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Fit-to-NZEB
Innovative training schemes for retrofitting to nZEB-levels

Report from conducted courses for EQF level 3-4

Deliverable 6.3

of the FIT-TO-NZEB project, financed under grant agreement No 754059 of the HORIZON 2020 Programme of the EU

Led by: Passive House Academy, Ireland

Training Programmes for Building Professionals. On-the-job Training and Validation Programmes

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Executive Summary

The core objective of this project is to facilitate the wider uptake of deep retrofitting to the NZEB standard across Europe through developing training programmes for all players involved – right through from general operatives working on construction sites to project supervisors, members of the design team and academics. This report presents a summary of the pilot training delivered by some of the Fit-to-NZEB partners to EQF levels 3 to 4, consisting mostly of construction workers.

The five research teams involved in this task are Bulgaria, Ireland, Italy, Greece and the Czech Republic. Each of the partners had a choice of delivering the training at a vocational training centre or directly at the job-site. Furthermore, the duration of training could be 'full-time' involving approximately 40 hours, or 'upskilling', requiring between 12 and 16 hours. Between the five partners, each of these different training types (considering both duration and location) were covered. In addition to the planned activities, the Romanian partner Pro-nZEB delivered an upskilling training course directly at the job-site for a special team of young people involved in the Solar Decathlon Europe 2019 competition (Hungary).

The learning outcomes for both Building Envelope and Mechanical Systems training programmes are presented in Tables 3 and 4 below respectively.

Across all five partners, a total of 17 training courses plus one additional 'pilot' course were delivered. Interestingly, most courses combined a blend of both building envelope and mechanical systems. An exception to this was delivered by the Bulgarian team which delivered 2 courses focus on building envelope plus 1 course on mechanical systems. The decision by most partners to deliver a blended course makes perfect sense as it is felt that all construction workers, whether working mostly on envelope or mechanical systems, need to appreciate the full range of deep retrofit measures required to bring about a whole-building transformation. In short, the envelope workers need to have a good understanding of the challenges presented on mechanical systems retrofitting, and vice versa.

A summary of the number of workers trained and the duration of the training delivered is presented in Table 1 below. Across all five partners, a total of 326 trainees completed the training.

Table 1: Summary of Trainee Numbers and Duration of Courses

	Partner					
	Bulgaria	**Ireland**	**Italy**	**Greece**	**Czech Republic**	**Romania**
Total Number of Trainees	117	31	29	118	32	16
Training duration	86 hours	68 hours	96 hours	30 hours	48 hours	6 hours

Key challenges encountered by the teams in the delivery of these trainings is summarised below (with further details provided later in this report):

- A general low awareness of NZEB means that there is not a high demand currently for training in this sector.
- The construction sector is not generally aware that a whole new skill-set will be required to deliver cost-effect deep retrofits.
- Construction workers tend to be time-poor (partly because they don't fully appreciate the benefit of deep retrofit training) and therefore getting them to participate in training is difficult.
- A few of the partners found that whilst workers might initially be anxious about taking time to attend a training event, once they are exposed to the learning experience they often declare an interest in taking further courses. The key challenge, therefore, is to get them to make the decision to 'give it a go' in the first place.
- If the training centre is not located close to where the trainees live, it will be more difficult to convince them to attend.
- If the training is scheduled to take place during peak construction period (which will differ from region to region, greatly influenced by climate), then participation rates will be lower.
- While delivering training at building knowledge hubs provides an opportunity for hands-on practice of deep retrofitting skills, the optimal experience for construction workers would be to hold the training directly at the construction site.
- When delivering training on the job-site, it is important to involve experienced practitioners who can professionally demonstrate the skills required (most full-time trainers will not have extensive practical experience in all envelope and mechanical systems required to deliver deep-retrofits).
- The sequencing of training is important when delivered at the construction site. It is important to deliver the training ahead of the work taking place on-site, otherwise elements already completed might have to be removed or modified, causing frustration for the construction workers.
- Inclement weather (or indeed, extreme heat, in some climates) can adversely impact on the training delivered on-site (this is not an issue when training is delivered at a building knowledge hub where the indoor environment is conditioned).
- Availability of construction details for the deep retrofit measures is critical to success when training on-site. If the Architect has not prepared details in advance, developing them on-the-spot can be a challenge and interrupt the flow of training.

Referring briefly to trainee feedback to the training, the overall impression was very positive, with the majority of respondents stating that the training was either 'excellent' or 'very good'.

In terms of advice for others considering delivering deep retrofit training, the following points are highlighted by the researcher teams:

- Try to deliver at least some training at the construction site if possible – this is found to be most positive experience for the trainees.
- If you cannot deliver training on-site, ensure that there are sufficient hands-on props for the learners to work on.
- Performing an airtightness test on a project provides a great focus for all involved in the training.
- Invite professional applicators to participate in the delivery of some of training which will add significant credibility to the event.
- Make sure the training materials are directly relevant to the climate / region / prevalent construction types, otherwise learners will disengage.
- Limit class sizes to approximately 15 to 20 persons so that they can all actively participate in the learning experience.
- One of the research partners felt that the training should be more focused towards specific topics (possibility of delivering 17 topic-oriented courses).

In conclusion, this task in the Fit-to-NZEB project was a great success in terms of the number of trainees, the variety of training scenarios presented and the feedback received.

1. Introduction

In this part of the project, Partners could choose between delivering training either at Vocational Training Centres or directly on-the-job at construction projects. The training has to deal with the two overarching deep retrofit themes of (a) building envelope and (b) mechanical systems.

The goal of this report is to provide an overall concept for quality assurance and monitoring of training programs for building professionals, therefore, setting a common framework between the different training institutions for quality assurance. The training programs have been conducted in six countries: Bulgaria, Ireland, Italy, Greece, Czech Republic and Romania.

Good quality practice of on-the-job education are based on the pillars:

- Clear definitions of learning outcomes,
- Design and structure of the programme course,
- Evaluation and monitoring of the learning outcomes, including possible reference to meeting energy efficiency targets such as reduction in primary energy demand or airtightness

To assure a good quality of the vocational centre and / or on-the-job training, the following criteria will be evaluated and monitored:

- **lecture's content and learning materials**: the training programmes should meet the learning outcomes objectives through a clear and precise communication. For this, the learning content and how it is presented (layout, presentation and others) will be evaluated;
- **learning outcomes**: the effectiveness of the learning procedures used on-site, and therefore achievement of the expected learning outcomes. For this, the obtained knowledge and its future applicability will be evaluated.

The main goal of this report is to provide guidance for future vocational and on-the-job training programmes for EQF 3-4, based on the experience during the project. Therefore, this report will present the following:

- Summary of the learning outcomes;
- A report of the conducted courses (whether delivered at the vocational training centre or on-the-job);
- Evaluation of the courses; and
- Recommendations for future courses, including for improvement of future courses.

2. Learning outcomes and training programme

The learning outcomes and training programme were presented and defined in detail in other Fit-to-NZEB reports and deliverables. Therefore, only a summary is presented hereunder.

Training can either be presented at a vocational training centre or on-site and can be classified as either 'full time' (40 hours) or 'upskilling' (16 hours). A matrix summarising the different approaches is presented in Table 2 below. All Fit-to-NZEB partners could choose which format they would like to trial.

Table 2: Format Options for Training for Building Professionals

Location of Training	Duration	Construction Sector	
Vocational Training Centre	Full Time Training (40 hours)	Building Envelope	Mechanical Systems
Vocational Training Centre	Upskilling (16 hours)	Building Envelope	Mechanical Systems
On-Site	Full Time Training (40 hours)	Building Envelope	Mechanical Systems
On-Site	Upskilling (16 hours)	Building Envelope	Mechanical Systems
Either at Vocational Training Centre or On-Site	Upskilling (12 hours)	Building Envelope	Mechanical Systems

Learning outcomes are presented below for both building envelope (Table 3) and mechanical systems (Table 4). It should be noted that the learning outcomes below pertain to the longest of the above three formats (40 hours). A reduced list of learning outcomes would therefore be used for the 16-hour and 12-hour training formats.

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Table 3: Key Learning Outcomes for Building Professionals (EQF 3-4) Pertaining to Building Envelope (40-hour format)

№	Subject
1.	Basis of building physics, Passive house principles, optimal solar gains • Heat and Heating Energy (Heat Flux/Thermal Conduction) • Thermal Environments • The 5 Passivhaus Pillars ○ Thermal envelope, Windows, Airtightness, Thermal Bridges and Mechanical Ventilation System • Optimal solar gains • Climate data and climate zones • Solar radiation and window orientation: reduction factor for solar gains, windows comfort criterion, windows U-value calculation • Windows installation: concept sketches • Glazing: descriptions of the glazing and g-Values (in accordance with EN410) • special aspects in curtain wall facades • Shading: additional shading elements, a line of deciduous trees, optimum roof overhangs, reveal shading on one side, courtyards, green roofs
2	Comfort, health and safety requirements in buildings, incl. indoor air quality • Indoor air quality (contaminants and performance levels), • Thermal comfort, daylight and lighting, noise, influence of nearby landscape, • Safety requirements in buildings and the compliance ensured during the renovation process: Fire Safety and legal responsibilities in Buildings, Environmental regulations.
3.	Insulation of the opaque envelope • insulating materials and their properties (thermal conductivity, water vapor diffusion resistance factor, reaction to fire, etc.) • properties of elements comprising building envelope (U-values, water vapor resistance, fire behaviour on different kind of building envelopes) • correct installation of thermal insulation • risks and construction damage resulted from poor workmanship • quality control of thermal insulation • cross-crafting
4.	Airtightness, vapour and moisture movement as well as windtightness • Benefits of airtightness, windtightness and vapour control in high performance buildings and risks associated with interstitial condensation • Standard required for Passive House airtightness and comparison with national building regulations • Materials suitable for permanent airtightness and vapour control • Detailing for connections, penetrations and corners • Construction sequencing and timing of airtightness testing • Airtightness testing protocols and equipment
5.	Solving and avoiding thermal bridges • thermal bridges • moisture related building damage due to thermal bridges • prevention and minimisation of thermal bridges • thermal bridge optimised window installation • cross-crafting

6.	Installation of highly efficient windows and exposure to high performance building components, products and installation • general requirements for windows (airtight, thermally insulating (U-value), transparent, possibility of opening and providing shade when necessary) • role of windows regarding energy efficiency and comfort (view towards the outside, thermal protection, solar gains, ventilation during day and during night) • window installation in a thermal bridge minimised/free manner, airtight window installation
7.	"Step-by-step" renovation and the EnerPHit standard • Potential for energy savings assessment • Renovation standards; certification of the energy performance • Details, products and materials • RES • Economic efficiency of the different steps
8.	Site visit – deep energy renovation of an existing building
	Part II Project management and planning and design instruments
9.	Overview of building services and how they interface with the thermal envelope: MVHR, heating and / or cooling, RES • Walk-through of key MVHR elements and insulation and airtightness detailing for ducts which penetrate the external envelope • Heating and cooling systems overview and insulation and airtightness sealing of heating / cooling and RES equipment penetrations
10.	Conservation of historic building fabric, renovation of buildings and monuments of cultural significance • Retrofit for non-residential historical buildings with high IHG • Internal Insulation as a solution in historical buildings • Improving thermal protection towards the ground when modernising historical buildings • Solutions for ventilation in retrofits of historical buildings • Thermal comfort in summer • The house-in-a-house principle • Built examples • Step-by-step refurbishment examples
11.	Project management and quality assurance • Introduction – basic principles; • Necessary legislation; • Executing and Monitoring in project management and energy management; • Basic Energy Efficiency principle; • Quality assurance of construction structures; • Coordination of professions on site.
12.	Economic efficiency of deep energy retrofitting up to the level of "passive" and "nearly zero energy" buildings • EED and EPBD II – What is it nZEB? • Prices of construction materials, bill of quantities • Energy savings and operational costs- Energy efficiency measures – construction • Payback period

Table 4: Key Learning Outcomes for Building Professionals (EQF 3-4) Pertaining to Mechanical Systems (40-hour format)

№	Subject
1.	Comfort, health and safety requirements in buildings, indoor air quality, airtightness, vapour/moisture movement, windtightness • indoor air quality (contaminants and performance levels), • thermal comfort, daylight and lighting, noise, influence of nearby landscape, • safety requirements in buildings and the compliance ensured during the renovation process: Fire Safety and legal responsibilities in Buildings, Environmental regulations.
2.	Mechanical Ventilation with Heat Recovery (MVHR) • Indoor air quality parameters (CO_2 and RH) • Recommended air flow rates for supply and extract • Core components of MVHR units • Ducting design and layout options • Balancing flow rates • Quality assurance issues
3.	Heating and / or cooling systems • Sizing systems appropriate for high performance retrofits • Heating and / or cooling generation systems and efficiencies • Heating and / or cooling distribution options • Insulation of circulation pipework
4.	Summer comfort / passive cooling strategies • solar loads, • air exchange / ventilation, • indoor heat sources, • impact of external colours, of thermal insulation and of thermal masses, • shading in summer; • passive cooling technologies to avoid overheating / to reduce the cooling demand during summer.
5.	Highly efficient DHW generation, storage and distribution (including drain waste water heat recovery) with special emphasis on full and complete insulation of pipes • DHW generation systems • DHW circulation strategies • Heat losses from circulation pipes • Insulation of DHW circulation pipes including sourcing specialist fittings for awkward pipe connections • Drain waste water heat recovery systems, efficiencies and installation principles
6.	Energy efficient lighting systems and controls • Energy labelling for lighting • Light (lux) levels required for different tasks • Overview of energy efficient lighting systems for internal and external use • Control systems for energy efficient lighting, including occupancy sensors • Emerging lighting technology innovation
7.	RES in building retrofit, long and short-term energy storage
8.	Site visit – deep energy renovation of existing building
	Part II Project management and planning and design instruments

9.	Basics of building physics, Passive House principles, optimal solar gains, insulation, thermal bridges, airtightness and wind-tightness, high performance building components, highly efficient windows: products and installation • Heat and Heating Energy (Heat Flux/Thermal Conduction) • Thermal environments • The 5 Passivhaus Pillars ○ Thermal envelope, Windows, Airtightness, Thermal Bridges and Mechanical Ventilation System • insulating materials and their properties (thermal conductivity, water vapor diffusion resistance factor, reaction to fire, etc.) • properties of elements comprising building envelope (U-values, water vapor resistance, fire behaviour on different kind of building envelopes) • thermal bridges • prevention and minimisation of thermal bridges • role of windows regarding energy efficiency and comfort (view towards the outside, thermal protection, solar gains, ventilation during day and during night) • airtight window installation • cross-crafting • Solar radiation and window orientation • Windows installation • special aspects in curtain wall facades • Concept sketches • Shading elements • Green roofs
10.	Conservation of historic building fabric, renovation of buildings & monuments of cultural significance, “Step-by-step” renovation & overview of EnerPHit • potential for energy savings assessment • renovation standards; certification of the energy performance • details, products and materials • Solutions for ventilation in retrofits of historical buildings • Thermal comfort in summer • Built examples • Step-by-step refurbishment examples
11.	Project Management, Quality Assurance • Introduction – basic principles; • Necessary legislation; • Executing and Monitoring in project management and energy management; • Basic Energy Efficiency principle; • Quality assurance of technical equipment of buildings; • Coordination of professions on site.
12.	Economic efficiency of deep energy retrofitting up to the level of "passive" and "nearly zero energy" buildings • EED and EPBD II – What is it nZEB? • Prices of construction materials, bill of quantities • Energy savings and operational costs - Energy efficiency measures – technological • Payback period

2.1 Training Format Used by Fit-to-NZEB Partners

Table 4 below presents an overview of the training formats used by each of the six relevant Fit-to-NZEB partners in dealing with building professionals. In many cases, the format used does not neatly fit to the classifications illustrated in Table 2 above. Partners typically had to adapt the format depending on the timing, location and availability of trainees.

Table 5: Training Format Used by Fit-to-NZEB Partners for Building Professionals (EQF 3-4)

	Partner					
Training Format	**Bulgaria**	**Ireland**	**Italy**	**Greece**	**Czech Republic**	**Romania**
Vocational Training Centre 40 hours			1 course, blending both building envelope and mechanical systems			
Upskilling on-site 40 hours		1 course, blending both building envelope and mechanical systems				
Vocational Training Centre 16 hours	2 courses blending both building envelope and mechanical systems 2 courses for validation of skills focused on building envelope	1 course, blending both building envelope and mechanical systems		1 course, blending both building envelope and mechanical systems	2 courses, blending both building envelope and mechanical systems	
Upskilling on-site 16 hours		1 course, blending both building envelope and mechanical systems	1 course, blending both building envelope and mechanical systems	1 course, blending both building envelope and mechanical systems		1 short course blending both building envelope and mechanical systems
Vocational Training Centre 12 hours	1 pilot course, blending both building envelope and mechanical systems 1 course on mechanical systems					
Upskilling on-site 12 hours		1 course, blending both building envelope and mechanical systems	1 course, blending both building envelope and mechanical systems			
Total number of courses	**5 + 1 pilot**	**4**	**3**	**2**	**2**	

3. Conducted courses

3.1 Bulgaria

- Number of students: 1st Course (pilot) -> 10, 2nd course -> 13, 3rd course -> 21, 4th Course -> 34, 5th course -> 15, 6th course -> 24
- Number of hours: 1st Course (pilot) -> 10, 2nd course -> 16, 3rd course -> 12, 4th Course -> 16, 5th course -> 16, 6th course -> 16
- Course duration: 1st Course (pilot) -> 10, 2nd course -> 16, 3rd course -> 12, 4th Course -> 16, 5th course -> 16, 6th course -> 16
- Photos included below


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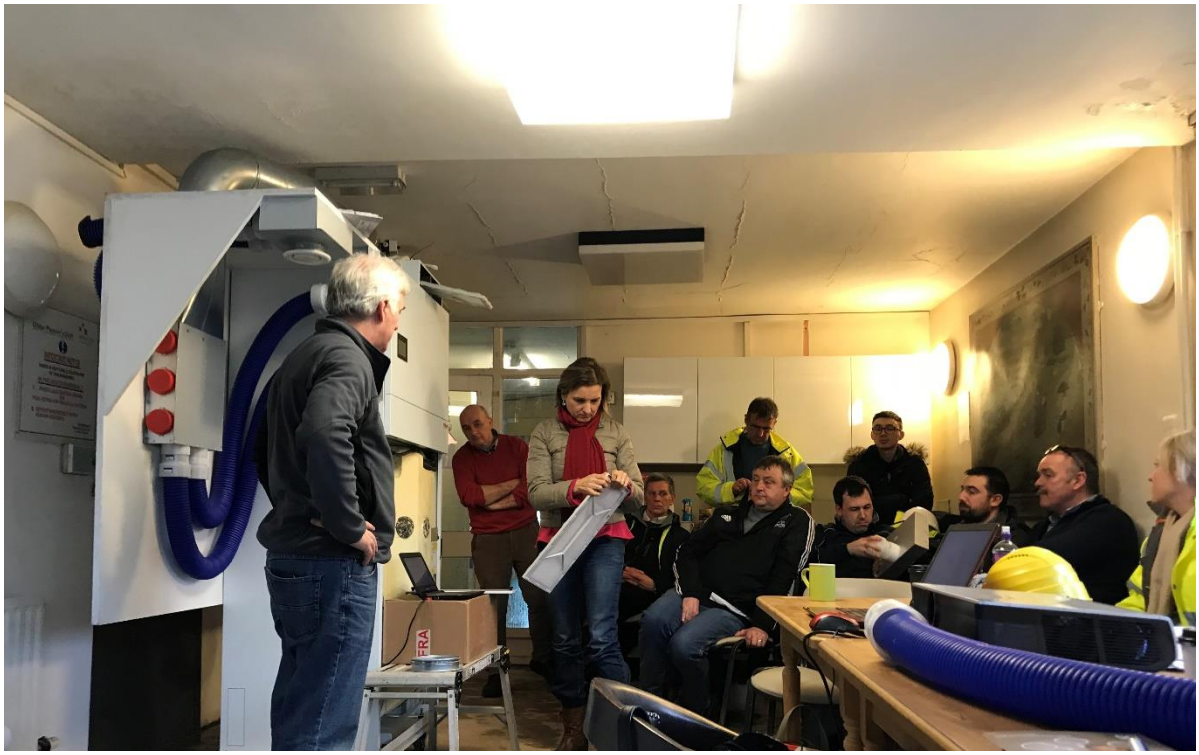
3.2 Ireland

- Number of students: 1st Course -> 18, 2nd course -> 6, 3rd course -> 7
- Number of hours: 1st Course -> 40, 2nd course -> 16, 3rd course -> 12
- Course duration: 1st Course -> 40, 2nd course -> 16, 3rd course -> 12
- Photos included below

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3.3 Italy

- Number of students: 1st Course -> 14, 2nd course -> 10, 3rd course -> 5
- Number of hours: 8+8+8+8 = 32
- Course duration: 32h
- Photos included below

3.4 Greece

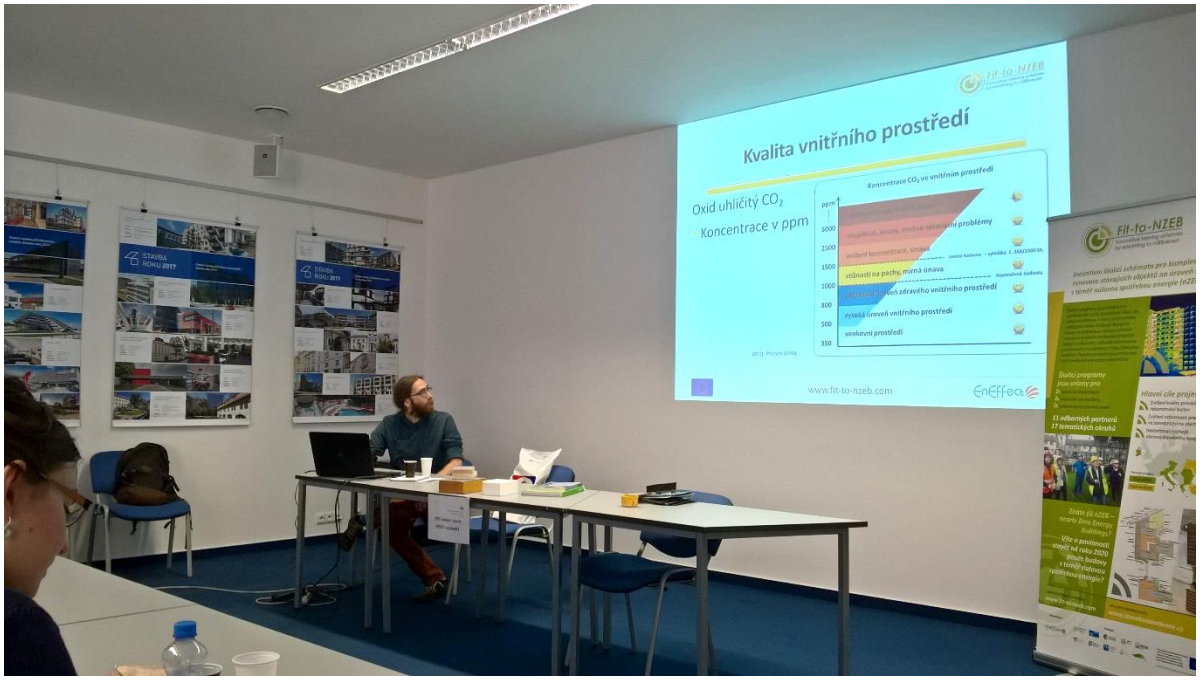
- Number of students: 1st Course -> 29 , 2nd course -> 60 , 3rd course -> 29
- Number of hours: 5+5=10
- Course duration: 10
- Photos included below.


FRAGOULAKIS

3.5 Czech Republic

- Number of students: 1st Course -> 11, 2nd Course -> 21
- Number of hours: 8+8+8=24
- Course duration: 24 hours
- Photos included below.


Komplexní renovace budovy a NZEB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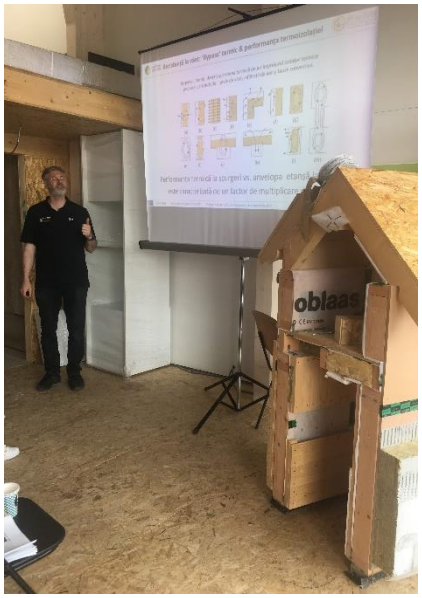
3.6 Romania

- Number of students: 16
- Number of hours: 6
- Course duration: 1 day
- Photos included below.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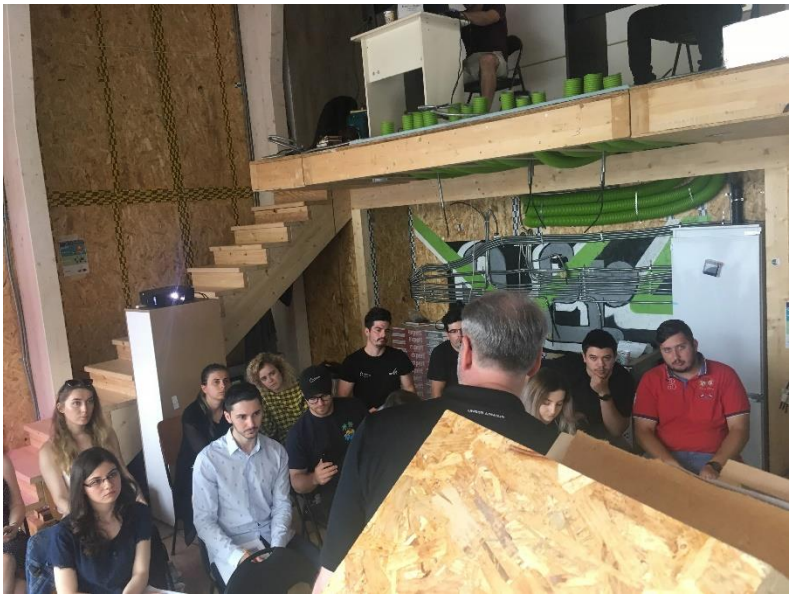



Etanșare la aer, difuzia vaporilor și rezistență la vânt

3. Evaluation of conducted courses

4.1 Bulgaria

- Total combined number of students: 117
- Total combined number of hours: 86
- Total combined courses duration: 86

Key Challenges Encountered

NZEB awareness is key to demand for training

Unfortunately, the understanding of the benefits and the principles of low-energy buildings is still insufficient, and there is no explicit market demand for nZEBs and deep energy renovation; hence – there is limited demand for nZEB training as well. The training demand is related mostly to the execution of the National Programme for Energy Efficiency, which poses requirements that are miles away from achieving ambitious energy performance parameters.

Appreciation of skills gap and recognition of skills

Not being pressed by market demand, workers (and their employers) don't really appreciate the fact that nZEB and deep renovation require a qualitatively new set of knowledge and skills. In addition, the certification scheme is not yet recognized by employers and there is no active register of skilled workers. The working solution is collaboration with professional chamber associations, as well as product manufacturers and suppliers, which brings credibility to the training scheme.

Practical training

Lectures, PowerPoint presentations, calculations, written tests are obviously not a point of attraction for construction workers. While the facilities in BKH provide acceptable conditions for hands-on practical training on the regular construction types, they are still not comparable to training on-site and is only limited part of the equipment is portable. Being a good first step, BKH-based training can be coupled with on-site sessions, if there is sufficient market demand. However, this may be complicated in terms of timing and aligning with the construction process. In addition, the teams of trainers (usually consisting of an architect and a mechanical engineer) should attract experienced onsite professionals to perform the demonstrations which are still rare to find.

Lack of time

Without appreciation of the benefits, wide market recognition of skills, and relation to a specific project, lack of time is cited as one of the most pressing barriers from both companies and workers. Although the return visits of certain construction companies show that this is not the case when benefits are realized, still we need to fight this barrier through blending of web-based first presentation of the theory with shorter face-to-face sessions.

4.2 Ireland

- Total combined number of students: 31
- Total combined number of hours: 68
- Total combined courses duration: 68

Key Challenges Encountered

Key challenges encountered by the PHA team in Ireland in delivering this training are summarised below.

Recruiting Trainees

It can be difficult to recruit trainees for such training programmes – even though there was no charge for the training. In Ireland, there is a major shortage of construction workers in the capital region, so everybody working in the sector is busy and finds it difficult to take time away from work to undertake training. It is important that leadership and management in construction companies buy-in to the benefits of education and training in deep retrofit and facilitate their employees taking the training. Self-employed single-firm construction workers often find it difficult to take time off for training and are not even conscious of the need to upskill as it is typically not required in the industry. In terms of generating interesting in future trainings, it is important to broadcast the legislative requirements for NZEB from 1st November 2019 (in Ireland) which will hopefully stimulate greater demand.

Joining a Project Mid-Way

On two of the on-site trainings that PHA delivered, work had already progressed on dealing with airtightness which was incorrect and needed to be altered. This involved removing materials and applying a new approach in terms of sealing the external envelope. In both cases, the contractors and owners were fully on-board in following a new approach and proactively applied the new measures in good spirit. Furthermore, the contractors in both of these cases were more confident of getting a good airtightness result following the on-site training and the overall 'mood' on the site improved. Nevertheless, there was a cost involved in re-applying airtight materials and it would have been much better to catch these things from the outset. The lesson from this is to try and get involved with projects from the very beginning, ideally before they start on site.

Inclement Weather

Winters in Ireland tend to be wet and cold (though not as cold as some other regions in Europe). This presents a significant challenge in terms of delivering training on-site from October through March. On a positive note, it is also a time of the year when contractors tend to be less-stressed about taking time away for training, however, so participation rates can be higher. One of the trainings that PHA delivered took place in very cold weather where the learners were uncomfortable outside and where their attention-spans were compromised. Furthermore, cold weather can place a constraint on some deep retrofitting activities, such as application of plaster on external wall insulation or application of liquid-applied airtightness membranes. PHA can imagine that weather could be even more constraining in some of the partners' regions.

Expertise in Hands-On Application Training

The trainers at PHA are quite practical people and have considerable experience in visiting construction sites and advising design teams and contractors alike in terms of best-practices in deep retrofitting. However, the PHA trainers are not qualified tradespersons (with no qualifications in electrical, plumbing or ventilation, for example) and thus cannot competently demonstrate hands-on all elements involved in deep retrofitting. In order to compensate for this lack of 'everyday' skills in hands-on application, therefore, PHA invited specialist and highly experienced applicators to co-deliver some of the material. We referred to such external contributors as 'Pro-Demos'. These pro-demos proved to be very positive and well-received by the learners. They also provided some variety in terms of shared-stories of experiences from different projects.

4.3 Italy

- Total combined number of students: 29
- Total combined number of hours: 96
- Total combined courses duration: 96
- Photos and / or videos: See above
- **Key challenges encountered:** difficulty in recruiting trainees, difficulty in convincing trainees to attend courses in other cities, where the training facilities are located.

4.4 Greece

- Total combined number of students: 118
- Total combined number of hours :30
- Total combined courses: 30
- Photos and / or videos: See above
- **Key challenges encountered:** Some of the trainees thought that "all this is too much for Greece and our climate". We've tried to convince them that everything will change in 1,5 year and if they are not well prepared, they won't have any chance to survive.

4.5 Czech Republic

- Total combined number of students: 32
- Total combined number of hours: 48
- Total combined courses: 48 hours
- Photos and / or videos: See above
- **Key challenges encountered:** difficulty in recruiting the trainees, lack of interest in training courses during the construction period within the target group. They tackle with the construction managers who should concentrate more on deep retrofit as the approach.

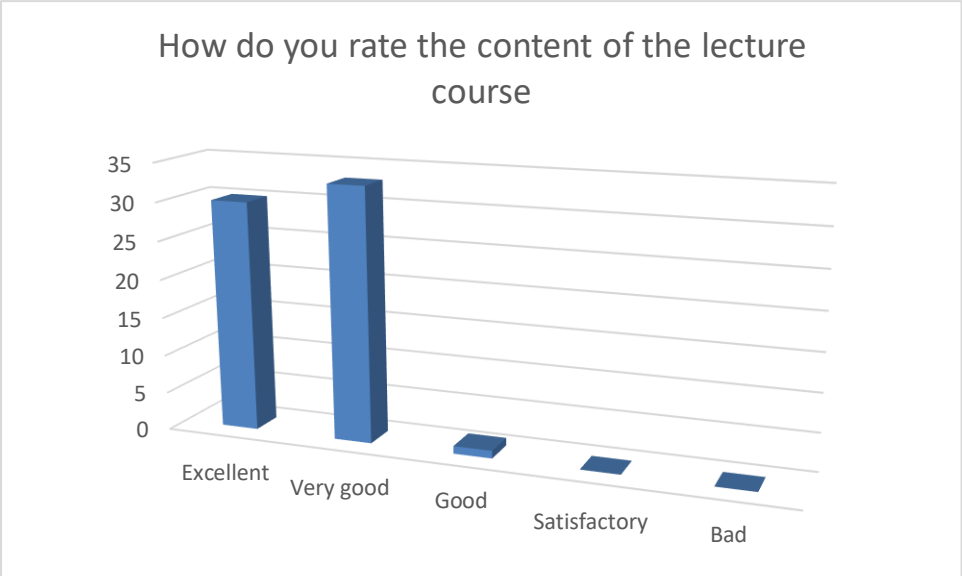
4.6 Romania

- Total combined number of students: 16
- Total combined number of hours: 6
- Total combined courses duration: 1 day
- Photos and / or videos: See above
- **Key challenges encountered:** the participants in the training course were members of the team Over4 (Association of students and young professionals – mainly architects, civil and building services engineers, https://www.over4.org/home) who prepared the Romanian prototype house for the participation in the Solar Decathlon Europe 2019 competition (https://sde19.konkrete.me/competition) in Hungary. Some of the members of Team Over4 already attended the courses organised within Train-to-nZEB project the aim of the short training was to update their knowledge and skills on retrofit at nZEB level, taking into account their level of expertise, their achievement with the retrofit prototype house prepared for the conference and, last but not least, their enthusiasm in learning and doing buildings better. The building itself was used as training model and one additional small-size wooden house mock-up was included in the demonstration of nZEB retrofit technologies. Key issues in the concept and execution of the pilot building were highlighted during the course.

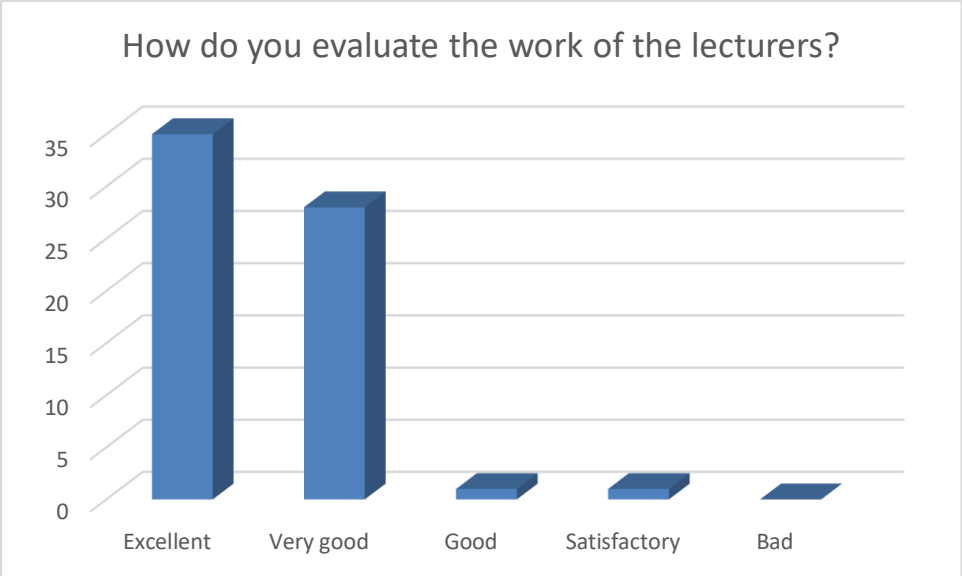
4. Conclusions and Suggested Improvements for Future Courses

5.1 Bulgaria

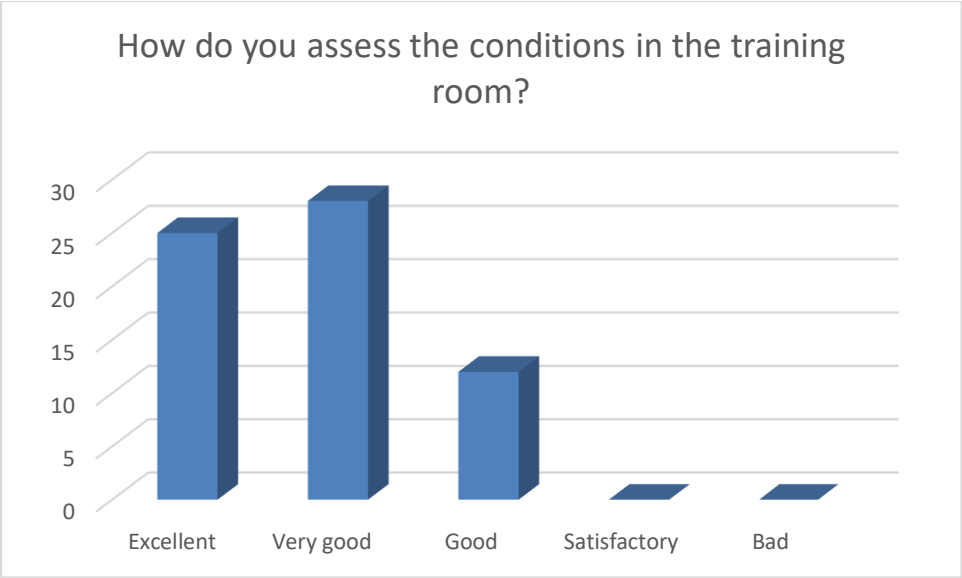
The results from the survey in Bulgaria demonstrate overall positive appreciation of the courses and willingness of the participants to engage in additional training on specific topics, which is considered a positive sign. Out of 65 received questionnaires, the responses are as follows:



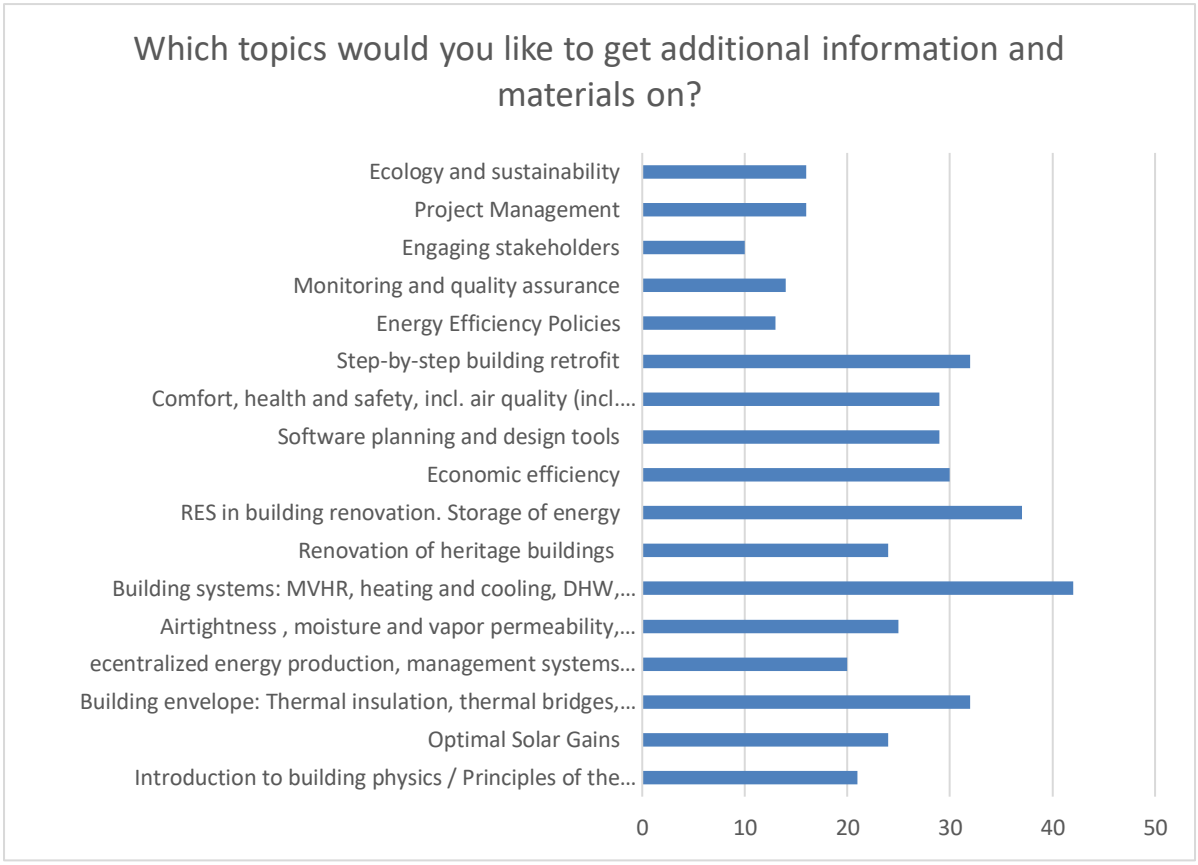
Although demonstrating an overall good appreciation, based on informal discussions with course participants, it is believed that the courses didn't entirely meet the expectations to be aligned with the National Programme for Energy Efficiency. This is a serious issue, as the programmes targets energy class C (up to 240Kwh/sq.m/a) which doesn't fit with the concept of deep energy retrofit.



The lecturers are evaluated as well prepared, although some improvement should be targeted, especially in the practical demonstration area.

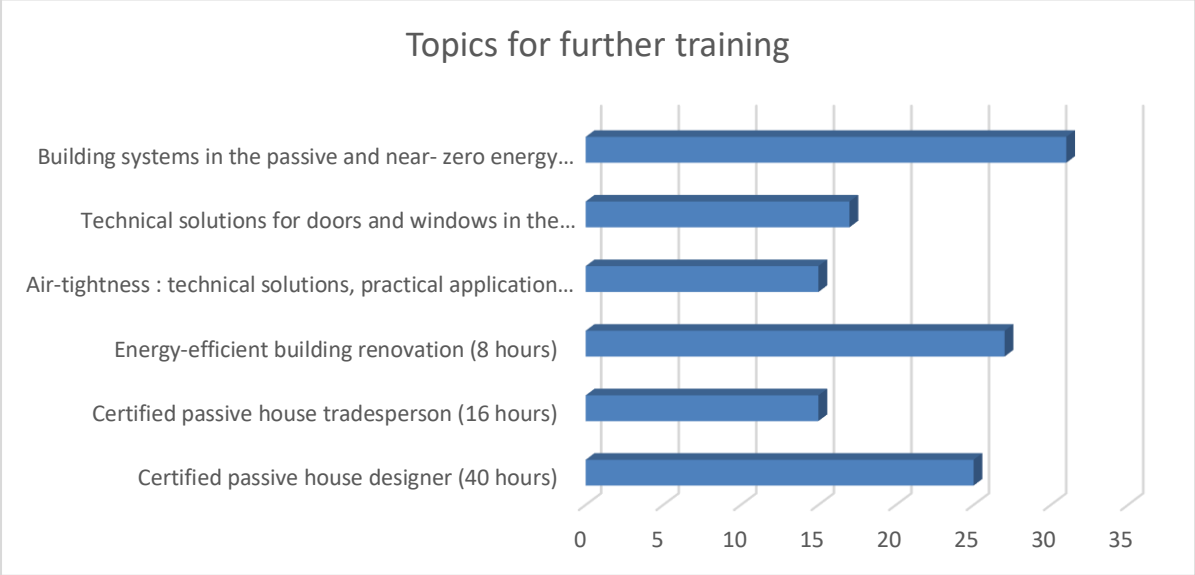


The courses were conducted in different locations so the full equipment was not available everywhere, although the Bulgarian Construction Chamber invested own resources to replicate most of the practical training facilities in joint courses outside Sofia. The temperature comfort in the rooms also influenced the evaluation – unfortunately, it is still not optimal in the University of Architecture in Sofia, where the BKH is situated. The training equipment and facilities are however equivocally recognized as unique for Bulgaria.


Which topics would you like to get additional information and materials on?
Ecology and sustainability
Project Management
Engaging stakeholders
Monitoring and quality assurance
Energy Efficiency Policies
Step-by-step building retrofit
Comfort, health and safety, incl. air quality (incl....
Software planning and design tools
Economic efficiency
RES in building renovation. Storage of energy
Renovation of heritage buildings
Building systems: MVHR, heating and cooling, DHW,...
Airtightness , moisture and vapor permeability,...
ecentralized energy production, management systems...
Building envelope: Thermal insulation, thermal bridges,...
Optimal Solar Gains
Introduction to building physics / Principles of the...
0
10
20
30
40
50


On which topic do you need more practical training?
Ecology and sustainability
Project Management
Engaging stakeholders
Monitoring and quality assurance
Energy Efficiency Policies
Step-by-step building retrofit
Comfort, health and safety, incl. air quality (incl....
Software planning and design tools
Economic efficiency
RES in building renovation. Storage of energy
Renovation of heritage buildings
Building systems: MVHR, heating and cooling, DHW,...
Airtightness , moisture and vapor permeability,...
ecentralized energy production, management systems...
Building envelope: Thermal insulation, thermal bridges,...
Optimal Solar Gains
Introduction to building physics / Principles of the...
0
10
20
30
40

After visiting the course, the participants are already aware of the need of new information on specific topics, which is demonstrated by the graphs above. However, this does not indicate a specific interest and intent to visit and pay for training. The surprising fact that mechanical ventilation with heat recovery and RES in building renovation receive most positive answers is due to the fact that in most of the courses, this content was limited as the focus was on building envelope. Similarly, practical training on BIM solutions and other planning and design software tools require more time and dedication. However, the responses provide a solid general guidance for the structure of future courses, as well as for the expectation of the construction professional for the development of the building renovation practice.



Confirming the conclusions above, due to the raised awareness and interest, there is a stated demand for additional training on building systems, focused on MHVR solutions, which will be tested on the market with the course participants despite the previous unsuccessful attempts to organize individual courses on this topic. After the training, the courses are already recognized as too short (while considered as **too long** before attending), which is why half of the respondents would like another course on the same topic. It is interesting that many of the participants declare interest to the Passive House Designer course, which is explained from one side with the newly created understanding of the existing knowledge gaps, but from the other that despite courses were marketed to workers at level 3 and 4 under the EQF, they were also visited by professionals with higher qualification (which is deemed as a positive feature as actually they are the ones that would transmit the knowledge to the building sites).

5.2 Ireland

- **What would you do differently if you were to repeat these trainings – what improvements would you make?**

Timing is critical

We found it to be critical to get on-board with the training delivery before mistakes are made by the construction crew. If the training takes place after project commencement, and significant errors have already been made (for example on the airtightness strategy), then the construction crew are often reluctant to accept changes to their approach. This can create a 'tension' between trainees and trainer, with a defensive position being adopted perhaps by those that were involved in incorrectly implementing the deep retrofit measures.

On one of the trainings that PAH delivered, the contractor had installed internal partition walls upstairs that were going to make it very difficult to achieve a continuous airtight layer on the underside of the roof rafters. It would have taken very little effort to temporarily remove these stud partitions, install a continuous membrane and then refit the walls. The contractor declined to follow this recommendation, however. We await to see what level of airtightness they achieve.

Pre-Prepared Construction Details

For one of the on-site trainings that PHA carried out, the Architect had already prepared detailed construction drawings for all of the key junctions and penetrations. These drawings were then used in-class to explain what the strategy was, for example, pertaining to airtightness. Later, these same drawings were used on-site to implement the retrofit details. The details illustrated clearly how insulation, thermal bridging and airtightness were to be handled. On the other two projects, there were no such construction details available, so we had to 'think on our feet' on several occasions as to how to deal with specific junctions. This presented a challenge to the trainer which, whilst not insurmountable, would have been easier for all involved if details were available.

More Time Needed – to include Theory

For one of the on-site training sessions, we had ample time to cover all modules sufficiently. The other two training sessions were shorter and didn't enable us to deliver the material to the same level of detail. In relation to the shorter sessions, there was not the same scope to cover the theoretical side of training as much as we would have liked. When time is short, the contractor will generally want the training to focus on hands-on application and practice, rather than theoretical aspects. PHA contends that some minimum amount of theory is important for all trainees, so that they understand not only 'how' to do something, but also 'why' they need to do it in a particular way.

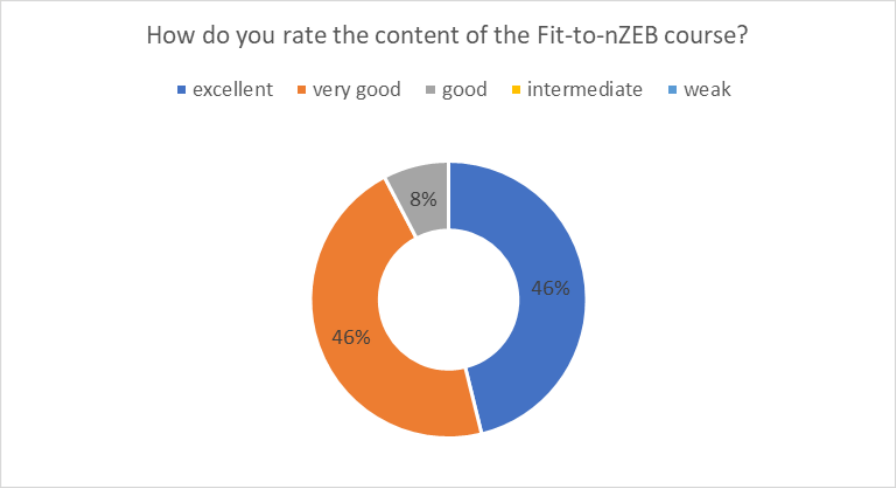
- **What advice would you give other training providers if they were to undertake such training in the future – what should they most-definitely do, what should they avoid?**

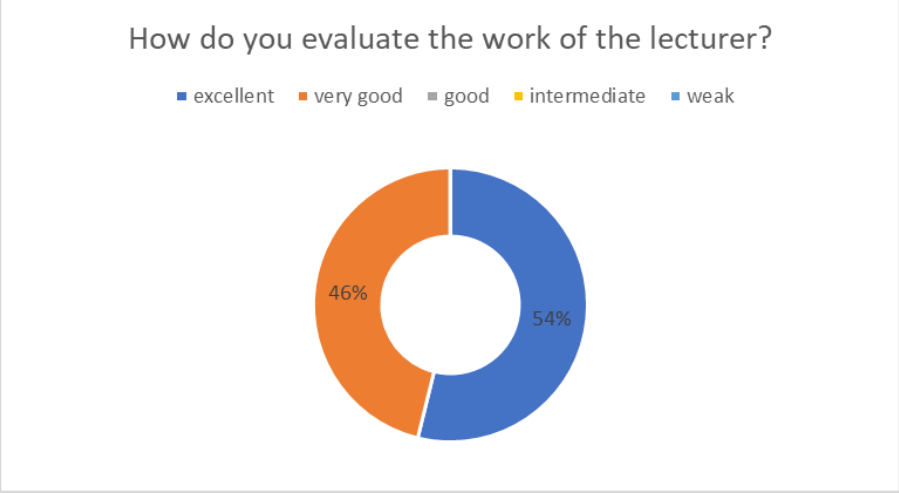
PHA recommends the following based on their experiences in delivering the three Fit-to-NZEB on-site training sessions:

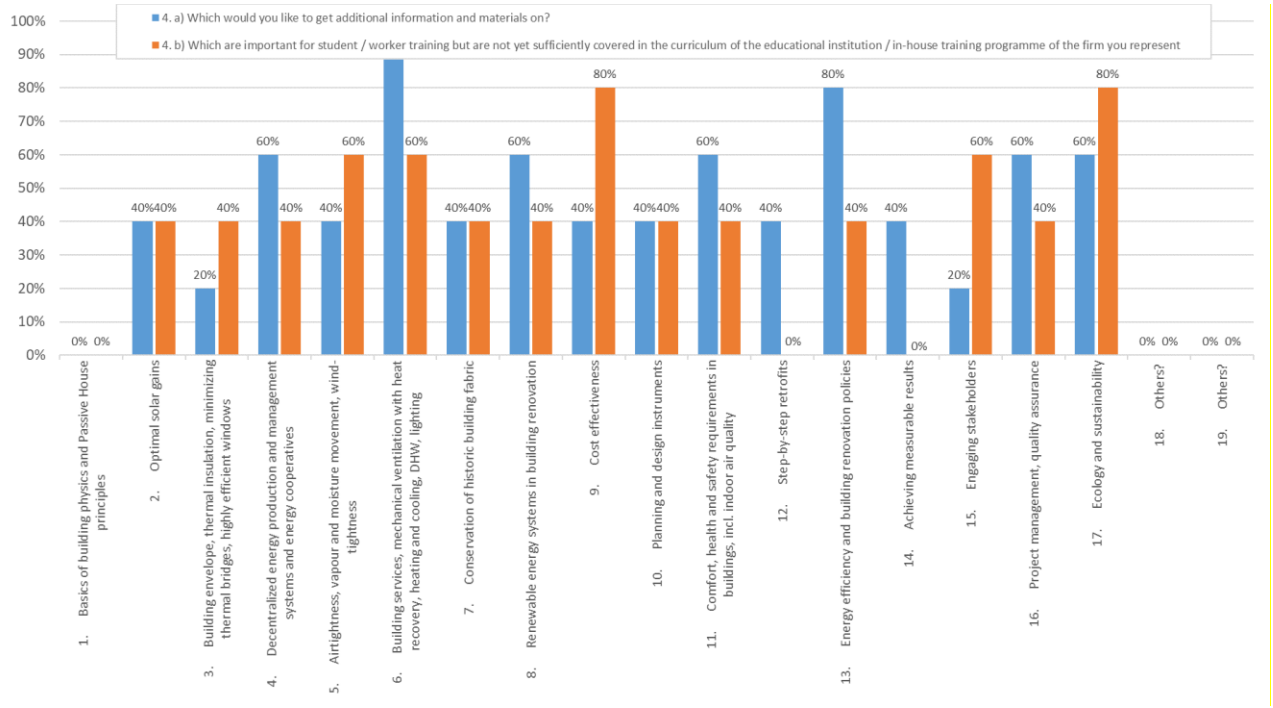
- DO deliver at least some **training on-site whenever possible**. There is simply no better substitute for seeing the application of best practice right on the job-site.
- DO follow the **logical training sequence** of (1) theory and key principles, (2) hands-on application on practice models where no damage can be done to the 'actual' project followed by (3) hands-on application on the project proper.
- DO get the trainees to sketch or **draw construction details** – even if they are very simple. In 'requiring' someone to draw a construction detail, they will get to learn a lot more about construction sequencing than they would by just 'passively' observing a detail without full engagement. PHA has found this to be a great teaching tool over the years. Some learners will struggle initially with this ask – they might never have been asked to draw anything before! Make sure that they all give it a go – they will be pleasantly surprised at how well they do.
- DO frequently refer to the impending **airtightness test** where the impact of their quality of application will be quantitatively tested. There was great excitement on the day of the airtightness test on two of the projects in Ireland, with everybody anxiously wondering what the final result would be. This creates a memorable event for all and a great sense of pride (and relief) when the result is really good.
- DO bring in external practitioners to provide **'pro-demos' (professional demonstrations)** for key parts of the training such as airtightness installation and ventilation. Their hands-on skills will generally be far greater than those of the trainer (who will probably not be a contractor in their 'day-job'). Their shared experiences from 'real' building sites will be very helpful to the trainees and the trainees will generally place greater 'trust' in learning from an experienced practitioner. Plus, the practitioner will most likely enhance their teaching skills each time they deliver such a 'pro-demo', assisting them in spreading knowledge in their regular job.
- **DON'T start with practical exercises and then follow-on to theory** – that won't work in most cases. PHA developed a routine whereby theory was delivered first-thing, following by practical exercises later.
- **DON'T use training materials which are not directly relevant** or applicable to the project where training is being delivered. Take care not to include training content from another climate, or building type, for example. An example of this might be a very expensive option for fixing a thermal bridge which, while achieving good results, is rarely used in practice due to cost reasons. Contractors are very practical and cost-focused trainees. If a trainer is presenting ideas, materials, details, or whatever, which are too difficult or too expensive to construct they (the trainer) will loose credibility with their audience.

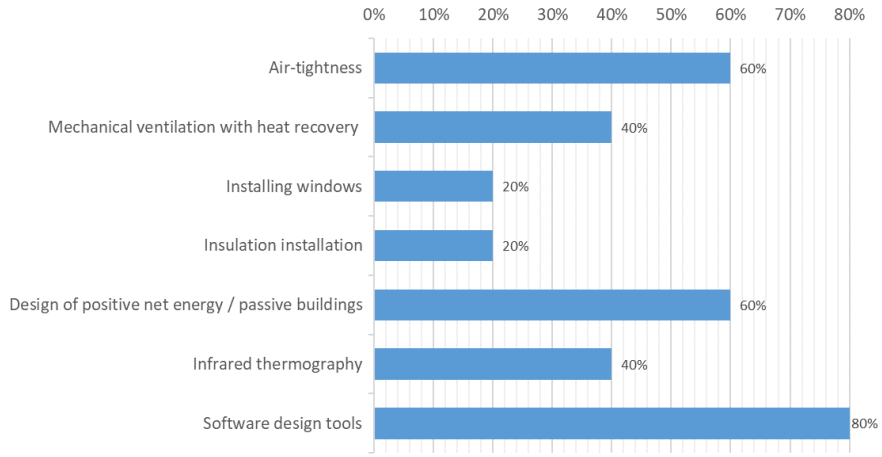
- **DON'T forget that a contractor trainee group will typically consist of very different levels of education** and that it is the responsibility of the trainer to ensure that all of their students can adequately follow the material. Be sensitive to the fact that the students may include persons that have reading and writing difficulties, might not be familiar with doing even the simplest calculations or might be totally flummoxed by too many acronyms and units for various measurements.
- **DON'T have such large classes that people miss out on practical experiences.** With on-site training, it is important that all learners get the experience of hands-on applications – this can be difficult with very large classes.

5.3 Italy









- **What would you do differently if you were to repeat these trainings – what improvements would you make?**

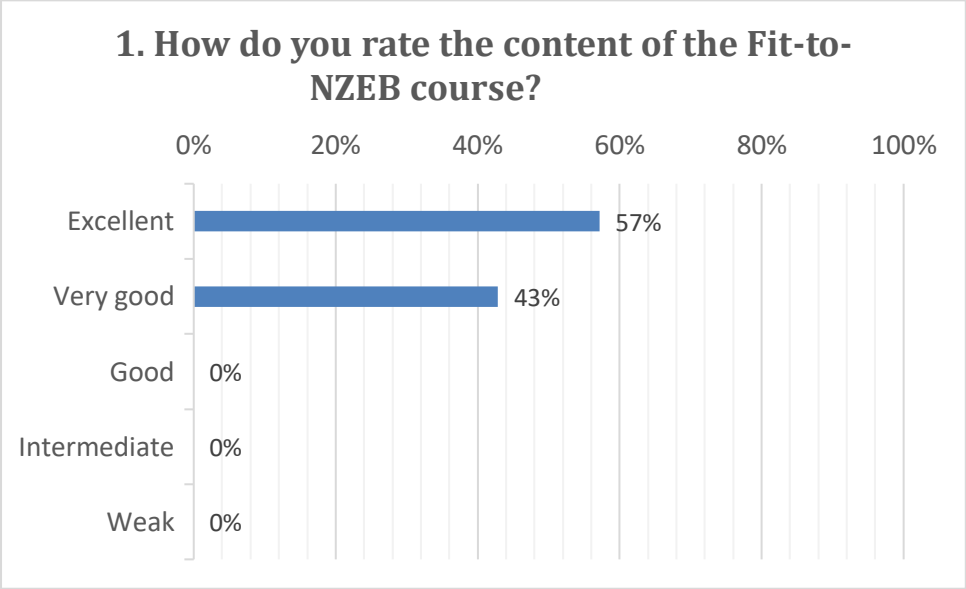
A bigger mockup is required in order to give the possibility to all trainees to practice by doing.

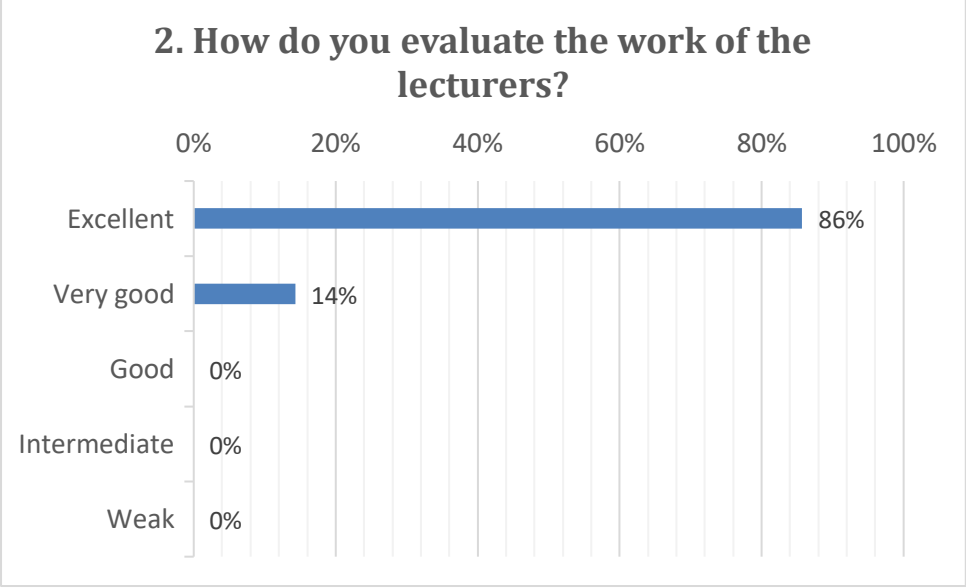
- **What advice would you give other training providers if they were to undertake such training in the future – what should they most-definitely do, what should they avoid?**

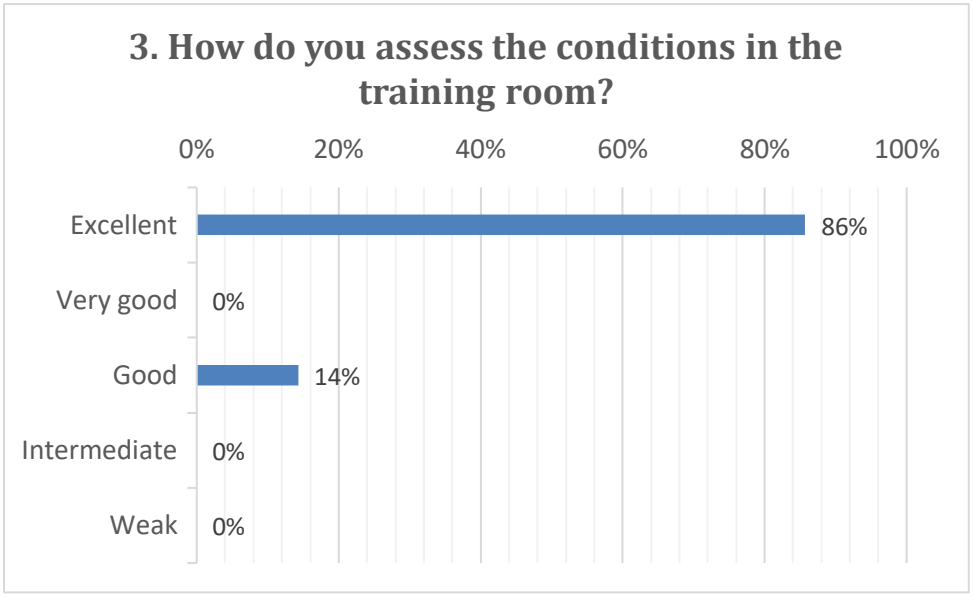
I would suggest to have trainees' groups with no more than 25 people. This is the maximum to guarantee trainees to be adequately followed by the trainer.

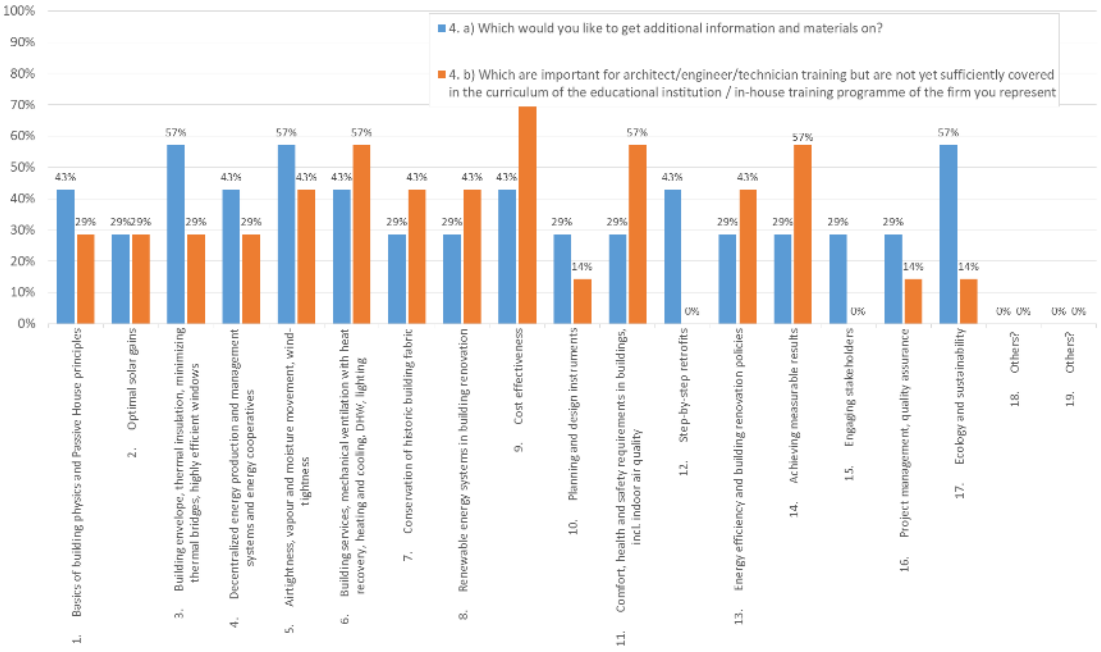
5.4 Greece

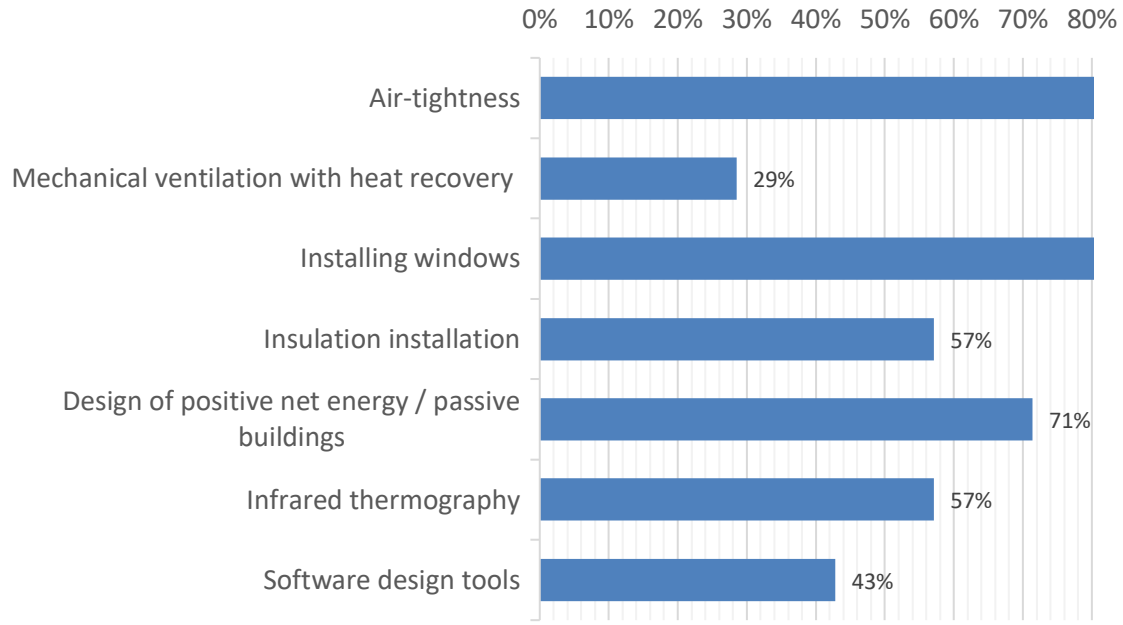
- Results from survey questionnaires






3. How do you assess the conditions in the training room?
0%
20%
40%
60%
80%
100%
Excellent
86%
Very good
0%
Good
14%
Intermediate
0%
Weak
0%


4. a) Which would you like to get additional information and materials on?
4. b) Which are important for architect/engineer/technician training but are not yet sufficiently covered in the curriculum of the educational institution / in-house training programme of the firm you represent
1. Basics of building physics and Passive House principles
2. Optimal solar gains
3. Building envelope, thermal insulation, minimizing thermal bridges, highly efficient windows
4. Decentralized energy production and management systems and energy cooperatives
5. Airtightness, vapour and moisture movement, wind-tightness
6. Building services, mechanical ventilation with heat recovery, heating and cooling, DHW, lighting
7. Conservation of historic building fabric
8. Renewable energy systems in building renovation
9. Cost effectiveness
10. Planning and design instruments
11. Comfort, health and safety requirements in buildings, incl. indoor air quality
12. Step-by-step retrofits
13. Energy efficiency and building renovation policies
14. Achieving measurable results
15. Engaging stakeholders
16. Project management, quality assurance
17. Ecology and sustainability
18. Others?
19. Others?



- **What would you do differently if you were to repeat these trainings – what improvements would you make?**

I would do the groups smaller in order to give more time to trainees to ask questions and to practice.

- **What advice would you give other training providers if they were to undertake such training in the future – what should they most-definitely do, what should they avoid?**

Avoid groups larger than 20 people. Give the trainees all the time they need to practice and solve all of their questions.

5.5 Czech Republic

Survey questionnaires	Number of answers	
	TOTAL	%
1) Did the course meet your expectations?		
Absolutely yes	3	21,4 %
Yes	9	64,3 %
Not really	2	14,3 %
No	0	0,0 %

2) You will use the newly acquired knowledge?

Yes, I will use it	10	66,7 %
I will try it	5	33,3 %
Difficult to use	0	0,0 %
I don't now	0	0,0 %

3) What was the total duration of the training?

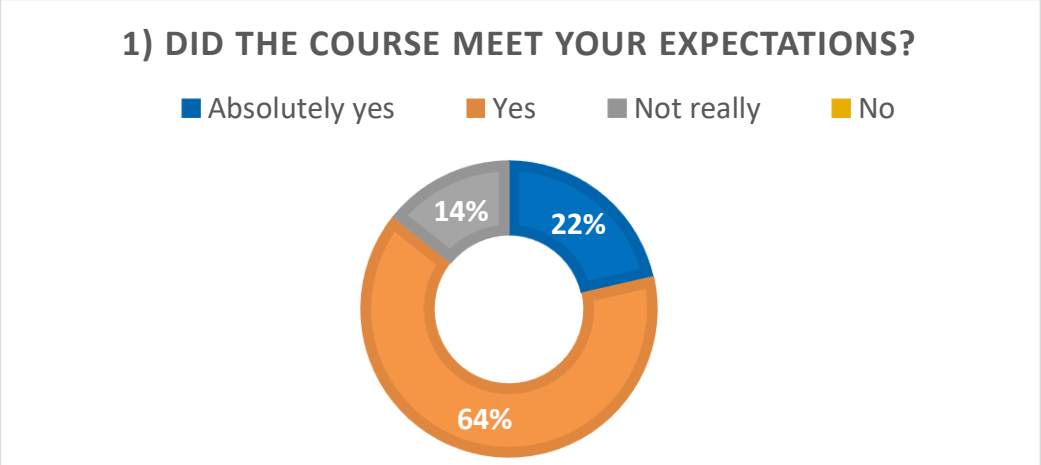
Too long	0	0,0 %
Satisfactory	14	93,3 %
Too short	1	6,7 %

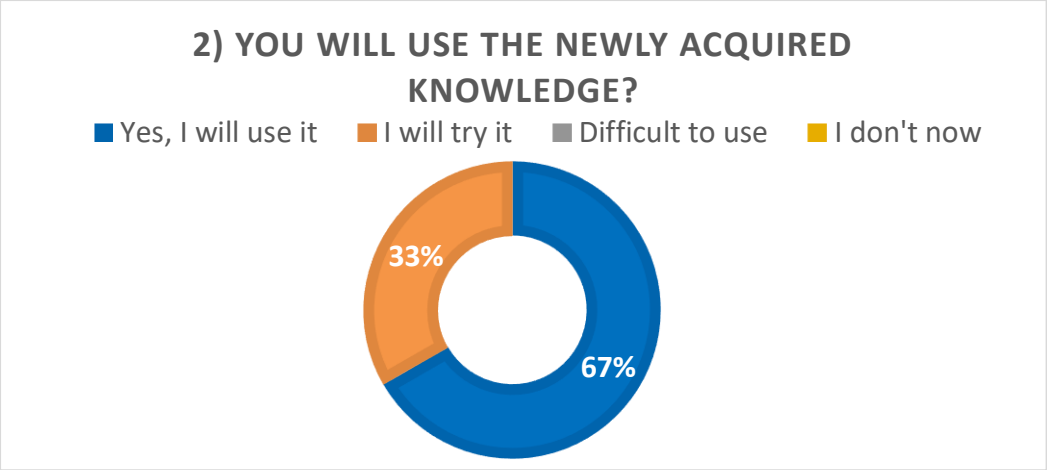
4) What are the indoor spaces for the course?

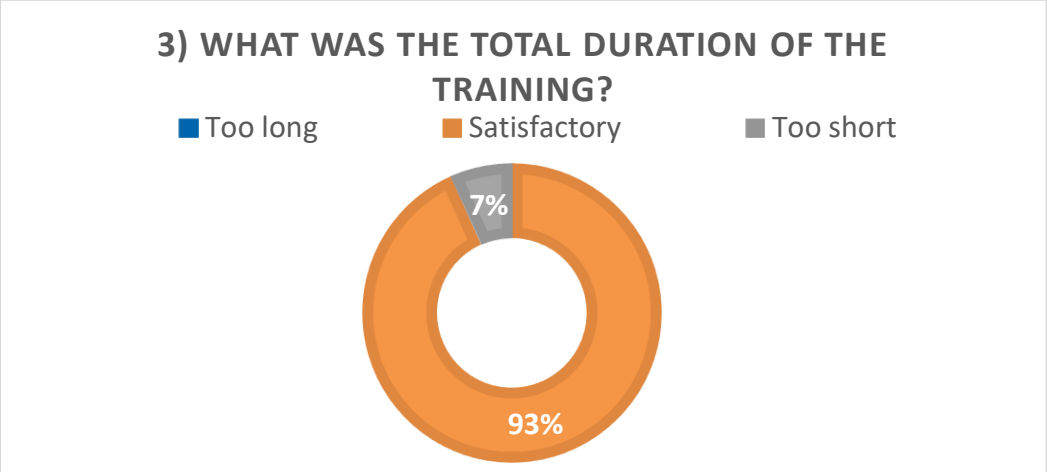
Absolutely satisfactory	8	57,1 %
Satisfactory	6	42,9 %
Unsatisfactory	0	0,0 %

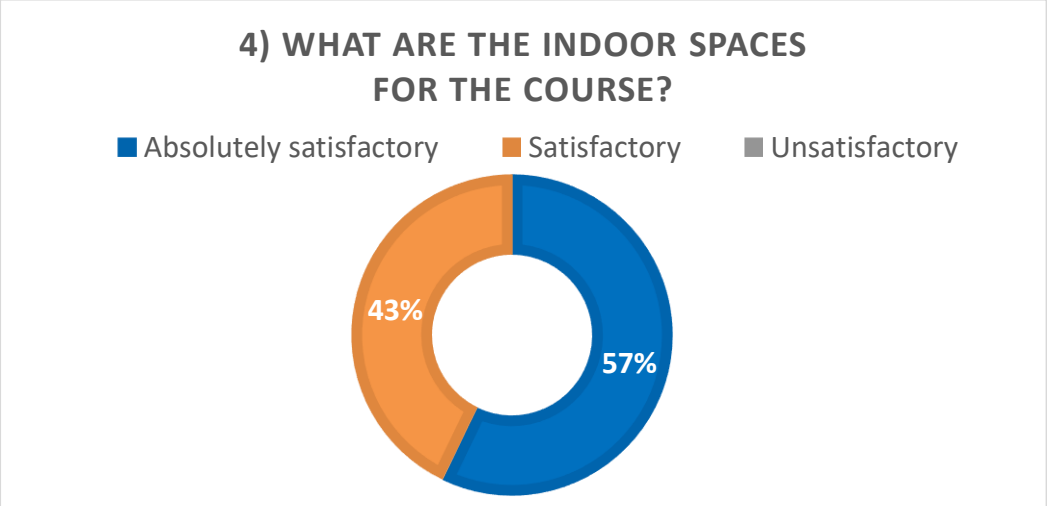
5) How did you hear about the course?

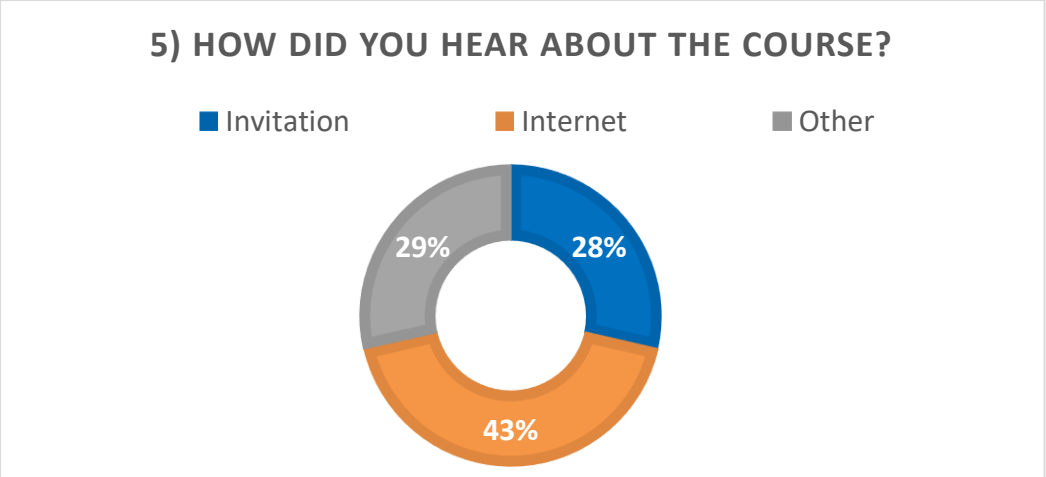
Invitation	4	28,6 %
Internet	6	42,9 %
Other	4	28,6 %




2) YOU WILL USE THE NEWLY ACQUIRED KNOWLEDGE?
Yes, I will use it
I will try it
Difficult to use
I don't now
33%
67%


3) WHAT WAS THE TOTAL DURATION OF THE TRAINING?
Too long
Satisfactory
Too short
7%
93%


4) WHAT ARE THE INDOOR SPACES FOR THE COURSE?
Absolutely satisfactory
Satisfactory
Unsatisfactory
43%
57%



- **Results from interviews post-completion of the training**

"The unique models of building constructions in the Prague training center are great examples of nearly Zero Energy Buildings and deep energy retrofits. The trainees see the real details of modern construction solutions presented at the attractive practical form."

Jan Fibiger, ABF Foundation

The participants of the courses were impressed with the volume of information presented within the course and cover by the training materials. They love the training models and will use the details in their personal praxis.

- **What would you do differently if you were to repeat these trainings – what improvements would you make?**

We would do only one-day topic-oriented courses. There is a chance to present at least 17 topic oriented courses; each with the practical part and cross-craft part.

- **What advice would you give other training providers if they were to undertake such training in the future – what should they most-definitely do, what should they avoid?**

We would advise to organize shorter (one-day) topic oriented courses for no more than 25 trainees (ideally 12). Secondly, there is a critical need for interactive sessions when providing the trainings.

5.6 Romania

The feedback from participants was very positive. The Team Over4 successfully participated in the SD Europe 2019 competition, where they placed on the third place being awarded with the bronze medal (one of the highest scores obtained was for Energy balance). Maybe part of their success was due to the participation in the Fit-to-NZEB course.

Appendices

АНКЕТА

Към семинар „Основи на почти нулево-енергийната сграда (ПНЕС). Енергийно ефективно сградно обновяване“ по проект Fit-to-NZEB, София, 21.02.2019 г.

Име, фамилия, организация (по желание)

……

1. Как оценявате съдържанието на лекционния курс?

☐ Отлично ☐ Много добро ☐ Добро ☐ Посредствено ☐ Слабо

2. Как оценявате работата на преподавателите?

☐ Отлично ☐ Много добро ☐ Добро ☐ Посредствено ☐ Слабо

3. Как оценявате условията в залата, в която се провежда обучението?

☐ Отлично ☐ Много добро ☐ Добро ☐ Посредствено ☐ Слабо

4. По кои от темите бихте искали да получите допълнителна информация и материали?

☐ Тема 1: Въведение в строителната физика / Принципи на пасивната и почти нулевоенергийната сграда	☐ Тема 2: Оптимални слънчеви печалби	☐ Тема 3: Сградна обвивка: Топлоизолация, топлинни мостове, Високоефективни прозорци	☐ 4. Децентрализирани системи за производство и управление на енергията и енергийни кооперативи	☐ Тема 5: Въздухоплътност, влаго- и паропреминаване, ветроустойчивост	☐ Тема 6: Сградни системи: Вентилация с рекуперация, отопление и охлаждане, БГВ, автоматизация, осветление
☐ Тема 7: Обновяване на сгради –	☐ Тема 8: ВЕИ при сградното обновяване.	☐ Тема 9: Икономическа ефективност	☐ Тема 10: Софтуерни инструменти за	☐ Тема 11: Комфорт, здраве и безопасност, вкл. качество на въздуха	☐ Тема 12: Поетапно сградно обновяване (стъпка по стъпка)

паметници на културата	Съхранение на енергия		планиране и проектиране	☐ 11.1 Летен комфорт ☐ 11.2 Противопожарна безопасност	
☐ Тема 13: Политики за енергийна ефективност	☐ Тема 14: Мониторинг и контрол на резултатите	☐ Тема 15: Ангажиране на заинтересованите страни	☐ Тема 16: Управление на проекти	☐ Тема 17: Екология и устойчивост	*/Предложете тема/*

5. По кои от темите смятате, че са Ви необходими допълнителни практически обучения?

☐ Тема 1: Въведение в строителната физика / Принципи на пасивната и почти нулевоенергийната сграда	☐ Тема 2: Оптимални слънчеви печалби	☐ Тема 3: Сградна обвивка: Топлоизолация, топлинни мостове, Високоефективни прозорци	☐ 4. Децентрализирани системи за производство и управление на енергията и енергийни кооперативи	☐ Тема 5: Въздухоплътност, влаго- и паропреминаване, ветроустойчивост	☐ Тема 6: Сградни системи: Вентилация с рекуперация, отопление и охлаждане, БГВ, автоматизация, осветление
☐ Тема 7: Обновяване на сгради – паметници на културата	☐ Тема 8: ВЕИ при сградното обновяване. Съхранение на енергия	☐ Тема 9: Икономическа ефективност	☐ Тема 10: Софтуерни инструменти за планиране и проектиране	☐ Тема 11: Комфорт, здраве и безопасност, вкл. качество на въздуха ☐ 11.1 Летен комфорт ☐ 11.2 Противопожарна безопасност	☐ Тема 12: Поетапно сградно обновяване (стъпка по стъпка)
☐ Тема 13: Политики за енергийна ефективност	☐ Тема 14: Мониторинг и контрол на резултатите	☐ Тема 15: Ангажиране на заинтересованите страни	☐ Тема 16: Управление на проекти	☐ Тема 17: Екология и устойчивост	*/Предложете тема/*

7. Кои от следните курсове биха представлявали интерес за Вас?

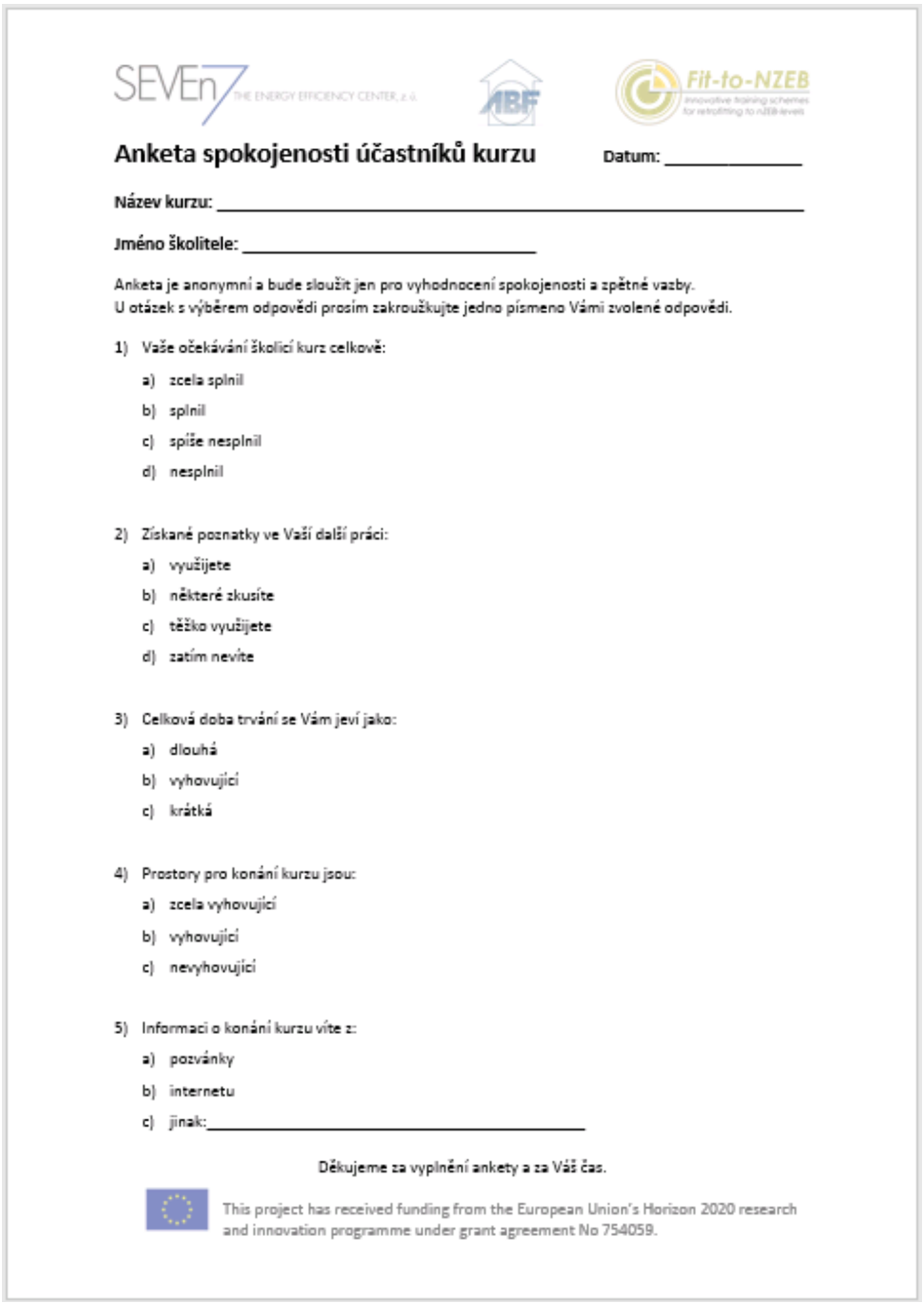
☐ Сертифициран проектант на пасивни сгради (40 часа)

- ☐ Сертифициран строителен специалист за пасивни сгради (16 часа)
- ☐ Енергийно ефективно сградно обновяване (8 часа)
- ☐ Въздухоплътност: технически решения, практическо приложение и тестове за въздухоплътност (4 часа)
- ☐ Технически решения за врати и прозорци в пасивната и почти нулевоенергийната сграда (4 часа)
- ☐ Сградни системи в пасивната и почти нулевоенергийната сграда. Механична вентилация с рекуперация (4 часа)
- ☐ */Предложете тема/*

This project has received financing under the
Horizon 2020 Programme of the European Union

Greece : Survey was electronic. We used the same scheme as in the TTT-course

Czech Republic: Survey questionnaire (only in Czech language). We used the same scheme as in the Train-to-NZEB project for comparing both project.



SEVEn THE ENERGY EFFICIENCY CENTER, z.ú. ABF Fit-to-NZEB innovative training schemes for retrofitting to nZEB levels

Anketa spokojenosti účastníků kurzu

Datum: _____

Název kurzu: _____

Jméno školitele: _____

Anketa je anonymní a bude sloužit jen pro vyhodnocení spokojenosti a zpětné vazby.
U otázek s výběrem odpovědi prosím zakroužkujte jedno písmeno Vámi zvolené odpovědi.

1) Vaše očekávání školicí kurz celkově:
   a) zcela splnil
   b) splnil
   c) spíše nesplnil
   d) nesplnil

2) Získané poznatky ve Vaší další práci:
   a) využijete
   b) některé zkusíte
   c) těžko využijete
   d) zatím nevíte

3) Celková doba trvání se Vám jeví jako:
   a) dlouhá
   b) vyhovující
   c) krátká

4) Prostory pro konání kurzu jsou:
   a) zcela vyhovující
   b) vyhovující
   c) nevyhovující

5) Informaci o konání kurzu víte z:
   a) pozvánky
   b) internetu
   c) jinak:_____

Děkujeme za vyplnění ankety a za Váš čas.

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