Module 11

Quality Checks on Site

Digitalisation in Construction

24 partners 12 countries

Date of Event

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To equip the learner with the relevant knowledge and skills required to understand and know how digital tools can support the quality checks of the installation and detailing of building materials, products and equipment.

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Quality checks on site | Objectives

1. List and outline different quality controls for the building fabric
2. Outline how digital tools can assist in building fabric checks on site (such as heat loss, air tightness, thermal bridging, glazing etc.)
3. Demonstrate an air tightness quality check using digital tools in collaboration with other team members.
4. Demonstrate an air tightness quality check using digital tools in collaboration with other team members.
5. List and outline different quality controls for the building services
6. Outline how digital tools can assist in building service checks on site (such as ventilation, heating and cooling, lighting and smart controls etc.)
7. Outline and discuss good and bad examples using case studies
8. Outline how digital tools can assist in monitoring the operation and maintenance of building services.
9. Demonstrate a ventilation check quality check using digital tools in collaboration with other team members.

Quality checks on site | Content

Topic 1 – Building fabric checks

Topic 2 – Building services checks

1. Building fabric checks

Envelope Checks

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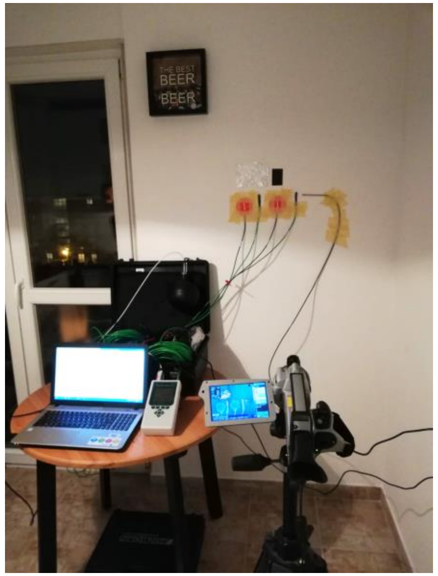
Thermal

A thermal assessment of the envelope of a building is a good tool for retrofitting surveys in order to check actual heat losses through building elements compared to designed and installed values.
It is also shown U-values can increase during the time of building occupancy.
Two methods can be used to determine the (approximate) U-values of existing building elements.

Heat Flux Method (HFM)



Thermography

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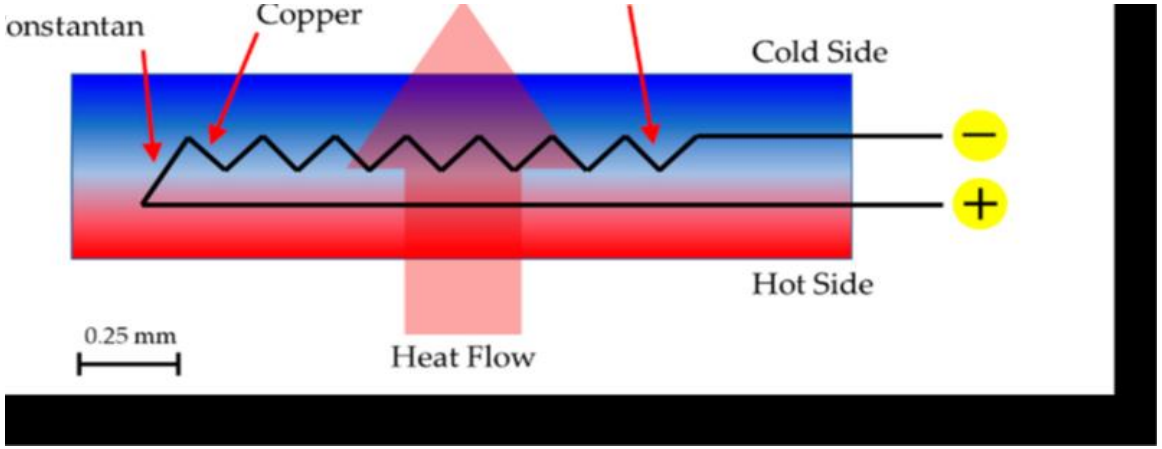
Heat Flux method

Heat flux is the amount of heat energy which flows through an imaginary surface of 1 m² in a certain amount of time.
Heat Flux Method as defined in ISO 9869 measures the heat flow using a heat flowmeter which produces an electrical signal of the heat passing through the sensor, while measuring the indoor and outdoor air temperatures using thermocouples.
A disadvantage of the HFM is that it gives results only for one or a few data points (depending on how many heat flux sensors are being used). To get satisfactory results, a minimum temperature difference of 10*C between the indoor and outdoor air is needed



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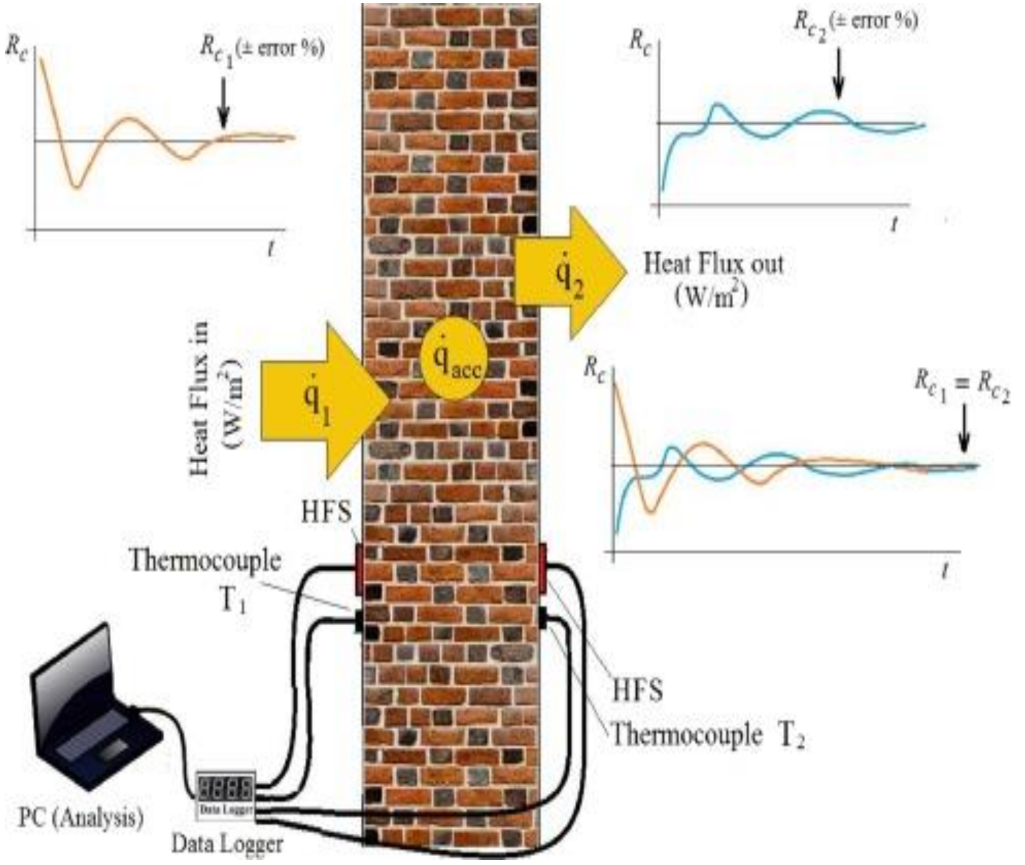
Heat Flux method

Heat Flux measurement is also influenced by thermal bridges, mould, humidity and sensor adhesion.

These factors explain why the real (experimental) U-value differs from the design U-value. In older historical buildings it can be up to 60%.



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Infra-red Thermography

Infra-red (IR) thermography is a non-contact method of measuring temperature and its distribution on the object's surface.
One can only see temperature effects on the surface - It isn't possible to see *inside* an object.

Why Use Thermal Imaging?

- Structural survey – localization of deficiencies in the construction
- As a foundation for refurbishment measures
- Quality / process control
- Post Occupancy Evaluations POE

What the human eye can't detect, infra-red can!

Thermal image (inset) of a residential building illustrating thermal bridging around openings and junctions

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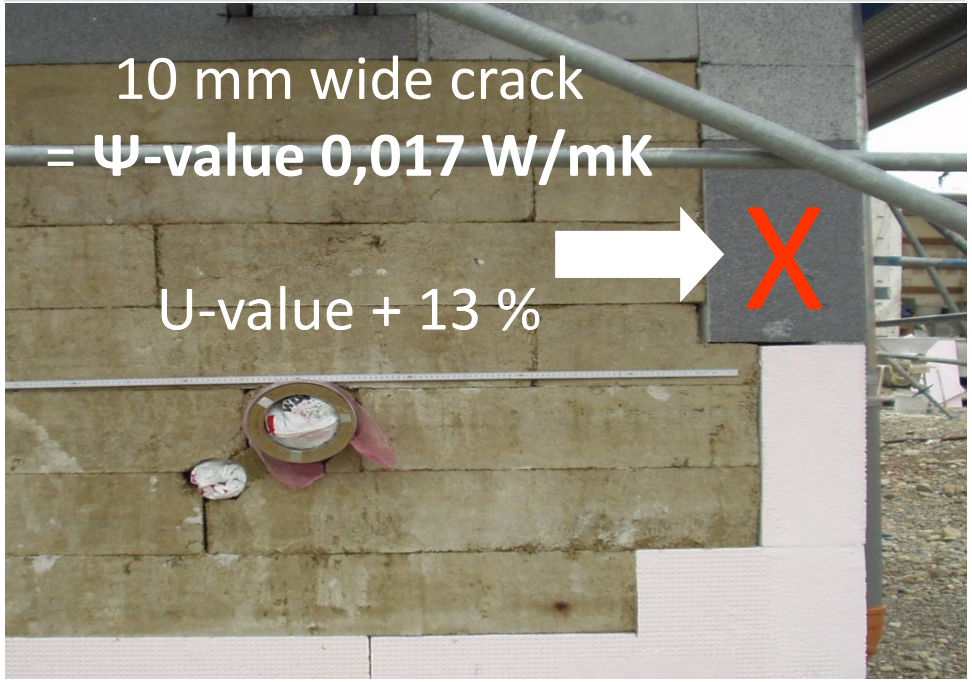
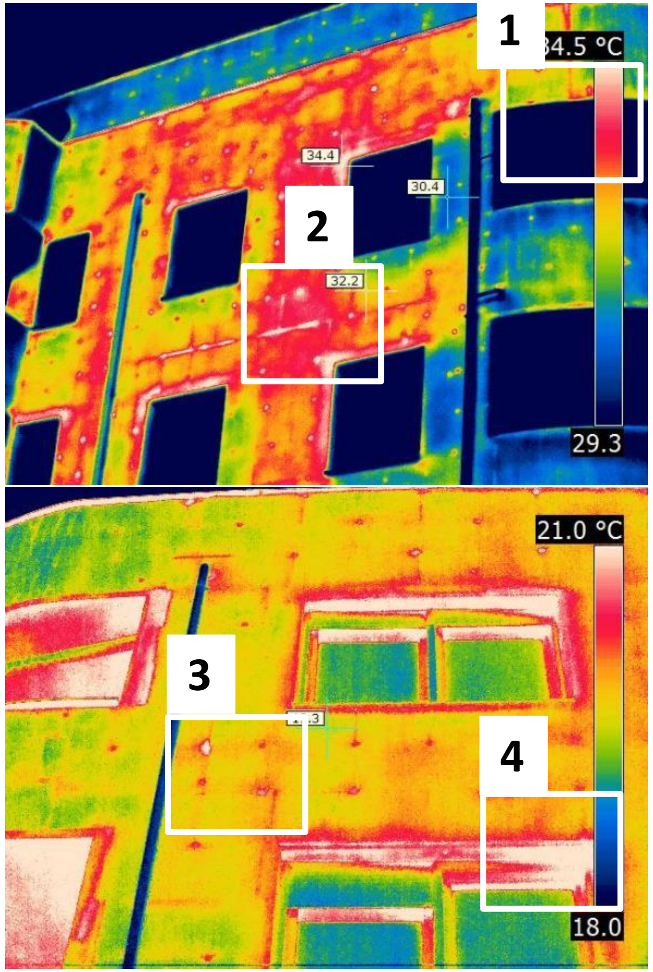
Daily routine on site

How is the handling of the insulation boards to be assessed?





Source: B. Milovanović

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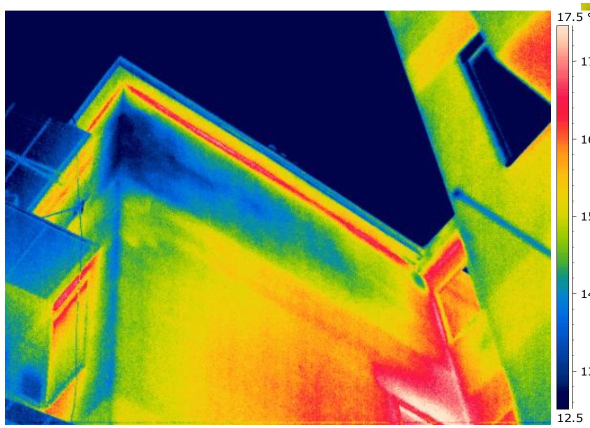
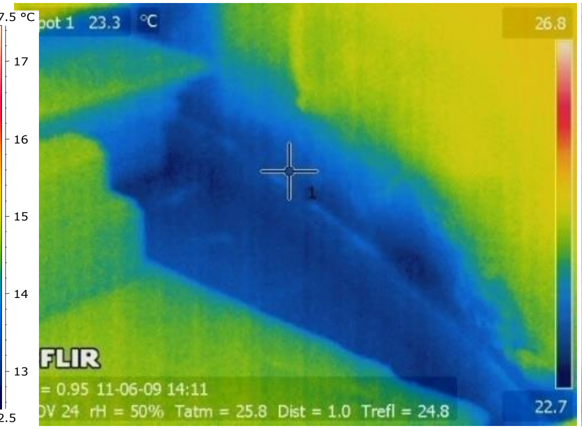
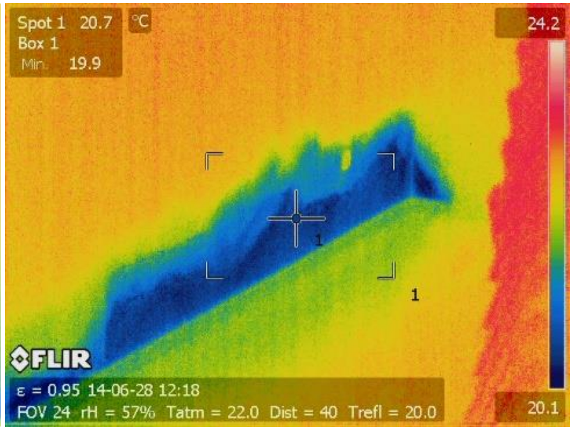
Infrared thermography – This is used in buildings mostly for…

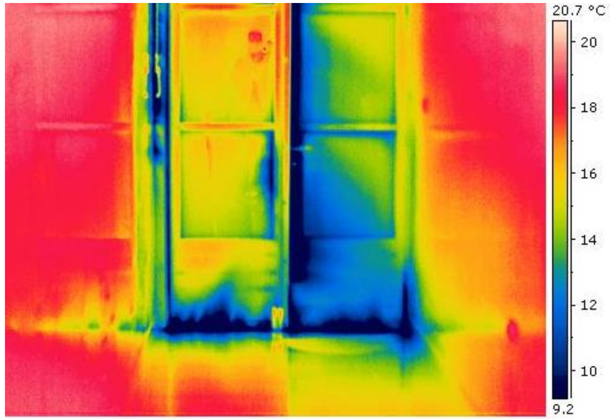
Detection of transmission heat losses

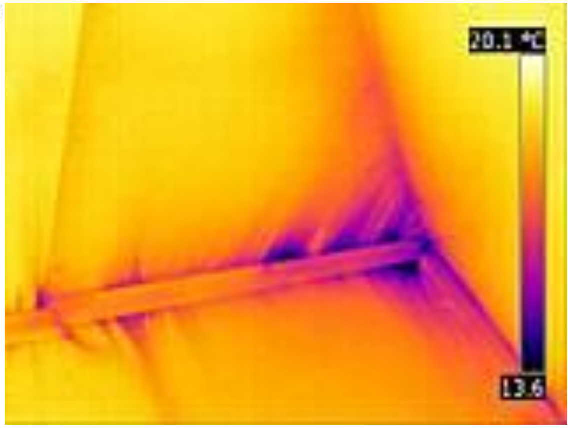


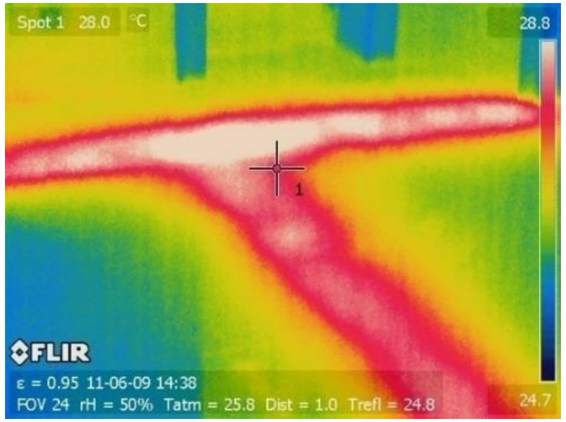
Detection of damp areas

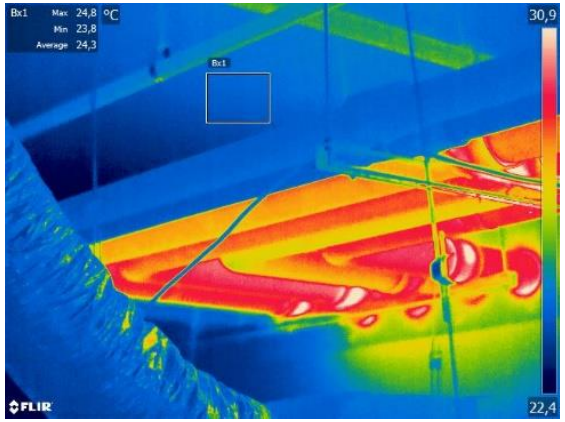












Detection of leakages

Control of HVAC systems

Envelope Checks

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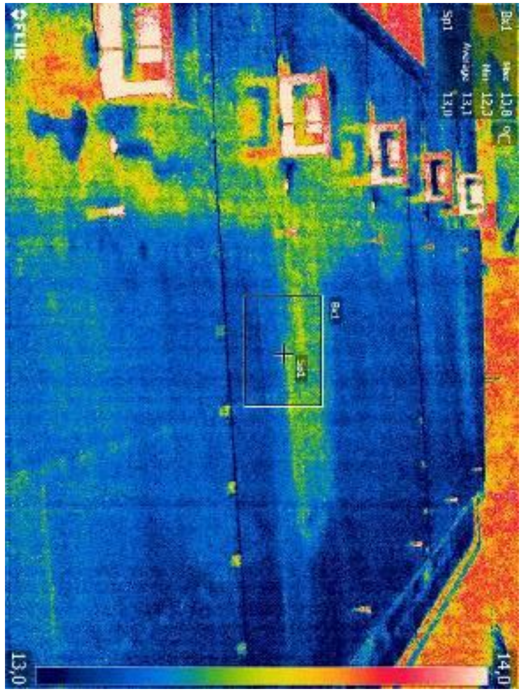
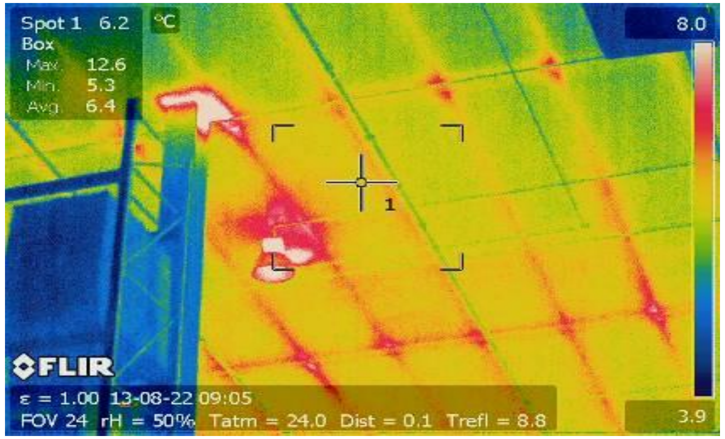
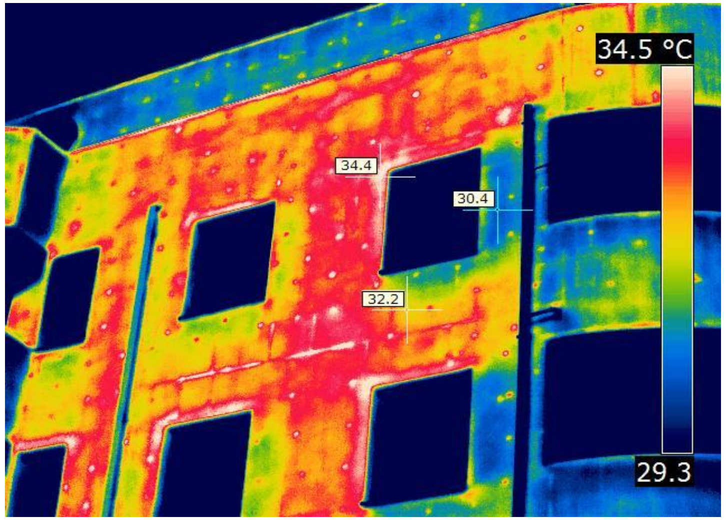
Infrared thermography – Thermal Bridges

Due to new technological advances and increased supply, the cost of thermal imaging cameras is becoming more affordable.

This is increasing the use of infra-red thermography across the construction sector .







Envelope Checks: Airtightness

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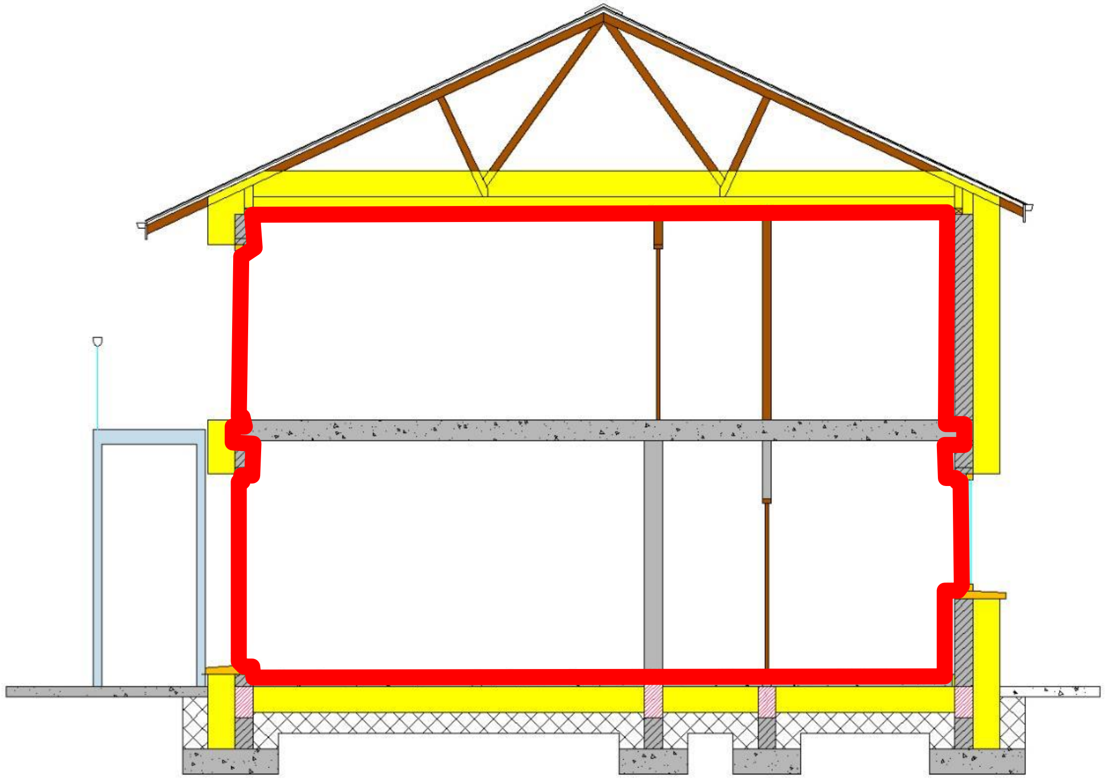
Air Tightness Strategy

In a well-insulated building, uncontrolled air leakage can account for a high proportion of the total heat loss of up to 35% , due to warm air being replaced by cold air or vice versa in warmer climates. The aim is to minimise uncontrolled infiltration and exfiltration.

Airtightness should be considered at design stage by sketching on the paper or digital drawing, a line that will form the airtightness barrier. It should be continuous around or through all elements and is best placed on the warm side of the insulation layer.

In addition to airtightness the designer/builder must also be mindful of the implications for moisture and vapour management through the use vapour control and breather membranes, which limit both vapour diffusion and air movement. And be aware of the interstitial condensation risks of certain envelope typologies.



Envelope Checks - Airtightness

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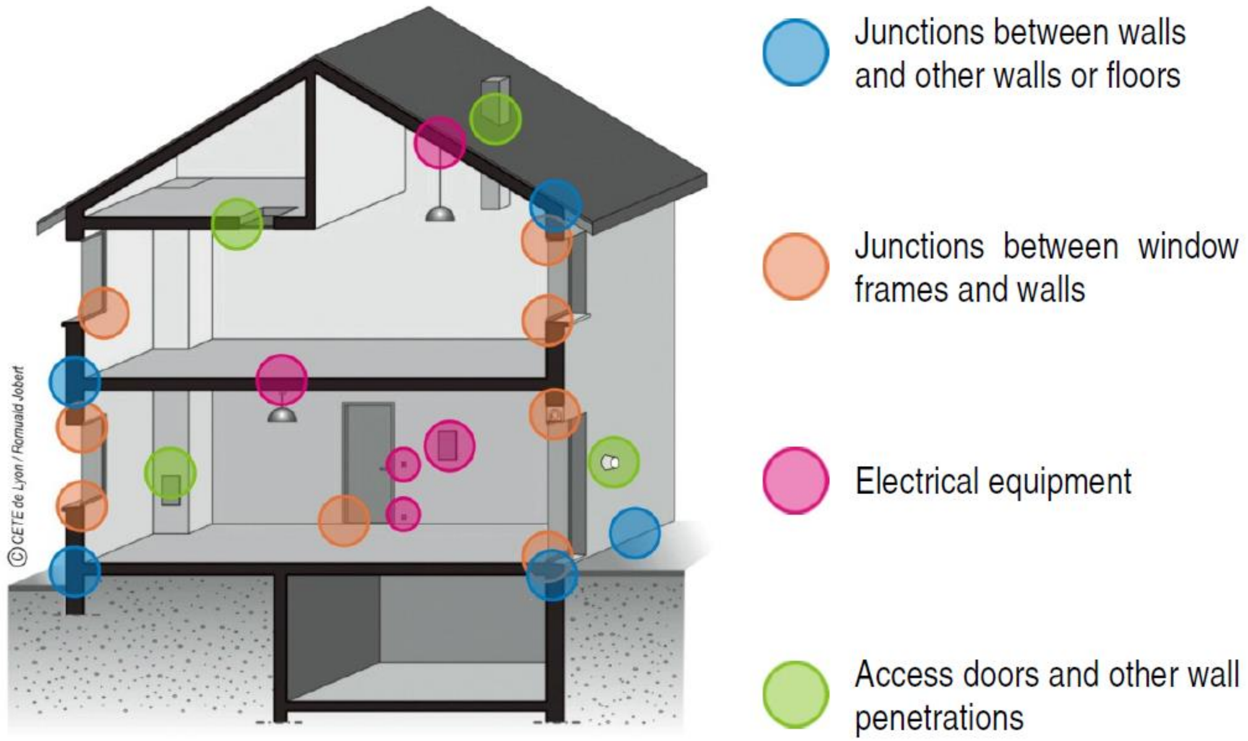
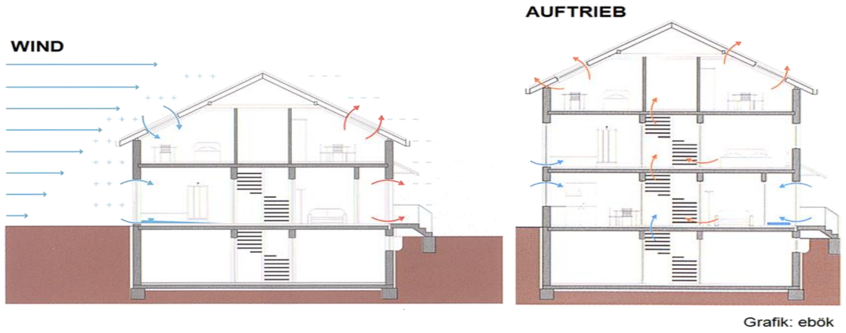
Where are the gaps?



Common leakage sites



Envelope Checks: Airtightness

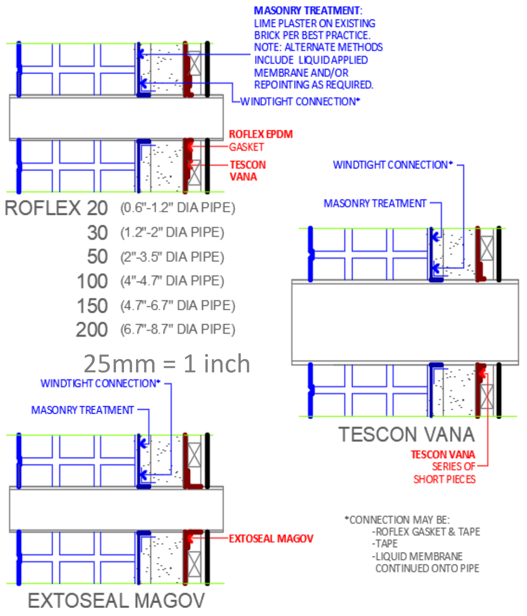
Responsibility

Designers

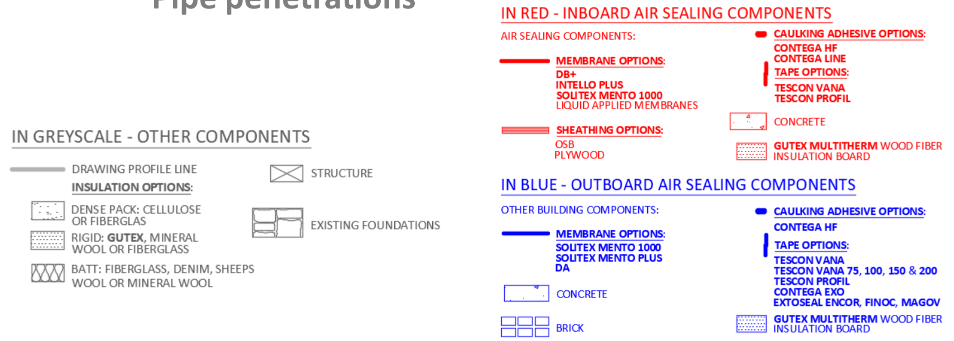
- Produce designs that allow the contractor to construct an airtight envelope.
- Details with the line of airtightness at all junctions (window-wall, etc.) which must not be covered over.

Contractor

- Confirm and certify that all the airtightness details are executed on site as it is drawn.
- Organise airtightness test as soon as the line of airtightness is complete yet fully accessible. Common practice now to carry out 2-3 airtightness tests



Pipe penetrations



Envelope Checks: Airtightness

Strategy To Achieve Airtightness

- Clear strategy from the architect – with details
- Explain and demonstrate the importance of airtightness
- Buildability is key - involve contractors as early in the design process as possible
- Hold a pre-start airtightness meeting to discuss details and blower door test programme
- On site airtightness training or "toolbox talk" with all key trades during construction
- Appoint an "airtightness champion" responsible for inspecting the completed work and training any new site operatives
- Arrange for key site operatives to attend a blower door test on another project – this will help them understand what they need to achieve.

Not just 'what' to do, but 'why' to do it

Envelope Checks: Airtightness

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A strategy should be developed and agreed with all designers, contractors and specialists before works start on-site. Airtightness Strategy.

- Identify the line of the air barrier at an early stage in the design process.
- Appoint an airtightness supervisor on site who will manage the airtightness layer.
- Ensure all those involved understand the importance of the airtightness layer.
- Refer to airtightness in all contracts which impact on the air barrier and allow for any penalties to be applied should the barrier be penetrated without repair
- Specify all components and materials prior to project commencement
- Check intersection of all elements (junctions, change of materials etc) to ensure the continuity of the air barrier.
- Have an airtightness notice board live onsite that any penetrations and concerns can be logged and referred to the airtightness champion manager. Best practice is to use a digital mobile field App such as Trello.
- Inform operatives carrying out airtightness critical works through tool box talks.
- Check the air barrier for completeness before it becomes impossible to access: Many construction companies now have their own airtightness equipment such as blower door fans and trained operator for this process
- Schedule well in advance for a competent testing body to carry out an airtightness test. For larger sites, a pre-test visit to site by the testing body should be had this will identify preparation required such: sealing and closing all vents and open flues, external doors and windows and the optimum positioning of the fans. For retrofitting a pre project test is required.
- Ensure that all airtightness works are complete.
- Submit results to Building Control.

Envelope Checks: Airtightness

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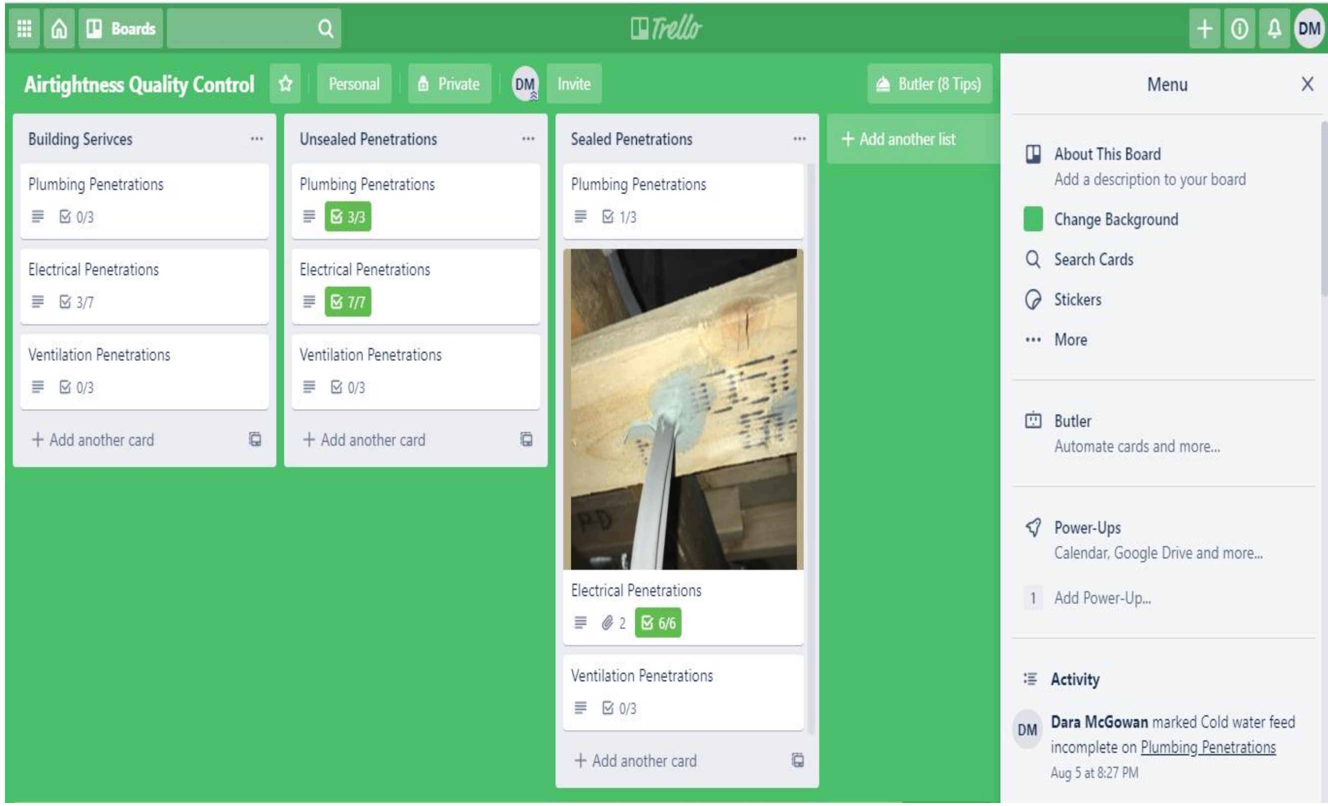
BIM and Digital Apps

Using digital tools can enhance quality controls and check on-site airtightness details

There are Field Apps, suitable for use by mobile phones and tablets, such as Trello, StreamBIM, Revizto, Revit, Archicad & BIM-360 these apps are especially suited to site checks some also allow for reporting from site directly back to the BIM model



Envelope Checks: Airtightness

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Checklist

- On your first project(s), it is recommended to **do several intermediate tests** to determine how the building is performing
- If you leave the test to the very end, you will probably not have **access to the sources of any leaks**
- Build testing into the **construction programme – allow for this in the tender documents**

Typically, on a house project the contractor should allow for 3 pressure tests:

1. Building sealed, including electrical first fix in place.
2. Mechanical ventilation system & all services penetrating external fabric of building have been fully installed.
3. Practical completion

100	Same schedule as Ground Floor - To be revised with proposed drawings	[illegible]	[illegible]	[illegible]
101	FS - Inspection 04	0.00	02/05/2018	02/05/2018
102	ME - Inspection 05	0.00	04/07/2018	04/07/2018
103	EXTERNAL WORKS	8.00	31/01/2018	31/01/2018
104	External insulation	304.00	27/03/2018	22/05/2018
105	External drainage	120.00	10/04/2018	30/04/2018
106	SE - Inspection 06	0.00	25/04/2018	25/04/2018
107	Aluminium works	160.00	17/05/2018	13/06/2018
108	External service ducts for gas/electric/cable/telephone etc	64.00	14/06/2018	25/06/2018
109	EE - Inspection 7	0.00	27/06/2018	27/06/2018
110	Railings	120.00	01/05/2018	22/05/2018
111	Hard landscaping	96.00	14/06/2018	29/06/2018
112	SE - Inspection 07	0.00	09/05/2018	09/05/2018
113	Soft landscaping	56.00	27/06/2018	05/07/2018
114	Power on	8.00	21/05/2018	21/05/2018
115	FS - Inspection 05	0.00	13/06/2018	13/06/2018
116	Handover	8.00	31/01/2018	31/01/2018
117	AIR TIGHNESS BREAKDOWN	8.00	31/01/2018	31/01/2018
118	Flooring	8.00	31/01/2018	31/01/2018
119	Sealing ground floor services	8.00	31/01/2018	31/01/2018
120	Sealing ground floor to wall	8.00	31/01/2018	31/01/2018
121	Internal plastering for internal wall	8.00	31/01/2018	31/01/2018
122	Sealing walls and upper floors	8.00	31/01/2018	31/01/2018
123	Sealing around windows	8.00	31/01/2018	31/01/2018
124	Sealing wall services and opes	8.00	31/01/2018	31/01/2018
125	Sealing around windows and doors	8.00	31/01/2018	31/01/2018
126	Sealing ceiling to walls	8.00	31/01/2018	31/01/2018
127	Sealing around services through roof penetrations	8.00	31/01/2018	31/01/2018
128	IMPORTANT ORDERING DATES	8.00	31/01/2018	31/01/2018
129	Prepare, check and order door/windows	8.00	05/03/2018	05/03/2018
130	Prepare, check and order external wall insulation	8.00	27/02/2018	27/02/2018

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BIMzeED education for zero energy buildings

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Envelope Checks: Blower Door Test

Airtightness Testing Equipment

- Adjustable Aluminium Frame
- Elasticated Cloth Curtain
- Elasticated Cloth Fan Cover
- Depressurising/Pressurising Fan
- Flexible Hoses
- Manometer
- Power Cables & Fan Speed Controller

Envelope Checks: Blower Door Test

Timing of Testing – Don’t Leave to the End

The airtightness of a building is measured with a differential pressure measurement using a ‘blower door’.

The procedure is used to detect leaks in the building envelope and to determine the air exchange rate / air permeability.

A fan is installed into the opening of a window or door with an airtight seal.

Measurements are made at varying pressure differences and results are normalized to 50 Pa.

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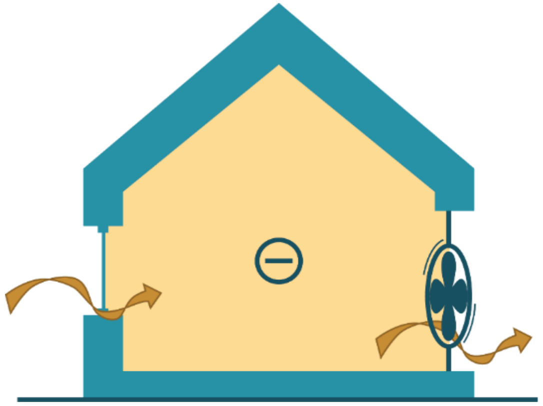
Blower Door Targets



Test in Both Directions

- recommended to carry out 10 **positive and negative** airtightness tests
  - you can evaluate the **sealing provided by the window and door gaskets** when they are inward opening a better airtightness result is expected for a positive pressure test where the sash gasket is 'pressed-against' the frame

- Official result is the **average of all tests positive and negative**

Envelope Checks

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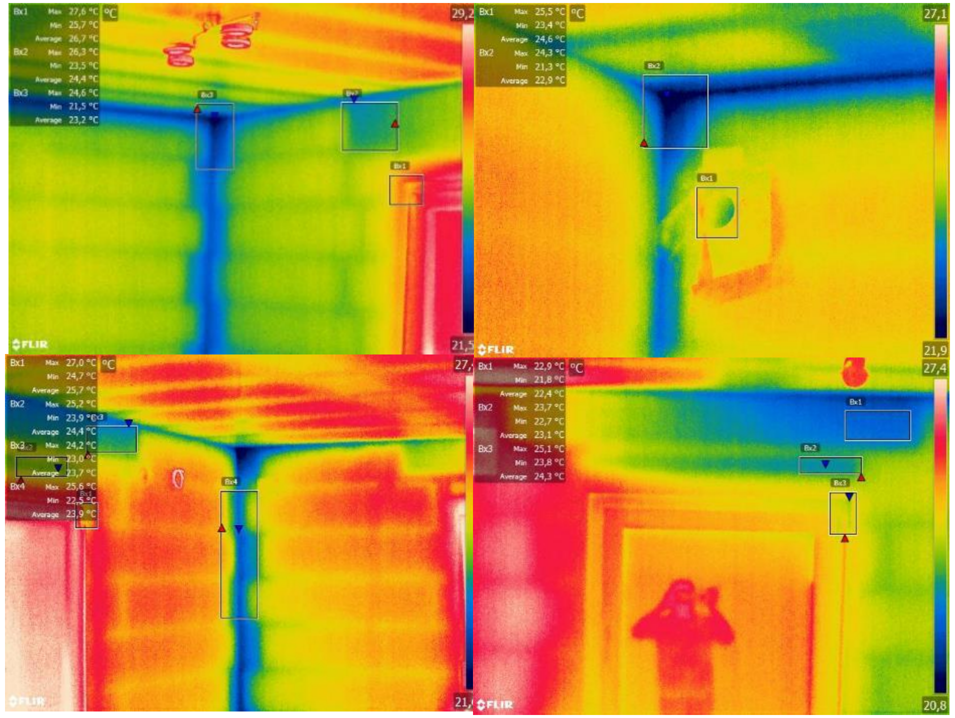
Quality Assurance – airtightness measurements and thermography

Source: B. Milovanović

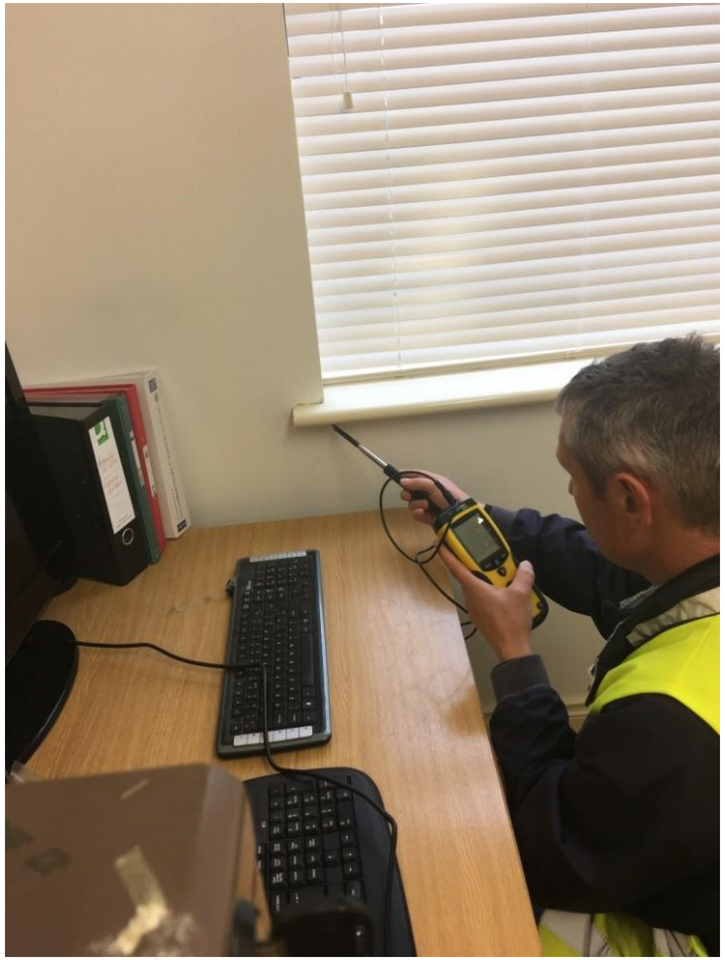


Blowerdoor test makes it easier to see thermal bridges!

Source: B. Milovanović

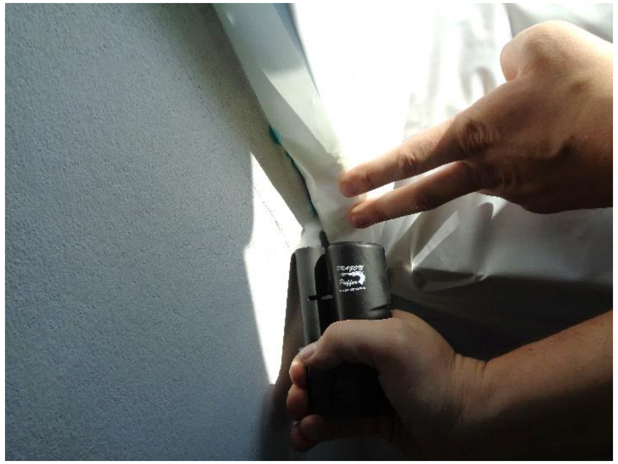
Leak Detection - Anemometer

- Cannot find unexpected leaks?
- Severity of leaks to be gauged
- Will prove a leak if others doubt its presence



Leak Detection - Smoke

- Allows leaks to be visualised, and to a certain extent for their severity to be gauged.
- There are 3 main types of smoke used:
  - **mini-smoke** – smoke puffers and pencils that are useful for determining draughts at specific locations
  - **small smoke gun** – handheld smoke guns are useful for especially around windows and to determine air movement paths in discrete areas of the building
  - **mega smoke** – such as disco generators. These are handy for particularly larger, perhaps single skinned buildings, to determine leakage locations from outside.



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Airtightness Tests

Airtightness is typically measured in two units: n50 - Air Changes per Hour (ACH) @ 50Pa and air permeability q50 m3/hr/m² @ 50Pa. The n50 value measures the number of times the entire volume of air in a building changes within an hour, while q50 measures the number of cubic meters of air leakage per hour per m² of envelope area. This is said to be equivalent to a 20mph or 30kmh wind hitting the home at the same time from all sides. In other words, a very windy day.

For a typical building, there is usually little difference in the two figures, a coincidence due to their geometry: See table below

However, the two measures, Air Permeability and Air Change Rate, do not have a direct relationship with each other (so you can't apply a conversion factor to one to get the other).

	Dwelling 1	Dwelling 2	Dwelling 3	Dwelling 4
air permeability m3/h.m2 @ 50PA	8.48	7.73	3.56	5.15
air leakage rate ACH @ 50PA	8.45	7.71	3.33	4.4

Estimating the Background Ventilation Rates in New-Build UK Dwellings – is n50/20 Appropriate? https://journals.sagepub.com/doi/full/10.1177/1420326X15626234, (2016)

Air Tightness Regulations

	buildings with MVHR	buildings without MVHR
Spain	NA	NA
Ireland	$q_{50} \leq 3$ m^3/h.m^2	$q_{50} \leq 5$ m^3/h.m^2
Hungary	NA	NA
Croatia	≤ 1.5 ACH50	≤ 3.0 ACH50

Passive House
- 0.6 ACH50 (~0.60 L/(s·m²))

LEED, 6-sided apartment test
- (~1.25 L/(s·m²) at 50 Pa)

UK (AATMA) Large Buildings
- ~0.70 to 1.75 L/(s·m²) at 75 Pa

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Glazing inspection

Glass components of a building can lead:

- to higher energy costs and
- higher susceptibility to damage, creating safety issues for the building's tenants.

A building glazing inspection is essential in ensuring that your glazing is well-protected in order to prevent potential problems before they occur.

In addition to the building's installed glass, a glazing inspection will also analyze the surrounding structure to identify potential weaknesses and deficiencies

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Glazing inspection

Double/Triple Pane Thickness Measurement:

- Glass thickness affects thermal, acoustic and transmission properties of glazing

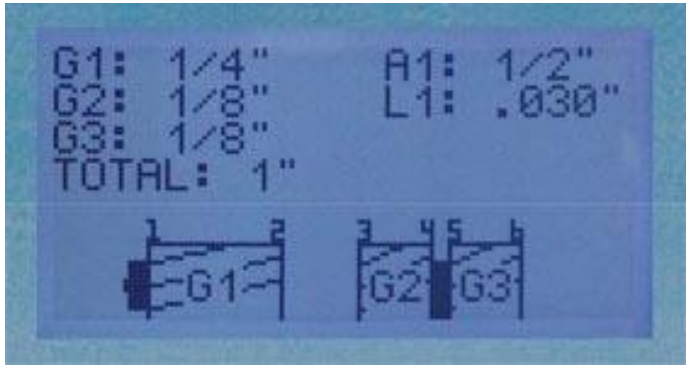
Detect location and determine type of Low-E coatings present

- to locate a Low E coating on a double/triple pane window
- The type of Low-E coating (hard or soft coat)

Importance of knowing Low-E Type

- Using the wrong coating can negatively affect the energy performance of a window.
- the type of coating used on glass significantly effects the way a window reflects light.
- the visual appearance is also affected.

Thickness display including glass, air space, laminate, and overall thickness.



Low-E display including location and type of Low-E coating.

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REMEMBER, IT'S THE DETAILS THAT MATTER!

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Building Services Checks

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Services Checks for Ventilation - Ireland

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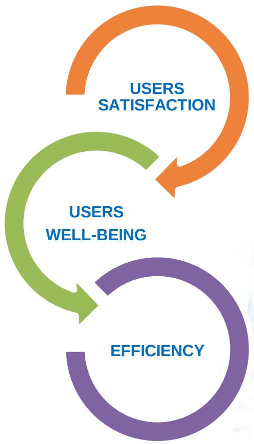
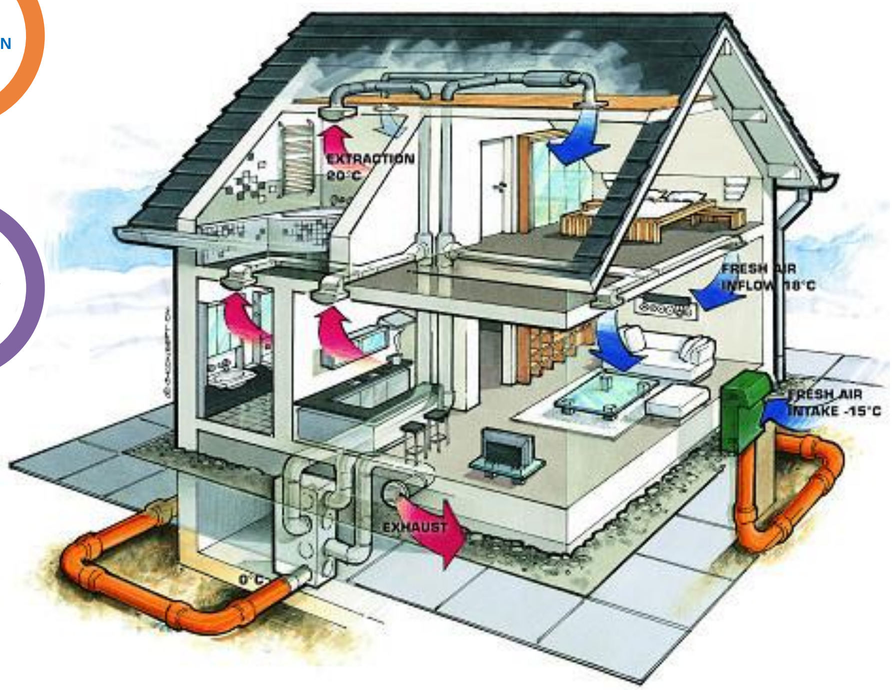
Mechanical ventilation systems require commissioning and certification as stipulated in the building regulations 2019 TGD-L (Dwellings) which specify that maximum provision for airtightness is to achieve a pressure test result of less than or equal to 5m3/(hr.m2)@50Pa, best practice aims for 3m3/(hr.m2)@50Pa, which triggers a requirement for mechanical ventilation.





Services Checks for Ventilation - Ireland

TGD Part F 2019 provides guidance ventilation for buildings with an air permeability of $5m^3$ / (h.m2) at 50pa or less. It is important as buildings become more airtight that adequate ventilation is maintained, which may be achieved through the supply or extraction of air by mechanical means or by natural ventilation, or by a combination of these methods. The Building Regulations require that an air permeability test should be carried out on all buildings.

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Heating and Cooling

Part L for both domestic and non-domestic buildings require provision and commissioning of energy efficient

- space heating and cooling systems,
- heating and cooling equipment,
- water heating systems,
- effective controls

There is also a requirement to provide to the building /dwelling owner or occupants enough information about the building, the fixed building services, controls and their maintenance requirements so that the building can be operated in as an efficient manner as possible.

Services Checks for Lighting

Co-funded by the
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Lighting – checks
levels and render EN12464-1
CIBSE guides for compliance

Illuminance-lux, can be measured by devices, known as lux meters. Standards and lighting regulations define light lux levels. To test the regulatory compliance of a lighting installation the illuminance values are measured in several points on the floor. As modelled in lighting software.

Designers –
Dialux lighting design software
Plan, calculate and visualize light for indoor and outdoor areas. From entire buildings and individual rooms to parking spaces or street lighting.

Services Checks for Renewables

Co-funded by the Erasmus+ Programme of the European Union

Designing an NZEB or ZEB involves reducing, initially, the energy requirements of the house and then ensuring that the nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, this is called the Renewable Energy Ratio (RER): the ratio of the primary energy from renewable energy technologies to total primary energy calculated in the EAPs.

Renewables include –but are not limited to :

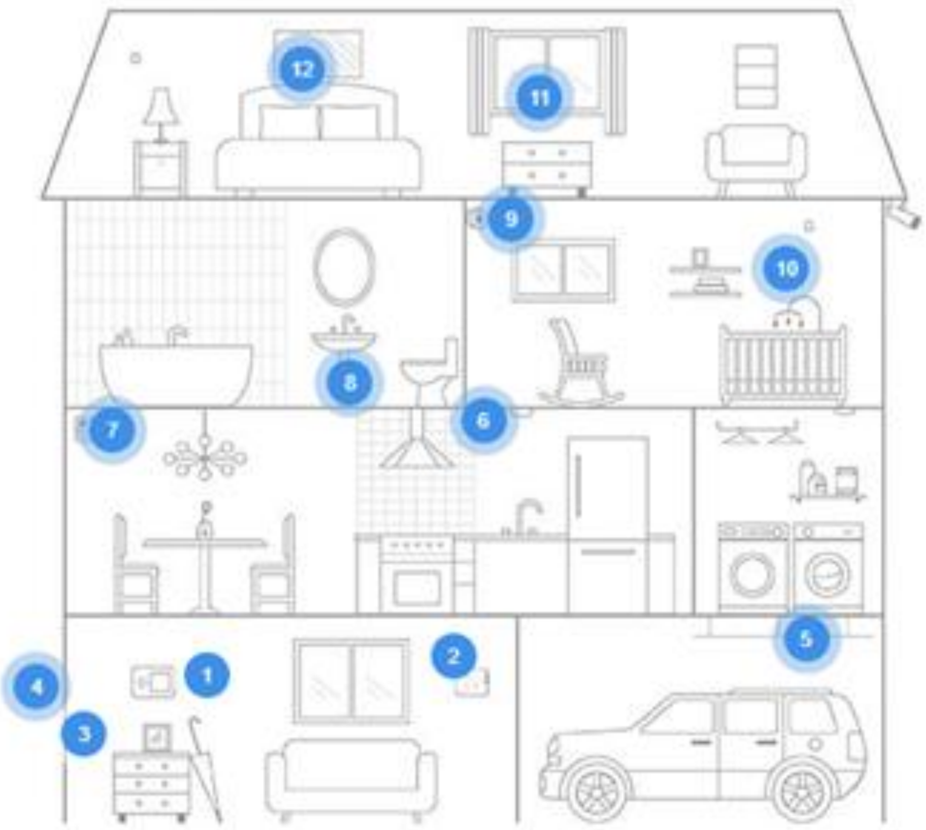
- solar thermal systems
- solar photovoltaic systems
- biomass systems
- systems using biofuels
- heat pumps,
- aerogenerators
- combined heat and power
- aerothermal
- geothermal
- hydrothermal
- wind
- biomass
- biogases

Services Checks for Smart controls and Sensors

Co-funded by the Erasmus+ Programme of the European Union

A smart home can include the following:

- control panel
- heating controls
- smart locks
- video doorbell
- garage door control
- smoke & CO_2 alarms
- motion sensor with camera
- temp humidity sensor/water meters
- video cameras
- video cameras
- window sensors
- lighting controls



Services Checks

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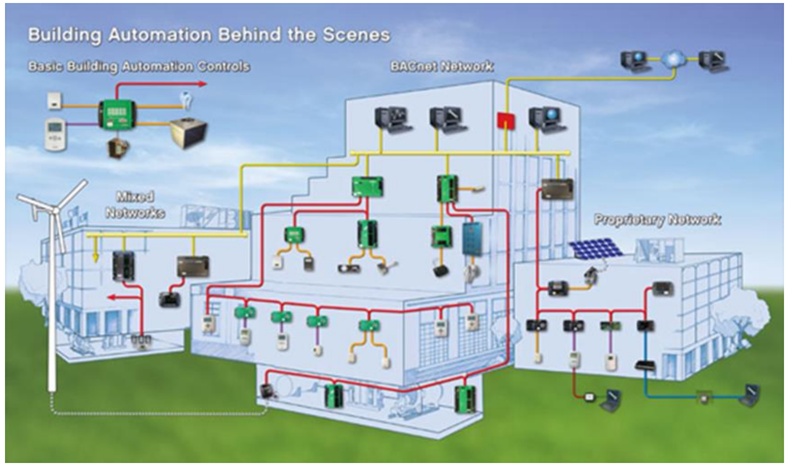
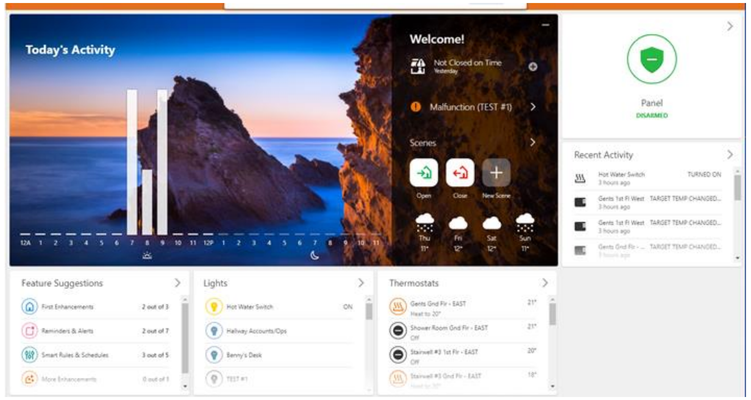
Smart buildings can be controlled remotely over either a Wi-Fi or cellular connection ensuring the system will not go down.

Smart buildings are growing in popularity due to their many advantages. They also include security making it easier to monitor a building or home whether you're inside or away. Energy management is also a main feature of smart controls, which include adjusting the thermostat, turning on and off lights and monitoring water usage.



Smart controls for a large building



Services Checks

Use of BIM for NZEB quality management

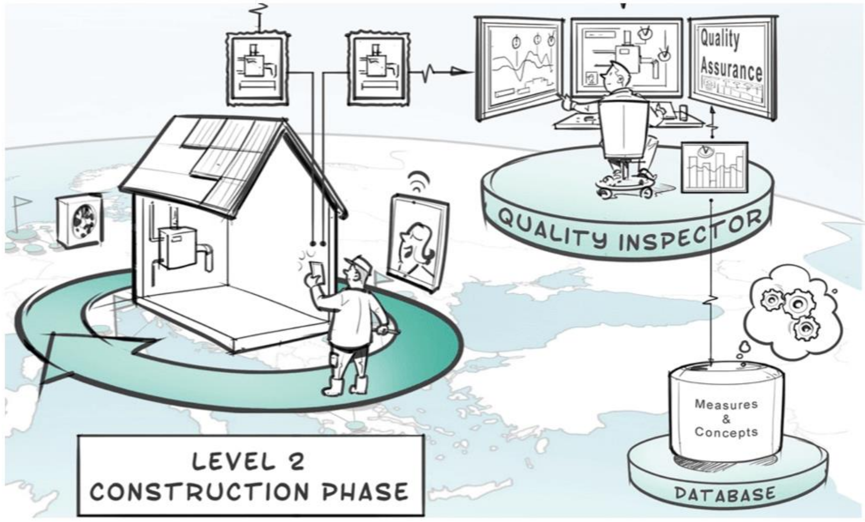
BIM model can contain documents and information related to installation of specific materials, products and systems.

- blue-collar worker could get a short work-instruction before-hand and a self-inspection of quality during installation of e.g. the ventilation system

Professional in charge of the supervision of the construction works

- can ensure that any change made during the construction is correctly reported in the model.

Linked to Design and inspection



Source: Jan Cromwijk - BUSleague

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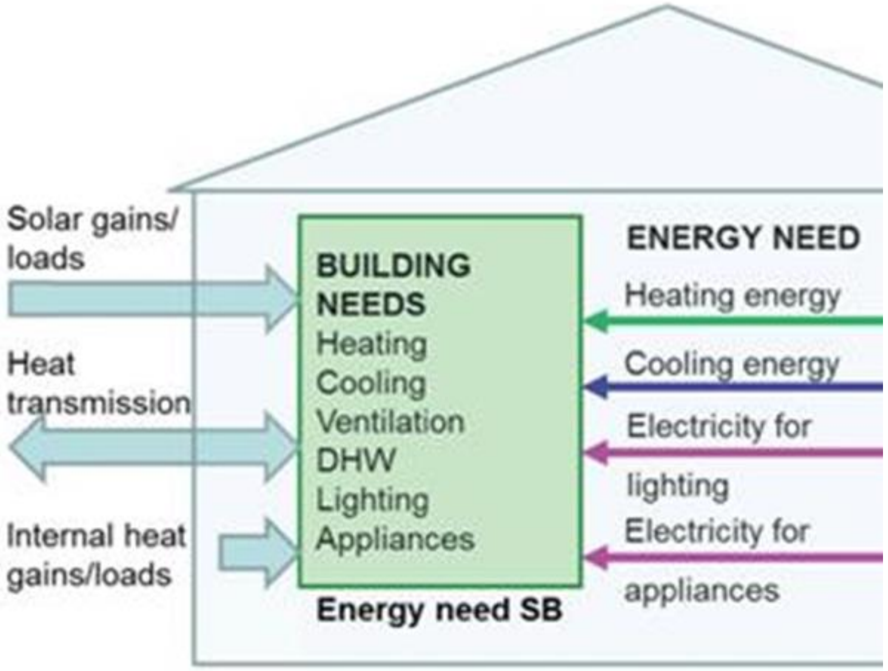
Use of BIM for NZEB quality management

There is a need, as Facilities/Building Managers, to keep an eye on the daily activities of the building and the maintenance and operations of NZEBs. The as-built BIM model is crucial to assist in this.

Top regard must be given to :

- Thermal Comfort
- Humidity
- Lighting
- Acoustics
- Quality of Services Provided
- Building Operating Costs
- Energy Use, Water Use, Recycling, And Waste Reduction.

All of these systems are data-intensive



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DIAlux Activity

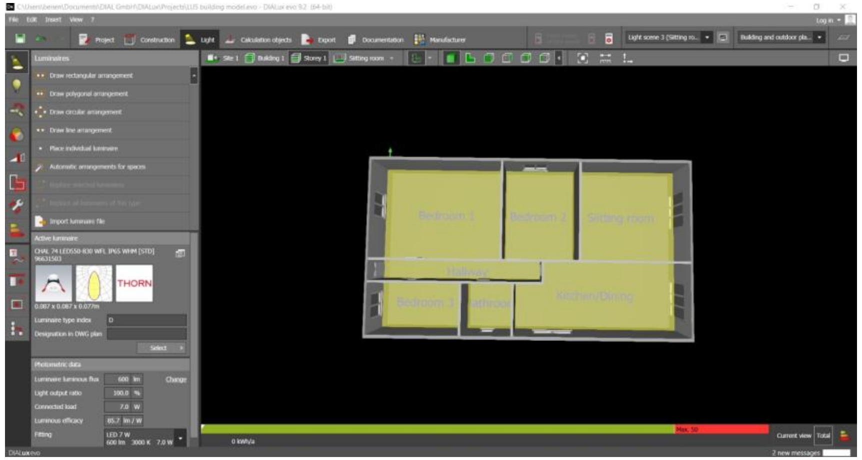
Create your own Dialux project by installing lighting-luminaires to the Evo Model using Dialux software:

Download DIALux

- Select suitable lights for the interior of the building
- Install lights into the model in all the rooms.
- Check compliance with EU regulations defined in the Dialux software

On completion:

- Save the EVO file and create a PDF file of the energy performance of the building report
- Upload the EVO file and PDF report on the energy performance of the building.



If you prefer to use different lights, then use other catalogues to load into the software.

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QUIZ!

Thank You

Insert Organiser Logo Here

For illustrative purposes only delete this shape from final presentation

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