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Train-to-NZEB

The Building Knowledge Hubs

Terms of Reference

for local teams for the creation of Building Knowledge Hubs

Deliverable 2.1 of the

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MosArt / Passive House Academy

TERMS OF REFERENCE

for Local Teams for the creation of Building Knowledge Hubs (BKH's)

The Train-to-NZEB project is designed to establish a functioning network of training and consultation centres (Building Knowledge Hubs, BKHs), providing practical trainings, demonstrations and complex consulting services for the implementation of nearly-zero energy buildings (nZEB). This is a development of the BUSI Build UP Skills initiative and reflects nZEB criteria, with the latter, in turn, reflecting the Passive House Standard as one existing, supra-national, consistent, tried and tested implementation of the nZEB definitions that meets the manifold criteria, including from "nearly-zero energy demand", to "cost-optimal levels in life cycle perspective", to "significant energy supply from on-site or nearby renewable energy systems (RES). Using the improved training facilities, the BKHs will provide enhanced capacity for conduction of trainings on curricula developed on BUILD UP Skills II, thus reaching a significant number of workers not covered by the initiative. Additionally, BKHs will offer trainings for highly-qualified building professionals and demonstrations for non-specialists with decision-making authority, which, combined with administrative and financial consultancy service, will result in increased capacity for implementation of nZEB projects in the involved countries. Five European countries will benefit directly from the establishing of BKHs, namely, Bulgaria, Czech Republic, Turkey, Romania and Ukraine.

In order to assist the participating countries to set up the required BKH's, MosArt, which also operates as the Passive House Academy (PHA), has been assigned the task of producing Terms of Reference (ToR). The ToR document will provide an essential structure including the physical infrastructure required as well as an indication of course content and delivery mechanism. More fundamentally, it will outline alternative structures for the support and operation of the BKH's. This information will be presented generically at first and then expanded upon and illustrated in the form of five case study examples in which the PHA has played a central role regarding their establishment and continues involvement for training delivery.

Generic description of a BKH

The most effective means of achieving highly energy efficient buildings cost effectively, such as intended by the EPBD recast is to start by focusing on the building envelope, ie. the 'fabric first' approach. This will result in significantly improved levels of airtightness which, in turn, necessitate the use of mechanical ventilation and heat recovery. With this as a fundamental basis, Renewable Energy Systems (RES) are added, as called for in the nZEB definition. Thus, in combination with highly efficient energy use in the first place concerning the building fabric, these RES's can make a significant contribution to moderate cost.

The first step in creating BKH's regarding nZEB implementation, consist of a facility that caters for both theory (the *why*) and practical (the *how*). Whereas the former could be delivered in a large classroom with many trainees, the latter will likely be the determinant of trainee group numbers - a single trainer is unlikely to be able to manage more than 14 trainees in a practical workshop situation.

Classroom Training - Theory

This should be a well light and heated space and consist of a single desk and chair for each trainee. This might comprise either the conventional classroom seating layout or a horse-shoe layout, but the space available might determine this. The trainer should also be provided with a table and chair as well as a generously sized white board and an overhead projector connectable to a computer and server. A training manual should be provided to each trainee covering the sides of which the course is comprised along with a copybook and pen.

The learning objectives for the nZEB training, in general, include:

- Learn about nZEB definitions and basic principles of designing accordingly, including long term experience with buildings that meet these criteria (such as those built to the Passive House Standard);
- Understand the importance of thermal bridging and both airtightness, vapour resistance and windtightness;
- Locate the correct positioning of the airtightness and vapour control layers in relation to the insulation and structural layers in a range of typical construction types;
- Outline the steps and procedures involved in the performance of an airtightness test using the n50 and q50 methods;
- Demonstrate correct airtightness treatment at door and window openings, service penetrations, joints vertically and horizontally, corners and where the wall meets other constructional elements;
- Identify suitable high performance glazing, edged and frame types and compare them to those commonly used in construction;
- Understand mechanical ventilation heat recovery systems, including the basics of design, installation and maintenance;
- Demonstrate correct layout design of ventilation system as well as calculation of airflow rates for whole building and each room and calculation of duct sizes;
- Outline the key elements of ventilation ducting in nZEB projects and ensure high performance in terms of airtight and highly insulated penetrations;
- Summarise supplementary heating and cooling in nZEB projects, technologies, sizing and installation;
- Understand the importance of and approach to highly efficient use of electricity in mechanical services, lighting and other applications;
- Describe the function and application of different renewable energy systems (RES's)
- Define the effectiveness of these RES's and their interface with other mechanical services;
- Outline the principles of the 'intelligent building', concerning smart technologies that minimise energy consumption through, for example, optimised operation and coordination of services;
- PRACTICAL: Perform the highest quality fixing of a range of insulation types to different construction types;
- PRACTICAL: Practice optimal fitting techniques and understand associated thermal bridge values for nZEB suitable window and door installations in different construction types.

- PRACTICAL: Perform the balancing of supply and extract air flow as well as duct assembly that is airtight, insulated and vapourtight.

Course duration can vary in respect of the background, knowledge / experience and the availability of trainees. Regarding tradesperson training, courses could be as long as three weeks, as for the Certified passive House Tradesperson - Building Envelope / two weeks for the Certified passive House Tradesperson - Building Services in respect of the unemployed (see the CDETB Case Study below) or reduced to the equivalent of two / three-days theory on-line and two days practical for the employed who are not so available due to work demands, but involving on-line theory training (see On-line Training – Theory below). The latter combination is deemed empirically by PHA as the minimum in order to ensure a balanced and reasonably comprehensive imparting of the necessary knowledge, skills and attitude. The equivalent of eight days minimum would be required for Designers /Consultants and this could all be on-line, although experience shows that direct contact proves very useful. Specialised course, such as those on energy analysis software (eg. the Passive House Planning Package (PHPP)) and thermal bridging analysis, would require the equivalent of two or three days and could be on-line.

On-line Training - Theory

This facilitates distance learning and, thus, reduces the need for classroom sessions with the associated need of the physical presence of trainees as distinct from the convenience of being able to learn from home or office in a suitable timeframe. In other words, on-line training can minimise the need for direct face-to-face contact between trainer and trainee, with the potential of the latter being used primarily for practical training. This method of training can easily be combined with specific location learning, such as can be delivered through Moodle, an on-line learning platform which is free of charge, involving the kind of presentation systems listed below. Note that voice-over audio recording and/or slide-related notes are highly recommended in order to facilitate the interpretation of material. Where audio recording is to be used, a high quality microphone is critically important.

- Video link-ups whereby trainees are watching live delivery in real-time involving a pre-determined time and day
- Slide presentation (eg. PowerPoint) with / without voice-over
- Access to various resources, texts, links and self-assessment tests.

Airtight Room - Practical

This is a single space structure, including a roof, door, window and rooflight (none of which need to be to a particularly high thermal performance level for the pure air tightness related learning but should, nevertheless, showcase highly efficient products suitable for nZEB), along with exposed materials directly associated with airtightness in buildings, such as membranes and tapes. This Airtight Room could be constructed of monolithic or precast element construction where this type of construction is most typical. The room is used to demonstrate the carrying out of a pressurisation test in respect of the achievement of required airtightness standards. It should be illuminated with lighting, ensuring good visibility throughout. The same space, for convenience and security, can house mechanical ventilation neat recovery equipment (MVHR). Suitable means of temporarily sealing the ODA/EHA ducts must be at hand for the air tightness testing (eg. football bladders and hand pump to temporarily seal the external ducts during a pressurization test).

Mechanical Ventilation Heat Recovery - Practical

MVHR equipment is critically necessary for the provision of adequate ventilation where high levels of airtightness are to be achieved. It comprises an operational MVHR machine certified by the Passive House Institute (PHI), control panel, pre-heater, post-heater, ducting and sound attenuators as well as a supply air duct with four supply outlets and an extract duct with a minimum of three extract inlets. Note that the requirement for a PHI certified unit is important, notwithstanding the possible need to import, in order to ensure sufficiently high efficiency of heat exchange and general integrity in fabrication – the MVHR unit plays far too critical a role to be compromised, in this regard. Whereas it may prove useful for demonstration purposes to have the various components visible, alternatively it is possible to obtain integration of some of these, such as the incorporation of a pre-heater or, indeed, the elimination of this all together where new MVHR systems permit. In any case, it is vital that the system chosen makes the entire process explicit, from intake, through the MVHR, ducts and attenuators (silencers) and back to the exhaust.

Outlets/inlets should be mounted into a plate (eg. ceiling / wall panels) of sufficient size to enable the use of flow measuring equipment. At least one sound attenuator is to be incorporated in line on the supply duct. It is advisable to provide two types of silencer, one to suppress noise emission of the unit to the duct system, such as decoupling, and the other to suppress telephonic sound transfer between rooms. All equipment, in particular ducting, is to be properly fixed to the ceiling with sound absorbing / rubber insulated clamps and all joints sealed with airtight tape. The outdoor air duct is to be fully insulated with vapour tight insulation (dense foam or foil-backed fibre≥50mm thick and this insulation must be fully sealed with airtight tape (not foil tape) along its length to ensure vapour-tightness. If an air heater for supply air is incorporated, the heater box as well as all downstream ducts should be insulated ~ 25mm (no need for vapour resistance here). Both the intake and exhaust ducts will penetrate the external wall of the room, fitted with hoods and mesh screens as in real life and should be accessible for testing in respect of airflow (m3/h).

Additionally they can be equipped with baffle crosses to measure the flow. An external filter box as well as an electrical or hydronic pre-heater for outdoor air can also be provided, integrated into the system or as specimen for explanation. A room-based pendulum (alternating intake and exhaust) MVHR unit, whether 100mm or 150mm, would also be a useful attribute, not least for retrofit training.

Loose Equipment - Practical

Two main items for the kitting out of the Airtight Room are:

Main items for the kitting-out of the Workshop or practical area are:

- Pressurisation equipment suited to fitting to a door (Airtight Room)
- Wizard stick, ie. smoke leak detector (Airtight Room)
- Anemometer, including a device with zero pressure compensation (like the ‘Flow Finder’ or similar), for the supply and extract points as well as for the exterior intake and exhaust points (Airtight Room)

- Whiteboard to be provided contiguous to the Construction Models and Airtight Room
- Alternative MVHR units that are not necessarily operational, as examples of other possibilities or of faulted systems. A compact unit is strongly recommended.
- Samples of construction components and systems, eg. insulation and airtight material, window sections and items associated with mechanical ventilation, specialized products to avoid / minimize thermal bridges (insulating blocks, low conductivity structural insulation for walls and window support, balcony slab connectors, grommet seals for fixtures and ducts, etc…).
- Equipment to demonstrate the process of pumping cellulose, such as between studs, would be useful. This involves the achievement of a certain density and compaction in order to ensure stability and the need to open parts of the construction, such as the airtight membrane, in order to perform the operation and to close it up again without loss of fabric integrity or performance.
- A full set of tools necessary to carry out the practical work must be provided. This includes a tape measure per trainee, a craft knife per trainee with spare blades, four saws, four keyhole saws, a hammer, a screw driver, four files, four hacksaws with spare blades, a mallet, a 1m long spirit level, a 2m long straight edge, a cordless automatic drill, boxes of screw for the fixing of mechanical supports (where ducting support is required), and a set of markers
- Cleaning equipment and bins must be provided, including broad and normal brushes and dust pans and broad shovels.

Construction Models - Practical

Fabricate and install construction types that are relevant to the local culture but adapted to ensure significantly higher energy and comfort performances, comprising:

- 3 – 5 Demonstration Models involving floor external wall with cut window section, suspended first upper floor, ceiling and roof as well as different materials and methods. This, accordingly, affords a sound basis for systematic presentation of alternative high performance construction, including trainer description, trainee drawings and trainee description (each of these proves an extremely useful means or effective teaching / learning). These models involve viewing only and, therefore, can be constructed of light weight materials and made to look like the real thing, eg. use fermacell board on wooden stud construction painted to look like a poured concrete floor slab / beam or concrete block / brick wall.
- 3 – 5 Practice Models accommodating 2-3 trainees at a time focused on the achievement of insulation, thermal bridge elimination and airtightness, but preferably excluding wet trades, such as plaster, due to inconvenience in application and the ultimate need for deconstruction. These models must be made of the correct materials and be sufficiently robust to take repeated practice sessions. Models can be more or less complex, depending on the level building components best suited to the training task and the number of trainees intended to work simultaneously on a single model (see Case studies and Appendix A). Where monolithic or precast construction is common, a decision will be necessary in respect of where and how, for instance, insulation and airtight materials are

to be placed. Experience suggests that airtight membrane is most effective where models are to be used over and over again.

- 6 mock MVHR units comprising a 75x75x90cm high MDF boxes fitted with 4 20cm short ducts to represent the four duct connections in reality. A selection of 20, 15 and 10cm ducts should be provided as part of a pre-designed mock-up duct assembly.

Note:

a) It is critical that all surfaces to receive airtight tape as part of practical training must be generously covered with duct tape in order to allow for complete removal of the airtight tape without resulting in any damage. [Note that trainees should be clearly instructed that duct tape otherwise has no place being used as part of high performance work due to the limited durability of its glues!]

b) Airtight membranes and tapes can be applied as a worthwhile exercise in high performance construction technique even where a given construction type is inherently airtight (eg. Involving poured concrete). In any case, particular attention will be required at joints.

c) Models are likely to need maintenance every few years, such as replacement or strengthening of masonry parts of replacement of parts where airtight tape is left and adheres in error. If fixing of some component by screws is required, wooden liners should be used so that they can be removed when pocked by screw holes – such ‘skinning’ with thin plywood can prove effective as a removable protective layer.

Supplementary Accommodation and Material

Consultation space will be important and would require a minimum of one meeting room sufficient to accommodate two chairs and a reasonably sized table for a computer (and maybe a printer) as well as for the spreading out of drawings. As privacy and confidentiality will be important, acoustic separation should be considered. Electrical sockets and good lighting will also be important.

Space is necessary for the storage of bulky materials, such as insulation and membranes. This could be ancillary to or part of the main workshop area that houses the models and airtight room. A small lockable office providing a clear view of the workshop for reasons of security as well as health and safety is important. This room can also be used to house tools and small amounts of material, such as tapes and samples.

The use of tapes and membranes in the classroom for demonstration would be facilitated by their being transported on a small light-weight trolly. Note that airtight tape rolls are most effectively used where fitted to dispensers that hang from one’s hip with a belt. External space must be available to accommodate a skip for the discarding of waste material, which can prove substantial and bulky, and this requires an agreement being in place for its removal and replacement as necessary.

Additional training supports might be included involving 3-D graphics. These are particularly useful where a full range of models cannot initially be produced or where important variations to a construction type need to be presented to complement or compare with a model of that type. They might include: A fixed 3-D axonometric renderings of construction types; Animated 3-D axonometric renderings of construction types depicting the build-up of a model; Thermographic renderings of construction components and junctions; Hygrothermal analysis of construction components and junctions. See Appendix under Generic Supplementary Material.

Renewable Energy Systems (RES) - Practical

Operational full-size examples of photovoltaic panels, solar-thermal panels, domestic solar hot water systems, domestic heat pump installations and domestic biomass heating installations, small scale wind systems, photovoltaic systems and installation and micro-generation (and also possibly rainwater harvesting) will be provided in a workshop, demonstrating the functioning of the object itself and its workings within the larger system, eg. electrical and plumbing connections to hot water cylinders, domestic electrical system, national grid and within an automatically (intelligent) controlled integrated complex of services. Ideally, the BKH would actually be served by some or all of these renewable energy systems, so providing a working example with recorded results in terms of energy production and monies saved. See Appendix under RES.

The following are is a summary course description for RES courses:

1. Domestic Solar Hot Water Systems Installation

Course Description

The aim of this 2-week course is to supplement the apprenticeship training for Plumbers and other suitably qualified people, by developing the necessary skills, knowledge and competence to enable the participant to design, install and commission domestic solar hot water heating systems in a safe and competent manner.

Modules:

- Site and suitability for solar water heating installations
- Introduction to solar water heating systems
- Solar water heating systems
- Installation of solar water heating systems and controls
- Commissioning and handover of a completed system

2. Domestic Heat Pump Installation

Course Description

The aim of this 1-week course is to supplement the apprenticeship training for Plumbers and other suitably qualified people, by developing the necessary skills, knowledge and competence to enable the participant design, install and commission domestic heat pump systems. Successful candidates will meet the training criteria to register as an installer with Sustainable Energy Ireland (SEI).

Modules:

- Site and systems suitability for heat pump installations

- Principles of heat pump operation
- Introduction to heat pump technology
- Installation of heat pump systems an controls
- Commissioning and maintenance – domestic heat pump

3. Domestic Biomass Heating Installation

Course Description
The aim of this 1-week course is to supplement the apprenticeship training for Plumbers and other suitably qualified people, by developing the necessary skills, knowledge and competence to enable the participant design, install and commission small scale biomass heating systems in a safe and competent manner. Successful candidates will meet the training criteria to register as a biomass installer with Sustainable Energy Ireland (SEI).

Modules:

- Site and systems suitability for biomass combustion plant
- Principles of biomass combustion
- Introduction to biomass technology
- Installation of biomass combustion plant and controls
- Commissioning and maintenance - biomass

4. Small Scale Wind Systems Implementation

Course Description
The aim of this full-time 2- week training course is to introduce the learner to the concept of electrical micro-generation systems by the means of modern wind turbine technology. Most of the course material is generally applicable to wind turbines that generate electrical power up to a maximum of 6kW, but specific remarks are given to grid connected turbines that may generate above the 6kW and up to 25 kW. Basic skills in electrical circuits and installations are required.

The theoretical part of the course will give the leaner a solid base for understanding:

- The forces of wind
- Wind meteorology
- Site assessment
- Simplified performance prediction
- Technical understanding of wind turbine constructions
- Economic and environmental aspects

Participants will be provided with specific knowledge to ensure they are conversant with wind turbine generating systems and their current related regulations and code of practice with regard to:

- Design and installation of wind generators
- Health & safety
- Planning
- Building regulations
- A/C & D/C electrical supplies

- Wind turbine civil works systems
- Maintenance requirements
- An understanding of the testing and commissioning that is required for wind turbine systems
- Measurement of power quality from wind turbine electrical generators

5. PhotoVoltaic (PV) Systems Implementation

Course Description

The aim of this full-time 2-week training course is to introduce the learner to the concept of electrical micro-generation systems by the means of modern Photovoltaic technology. This course provides information and skills for required for the installation of photovoltaic micro-generation systems. It covers all key aspects which is required for the installation of P.V systems. The course informs the learner of the regulations with regard to the following:

- Health & safety
- Planning.
- Building regulations
- A/C & D/C electrical supplies
- P.V Mounting systems
- Testing and commissioning domestic grid connected P.V systems
- The course covers
- PV Basics
- Types of PV systems Grid connection/Off grid
- Mounting systems
- PV components
- Installation Sequence
- Tools
- Performance of PV systems
- Design of PV systems
- Electrical Installation
- Configuration series/parallel
- Inspection requirements
- Electric safety
- Electricity
- Handover and Customer Care
- The storage of P.V modules and inverter.
- Safe lifting, handling of the modules and inverter.
- Electrical termination of PV accessories.
- Fixing methods of brackets to roof (to comply with building regulations).
- Fixing methods of integrated systems (to comply with building regulations)

6. Micro-Generation

Course Description

The aim of the Micro-Generation course is to provide the leaner with a high level overview of the process of connecting a micro-generation scheme to the electricity network. The main tasks are outlined and the leaner is referred to the relevant regulations and guidelines, where appropriate, for a more detailed description of the connection process.

The stages required for the connection of a generator installation are explained and the leaner will be required to demonstrate their skills by commissioning and connecting an operating micro-generator. The course summarises the main features and issues associated with each of these stages involved.

- Feasibility
- Connection applications
- Connection process
- Infrastructure required for connection
- Connection process for PV, Wind & CHP on-site generation
- Commercial & domestic regulatory overview
- Connection offer process
- Documentation
- Testing and commissioning required for Grid connected systems
- Testing and commissioning required for Off Grid/Stand-alone systems

Mini-Models and Mobile Training Unit - Practical

Mini-Models

Where classroom based practical training is desired or where a training organisation wishes to initiate training without their BKH being equipped with full practice models, mini-models are a useful option. These might measure, for instance, 45x60cm, forming an L-shaped structure to accommodate a pseudo window frame (say, 7x4cm softwood) within the L-shape and made of MDF. Service penetrations should be accommodated, comprising, for example, a 10cm diameter PVC pipe, waste water pipe and electrical conduit. The mini-model can be mounted on a table and used to practice the basics of airtight membrane and tape application. It might be possible to have a trainee working on either face, depending on the stability of the model and width of the supporting table. See Appendix under Generic Supplementary Material.

Mobile Training Units

The fitting out of a mobile unit would prove very effective in reaching distant towns / cities and construction companies directly in order to provide training. For practicality, it is suggested that this comprise a rigid truck with maximum height permitted in order to accommodate both demonstration and practice models. Challenges with this include ensuring access up onto the truck and free movement of a group around the main parts of each model and from one to the next. A further challenge concerns insurances to operate this process. It is recommended that classroom based teaching be conducted in a separate space locally sourced, thus allowing the mobile unit to be fully dedicated to practical training.

CASE STUDIES

CDETB, Dublin – Finglas and Ballyfermot Training Centres

An example of training being fully funded by the Irish Government and where a government training organisation contracts an external contract training provider

Organisation and Support:

CDETB or City of Dublin Educational Training Board is the training organisation that instigated and continues to support the Certified Passive House Tradesperson courses run in Finglas (northwestern edge of Dublin City). This organisation is fully government supported and is primarily concerned the provision of training for tradespersons and courses of comparable level. These Passive House courses are funded by the CDETB, with the PHA paid as contractors for course delivery. Two distinct courses are provided, comprising Building Envelope and Building Services (mechanical systems) and have been in operation since 2011 when the organisation, then called FÁS, approached PHA with the request for the creation of such courses (which happily coincided with the same aspiration on the part of PHI). The majority of trainees end up taking both courses by choice, something that is strongly encouraged by both the ETB and PHA as it ensures a very thorough understanding of how high performance are realised and operate.

FÁS paid for the construction of all the models, Airtight Room, mechanical ventilation system and supporting loose equipment, including tools. All of these are located in a dedicated workshop that is not used for any purpose other than training the Passive House tradesperson. The RES material, however, belongs to a separate course delivered by the CDETB training staff, with the associated workshop contiguous to that used for the Passive House tradesperson. Three RES courses are delivered in the Finglas Training Centre and three in the sister centre at Ballyfermot (plus a course on rainwater harvesting).

Canteen facilities are provided.

Course Structure

Typically four Building Envelope of three week's duration and four Building Services of two week's duration are run per year. The luxury of such time is afforded as trainees are almost completely unemployed and continue to receive their social welfare during the training period. The two courses involve training in both theory and practical work. Notionally, the maximum number per class is 14 trainees but in practice it is 12. A training manual covering course classroom material is provided to each trainee along with a copybook and pen. Trainees are not expected to carry out any exercises outside of training hours.

The CDETB covers the fees for each trainee taking the Certified Passive House Tradesperson exam, paying the PHA per trainee.

It is worth noting here that a dedicated tradesperson retrofit course to the Passive House standard, or EnerPHit Standard, is currently being developed by PHA for the CDETB. The course will be of three week's duration and include both theory and practice. Practice models will be based on conventional / traditional construction types and will need to involve not only wall construction, but also floor and wall-to-roof construction. Robustness and reparability will be crucial. Trainees will be expected to have already taken one of the other two Passive House tradesperson course or to have proven relevant experience. Theory training will deal directly with condensation risk in respect of insulation types, thickness and location in retrofit situations.

Spatial Accommodation, Models and Equipment

- A Classroom is provided for the building envelope and mechanical systems courses, accommodating 14 trainees. A larger classroom (12x6m) is also available for trainees for RES and has a storage room (2x6m) directly attached in order to house small RES-related equipment and filing cabinets for trainee records (to be kept on the premises for 7 years and elsewhere for another 7 years).
- A workshop (10x10m) for new build building envelope and mechanical ventilation practical training accommodates demonstration and practice models, an airtight room (5.2x3.6) with an operational MVHR system, 4 mock MVHR units for use in the Building Services course, extra MVHR units, including a compact unit (Nilan), a small office (4x2.5m) and storage (2x6m).
- A separate workshop (10x10m) for retrofit building envelope practical training accommodates three practice models: masonry base and timber roof (5x5m) and timber frame (2x6m).
- Models:
    - 5 demonstration models (1.0m deep): two timberframe each with a different cladding system: one solid concrete block with external insulation, one wide cavity between concrete block walls and one insulated concrete formwork (ICF)
    - 7 practice (hands-on) models (1.0m deep): two timber frame, two wide cavity with concrete block walls and one ICF. Each of these comprises the basic structure with a window and different sized pipes / ducts and trainees, including a ventilation duct, passing through. Trainees are expected to adequately insulate the walls, as suited to the construction type, deal with thermal bridging, especially around the window, apply airtightness using membranes and tapes and dress the ventilation duct in respect of airtightness, insulation and vapour tightness. For convenience of deconstruction and in order to avoid a wet trade, airtight membranes are used on concrete block rather than wet plaster for airtightness. It is important to note that wear and tear on models can result in their requiring maintenance but, in any case, they must be constructed to be robust for on-going use by tradespersons.
    - 3 practice retrofit models comprise: (1) single-story masonry walls, suspended timber floor and pitched timber roof (3.5x5m) accessible on all four sides, (2) two-story masonry walls and flat timber roof (3.5x5m) accessible on three sides, and (3) single-storey timber frame walls, suspended timber floor with flat timber roof (3x4m) accessible on all four sides. The masonry and timber pitched roof models include stairs to a protected gallery in order to facilitate safe access and use by trainers and trainees.
- An Airtight Room (3.x5.5x2.4m high – additional shallow vaulted/pitched roof above) includes a window and a door and is used for pressurisation demonstration, including the

identification of leaks. It also houses the operational MVHR unit and. Electric lighting and sockets are included.

- Mechanical Equipment:

  A PAUL Novus 300 MVHR unit, a post-heater, spiral bound metal ducts and one sound attenuator. A compact MVHR unit (Nilan) is included as well as others of poor design in order to demonstrate important differences in fabrication (insulation and airtightness) and performance (heat exchange efficiency) and also a Lunos 150mm diameter MVHR unit is for demonstration and discussion purposes. A complete set of pressurisation equipment is also provided (Retrotec) as well as an anemometer for checking airflow.

Spatial Accommodation, Models and Equipment re Renewable Energy Systems

- A Classroom is provided for these courses (8x10m, sufficient for 14 trainees)) with a lockable storage area (2x6m) attached in order to accommodate equipment and lockers for trainee records (due to an obligation to retain these on the premises for a minimum of 7 years and 7 more years elsewhere). Larger classrooms are available for, say, up to 20 trainees.
- Assuming the need for practical training by trainees as distinct from simply demonstration without trainee practical activity, an area of 20x20 could accommodate all of the practical requirements in respect of the above five RES courses for 12 trainees. A larger class of, say, 20 trainees would require a greater area, especially where practical training activity is involved.
- The spaces provided for different RES workshop set-ups are:
  - Domestic Solar Hot Water Installation, Domestic Heatpump Installation and Domestic Biomass Heating Installation: L-shaped space of 12x8m and 11x4m
  - Small Scale Wind Systems Implementation 15 x 10m
  - PhotoVoltaics Systems Implementation 16 x 9m
  - Micro-Generation uses the above Small Scale Wind Systems and PhotoVoltaics Systems

AEA Training Centre, the Bronx, NYC

An example of an independent training and contracting organisation entering into partnership with a separate training provider

Organisation and Support

The association for Energy Affordability is a non-profit organisation that is partially supported by the government and partially by earnings from, for instance, construction related contracts (energy improvement and ventilation systems) and training. Revenues earned from the provision of training are apportioned between the PHA and the AEA, having subtracted all costs, in accordance with an agreement.

No canteen facilities are provided – lunch must be ordered in.

Fees pertaining to the Certified Passive House Tradesperson exam are separate and paid for by each trainee.

Course Structure

Typically four Building Envelope of three week's duration and four Building services of two week's duration are run per year. The luxury of such time is afforded as trainees are almost completely unemployed and continue to receive their social welfare during the training period. The two courses involve training in both theory and practical work. The maximum number per class is 12. A training manual covering course classroom material is provided to each trainee along with a copybook and pen.

Spatial Accommodation, Models and Equipment

- A Classroom is provided for these courses. A workshop (15x30m) for the practical training accommodates demonstration and practice models, an airtight room (5.2x3.6) with an operational MVHR system, 4 mock MVHR units for use in the Building Services course, extra MVHR units, including a compact unit (Nilan), a small office and storage.
- Models:
  - 2 **demonstation** models: These comprise singe stud and double stud construction and incorporate window sections. They are used as bases for explanation and discussion.
  - 4 **practice** (hands-on) composite models: These 3-part composite models comprise Z-shaped plans with one leg in timber frame, one in metal stud and one in solid masonry. In practice so far due to limited time, only the timber frame part has been used. These models consist of a basic structure and incorporate a window and different sized pipes / ducts and trainees, including a ventilation duct, passing through. Trainees are expected to adequately insulate the walls, as suited to the construction type, deal with thermal bridging, especially around the window, apply airtightness using membranes and tapes and dress the ventilation duct in respect of airtightness, insulation and vapour tightness. The timberframe part is also used to demonstrate the technique of cellulose insulation filling (behind the airtight membrane and between the studs)
- Airtight Room (5x10m) with a window and a door that also houses the operational MVHR system and is used for pressurisation demonstration, including the identification of leaks. Electric lighting and sockets are included.
- Mechanical Equipment:

  An operational Zehnder Comfo 350 unit is used along with a distribution box octopus ducts which also functions as a sound attenuator and pre-insulated ducting. The air intake and exhaust ducts comprise pre-insulated components. Pressurisation equipment is also provided (Retrotec) as well as an anemometer for checking airflow.

Saint-Gobain Technical Academy, Erith, London

An example of a commercial organisation that includes training in its provision where a partnership is entered into with a separate training provider

Organisation and Support

Saint-Gobain is an umbrella organisation that distributes a myriad of different building and high performance materials, provides innovative solutions that include energy efficiency. Given its interest in the proper application of materials pertaining to sustainable building construction and performance, it is concerned with the provision of training and support. It has developed a performance standard called 'Multi-comfort' which is more or less the same as that of the Passive House Standard and, thus, is intent on promoting Passive House Tradesperson courses. Revenues earned from the provision of training are apportioned between PHA and Saint-Gobain in accordance with an agreement. PHA is responsible for its own travel and accommodation costs and for the provision of training manuals.

No canteen facilities are provided – lunch must be ordered in.

Fees pertaining to the Certified Passive House Tradesperson exam are separate and paid for by each trainee.

Course Structure

Typically four Building Envelope of three week's duration and four Building services of two week's duration are run per year. The luxury of such time is afforded as trainees are almost completely unemployed and continue to receive their social welfare during the training period. The two courses involve training in both theory and practical work. The maximum number per class is 12. A training manual covering course classroom material is provided to each trainee along with a copybook and pen.

Spatial Accommodation, Models and Equipment

- A Classroom is provided for these courses that can accommodate 18 trainees in a horseshoe layout. A workshop (6 x 4m + 4 x10m) for the practical training accommodates demonstration and practice models, open storage an Airtight Room (5 x3.6m) with an operational MVHR system.
- Models:

- 4 **demonstration** models: two timber frame each with a different cladding system, one wide cavity between concrete block walls and one retrofit brick wall type with part external insulation and part internal insulation. These models measure approximately 1.2x1.2x3m high and are on casters wheels in order to facilitate their being moved and packed close together, end-to-end, when not in use and otherwise wheeled out in open display during training.
- 4 **practice** (hands-on) models: two timberframe, two wide cavity with concrete block walls and one ICF. Each of these comprises the basic structure with a window and different sized pipes / ducts and trainees, including a ventilation duct, passing through. Trainees are expected to adequately insulate the walls, as suited to the construction

type, deal with thermal bridging, especially around the window, apply airtightness using membranes and tapes and dress the ventilation duct in respect of airtightness, insulation and vapour tightness. For convenience of deconstruction and in order to avoid a wet trade, airtight membranes are used on concrete block rather than wet plaster for airtightness. It is important to note that wear and tear on models can result in their requiring maintenance but, in any case, they must be constructed to be robust for on-going use by tradespersons.

- Airtight Room that also houses the MVHR system and is used for pressurisation demonstration, including the identification of leaks. Electric lighting and sockets are included.
- Mechanical Equipment (housed in the Airtight Room):

  An operational Renovent-Sky-150 ceiling-mounted unit, a post-heater, spiral bound metal ducts and a sound attenuator. Supply and extract ducts are spiral metal. Pressurisation equipment is also provided (Retrotec) as well as an anemometer for checking airflow.

CITB Training Centre, Glasgow

An example of a part-government funded training organisation contracting an external training provider

Organisation and Support

The CITB or Construction Industry Training Board is a training organisation promoting skills and development for the construction industry. This organisation is enabled by government and mostly funded by levies from a UK-wide construction industry membership. It is primarily concerned with the provision of training for apprentices and tradespersons along with health, safety and supervisory training for the industry. It also provides skills forecasting research for the GB construction industry. The Passive House related courses focus initially on the Building Envelope part, with the intention of following through with providing courses on Building Services in Passive House buildings.

Trainees in the Passive House Tradesperson courses are typically to pay a fee that is part-subsidised by the CITB based upon membership and part supplemented by energy saving training grant for up-skilling obtained for Scotland. PHA is to be paid per course delivered and to be otherwise responsible for its own travel and accommodation costs and for the provision of training manuals.

Canteen facilities are provided.

Fees pertaining to the Certified Passive House Tradesperson exam are separate and paid for by each trainee.

Course Structure

Typically four Building Envelope of three week’s duration and four Building services of two week’s duration are run per year. The luxury of such time is afforded as trainees are almost completely unemployed and continue to receive their social welfare during the training period. The two courses involve training in both theory and practical work. Notionally, the maximum number per class is 14 trainees but in practice it is 12.

Spatial Accommodation, Models and Equipment

- A Classroom is provided for these courses. A workshop (18x7m) for the practical training accommodates demonstration models on casters (wheels) and practice models comprising four walls as a ‘room’, an airtight room (one of the demonstration ‘room’ models of 3.0x3.6x2.4m high) with an operational ceiling-mounted MVHR system. Storage is provides in a general shared store.
- Models:

- 4 **demonstration** models: two timber frame models, each with a different cladding system, one wide cavity between concrete block walls and one retrofit brick wall type with part external insulation and part internal insulation. These models measure approximately 1.2x1.2x3m high and are on casters wheels in order to facilitate their being moved and packed close together, end-to-end, when not in use and otherwise wheeled out in open display during training. In addition and contiguous to the two practice models (see below), there is the Airtight Room of four-wall model (3.0x3.6x2.4m high) timber frame with outer leaf of concrete block (accommodating the ceiling-mounted MVHR unit and ducts), used to demonstrate Passive House Standard airtightness and the balancing of the mechanical ventilation system. The model incorporates one window and one door and different sized pipes / ducts and trainees, including a ventilation duct, passing through.
- 2 **practice** (hands-on) adjoining models (3.0x3.6x2.4m high) each comprising four walls forming a space: one timber frame with outer leaf of rain-screen board (trainees practice insulation between studs, airtightness and to windows), and solid concrete block with external insulation (trainees practice installation of external insulation and overlapping on to the windows which are in the insulation layer). Each of these models incorporates three windows and one door and different sized pipes / ducts and trainees passing through. For convenience of deconstruction and in order to avoid a wet trade, airtight membranes are used on concrete block rather than wet plaster for airtightness. It is important to note that wear and tear on models can result in their requiring maintenance but, in any case, they must be constructed to be robust for on-going use by tradespersons.

  The total area provided to accommodate the 2 practice models and the (similar) Airtight Room amounts to 9.5x4.0m.

- Airtight Room, mentioned already, is used for pressurisation demonstration, including the identification of leaks (3.0x3.6x2.4m high). Electric lighting and sockets are included.
- Mechanical Equipment:

An operational Zehnder ComfoAir 160 wall-mounted unit is provided with a pre-heater and post-heater, supply and extract ducts and associated outlets and inlets, respectively. The majority of the supply and extract ducts are spiral metal bound but part of the extract comprises semi-rigid plastic simply to demonstrate an alternative. Pressurisation equipment is also provided (Retrotec) as well as an anemometer for checking airflow.

Institute of Technology, Sligo (Ireland)

An example of an academic institute providing training to tradespersons that includes the Passive House Standard

PHA has not been involving in setting up this training, although has delivered some training as a contracted external provider. The Institute of Technology (IT) has developed the BSc. Advanced Wood and Sustainable Building Technology Program with Year 3 involving Training in Low Energy Building.

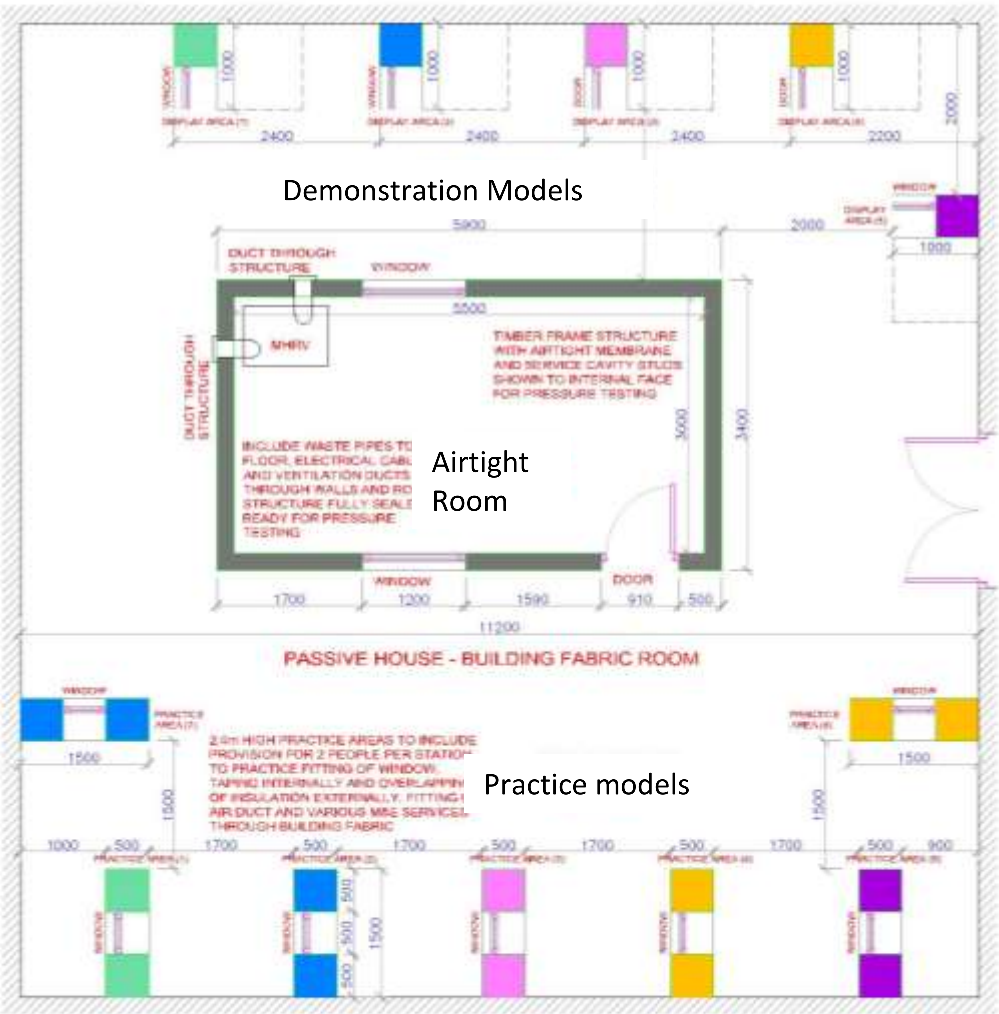
An integral part of the course is the design and construction of wall, floor and roof sections to the Passive House Standard, similar to those used in the four case studies described above. Whilst they end as demonstration models, the design and construct exercises effectively comprise the practice process; in other words, the same model serves practice and demonstration. This, in turn, is supported by classes in the relevant theory. Some of the students in their final year, with modest support from PHA, have taken and passed the Certified Passive House Tradesperson exam.

The workshop used for this includes not only the models, but also a range of alternative construction types. A structure is also used for the purpose of airtight construction, incorporating services as well as window and door opes. The absence to date of an operational mechanical ventilation system is a significant omission: it is critical that the five fundamentals for the construction of a Passive House building, namely, high levels of insulation, elimination of thermal bridging, high performance windows and doors, high level of airtightness / draught proofing and mechanical ventilation heat recovery, are taught as a unit of design and build and that trainees work with some, if not all, of the relevant components. Without this complete package, there is a very high risk that trainees will not understand how realising the standard necessitates a flexible and adaptable but integrative and systematic approach.

APPENDIX

CDETB Training Centre, Finglas, Dublin

Plans



Workshop Layout

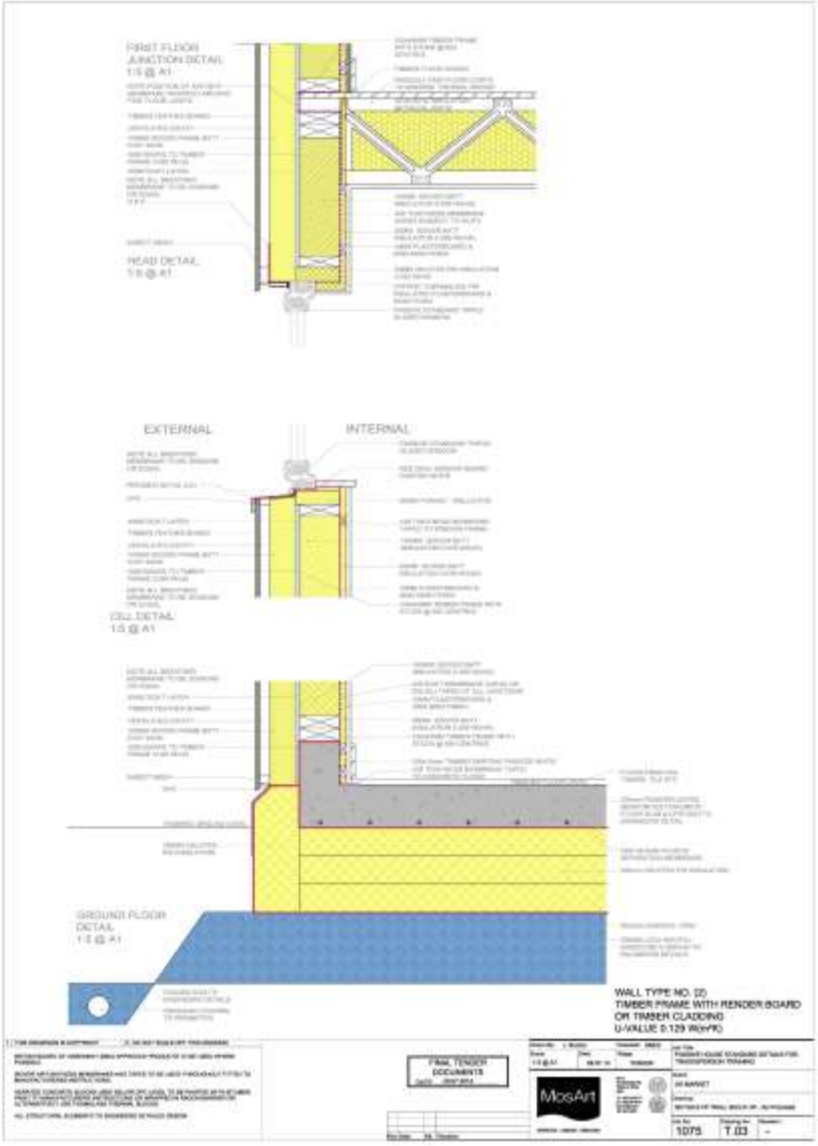
Classroom

Classroom with teaching aids

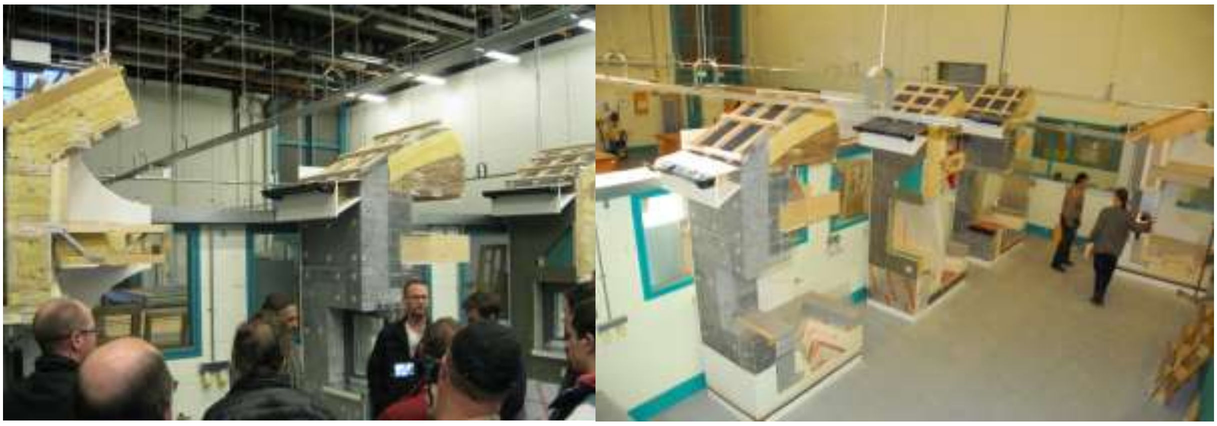
Models

Completed Timber frame Practice model

Practice models partially completed



Example of technical drawing required for the construction of models



Demonstration models

Trainees working on practice models

Wall, floor & roof demonstration models ranging in height from 1.5 – 2.4m

Retrofit models

Models of conventional construction (masonry & timber frame) suited to training in retrofitting

Note: Gallery structure with stairs for high level access to roof / wall junction

Airtight Room and MVHR Equipment


Exterior of Airtight Room Interior of Airtight Room

Operational MVHR Unit with supply, extract, intake and exhaust ducts and post-heater

Controls for MVHR unit

Construction of ducting on pseudo MVHR units, located between practice models

MosArt

PHA Passive House Academy

Renewable Energy Systems



Energy generating wind turbines and practical demonstration of micro wind generation

Wind speed control for workshop-based set-up of turbine

Reinforcement steel cage for turbine foundations

Wood pellet room-stove (max 2-day supply of pellets) and 800 Liter hot water cylinder
Solar thermal collector panel: 4 semi-circular sections (optimal gain) on a dark flat

Air source heat pump / Under-floor and wall mounted heating pipes, heat pump, geothermal piping

27kW wood pellet burner (1 month's supply) & 22kW room-stove (1 week's supply) connections to hot water cylinder



Solar thermal panel directly connected to hot water cylinder - note bases on casters for mobility

Photovoltaic panels on external rig used to assess solar energy


Photovoltaic panels located externally to face sun for training in operation of energy gain readings


Space beneath roof rigs used for computer workstations and harness for panel installation on roofs

Partially stripped PV panel: copper pipes and insulation underlay exposed


Equipment workbenches in workshop

Solar thermal panels on mock-up roofs

Small Office providing good view of work

Equipment for panel mounting exercise

Trainee records filed

Storage of connectors for PV panels

Rainwater harvesting equipment, including storage tank (usually buried

Classroom

Pre-fabricated classroom in Finglas accommodating 14 trainees with "classroom" desk layout

Airtightness testing

Pressurisation test using door ope

Air tightness test using Wincon fan

AEA Training Centre, the Bronx, NYC

Plans

Classroom

Models

Demo

Small Demonstration Model, supplied by industry

Practice

Z-Shaped (in plan) practice models comprising of 3 wall types

Airtight Room

Airtight Room exterior

Interior of Airtight Room with service zone / battens and pressurization fan

Interior of Airtight Room with display tables as well as MVHR unit to right

Mechanical Equipment

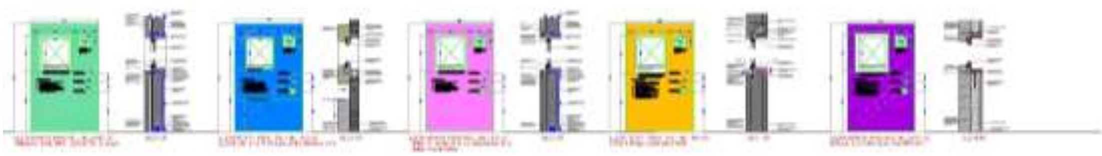
MVHR Unit and ducting viewed inside Airtight Room

Saint-Gobain Technical Academy, Erith, London

Plans

Demonstration models on castors for relocation during training

Practise models fixed to floor and wall



All models, with demonstration models shown arranged compactly for storage

Classroom

Classroom horseshoe seating arrangement

Models

Practice and Demo

Area for models: fixed practice models to right and space to left available for compact storage of demo models (requiring removal of work benches) which are wheeled on castors.

Demo models on castors for flexibility in use of space

Mechanical Equipment

Ceiling mounted MVHR unit and ducting

CITB Training Centre, Glasgow

Models

Practice

Practice models comprising three adjoining rooms: masonry, timberframe (part-masonry exterior) and timberframe used for airtightness testing and MVHR demonstration



Masonry model used to practice external insulation


Timberframe model (part-masonry exterior) being made airtight – walls and ceiling membrane and taped

Fitting a duct, making an airtight, insulated and vapour tight connection - using membranes, tapes and vapour tight insulation

Exploring different taping techniques

Mechanical Equipment

MVHR equipment setup in Airtight Room involving wall mounted unit, single trunk (rigid) spiral metal duct and multi-duct (semi-rigid) ‘octopus’ system with distribution box as well as supply and extract fixtures

Views from outside Airtight Room showing intake and exhaust ducts fitted with airtight tape and awaiting completion by fitting external louvered grills (see lower left corner for partial view of one)

Sligo Institute of Technology, Ireland

Models

Demo


Combined practice and demonstration model


Application of low impact material (woodfibre, hemp and cellulose)

Practice

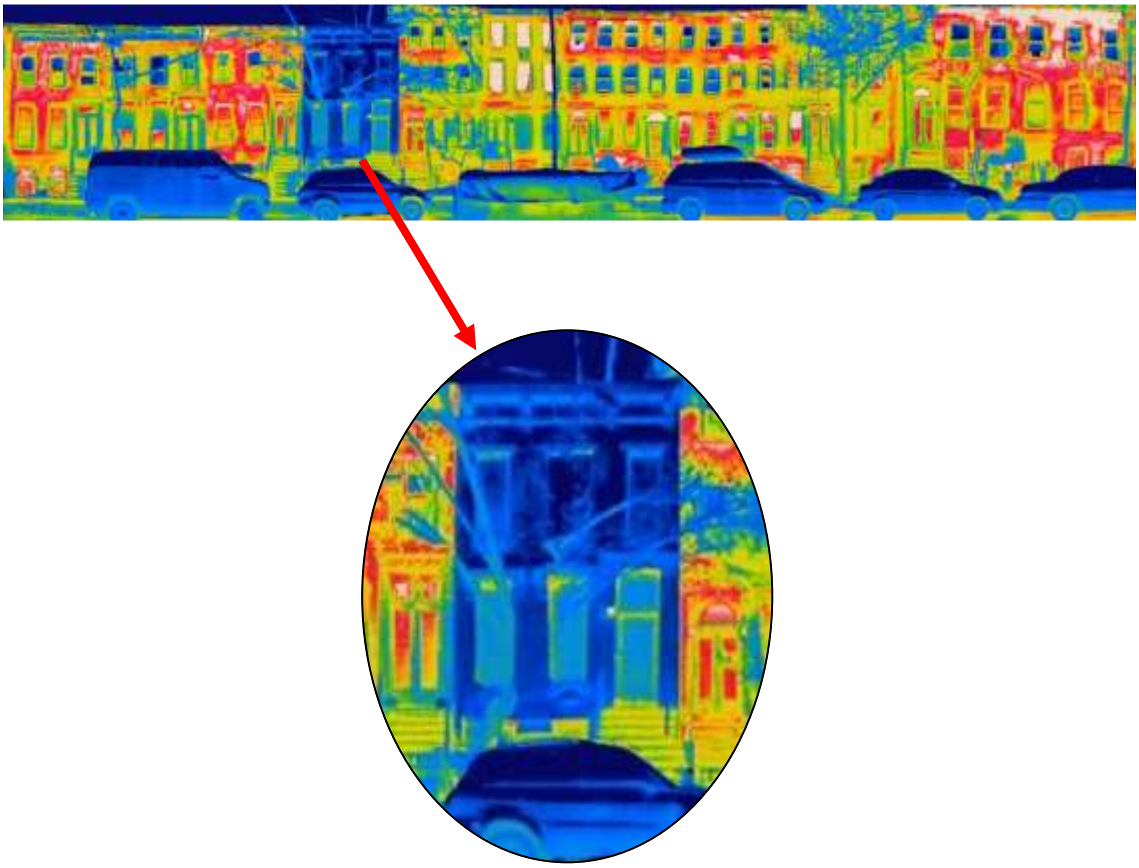

Building with low impact material (Hemp)

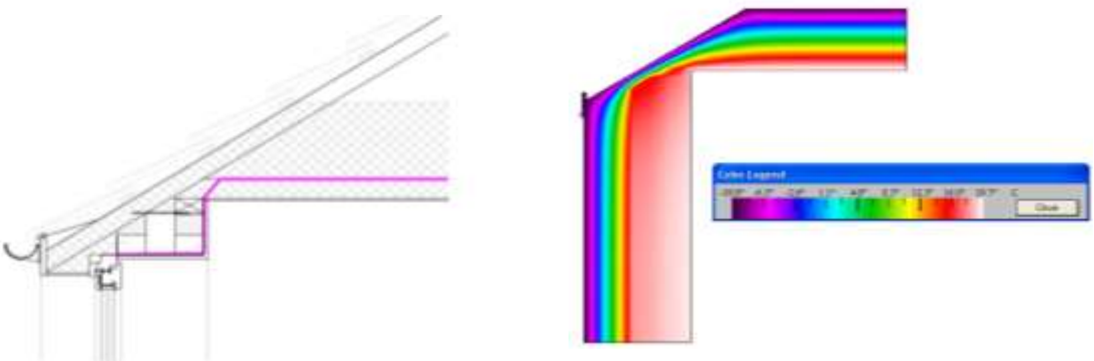
Airtight Room

Airtight room and pressurization equipment

Generic Supplementary Material

Thermo-graphic Images

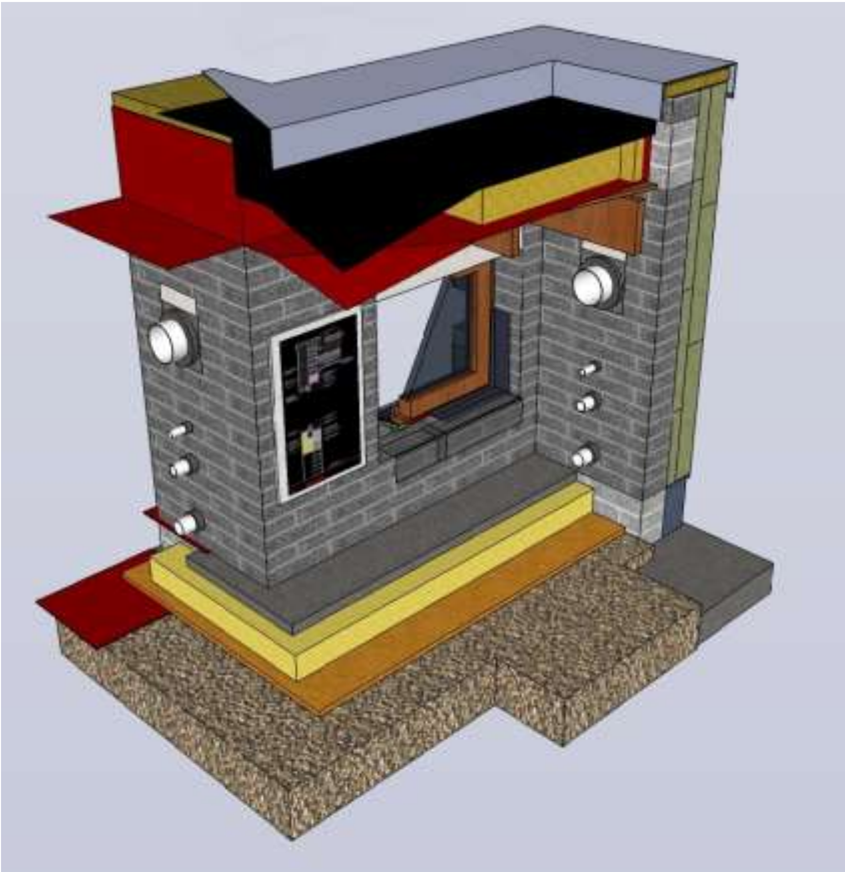




Supplementary graphic material illustrating building physics

3D Drawings

Base structure of Z-shaped (in plan) practice model – potential variation in construction types



3D view of Z-shape (in plan) practice model – masonry walls and concrete flat roof with parapet and service duct penetrations. This model type provides greater complexity and variety of conditions for training than those shown above.

Cellulose blowing

Cellulose pumping through hole in airtight membrane

Window sample

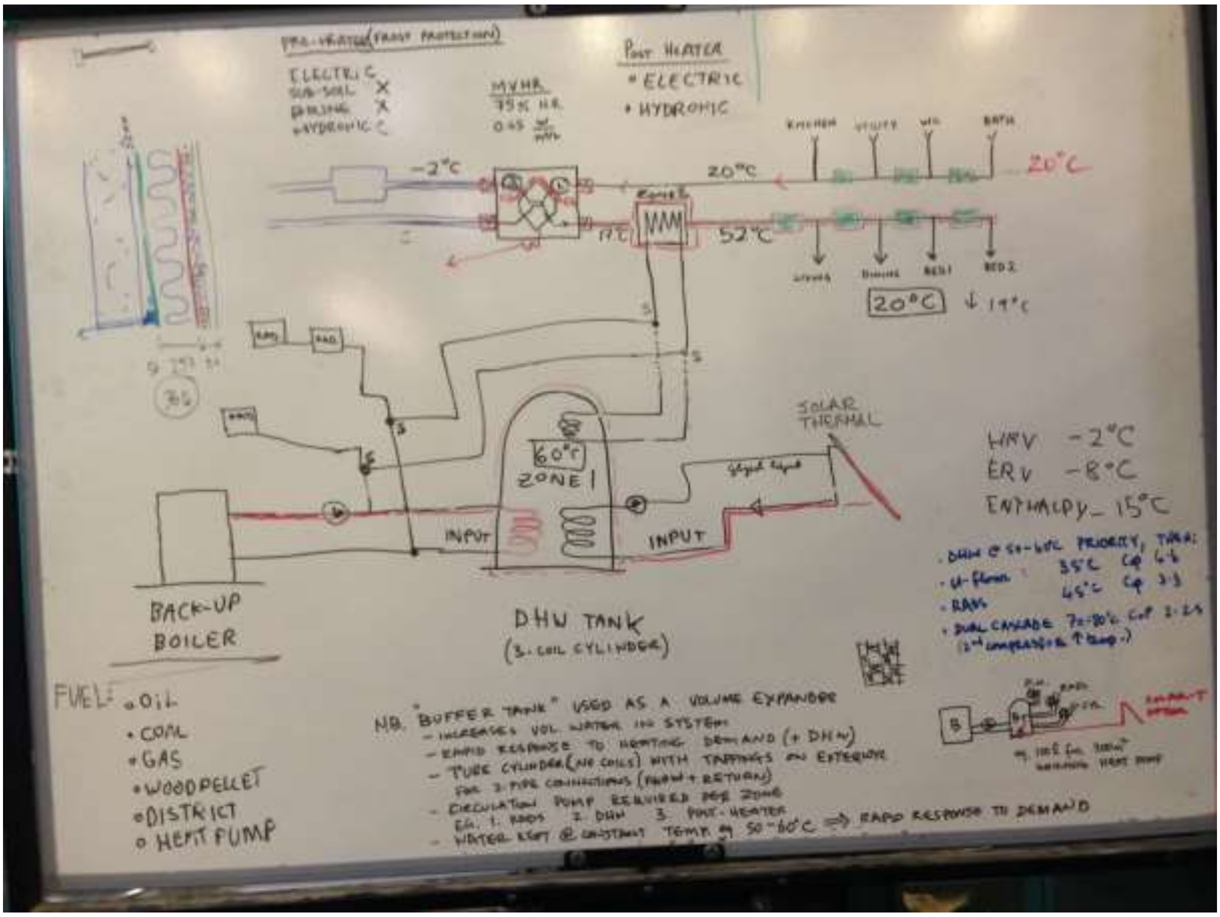
Window sample

Trolleys

Mobile table on castors

Tabletop Models

Tabletop models: Basic structure fitted with membranes and tapes (Note: Large pipe is 100mm Diameter)



Workshop whiteboard in Workshop