ecological
BUILDING SYSTEMS

Putting People First: Airtightness & Indoor Air Quality

15th February 2017

Niall Crosson, Senior Engineer BTech, MEngSc,MIEI, CEPHC

HEALTHY BUILDINGS CONFERENCE & EXPO 2017
PRODUCTS • PEOPLE • PLANET

Meet our UK Team

ecological
BUILDING SYSTEMS

- Extensive technical support on Airtightness & Insulation
- Building Regulation advice
- U-Values & Hygrothermal Modelling
- Site support – Toolbox Talks
- Centre of Knowledge training centre
- Airtightness installation Videos
- specification clauses

Introduction to Ecological Building Systems Demonstration and Training Centre:

ecological
BUILDING SYSTEMS

Presentation Overview

- What is Airtightness?
- What are the benefits of airtightness?
- What about IAQ
- Selecting products and systems
- Potential moisture penetration into structural elements
- Solutions to help offset high VOCS
- Presentation summary
- Q & A

utting People First: Airtightness & Indoor Air Quality

otball opinion culture business lifestyle fashion environment tech travel

imate change wildlife energy pollution

Green buildings make you work smarter and sleep sounder, study reveals

Improved light, ventilation and heat control can boost workers' productivity by thousands of dollars a year and reduce instances of sick building syndrome

Working in a green building can make you healthier and brainier. Photograph: James Leynse/Corbis/Getty Images

https://www.theguardian.com/environment/2016/dec/16/green-buildings-make-you-work-smarter-and-sleep-sounder-study-reveals?CMP=Share_iOSApp_Other

CURRENT TOPIC & OPINION

Are our homes making us ill? The impact of energy efficiency on indoor air quality

The World Health Organization estimates that over 100,000 people die every year from conditions resulting from occupational exposure to asbestos. Similar to this, a significant proportion of asthma and related ill health is driven by poor indoor air quality. Stirling Howieson, Senior Lecturer in Architecture at the University of Strathclyde, takes a look at the increasing prevalence of asthma and asks the question, are our homes making us ill?

In 1898, the UK Chief Inspector of Factories reported that asbestos had 'easily demonstrated' health risks. Circa 3,000 deaths in the UK each year are due to asbestos exposure, and this is likely – given the incubation period – to rise to 10,000 by 2020.[1] The World Health Organization[2] (WHO) estimates that more than 107,000 people die each year from mesothelioma and asbestosis, resulting from occupational exposure. The use of asbestos was banned in the United Kingdom in 1999, 100 years after the emergence of an evidence base.

ENERGY EFFICIENCY VERSUS INDOOR AIR QUALITY

The quality of the air we breathe in our homes is predicated on the quality of the external air and internal ventilation rates. The drive to reduce carbon emissions through domestic energy efficiency has, in the last decade, driven increasing levels of air tightness in the building envelope – a strategy that has dramatically reduced what could be considered as fortuitously high, historical air infiltration rates. Recent research testing and post-occupancy evaluation[3] of new-build homes across Scotland constructed to the 2010 standard of 5 m³/m²/h at 50 Pa measured carbon dioxide levels in occupied bedrooms to be two to four times above the 1,000 ppm threshold that is commonly taken to represent reasonable indoor air quality.

At the outset of the 20th century, there were approximately 50 materials used to construct buildings. By the end of the century, Raw[4] claimed that this list had grown to around 55,000, half of them being synthetic. Compounds found in indoor air have off-gassed from the building materials, furnishings and fittings, internal processes and cleaning products. The most common gases found in the indoor environment are carbon dioxide and carbon monoxide, nitrogen and sulphur dioxide, formaldehyde and other volatile organic compounds, radon and ozone. The most common suspended matter are asbestos fibres, fibrous particulates (fibreglass or rockwool), bacteria and fungi, tobacco smoke, house dust mite (HDM) allergens, pollen and dust. Changes in lifestyle such as indoor clothes drying has also increased indoor humidity – a precondition for the colonisation and proliferation of HDMs.

INCREASING PREVALENCE OF ASTHMA

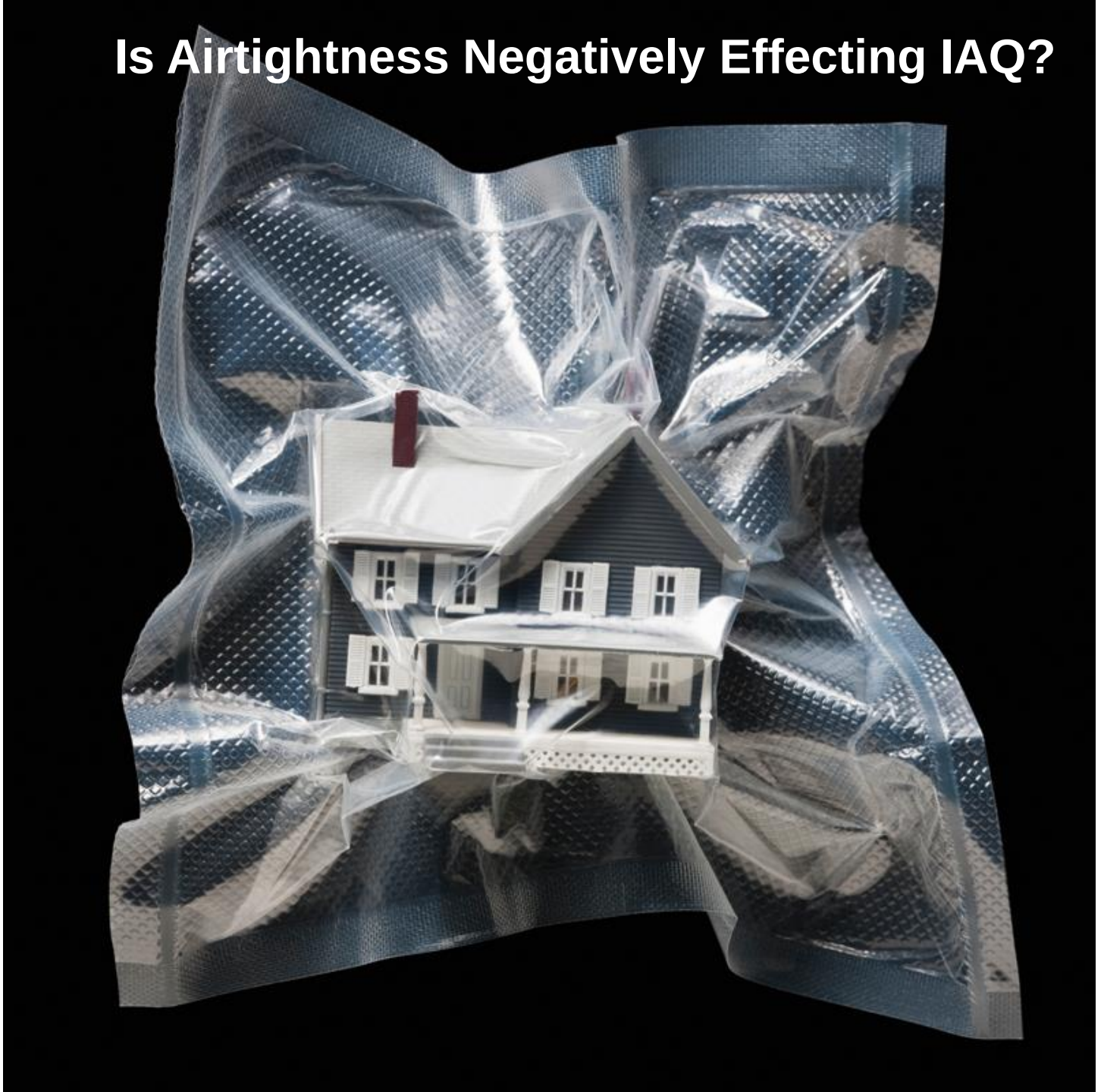
In February 2004, the Global Initiative for Asthma (GINA)[5] reported that 18.4% of Scots suffer from asthma. This compares with 15.3% in England, 10.9% in the United States, 6% in Belgium, 4.5% in Italy and 2.3% in Switzerland. Over the past 25 years, the incidence of asthma episodes has increased by a factor of three to four in adults and six in children. Although allergic disease is on the increase across the developed world, what factors are unique to Scotland and the UK that can be identified as key causal mechanisms driving these differentials?

The genesis of the asthma pandemic in Scotland is co-incident with the Organization of the Petroleum Exporting Countries (OPEC) oil crisis in the mid-1970s that produced a drive for energy efficiency. Increasing levels of insulation, combined with double-glazing and the sealing of open chimneys started to reduce domestic ventilation rates, which in turn produced a warmer and more humid indoor environment. HDMs thrive in high humidity that moistens their major food source, human skin scales. They excrete a range of highly allergenic proteins that have been identified both as a causal mechanism in the development of the disease, and as irritants likely to trigger and exacerbate asthmatic symptoms. Eight out of 10 asthmatic children have been found to be allergic to these proteins.[6] Such a hypothesis was further supported by two interventionist trials undertaken in North and South Lanarkshire[7,8] that confirmed the majority of dust reservoirs in dwellings contained HDM allergen levels above the WHO sensitisation threshold of 2 µg/g of fine dust, with 56% of beds found to contain concentrations known to cause an immediate acute reaction (10 µg/g). Steam-cleaning carpets and replacing bedding and mattresses successfully reduced HDM allergen levels by around 95%. Improving indoor air quality by installing mechanical whole house ventilation systems incorporating heat recovery increased lung function by over 20 L per minute in a cohort that had general practitioner diagnosed 'severe' asthma – compelling evidence that comprehensive allergen avoidance measures can produce immediate and significant improvements in a sensitised cohort.

Thirty years ago, the average house price in Scotland was less than three

http://journals.sagepub.com/doi/pdf/10.1177/1757913914551916

Is Airtightness Negatively Effecting IAQ?



What if a “Leaky” house has poor ventilation?

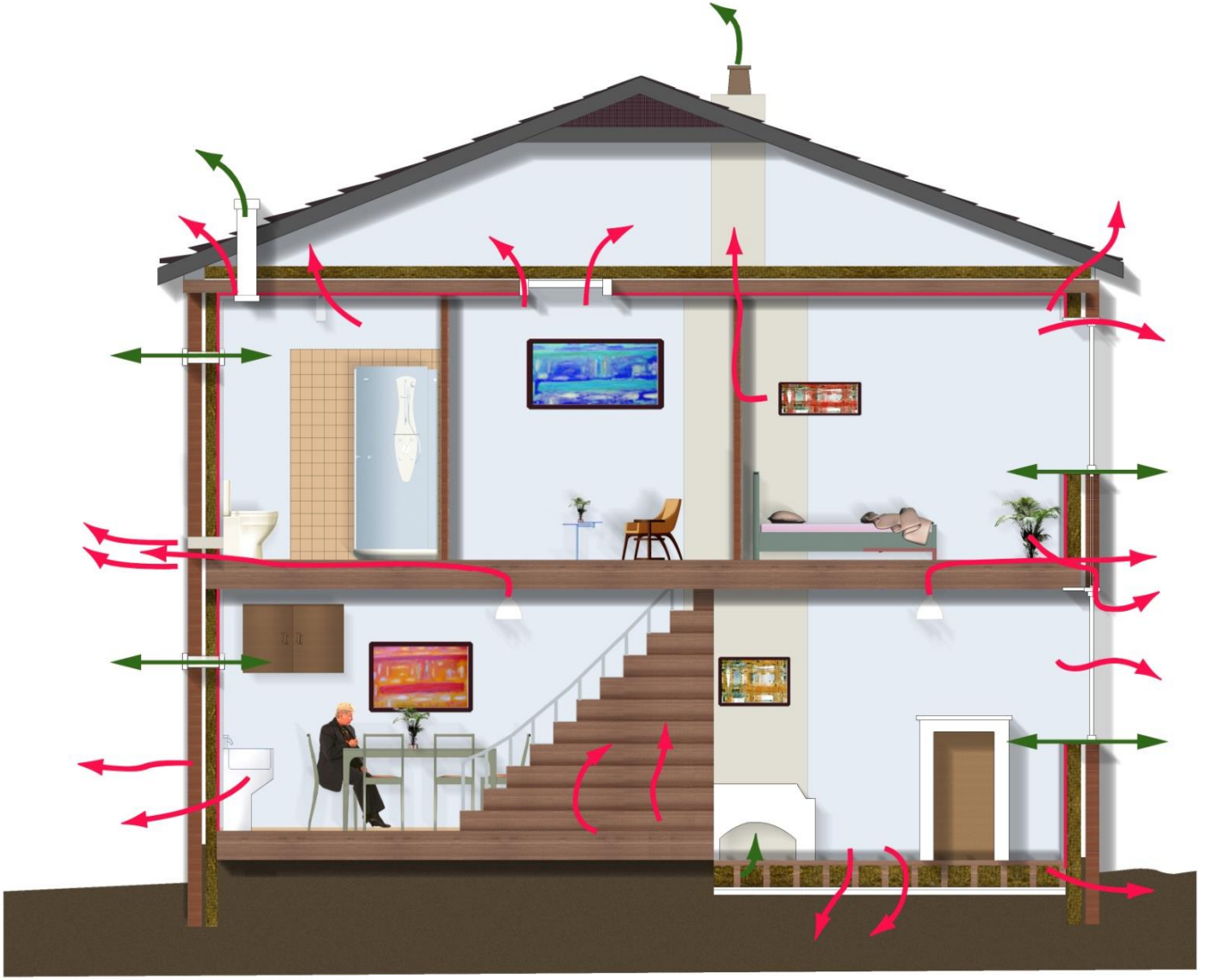
Why Airtightness – Infiltration and Ventilation

Air Infiltration/Draughts and exfiltration – The uncontrolled entry or exit of outdoor or indoor air from the habitable space

Ventilation – The controlled/designed replacement of stale indoor air with fresh outdoor air

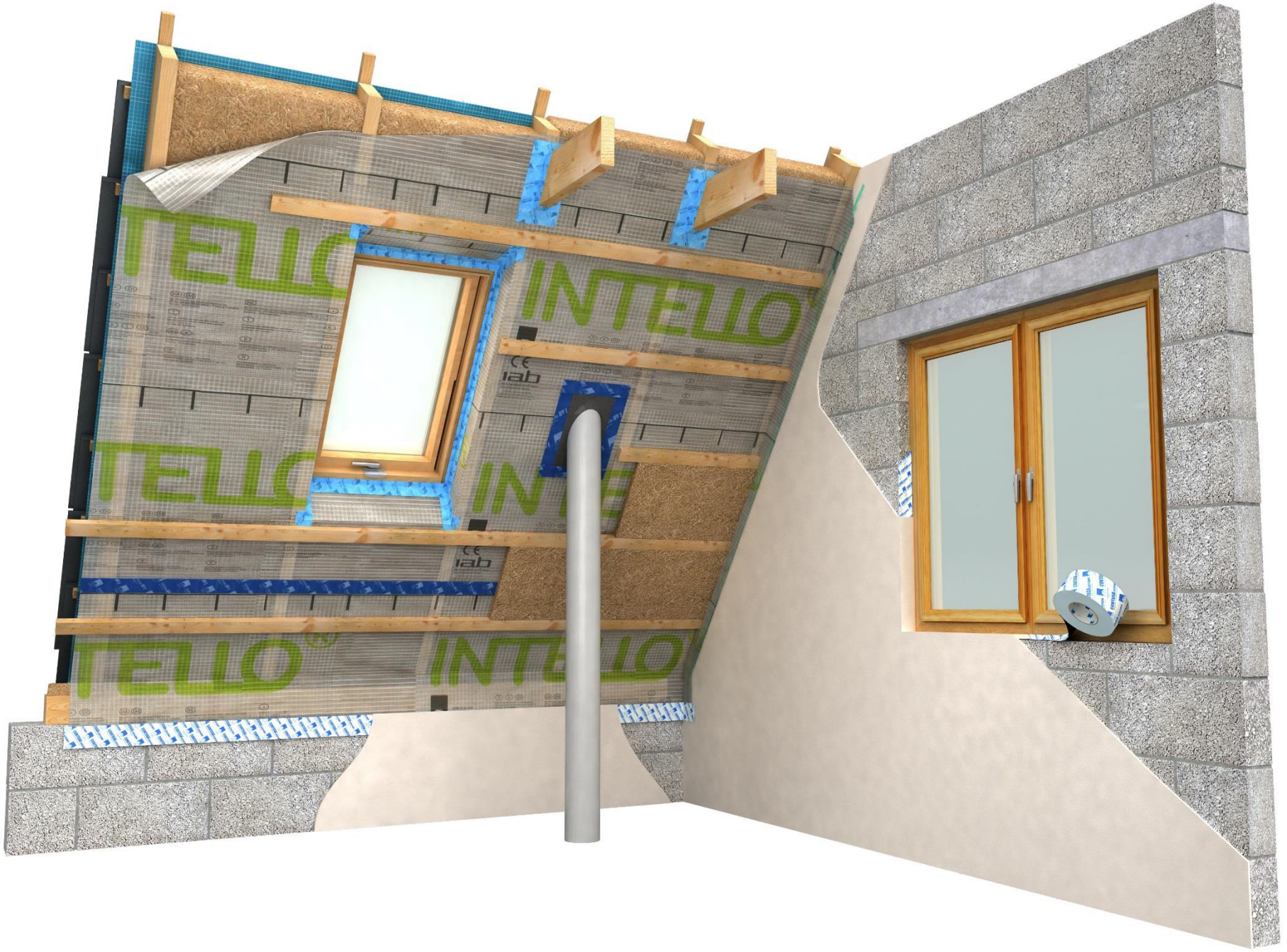
Airtightness – The elimination of uncontrolled air infiltration

BUILD TIGHT AND VENTILATE RIGHT!

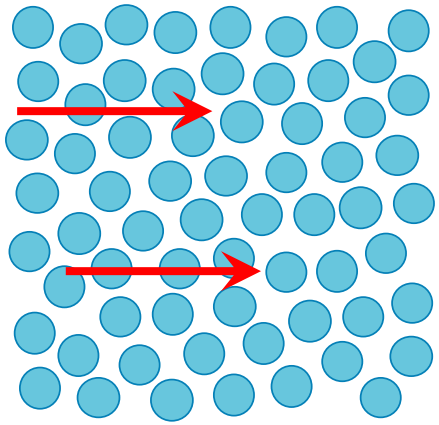


A draughty, “leaky” building

The principle of thermal insulation: Airtightness

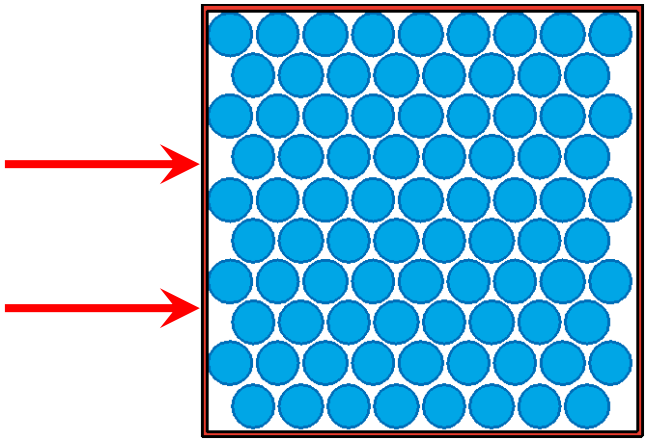


The principle of insulation



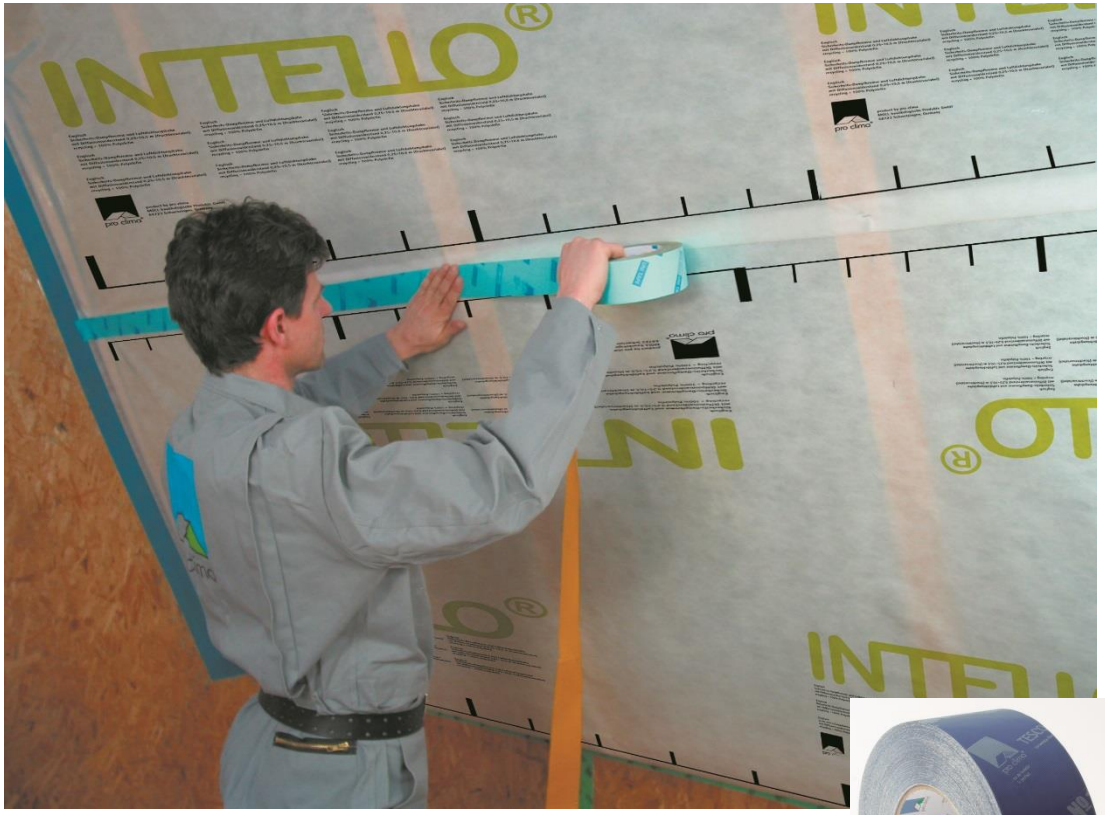
air movement

= **heat transport**



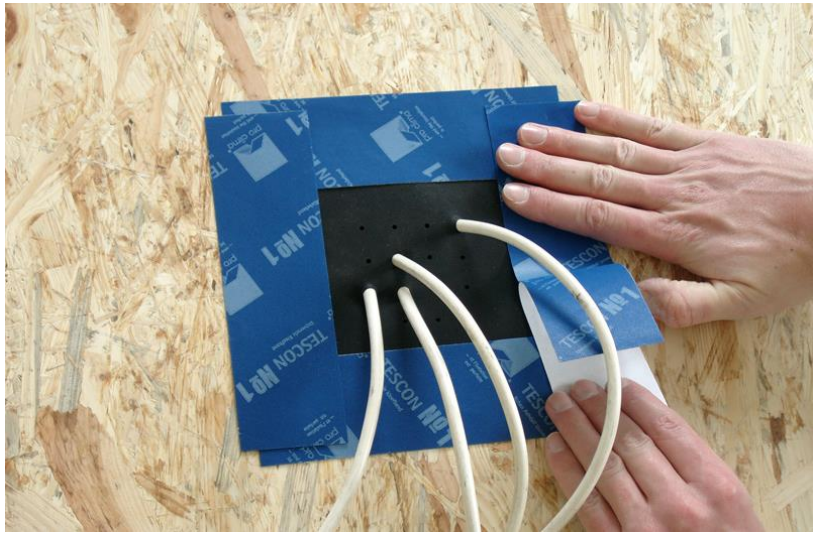
only inclusions of air that are protected against air movement insulate!

Airtightness details: Sealing of overlaps – TESCON VANA



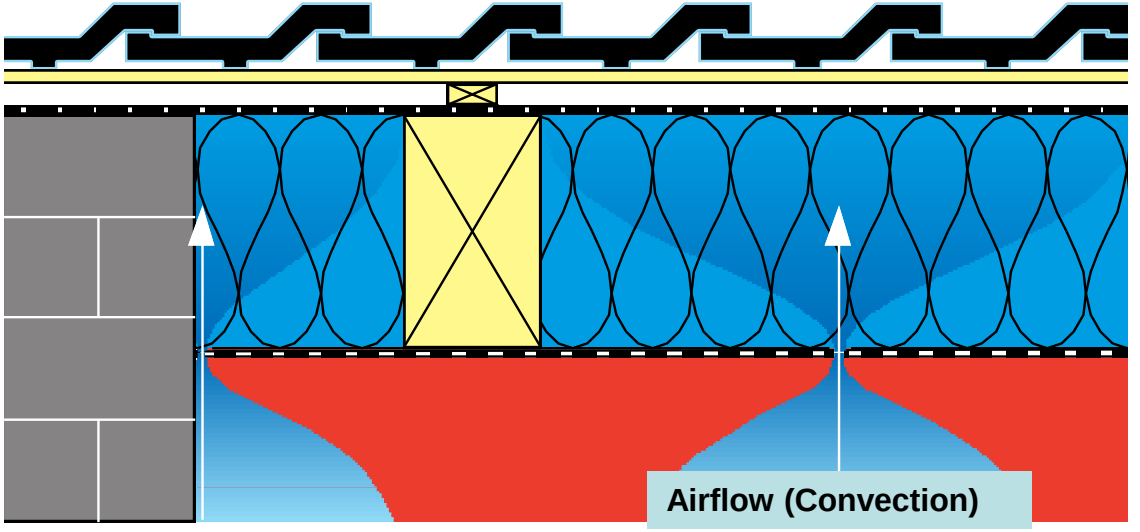
- Fix vapour check to timber studs securely
- Overlap joints by 50-60mm
- Seal all overlaps using suitable airtightness tapes

Airtightness details: Sealing Pipes & Cables



Airtightness details: Window Sealing: CONTEGA SOLIDO SL/EXO

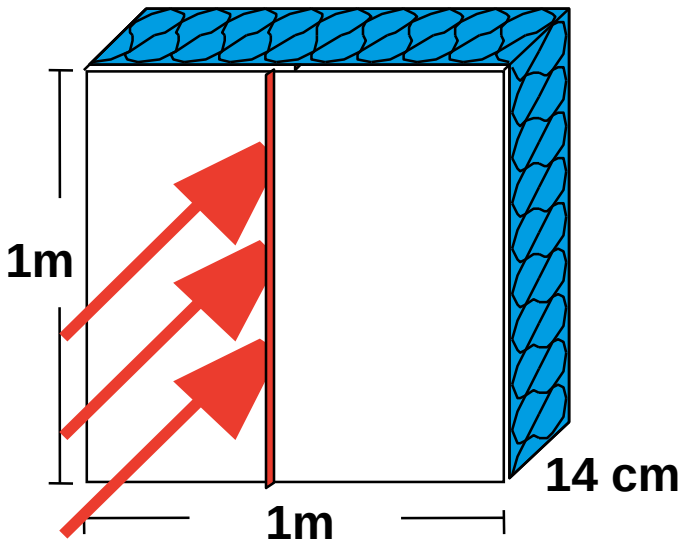
Typical construction situation



Consequences of defective air-tightness

1. Heat loss
2. Building damage due to moisture
3. Deficient heat protection in summer
4. Deficient sound proofing

Heat losses due to Convection



Without gap: U-Value = 0,3 W/m²K

With 1 mm gap : U-Value =1,44 W/m²K

Performance reduced by factor 4,8

Experiment set-up

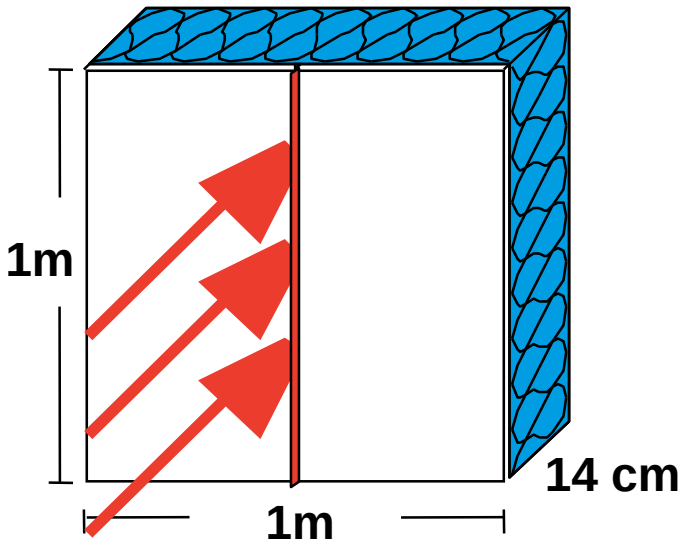
Construction of insulating material

Gap in the vapour Check (air-tightening).

Frame conditions:
Inside temperature +20°C
Outside temperature -10°C
Pressure difference 20 Pa
= wind force 2-3

Measurement:
Institute of building physics, Stuttgart
Source: DBZ 12/89, page 1639ff

Comparison diffusion/convection



Without gap: 0,5 g water/m²x24h

With 1 mm gap: 800 g water/m²x24h

Performance reduced by factor 1600

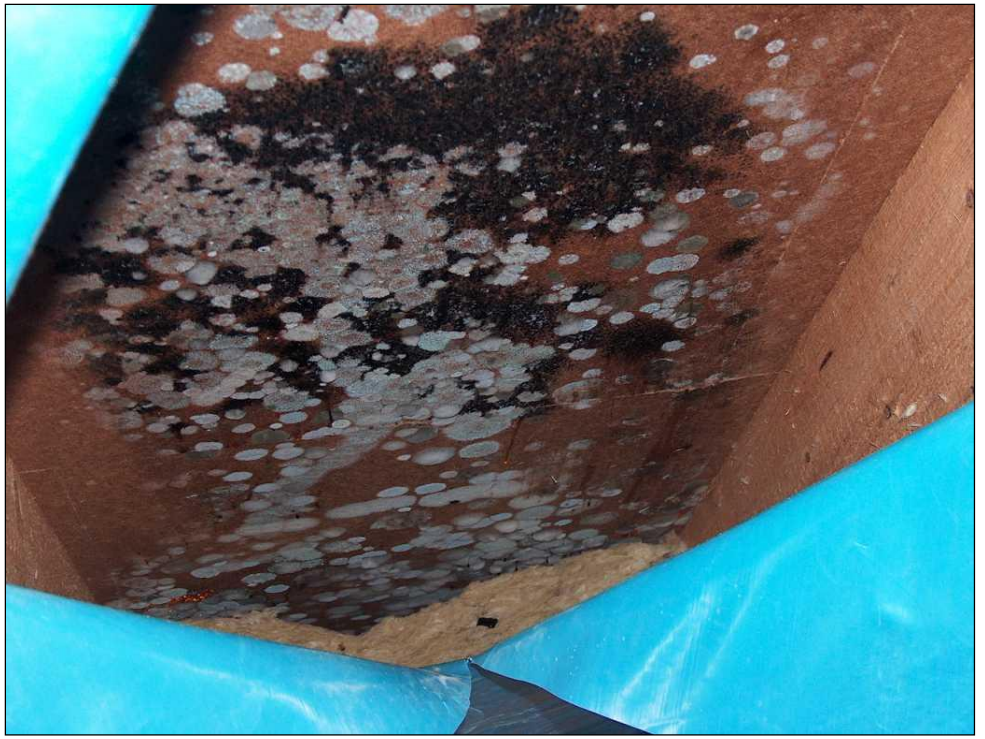
Experiment set-up constr. of insulating material

Inside vapour seal
s_d = 30 m (mvtr = 150 MNs/g])
Gap in the vapour Check
(air-tightening)

Frame conditions:
Inside temperature +20° C
Outside temperature -10° C
Pressure difference 20 Pa
= wind force 2-3

Measurement:
Institute of building physics, Stuttgart
Source: DBZ 12/89, page 1639ff

Consequences of air leakage



Building damage due to moisture penetration by convection

Consequences of faulty airtightness

Abb. 4: Bei der Öffnung des Daches vorgefundene Fäulniserscheinungen in der Schalung des Unterdaches.

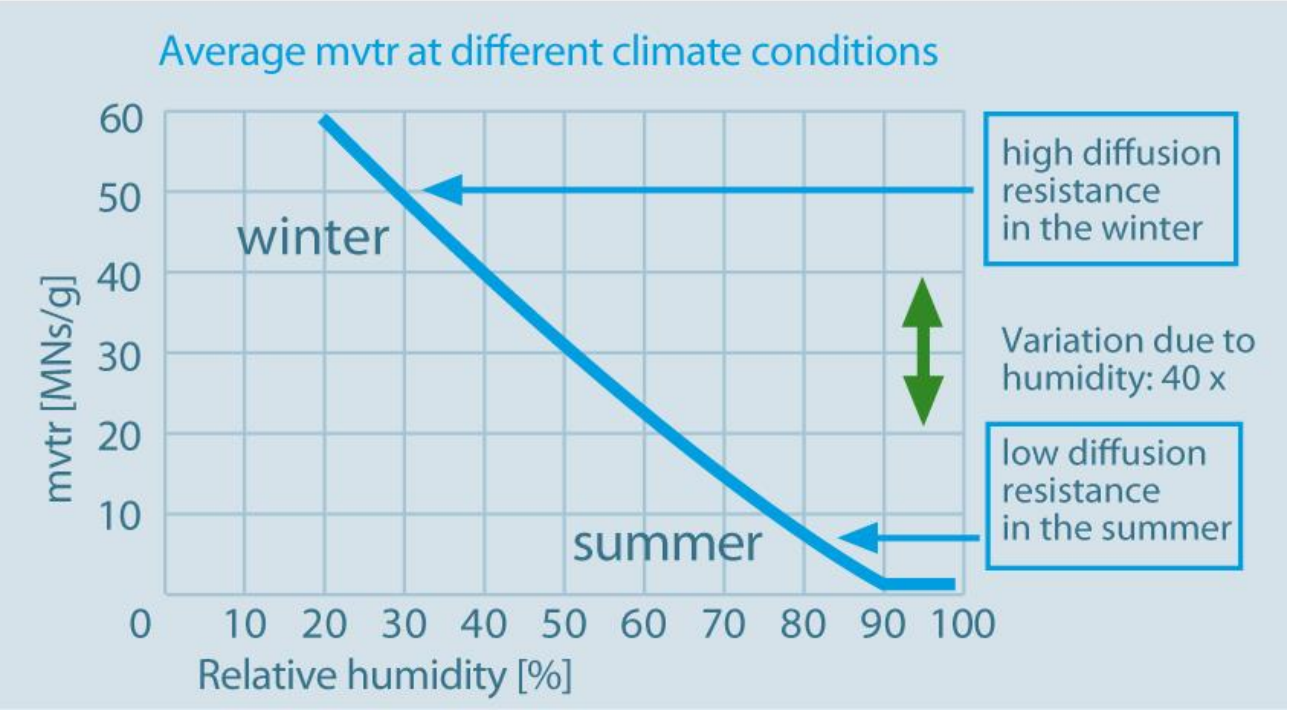
There is no absolute protection against moisture

Solution:
high drying potential

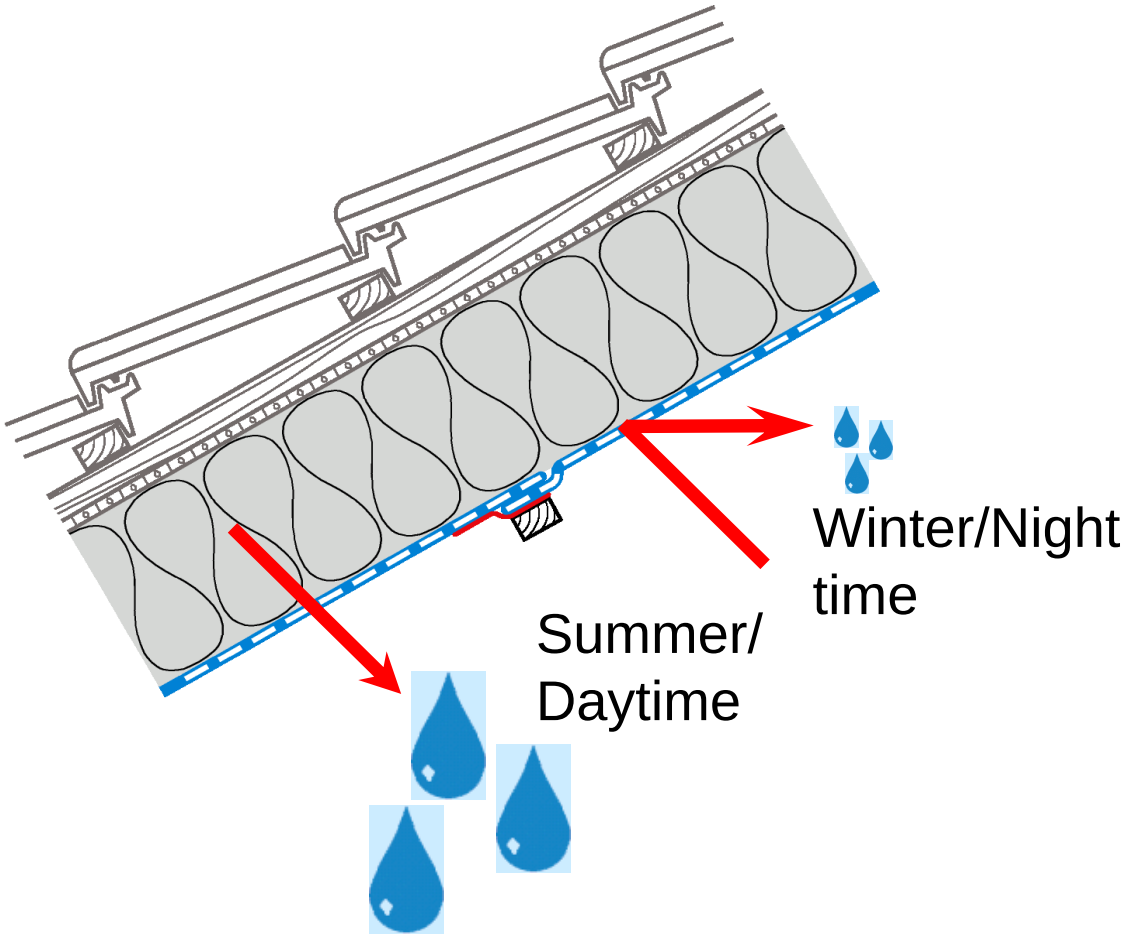
Ideal:
Intelligent membranes with Humidity – variable diffusion resistance

Back Diffusion in summertime

Humidity – variable diffusion resistance: Intelligent Technology



Vapour Checks with humidity – variable diffusion resistance



Freedom from structural damage due to vapour checks with humidity – variable diffusion resistance

In winter: protection against moisture entry

In summer: high drying potential

Why Airtightness?

More than 2.3m families living in fuel poverty in England

Tories urged to act as one in 10 households is fuel poor, rising to about one in five for those renting from private landlords

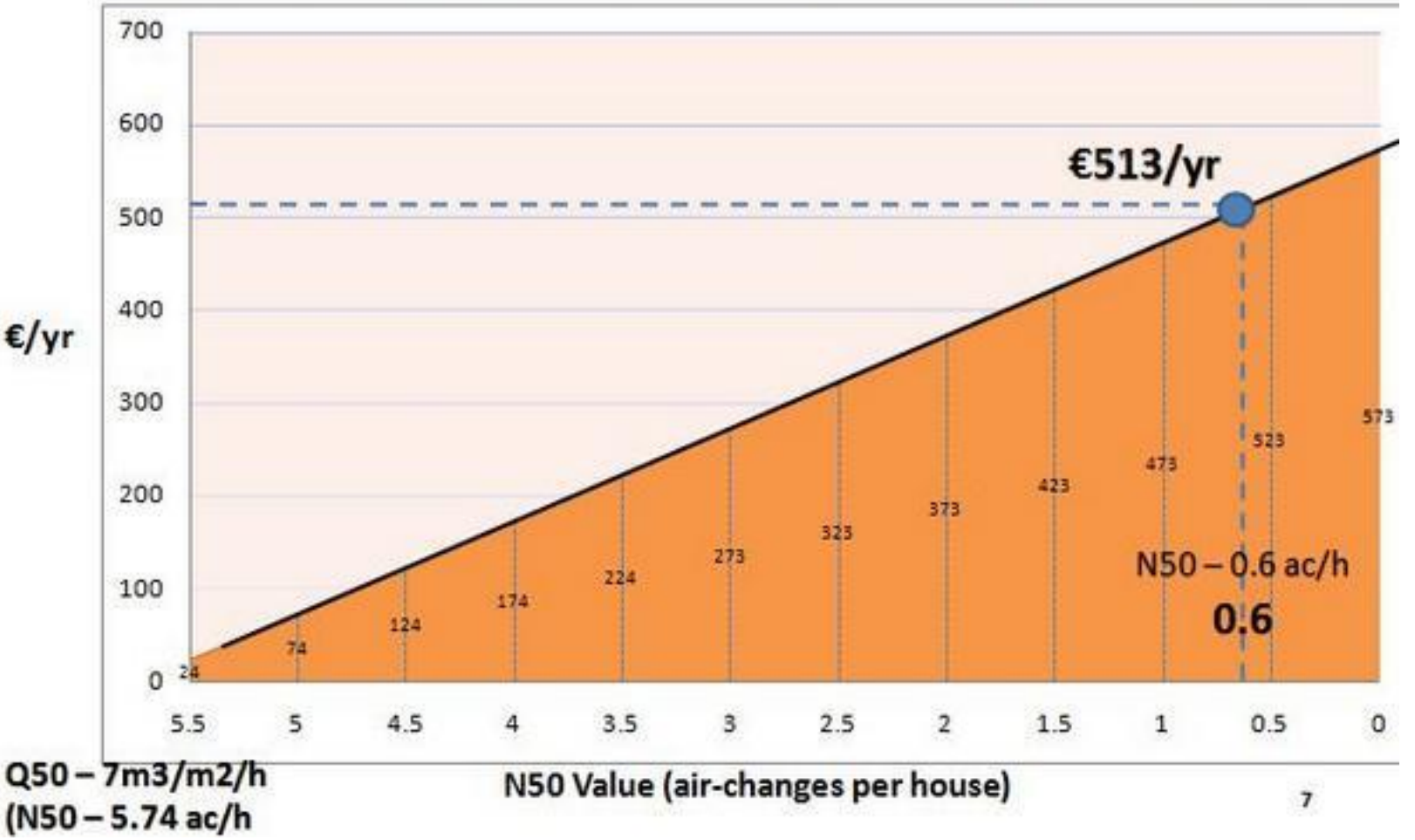
Houses in Birmingham, where nearly 60,000 families face an 'eat or heat' choice this winter. Photograph: Alamy

https://www.theguardian.com/society/2016/dec/30/millions-families-living-fuel-poverty-england-statistics?CMP=share_btn_tw

Why Airtightness?

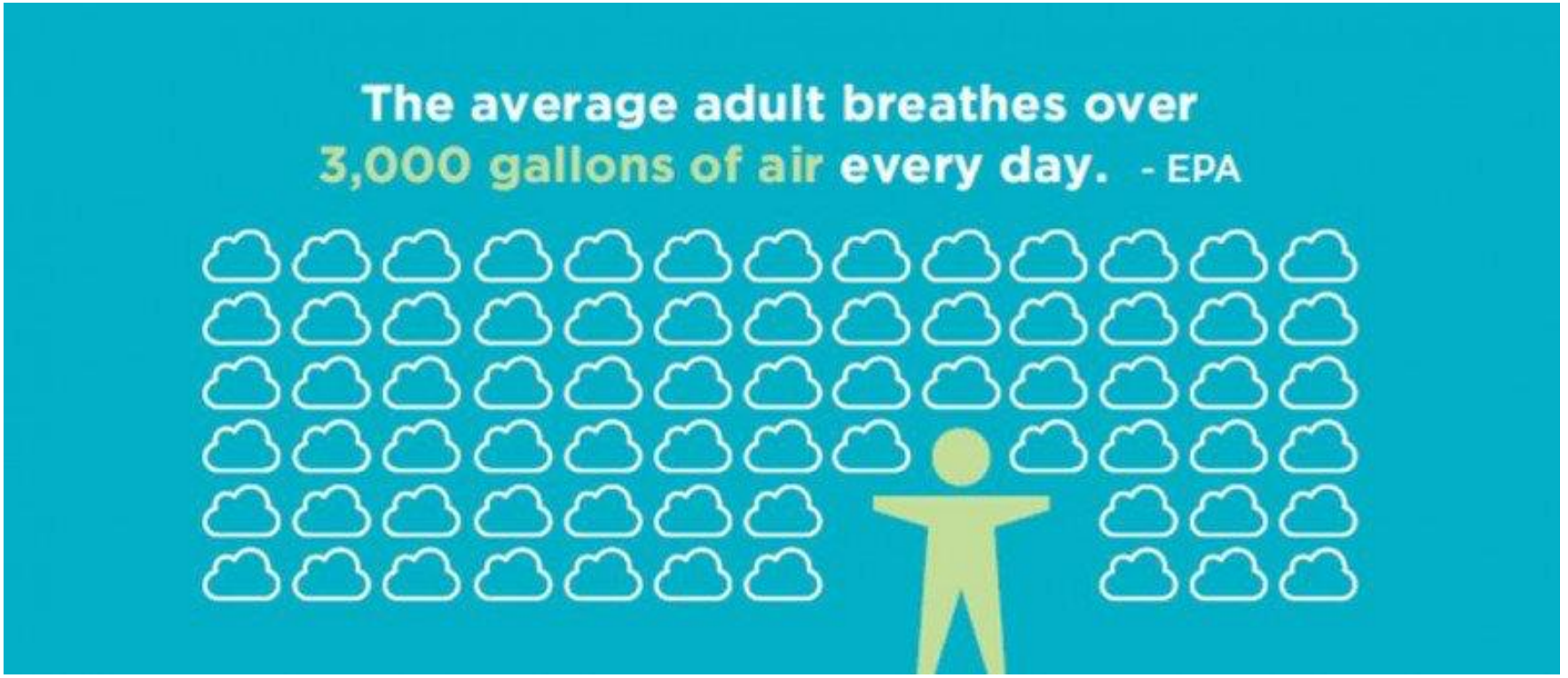
Savings from making building airtight

Based on a 200m2 two storey Dwelling , based on €0.12/kwh using oil of gas.
Compared to Naturally Ventilated Building that meets Part Q50 of 7m3/m2/h



REF: TARGET ZERO GROUP

We spend 90% of our time indoors



Ventilation Systems

Natural Ventilation

- Trickle vents
- Passive Stack
- Supply air windows
- Opening windows

Mechanical ventilation

- Extract fans
- Whole house extract
- Room ventilator with heat recovery
- Whole house mechanical ventilation with heat recovery
- Demand Controlled Ventilation

Ventilation Systems

QualiBuild

Upskill • Train • Improve

Airtightness & Ventilation

https://www.youtube.com/watch?v=dznIu2dsh1s

Ventilation Systems

- At the outset of the 20th century, there were approximately 50 materials used to construct buildings

- By the end of the century, it is claimed that this list had grown to around 55,000, half of them being synthetic. (Raw GJ. Sick building syndrome: A review of the evidence on causes and solutions. HSE Contract Research Report No. 42, 1992. Watford: Building Research Establishment.)

- Compounds found in indoor air have off-gassed from the building materials, furnishings and fittings, internal processes and cleaning products.

- Most common gases found in the indoor environment are carbon dioxide and carbon monoxide, nitrogen and sulphur dioxide, formaldehyde and other volatile organic compounds, radon and ozone.

- The most common suspended matter are asbestos fibres, fibrous particulates (fibreglass or mineral wool), bacteria and fungi, tobacco smoke, house dust mite (HDM) allergens, pollen and dust.

IAQ and its effect of Health

Ireland has highest rate of asthma in Europe

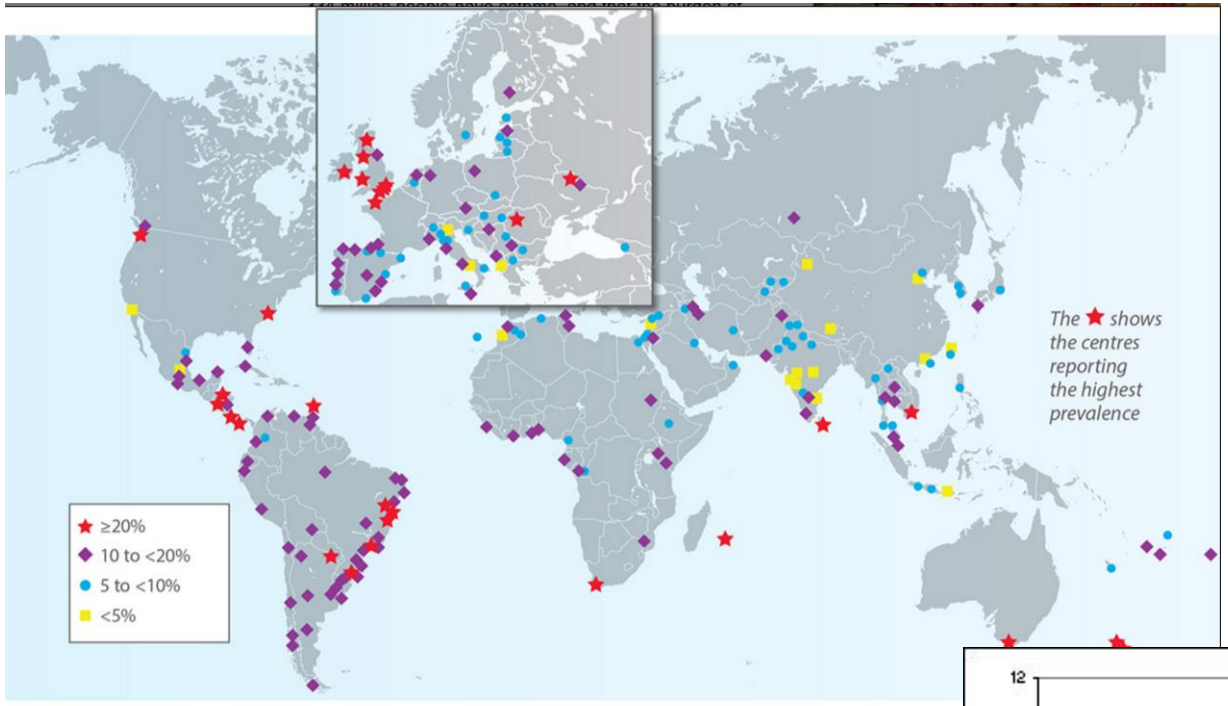


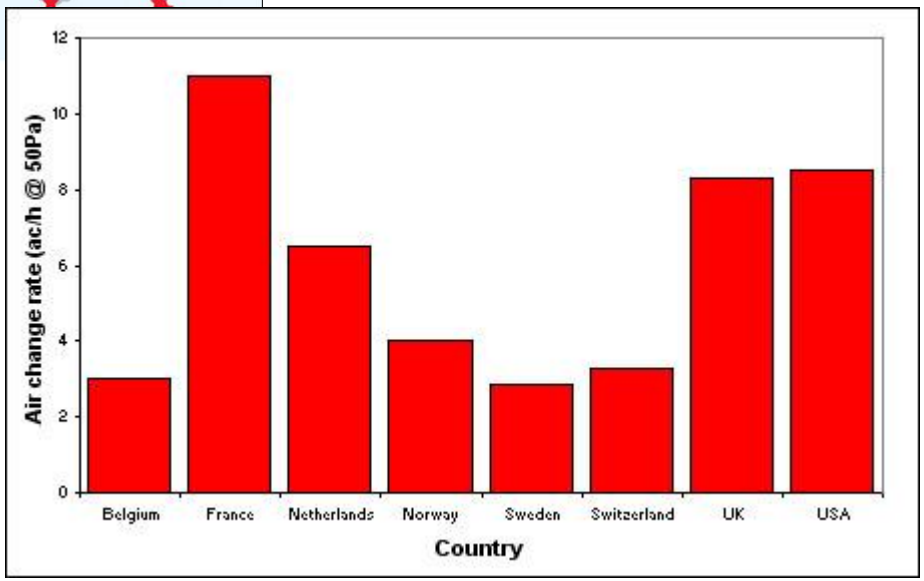
Figure 1: Prevalence of asthma symptoms among 13-14 year olds (ISAAC).

http://www.globalasthmareport.org/burden/burden.php

And what about the UK?

- 1 in 11 children and 1 in 12 adults
- 3 people die per day on average from Asthma related disease
- In 2014, 1216 people died from asthma.
- NHS spends around 1 billion/ year treating and caring for

www.asthma.org.uk

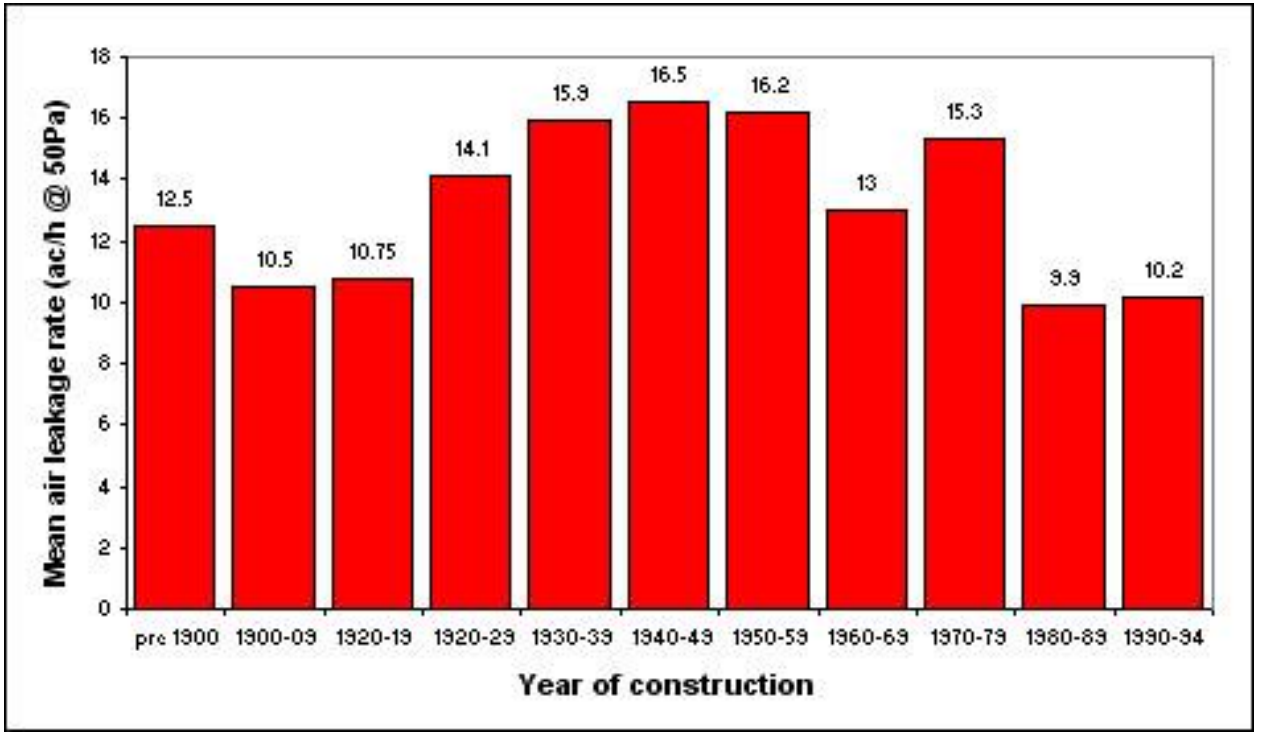


Is there a correlation between international airtightness standards and rates of asthma?

http://www.leedsbeckett.ac.uk/teaching/vsite/low_carbon_housing/airtightness/housing/

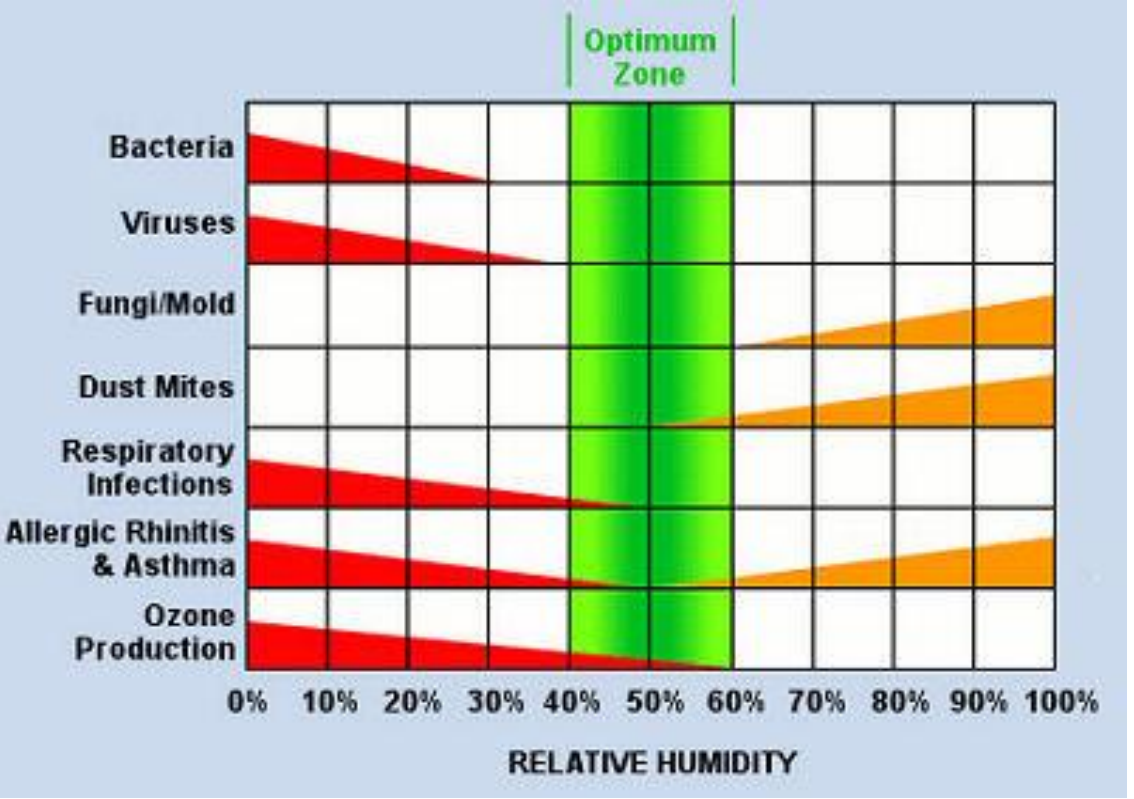
How do older buildings compare to modern buildings?

"Whilst the air leakage data for the older dwellings is not likely to be representative of their airtightness when first built, the data suggests that the airtightness of new dwellings has not improved significantly over the last century."



http://www.leedsbeckett.ac.uk/teaching/vsite/low_carbon_housing/airtightness/housing/

Relationship between Humidity and IAQ



Source:Basics of air humidification,Iselt/Arndt, publishing comp.C.F.Müller Heiderlberg

Is ventilation the silver bullet?

Why not also reduce exposure to VOC’s if possib

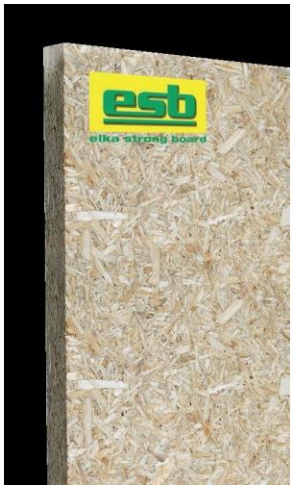
Use Materials with 3rd Party Labelling

natureplus®
No. 0101-1401-001-3

DER BLAUE ENGEL
JURY UMWELTZEICHEN
schützt
MENSCH UND UMWELT

SENTINEL HAUS
INSTITUT

THERMO
HANF



Airtightness Glues and Tapes 3rd Party Tested for VOC's

pro clima®
Intelligent
Airtight Systems

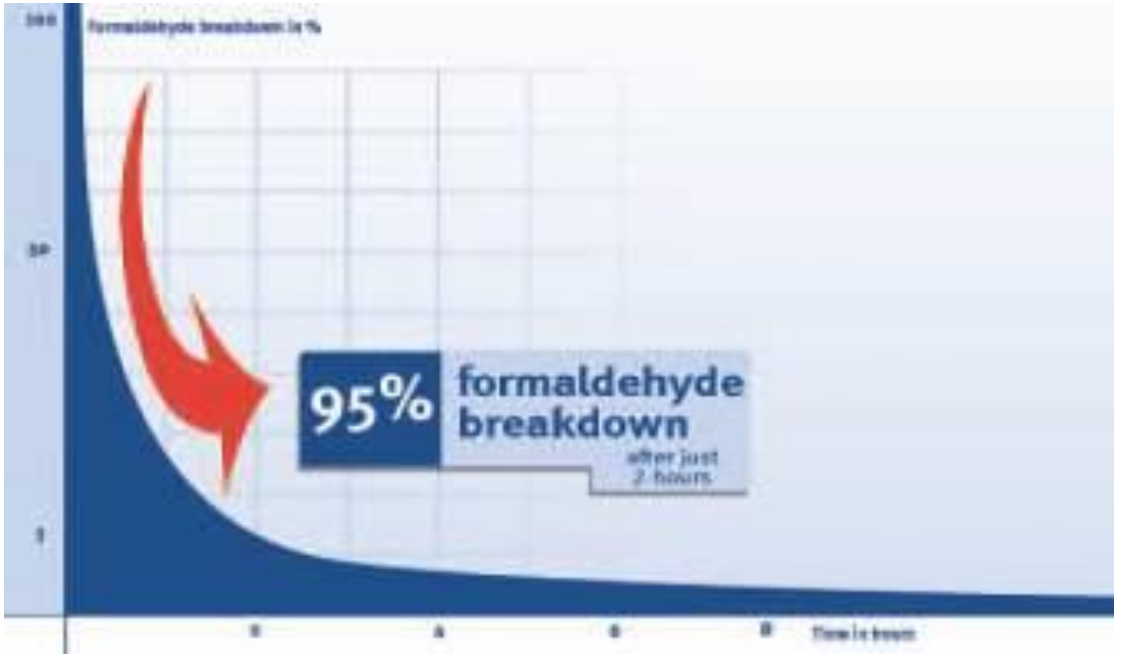
*Information sur le niveau d'émission de substances volatiles dans l'air intérieur, présentant un risque de toxicité par inhalation, sur une échelle de classe allant de A+ (très faibles émissions) à C (fortes émissions)

TESCON Vana

SENTINEL HAUS
INSTITUT

Or use materials which help break down VOC's

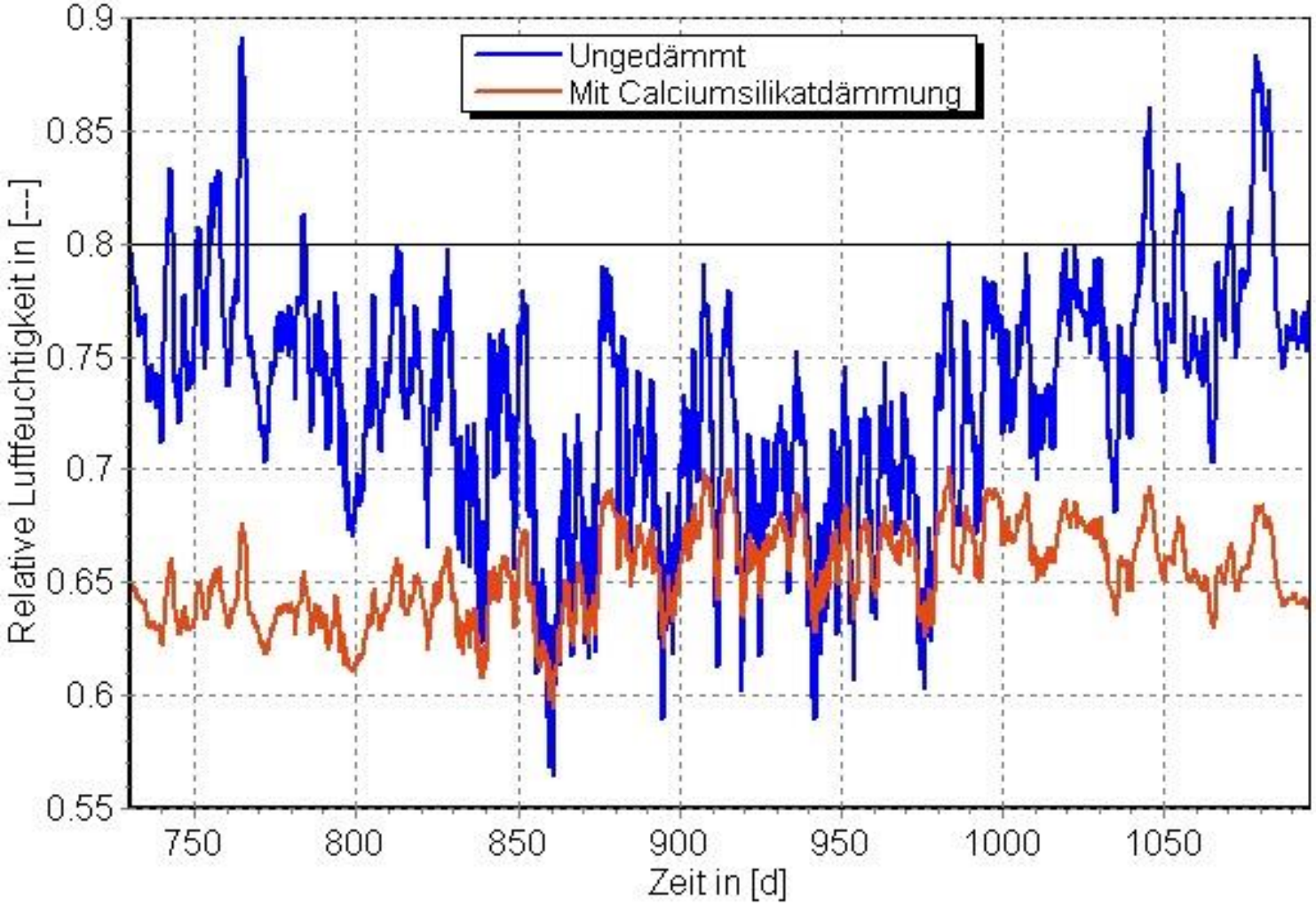
Photocatalytic natural paint



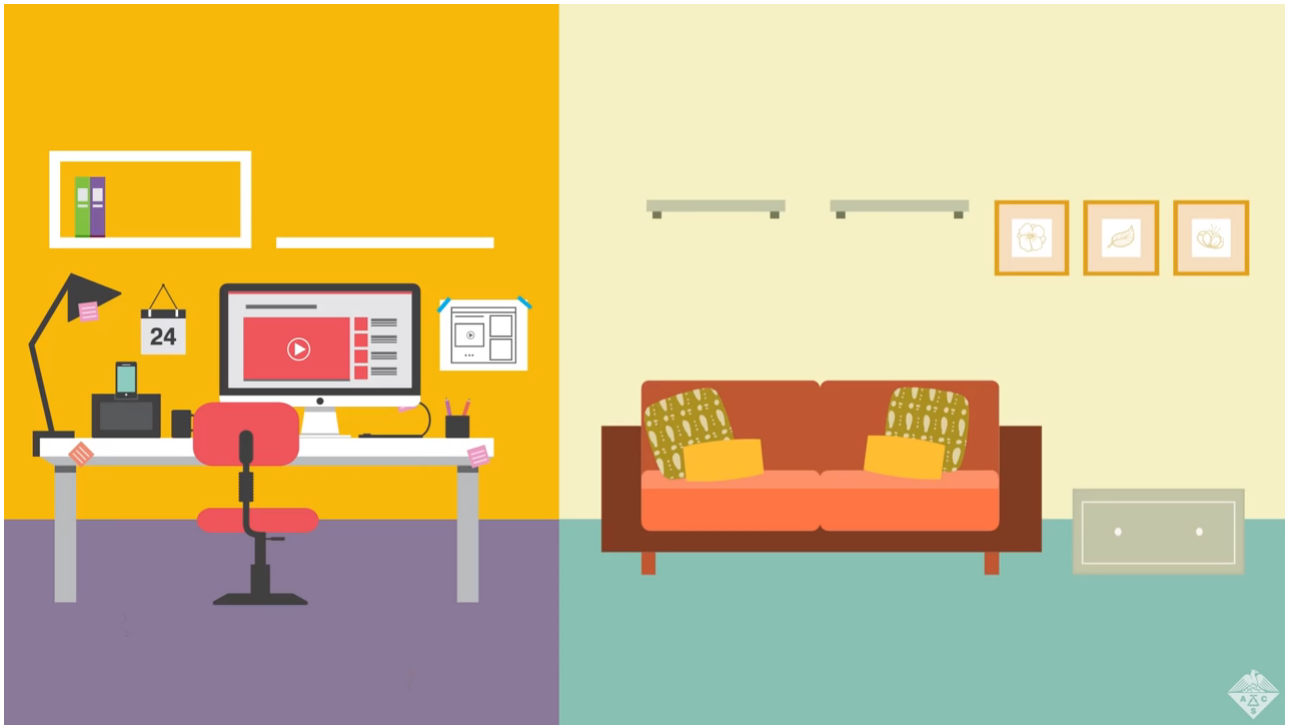
Some insulation materials help regulate surface humidity

CALSITHERM®
CLIMATE BOARD

Lime base capillary active insulation regulates surface humidity



Some Indoor plants can assist in breaking down VOC’s

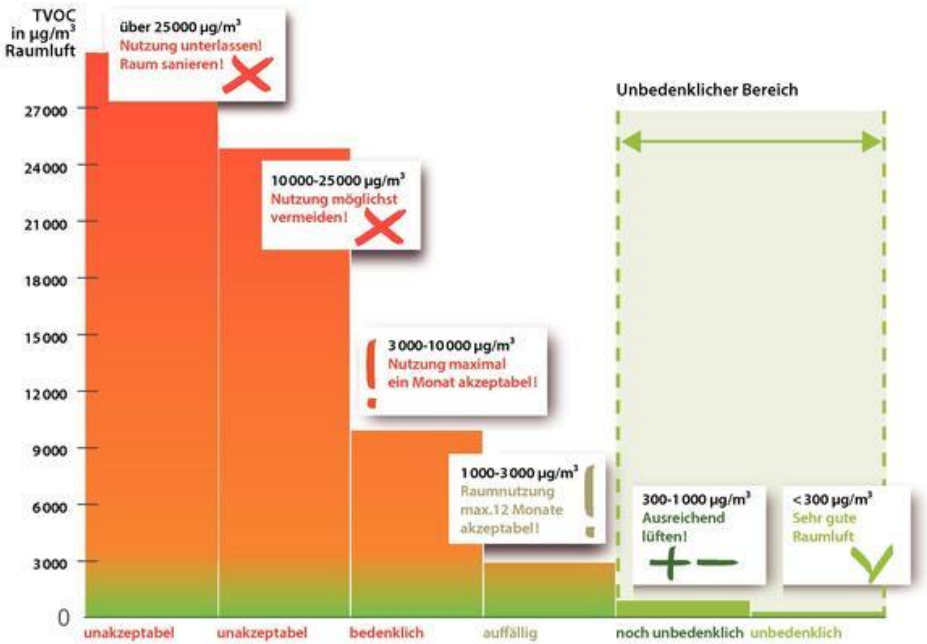


https://www.youtube.com/watch?time_continue=35&v=HdOibycDIA4

Housing Standards Which Measure VOC's Prioritising IAQ

SENTINEL HAUS INSTITUT

http://www.sentinel-haus.eu/en/



LIVING BUILDING CHALLENGE

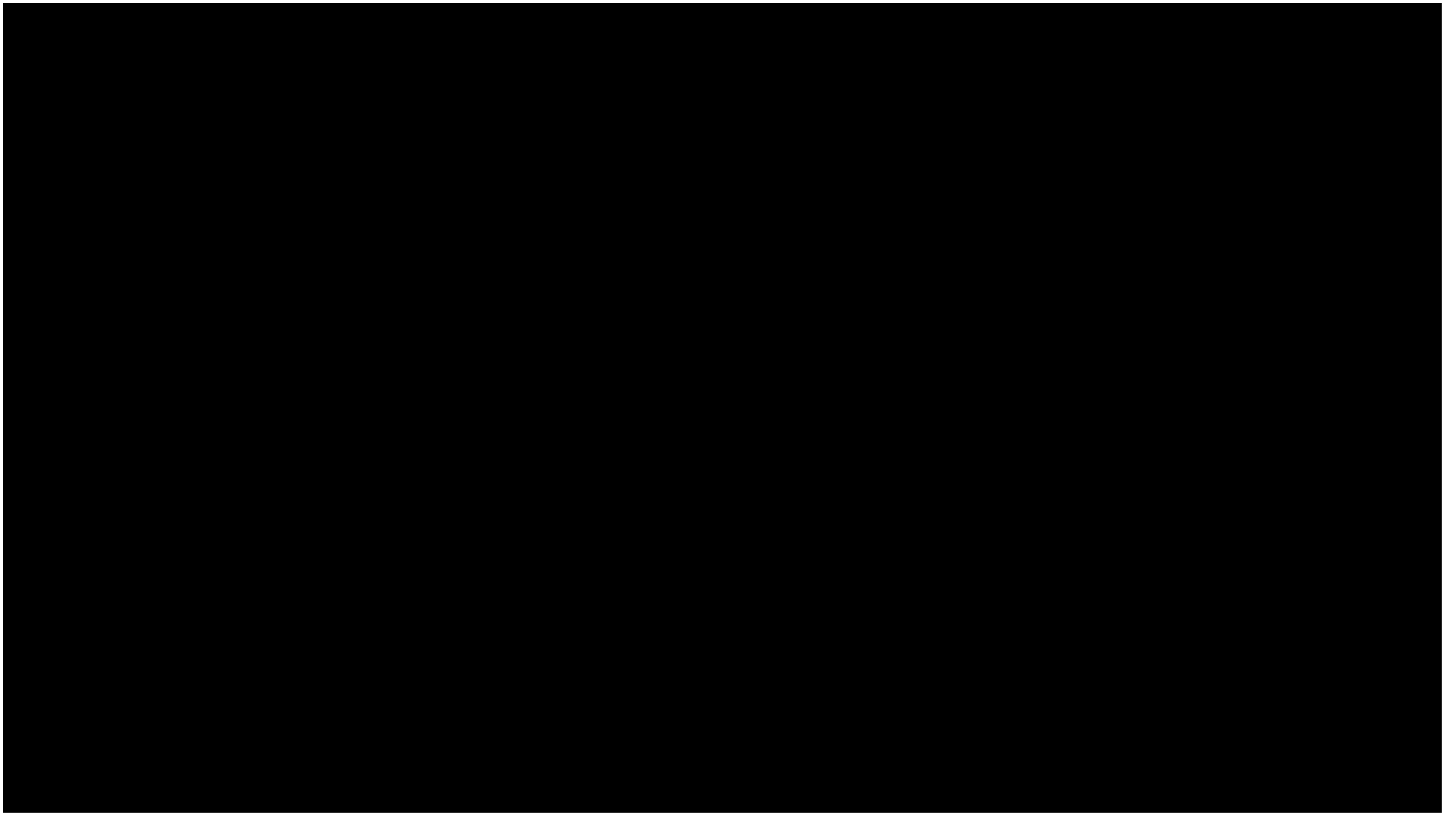
https://living-future.org/lbc/

Housing Standards which measure Comfort and IAQ

The Passive House is not an energy standard but an integrated concept assuring the highest level of comfort. The exact definition is as follows:

"A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air."

Monitoring IAQ: Utilising Technology



https://foobot.io/

Airtightness Summary

Airtightness:

1. Determines the effectiveness of the insulation Layer
2. Airtightness must be planned at design stage to deliver airtight buildings
3. A lack of foresight at design and construction stage leads to increased costs, and poorer results
4. Materials fit for purpose must be used to deliver durable airtightness solutions
5. Coordination and planning on site central to delivering positive results
6. To achieve this the membranes must be meticulously sealed to one another and to proximal structural components
7. Knowledge & training from design to site critical

Airtightness Summary

Airtightness and IAQ:

1. Leaky, “well insulated” buildings lead to poorer IAQ, increased interstitial condensation risk and mould, poor comfort and increased energy usage
2. Whether a building is airtight or not it must be adequately ventilated
3. As building regulations require higher levels of airtightness ventilation requirements must be adapted accordingly.
4. Retrofit of existing buildings particularly prone to reduction in IAQ if whole house approach not used
5. Where mechanical systems are introduced these must be installed and commissioned correctly and maintained in the long term
6. In ROI if Q50 < 5m3/hr/m2 openings for permanent vents must be increased by 40%. Is this adequate for a system which is already not adequate?

To improve health nationally we must start with health of our ho

perennial tree fruit as an option."

mixture with other colours).

gardening@sunday-times.ie

For a healthy population, we must start with healthy homes

Environmental toxins and a cold living space are implicated in thousands of preventable deaths

How do we go about making our homes healthy? We would be well served to start with some basic scientific literacy to enable us to resist falsehoods that paint pictures that are as deceptive as they are reassuring.

Take the supposed conflict between natural and chemical substances, a false dichotomy that peddles the notion that chemicals are inherently synthetic and unnatural. Our world is replete with naturally occurring chemicals, and mixtures thereof, that are essential to our existence — from water and air to blood.

Building on this false natural/synthetic divide, the message that natural products are virtuous and beneficial is touted with near ubiquity. It's easy to debunk.

JEFF COLLEY
GREEN LIVING

Asbestos, for instance, is a naturally occurring mineral — or rather a set of six such minerals, to be precise — and a known carcinogen that is no longer used in construction. This isn't to say that other natural products aren't a good thing — they'll often tend to be more environmentally inert than more processed products — but we must stop imagining benefits.

Even establishing the individual properties of a given product isn't enough. In reality, our homes are an assembly of factors with potential health impacts, ranging from location, design and construction materials to finishes, furniture and household contents.

That said, aside from obvious no-nos such as flooding our homes with toxic cleaning products, here are a few of the strategies that we can and should employ to make our homes more healthy.

About 2,800 more deaths on the island of Ireland happen during the winter months compared with the rest of the year — a phenomenon known as excess winter mortality — and living in a cold home is implicated in this.

We should insulate and air-tighten our homes, while also ventilating them, and install efficient heating systems of the correct size so that we can afford to heat our buildings to healthy temperatures in winter.

A central concern should be to ensure that the approaches we take eliminate mould, the scourge of Irish homes, not just from surfaces but from the structure itself.

Insulation, efficient heating and ventilation are vital for a healthy home

We should install radon monitors, which are available for as little as €40 and are simple to use, to establish whether radon levels are dangerously high. This invisible, odourless radioactive gas naturally occurs in the earth, and is associated with 150-200 lung cancer deaths per year in Ireland.

One way to lessen the impact of potentially harmful indoor air pollution is dilution by ventilation. However, while a reliable supply of fresh, clean air is a must, increased ventilation won't always deliver clean air. As our air quality in Ireland is variable, in areas where homeowners are concerned about air pollution, mechanical ventilation systems that filter external air to a sufficiently high quality before introducing it into the house should be considered.

Making our homes healthy requires care and consideration. There are a slew of other factors to consider, too, such as noise pollution, lighting, carbon monoxide, fire safety, overheating, legionella, water quality, and avoiding materials or combinations of materials that may cause off-gassing. The net effect is to place tough demands on the design and construction of our homes, but they're demands we can ill afford to ignore.

Jeff Colley is editor of Passive House Plus magazine passivehouseplus.ie

1RR

Fabric FIRST

ecological

BUILDING SYSTEMS

Thank you for your attention

Questions?

www.ecologicalbuildingsystems.com

GUTEX® NATURALLY MADE FROM WOOD

pro clima® Intelligent Airtight Systems

esb elka strong board

CALSITHERM® CLIMATE BOARD

DIASEN® IMPROVE YOUR BUILDING

ecological

BUILDING SYSTEMS

http://portfolio.cpl.co.uk/CIBSE/201510/napier-gold-metal/

http://www.sentinel-haus.eu/en/

https://living-future.org/lbc/

www.asthma.org.uk

http://www.ukgbc.org/campaigns-policy/campaigns/health-wellbeing-and-productivity/health-and-wellbeing-homes