyles and the performance required from buildings means that many homes have been adapted, improved and their occupation patterns have changed.

As a society we now face problems associated with damp and mould growth in some of our housing stock that can cause significant risks to the health and welfare of those that occupy them.

This has been an emerging issue for some time but recent tragic events, including occupant deaths, have brought this issue to much wider attention. As a result, and following louder resident voices, legal proceedings, ombudsman reports and forthcoming changes in legislation, there is an acceptance by Landlords in the Housing Sector of the need to act in relation to damp and mould growth in our housing stock.

Landlords in the Social Housing and Private Sector face multiple challenges and calls on their financial resources. Seen holistically, the problems of damp and mould growth now sit at an intersection of different challenges faced by Landlords in meeting their obligations to provide warm, safe and comfortable homes for a diverse group of residents, whilst achieving their **Net Zero** ambitions and increasing the overall stock of social housing.

Baily Garner's purpose statement is **"making a positive impact on people's lives"** and in providing a Toolkit to assist in resolving damp and mould growth problems in residents' homes, we certainly believe we are contributing to our purpose.

Our previous New Build and Retrofit Toolkits were well received by the Housing Sector. They provided sound practical explanations of the key issues, outlined the challenges and offered a template of how issues might be best addressed. Our aim, with this Damp and Mould Growth Toolkit, is to provide simple guidance and approaches to resolve issues for those dealing with damp and mould growth problems.

We have not produced the Toolkit in isolation but in liaison with the Government, Local Authorities, Housing Associations, Contractors, the Supply Chain and Industry Specialists, many of whom are credited in the Toolkit. In particular, we have worked with Professor Michael Parrett, a subject matter expert, technical author and member of Royal Institution of Chartered Surveyors working groups on Damp and Mould Growth in Buildings.

The Toolkit is essentially presented in three parts:

Part 1 - Overview - provides readers with an introduction into damp and mould growth and provides an explanation of:

- the basic physics,
- the current and likely legislative position,
- data science,
- ventilation and
- air quality.

Crucially we address the "mammoth in the room" of occupant behaviour where there are multiple and sensitive aspects to this complex area which make every case unique.

Part 2 - Process map: Assessment methodology - is at the heart of the Toolkit and presented in the form of a damp and mould growth diagnosis flow chart. It is the shared desire of ourselves and our fellow contributors that this may lay the foundations for the development of a **National Assessment Methodology**. At its core, the flow chart advocates a forensic and pathological approach to assessing and reporting on damp and mould growth that will benefit residents and landlords alike. This should allow a better use of limited resources and a holistic implementation of measures to support other key issues such as reducing fuel poverty, reduction of risks to resident health and lower carbon emissions.

Part 3 - Actions - considers the issues outlined in Part 1, as well as the proposed forensic and pathological approach to be adopted within Part 2, and aims to advise how organisations might address damp and mould issues within their own housing stock. In particular, Part 3 references a library of archetype/build forms and suggests how:

- Previous interventions may have affected property performance and made problems worse
- Inadequate ventilation performance may be addressed
- Properties may move towards more 'occupation blind' performance
- Thermal upgrades to properties may be undertaken over longer periods of time
- Monitoring of performance and data will inform strategy and culture

Appendices within the Toolkit include a glossary of terms used within the Toolkit, a library of archetypes, information on surveyors, examples of an approach to costs and equipment and case studies on damp and mould growth related projects.

Readers can navigate around the Toolkit between sections using arrows as indicated, read glossary terminology by clicking on words and use hyperlinks that will take the reader to key external documentation referenced in the text.

Finally, this Toolkit is published as an "open source" document and we hope that feedback received will allow us to update and improve it over time for the benefit of all readers. In this context, we would welcome feedback to any of the Toolkit authors identified on the rear cover of the Toolkit.

1. WHAT IS DAMP AND MOULD?

Damp

There are many interpretations of what damp is in the context of a building, and how to go about defining it. This has resulted in many property owners undertaking inappropriate remedial works following misdiagnosis. The extent of damp and mould growth across the UK's housing stock has been estimated to affect one in five properties which is around 5 million homes. Any form of damp is the presence of excess moisture that should not be there. In order to determine if the material of a building element is damp, it's important to distinguish what the normal **dry (hygroscopic) state** is for that material.

The commonly known forms of damp in buildings are **Rising Damp**, **Penetrating Damp, Traumatic Damp** and **Condensation**.

Rising Damp

Rising Damp is the movement of ground moisture through a material via **capillary suction**. The rate at which capillary suction can occur depends on the porosity of that material (i.e. the volume of empty space within its structure). The greater its porosity, the greater the rate of capillary suction.

The main factors that make a building susceptible to Rising Damp include the building age i.e., pre-1875, general building defects, building design & construction, raised external abutting ground levels, physically blocked cavity wall voids, potable water and service pipe leaks, defective drainage and rainwater goods and ground conditions as well as the porosity of the building materials.

Within the industry, rising damp is often diagnosed as the result of a failure of the building's **damp proof course (DPC)**. In reality, the failure of a damp proof course is extremely rare and this misdiagnosis often results in the inappropriate and costly installation of a retrofit damp proof course which does not rectify the issue.

The diagnosis process should employ a holistic review and a process of elimination of all potential contributory causes and sources of low-level damp in walls. Remember that not all of the damp present in the walls has resulted from a failure in the wall itself.

Rising Damp is often diagnosed where there is a low level 'tide line' on the ground floor caused by the evaporation of moisture containing hygroscopic salts, naturally present in many building materials.

Figure 1 - Rising Damp

Figure 2 - Rising Damp

Penetrating Damp

Penetrating Damp is the isolated occurrence of lateral movement of moisture through the building fabric, though localised or more widespread moisture movement. Damp will also spread in all directions in most porous building materials e.g. masonry, and can also result in rising damp. Common causes of Penetrating Damp include a bridged Damp Proof Course (DPC) due to raised ground levels since original construction, cavity bridging, internal escapes of water, defective rainwater goods and/or flashings. Also exposure to wind driven rain can cause penetrating damp and reference should be made to Building Regulations Part C and BRE Paper 262.

Traumatic Damp

Traumatic damp can be caused by leaking water from waste and heating pipes, overflowing baths or sinks, burst pipes or defective water storage vessels inside the building. Traumatic damp can also originate from outside the property, for example from another building or from environmental flooding.

Water Vapour Generation

Water vapour is generated by people, pets, plants, and appliances (e.g., liquid fuel heaters, Tumbler dryers etc) in our homes and by the evaporation and movement of excess moisture from building fabric through design, construction and/or defects. How we live in our homes will have a profound impact on the amount of moisture we generate, and therefore the amount of water vapour in the air. The below image illustrates the typical moisture generation in the home.

It should be noted, penetrating and rising damp both contribute to condensation in the building, however, it is extremely rare to find effects of condensation generated by use and occupation of a building resulting in penetrating or rising damp deep into masonry walls beyond the internal plaster or cementitious render.

A typical family of four can produce around twenty four pints of moisture per day. Taking into consideration modern day contributing factors such as a shift towards more home-based working, overcrowding and fuel poverty, the reality is that this quantity is likely to be higher than illustrated in many homes.

Two people active for one day	🧴🧴🧴	3 pints
Cooking and boiling a kettle	🧴🧴🧴🧴🧴🧴	6 pints
Having a bath or shower	🧴🧴	2 pints
Washing clothes	🧴	1 pint
Drying clothes	🧴🧴🧴🧴🧴🧴🧴🧴🧴	9 pints
Using a paraffin or bottled gas heater	🧴🧴🧴	3 pints
Total amount of moisture produced in your home in one day		**24 pints**

Figure 3 - Moisture production

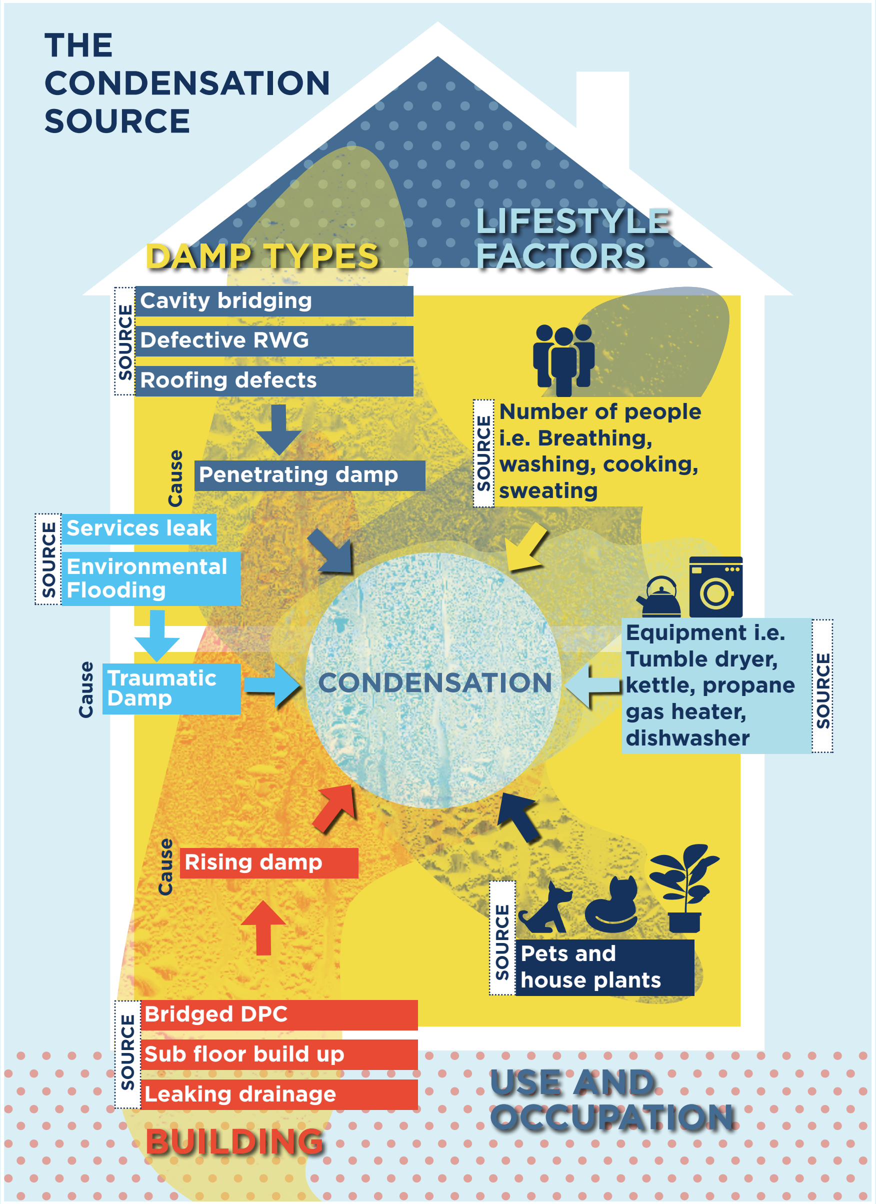

Figure 4 - the condensation source

Condensation and Dew Point

Condensation forms as the result of water vapour in the air cooling and transforming into a liquid state.

The **dew point** is the critical point at which this process occurs as this is where the air loses its capacity to retain water vapour.

This often occurs when water vapour in the air comes into contact with a cooler substrate. When the temperature of that substrate is lower than the dew point, condense will begin to form on its surface.

We see it on a cold glass of water on a hot day, a mirror in a shower and on cold windows in winter as seen in Figures 5 and 6 below.

Although less visible, this process also takes place on the surface of walls and ceilings within our homes and can result in the propagation of mould growth as illustrated in Figure 7.

The dew point is influenced by two main factors:

1. **The amount of water vapour in the air**
2. **Air temperature**

From the recording of the internal air temperature and the amount of moisture in the air expressed as either relative or **absolute humidity**, the dew point temperature can be calculated (historically based on both **wet and dry bulb temperatures**).

It is then essential that surface temperatures are taken to determine whether the surface temperatures fall below the calculated Dew point temperature of the air at any given time and temperature.

As the internal air temperature rises, the air's ability to hold moisture increases. Conversely, when the internal air temperature falls, its ability to retain moisture decreases, resulting in an increase risk of condensation.

It is therefore essential to control indoor environments to prevent the water vapour content of the air rising above 70% **relative humidity**. Where relative humidity meets or exceeds 70% for sustained periods, the risk of condensation and subsequent mould growth forming on cooler surfaces will increase.

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Figure 5 - Condensation on glazing

Figure 6 - Condensation on glazing

Figure 7 - Pattern mould growth on cooler surface

Relative Humidity

The amount of water vapour in the air is known as Relative Humidity and is expressed as a percentage (%) of the total amount of moisture which can be held at any given temperature.

As illustrated in figure 9, relative humidity will fluctuate depending on the ambient room temperature, irrespective of whether the water vapour content remains the same.

This is due to the fact that warmer air can hold more water vapour than colder air. The optimum relative humidity for an internal household environment is in the region of RH 45-60%.

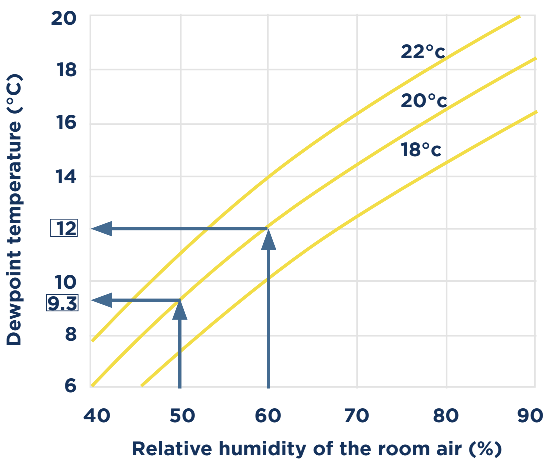


Figure 8 - Relative humidity and dew point graph

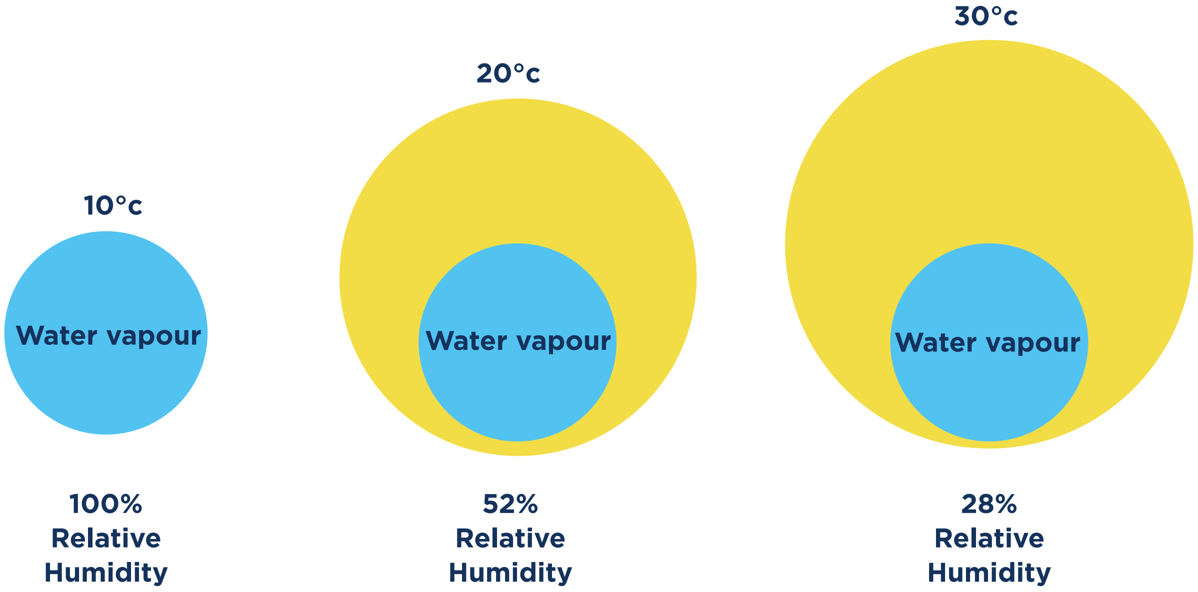


Figure 9 - Fluctuation of relative humidity

Mould growth

The presence of mould growth is an indicator that excess moisture is present. This is because mould requires moisture to germinate. Mould is a type of fungus that germinates and grows in damp and humid environments and can assume many different characteristics dependant on species and severity, though it often develops as 'black spot' moulds in the context of condensation in buildings. It should be noted, some mould types can release extremely harmful mycotoxins, and others do not. Moulds produce spores to allow continued reproduction and these are responsible for most health problems associated with damp and mould growth in buildings, such as respiratory infections, asthma etc. The spores produced are allergens meaning they can result in allergic reactions with varying severity depending on the person affected and age or health conditions that may make them susceptible.

2. WHY AND HOW DO WE MEASURE DAMP?

In this toolkit, the word 'intangible' is used to describe something that exists but cannot be measured. For example, a musty smell or a wall that feels damp to touch. Conversely, the word 'tangible' is used to describe something that exists beyond doubt, because it has been proven to exist by measurement. For example, using an electrical resistance meter to measure the moisture content in a timber skirting.

To conclusively diagnose **intangible damp** and **tangible damp**, and mould growth relating to damp, it must be measured. There are several surveying tools that can be used to carry out this measurement and these tools quantify information which would otherwise be 'intangible', or open to interpretation.

It is important to note that measuring damp should not be carried out in isolation. It must be measured holistically with multiple factors considered and not with a single reading from a single piece of equipment. In measuring damp, the aim is to conclusively eliminate what isn't causing the damp to leave behind what is. Through measurement, we are able to move from intangible to a tangible determination of the cause and source:

Building Regulations Part F describes performance criteria in relation to mould which is in relation to a calculated value of **Surface water activity**.

How do we physically measure it?

How we measure it starts with **non-intrusive** methods and may move to **intrusive** methods if we haven't been able to eliminate all possibilities.

In appointing a surveyor to carry out damp and mould inspections, the scope of the appointment and their ability to go through this process of elimination is immediately reduced if the appointment is based on non-intrusive methods only, therefore, it is best not to limit the scope if a conclusive outcome is required. A surveyor should use both non-intrusive and intrusive methods and a range of tools and equipment. A full understanding of these tools, their correct application, limitations, interpretation of readings and understanding of potential incorrect readings is required.

A schedule of the surveying tools and these factors is included at **appendix 4** but the following summarises the key tools.

Hygrometer (with inbuilt air temperature thermometer and surface temperature thermistor) - Is used to measure water vapour in grams per kilogram of air (absolute humidity) which can be translated to relative humidity % of the air. Hygrometers can also measure air temperature and surface temperature. These measurements determine the dew point using the Psychrometric chart, which is important because it can demonstrate at what point condensation will form and where. The hygrometer has in-built capabilities to calculate all of this.

Figure 10 - Hygrometer

Electrical resistance meter – The electrical resistance meter (often misconstrued as a damp meter or known by its former trade name of 'protimeter') is calibrated to accurately measure % of dampness (or dryness) in timber (wood moisture equivalent - WME). Some meters can provide readings for other materials using a pre-set measuring range but these are for guidance only to show the changes in moisture level.

However, there is no certainty that the % readings are accurate. This is due to the possibility that other conductive materials may be present and therefore the instrument could record a high reading beyond the level at which timber would decay (~22%). In this scenario, it may be incorrectly assumed that the high reading is the result of excess moisture in the substrate and therefore also assumed that the high reading is the result of dampness. However, if a dry reading is obtained, there is more certainty that the material is dry, because there is nothing present in the material, i.e. conductive material or dampness, to trigger a high reading.

The same meter can often be used to measure electrical capacitance which can be used as a proxy for moisture content.

Figure 11 - Electrical resistance meter

Thermographic camera – This can create an image using infrared radiation to produce an image that looks similar to a standard image but with a selected colour pallet. Each pixel in the image represents a temperature and can be analysed. It can be used to identify loss of heat and temperature differences in building elements and air leakage. It can also show the presence of water/moisture in structures due to greater heat transfer.

Borescope – Is an illuminated optical instrument which can be used to view and record still images and videos of inaccessible spaces such as cavities within walls and sub floor voids etc. A rigid or flexible extension to an eyepiece allows on site viewing. A small hole will often be drilled to allow access for the borescope.

Vane anemometer – Is a handheld instrument that can be used on an extractor fan. This will determine and measure the extraction rate of the fan to determine whether the required rates of air extraction (expressed as litres per second - l/s) are being met, when compared to official guidance i.e., Part F of the current building regulations et al.

Floor hygrometer – Is an impermeable humidity box, capable of being sealed to a solid floor to entrap a pocket of air immediately above the floor. A temperature and humidity hygrometer probe is then inserted and connected to a data capture device to regularly record (at pre-set intervals) the moisture content of the entrapped air within the humidity box. Monitoring ordinarily happens over a seven day period and to achieve a state of acceptable dryness, the pocket of air should not exhibit higher than 75% relative humidity +/- 5% in accordance with BS 8203.

Speedy carbide meter (Calcium carbide test) – A speedy carbide test is used to measure moisture content in a sample of masonry. This is an intrusive method of testing which involves taking a sample from the wall and testing that sample on site.

This toolkit has purposefully excluded the testing for the presence of chloride/nitrite and sulphate salts as these tests are no longer recognised in BRE Digest 245. The gravimetric method remains a reliable and tangible means of testing for the presence of moisture, especially in masonry walls. However, most diagnosis of the presence of excess dampness in masonry walls can be undertaken using the calcium carbide method to record the total found moisture content. This can then be compared with the acceptable hygroscopic moisture content (dry state).

Interpreting the readings

A full understanding of the tools, their correct application and analysing the combined readings from them is required to gain a holistic picture of the property being measured. The limitations and acceptable ranges of readings are shown in the table at appendix 4.

Figure 12 - Borescope inspection

3. WHAT ARE THE CURRENT AND PROPOSED LEGAL STANDARDS?

A letter issued to social landlords by The Secretary of State for Levelling Up, Housing and Communities in November 2022 and anticipated legislative changes undeniably point to a shared belief by Government alongside the Housing Ombudsmen that both regulation and landlord behaviours need to go further in protecting the health and wellbeing of those affected by damp and mould growth. This is further supported by the Government's recent publication of 'Understanding and addressing the health risks of damp and mould in the home'.

The Decent Homes Standard

Following its introduction, **The Decent Homes Standard (DHS)** was updated in 2006 to take into account the Housing **Health and Safety Rating System (HHSRS)** which stipulated that if a home is to be considered 'decent' it must:

1. Meet the current statutory minimum standard for housing
2. Be in a reasonable state of repair
3. Have reasonably modern facilities and services, and
4. Provide a reasonable degree of thermal comfort.

The DHS has come under close scrutiny since the tragic death of **Awaab Ishak** and according to the 2021-22 **English Housing Survey**, despite a notable decline in 'non-decent' homes since 2011, 3.4 million occupied dwellings still failed to meet the Decent Homes Standard. Somewhat surprisingly, the survey identifies the highest proportion of non-decent homes lie in the privately rented sector, solidifying the conclusion in the '**A Fairer Private Rented Sector**' white paper published in June 2022 that a legally binding Decent Homes Standard should also be implemented for the private rental sector.

The **Social Housing White Paper** published in December 2022 maintains that the Decent Homes Standard does not 'reflect present day concerns', a view shared by the **Prevention of Future Deaths** report published by the coroner Ms Kearsley. This identified five primary concerns, one of which is the Decent Homes Standards' inability to consider damp and mould growth and to provide guidance on ventilation in homes. The **Levelling up White Paper** published in February 2022 committed to halving the number of non-decent homes by 2030. Although this timeline is anticipated to accelerate with the renewed industry focus concerning Damp and mould growth and the purported failings of the standard to drive change.

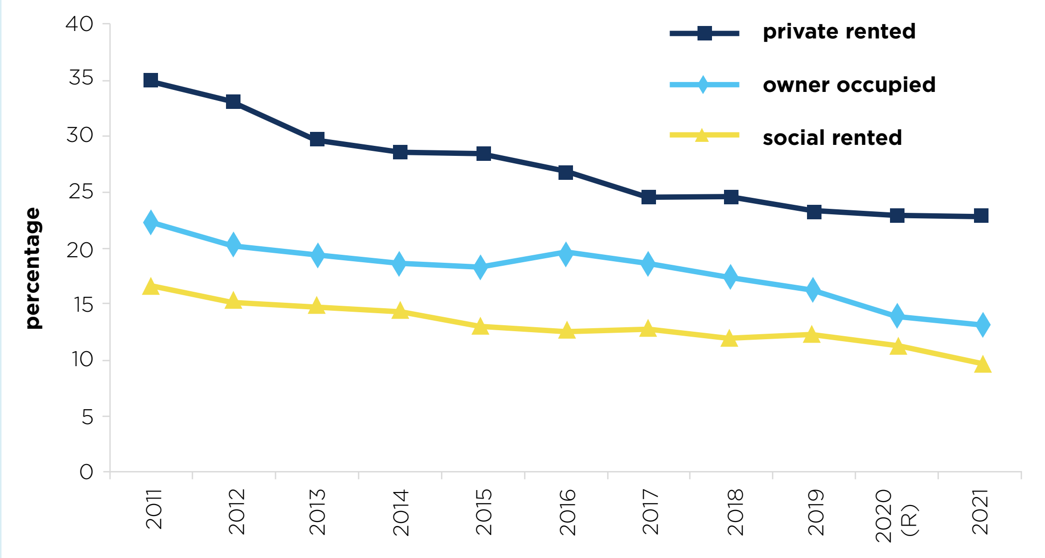


Figure 13 - Non-decent homes by tenure, 2011-2021

The Housing Act 2004

This act states that properties must be free from hazards at the most dangerous 'category 1' level as assessed using the Housing Health and Safety rating system. This includes mould and all types of damp.

The Environmental Protection Act 1990

The Environmental Protection Act 1990 applies where a tenant's home is suffering from a 'statutory nuisance'. The Act sets out circumstances which might give rise to a statutory nuisance, including: "… any premises in such a state as to be prejudicial to health or a nuisance". Damp, condensation or mould growth are examples of defects in premises which are considered prejudicial to health.

Private and housing association tenants can request an inspection by a local authority environmental health officer (EHO). Where a statutory nuisance is identified, the EHO must serve an abatement notice requiring the nuisance to be addressed.

Tenants have the option of pursuing a private prosecution for statutory nuisance in a magistrate's court under section 82 of the 1990 Act.

The Landlord and Tenant Act (LTA) 1985

Under Section 11(1)(a) of the LTA, landlords have an obligation to 'keep in repair the structure and exterior of the dwelling-house' and by virtue of this, are responsible for damp and mould growth resulting from structural failure and more generally, poor maintenance of the external fabric of a building. Given that this obligation doesn't relate specifically to damp nor maintaining the internal environment i.e. ventilation, it's arguable that it doesn't provide tenants with much recourse, particularly when dealing with condensation which is inherently an internal issue and not necessarily impacted by the structure or exterior of the building. Undeniably, landlords should have an equivalent obligation to ensure that the provisions within their control, i.e. mechanical ventilation are provided to the standard dictated by **Building Regulations Part F** – see below.

The Homes (Fitness for Human Habitation) Act 2018

The Homes (Fitness for Human Habitation) Act was introduced in 2018 to reinvigorate sections 9A and 10 of the LTA 1998 and placed obligations on both private and social landlords to ensure their properties are fit for human habitation at the beginning of their tenancy and throughout. The Act also sought to strengthen tenants means of recourse in circumstances where landlords are alleged to not be fulfilling their obligations under the Act. The issue remains however that the Act is ambiguous in respect of tenant behaviours and responsibility for dampness and mould growth if an issue is alleged to have been caused by a resident behaviour.

The Defective Premises Act 1972

Section 4 of the act relates to a Landlords duty of care. Usually linked to section 11 of the Landlord & Tenant Act 1985. If a landlord is found to be in breach of their repairing obligation, then almost certainly the Landlord would be found to be in breach of their duty of care towards their tenant.

Building Regulations

Approved Document F: Ventilation, provides the framework for complying with Building Regulations in regard to ventilation requirements to maintain indoor air quality. The standard clearly sets out the ventilation requirements for 'building work' as defined by the Building Act 1984 which is subject to Building Regulations Approval – 15 l/s for bathrooms and 30/60 l/s for kitchens dependant on whether an extractor hood has been fitted. The issue however is that Building Regulations often do not apply in the context of existing buildings and therefore despite the stringent guidance, have minimal impact in tackling damp and mould growth in existing homes.

Approved Document C - Site preparation and resistance to contaminants and moisture contains useful guidance on the exposure to wind driven rain (a possible contributor to penetrating damp) including an exposure map with levels of severity.

2021 Management of Moisture in Buildings - Code of practice

This CoP is a key reference point for any technical consideration of Damp and Mould growth in new build and existing homes. It introduces the concepts of 'as built in service' buildings and identifies routes to assess and mange moisture risk including the whole building approach first laid out in The BSI white paper in 2017.

PAS 2035

Publicly Available Specification (PAS) 2035 : 2023 'Retrofitting dwellings for improved energy efficiency – Specification and guidance' (here) provides an overarching framework for the retrofitting of homes and has been adopted by Government for publicly funded retrofit works. It's risk based approach seeks to achieve the correct **moisture balance** in a home through correctly applied **Energy Efficiency Measures (EEM's)** and ventilation strategies.

PAS 2035:2023

Retrofitting dwellings for improved energy efficiency – Specification and guidance

Department for Energy Security & Net Zero

bsi.

Figure 14 - PAS 2035:2023

Current Legislative and Regulatory Response

The Social Housing (Regulations) bill 2023 received Royal Assent in July 2023 and includes provisions to strengthen the role of the Social Housing Regulator and make Housing Ombudsman's recommendations mandatory. It also requires Landlords to control and manage data more effectively, to find and resolve problems proactively and to ensure social housing managers are suitably qualified.

In addition, this amendment will eventually include the introduction of '**Awaab's Law**', a legal change which will introduce mandated "strict new time limits" for landlords in taking the necessary remedial action to remove reported health hazards.

On 7th September 2023 the Government published it's response to the coroners report. The guidance **Understanding and addressing the health risks of damp and mould in the home** sets out the governments view of best practice in responding to reports of damp and mould growth from residents in the public and private sectors.

4. WHAT IS THE CURRENT POSITION ON DAMP AND MOULD GROWTH?

According to data published in the Building Research Establishment (BRE) ‘The Cost of Poor Housing’ 2021 briefing paper, the National Health Service (NHS) spends an estimated £1.4 billion annually on treating illnesses associated with occupants living in damp and mouldy environments.

Damp and mould growth have been justly forced into the spotlight in recent times following the tragic death of Awaab Ishak in December 2020 who sadly passed away as a result of a respiratory condition caused by ‘extensive mould’ in the one bedroom flat he shared with his parents.

Awaab’s death has prompted a number of critical evaluations of typical landlord behaviours towards damp and mould growth and the existing legislation to ensure those affected have a means of redress. Arguably the most prominent of these evaluations is the **Spotlight on Mould & Damp: It’s not lifestyle** report published by the Housing Ombudsmen in October 2021, which amongst many other issues, criticises a frequent ‘knee jerk’ reaction from landlords in assigning culpability for damp and mould to residents and their lifestyle habits, and calls for a need for regulatory and legislative reform to support those living in damp and mould-ridden environments.

Whilst there is undeniably a degree of truth and accuracy to this issue, it is equally undeniable that the lifestyles of occupants can have a profound effect on a buildings’ vulnerability to damp and mould growth, and behaviourally there is certainly a role for residents to play in the damp and mould equation.

However, as explored below, the prevalence of modern day contributing factors drastically inhibit an occupants ability to ensure their lifestyle is aligned with providing a healthy internal environment and landlords need to remain cognisant and accommodating of these.

Damp and mould growth and Resident Lifestyle – The Inconvenient Truth

Whilst a precise quantity cannot be determined, occupants can have a significant effect on moisture production in buildings. It is estimated that a family of four alone can produce up to twenty four pints of moisture in a single day.

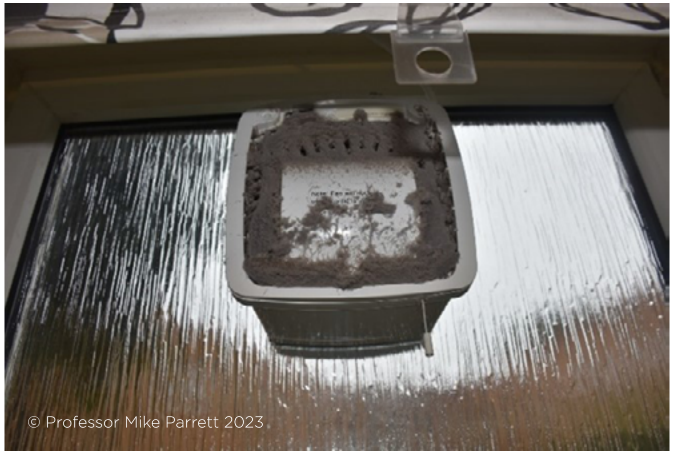

© Professor Mike Parrett 2023

Figure 15 - Blocked extract fan


© Professor Mike Parrett 2023

Figure 16 - Moisture Generation

Overcrowding

According to data provided by The English Housing Survey in 2021-22, 8% of social tenancies and 5% of private tenancies were overcrowded. However, given much overcrowding is unknown to landlords and certainly not broadcast by residents, the reality is that the prevalence of overcrowding across tenanted housing stock is likely to be significantly higher than suggested by both of these sources. Furthermore, with a constricted housing supply, overcrowding across the UK housing stock will undoubtedly increase further.

Looking comparatively at the moisture potential of a family of four in Figure 3 on page 8, this certainly provides a stark realisation of the impact that overcrowding can play in widespread damp and mould growth and the health risks associated.

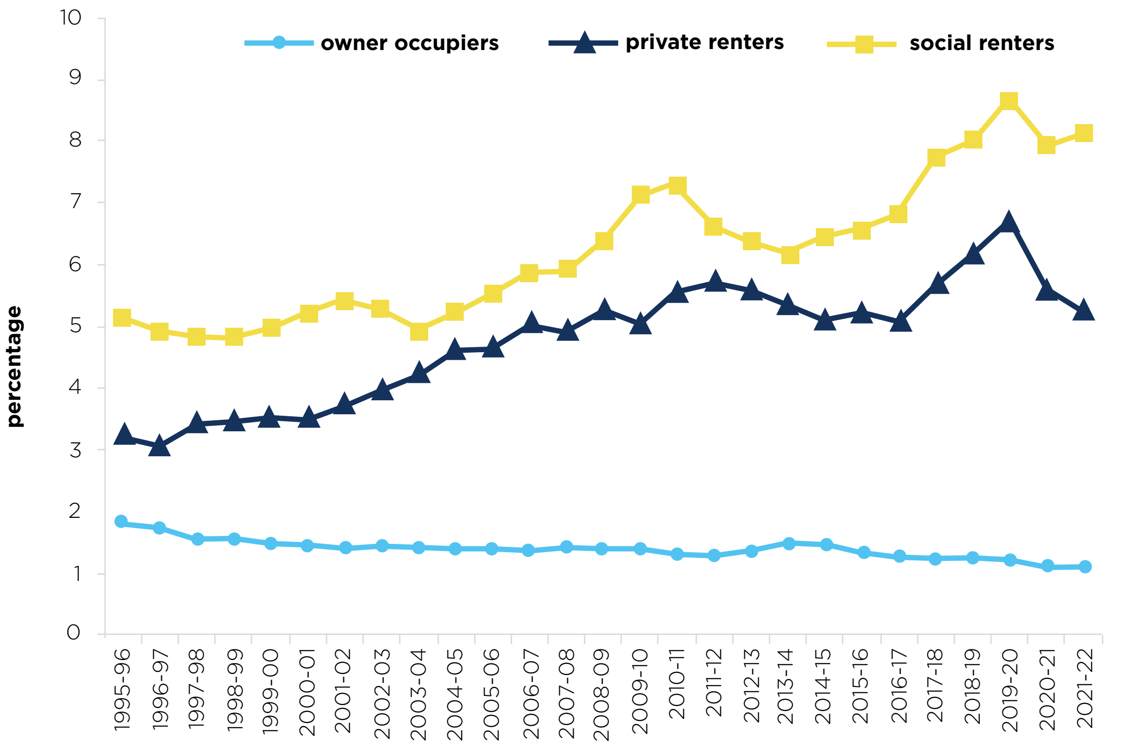


Figure 17 - Overcrowding, by tenure, 1995-96 to 2021-22

Fuel Poverty

One of the primary control mechanisms for mitigating dampness and resultant mould growth is heating. A sufficient and sustained ambient temperature will reduce the relative humidity and the likelihood of mould growth occurring. The issue however is that for many households simply turning on their heating for longer periods of time throughout the day is not affordable, especially considering the UK's 27 million homes constitute the oldest and most energy inefficient stock in Europe (See Figure 19).

As recommended by Public Health England, the ideal temperature range in a property is between 18-24 degrees Celsius to safeguard the health and wellbeing of residents. Smart Thermostat and data company **Switchee** have provided data for this toolkit which is examined further in the section on data though as evidenced in image (figure 18 below), the prevalence of properties with an average temperature of below 18 degrees Celsius is increasing rapidly.

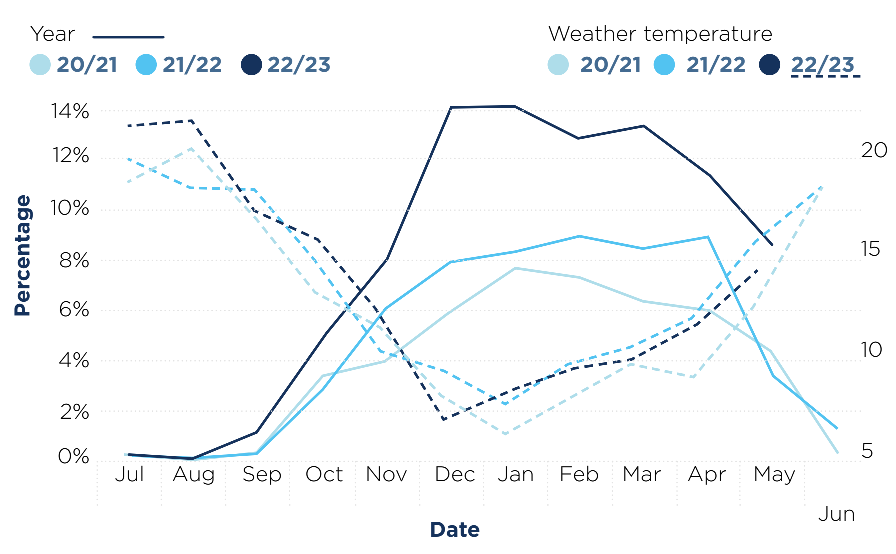
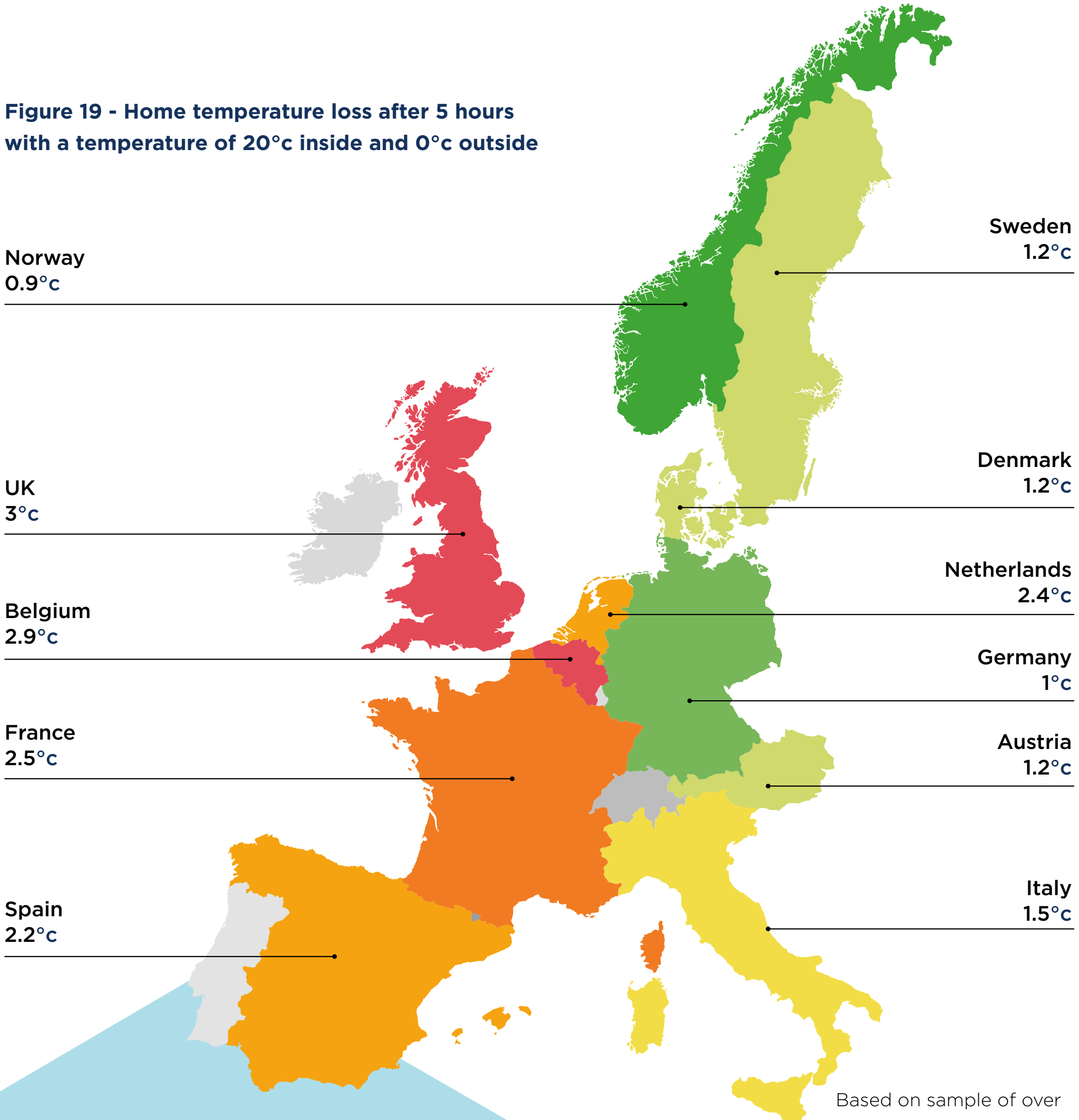


Figure 18 - % of properties with average temperature below 18°C

Figure 19 - Home temperature loss after 5 hours with a temperature of 20°c inside and 0°c outside



Tado.com

Based on sample of over 80,000 European homes

According to the **Annual Fuel Poverty Statistics Report 2022**, fuel poverty has been on a gradual decline since 2010 however, approximately 13.2% of all UK households were still estimated to be in fuel poverty. The situation has worsened since the Russian invasion of Ukraine in February 2022 due to significant volatility in the energy markets.

There continues to be significant risks of further fuel poverty and a reduced ability for residents to utilise their heating to combat the health risks associated with damp and mould growth. This is particularly challenging for those residents already living within thermally inefficient dwellings who are now having to pay inflated energy costs. This does raise the question as to whether rents should reflect the thermal efficiency of homes. This could encourage energy efficiency investment in housing stock and benefit residents in the long run.

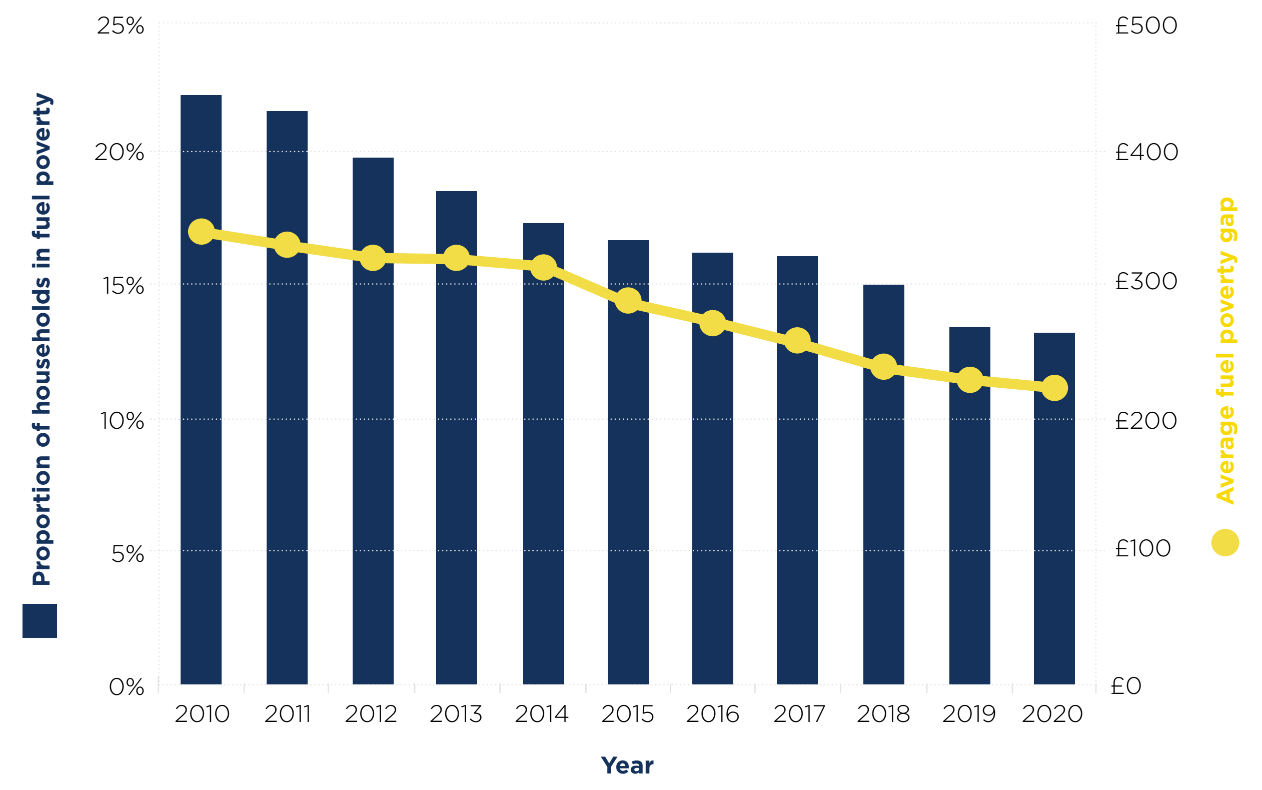


Figure 20 - Annual Fuel Poverty Statistics Report 2022

Changing Patterns of Occupation

Lastly, and unsurprisingly, the number of UK employees working from home has increased dramatically in the aftermath of the COVID-19 lockdown. Whilst recent data illustrates a continued rise in employees travelling back to the office for work, a hybrid approach to working is here to stay. With increased resident occupation during working hours, this will inevitably result in an increase to moisture production within the home and consequential risk of damp and mould growth.

5. THE ROLE OF DATA AND WHAT IS IT TELLING US?

Analytical and anecdotal data on property performance is becoming cheaper and easier to collect through lower cost data loggers or resident reporting interfaces linked to central databases. We can collect data in relation to indoor air temperature, humidity, CO2 concentrations (as a proxy for air quality) and surface temperatures. Data can be collected at one or multiple places in the home at different frequencies over different seasonal periods.

In simple terms data will tell us whether the **air quality** in a home is within an expected range and to some extent, whether the air quality reflects the expected performance of the home. Data and patterns of data may also tell us something about the use of the home.

Where does data come from?

Data related to damp and mould growth will come from a range of sources which are changing over time as technology and customer reporting develops. These can include:

Data collected from surveys and self reporting

High level data on whether '**Severe damp**' exists in homes is collected in the English Housing survey. Data also exists within the NHS and from health professionals in relation to reported health conditions by occupants of homes. Currently those collecting analytic data are seeking to link NHS and health data with analytical data collected via themselves.

Social landlords will also have some data reported by their residents through repairs, calls, property visits and complaints. Residents may now also report damp and mould growth following question prompts on **smart thermostats**.

Data gathered from occupied property monitoring

A fast developing area is smart monitoring devices that can either be permanently installed and alert landlords to readings outside of expected norms, or those that are temporarily installed to collect more granular data on specific properties. One such permanently installed device is the Switchee smart thermostat which are connected to the internet and have already collected over 8 billion data points in social housing. The data can give landlords insights to support residents including flagging up potential risks of damp and mould growth. Multiple temporary **data loggers** can be installed in specific properties to collect more granular data as was done with **Purrmetrix** as illustrated in our case study in **appendix 5.**

Data Gathered from Physical Surveys

The **damp and mould growth diagnosis flow chart** in this tool kit illustrates how a forensic approach to surveying can be used to gather readings and data on property condition, including similar data to that collected by monitoring such as temperature and humidity. In addition, data such as the moisture content of building elements and components can be collected. The tools used to collect such data and the approach that is used with the tools and equipment are described in **Section 2** and in **appendix 4.**

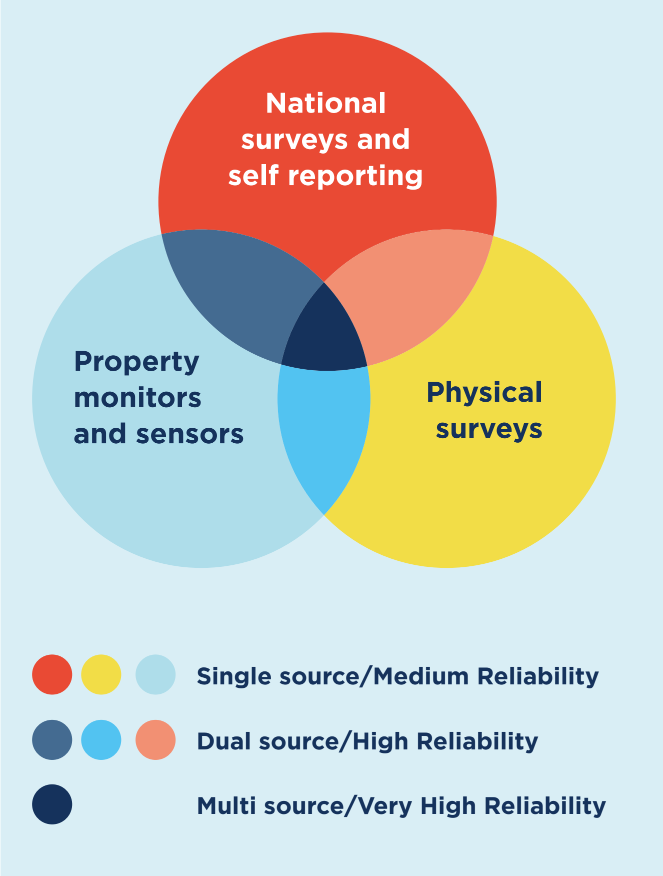


Figure 21 - Sources of Data on Damp and mould growth

Incorrect Data

Is data providing the Complete Picture? The outputs are only as good as the inputs and in some cases incorrect data will be used, data will be missed and there may be data overload from which it is difficult to extract the correct data.

As described in other sections on equipment, those collecting data may use equipment incorrectly and produce incorrect data. For example, damp meters are used on masonry when they are only calibrated for timber. The use of such equipment by those unqualified to use it will also increase the likelihood of incorrect readings.

Those inspecting properties may not use all the tools at their disposal or have an agnostic view of damp and mould growth causes as they are conflicted by their implied obligations to sell a specific remedial product or component treatment which may skew the reporting of data.

The energy performance of a property and the efficiency of its heating system are closely linked with risk of damp and mould growth forming within that property. **The Energy Performance Certificate (EPC)** which captures this information is often found to be either out of date, inaccurate or contain inaccurate assumptions.

Missing Data

Quite often data regarding temperature is linked to energy input from heating systems and sub-metering, but the granularity of energy use within properties is often missing.

Data can also be collected from a single point sensor within homes, but sometimes additional sensors to collect data for additional spaces may be required. Trends within groups of properties from central data collection can be useful, but it is important to understand whether additional data collection is required. The internal surface temperature of walls and floors etc is often not collected and is missing from data sets. This can be collected but it is often seen as impractical and costly over large numbers of properties.

Specifically, in relation to potential health impacts from mould growth, data on the type of spores originating from mould growth and other toxic compounds is not collected. This is a specific data set that is more relevant to very specific individual cases rather than macro data collection.

Too much data?

We are in the age of data and meta data (data about data) and need to be careful that data that is collected is actioned and managed correctly by the property owners. The general tendency is to collect as much data as possible but it is important to ensure that data does not overwhelm an organisation and those aspects of data that are most important are clearly understood by the organisation.

General data protection regulation (GDPR) issues.

GDPR is a specialist area which is outside the remit of this tool kit, however, landlords are considered to be data controllers and the organisations collecting and reporting on data are considered the data processors. The data processors are authorised by the data controller to collect and provide the information. In accordance with GDPR, individuals should not be identifiable from the data collected in relation to subject properties.

What Is data currently telling us?

One of the largest data sets currently available within the social housing sector comes from Switchee whose devices are installed in over twenty thousand properties. The data provided by Switchee in relation to damp and mould growth identifies some interesting trends in relation to damp and mould growth, under heating and correlation between property performance and EPC's.

Switchee is a platform of internet-connected devices in social housing, receiving over 8 billion data points per year, giving real-time actionable insights into property performance. The platform contains a dashboard with which landlords may identify properties at risk of damp and mould growth and take proactive actions. It also enables two way messaging between residents and landlords, including reporting condensation and mould growth.

We are grateful to Switchee for their contribution to this toolkit but obviously there are other providers.

In the graphs below, absolute and relative % changes are shown. The absolute change is the raw % number difference (e.g. absolute change between 50% and 75% is 25%). The relative change is the change in relation to the original value (e.g. relative change between 50% and 75% is 50%).

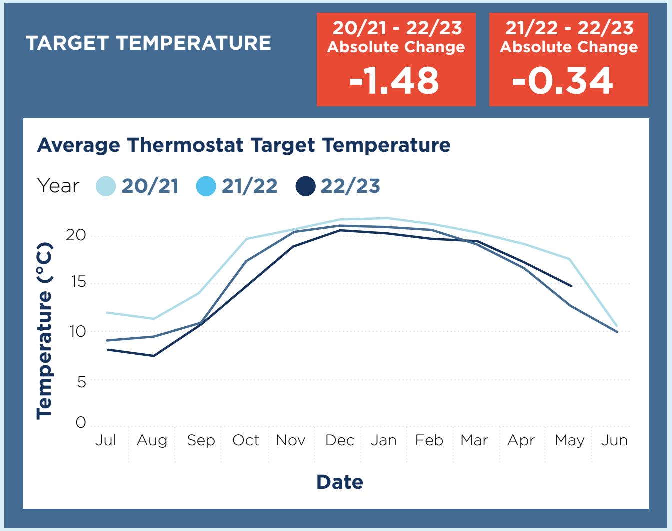


Figure 22 - Target temperature

The graph illustrates the average target thermostat temperature within properties over the last three years. As shown, target temperatures have been gradually in decline over this period, further evidencing the effects of energy affordability. Noting that Public Health England recommends a minimum temperature of 18 degrees Celsius, this provides a stark realisation that on average, residents are scarcely heating their homes to the minimum recommended temperature.

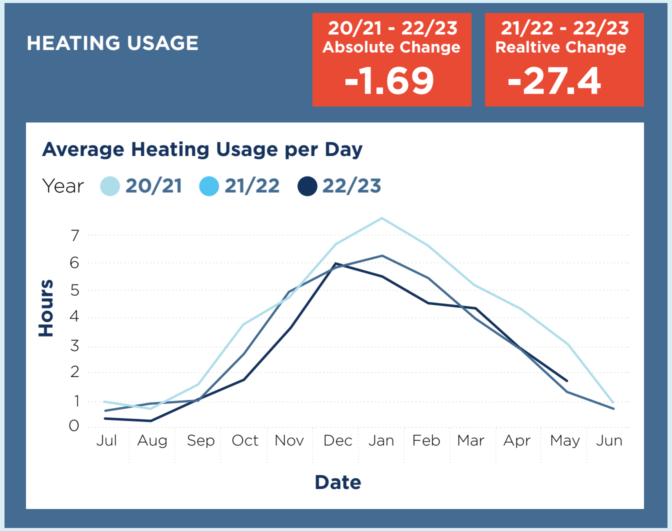


Figure 23 - Heating usage

Similar to the 'Target Temperature' graphic, there is further evidence of the significant decline in residents using their heating, one of the key mechanisms for preventing damp and mould growth.

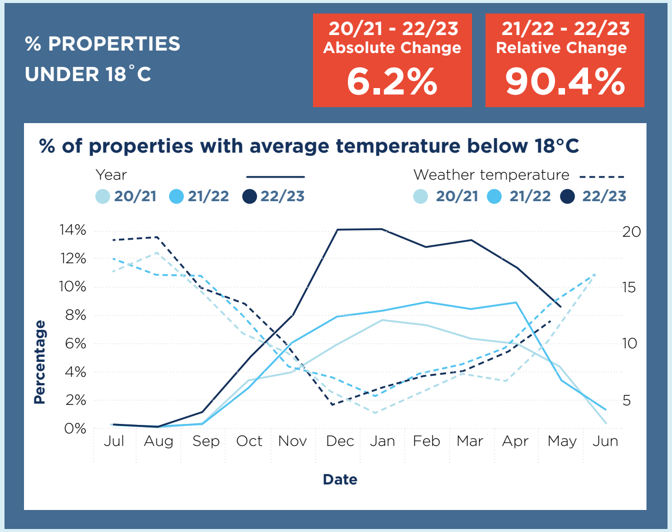


Figure 24 - % Properties under 18°C

Again building on evidence from average thermostat target temperature and average heating use graphs, this shows a very significant increase in the percentage of properties with average temperatures below 18°C. In these properties this is likely to increase the risk of damp and mould growth occurring.

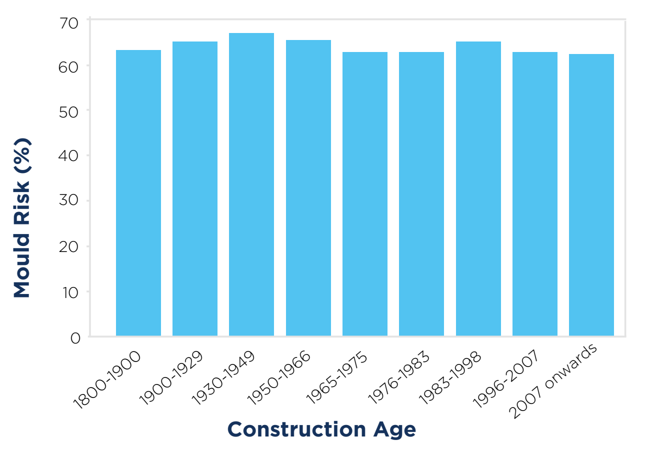


Figure 25 - Mould Risk and Building Age

The graph provides a visual representation of the relationship between a building's age, taken from EPC records, and the subsequent risk of mould based on Switchee's proprietary mould algorithm. This uses data collected (including internal temperature and humidity plus weather data) to calculate the risk of condensation, damp and mould problems occurring in a home. The model predicts whether the conditions in the home are conducive to mould growth. The model is proprietary but is based on academic research and is not intended to specifically state "there is mould" - rather "the ambient air conditions in this home are very likely to promote mould growth".

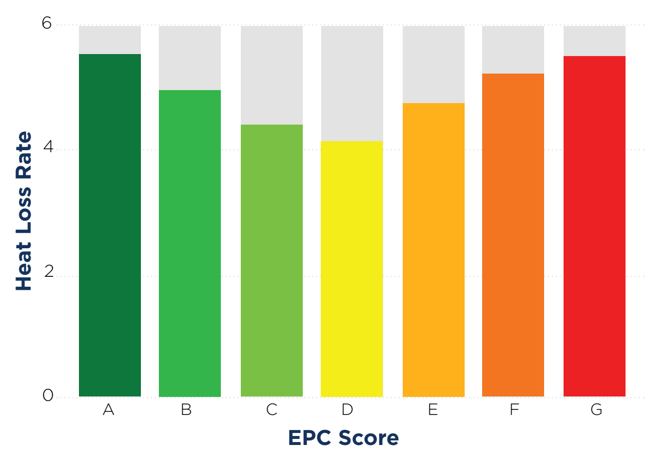
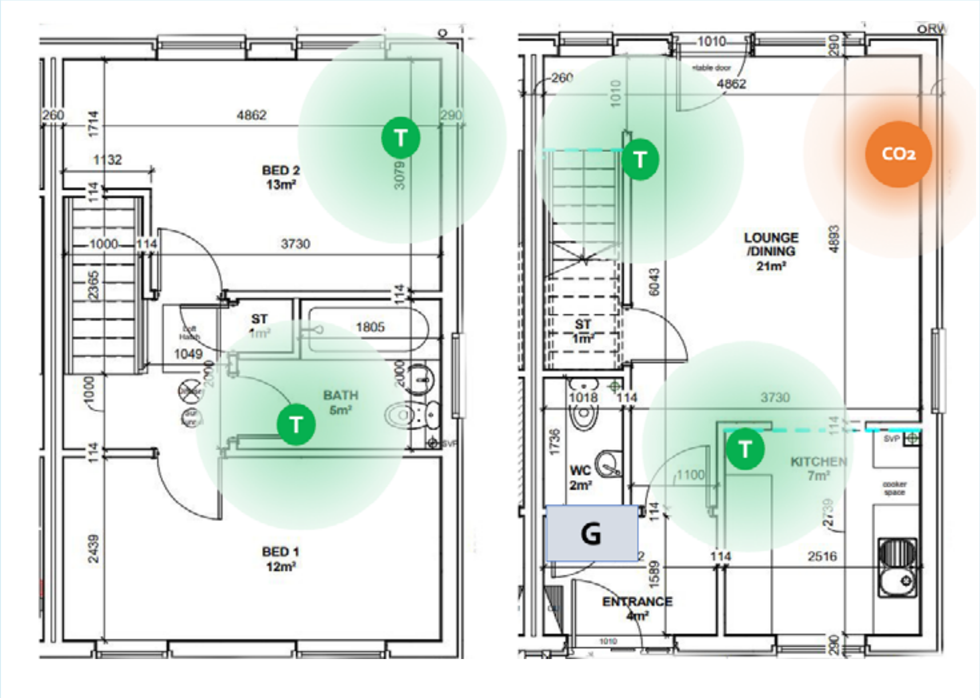


Figure 26 - Average Heat Loss Rate by EPC Score

Interestingly, this finding suggests that EPC scores are not such a reliable indicator of a property's energy efficiency or heat retention capabilities. While EPC scores measure the energy efficiency of a property by assessing various aspects of its construction, design, and performance, the **Heat Loss Rate** metric is a good proxy for the true effectiveness of the insulation and air tightness of a property. The general assumption is that properties with a higher EPC rating would have a lower Heat Loss Rate than properties with a low EPC rating however, this is not strictly the case. More research is required to determine why this may be occurring.



Our case study in [appendix 5](#) for London Borough of Havering also describes our collaboration with Purrmetrix who provide temporary data logger installs to monitor temperature, air quality and ventilation rates pre and post retrofit works. As can be seen in figure 27 this type of approach produces property specific granular data, to provide a room by room risk assessment and assist in the diagnosis of root causes.

Figure 27 - Typical deployment of Purrmetrix equipment

What would be considered a good approach to collecting and managing damp and mould growth data?

We would advise that all data collection and processing is undertaken with a very clear data strategy in place which considers:

- The objective/s of the data collection and what outputs are required.
- How the data will be stored
- How the data will be used

This might follow conventions of [BS19650 – Building Information Modelling (BIM)](#). In relation to damp and mould growth, a data strategy would identify data being collected and the actions taken as a result of data readings that are outside of a normal range. This would include a clear approach to action/escalation as a result of data feedback and an action plan for specific properties which may require immediate remediation and monitoring, but also links into longer term property investment and asset management.

The Government guidance [Understanding and addressing the health risks of damp and mould in the home](#) sets out some considerations in relation to monitoring and data management.

The future of data collection and analysis

It seems clear that a shift within the culture of organisations is required to ensure that data collected is used in an appropriate way to support good decision making and add value for all organisations. Data collection and management needs to enhance the occupiers experience of the properties on which data is being collected.

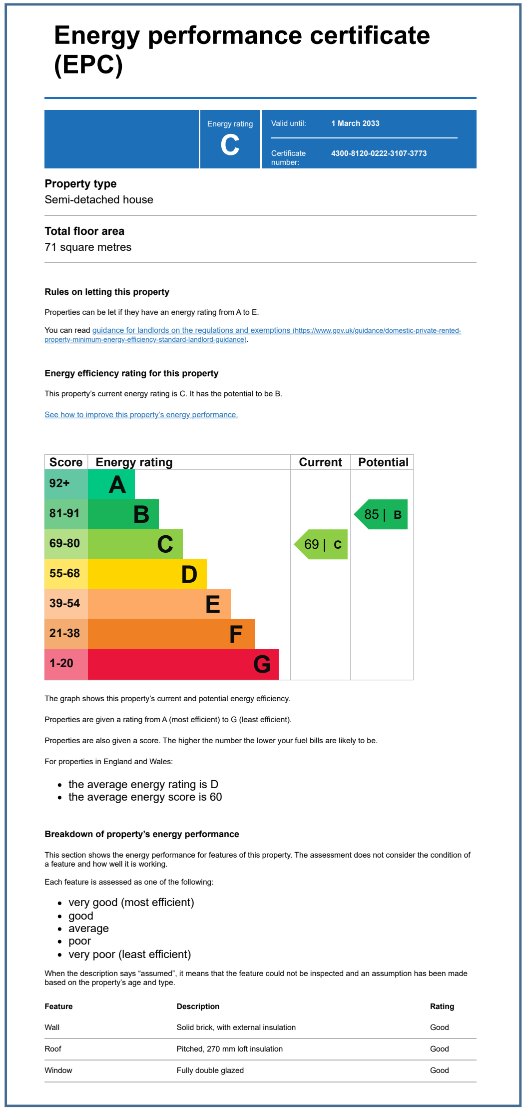
6. THERMAL EFFICIENCY

What do we mean by thermal efficiency? In simple terms, a home that is more thermally efficient will be better at retaining heat within the thermal envelope when the outside temperature is lower than the inside temperature.

Over the years the cost to heat homes has increased and the carbon emissions associated with that heat have become better understood. These factors have led to an increase in the thermal efficiency of new homes and existing homes by adding insulation or better performing elements and components. Different building materials transfer heat at different rates with some dense materials such as concrete and metal transferring it very effectively. Other more lightweight materials such as fibre, quilt or expanded lightweight materials transfer heat much less efficiently and are generally recognised as good insulators.

The measurement of materials, components and elements heat transfer properties is complex but the most commonly understood measure of the effectiveness is "U" values which are measured in degrees W/m²K. This is effectively how many watts of energy are lost through an area of one square meter for each degree of temperature difference on either side of the element.

"U" Values are not consistent across elements. Specific areas in an element (eg a wall or ceiling) which have poorer U values compared to the whole element are known as 'thermal bridges'. These are often present where an element is bridged by another component such as a lintel or by an element of the structure e.g. a concrete frame.



Energy performance certificate (EPC)

	Energy rating	
	C	Valid until: 1 March 2033 Certificate number: 4300-8120-0222-3107-3773

Property type
Semi-detached house

Total floor area
71 square metres

Rules on letting this property

Properties can be let if they have an energy rating from A to E.

You can read guidance for landlords on the regulations and exemptions (https://www.gov.uk/guidance/domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance).

Energy efficiency rating for this property

This property's current energy rating is C. It has the potential to be B.

See how to improve this property's energy performance.

Score	Energy rating	Current	Potential
92+	A		
81-91	B		85 | B
69-80	C	69 | C	
55-68	D		
39-54	E		
21-38	F		
1-20	G		

The graph shows this property's current and potential energy efficiency.

Properties are given a rating from A (most efficient) to G (least efficient).

Properties are also given a score. The higher the number the lower your fuel bills are likely to be.

For properties in England and Wales:

- the average energy rating is D
- the average energy score is 60

Breakdown of property's energy performance

This section shows the energy performance for features of this property. The assessment does not consider the condition of a feature and how well it is working.

Each feature is assessed as one of the following:

- very good (most efficient)
- good
- average
- poor
- very poor (least efficient)

When the description says "assumed", it means that the feature could not be inspected and an assumption has been made based on the property's age and type.

Feature	Description	Rating
Wall	Solid brick, with external insulation	Good
Roof	Pitched, 270 mm loft insulation	Good
Window	Fully double glazed	Good

Figure 28 - Energy performance certificate (EPC)

For existing homes, Domestic Energy Assessors (DEA`s) are responsible for producing EPC's. The DEA is qualified to assess the home in accordance with Reduced Data Standard Assessment Procedure (RdSAP) rules and conventions. All of the DEA's observations about the thermal efficiency of the building fabric and services, such as heating systems and lighting, are used to produce an EPC. The EPC gives a thermal efficiency rating in the form of a letter ranging from F to A and an RdSAP score. EPC`s are lodged on a Government database and whilst they provide a good data set and form the basis of policy direction and targets, they are generally recognised as not providing a holistic view of a property. EPC's assume a default air permeability value for the property (i.e. how drafty it is) and default "U" values for components and elements of the building fabric.

This is not helpful when considering specific instances of damp and mould growth. In fact, in some cases single Energy Efficiency Measures (EEM's) have improved thermal efficiency and SAP scores but have made damp and mould growth more likely because they have not considered the home holistically or considered thermal bridges and ventilation.

This key risk is now managed by a by the latest version of 'PAS2035:2023 Retrofitting dwellings for improved energy efficiency - Specification and guidance' which considers the improvement of thermal efficiency through the retrofit of EEM's to existing homes from a holistic risk based perspective. PAS 2035 requires specific qualified roles to be appointed on projects to control these risks. In such circumstances Full SAP (or Passivhaus Planning Package) software is used to allow better analysis

It is possible to assess the thermal performance in relation to condensation and potential mould growth in more detail. Specifically, areas which may be thermal bridges and lead to damp and mould growth can be assessed using specialist software such as '**Psi Therm**'.

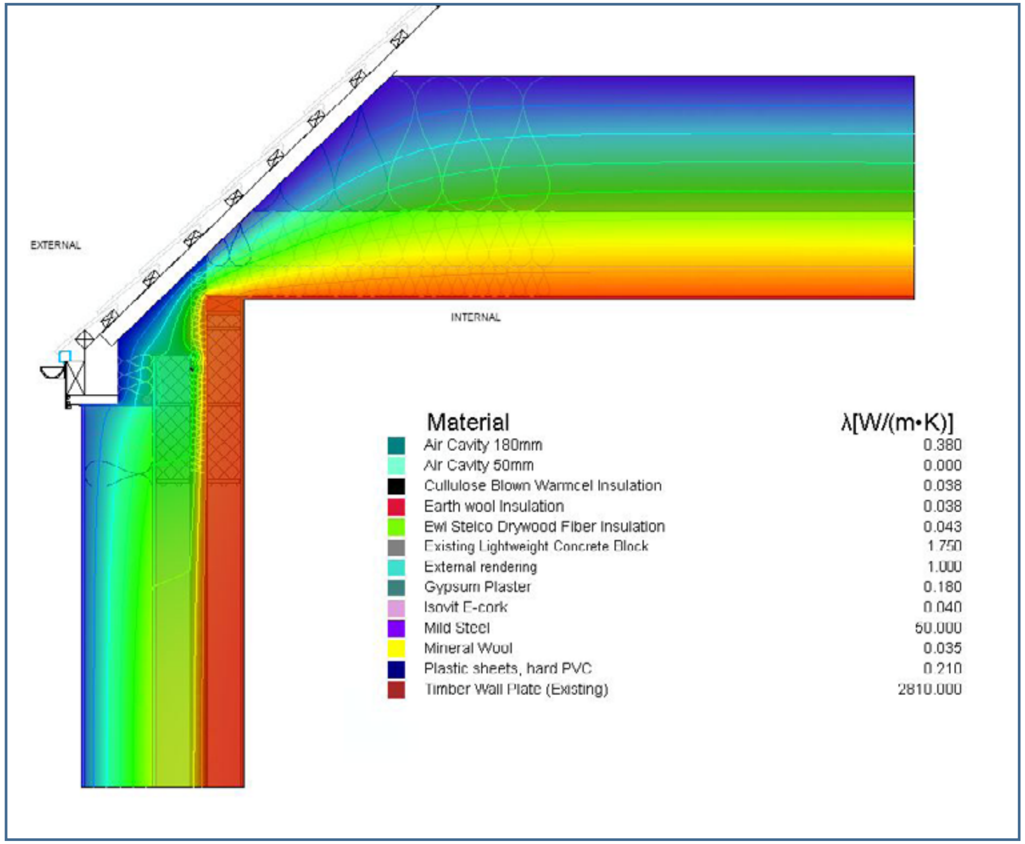


Figure 29 - Thermogram of bespoke thermal bridge calculation at ceiling and wall junction

The extent to which area of a building element is thermally under-performing when compared to a different area or to adjacent building elements (which in turn is linked to condensation risk), can be calculated in accordance with with Building Research Establishment (BRE) paper **IP 1/ 06 'Assessing the effects of thermal bridging at junctions and around openings'**. This paper gives a value of 0.75 as a threshold, below which the risk of surface condensation is greater than above this threshold. It is a good indicator of whether a thermal bridge is likely to occur and whether there is a risk of condensation occurring.

The costs of thermally upgrading building envelopes with EEM`s can be very significant (e.g. external or internal wall insulation) or very cost effective (e.g. loft top up insulation). Some forms of EEM`s may carry inherent risks that need to be carefully managed as they may compromise the way in which the original building (as constructed) performed in relation to the moisture balance within the home. Examples of this may include the addition of insulation to traditional solid brick walls or the infill of unsuitable cavities in cavity walls.

Some concerns are emerging about inappropriately installed cavity wall insulation which has been installed in narrow cavities (in contravention of BRE guidance), blocked/bridged cavities or in overly exposed locations all of which may contribute to penetrating dampness. Assessment of this is addressed in the Damp and Mould Growth diagnosis flow chart in section 9.

There are undoubtably benefits at a household and national level to upgrading our homes thermal performance and alongside ventilation, it is seen as a prerequisite of remediating or preventing damp and mould growth.

However, with increasing competition for limited financial resources, the time scales involved with upgrading thermal efficiency and the move towards low carbon heat sources, a ventilation led retrofit approach is sometimes being considered. Indeed PAS2035 requires a Ventilation Strategy as a standard part of any project to minimise any unintended consequences in relation to Damp/Mould & Condensation. This has the advantage of reducing risk associated with damp and mould growth at lower costs whilst the more capital and time intensive retrofit programmes to upgrade thermal efficiency of dwellings are delivered.

7. WHAT IS GOOD AIR QUALITY?

Good or acceptable air quality is hard to define but could be described as:

> 'Air in which there are no known airborne contaminants at harmful concentrations as determined by organisations like the World Health Organisation and in which the substantial majority of people do not express dissatisfaction'

Airborne contaminants are unwanted substances in the air, and these can contain Microbial organic compounds caused by damp and mouldy conditions. Some come from building materials, furnishings, or people's activities. Others enter from outside. When someone is in a space with contaminated air, they're exposed to these substances.

Exposure depends on how much contaminant is in the air and how long someone is in that space. The amount they breathe in can vary depending on age, gender, and overall health.

The response to the dose received may have chronic effects that last over a lifetime and accumulate, or the effects may be acute. The dose received in different spaces and for different occupancy scenarios will also be different.

How do we currently define acceptable indoor air quality?

Temperature

In the UK acceptable air temperature is typically between 18-24°C as recommended by Public Health England. What is acceptable to an individual can vary depending on age, gender, medical condition, affordability and many other factors.

Humidity

At comfortable temperatures, humidity is typically measured in **Relative Humidity values (RH%)**. Values between 45% and 65% are a common target. Much above or below these levels can lead to problems with building fabric, mould growth and dust mites or, in excessively dry conditions, the vulnerability of the airway to irritation and infection.

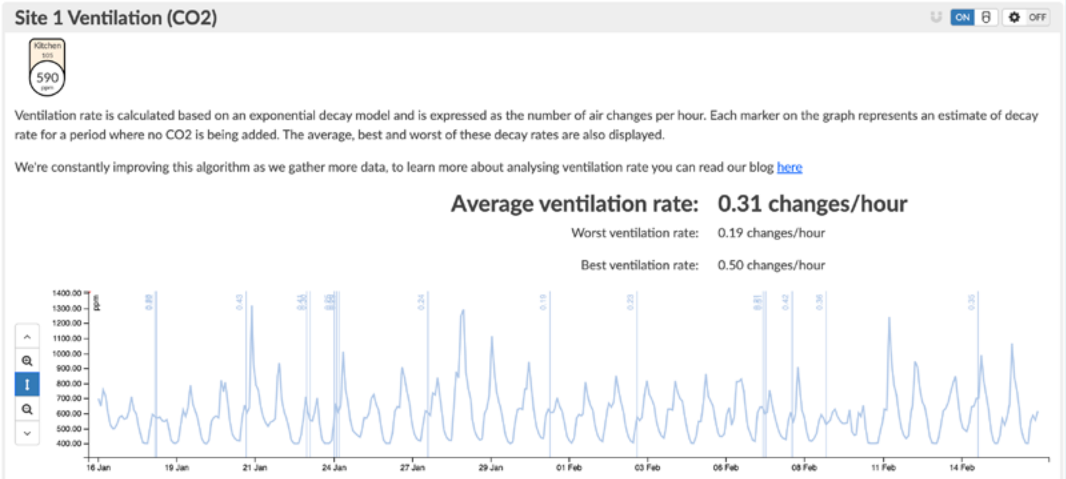
Aerobic Mould and yeast spores

There are over 5,000 species of different moulds, a large number of which release mycotoxins that can be extremely harmful to health. This is especially the case with those with immune suppressant illnesses and other medical conditions. The link to upper respiratory track infections, asthma and Rhinitis being the most common.

According to the Journal of Bacteriology & Mycology published in July 2023, the air quality and clinical threshold for two of the most harmful of aerobic mould spores is 3000 spores/m^3 for Cladosporium and 100 spores/m^3 for Alternaria.

Carbon Dioxide (CO_2)

Whilst not a pollutant (at least not until very high levels) it is becoming popular as a proxy for the effectiveness of ventilation. In homes it can be difficult to set meaningful targets. However, if spaces are above 1000-1500 **parts per million (ppm)** of CO_2 for extended periods, those spaces are likely to be under-ventilated.



Ventilation rate is calculated based on an exponential decay model and is expressed as the number of air changes per hour. Each marker on the graph represents an estimate of decay rate for a period where no CO2 is being added. The average, best and worst of these decay rates are also displayed.

We're constantly improving this algorithm as we gather more data, to learn more about analysing ventilation rate you can read our blog here

Average ventilation rate: 0.31 changes/hour

Worst ventilation rate: 0.19 changes/hour

Best ventilation rate: 0.50 changes/hour

Figure 30 - CO_2 monitoring graph

Categorisation of internal and external pollutants

There are hundreds, if not thousands, of potential pollutants in the air, but a few are the most common and cause the most harm.

Particulate matter

A complex mixture of solid and liquid particles suspended in the air. The sources of particulate matter can be from both inside and outside the home. They can be very small and travel deep into the lungs and bloodstream. Typical indoor sources are cooking and combustion appliances like gas cookers. Outdoor sources can be combustion engines, brake dust and construction activities.

Bio aerosoles and mould

A bio aerosol is an airborne collection of biological material. Bioaerosols can comprise of bacterial cells, fungal spores and viruses. Pollen grains and other biological materials can also be airborne as a bioaerosol. As noted earlier, damp and specifically condensation will likely lead to some mould growth and resultant microbial compounds which will have a detrimental affect on air quality.

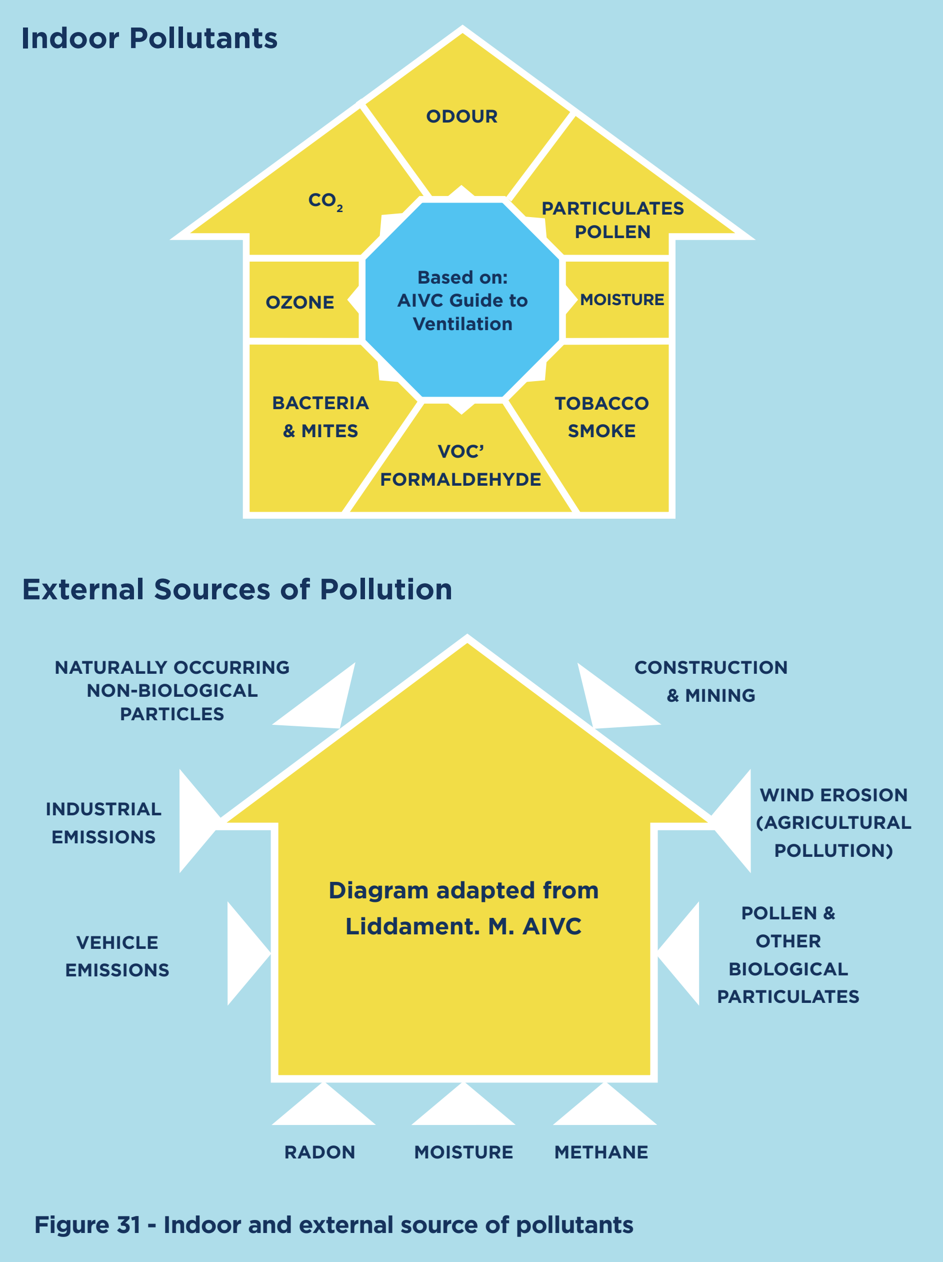


Figure 31 - Indoor and external source of pollutants

Volatile organic compounds

Volatile organic compounds (VOCs) are an important grouping of pollutants as they are used in almost everything around us and generally turn into gas at room temperature, which means they can be inhaled. There are many thousands of compounds used, but some are more harmful than others. Formaldehyde is probably the VOC of most significant importance due to its prevalence in the indoor environment and its known adverse health effects.

Nitrogen Dioxide

Nitrogen Dioxide (NO_2) is emitted directly during the combustion of fuels, such as gas and diesel. Together NO_2 and NO are called oxides of nitrogen (NO_x). Gas appliances (e.g. cookers) are the primary indoor sources of NO_2. Short-term exposure to elevated concentrations of NO_2 can cause inflammation of the airways in the lungs. Long-term exposure to NO_2 has been associated with dementia, lung cancer, diabetes and increased mortality.

Radon

Radon is a radioactive gas and a known cause of lung cancer. It is formed by the radioactive decay of small amounts of uranium that occur naturally in all rocks and soils. It enters buildings from the ground beneath or from the materials from which they are built.

How is good air quality achieved?

Like most risks, it's best to consider managing them through first principles and a **hierarchy of controls**.

Elimination

Can a source of pollution simply be removed?
For example open fires etc.

Substitution

If a product or activity is necessary can those products be substituted for lower-emitting products or products that don't emit pollutants?

Engineering Controls - Ventilation

This could be an airtight home to prevent external pollutants entering the home, but is more commonly understood as ventilation systems to remove pollutants via extraction and provide fresh air. In the context of this toolkit, poor air quality resulting from mould is improved by removal of moist air by ventilation systems. This is governed by **Building Regulation Part F** which classifies ventilation systems as extract ventilation, whole dwelling ventilation or purge ventilation.

One aspect of ventilation systems that Part F ignores is ventilation system noise, specificaly when systems are in boost mode. This is problematic, as alongside residents perception of excessive energy consumption by fans, noise can be a major reason why ventilation systems are turned off. This aspect should be considered carefully as part of any design or installation.

What Is the link between ventilation and damp and mould growth?

Mould grows in the home when we provide it with the conditions it needs. As our typical comfort temperatures are ideal, all we need to add is moisture. When internal surfaces are at or near dew point for long periods, they become saturated with moisture, and the conditions for mould growth are provided.

Adequate ventilation and the effective removal of moisture from the air in moisture-producing spaces like bathrooms help to limit these conditions, as well as ensuring that the surface temperature of floors, walls and ceilings are higher than the dew point temperature.

Investigation of the effectiveness of any ventilation system present forms part of the process set out in the toolkit flow chart. There are ventilation systems which may be found in existing properties which are now considered to be unsuitable.

A useful guide to ventilation systems produced by **The Retrofit Academy** may be found **here**. In summary these systems are:

Intermittent extract ventilation (IEV)
This is the most commonly found system in existing homes with extract fans in wet rooms which operate intermittently, manually or via sensors. These fans are combined with trickle vents in windows or permanent vents.

Decentralised mechanical extract ventilation (dMEV)
This is the same as IEV but fans run continuously at a low level and boost when necessary. Some models can boost too late and boost mode can be noisy. Door undercuts are required to permit a flow of air through the dwelling.

Centralised mechanical extract ventilation (cMEV)
One centralised fan, usually variable speed and located in a roof space or cupboard extracts continuously from wet rooms via ducts with a balancing supply of fresh air provided via background ventilators and door undercuts. This system requires less ductwork than MVHR and has been shown to be very effective in dealing with condensation, damp and mould problems.

Centralised Demand controlled ventilation (DCV)
Similar to cMEV, this consists of a centralised, constant pressure fan that continuously extracts from wet rooms. The difference to CMEV is that DCV uses smart extract valves that measure the humidity and vary the extract rate room by room, based on demand. The balancing supply of fresh air is provided via humidity sensitive trickle vents or ventilators which can adjust the supply air to match demand.

In some circumstances designers and installers of such systems, such as **Aereco**, are offering ventilation as a service and can offer performance guarantees around acceptable relative humidity for 4/5th's of the time. A case study of it's use can be found **here**.

Mechanical ventilation with heat recovery (MVHR)
A centralised fan unit extracts (via a heat exchanger) warm moist air from wet rooms and replaces it with fresh incoming air, which is warmed via the heat exchanger, in other habitable room. It requires careful design and installation to avoid using more energy than it saves and is suitable for high performing energy efficient properties such as Passivhaus. MVHR units and associated ducting will often take up valuable space and may not be suitable for existing homes.

Figure 32 - Intermittent extract ventilation (IEV)

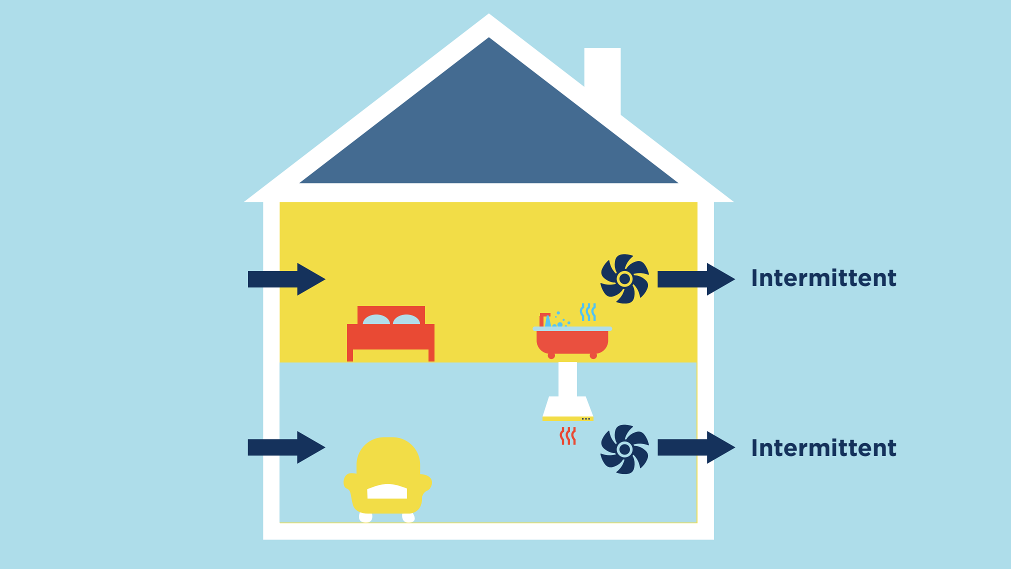


Figure 33 - Decentralised Mechanical Extract Ventilation (DMEV)

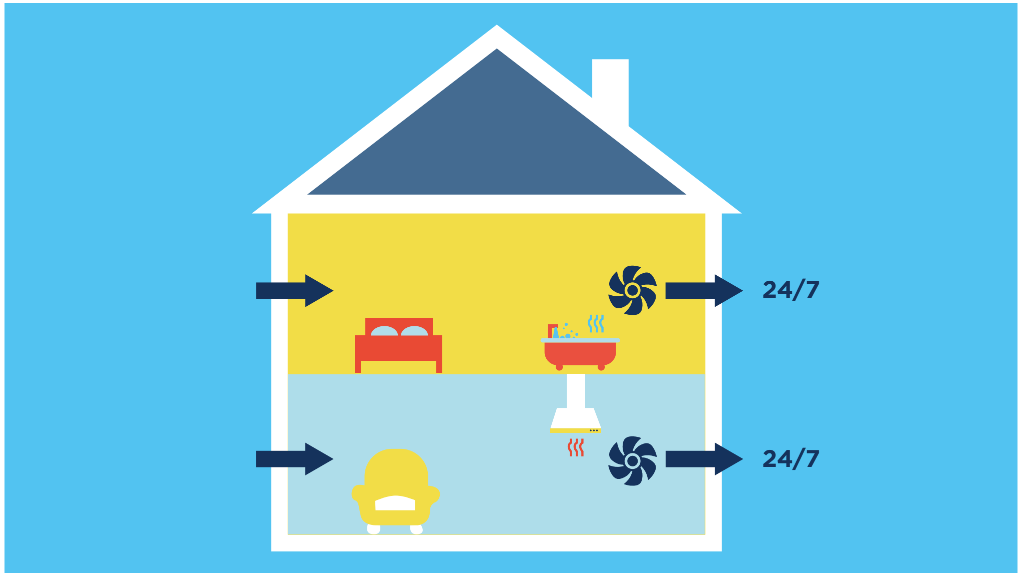


Figure 34 - Centralised Mechanical Extract Ventilation (CMEV)

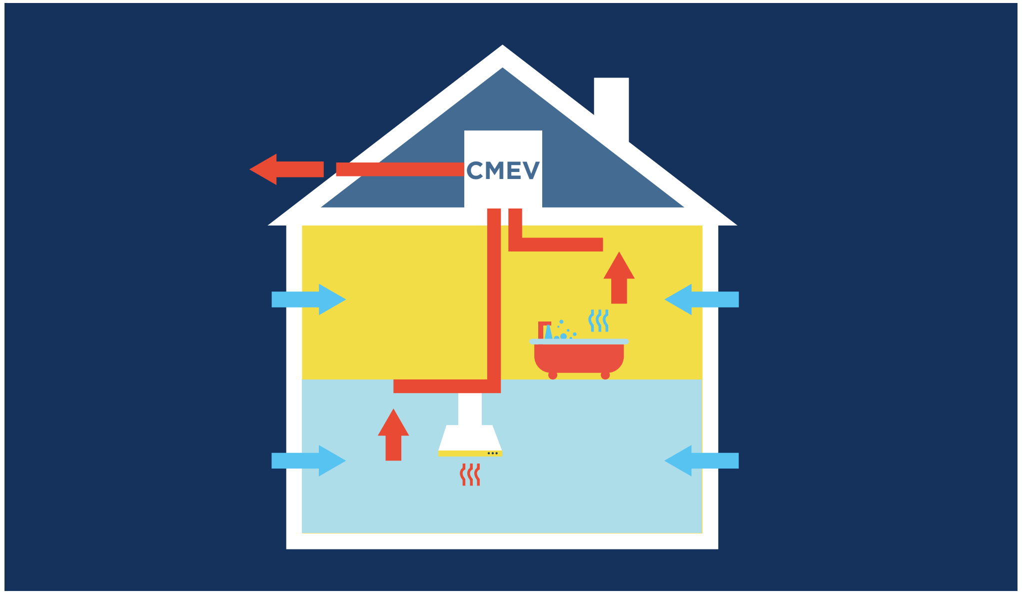
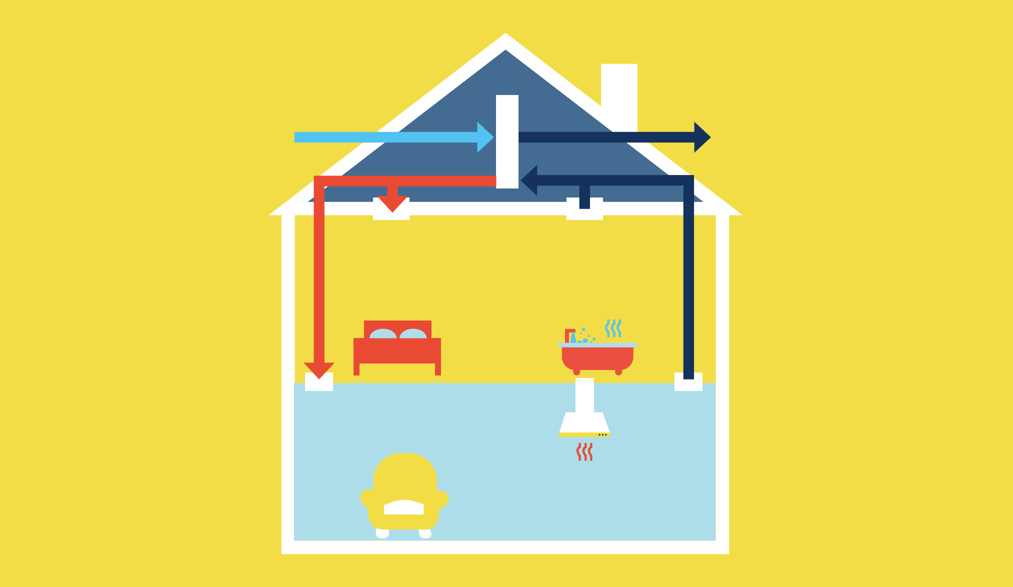


Figure 35 - Mechanical Ventilation with Heat Recovery (MVHR)



Single room heat recovery ventilators (SRHRVs)
A fan extracts warm moist air from a wet room via a heat exchanger and introduces pre-warmed fresh air. They can be noisy or may 'short circuit' but some models can alternate between extract and input. They can be used to supplement systems in difficult floor layouts.

Passive stack ventilation (PSV)
This system works by ducting air from wet rooms in a vertical duct to roof vents with incoming air provided by background ventilators. They are not considered suitable for existing homes.

Positive input ventilation (PIV)
This system works via the use of a centralised fan, taking fresh air from outside and pushing it into the habitable spaces from where it leaves via vents. It is considered to be problematic as it can force warm moist air to be absorbed into the structure, leading to **interstitial condensation**. It is not considered suitable for existing homes.

The 4 C's' and ventilation

A BSI document '**Moisture in buildings: an integrated approach to risk assessment and guidance**', which was produced to stimulate and assist in revising existing standards and guidance such as BS5250:2011 Code of practice for control of condensation in buildings, introduced the concept of the 4 C's, using risk management principles for spaces that consider the realities of managing moisture.

The 4 C's have since been picked up in Annex A of BS 5250:2021 Management of Moisture in Buildings - Code of Practice.

The 4 C's are Context, Coherence, Capacity and Caution. These are generally self evident but capacity has particular relevance to overcrowding and occupancy.

Principle	Sub-Principle
Compatibility with context	Geography
	Form
	Material and construction method
	Condition
	Use
Coherence	Coherence of moisture approach
	Thermal coherence
	Airtightness
	Weathering/waterproofing
	Ventilation, heating and insulation
Capacity	Design
	Process
Caution	Usability
	Maintenance
	Monitoring
	Feedback

Figure 36 - Summary table of the 4 C's

Capacity is an important concept to understand and deploy in ventilation. There are many unknowns in ventilation requirements resulting from occupation and use therefore, including some additional capacity within ventilation systems with careful installation and commissioning (particularly in respect of flow rates) give a system the ability to manage different moisture scenarios.

For example, more people may use a home than anticipated, their activity may be more intense than anticipated or there may be unforeseen challenges with installation, commissioning or degradation of the system over time. Capacity gives us the bandwidth to adapt if need be. Typically, an increase of 30% - 50% in excess of the design flow rates can account for these.

A case study of this approach can be found **here.**

Finally, the document made a call for Moisture Safety Experts and Moisture Safety officers to be involved in the whole building holistic approach. This is a historic recommendation but does correlate with some of the expertise now perceived to be missing in the industry in relation to Damp and Mould growth.

8. OCCUPIERS

Britain is a truly multicultural society which we have formally embraced in all walks of life. However, our housing stock does not always accommodate for multicultural living, particularly in the social sector where over 72% of the properties are over 60 years old and many of which will not suit the lifestyles of different occupants.

For example, in different cultures it is typical to have a wet kitchen and a dry kitchen. A wet kitchen is designed for cooking that typically produces very high levels of water vapour and heat. The wet kitchen therefore needs to be designed to accommodate this with significant extraction, natural ventilation, wipe down surfaces and moisture resistant materials. A dry kitchen on the other hand is used for 'drier' activities such as food preparation, making toast and microwaving food which produce much lower levels of water vapour.

A family that may traditionally require a wet kitchen may find themselves in the UK in a period property, with one small kitchen, lacking both natural and mechanical ventilation, and finished with a multitude of cold and porous surfaces. Clearly in this instance the occupants and property are highly incompatible and there is a high risk of damp and mould caused by condensation.

Whilst this stands as a very broad and generalised example, it is factual and highlights questions about new build and refurbishment spacial, material and ventilation standards and how these will not always accommodate multicultural use. We need to re-address these to ensure we are catering for the highest moisture generators.

'BS5250:2021 Management of moisture in buildings – code of practice' examines the causes and effects of moisture within a building. It recognises the difference between different moisture generators and highlights that the number of occupants within a property does not lead to one typical scenario of moisture generation. The previous version of the document (now withdrawn) clearly demonstrated this with 'Table 3: Dry, Moist and Wet Occupancy'. This table does not appear in the 2021 version. Table 3 illustrated that dry occupancy produces around a third to a half of the moisture of wet occupancy from the same number of people within the dwelling.

Number of persons in household	Daily moisture generation rates		
	Dry occupancy (kg)	Moist occupancy (kg)	Wet occupancy (kg)
1	3.5	6	9
2	4	8	11
3	4	9	12
4	5	10	14
5	6	11	15
6	7	12	16

Table 3 - Dry, Moist and Wet Occupancy

The 2021 version Section 5 : Condensation Risk does contain table 9 - moisture production rates in housing from which similar conclusions can be drawn.

Over its lifetime, a dwelling may be occupied by many different types of occupants from different cultures and family sizes and with different propensities to generate moisture. By designing ventilation systems to a capacity that caters for different occupancies and levels of moisture generation, a property has the potential to be blind to users and capable of providing a warm comfortable damp free home to any occupier.

With this in mind, when referring to the **Building Regulations Part F,** we should already be aware that the current regulations try to provide a 'one size fits all' and should therefore be used as minimum guidance to build upon and exceed, rather than as a definitive level to design to.

Issues surrounding overcrowding in homes have been discussed earlier in this toolkit as a contributing factor to damp and mould growth. In a housing crisis, levels of overcrowding are likely to increase. Overcrowding and resultant patterns of occupation are likely to move households towards the wetter end of the occupancy spectrum. It is accepted that movement within social housing stock due to overcrowding is problematic. One approach within a landlords strategy may be to work harder to identify overcrowded homes and install appropriately designed ventilation systems with additional capacity. This may align well with the potential to collect headline data on temperature and air quality via smart thermostats and data collectors described in **section 5,** that falls outside of expected norms.

Many Clients now find themselves with costly exercises to identify those properties with issues, particularly damp and mould growth. With some Local Authorities and Housing Associations having in excess of 20,000 properties, this is no small task and with the short timeframes implemented by the Government, it requires a small army. We need to therefore look at how modern methods and technology can be implemented to assist with future management and to highlight issues as soon as they occur, or even better, before they present.

Occupancy related issues are a 'sensitive subject' and stray into individuals rights and responsibilities. The toolkit hopes to apply a logical and forensic approach to analysing damp and mould growth, that firstly, can demonstrate that a building is at fault and secondly, if this is found not to be the case, what the occupier related issues might be. If such a process is followed, it will protect landlords from penalties under forthcoming legislation but equally, protect residents against health risks by ensuring the correct remedial measures are implemented.

The key issue is that occupiers are a very diverse group with different needs, aspirations and requirements. However landlords choose to try and collect data about damp, they must communicate and collaborate with residents and act to resolve damp and mould growth. Residents must be front and centre in developing acceptable solutions and achieving good outcomes.

The Government's recent guidance **Understanding and addressing the health risks of damp and mould in the home** recognises the diversity of residents, the importance of communication and data, and very much puts residents at the centre of addressing damp and mould growth in their homes.

9. DAMP AND MOULD GROWTH DIAGNOSIS FLOW CHART – BACKGROUND AND USE

Our research indicated that there are no existing standards concerning damp and mould growth identification and survey techniques which can be adopted on an individual property basis and can take account of variables in damp diagnosis such as the building archetype and resident lifestyle behaviours.

As a result, typical surveyor behaviours favour a less invasive and largely electronic moisture resistance meter led approach, with minimal forensic analysis and questionable accuracy.

To address this we have produced the damp and mould growth diagnosis flow chart. The intention is to move towards an agreed industry recognised survey sequence and methodology relying on forensic Building Pathology which, if followed correctly, will allow the surveyor to arrive on an exact cause and source of excessive moisture on an individual property basis.

A Building Pathology approach in the context of damp and mould growth is a behaviour shift away from the reliance on electric moisture resistant meter-led surveys, to the use of a multitude of different tools, techniques and measurements. In turn, this will enable identification of the exact cause, whether from the building or the occupants, or a combination of the two, and the most appropriate solution to be considered.

As can be seen, the flow chart has been subdivided into 'intangible' and 'tangible' phases which in this context, denotes whether damp, and its source, can be determined by observation or whether Building Pathology is required to determine an intangible and unobservable cause and source of damp and mould growth.

In terms of sequence, the preliminary 'intangible' phases set out the necessary survey considerations for a surveyor to determine the presence of visible damp, defects causing/contributing to damp and mould growth and the appropriate steps which can be taken to make safe the property and its occupants.

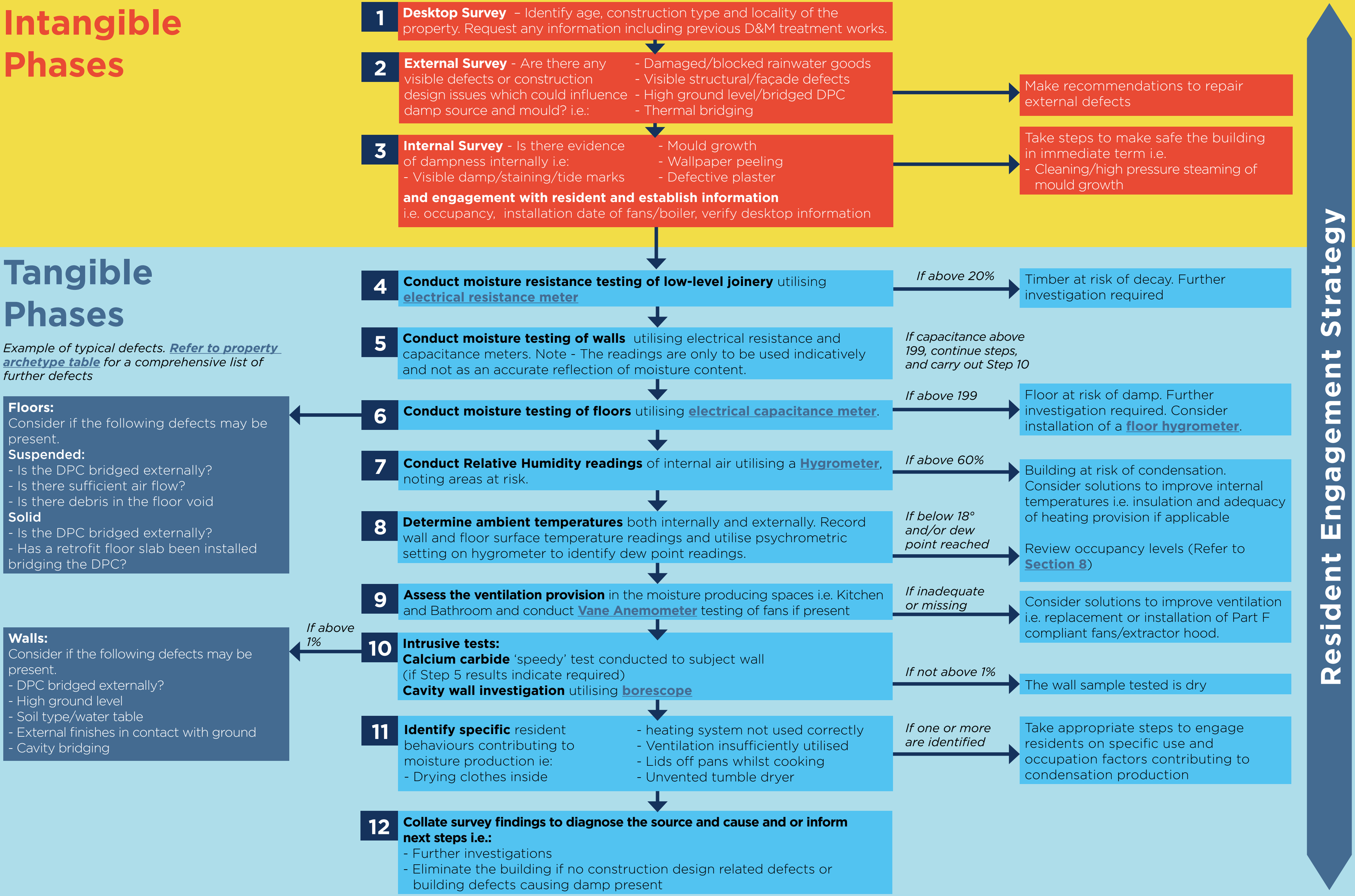
The 'tangible' sequence details a series of survey and measurement stages and techniques which are to be adopted by the surveyor during their inspection to assist in identifying a cause or causes of damp within that particular property. These stages include, but are not limited to, the measurement of relative humidity, ambient temperature, dew point, extraction rates via Vane Anemometer testing and psychrometric readings relative to occupancy.

If a cause can be determined through these steps, the toolkit details potential solutions. If a surveyor is still unclear, the sequence culminates in calcium carbide testing – an invasive test to determine whether moisture is present within the building fabric or the internal surface. Using this information, a further sequence is to be followed to finally arrive at a conclusive diagnosis and appropriate course of remedial action.

The flow chart also includes a number of hyperlinks which provide the surveyor with access to a significant amount of additional information both within the Damp and Mould Toolkit and to outside external sources i.e. Approved Document F and a table to determine whether a property is dry, moist or wet Occupancy relative to the number of occupants.

Figure 37 - Borescope inspection

Figure 38 - Electrical resistance meter



Intangible Phases

1 **Desktop Survey** – Identify age, construction type and locality of the property. Request any information including previous D&M treatment works.

2 **External Survey** - Are there any visible defects or construction design issues which could influence damp source and mould? i.e.:
- Damaged/blocked rainwater goods
- Visible structural/façade defects
- High ground level/bridged DPC
- Thermal bridging

→ Make recommendations to repair external defects

3 **Internal Survey** - Is there evidence of dampness internally i.e:
- Visible damp/staining/tide marks
- Mould growth
- Wallpaper peeling
- Defective plaster

and engagement with resident and establish information i.e. occupancy, installation date of fans/boiler, verify desktop information

→ Take steps to make safe the building in immediate term i.e.
- Cleaning/high pressure steaming of mould growth

Tangible Phases

Example of typical defects. ***Refer to property archetype table*** *for a comprehensive list of further defects*

4 **Conduct moisture resistance testing of low-level joinery** utilising **electrical resistance meter**

If above 20% → Timber at risk of decay. Further investigation required

5 **Conduct moisture testing of walls** utilising electrical resistance and capacitance meters. Note - The readings are only to be used indicatively and not as an accurate reflection of moisture content.

If capacitance above 199, continue steps, and carry out Step 10

6 **Conduct moisture testing of floors** utilising **electrical capacitance meter**.

If above 199 → Floor at risk of damp. Further investigation required. Consider installation of a **floor hygrometer**.

← **Floors:**
Consider if the following defects may be present.
Suspended:
- Is the DPC bridged externally?
- Is there sufficient air flow?
- Is there debris in the floor void

Solid
- Is the DPC bridged externally?
- Has a retrofit floor slab been installed bridging the DPC?

7 **Conduct Relative Humidity readings** of internal air utilising a **Hygrometer**, noting areas at risk.

If above 60% → Building at risk of condensation. Consider solutions to improve internal temperatures i.e. insulation and adequacy of heating provision if applicable

8 **Determine ambient temperatures** both internally and externally. Record wall and floor surface temperature readings and utilise psychrometric setting on hygrometer to identify dew point readings.

If below 18° and/or dew point reached → Review occupancy levels (Refer to **Section 8**)

9 **Assess the ventilation provision** in the moisture producing spaces i.e. Kitchen and Bathroom and conduct **Vane Anemometer** testing of fans if present

If inadequate or missing → Consider solutions to improve ventilation i.e. replacement or installation of Part F compliant fans/extractor hood.

10 **Intrusive tests:**
Calcium carbide 'speedy' test conducted to subject wall
(if Step 5 results indicate required)
Cavity wall investigation utilising **borescope**

If not above 1% → The wall sample tested is dry

If above 1% ← **Walls:**
Consider if the following defects may be present.
- DPC bridged externally?
- High ground level
- Soil type/water table
- External finishes in contact with ground
- Cavity bridging

11 **Identify specific** resident behaviours contributing to moisture production ie:
- Drying clothes inside
- heating system not used correctly
- Ventilation insufficiently utilised
- Lids off pans whilst cooking
- Unvented tumble dryer

If one or more are identified → Take appropriate steps to engage residents on specific use and occupation factors contributing to condensation production

12 **Collate survey findings to diagnose the source and cause and or inform next steps i.e.:**
- Further investigations
- Eliminate the building if no construction design related defects or building defects causing damp present

Resident Engagement Strategy

10. SHORT TERM NEXT STEPS

Introduction

Previous sections of the Toolkit have discussed the events that have led us to where we are today and it is clear that surveying professionals inside landlord organisations and professionals engaged by Landlords, must take a more pathological and forensic approach to damp and mould growth.

Our Toolkit is written to assist everyone. We hope it will have opened many eyes to the extent of the problem facing social landlords who have a legal obligation to act now.

So what are the next steps? It's simple, we must all change, embrace change, learn and do what we should have been doing already. Damp in buildings is not new so why have we struggled to deal with it, or worse ignored it?

When developing an asset management strategy we generally break it down into the short, medium and long term. Where **short term immediate** action is required, **Steps 1-6** are designed to achieve this. Medium and long term action is covered in the next section.

STEP ONE

Understanding the Process

The flow chart indicates that the '**intangible phase**' requires an external and internal survey of the affected property. It provides a methodology for undertaking a comprehensive inspection to determine the cause and source of damp. It is possible to mis-diagnose damp through inappropriate, and often, misuse of equipment which highlights the need for a more pathological and forensic approach to diagnosis.

In addition to a property specific pathological and forensic approach, a wider stock strategy, informed by data collection and risk profiling of property archetypes, is required. An analysis of property archetypes is included as **appendix 2**. Many landlords are of course doing this already but it is hoped that the Toolkit will assist to refine and develop these strategies and develop a more consistent approach across the Housing Sector.

STEP TWO

Identifying which Survey Level is required

This step assumes there is an immediate need for action. It is very important to identify the correct level of survey. Broadly speaking, surveys to investigate moisture and damp can be categorised into the following levels.

- **Level 1** – undertake a rudimentary review of the property that is primarily based on a visual inspection.
- **Level 2** – Undertake a Level 1 survey, including the use of an electrical moisture meter.
- **Level 3** – Undertake a more detailed inspection involving the full range of equipment described in **section 2** and set out in full in **appendix 4**
- **Level 4** – Undertake a full pathology survey, undertaking invasive testing, remote monitoring, chemical analysis as required.

The level of survey required will be determined by different factors. This may be the number of properties which need to be inspected or could be a response to a specific situation. For example, significant mould growth in a resident's home has already been identified and requires investigation, prompting the need for a Level 3 or 4 survey to be undertaken immediately.

In some instances, the Level 4 survey may determine that further pathological investigation is required, which could typically involve opening up a suspended concrete floor or removing masonry to open up cavity walls in order to get to the root cause of a defect.

STEP THREE

Formal appointment/instruction

Instruct a suitably qualified person to undertake the inspection. This should be based on the type of survey you are commissioning. This may be a surveyor within your organisation or an externally appointed consultant. Either way, the individual or organisation undertaking the inspection must be appropriately experienced, skilled and able to evidence this technical competence.

As a minimum, we recommend the client landlord/organisation requires the following information before a survey or programme of surveys is undertaken:

- details of the inspection methodology – this may have already been prescribed by you or provided by the individual/organisation undertaking the inspection.
- The inspection methodology must include details of the specialist equipment that will be used by the surveyor
- Evidence of technical expertise relating to the level of survey you are seeking

STEP FOUR

Site Reconnaissance & Investigation

Undertake an initial desktop exercise to gather all relevant information which will be shared with the surveyor undertaking the inspection. Useful information will include historic repair information and where available 'as built' information.

It is important that an internal survey is preceded with a full external inspection of the property to understand its construction, condition and identify potential sources of moisture. This is essential and will assist the surveyor in correctly identifying the potential source and cause of the problem, when working through the methodology in the flow chart to move from intangible to tangible damp and mould identification.

STEP FIVE

Resident Engagement

The importance of engagement with the resident cannot be underestimated and should be one of the initial recon stages as highlighted in our flow chart. The importance of gathering information in order to understand occupancy levels, family demographics and historic information on when boilers or windows were replaced is invaluable as it feeds into the holistic inspection and report process and our archetyping exercise which is included at appendix 2.

Consistency of information is important so developing a standard form to record resident feedback is vital, even if it is anecdotal.

STEP SIX

Survey and Reporting

Follow the clear steps in the flow chart and develop your own standard survey methodology and report template for consistency.

Follow the recommendations detailed in the report. If the survey has been undertaken correctly, you have moved away from 'intangible' to 'tangible' damp and mould identification.

You may need to take immediate action and undertake remedial works or the output of the report will inform a wider asset management approach as discussed in the following section.

Figure 39 - Short term next steps

11. MEDIUM AND LONGER TERM STRATEGIES

Let’s be very clear, there is no standard fix or single remedy that suits every situation.

Although it is possible to identify typical archetypes based on age and typical construction, every building and home is unique and is used in different ways. The location of the property and it’s orientation are also factors. Crucially, we also need to acknowledge that residents themselves are a major factor. We all use our homes differently and as such, we need to acknowledge and factor this in when assessing and presenting options for eradicating damp and mould growth in any home. So engagement and communication with residents must be a ‘**golden thread**’ through any strategy.

Current Information

Following direction from the Government, many landlords have undertaken high level surveys to identify homes with damp and mould issues. It is yet to be fully understood how this data collection will be used, but anecdotally we understand landlords are using this to risk profile their stock. Other approaches include desk top studies of stock to identify homes that are perceived to be high risk. This approach is acceptable as an initial medium term step, but it doesn’t actually take into account the specifics of the property or consider occupancy in use. Any information on this needs to be overlaid with survey information.

We know that internal damp and mould issues can broadly be categorised into three contributing factors:

1. **A failure in the original design and construction of the building**
2. **Any defects present**
3. **Use and Occupation**

Factors 1 & 2 can be contributing factors to internal damp and mould issues within a property, but ‘Use and Occupation’ cannot be the cause of a design and construction failure or defect. It is therefore necessary to rule out Factors 1 & 2 from any assessment before concluding that the damp and mould is an occupancy related matter.

Responsive and planned maintenance

Ensuring that the building is defect free, particularly in respect of defects that can contribute to damp and moisture is critical. The obvious examples are repairing leaking rainwater goods and rectifying internal sources of water leaks in heating and water installations.

We have highlighted the need for landlords to have a better understanding of their stock. Historically, data collection through large scale stock condition surveys (SCS’s) is limited. For example, a SCS or desk top exercise would not necessarily identify if a first floor flat is situated above another flat or a cold unheated refuse and cycle storage area which could be a contributing factor to damp and mould. It is suggested that SCS’s briefs are reviewed to include contributing factors such as adjacent unheated spaces, significant thermal bridges and poor or non-existent ventilation.

In terms of planned maintenance and servicing visits, there are opportunities to identify properties suffering from damp or mould growth or those perceived to be at risk because of factors 1 and 2 above. These visits could also be an opportunity to engage with residents if damp and mould growth is perceived to be associated with use and occupation. For example, electrical testing inspections require access to every room which not all inspections do and outcomes could be referred back to specialist staff in landlords teams.

Stock Profiling and understanding the past

In addition to immediate and reactive short term 'next steps' which allow landlords to successfully diagnose damp and mould in their known worst-affected stock, there needs to be a proactive focus on the medium and long term. One method which can be adopted by landlords to assist in proactively identifying potential 'at risk' properties is stock profiling and assessing risk allocation. We have included an example of how this approach might work in the **property archetype table.**

The table overleaf provides a summary view and each example links to the full table contained in **appendix 2**. Each table identifies a typical archetype dating from present day buildings, back to traditionally built Georgian buildings of the early 18th century. The bracketed letter in the archetype reference number column relates to the 'table S1: Age bands' from the RDSAP conventions document (see Figure 40) to allow comparison with EPC assumptions. The archetyping:

1. Provides an overview of the typical construction of the period, identifying the typical risks associated with this type of construction, which follows with a simple RAG rating for the likelihood of damp and mould risk. (if the building was as original)
2. identifies typical inappropriate measures and interventions that have been undertaken in isolation or more likely, a combination of measures implemented over the life of the building.
3. seeks to identify potential remedial solutions which in some cases will undo and/or remove previous measures.

Year of construction			
Age band	**England and Wales**	**Scotland**	**Northern Ireland**
A	before 1900	before 1919	before 1919
B	1900-1929	1919-1929	1919-1929
C	1930-1949	1930-1949	1930-1949
D	1950-1966	1950-1966	1950-1973
E	1967-1975	1967-1975	1974-1977
F	1976-1982	1976-1983	1978-1985
G	1983-1990	1984-1991	1986-1991
H	1991-1995	1992-1998	1992-1999
I	1996-2002	1999-2002	2000-2006
J	2003-2006	2003-2007	(not applicable)
K	2007-onwards	2008-onwards	2007-onwards

Figure 40 - Table S1 : Age Bands from RdSAP Guidance

What is interesting, maybe even alarming, is the degree of inappropriate measures that have been undertaken. These range from well intentioned, to poorly thought out and designed, to incorrectly installed or simply wrong and not fit for purpose measures.

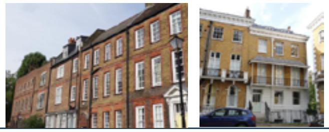
So a good starting point is to reflect on these and understand why previous remedial solutions have failed and ultimately, employ a 'lessons learnt' approach as part of medium and long term rectification measures and record these on asset databases. This should be complimented by technical training for surveyors to assist in raising awareness and identification of inappropriate measures.

Informing the Future

Landlords can use the archetype information alongside their existing asset data to act strategically and proactively identify potential at risk properties and tailor their strategic asset management strategy accordingly.

Thinking holistically, addressing damp and mould is intrinsically linked to the retrofit agenda, building safety and compliance and to the new **Decent Homes Standard** when launched. The synergy and overlap between these themes should be accounted for in any developing asset management strategy.

Property Archetype Summary table

Archetype No (and Table S1 age band)	Typical representative photos	Construction Period	RAG rating	Link
1 (A)		Georgian 1714-1837	Amber (3)	**View here**
2 (A)		Victorian 1837-1901	Amber (4)	**View here**
3 (B)		Edwardian 1901-1910	Amber (4)	**View here**
4 (B)		1920-1930	Amber (4)	**View here**
5 (C)		1930-1940	Amber (4)	**View here**
6 (C/D)		1940-1960	Red (5)	**View here**
7 (D/E/F)		1960-1980	Red (5)	**View here**
8 (G/H/I)		1980-2000	Amber (4)	**View here**
9 (J/K/L)		2000-present	Amber (4)	**View here**

Previous (sometimes inappropriate) Works

When considering strategic asset management, it is necessary to consider previous works, whether they are contributing to current problems and how they might be rectified. Often problems relate to a lack of understanding of whether the building was originally based upon **moisture open** (i. e. breathable) or **moisture closed** principles. The archetyping in **appendix 2** covers a range of inappropriate measures but some common examples are:

Retrospective Damp proofing measures

Injecting DPC's and installing internal waterproof renders which were not originally installed when the moisture open building was constructed, in certain cases poorly or inappropriately installed and may not have been necessary in the first place (see Figure 41).

Possible solutions: It is not possible to uninstall an injected DPC, but it is possible to follow the methodology outlined in the flow chart to diagnosis the actual source and cause of the damp. Internal waterproof renders can be removed, but this would need to be a considered decision based on correctly diagnosing the cause of the damp.

Double glazed windows

The introduction of double glazed windows improves thermal efficiency and reduces heat loss previously associated with draughty single glazed windows, particularly timber sashes. However, it is common that improved ventilation is not considered, therefore trapping high levels of moisture within the building (see figure 42).

Possible solution: Install ventilation as discussed later in this section to remove excessive moisture.

Retrospective cavity wall insulation

Retrofitting cavity wall insulation is commonly undertaken to improve thermal efficiency. Cavity walls were originally designed to prevent penetrating damp reaching the inner leaf. We have found cases where retrospectively installed cavity wall insulation has become so saturated, that it is causing internal damp (see figure 43). In addition, if there are blockages in the cavity or the cavity is too narrow, this will affect the performance of the insulation. This may be as a result of a narrow cavity that should never have been filled or excessive exposure to driven rain.

Possible solutions: Remove the saturated cavity wall insulation, consider alternative options such as EWI or IWI.


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Figure 41 - DPC at intermediate floor level

Figure 42 - Condensation

Figure 43 - Exposure of blocked cavity

Ground floor replacement

Replacing suspended timber floors with a solid concrete floor. This would not be an effective remedial measure in areas with a high water table as the water will simply be forced elsewhere (see figure 44). In addition, it is not possible to lap the new damp proof membrane with the existing damp proof course.

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Figure 44 - Inappropriate retrofit of solid floor

Possible solutions: Introduce measures to reduce the water table with attenuation systems to manage the water table or create trenches/French drains to improve drainage. In extreme cases, consider reinstating the suspended floor to reintroduce the ventilated void.

Ventilation

We have outlined in **Section 7** the definition of air quality and the linkages between ventilation and damp and mould growth.

Whilst thermally led retrofit projects include ventilation as part of the holistic design strategy, there are pilot projects that are essentially ventilation led retrofit (with thermal upgrade of elements to follow) and the published results show that they have been successful. This is not a reason to move away from holistic retrofit which ultimately provides warmer and more energy efficient homes, but it does provide a more immediate and cost effective intervention to deal with damp and mould issues as is outlined in the Case Study which can be found **here**.

A further consideration, discussed in earlier sections, is that the UK is a multi-cultural society and we need to consider and design for this. Unfortunately our Building Regulations are based on generic metrics and perhaps these need to be updated to reflect who is living in a home. At the very least we need to use these as minimum standards. A simple example is Approved Document F: Volume 1, which covers means of ventilation requirements in a dwelling where minimum litres/second are specified for kitchens and bathrooms and for whole dwelling systems. Are these extraction rates suitable for families that generate different levels of moisture?

What is actually happening and how might this affect strategy?

As has been discussed in **Section 5**, data on air quality, and by inference the risks of damp and mould growth, is becoming increasingly easy to collect and process via either permanent smart thermostats such as Switchee or by temporary sensors that can be installed for a shorter period in homes.

Data such as this may complement immediate actions in **section 10** or feedback into medium and longer term actions discussed above. This is fast evolving and should definitely play a part in landlords strategies.

Conclusion

In summary, there is a requirement to upskill all those responsible for undertaking damp and mould inspections, which we believe requires the development of a **National Standard Assessment Methodology** to provide a comprehensive process for undertaking inspections and implementing medium and longer term strategies.

We would be happy to discuss inputting into the development of a methodology with any organisations.

12. COST

As noted in our introduction financial pressures on social landlords are acute with different priorities competing for limited resources. Other than resolving the physical manifestations of damp and mould growth and addressing its detrimental effects on those living with it, the next immediate question often revolves around costs.

This is a difficult aspect, as unlike condition or performance led building issues, the remedial cost will often relate to the tangible and intangible aspects of damp and mould growth.

The costs could be categorized as short term investigative and remedial costs incurred immediately, or longer term investigative and remedial costs. For example, when significant upgrades of building fabric are proposed to improve thermal performance, alleviate fuel poverty and reduce carbon emissions.

Some costs such as the forensic and pathological survey process advocated by this toolkit, the installation of different ventilation systems and minor remedial works to remove mould, may be quantified. However, as so much of the cost that may be incurred relates to various specific circumstances that are bespoke to particular building forms and typologies, it seems unwise to publish data at this stage until better industry data is available and understood.

That said, the archetype library set out in section 11 does address and pick up issues with built forms and typologies over a range of build periods. This is expanded upon in **appendix 2**, where property archetype tables with more details of typical building defects by age type and typology are provided.

Baily Garner has undertaken a great deal of similar remedial work in the past. Whilst not directly badged as damp and mould growth remediation work, this has generated a significant cost data base. In addition, recent commissions, as illustrated in our case studies in appendix 5, have provided some specific detail.

An example of cost data and the approach that can be taken is provided at **appendix 3**. We stress again that the cost for remedial work should be applied on a bespoke basis and we will be happy to discuss this further with you.

A further consideration in the cost of work is the selection of experienced construction partners. As we have previously advocated in our retrofit work, the best partner is often the one a client already has. Those contractors delivering responsive and planned maintenance works will already have focused resident engagement procedures and a good understanding of their client’s stock. Clients and contractors should be able to work collaboratively together to ensure that the costs associated with damp and mould growth remediation are at a similar level to those experienced for existing planned and responsive work. They may also be able to identify programmes of work to alleviate damp and mould growth risk that prepare homes for future, more capital intensive works.

13. A CHANGE IN CULTURE

Those whose work involves access and inspection to people's homes will not be unfamiliar with encountering damp and mould growth. This is not a new phenomenon.

With experience, senses become attuned to its presence and even before entering a dwelling you will be spotting damp patches, leaks, vegetation growth, evidence of rot, faulty rainwater goods and services plus condensation on window panes.

Upon entering the home, you may be familiar with the stale smell, the feeling of airlessness, even humidity, before visually picking up staining, mould growth and evidence of moisture generating activity/practices. You will also probably be able to list out the areas that will be worst affected, at thermal bridges such as cold wall junctions, window corners/cills and maybe from what you noticed on the outside of the building, corresponding evidence of penetrating damp.

So when the Housing Ombudsman stated that it is no longer acceptable to be using language such as "lifestyle choices" and "behaviours" we don't believe that the Ombudsman doesn't accept overcrowding, underheating and a lack of ventilation can exacerbate moisture levels, leading to excessive condensation and consequent mould growth. But instead it is a clarion call for landlords to properly know and understand their housing stock and to have carried out the necessary steps to diagnose damp arising from the home itself. One would hope that the surveyor would understand typical failures associated with particular building types or periods, products or details before turning their attention to occupancy patterns, moisture generation and use. So what are the aspects of culture change we believe are required?

Culture Change #1: Automatic Association of Mould Growth with Residents.

Back in October 2021, the Ombudsman published his report finding that there was a general frustration amongst tenants who felt that they weren't being heard and landlords weren't taking their complaints seriously.

The **Social Housing Regulation Bill** will give the Government the right to publish a policy statement to tackle serious hazards such as damp and mould growth in social housing and the Department of Health and Social Care will publish guidance for housing professionals on the health risks of damp and mould.

Ultimately, we anticipate a review of **Housing Health and Safety Rating System** to be incorporated into the next iteration of the Decent Homes Standard, with a greater emphasis on how damp and mould growth is assessed.

All of which support the direction of travel signposted by the **Social Housing White Paper** to give residents a voice that will be heard, and this must be welcomed.

This direction of travel has been maintained in the governments response to the Coroners report into the tragic death of Awaab Ishak published in September 2023. '**Understanding and addressing the health risks of damp and mould in the home**' is a very resident focused report and strongly refutes this automatic association.

Culture Change #2: The Surveyor

Historically, a surveyor would encounter a damp patch and then hopefully, would do the leg work to determine its cause and specify or instruct remedial works. The uncomfortable truth is that when condensation and mould growth was apparent, all too often, the surveyor jumped to the conclusion that it was neither rising nor penetrating dump, but simply lifestyle, taking the quantum leap directly over "diagnosis" to reach a solution. The solution usually involved a fungicidal wash, liberal application of some form of insulation and possibly taking heating and ventilation into consideration.

We suspect that this approach is still practiced to some extent. The point of this toolkit is to promote a far more forensic and pathological approach to building defect diagnosis, incorporating the use of scientific tools and methods to systematically eliminate suspected causes, fully understanding the building issue and what is required by way of resolution ahead of specifying the proportionate solution. This will be far more cost effective and beneficial to the occupants' health and wellbeing.

The approach is intentionally methodological, to understand what we are dealing with, enabling us to prescribe intervention, such as a coherent series of remedial responses, which may, having followed the flow chart steps, involve a resident strategy to assist in controlling the generation of moisture and management of condensation. This may need further training, to ensure competence and in some cases, professional input outside of the Surveyor's core expertise.

Figure 45 - Surface temperature thermistor

Culture Change #3: Use of Data

In our eagerness to solve the issue, we too often overlook the need to patiently monitor and record how the building is used and how it responds. The toolkit introduces various tools and digital technology.

Good data provides indisputable evidence and this is undoubtedly the direction of travel. Understanding and using data correctly negates the need for anecdotal evidence or assumptions, which could lead to wasted resources and unnecessary disruption through the actions which are based on incorrect conclusions. The issues surrounding data and issues arising from current findings are covered in section 5.

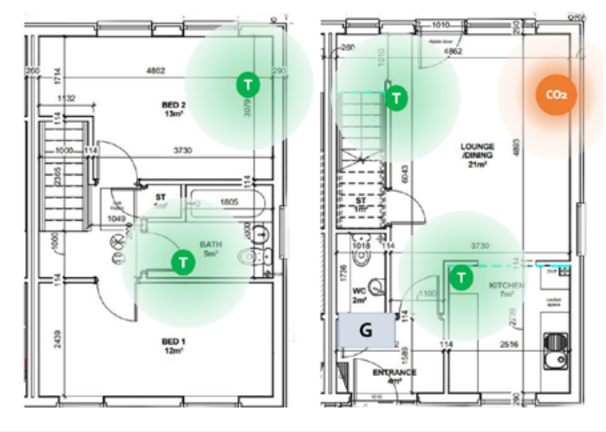

Fig 46 - Typical deployment of Purrmetrix equipment

Culture Change #4: Leadership and Strategic Approach

All change needs to be led from the top of the organisation, with the executive team understanding the need to avoid silo working and adopting a far more holistic view in strategic asset management planning. Again the Government's response to the coroners report supports a much more strategic approach. This will encompass all initiatives, to ensure that they complement, rather than counteract each other, which means collaboration between development, fire safety, energy performance and disrepair.

The fact that the UK is a multi-cultural society should unquestionably be celebrated. It is also an undeniable fact that we are all different, in our behaviours and our cultures and this directly translates to the amount of moisture that an individual and indeed a family generates. Whilst a relatively low cost intervention such as a smart ventilation system, could be considered, it is often impractical to always design to the threshold of the highest moisture generators. In order to understand the issue and propose a solution, we should be tolerant of these cultural and individual differences. If it is clear that a particular method of cooking, cleaning or drying is going to be adopted regardless, then we begin to use data to understand embedded behaviours that may inform a bespoke solution.

14. SOME FINAL THOUGHTS

One undeniable truth following the tragic death of Awaab Ishak is that industry and wider Government focus on damp and mould growth is here to stay – as it absolutely should be. Equally undeniable and not unlike the Grenfell Tragedy of 2017, is that it shouldn't take such an event for the industry to burst into life reactively.

A missed opportunity and new approach

One question which has been asked continuously is how well the industry really understands the science sat behind damp and mould growth and the necessary investigative measures required to arrive at an exact cause and source, on an individual property basis. The letter issued by the Secretary of State to all social landlords prompted an unparalleled demand for damp and mould surveys which were of such a scale and time pressure, they could largely only be serviced by basic, non-intrusive and non pathological assessments. This should have identified landlords worst affected properties and prompted immediate action to make safe these homes. However, to really understand the issues specific to each property and the long term remedial intervention required, building pathology – 'a holistic approach to studying and understanding buildings, and in particular, building defects and associated remedial action' – outlined by this toolkit is required.

Occupants

It is clear that the industry needs to drive awareness of the role that resident lifestyle behaviours play in promoting and maintaining a good moisture balance and this shouldn't be shied away from. This needs to be carefully addressed ensuring that 'lifestyle' as a generalisation is removed from landlords initial responses towards eradicating damp and mould growth, and instead landlords need to ensure that the science and pathology is properly understood to arrive at an exact cause on an individual property basis. Furthermore, the external factors inhibiting a residents ability to combat damp and mould growth need to be considered by landlords and any remedial solutions proposed need to function within a range of lifestyle behaviours and should include additional and innovative provisions to further support their residents.

Figure 47 - A national problem

A better framework

Citing the information and data provided within this toolkit and the significant amount of recent industry publications, it is equally evident that standards and regulations concerning damp and mould growth need to be improved to better protect the health and wellbeing of those affected by mould exposure. The anticipated regulatory and legislative changes should be well received. At Baily Garner, we recognise the role we can play in supporting this, hence our latest toolkit offering a damp and mould growth diagnosis flow chart.

Improved Efficiency in Asset Management

As a final point, as the society takes action to meet our 2050 Net Zero target, focus on sustainability, and more specifically Retrofit, will undoubtedly increase further. This presents a significant opportunity for landlords to think far more holistically and strategically about asset management. This in turn will allow landlords to utilise the considerable crossover between retrofit principals, specifically in relation to ventilation strategies, affordable heating and improvement of thermal elements, and the damp and mould growth agenda. Their ability to futureproof their stock in terms of thermal efficiency, whilst also ensuring these provisions serve to minimise their occupants exposure to damp and mould growth and the associated health benefits, is a great opportunity.

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APPENDIX 1 - GLOSSARY

Absolute Humidity - A measure (expressed as grams of water vapour per cubic metre volume of dry air) of the actual amount of water vapour (moisture) in the air, regardless of the air temperature. The higher the amount of water vapour, the higher the Absolute Humidity.

Air Permeability Value - The quantity of air flow that passes through a certain area of a fabric, or more appropriately a building in this context, and is used to measure the air tightness of a building. The unit of measurement/value is defined as air leakage rate per hour, per square metre of envelope area, at a test reference pressure differential across the building envelope of 50 Pascal (50N/m^2).

Air Quality - Generally, air quality is the term we use to describe how polluted the air we breathe is. When air quality is poor, pollutants in the air may be hazardous to people, particularly those with lung or heart conditions. Clean air is a basic requirement of a healthy environment for us all to live and work in.

Awaab Ishak - A two-year old child living in a one-bedroom flat at the Ilminster block on Rochdale's Freehold estate, who died in December 2020 as a result of a severe respiratory condition adjudged by the Coroner to have been caused by prolonged exposure to black mould in his home.

Awaab's Law - An impending legislative change which will seek to apportion more responsibility to landlords in tackling mould and damp in their stock and will mandate strict response times for landlords in identifying and eradicating instances presenting a series risk to residents safety and wellbeing.

Bio Aerosol - Airborne particles that are living (mould, viruses and fungi) or originate from living organisms. Their presence in air is the result of dispersal from a site of colonisation or growth.

Capillary Suction - Sorptivity, or capillary suction, is the transport of liquids vertically in porous solids due to surface tension acting in capillaries. In simple terms capillary suction/action, is a scientific expression explaining the process of water rising within a capillary.

Damp Proof Course - First introduced in 1875, a Damp Proof Course is a physical barrier built into a masonry wall to prevent the passage of moisture via capillary action/rising damp.

Data Loggers - Data loggers are electronic devices which automatically monitor and record environmental parameters (such as Relative Humidity, temperature etc) over time, allowing conditions to be measured, documented, analysed and validated. The data logger contains a sensor to receive the information which is then stored in the data logger and transferred to a computer for analysis.

Decent Homes Standard - A programme introduced by Government in 2001 aimed at improving council and housing association homes to bring them all up to a minimum standard by 2010.

Dew Point - The temperature to which the air must cool for it to become completely saturated with water. If the air continues to cool lower than the dew point, airborne water will begin to condense in the form of dew.

Domestic Energy Assessor (DEA) - An individual who is qualified to assess the energy efficiency of residential properties like houses and flats. They prepare reports and make recommendations for cost effective ways to improve energy performance in buildings.

Energy Efficiency Measures ("EEM's") - Equipment, devices, or materials intended to decrease energy consumption, including, but not limited to, upgrades to a building envelope such as insulation and glazing; improvements in heating, ventilating and cooling systems and automated energy control systems i.e. improved lighting, smart thermostats etc.

Energy Performance Certificate (EPC) - A rating scheme to summarise the energy efficiency of buildings. The building is given a rating between A (Very efficient) - G (Inefficient). The EPC will also include tips about the most cost-effective ways to improve the home energy rating

English Housing Survey - A continuous national survey commissioned by the Department for Levelling Up, Housing and Communities (DLUHC). It collects information about people's housing circumstances and the condition and energy efficiency of housing in England.

Formaldehyde - A colourless, strong-smelling, flammable chemical that is produced industrially and used in building materials such as particleboard, plywood, and other pressed-wood products. It is controlled and classified as a Category 1B carcinogen such is the associated health risk with exposure.

General Data Protection Regulations (GDPR) - The GDPR is a European Union regulation on information privacy in the European Union which regulates the processing by an individual, company or an organisation of personal data relating to individuals in the EU.

Golden Thread - The golden thread is a tool consisting of building safety information and its management. As a concept, the golden thread helps duty holders and accountable persons work together to maintain a database of readily accessible information for the use of various stakeholders throughout the building's life cycle.

Heat Loss Rate - This is the rate at which heat is lost through the thermal envelope of the building over a set period of time, for a set internal and external temperature. There are industry criteria however, a lower heat loss rate would indicate a better performing fabric.

Hierarchy of Controls - The hierarchy of controls is a way of determining which actions will best control exposures. The hierarchy of controls has five levels of actions to reduce or remove hazards. The preferred order of action based on general effectiveness is; Elimination, Substitution, Engineering controls, Administrative controls and Personal protective equipment (PPE).

Housing, Health and Safety Rating System (HHSRS) - Introduced in 2006 to amend the Decent Homes Standard, the HHSRS is a risk-based evaluation tool to help local authorities identify and protect against potential risks and hazards to health and safety from any deficiencies identified in dwellings.

Hygroscopic - This indicates that a substance has the ability to absorb moisture or water from the surrounding environment.

Intangible - Is used to describe something that exists but cannot be measured. For example, a musty smell or a wall that feels damp to touch.

Interstitial Condensation - This is condensation which occurs within or between layers of construction.

Intrusive - In the context of a Damp Survey, a survey/investigation which utilises thorough and often destructive means to access areas and surfaces not readily accessible through ordinary observation.

Moisture Balance - The act of regulating an internal environment to provide a healthy balance of moisture within the air, typically between 45-65% Relative Humidity.

Moisture Open (And closed) - Building construction that allows moisture (vapour and liquid) to move freely in and out of it. Traditional buildings (open) have tended to absorb moisture but allow it to evaporate when conditions become drier. Closed construction means moisture is kept out through impermeability of construction materials.

National Assessment Methodology - An anticipated Government document to provide a National Assessment Methodology for identifying the severity of damp and mould in properties and a sequence of actions to ensure accurate diagnosis and arriving at an exact cause and source.

Net Zero - Net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance.

Nitrogen Dioxide - Nitrogen Dioxide (NO_2) is emitted directly during the combustion of fuels, such as gas and diesel. Short-term exposure to elevated concentrations of NO_2 can cause inflammation of the airways in the lungs. Long-term exposure to NO_2 has been associated with dementia, lung cancer, diabetes and increased mortality.

Non-Intrusive - In the context of a Damp Survey, a survey/investigation which does not ultise disruptive and often destructive means to access areas and surfaces not readily accessible, and instead relies on ordinary observation and non-invasive tools and techniques.

PAS 2035 - A British standard that creates a recognisable quality standard for the retrofit and energy efficiency sector for housing. All projects funded by the Social Housing Decarbonisation Fund, Energy Company Obligation, Local Authority Delivery Scheme or Home Upgrade Grant will be required to comply with the standard. A revision was introduced in September 2023 simplifying some aspects of the previous version.

Passivhaus - A performance-based set of design criteria for very low energy buildings, which can help create buildings which use around 90% less energy than standard UK buildings.

PPM - Planned preventative maintenance (PPM) is a technique which allow a landlord to substantially reduce reactive maintenance and retain their buildings and assets to the desired/required quality. Planned preventative maintenance is either time-based or condition monitored.

Psi Therm - Computer software which allows the user to carry out Thermal Bridging calculations to determine the likelihood of Thermal Bridging occurring across particular construction types and details etc.

Radon - A colourless, odourless radioactive gas. It is formed by the radioactive decay of the small amounts of uranium that occur naturally in all rocks and soils. Exposure to this type of radiation in high volume is a risk to health - radiation is a form of energy and can cause damage in living tissues increasing the risk of cancer. Radon can be found anywhere given it is formed from the Uranium in all rocks and soil.

Reduced Data Sap Assessment Procedure (RdSAP) - Software used to assess the energy performance of existing building. An RdSAP assessment will use a set of assumptions about the dwelling based on conventions and requirements at the time it was constructed.

Relative Humidity - The amount of detectable moisture, expressed as a % of the total amount of moisture which can be detectable in the air at a given temperature.

Severe Damp - Severe damp is evidence of damp within a building which is adjudged by the surveyor to be of such a severity that it poses a risk to the occupants and/or the integrity of the building.

Smart Thermostats - Internet linked thermostats that can be used with both home and smart phone automation and are responsible for controlling a home's heating, ventilation, and air conditioning.

Social Housing (Regulations) Bill - A recent Act of parliament which aims to give tenants greater powers and improve access to swift and fair redress. The Act offers greater protection to social housing tenants against serious hazards in their homes, ensuring a better service and quality of life.

Social Housing White Paper - This is a Government publication which sets out what social tenants can expect from their landlord, and the intended actions the Government will take to ensure that residents are safe, are listened to, live in good quality homes, and have access to redress when required.

Surface Water Activity - A measure of the availability of water to micro-organisms. Surface water activity is determined from the ratio of the vapour pressure of the water in the substrate to the vapour pressure of pure water at the same temperature and pressure.

Survey levels - Survey levels are categorised by the RICS as level 3 (a full building survey or full structural survey), level 2 (a home buyer type survey), or level 1 (a condition type survey).

Tangible - Is used to describe something that exists beyond doubt, because it has been proven to exist by measurement. For example, using an electrical resistance meter to measure the moisture content in a timber skirting.

The Retrofit Academy - A not-for-profit training company dedicated to retrofitting, the improvement of buildings through the installation of energy efficiency measures ranging from insulation to low carbon heat.

Thermal Bridge - Thermal bridges, also known as cold bridges, are weak points (or areas) in the building envelope which allow heat to pass through more easily. They occur where materials which are better conductors of heat are allowed to form a 'bridge' between the inner and outer face of a construction.

Thermal Envelope - Any element of a building which separates the air inside from the air outside i.e. insulation, windows, floors, external walls etc. The thermal envelope's purpose is to prevent heat transfer from the interior of a building to the exterior in winter and vice versa in the summer.

"U" Values - Thermal transmittance, also known as U-value, is the rate of transfer of heat through a structure (which can be a single material or a composite), divided by the difference in temperature across that structure. The units of measurement are W/m^{2}K. The better-insulated a structure is, the lower the U-value will be.

Volatile Organic Compounds (VOC's) - Gases that are emitted into the air from products or processes. Some are harmful by themselves, including some that cause cancer. In addition, some can react with other gases and form other air pollutants.

Water Vapour - The gaseous phase of water. Water vapor is transparent, like most constituents of the atmosphere.

Wet and Dry bulb temperatures - A wet bulb temperature is read by a thermometer covered in water (at ambient temperature) soaked cloth over which air is passed. At 100% relative humidity the wet bulb temperature is equal to the air temperature (the dry bulb temperature) at lower humidity the wet bulb temperature is lower than the dry bulb temperature because of evaporative cooling.

APPENDIX 2 - PROPERTY ARCHETYPE TABLE

Archetype 1 (A*)

Georgian – 1714 - 1837

Solid masonry construction and often characterised by the use of symmetry. Similarly the use of small glazing panels within sash windows, mansard roofs and decorative stone facades. Often built in terraces and of considerably scale i.e. often in four stories and above.

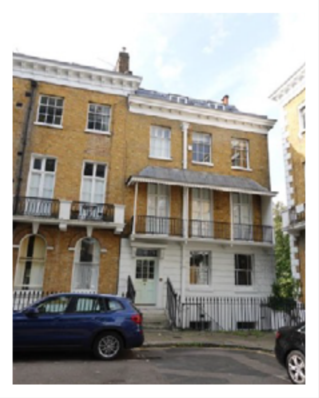
Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating Amber (3)		
No horizontal damp proof course to walls	Sand and cement 'remedial' damp proofing plastering systems preventing breathability.	Removal of impervious plastering system and replaster with a breathable application.
Pitched roofs without undersarking, tile delamination leading to water ingress.	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
• Passage of lateral penetrating through solid wall construction and inherently more porous structure • Rear wall construction often inferior to front/ street facing elevations and vulnerable to water ingress	• Sand and cement pointing in lieu of lime-based and resultant trapped moisture • Retrofit external rendering preventing building breathability.	Correction of inappropriate fabric repairs i.e. reinstate lime-based breathable pointing and remove external rendering.
Single glazed thermally inefficient windows.	• Replacement windows still thermally insufficient • Double glazed replacement windows without consideration for maintaining ventilation and air movement	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/ or installed in consideration with improving ventilation strategy generally - subject to planning permission as likely to be listed.
Flagstone floors to basements and some ground floors vulnerable to ground moisture	Retrofit concrete floor construction in lieu of suspended timber floors and original solid floor constructions susceptible to ground moisture.	• Remove retrofit concrete floors and reinstate timber floors with adequate sub-floor ventilation • Remove and replace concrete floors with DPM and correct termination detailing
Below ground basements with earth retaining walls vulnerable to ground water intrusion	Installation of type A cementitious tanking system preventing breathability and exerting additional pressure on the structure.	Remove cementitious tanking system and installation of Type C Cavity membrane water management system

Back to the archetype summary table

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 1 (A*) (continued)

Georgian – 1714 - 1837



Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating Amber (3)		
No mechanical extraction and instead reliant on natural ventilation.	Insufficient mechanical extraction (assuming it has been installed since original construction)	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms • Consideration for whole house ventilation and possible heat recovery.
Insufficient heating system reliant on coal/wood burning fires	Insufficient heating system installed (assuming it has been installed since original construction)	• Installation of more efficient and effective heating system. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation)
	Lack of sub-floor ventilation i.e. raised external ground levels, blocked sub-floor air vents	• Lowering external ground levels and installing of French drain when less feasible to lower level entirely. • Installation of additional sub-floor ventilation
Shallow brick foundations render the buildings vulnerable to structural movement	Lack of on-going maintenance and remediation	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Problems associated with rainwater disposal, blocked and defective box gutters behind parapet walls		
Disused chimneys (defective flaunching, lack of pots etc) may be vulnerable to rainwater ingress.		
Often buildings of this era are of 'special interest', warranting every effort to preserve them. Therefore they may be listed by English Heritage under the control of a Local Authority building conservation officer and special planning restrictions.	Lack of on-going maintenance and remediation as a result of statutory restrictions.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope in collaboration with relevant consultants and authorities.

Back to the archetype summary table

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 2 (A*)

Victorian – 1837 - 1901

Typically solid masonry construction varying in thickness dependant on height, and built with a multitude of different bricks including original London and yellow stock. Varying roof constructions including pitched, roof and inverted 'London Roofs'. Introduction of Public Health Act to improve internal conditions and the health of occupants within this period.

Back to the archetype summary table

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
No horizontal Damp Proof Course (DPC) - pre-1875	Sand and cement 'remedial' damp proofing plastering systems preventing breathability.	Removal of impervious plastering system and replaster with a breathable application.
Bridged DPC i.e. rendered plinth in contact with ground	Further bridged DPC i.e. external rendering in contact with ground, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors
Original slate or tiled roofing without undersarking and damaged/dislodged tiles.	Inappropriate roofing materials installed leading to associated defects and water ingress i.e. concrete tiles leading to spread, poor flashing replacement with non-metal equivalent.	Replacement roof with appropriate materials, terminations and preparation etc.
Passage of lateral penetrating through solid wall construction and inherently more porous structure	• Sand and cement point in lieu of lime-based and resultant trapped moisture • Retrofit external rendering preventing building breathability.	Correction of inappropriate fabric repairs i.e. reinstate lime-based breathable pointing and remove external rendering.
Single glazed thermally inefficient windows.	• Replacement windows still thermally insufficient • Double glazed replacement windows without consideration for maintaining ventilation and air movement	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
• Solid floor construction without DPM and susceptible to ground water intrusion. • Suspended timber floor construction	Retrofit concrete floor construction in lieu of suspended timber floors and original solid floor constructions susceptible to ground moisture.	• Remove retrofit concrete floors and reinstate timber floors with adequate sub-floor ventilation • Remove and replace concrete floors with DPM and correct DPC termination."
Below ground basements with earth retaining walls vulnerable to ground water intrusion	Installation of type A cementitious tanking system preventing breathability and exerting additional pressure on the structure.	Remove cementitious tanking system and installation of Type C Cavity membrane water management system
No mechanical extraction and instead reliant on natural ventilation.	Insufficient mechanical extraction (assuming it has been installed since original construction)	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 2 (A*) (continued)

Victorian - 1837-1901

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Insufficient heating system reliant on coal/wood burning fires	Insufficient heating system installed (assuming it has been replaced since original construction)	• Installation of more efficient and effective heating system. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation) • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation)
Excessive humidity in sub-floor void owing to saturated substrate and inefficient ventilation	Lack of sub-floor ventilation i.e. raised external ground levels, blocked sub-floor air vents	• Lowering external ground levels and installing of French drain when less feasible to lower level entirely. • Installation of additional sub-floor ventilation
Shallow brick foundations render the buildings vulnerable to structural movement	Lack of on-going maintenance and remediation	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Problems associated with rainwater disposal, blocked and defective.		
Differential movement of bay wall structures from main wall leading to water ingress through flat and pitched roofs and affecting timber bressmer.		
Cracking of stone window cills allowing rainwater penetration into core of solid walls below cill height.		
Disused chimneys (defective flaunching, lack of pots etc) may be vulnerable to rainwater ingress.		
Underground drainage and mains feed routed beneath the property inhibiting access and maintenance	Lack of on-going maintenance and remediation of existing services as required.	Replacement services with modern materials, and re-routed as feasible to ensure on-going accessibility and maintenance.
Lead mains water feed routed beneath property and susceptible to degradation.		
		Installation of on-going smart monitoring

Back to the archetype summary table

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 3 (B*)

Edwardian – 1901 - 1910

Buildings very much followed the influence of Victorian builders and regulations and many of the buildings similar in design and construction with mainly solid external walls and timber suspended ground floors.

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Bridged DPC i.e. rendered plinth in contact with ground and allowing Rising Damp.	Further bridged DPC i.e. external rendering in contact with ground, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors
Original slate or tiled roofing without undersarking and damaged/dislodged tiles and prone to ingress.	Inappropriate roofing materials installed leading to associated defects and water ingress i.e. concrete tiles leading to spread, poor flashing replacement with non-metal equivalent.	Replacement roof with appropriate materials, terminations and preparation etc.
• Passage of lateral penetrating through solid wall construction and inherently more porous structure.	• Sand and cement point in lieu of lime-based and resultant trapped moisture. • Retrofit external rendering preventing building breathability.	Correction of inappropriate fabric repairs i.e. reinstate lime-based breathable pointing and remove external rendering.
Single glazed thermally inefficient windows prone to heat loss.	• Replacement windows still thermally insufficient • Double glazed replacement windows without consideration for maintaining ventilation and air movement.	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
• Solid floor construction without DPM and susceptible to ground water intrusion. • Suspended timber floor construction.	Retrofit concrete floor construction in lieu of suspended timber floors and original solid floor constructions susceptible to ground moisture.	• Remove retrofit concrete floors and reinstate timber floors with adequate sub-floor ventilation • Remove and replace concrete floors with DPM.
No mechanical extraction of moisture-laden air and instead reliant on natural ventilation.	Insufficient mechanical extraction (assuming it has been installed since original construction).	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.
Insufficient heating system reliant on coal/wood burning fires to assist in controlling humidity.	Insufficient heating system installed (assuming it has been replaced since original construction).	• Installation of more efficient and effective heating system. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation). • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation).

Back to the archetype summary table

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 3 (B*)

Edwardian – 1901 - 1910

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Excessive humidity in sub-floor void owing to saturated substrate and inefficient ventilation.	Lack of sub-floor ventilation i.e. raised external ground levels, blocked sub-floor air vents.	• Lowering external ground levels and installing of French drain when less feasible to lower level entirely. • Installation of additional sub-floor ventilation.
Shallow brick foundations render the buildings vulnerable to structural movement and resultant ingress.	Lack of on-going maintenance and remediation.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Problems associated with rainwater disposal, blocked and defective.		
Disused chimneys (defective flaunching, lack of pots etc) may be vulnerable to rainwater ingress.		
Underground drainage and mains feed routed beneath the property inhibiting access and maintenance if defective.		Replacement services with modern materials, and re-routed as feasible to ensure on-going accessibility and maintenance.
Lead mains water feed routed beneath property and susceptible to degradation.		
	Sand and cement 'remedial' damp proofing plastering systems preventing breathability.	Removal of impervious plastering system and replaster with a breathable application.
		Installation of on-going smart monitoring

Back to the archetype summary table

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 4 (B*)

1920 - 1930

Evolution of Edwardian construction though with emergence and increased popularity of cavity wall construction though many building still constructed in traditional solid wall arrangement. Typically constructed in semi-detached pairs and largely served by hipped roofs with gable ends though mansard roofs also not uncommon.

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Clinker walls with high conductivity and misdiagnosed Rising Damp.	Sand and cement 'remedial' damp proofing plastering systems preventing breathability of structure.	Removal of impervious plastering system and replaster with a breathable application.
Bridged DPC i.e. rendered plinth in contact with ground and allowing Rising Damp.	Further bridged DPC i.e. external rendering in contact with ground, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors.
• Original roofs without undersarking , damaged/ dislodged tiles and prone to water ingress. • Imported interlocking clay roof tiles difficult to locate replacements.	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
• Passage of lateral penetrating through solid wall construction and inherently more porous structure.	• Sand and cement point in lieu of lime-based and resultant trapped moisture. • Retrofit external rendering preventing building breathability.	Correction of inappropriate fabric repairs i.e. reinstate lime-based breathable pointing and remove external rendering.
Original single glazed 'Crittal' type windows, prone to heat loss and internal condensation.	• Replacement windows still thermally insufficient. • Double glazed replacement windows without consideration for maintaining ventilation and air movement.	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
Solid floor construction without DPM and susceptible to ground water intrusion.	Retrofit concrete floor construction in lieu of suspended timber floors and original solid floor constructions susceptible to ground moisture.	• Remove retrofit concrete floors and reinstate timber floors with adequate sub-floor ventilation. • Remove and replace concrete floors with DPM.
Timber boarded and battened timber flooring overlaid onto solid oversite coated with bitument tar and flooring secured by ferrous nails. Prone to ground water penetration and floor timber decay.		
No mechanical extraction of moisture-laden air and instead reliant on natural ventilation.	Insufficient mechanical extraction assuming it has been installed since original construction.	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 4 (B*)

1920 - 1930

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Insufficient heating system to assist in controlling humidity.	Insufficient heating system installed (assuming it has been replaced since construction).	• Installation of more efficient and effective heating system. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation). • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation).
No cavity wall insulation to improve heat retention.	Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp.	Removal of inappropriately installed cavity wall insulation (as applicable) and installation of water-repellent cavity fill insulation.
Excessive humidity in sub-floor void owing to saturated substrate and inefficient ventilation .	Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp.	• Lowering external ground levels and installing of French drain when less feasible to lower level entirely. • Installation of additional sub-floor ventilation.
Shallow concrete foundations resulting in potential structural movement and resultant ingress.	Lack of on-going maintenance and remediation.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Cavity wall tie failure and lack of adequate number of ties, resulting on potential movement and resultant ingress.		
Problems associated with rainwater disposal, blocked and defective.		
Disused chimneys (defective flaunching, lack of pots etc) may be vulnerable to rainwater ingress.		
Services routed underground and prone to corrosion and associated leaks.		Replacement services with modern materials, and re-routed as feasible to ensure on-going accessibility and maintenance.
Cold water storage tanks in loft voids and risk of frozen and burst pipes.		
Lack of insulation behind lower mansard, curved ceiling (soffits) and around dormer windows -prone to heat loss and increased risk of condensation.		Installation of additional insulation and thermal detailing around susceptible cold bridging details.
		Installation of on-going smart monitoring.

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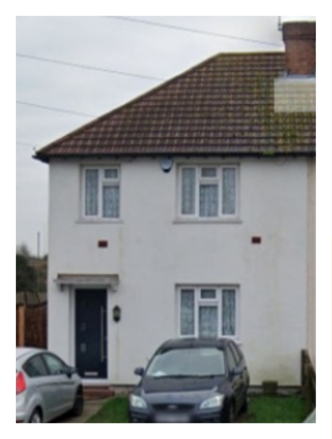
Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 5 (C*)

1930 - 1940

Similar construction to buildings constructed in 1920's though with increased popularity of cavity wall construction. Typically constructed in semi-detached pairs as per the previous era.



Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Clinker walls with high conductivity and misdiagnosed Rising Damp.	Sand and cement 'remedial' damp proofing plastering systems preventing breathability.	Removal of impervious plastering system and replaster with a breathable application.
Bridged DPC i.e. render in contact with ground.	Further bridged DPC i.e. raised ground levels, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors.
• Original roofs without undersarking and damaged/dislodged tiles. • Imported interlocking clay roof tiles difficult to locate replacements.	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
Original thermally inefficient windows prone to heat loss and condensation.	• Replacement windows still thermally insufficient • Double glazed replacement windows without consideration for maintaining ventilation and air movement.	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
• Solid floor construction without DPM and susceptible to ground water intrusion. • Sulphate attack to solid ground supported flooring.	Retrofit concrete floor construction still without DPM, bridging DPC etc.	Remove and replace concrete floors with DPM and appropriate detailing with DPC.
Insufficient mechanical extraction of moisture-laden air.	Insufficient mechanical extraction (assuming it has been replaced).	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.
Insufficient original heating system to assist in controlling humidity.	Insufficient heating system installed (assuming it has been replaced).	• Installation of more efficient and effective heating system. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation). • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation).
No cavity wall insulation to improve heat retention.	Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp.	Removal of inappropriately installed cavity wall insulation (as applicable) and installation of water-repellent cavity fill insulation.

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 5 (C*)

1930 - 1940

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Excessive humidity in sub-floor void owing to saturated substrate and inefficient ventilation.	Lack of sub-floor ventilation i.e. raised external ground levels, blocked sub-floor air vents.	• Lowering external ground levels and installing of French drain when less feasible to lower level entirely. • Installation of additional sub-floor ventilation.
Shallow concrete foundations resulting in potential structural movement and resultant ingress.	Lack of on-going maintenance and remediation.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Cavity wall tie failure and lack of adequate number of ties, resulting on potential movement and resultant ingress.		
Problems associated with rainwater disposal, blocked and defective.		
Disused chimneys (defective flaunching, lack of pots etc) may be vulnerable to rainwater ingress.		
Services routed underground and prone to corrosion.		Replacement services with modern materials, and re-routed as necessary to ensure on-going accessibility and maintenance.
Cold water storage tanks in loft voids and risk of frozen and burst pipes.		
	Retrofit external rendering preventing building breathability.	Correction of inappropriate fabric repairs i.e. remove external rendering.
		Installation of additional insulation and thermal detailing around susceptible cold bridging details.
		Installation of on-going smart monitoring.

Back to the archetype summary table

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 6 (C/D*)

1940 - 1960

Further popularity of cavity wall construction and introduction of timber frame 'cross wall' construction to construct properties in mass. Use of concrete frame construction and pre-fabrication techniques such as pre-fabricated concrete panelling also increasing in popularity. High-rise construction also far more prevalent than previous era's.

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Red (5)		
Clinker walls with high conductivity and misdiagnosed Rising Damp.	Sand and cement 'remedial' damp proofing plastering systems preventing breathability.	Removal of impervious plastering system and replaster with a breathable application.
Bridged DPC i.e. render in contact with ground allowing Rising Damp.	Further bridged DPC i.e. raised ground levels, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors.
Original thermally inefficient windows.	• Replacement windows still thermally insufficient. • Double glazed replacement windows without consideration for maintaining ventilation and air movement.	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
• Solid floor construction without DPM and susceptible to ground water intrusion. • Sulphate attack to solid ground supported flooring.	• Retrofit concrete floor construction still without DPM, bridging DPC etc. • DPM's to solid floors applied on top of the solid floor often resulting in ponding water.	Remove and replace concrete floors with DPM and appropriate detailing with DPC.
Insufficient mechanical extraction of moisture-laden air.	Insufficient mechanical extraction (assuming it has been replaced).	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.
Use of hot water back boiler systems behind coal/wood burning fireplaces, generally inefficient and poor control of humidity subsequently.	Insufficient heating system installed (assuming it has been replaced).	Installation of more efficient and effective heating system.
No cavity wall insulation to improve heat retention.	Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp.	Removal of inappropriately installed cavity wall insulation (as applicable) and installation of water-repellent cavity fill insulation.

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 6 (C/D*)

1940 - 1960

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Red (5)		
Cavity wall tie failure and lack of adequate number of ties, resulting on potential movement and resultant ingress.	Lack of on-going maintenance and remediation.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
• Problems associated with rainwater disposal, blocked and defective. • 'Finlock' concrete eaves gutters cast in-situ, prone to cracking and prone to water escape.		
High silica content brickwork, prone to expansion and contraction properties leading to widespread cracking of outer leaf masonry.		
Concrete external walls ranging from around mid 1920's through to late 1960's. 75mm thick outer concrete walls often overclad with cementitious render, prone to water ingress and steel banding corrosion.		
Cross wall' construction prone to heat loss and water ingress. Inherent concrete defects, particularly in high-rise construction leading to water ingress.	Retrofit external rendering preventing building breathability.	• Correction of inappropriate fabric repairs i.e. remove external rendering. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation). • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation).
Wimpey No fines concrete panel walls. Poor thermal resistivity leading to greater heat loss.		
	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
		Replacement services with modern materials, and re-routed as necessary to ensure on-going accessibility and maintenance.
		Installation of additional insulation and thermal detailing around susceptible cold bridging details
		Installation of on-going smart monitoring.

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 7 (D/E/F*)

1960 - 1980

“Continuation of construction techniques adopted, particularly around pre-fabrication and high rise construction which significantly increased in this period - about 55,000 blocks were built in this period – over 400,000 homes.”

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (5)		
Clinker walls with high conductivity and misdiagnosed Rising Damp.	Sand and cement ‘remedial’ damp proofing plastering systems preventing breathability.	Removal of impervious plastering system and replaster with a breathable application.
Bridged DPC i.e. render in contact with ground allowing Rising Damp.	Further bridged DPC i.e. raised ground levels, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors
Original thermally inefficient windows prone to heat loss and condensation.	• Replacement windows still thermally insufficient. • Double glazed replacement windows without consideration for maintaining ventilation and air movement.	Replacement thermally efficient windows with provision for ventilation i.e. trickle vents and/or installed in consideration with improving ventilation strategy generally.
• Vibrate reinforced concrete ground floor slabs without the installation of a DPM. • Sulphate attack to solid ground supported flooring.	• Retrofit concrete floor construction still without DPM, bridging DPC etc. • DPM’s to solid floors applied on top of the solid floor often resulting in ponding water.	Remove and replace concrete floors with DPM and appropriate detailing with DPC.
Insufficient mechanical extraction of moisture-laden air.	Insufficient mechanical extraction	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.
Insufficient heating system installed to assist in controlling humidity.	Insufficient heating system installed (assuming it has been replaced)	Installation of more efficient and effective heating system.
No cavity wall insulation to improve heat retention or inappropriately filled cavities inhibiting air movement and providing passage for lateral penetrating damp.	• Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp. • Blocked cavity walls i.e. debris.	Removal of inappropriately installed cavity wall insulation (as applicable) and installation of water-repellent cavity fill insulation.

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 7 (D/E/F*)

1960 - 1980

Back to the archetype summary table

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (5)		
Cavity wall tie failure and lack of adequate number of ties, resulting on potential movement and resultant ingress.	Lack of on-going maintenance and remediation	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Use of Reinforced Autoclaved Aerated Concrete (RAAC) used mainly in Public buildings, proven to have a lower structural loading capability than traditional concrete and therefore prone to collapse especially where water penetration is occuring.		
Use of high aluminium concrete leading to structural movement and resultant ingress.		
High silica content brickwork, prone to expansion and contraction properties leading to widespread cracking of outer leaf masonry.		
Blocked/deteriorating rainwater goods.		
Lack of adequate expansion and construction joints especially to parapet walls.		
Lack of weep tubes to perp ends to lead lined concrete 'boot' lintels.		
Inherent concrete defects, particularly in high-rise construction leading to water ingress.		
Use of concrete panel block walling resulting in high heat loss (see above).	Retrofit external rendering preventing building breathability.	• Correction of inappropriate fabric repairs i.e. remove external rendering. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation) • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation)
• Use of Copper roofing - Problems when replacing eaves guttering due to the eaves detailing and termination of the copper. • Lack of adequate expansion joints to flat roof parapet walls and resultant ingress.	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
Cold bridging detailing around exposed concrete elements.	Lack of intervention/detailing to remediate details inherently susceptitble to cold bridging.	Installation of additional insulation and thermal detailing around susceptible cold bridging details
		Replacement services with modern materials, and re-routed as feasible to ensure on-going accessibility and maintenance.
		Installation of on-going smart monitoring

Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 8 (G/H/I*)

1980 - 2000

Huge expansion in technical information and radically new, performance-based Building Regulations appeared in 1985. Safety standards in homes were improved significantly and set a path for much safer homes today. Considerable increase in the use of insulation within construction i.e. within cavity walls and loft voids etc.

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Insufficient mechanical extraction of moisture laden air	Insufficient mechanical extraction (assuming replacement)	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.
• No cavity wall insulation. • Greater insulation within building fabric i.e. cavities/loft voids etc lead to decreased air transfer and resultant damp.	• Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp. • Blocked cavity walls i.e. debris.	• Removal of inappropriately installed cavity wall insulation (as applicable) and installation of water-repellent cavity fill insulation. • See also improved ventilation solutions.
Cavity wall tie failure and lack of adequate number of ties, resulting on potential movement and resultant ingress.	Lack of on-going maintenance and remediation.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Blocked/deteriorating rainwater goods		
Cold bridging detailing around exposed concrete elements.	Lack of intervention/detailing to remediate details inherently susceptitble to cold bridging.	Installation of additional insulation and thermal detailing around susceptible cold bridging details
Plastic baths and WC cisterns prone to movement and leakage around and under baths/shower trays and to flush & waste pipes to WC's.	NA	Replacement services/appliances with modern materials.
Double glazed windows installed without consideration for maintaining ventilation and preventing air movement.	NA	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
	Bridged DPC i.e. raised ground levels, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors
	Retrofit external rendering preventing building breathability.	• Correction of inappropriate fabric repairs i.e. remove external rendering. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation). • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation).
	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
		Installation of more efficient and effective heating system.
		Installation of on-going smart monitoring

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 9 (J/K/L*)

2000 - present

Increased and considerable focus of the energy efficiency and safety of new homes. Residential construction remained similar to the prior era with cavity wall instruction still relevant in various forms. Steel and concrete frame construction widespread both in commercial and residential construction.

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Insufficient mechanical extraction of moisture-laden air at Construction.	Insufficient mechanical extraction (assuming replacement).	• Installation of Part F compliant mechanical ventilation in both Kitchens and Bathrooms. • Consideration for whole house ventilation and possible heat recovery.
Greater focus on improved energy efficiency and air tightness, leading to potential building risks such as greater insulation within building fabric i.e. cavities/loft voids etc lead to decreased air transfer and resultant damp.	• Cavity wall inappropriately/incorrectly filled with cavity wall insulation inhibiting air movement and providing passage for lateral penetrating damp. • Blocked cavity walls i.e. debris.	• Removal of inappropriately installed cavity wall insulation (as applicable) and installation of water-repellent cavity fill insulation. • See also improved ventilation solutions.
Cavity wall tie failure and lack of adequate number of ties, resulting on potential movement and resultant ingress.	Lack of on-going maintenance and remediation.	Ensure on-going asset management, maintenance and appropriate remediation to maintain the integrity of the external envelope.
Blocked/deteriorating rainwater goods.		
Cold bridging detailing around exposed concrete elements.	Lack of intervention/detailing to remediate details inherently susceptitble to cold bridging.	Installation of additional insulation and thermal detailing around susceptible cold bridging details
Plastic baths and WC cisterns prone to movement and leakage around and under baths /Shower trays and to flush & waste pipes to WC's.	NA	Replacement services/appliances with modern materials.

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Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

Archetype 9 (J/K/L*)

2000 - present

Typical risks/defects associated with period of construction	Typical measure (s)/ alterations since original construction	Possible upgrade/remedial solutions
RAG rating: Amber (4)		
Double glazed windows installed without consideration for maintaining ventilation and preventing air movement	NA	Replacement thermally efficient windows with provision for ventilation i.e trickle vents and/or installed in consideration with improving ventilation strategy generally.
	Bridged DPC i.e. raised ground levels, plastering in contact with solid floors etc.	Removal of DPC bridges i.e. cutting back external rendered plinth, plaster in contact with floors
	Retrofit external rendering preventing building breathability.	• Correction of inappropriate fabric repairs i.e. remove external rendering. • Installation of internal wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation). • Installation of external wall insulation to improve thermal efficiency (with consideration of maintaining/improving ventilation).
	Inappropriate roofing materials installed leading to associated defects and water ingress.	Replacement roof with appropriate materials, terminations and preparation etc.
		Installation of more efficient and effective heating system.
		Installation of on-going smart monitoring.

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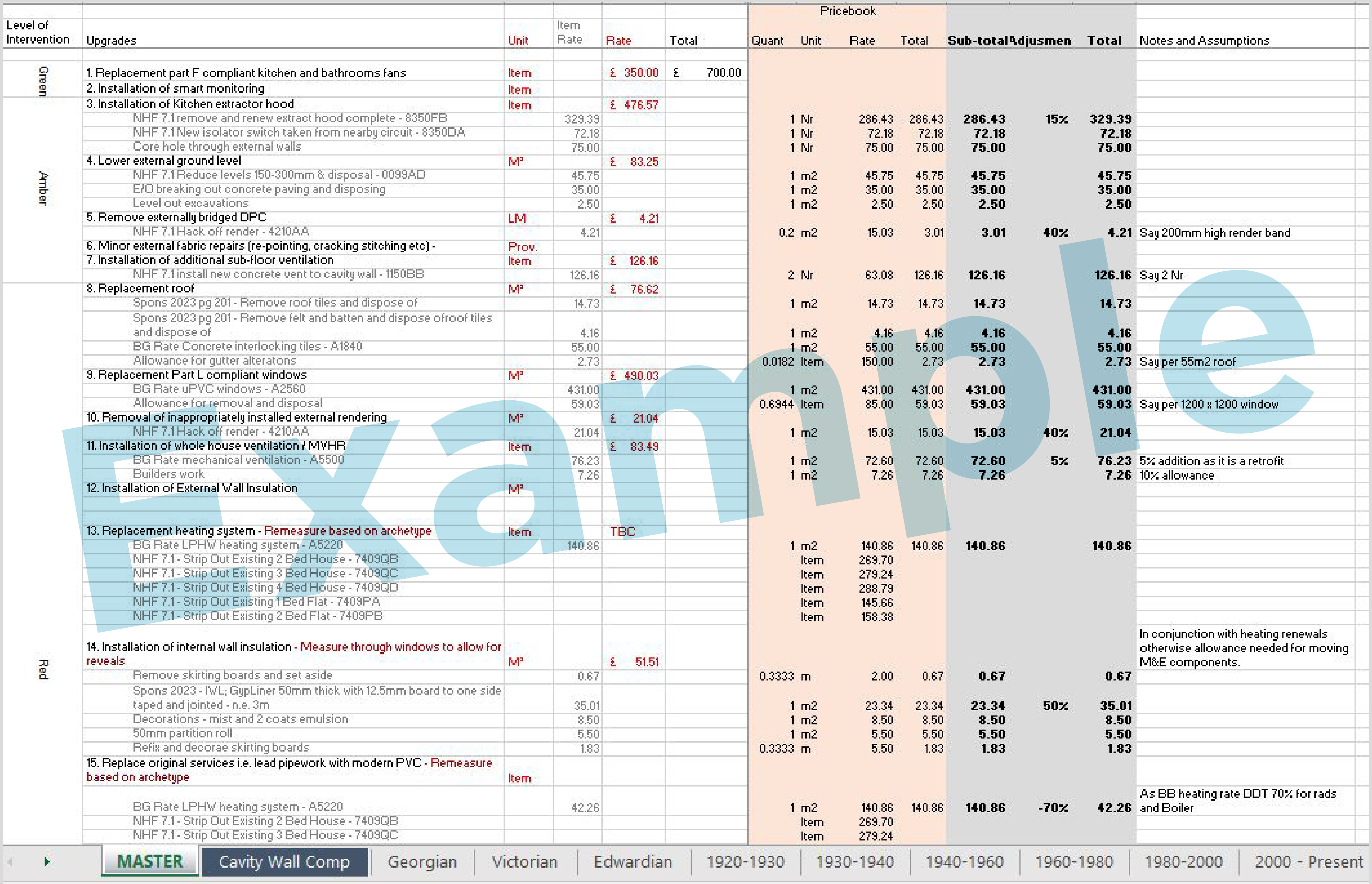
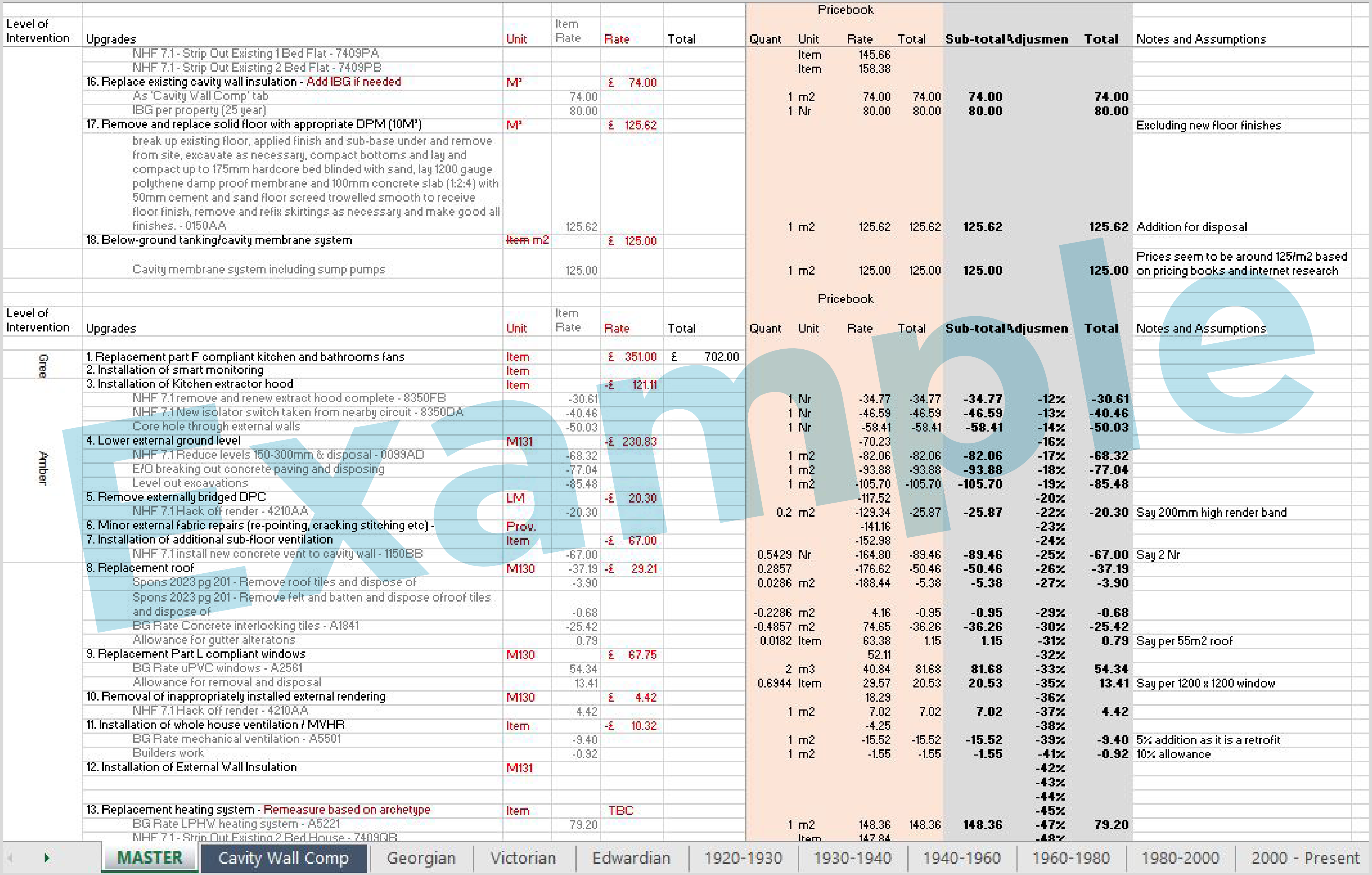
Note - * after (Letter) in brackets denotes age banding from table S1 shown in figure 40

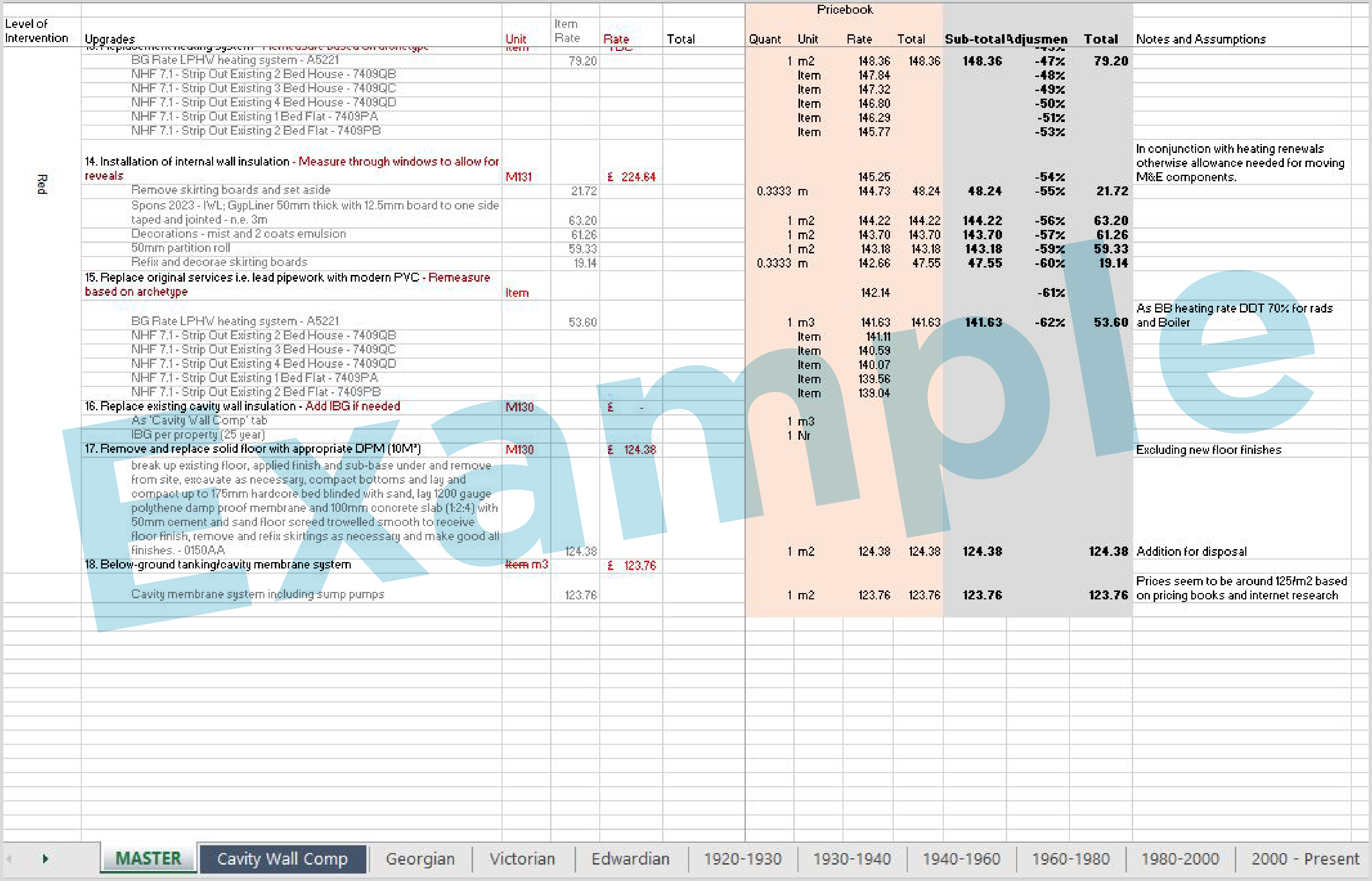
APPENDIX 3 - COST EXAMPLE



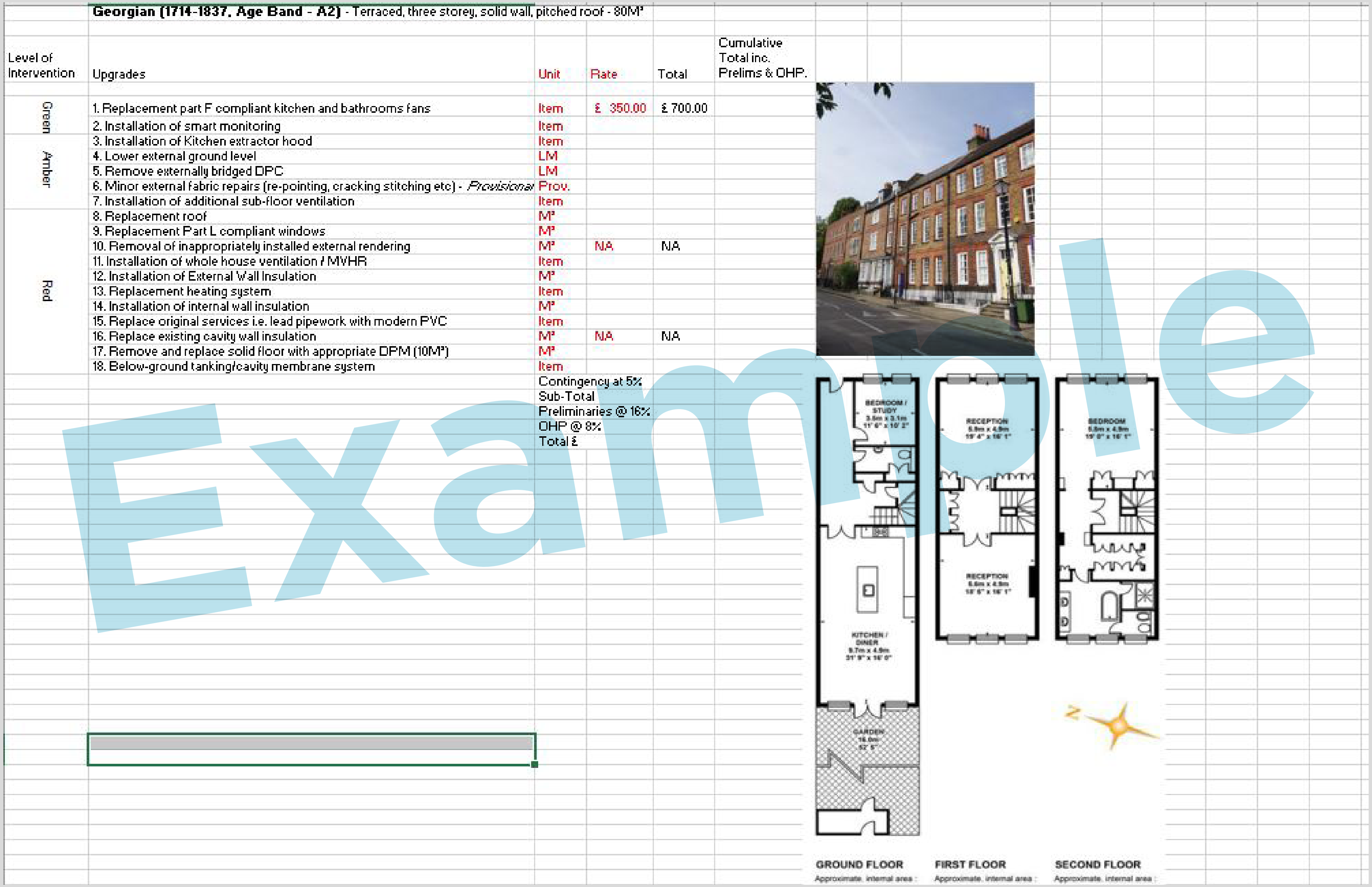
						Pricebook							
Level of Intervention	Upgrades	Unit	Item Rate	Rate	Total	Quant	Unit	Rate	Total	**Sub-total**	**Adjusmen**	**Total**	Notes and Assumptions
Green	1. Replacement part F compliant kitchen and bathrooms fans	Item		£ 350.00	£ 700.00								
	2. Installation of smart monitoring	Item											
Amber	3. Installation of Kitchen extractor hood	Item		£ 476.57									
	NHF 7.1 remove and renew extract hood complete - 8350FB		329.39			1	Nr	286.43	286.43	**286.43**	**15%**	**329.39**	
	NHF 7.1 New isolator switch taken from nearby circuit - 8350DA		72.18			1	Nr	72.18	72.18	**72.18**		**72.18**	
	Core hole through external walls		75.00			1	Nr	75.00	75.00	**75.00**		**75.00**	
	4. Lower external ground level	M²		£ 83.25									
	NHF 7.1 Reduce levels 150-300mm & disposal - 0099AD		45.75			1	m2	45.75	45.75	**45.75**		**45.75**	
	E/O breaking out concrete paving and disposing		35.00			1	m2	35.00	35.00	**35.00**		**35.00**	
	Level out excavations		2.50			1	m2	2.50	2.50	**2.50**		**2.50**	
	5. Remove externally bridged DPC	LM		£ 4.21									
	NHF 7.1 Hack off render - 4210AA		4.21			0.2	m2	15.03	3.01	**3.01**	**40%**	**4.21**	Say 200mm high render band
	6. Minor external fabric repairs (re-pointing, cracking stitching etc) -	Prov.											
	7. Installation of additional sub-floor ventilation	Item		£ 126.16									
	NHF 7.1 install new concrete vent to cavity wall - 1150BB		126.16			2	Nr	63.08	126.16	**126.16**		**126.16**	Say 2 Nr
Red	8. Replacement roof	M²		£ 76.62									
	Spons 2023 pg 201 - Remove roof tiles and dispose of		14.73			1	m2	14.73	14.73	**14.73**		**14.73**	
	Spons 2023 pg 201 - Remove felt and batten and dispose ofroof tiles and dispose of		4.16			1	m2	4.16	4.16	**4.16**		**4.16**	
	BG Rate Concrete interlocking tiles - A1840		55.00			1	m2	55.00	55.00	**55.00**		**55.00**	
	Allowance for gutter alteratons		2.73			0.0182	Item	150.00	2.73	**2.73**		**2.73**	Say per 55m2 roof
	9. Replacement Part L compliant windows	M²		£ 490.03									
	BG Rate uPVC windows - A2560		431.00			1	m2	431.00	431.00	**431.00**		**431.00**	
	Allowance for removal and disposal		59.03			0.6944	Item	85.00	59.03	**59.03**		**59.03**	Say per 1200 x 1200 window
	10. Removal of inappropriately installed external rendering	M²		£ 21.04									
	NHF 7.1 Hack off render - 4210AA		21.04			1	m2	15.03	15.03	**15.03**	**40%**	**21.04**	
	11. Installation of whole house ventilation / MVHR	Item		£ 83.49									
	BG Rate mechanical ventilation - A5500		76.23			1	m2	72.60	72.60	**72.60**	**5%**	**76.23**	5% addition as it is a retrofit
	Builders work		7.26			1	m2	7.26	7.26	**7.26**		**7.26**	10% allowance
	12. Installation of External Wall Insulation	M²											
	13. Replacement heating system - Remeasure based on archetype	Item		TBC									
	BG Rate LPHW heating system - A5220		140.86			1	m2	140.86	140.86	**140.86**		**140.86**	
	NHF 7.1 - Strip Out Existing 2 Bed House - 7409QB						Item	269.70					
	NHF 7.1 - Strip Out Existing 3 Bed House - 7409QC						Item	279.24					
	NHF 7.1 - Strip Out Existing 4 Bed House - 7409QD						Item	288.79					
	NHF 7.1 - Strip Out Existing 1 Bed Flat - 7409PA						Item	145.66					
	NHF 7.1 - Strip Out Existing 2 Bed Flat - 7409PB						Item	158.38					
	14. Installation of internal wall insulation - Measure through windows to allow for reveals	M²		£ 51.51									In conjunction with heating renewals otherwise allowance needed for moving M&E components.
	Remove skirting boards and set aside		0.67			0.3333	m	2.00	0.67	**0.67**		**0.67**	
	Spons 2023 - IWL; GypLiner 50mm thick with 12.5mm board to one side taped and jointed - n.e. 3m		35.01			1	m2	23.34	23.34	**23.34**	**50%**	**35.01**	
	Decorations - mist and 2 coats emulsion		8.50			1	m2	8.50	8.50	**8.50**		**8.50**	
	50mm partition roll		5.50			1	m2	5.50	5.50	**5.50**		**5.50**	
	Refix and decorae skirting boards		1.83			0.3333	m	5.50	1.83	**1.83**		**1.83**	
	15. Replace original services i.e. lead pipework with modern PVC - Remeasure based on archetype	Item											
	BG Rate LPHW heating system - A5220		42.26			1	m2	140.86	140.86	**140.86**	**-70%**	**42.26**	As BB heating rate DDT 70% for rads and Boiler
	NHF 7.1 - Strip Out Existing 2 Bed House - 7409QB						Item	269.70					
	NHF 7.1 - Strip Out Existing 3 Bed House - 7409QC						Item	279.24					



						Pricebook							
Level of Intervention	Upgrades	Unit	Item Rate	Rate	Total	Quant	Unit	Rate	Total	Sub-total	Adjusmen	Total	Notes and Assumptions
	NHF 7.1 - Strip Out Existing 1 Bed Flat - 7409PA						Item	145.66					
	NHF 7.1 - Strip Out Existing 2 Bed Flat - 7409PB						Item	158.38					
	16. Replace existing cavity wall insulation - Add IBG if needed	M²		£ 74.00									
	As 'Cavity Wall Comp' tab		74.00			1	m2	74.00	74.00	**74.00**		**74.00**	
	IBG per property (25 year)		80.00			1	Nr	80.00	80.00	**80.00**		**80.00**	
	17. Remove and replace solid floor with appropriate DPM (10M²)	M²		£ 125.62									Excluding new floor finishes
	break up existing floor, applied finish and sub-base under and remove from site, excavate as necessary, compact bottoms and lay and compact up to 175mm hardcore bed blinded with sand, lay 1200 gauge polythene damp proof membrane and 100mm concrete slab (1:2:4) with 50mm cement and sand floor screed trowelled smooth to receive floor finish, remove and refix skirtings as necessary and make good all finishes. - 0150AA		125.62			1	m2	125.62	125.62	**125.62**		**125.62**	Addition for disposal
	18. Below-ground tanking/cavity membrane system	~~Item~~ m2		£ 125.00									
	Cavity membrane system including sump pumps		125.00			1	m2	125.00	125.00	**125.00**		**125.00**	Prices seem to be around 125/m2 based on pricing books and internet research
						Pricebook							
Level of Intervention	Upgrades	Unit	Item Rate	Rate	Total	Quant	Unit	Rate	Total	Sub-total	Adjusmen	Total	Notes and Assumptions
Gree	1. Replacement part F compliant kitchen and bathrooms fans	Item		£ 351.00	£ 702.00								
	2. Installation of smart monitoring	Item											
Amber	3. Installation of Kitchen extractor hood	Item		-£ 121.11									
	NHF 7.1 remove and renew extract hood complete - 8350FB		-30.61			1	Nr	-34.77	-34.77	**-34.77**	**-12%**	**-30.61**	
	NHF 7.1 New isolator switch taken from nearby circuit - 8350DA		-40.46			1	Nr	-46.59	-46.59	**-46.59**	**-13%**	**-40.46**	
	Core hole through external walls		-50.03			1	Nr	-58.41	-58.41	**-58.41**	**-14%**	**-50.03**	
	4. Lower external ground level	M131		-£ 230.83				-70.23			**-16%**		
	NHF 7.1 Reduce levels 150-300mm & disposal - 0099AD		-68.32			1	m2	-82.06	-82.06	**-82.06**	**-17%**	**-68.32**	
	E/O breaking out concrete paving and disposing		-77.04			1	m2	-93.88	-93.88	**-93.88**	**-18%**	**-77.04**	
	Level out excavations		-85.48			1	m2	-105.70	-105.70	**-105.70**	**-19%**	**-85.48**	
	5. Remove externally bridged DPC	LM		-£ 20.30				-117.52			**-20%**		
	NHF 7.1 Hack off render - 4210AA		-20.30			0.2	m2	-129.34	-25.87	**-25.87**	**-22%**	**-20.30**	Say 200mm high render band
	6. Minor external fabric repairs (re-pointing, cracking stitching etc) -	Prov.						-141.16			**-23%**		
	7. Installation of additional sub-floor ventilation	Item		-£ 67.00				-152.98			**-24%**		
	NHF 7.1 install new concrete vent to cavity wall - 1150BB		-67.00			0.5429	Nr	-164.80	-89.46	**-89.46**	**-25%**	**-67.00**	Say 2 Nr
	8. Replacement roof	M130	-37.19	-£ 29.21		0.2857		-176.62	-50.46	**-50.46**	**-26%**	**-37.19**	
	Spons 2023 pg 201 - Remove roof tiles and dispose of		-3.90			0.0286	m2	-188.44	-5.38	**-5.38**	**-27%**	**-3.90**	
	Spons 2023 pg 201 - Remove felt and batten and dispose ofroof tiles and dispose of		-0.68			-0.2286	m2	4.16	-0.95	**-0.95**	**-29%**	**-0.68**	
	BG Rate Concrete interlocking tiles - A1841		-25.42			-0.4857	m2	74.65	-36.26	**-36.26**	**-30%**	**-25.42**	
	Allowance for gutter alteratons		0.79			0.0182	Item	63.38	1.15	**1.15**	**-31%**	**0.79**	Say per 55m2 roof
	9. Replacement Part L compliant windows	M130		£ 67.75				52.11			**-32%**		
	BG Rate uPVC windows - A2561		54.34			2	m3	40.84	81.68	**81.68**	**-33%**	**54.34**	
	Allowance for removal and disposal		13.41			0.6944	Item	29.57	20.53	**20.53**	**-35%**	**13.41**	Say per 1200 x 1200 window
	10. Removal of inappropriately installed external rendering	M130		£ 4.42				18.29			**-36%**		
	NHF 7.1 Hack off render - 4210AA		4.42			1	m2	7.02	7.02	**7.02**	**-37%**	**4.42**	
	11. Installation of whole house ventilation / MVHR	Item		-£ 10.32				-4.25			**-38%**		
	BG Rate mechanical ventilation - A5501		-9.40			1	m2	-15.52	-15.52	**-15.52**	**-39%**	**-9.40**	5% addition as it is a retrofit
	Builders work		-0.92			1	m2	-1.55	-1.55	**-1.55**	**-41%**	**-0.92**	10% allowance
	12. Installation of External Wall Insulation	M131									**-42%**		
											-43%		
											-44%		
	13. Replacement heating system - Remeasure based on archetype	Item		TBC							**-45%**		
	BG Rate LPHW heating system - A5221		79.20			1	m2	148.36	148.36	**148.36**	**-47%**	**79.20**	
	NHF 7.1 - Strip Out Existing 2 Bed House - 7409QB						Item	147.84			**-48%**		



Level of Intervention	Upgrades	Unit	Item Rate	Rate	Total	Pricebook							Notes and Assumptions
						Quant	Unit	Rate	Total	Sub-total	Adjusmen	Total	
Red	BG Rate LPHW heating system - A5221		79.20			1	m2	148.36	148.36	148.36	-47%	79.20	
	NHF 7.1 - Strip Out Existing 2 Bed House - 7409QB						Item	147.84			-48%		
	NHF 7.1 - Strip Out Existing 3 Bed House - 7409QC						Item	147.32			-49%		
	NHF 7.1 - Strip Out Existing 4 Bed House - 7409QD						Item	146.80			-50%		
	NHF 7.1 - Strip Out Existing 1 Bed Flat - 7409PA						Item	146.29			-51%		
	NHF 7.1 - Strip Out Existing 2 Bed Flat - 7409PB						Item	145.77			-53%		
	14. Installation of internal wall insulation - Measure through windows to allow for reveals	M131		£ 224.64				145.25			-54%		In conjunction with heating renewals otherwise allowance needed for moving M&E components.
	Remove skirting boards and set aside		21.72			0.3333	m	144.73	48.24	48.24	-55%	21.72	
	Spons 2023 - IWL; GypLiner 50mm thick with 12.5mm board to one side taped and jointed - n.e. 3m		63.20			1	m2	144.22	144.22	144.22	-56%	63.20	
	Decorations - mist and 2 coats emulsion		61.26			1	m2	143.70	143.70	143.70	-57%	61.26	
	50mm partition roll		59.33			1	m2	143.18	143.18	143.18	-59%	59.33	
	Refix and decorae skirting boards		19.14			0.3333	m	142.66	47.55	47.55	-60%	19.14	
	15. Replace original services i.e. lead pipework with modern PVC - Remeasure based on archetype	Item						142.14			-61%		
	BG Rate LPHW heating system - A5221		53.60			1	m3	141.63	141.63	141.63	-62%	53.60	As BB heating rate DDT 70% for rads and Boiler
	NHF 7.1 - Strip Out Existing 2 Bed House - 7409QB						Item	141.11					
	NHF 7.1 - Strip Out Existing 3 Bed House - 7409QC						Item	140.59					
	NHF 7.1 - Strip Out Existing 4 Bed House - 7409QD						Item	140.07					
	NHF 7.1 - Strip Out Existing 1 Bed Flat - 7409PA						Item	139.56					
	NHF 7.1 - Strip Out Existing 2 Bed Flat - 7409PB						Item	139.04					
	16. Replace existing cavity wall insulation - Add IBG if needed	M130		£ -									
	As 'Cavity Wall Comp' tab					1	m3						
	IBG per property (25 year)					1	Nr						
	17. Remove and replace solid floor with appropriate DPM (10M²)	M130		£ 124.38									Excluding new floor finishes
	break up existing floor, applied finish and sub-base under and remove from site, excavate as necessary, compact bottoms and lay and compact up to 175mm hardcore bed blinded with sand, lay 1200 gauge polythene damp proof membrane and 100mm concrete slab (1:2:4) with 50mm cement and sand floor screed trowelled smooth to receive floor finish, remove and refix skirtings as necessary and make good all finishes. - 0150AA		124.38			1	m2	124.38	124.38	124.38		124.38	Addition for disposal
	18. Below-ground tanking/cavity membrane system	~~Item~~ m3		£ 123.76									
	Cavity membrane system including sump pumps		123.76			1	m2	123.76	123.76	123.76		123.76	Prices seem to be around 125/m2 based on pricing books and internet research



Georgian (1714-1837, Age Band - A2) - Terraced, three storey, solid wall, pitched roof - 80M²

Level of Intervention	Upgrades	Unit	Rate	Total	Cumulative Total inc. Prelims & OHP.
Green	1. Replacement part F compliant kitchen and bathrooms fans	Item	£ 350.00	£ 700.00	
	2. Installation of smart monitoring	Item			
Amber	3. Installation of Kitchen extractor hood	Item			
	4. Lower external ground level	LM			
	5. Remove externally bridged DPC	LM			
	6. Minor external fabric repairs (re-pointing, cracking stitching etc) - *Provisional*	Prov.			
	7. Installation of additional sub-floor ventilation	Item			
Red	8. Replacement roof	M²			
	9. Replacement Part L compliant windows	M²			
	10. Removal of inappropriately installed external rendering	M²	NA	NA	
	11. Installation of whole house ventilation / MVHR	Item			
	12. Installation of External Wall Insulation	M²			
	13. Replacement heating system	Item			
	14. Installation of internal wall insulation	M²			
	15. Replace original services i.e. lead pipework with modern PVC	Item			
	16. Replace existing cavity wall insulation	M²	NA	NA	
	17. Remove and replace solid floor with appropriate DPM (10M²)	M²			
	18. Below-ground tanking/cavity membrane system	Item			
		Contingency at 5%			
		Sub-Total			
		Preliminaries @ 16%			
		OHP @ 8%			
		Total £			

APPENDIX 4 - SURVEYORS TOOLKIT AND INTERPRETING READINGS

Equipment	Application	Limitations	Interpretation
Hygrometer	Used to measure: • Relative humidity in % • Air temperature in °C • Surface temperature in °C	The hygrometer will only measure that snapshot in time, where a switchee device will measure conditions over a period of time. Seasonal limitations exist where the external air temperature and conditions may influence the internal conditions, and therefore readings tend to be more aligned in Summer months when windows are open more often than in Winter	**Internal air RH:** Dry - < 45% Ideal Range 45-60% **At risk of damp range 60 - 70%** High risk of Damp – 70% > **Ideal internal temperature range:** 18 – 24°C
Electrical Resistance Meter	Used to measure: • Moisture content in timber • Wood moisture equivalent in other materials	When used to measure wood moisture equivalent in materials other than timber, the meter can pick up other conductive materials that may be present such as foil backed wallpaper, clinker block, lead paint and hydroscopic salts. The meter records the moisture content in %. It does not identify the source or the cause of any damp. Different meters are calibrated to measure different materials, not all do the same.	**Timber:** Dry – 8-14% **Potential risk of damp 15-19%** Damp and at risk – 20%> If the meter reads the material as dry, whether timber or otherwise, it really is dry because water conducts electricity, and therefore if not present in any material, there is no conductivity. If all timber skirtings in a room are damp, the floor needs investigation. If only isolated timber skirtings in a room are damp, the wall needs investigation.
Thermographic camera	Used to measure: • Heat loss • Temperature difference • Air leakage • Moisture presence • Heat from electrical resistance in services or flows within service pipes	Thermographic cameras have seasonal limitations. In Summer, many households do not have heating on, and the external temperature is such that the range of temperature difference between building fabric to external air temperature, is not great enough to demonstrate problem areas or air leakage demonstrated by temperature differences in leaking air. Moisture presence in building fabric and heat present in building service installations are unlikely to be significantly affected by seasonal limitations.	Anything more than basic image interpretation should be undertaken by a thermographer qualified to level 1 (basic) through to level 3 (advanced)

Equipment	Application	Limitations	Interpretation
Borescope	Used for visibility and recording images of: • Cavities • Sub-floor • Voids	The borescope camera will only show the small sample area accessed and may require further opening up work if the view is obstructed. The type of borescope is important. i.e. flexible or rigid, and location of camera lens. The flexible type typically has the camera lens on the end of the nozzle, which is useful for sub-floor, but not for cavities. Rigid borescopes typically has the camera lens on the side which allows for a 180 degree view point.	A survey undertaken with a borescope will often only confirm the built condition and will often require further investigation if a higher level of certainty is required. Photos analysed by surveyor and recommendations made.
Vane anemometer	Used to measure: • Rates of extraction of air in litres/second	This does not determine if the rates are sufficient for the room type, occupation and size. Further calculations would need to be done in line with Part F.	The extraction rates measured should be interpreted as part of a holistic assessment and may indicate insufficient extraction or problems with installation or servicing.
Floor hygrometer	Used to measure: • Relative humidity in % • Air temperature in °C	This meter needs to be left at the property over a seven-day period and cannot be concluded during the initial survey. Although the measuring typically happens over a seven-day period, seasonal fluctuations could influence readings.	**RH:** At risk – 75%+ Damp – 85%+
Speedy carbide meter	Used to measure: • Moisture content in masonry. A measured sample of masonry is extracted and mixed with calcium carbide. If moisture is present, acetylene gas is formed and the pressure this exerts in the chamber is converted to a % based reading.	The height from which the sample is extracted may influence whether the result is dry or damp i.e. low level damp may be present, but may not rise above 500mm from floor level. The meter records with accuracy, whether the sample is dry or damp. It does not identify the source or the cause of any damp.	**Brick and plaster:** Dry - 0.2-0.5% Damp – 1%+ **Mortar:** Dry – 0.2-1% Damp – 1%+
Capacitance meter	Used to measure: • Radio frequency through a material (walls or floors) which translate to moisture content up to 19mm below the surface of the material	The height from which the measurement is taken if testing a wall, will influence readings. Good practice is to take measurements at a consistent range of heights throughout the property, including low, medium and high level. The meter records whether the sample is dry or potentially damp. It does not identify the cause of any damp.	**Dry** – 60 – 199 **Damp** – 200 – 999

APPENDIX 5 - CASE STUDIES

Case study 1 – Different factors contributing to to damp and mould growth

Introduction

Baily Garner were instructed to carry out Level 3 & 4 damp and mould surveys at two residential blocks. The scope of survey included a full external survey and our report provided detailed findings and recommendations outlining suitable measures and proposed remedial works.

Historic mould and damp issues had been reported by residents over several years and although a number of attempts at remedial works had been undertaken, damp issues were ongoing.

In the most severe case the resident had been decanted due to significant mould growth and condensation dripping from ceilings as seen in images 1 & 2.

Background

The brief identified flats which were reported as suffering with the most significant damp and mould. However, it was subsequently recommended and agreed that further surveys would be undertaken to additional flats to establish a wider understanding of the issues effecting the blocks and to gather information on typical archetypes, including ground floor, top floor and those with large areas of external walls.

The surveys were undertaken during July and August 2023 and 14 flats were inspected, which represented a 35% sample.

The extent of the survey included both non-intrusive and intrusive methods and followed all steps on ‘The A-Z of Damp Diagnosis’ flow chart.

Image 1 – Damp and mould growth

Image 2 – Condensation dripping from ceilings

Image 3 – Block 1 Courtyard

Image 4 – Block 2 elevation

Property details

The blocks are constructed in fair faced brickwork, with a Flemish bond to the outer leaf and blockwork to the internal leaf. On initial inspection it was thought that the walls were traditional solid construction, but it was subsequently determined following intrusive internal surveys and optical endoscope inspections that the main walls are cavity walls, with snapped headers giving the appearance of solid brickwork. Images 3 & 4 show typical elevations of the blocks.

The highest level of external perimeter walls are cast insitu concrete, approximately 750mm high. These walls are an extension of the brickwork cavity and presumably cast at the same time as the concrete roof slab.

Both blocks have flat roofs, which were found to have been overlaid with different roofing systems.

Floors are insitu concrete and walkways to communal are an extension of the floor slabs. It is assumed that the cavity walls were built off the concrete slabs, potentially creating a source of water ingress at the junction of the walkway and external wall.

Survey type and equipment used

Level 3 surveys comprised a rudimentary review of the property, primarily based on a visual inspection, including the use of an electrical moisture meter and the collection of key data involving the full range of moisture meter accessories as described in the Surveyors Toolkit, Appendix 4.

We used a GE Protimeter Moisture Measurement System (MMS) to test all low level timber skirting boards and door linings.

An Electrical Capacitance Meter was used to randomly map and test wall surface areas for any indication of raised reading. Where we recorded readings above 199, which is an indication of dampness, we carried out calcium carbide testing to ascertain the moisture of the masonry and undertook endoscope surveys to visually inspect the cavity.

To test the effectiveness of extract fans, we used a Velocity Volume Thermo-Anemometer to measure the internal and external extract pull rates as shown in images 5 & 6.

Level 4 surveys involved a full pathology survey, undertaking invasive testing, chemical analysis including calcium carbide testing using the specialist equipment shown in image 7. The resultant results in image 8 confirmed very high levels of moisture in the blockwork wall.

Image 5 – Internal extract pull testing

Image 6 – External extract pull testing

Image 7 – Calcium Carbide test kit

Image 8 – Calcium Carbide test results

Image 9 - Endoscope view into cavity

Image 10 – cantilevered concrete balcony

External Findings – following Step 2 of the Flow Chart

The external condition of the blocks was generally reasonable and reflective of the buildings age and construction with minor brickwork and repointing repairs being identified.

Where a number of the cavity walls were inspected, there was evidence of physical blockages within the cavity which require clearing, as shown in image 9.

Although vulnerable detailing was identified around the balcony door and wall junctions, there was no evidence of water penetration in these areas. All private balconies and communal walkways were in good condition with adequate drainage.

As shown in images 10 & 11, to check the integrity of the walkway and wall junction a water and dye test by locally flooding the external communal walkway covering, including the formed upstands, was undertaken. This there was no evidence of water penetration into the flat below, confirming the walkway detail as adequate.

The most significant issue is the flat roof to both blocks which were retaining moisture, potentially leaking and causing damp to internal flats.

Image 11 – Dye test in progress

‘Intangible’ Internal Findings – following Step 3 of the Flow Chart

The surveys did not identify any significant dampness or mould growth in any of the inspected flats. Where mould growth was found it was minor and localised. We were advised by several residents that the landlord had undertaken ad hoc cleaning/removal of mould over the last few years.

Many flats did not have mechanical extractor fans fitted within the kitchen and bathroom areas.

In addition, kitchen (and one case living room) doors within some flats had been removed by residents to maximise useful kitchen space.

This was encouraging the migration of any excess vapour water laden air produced during peak periods of cooking and washing, from the kitchen to the other vulnerable (habitable) rooms.

‘Tangible’ Internal Findings – following Steps 4-10 of the Flow Chart

The inspection and data recorded, as seen in image 12, confirmed the moisture content of the internal air within the flats inspected was below the benchmark of 70% relative humidity at which mould growth will typically occur grow on walls, ceilings and window surfaces.

However, in the majority of flats, as seen in image 13, the surface temperature of external walls and window wall reveals were found to be at or marginally above the dew point temperature of the internal air and therefore vulnerable to condensation and resultant mould growth particularly in colder weather. Certain archetypes were also deemed to be more vulnerable as they had significant areas of external walls with large ratios of windows.

Image 12 – Recording relative humidity and room temperature

Image 13 – Recording surface temperatures and dew point differences

There was evidence of internal drylining/boarding installed to external walls in bedroom and living rooms being installed on an ad hoc basis, in an attempt to improve the thermal performance of the external walls to minimise and/or prevent condensation and resultant mould growth.

Thermal imagery of the solid floor slab (image 15), located above the unheated storage area (image 14), identified significant heat loss via the solid floor (which forms the ceiling over the external storerooms and circulation area directly below the property.

A good example highlighting the difference between ‘tangible’ and ‘intangible’ was the diagnosis of damp in one of the top floor flats. There were no signs of mould, but the electrical capacitance meter readings were high and subsequent calcium carbide testing confirmed that the moisture content of the blockwork inner leaf was over 6%. Further investigations triggered by these results, determined that the flat roof was retaining water and causing dampness in the perimeter wall at high level.

Image 14 – Soffit to unheated space below flat

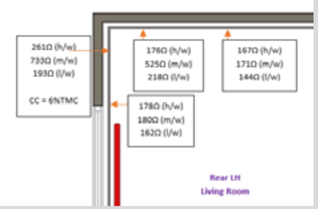


Image 16 - Electrical capacitance readings

Image 18 - high moisture reading

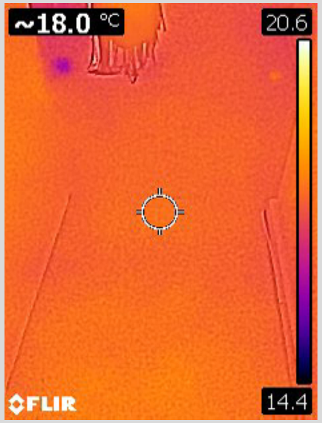


Image 15 – Thermal image of floor above unheated space

Image 17 - 733 Electrical capacitance reading

Conclusions and Lessons Learnt

A key lesson learnt is the importance of understanding the difference between the 'tangible' and 'intangible' damp diagnosis phases of an inspection and not assuming anything, as clearly highlighted when carrying out electrical capacitance testing.

As discussed in Section 11 of the Toolkit, we know that internal damp and mould issues can broadly be categorised into three contributing factors, including the failure in the original design & construction of the building, any defects present and use and occupation.

The Level 3 & 4 surveys concluded that there was evidence that all contributing factors existed and resulting in an increase to the damp and mould risk within these properties, including:

- Poor workmanship in the original construction ie debris in cavity walls.
- Poor design. ie. thermal bridging issues and lack of ventialtion.
- Current building defects – ie. overlaid flat roofing system retaining water.
- Use and Occupation – ie. removal of doors, underheating of flat.

Our findings and report followed Step 12 of the Flow Chart and provided recommendations on further investigations and proposed remedial works. This included measures such as rehanging missing kitchen doors and installing extract ventilation where not present. These were considered cost effective solutions that could be implemented in the short term.

Medium and longer term solutions, as outlined in Section 11 of the Toolkit, included replacing the flat roofs, general external maintenance and consideration of internal wall insulation to improve thermal efficiency.

The surveys identified that adhoc and reactive remedial measures had been undertaken at different times in an attempt to address damp and mould issues. Although some of these measures may have had a degree of success, the key takeaway is that a more holistic and strategic approach is required which considers the retrofit agenda, building safety and the new Decent Homes Standard when launched.

Case study 2 – Problems with interfaces between installed Energy Efficiency Measures

Introduction

This case study illustrates the risk of uncoordinated installation of Energy Efficiency Measures creating an increased risk of dampness and mould growth.

Baily Garner were appointed by our client, a Social Housing Landlord, to carry out non-intrusive damp and mould surveys inclusive of remediation recommendations. This particular survey was carried out in April 2023. The house is a typical social housing archetype in the Midlands and consists of a 3-bedroom semi-detached property with cavity wall construction (See image 1).

Background

The extent of the survey was limited to only non-intrusive methods, including the first ten steps on the Damp and Mould Growth Diagnosis flow chart in Section 9. Following interpretation of the non-intrusive testing results, the surveyor did not recommend further intrusive investigations be carried out. The surveyor was able to define the cause and source of dampness and mould growth utilising some of the equipment from the surveyor's toolkit.

Nature of the problem

The EPC rating of the property at the time of inspection was a D, and it was noted the property had recently benefited from a number of upgrades including 200mm of insulation to the loft as well as double-glazed windows with trickle vents. The cavity wall was filled with 90mm insulation.

During the inspection (Step 3 on the flow chart) the tenant reported that the second floor was particularly cold and advised that was where the mould growth was located. The property was not over-occupied. The surveyor still carried out testing on the ground floor to eliminate any building defects as the cause of dampness and condensation. Readings were taken using an electrical resistance meter to timberwork on the ground floor. All readings were found to be within a dry range.

The relative humidity (RH) on the ground floor was found to be between a dry and damp range at 65% in moisture producing rooms, and an average temperature of 19°C.

On the first floor, the temperature was 17.5°C, and the RH ranged from 47.5 to 54% in bedrooms. Surface temperature readings were also recorded and were 15.5°C on average in first floor rooms, but notably lower along the ceiling to wall junction.

Key Issues

Each room on the first floor had concentrated mould growth to the angled part of the ceiling to wall junction, commonly known as a skeiling. It can be clearly seen from image 2 that the mould growth was present between timber joists of the skeiling. This is a re-occurring detail across this archetype. It was also noted that there was a lack of mechanical extract ventilation in wet rooms contributing to humidity levels.

Mould growth occurs where condensation forms, and this particular mould growth pattern suggests that there is a cold spot between the timber joists as indicated in diagram 1. From the loft space inspection, there had been a recent installation of insulation at ceiling joist level. It is likely that through the introduction of this insulation, a cold spot (differential thermal bridge) has been introduced, between the cavity wall and the loft, that wasn't there previously.

Problems in the interfaces between Energy Efficiency Measures such as wall and loft insulation are common, as can be seen in Image 4, where the upper part of the external wall extends into the roof structure creating a thermal bridge.

Image 1

Initial findings

Having found no evidence of penetrating, rising or traumatic damp on the ground floor or first floors, the source of the condensation could only be attributed to the use and occupation in the property, though it should be noted that the cold spot exacerbates the ability for condensation to form.

Our remediation recommendations were to;

- Remove the contaminated plasterboard
- Install an eaves vent tray to allow continuous ventilation from soffit to roof space
- Install mineral wool insulation to fill gaps between joists
- Install insulated plasterboard cut to fit the skeiling and wall
- Re-decorate
- Install additional mechanical extraction in wet rooms

Conclusions and Lessons Learnt

As we enter an extensive programme of retrofit works there needs to be a greater awareness of the interfaces between installed energy efficiency measures.

In this particular case, the intentions were to improve the EPC rating and thermal performance of the property by replacing windows and introducing loft insulation, which in turn resulted in significant mould growth where the ceiling to wall junction interface detail was overlooked. Also, the impact of making the property more airtight with the upgraded windows perhaps wasn't communicated effectively with the tenant to help them understand how to manage condensation levels in the property and adjust to living in a better performing home.

If the installation of the Energy Efficiency Measures had been carried out in line with PAS2035 Retrofitting dwellings for improved energy efficiency – specification and guidance, or adopting it's risk based approach, this defect should not have occurred.

Image 2 - Pattern Mould Growth

Image 3 - Pattern Mould Growth

Image 4 - Problem interfaces

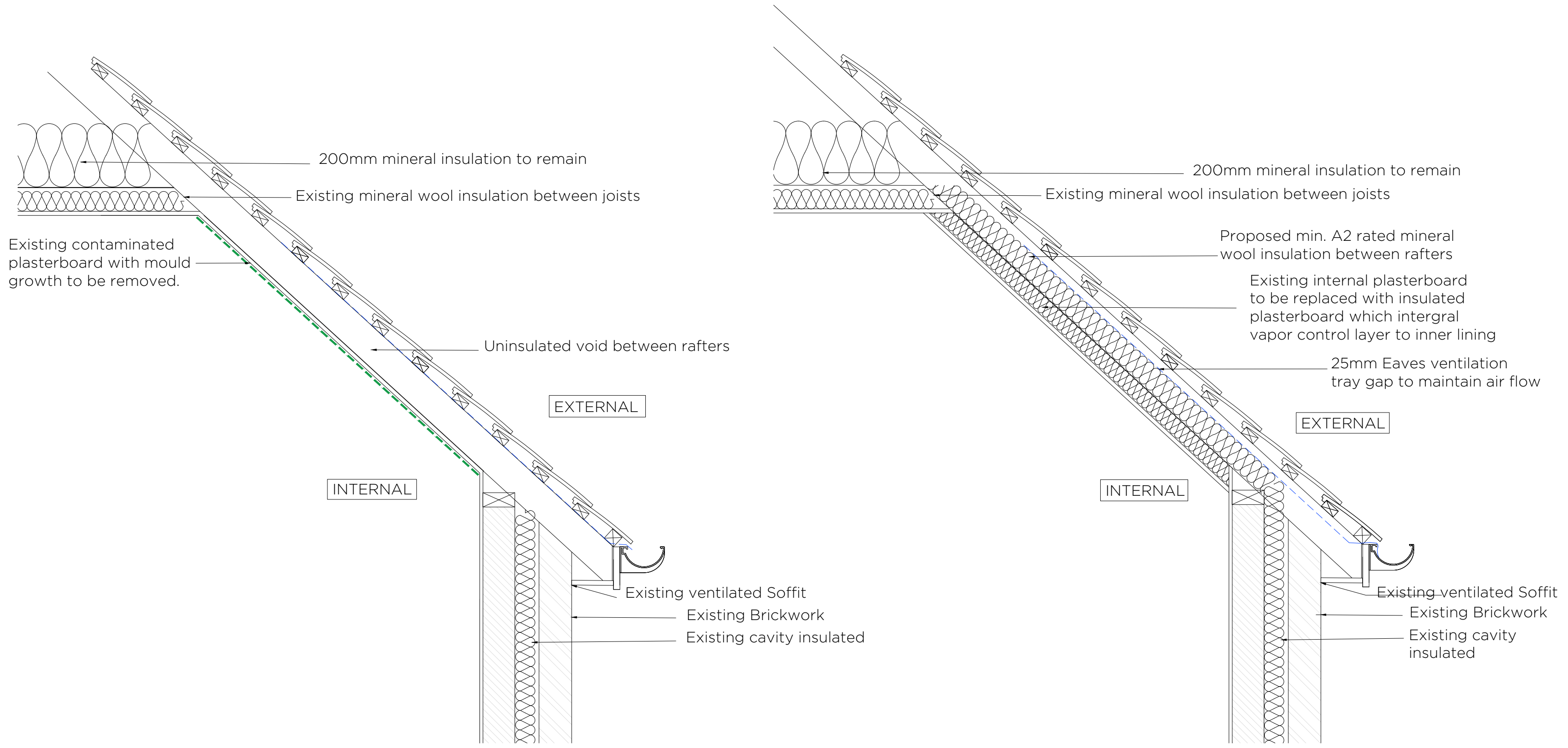


Diagram 1 – Existing and proposed soffit insualtion

Case Study 3 – The role of monitoring to verify results of thermal upgrade works to eradicate dampness and improve thermal efficiency.

Introduction

This case study illustrates the value of assessing ventilation and using monitoring to validate performance and changes in behaviour in relation to underheating by occupants and subsequent post works reductions in the likelihood of dampness and mould growth.

Baily Garner were appointed to act as Contract Administrator and provide all roles under the PAS2035 standard on a retrofit of 103 Local Authority properties funded under the Social Housing Decarbonisation Fund Wave 2.1.

Background

Properties were suffering from limited levels of condensation and dampness and the local Authority engaged with **Purrmetrix** to install temporary data loggers measuring temperature, humidity and CO_2 concentrations in properties pre and post funded retrofit works.

Properties were predominantly solid walled two story two and three bed end of terrace/semi detached or mid terrace properties with EPC ratings of D and below. Ventilation systems in properties were found to be intermittent extract fans to wet rooms. Some residents had reported problems with excessive heating costs and some condensation and mould growth.

Nature of the problem

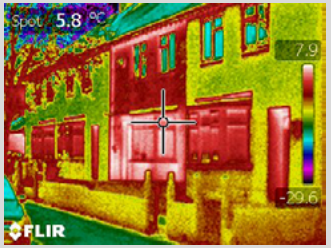
Works to properties included new external wall Insulation, loft insulation, new double-glazed windows and doors. The energy model was also targeting an air tightness value of 8m^3/m^2/hr which is lower that the default value of 15m^3/m^2/hr in RdSAP. Whilst improving energy efficiency this lower air tightness value was likely to increase the risk of damp and mould growth

Specific property problems were reported through the PAS2035 Retrofit Assessment Surveys. Properties were identified by the Local Authority for the pre works installation of Purrmetrix Data Loggers in typical areas as can be seen in figure 1. Data loggers were removed and then reinstalled following the works and data readings compared. This process is ongoing.

Key Issues

Concerns existed that whilst the themal envelope was being upgraded the reduction in air permeability and retention of existing ventilation systems may lead to condensation.

The internal conditions affecting air quality and in particular air temperature, relative humidity and CO_2 concentrations are not generally monitored before and after thermal upgrade works. Purrmetrix uses their 'warmscore' equipment and software to collect this data. It uses humidity data to assign a low / medium / high risk ranking for condensation at each of the points measured. This ranking is based on the duration and level of humidity. The risk is assessed in two dimensions, firstly the average level of humidity for each sensor and whether it is over a threshold, and secondly, the number of peak events where humidity is excessively high.



Initial findings

Pre works air pressure tests on properties demonstrated that the starting air pressure value was in fact closer to 10/m³/m²/hr.

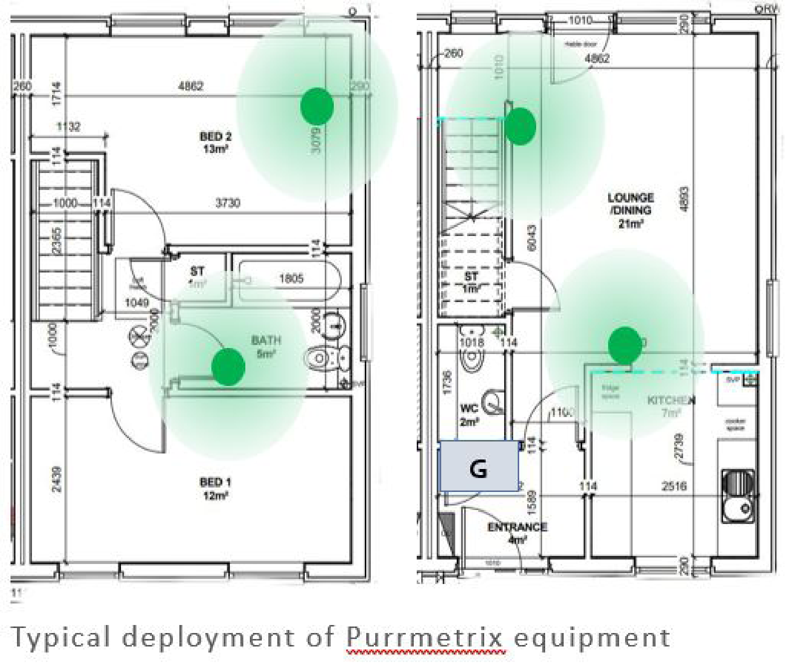
Monitoring of the properties demonstrated that the condensation risk in the properties had not increased as a result of the works but heating bills had reduced. See Figure 2.

Conclusions and Lessons Learnt

Mitigation of the risk of increased relative humidity, unresolved thermal bridges and inadequate mechanical ventilation systems resulting in condensation, damp and mould growth in retrofit projects needs to be carefully considered.

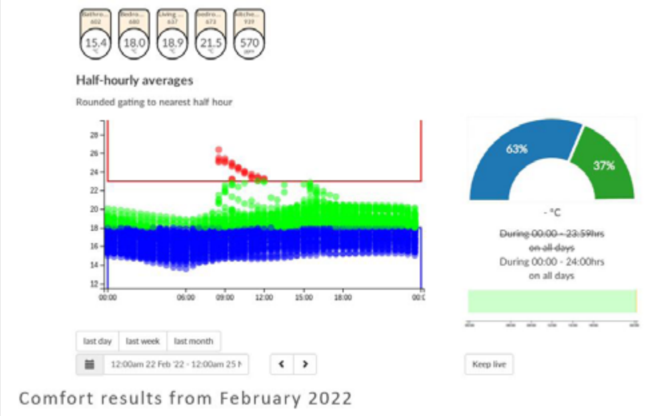
Air pressure test results found that the majority of properties were far more airtight that the RdSAP default values would suggest. However, if the converse were true the higher natural infiltration result would increase the post works risk of condensation through a reduced infiltration rate with the same residents in occupation.

Monitoring with Purrmetrix data loggers proved that the retrofit design had kept the condensation risk low in all properties monitored.



Typical deployment of Purrmetrix equipment

Figure 1 - Logger deployment



Half-hourly averages

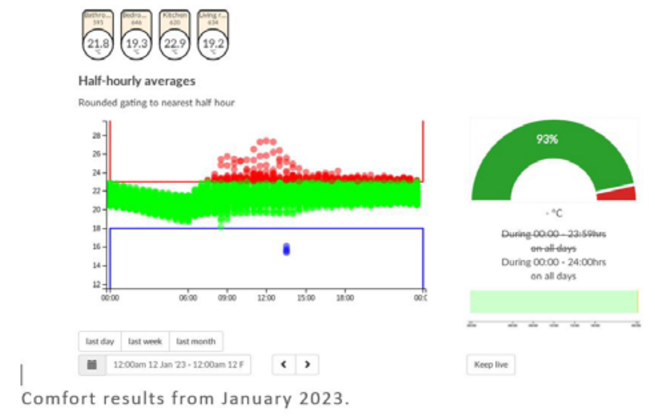
Rounded gating to nearest half hour

~~During 00:00 - 23:59hrs on all days~~
During 00:00 - 24:00hrs on all days

12:00am 22 Feb '22 - 12:00am 25 I

Comfort results from February 2022

Figure 2 - Part 1 Pre works



Half-hourly averages

Rounded gating to nearest half hour

~~During 00:00 - 23:59hrs on all days~~
During 00:00 - 24:00hrs on all days

12:00am 12 Jan '23 - 12:00am 12 F

Comfort results from January 2023.

Figure 3 - Part 2 Post works