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Fit-to-NZEB

Innovative training schemes for retrofitting to nZEB-levels

Training programme for EQF level 3-5

Development of the educational programme

Deliverable 5.1

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

Led by:

pRO-nZEB – Cluster for Promoting Nearly Zero Energy Buildings (Romania)

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D5.1 Training programme for EQF level 3-5

Training programme for EQF level 3-5 with all necessary requisites: entry requirements for students, capacity of trainers, educational modules, necessary equipment, examination programme etc. The new training programmes are targeted to professional high schools where the deep energy building renovation will be included as a topic in the training plans and programmes for the professions in:

1 **"Construction" professional direction (EQF level 3-5), consisting of 24 hours of theoretical and 36 hours of practical training,**
2. **"Electrical engineering and energy sector" professional direction (EQF level 3-5), consisting of 12 hours of theoretical and 24 hours of practical training.**

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Contents

1. Training programme for “Construction” professional direction (EQF level 3-5)

1.1 Introduction to the programme

The subject Deep Energy Retrofit: Retrofitting to nZEB Levels is conceived as an additional module to be introduced in the curricula of the Construction and Architecture High School and with specialty of Energy efficiency in construction. The programme is divided into 60 hours (24 hours of theoretical lectures and 36 hours of practical lessons) in which 21 topics will be taught.

The described deep energy retrofit course is based on the notion that the students already have some knowledge and basic understanding of the building design and construction process and building physics and materials. Some of them may also have certain practical experience in construction as a result of summer internships. The design process is structured using the basic principles of the Passive House concept applied to the renovation of existing buildings, resulting in the achievement of different levels of energy efficiency.

The course is divided in four major parts. The first part of the course is focused on the general knowledge of building physics, requirements in terms of health, comfort and safety in buildings and general retrofit approach including notions about ecology and sustainability.

The second part examines the deep energy retrofit (DER) in connection to the building envelope with particular attention being paid to the design and construction of the distinct building components, underlining the role of the comprehensive design to the DER and examining its key renovation principles. The basic renovation design principles are being introduced, emphasising on what makes a retrofit ‘a deep energy retrofit’ and what are the most common faults in the standard building renovation practices. The students get to grasp not only the theoretical knowledge behind the DER practices, but the insight on why it is advantageous and preferred to the standard energy renovation. Special and particular attention is paid to the step-by-step renovation.

The third part on the course covers the building services and deals with the ventilation, heating and cooling, DHW and RES in retrofitting.

The last part is dedicated to the project management and planning and design instruments as well as to the assurance of high quality building design and construction. The basics of the economic efficiency and cost-effectiveness of the renovation of existing buildings is covered. The main sustainability indicators, the involvement of stakeholders, and energy management at community level are also briefly mentioned.

1.2. Curriculum

FIT-TO-NZEB

Development of the educational programme
CURRICULUM

WP5 - Training programmes for professional high schools
Levels 3-5 under the EQF
"Construction" professional direction

Subject	**DEEP ENERGY RETROFIT: RETROFITTING TO NZEB LEVELS**
Academic hours	1-2 hours lecture + 1-2 hours practical lessons per week Total: 60 hours - 24 hrs lectures and 36 hrs practical lessons
Type of discipline	Elective (facultative)
EQF level	3 - 5
	Control and evaluation - ongoing assessment and examination
Credits ECTS	
Acquired knowledge	Comprehensive, specialised, factual and theoretical knowledge on: (a) deep energy retrofit process (b) principles and practices of the deep energy retrofit (c) overview of the basic deep energy retrofit details and their implementation during building renovation
Acquired skills	Comprehensive range of cognitive and practical skills on: (a) overall organization of building renovation design process (b) implementation of some basic tasks during renovation with regard to the: thermal bridges insulation, air tightness, fixing of thermal insulation, windows assembling etc.
Targeted responsibility and autonomy	Responsibility for: (a) read and process the planning documents of the main stages of the design and construction process in deep energy retrofit (b) reading the necessary drawings regarding the retrofit
Preliminary requirements	The students are expected to have general knowledge on: building physics & building materials, building construction basics.
Exam procedure	Midterm test and final written exam (incl. drawings done on site) and an oral examination.
Technical secure (hardware and software)	• White board; • Multimedia facility; • Demonstration models; • Practical training models; • Samples of components and materials, suitable for deep renovation; • Demonstration videos.
Leading lectors	Lecturers will be nominated per countries.

1.3. Distribution of lectures and practical lessons

Development of the educational programme - schedule of lectures and practical lessons[1]

№	Subject	Teaching units	
		Theory	Practice
	Part I Basic knowledge and criteria		

1	Basis of building physics, Passive house principles (Topic 1)
	• Heat and Heating Energy (Heat Flux/Thermal Conduction)
	• Thermal environments
	• The 5 Passive House Pillars
	  ○ Thermal envelope
	  ○ Windows
	  ○ Airtightness
	  ○ Thermal Bridges
	  ○ Mechanical Ventilation System
		2	2

2	Comfort, health and safety requirements in buildings, incl. indoor air quality (Topic 11) • 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	1

3	Ecology and Sustainability
	• Efficient use of resources:
	  • Energy;
	  ○ Equipment efficiency;
	  ○ Measuring technologies;
	  ○ Renewable Heating and cooling system (might be an overlapping with chapter Topic 6 – building services and 17 – RES in building renovation);
	  ○ Grey energy;
	  ○ Natural lighting (might be an overlapping with chapter 2 – optimal solar gains);
	  • Water;
	  ○ Low water demand technologies: ultra-low flush toilets; dry toilets (especially country side buildings);
	  ○ Water recycling/reuse concept: grey water;
	  • Waste;
	  ○ Waste recycling;
	  ○ Waste reuse;
	  • Materials;
	  ○ Degradability;
			1

[1] The programme itself will consist in a selection of topics as listed in Task 2.3, spread within a general framework of 60 teaching units (24 hours theoretical lectures and 36 hours of practical training).

	○ Recyclability; ○ Dismount by material exchange or end of life; • Building and Environment: • Transport connections; • Bicycle places; • E-Mobility; • Heat island (Green surfaces; green roof); • Climate change.		
	Part II **Building envelope**		
4	Optimal solar gains, Solar Energy – Introduction and basic concepts (Topic 2) • 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 ○ 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	2
5	Thermal insulation (Topic 3.1) • 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	2	2
6	Thermal bridges (Topic 3.2) • thermal bridges • moisture related building damage due to thermal bridges • prevention and minimisation of thermal bridges • thermal bridge optimised window installation	2	2

	• cross-crafting		
7	High performance building components, highly efficient windows: products and installation (Topic 3.3) • 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	2	2
8	Airtightness, vapour and moisture movement, windtightness (Topic 5) • Key psychometric concepts relating to (1) temperature (dry-bulb, wet-bulb and dew-point) and (2) vapour (relative humidity, humidity ratio and absolute humidity) and ability to interpret a simplified psychometric chart; • Sources of vapour in dwellings (generated internally and externally); • Vapour pressure and vapour drive in different climates and the optimal location for positioning the vapour control layer (internal, central or external); • Conditions that favour mould growth and condensation; • Understanding the term 'breathable' construction as it related to vapour diffusion; • Sd (or Perm) rating for different materials and best practice use according to different site conditions (vapour closed, vapour permeable / semi-permeable, vapour open and vapour variable); • Metrics used in airtightness testing including air changes per hour (h-1) as well as air permeability (m3/hr.m2) and targets for deep retrofitting, including 1.0 h-1 for EnerPHit; • Hands-on airtightness installation at key junctions, penetrations and connections for different construction types and using different materials (membranes, plaster, wooden boards (plywood), tapes, caulks and so forth); • Airtightness testing methods for local code compliance as well as Passive House / EnerPHit (considering pressure differences, testing direction (negative and / or positive), exterior weather conditions (temperature and wind speed)); • Airtightness demonstration test, including volume calculation, identification and fixing of leaks and re-testing; • Wind-tightness and its influence on interior comfort and performance of the insulation layer; • Materials used for achieving wind-tightness; and • Cross-crafting and quality assurance issues, including risks of failure.	2	2

9	"Step-by-step" retrofit plans (Topic 12) • potential for energy savings assessment • renovation standards; certification of the energy performance • details, products and materials • RES • economic efficiency of the different steps	1	2
10	Site visit – renovation of existing building		3
	Part III Building services	2	2
11	Mechanical Ventilation with Heat Recovery (Topic 6.1) • Overview of key building services including ventilation, heating, cooling and domestic hot water; • Key air quality indicators including relative humidity and CO2; • Mechanical ventilation strategies (centralised, de-centralised or hybrid) and methods (extract only or balanced, with heat recovery); • Calculation of supply and extract ventilation rates to ensure high indoor air quality; • Principles of air-to-air heat exchange and mechanical ventilation with heat recovery (MVHR); • Identification of key components in an MVHR unit (heat exchanger, fans, filters, condensate drain) • Optimal placement of an MVHR unit considering minimisation of thermal bridging from cold air ducts; • Vapour-proof insulation and air-sealing of cold air ducts to MVHR unit and penetration through the thermal envelope; • Duct sizing, materials, routing, air-sealing and consideration of pressure losses; • Supply and extract registers – types, placement, adjustment; • Balancing the MVHR system.	1	1
12	Heating and cooling (Topic 6.2) • Heating generation strategies (boiler, heat-pump, direct-electric, CHP, district heating and others); • Heating distribution strategies (using the ventilation air, hydronic (radiators, underfloor, wall or ceiling panels) or refrigerant); • Cooling (latent and sensible) generation strategies (heat-pump); • Cooling (latent and sensible) distribution strategies (using the ventilation air, hydronic (radiators, underfloor, wall or ceiling panels) or refrigerant).	1	1
13	Summer comfort / passive cooling strategies (Topic 11.1) • solar loads, • air exchange / ventilation, • indoor heat sources, • impact of external colours, of thermal insulation and of thermal masses,	1	

	• shading in summer; • passive cooling technologies to avoid overheating / to reduce the cooling demand during summer.		
14	DHW & Lightning (Topic 6.4+6.5) • Domestic hot water generation and distribution; • Insulation materials and thicknesses suitable for vessels, ducts and pipes conveying hot and cold water / refrigerant; • Application of insulation materials to pipework, including paying particular attention to awkward connections and junctions (which are typically poorly insulated); and • Drain water heat recovery systems.	2	
15	RES in building retrofit, Long and short-term energy storage (Topic 8)		1
	Part IV Project management and planning and optimization instruments		
16	Conservation of historic building fabric, Renovation of buildings, monuments of culture (Topic 7) • 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	1	2
17	NZEB neighbourhoods, Energy cooperatives (Topic 4) • Nearly Zero Energy Neighbourhood - concept; • Impact and benefits of the distributed electrical energy generation grid integration; • Legal framework for energy management, tariffs and inter-connection and inter-operability of energy systems; • Cooperatives energy management systems and correlation with new business opportunities.		2
18	Planning and design instruments • PHPP: verified performance • PHPP: the tool • Design PH: plugin for 3D modeling		2
19	Project management, Quality assurance (Topic 16) • Introduction – basic principles; • Necessary legislation; • Executing, monitoring and controlling; • Basic investment efficiency; • Energy efficiency principles; • Energy efficiency documents (EPC, Energy Audit).		2
20	Economic efficiency of existing buildings energy renovation up to	1	2

	the level "passive house" and "nZEB" (Topic 9) • EED and EPBD II • What is Life Cycle Assessment – LCA, LCC • Economic Calculations of Return on Investment • Prices of construction materials, bill of quantities • Energy savings and operational costs - Energy efficiency measures – construction		
21	Engaging stakeholders (Topic 15) • benefits of DER • stakeholders groups: demands, needs and requirements • national and EU policies to support DER • financial instruments • sources of information		2
	TOTAL	**24**	**36**

The curriculum defined the "Construction" professional direction has a certain flexibility regarding the number of hours and can be modified to fit the national requirements for the definition of educational plans (for professional high schools and technical colleges to adapt the programme to the duration of the specific year in which the program is approved and/or considering the number of weeks for theoretical and practical modules in the applicable national professional qualification standards).

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2. Training programme for “Electrical engineering and energy sector” professional direction (EQF level 3-5)

2.1 Introduction to the programme

The subject Deep Energy Retrofit: Retrofitting to nZEB Levels is conceived as an additional module to be introduced in the curricula of the “Electrical engineering and energy sector” professional direction (EQF level 3-5) in the professional high schools. The programme is divided into 36 hours (12 hours of theoretical lectures and 24 hours of practical lessons) in which 12 topics will be taught.

The described deep energy retrofit course is based on the notion that the students already have some basic knowledge and basic understanding of the building design and construction process and building physics and materials. Some of them may also have observations and certain practical experience in construction as a result of summer internships. The design process is structured using the basic principles of the Passive House concept applied to the renovation of existing buildings, resulting in the achievement of different levels of energy efficiency.

The course is divided in two major parts. The emphasis of the subject is on the first part of the course. It examines the deep energy retrofit (DER) in connection to the building envelope. The role of the comprehensive design to the DER is underlined and its key renovation principles are examined. The basic renovation design principles are being introduced, emphasising on what makes a retrofit ‘a deep energy retrofit’ and what are the most common faults in the standard building renovation practices. The students get to grasp not only the theoretical knowledge behind the DER practices, but the insight on why it is advantageous and preferred to the standard energy renovation. Special and particular attention is paid to the step-by-step renovation.

The second part is dedicated to the project management and planning and design instruments, where the basics of the economic efficiency and cost-effectiveness of DER, as well as the assurance of high quality building design and construction are mentioned.

2.2. Curriculum

FIT-TO-NZEB

Development of the educational programme
CURRICULUM

WP5 - Training programmes for professional high schools
Levels 3-5 under the EQF
"Electrical engineering and energy sector" professional direction

Subject	**DEEP ENERGY RETROFIT: RETROFITTING TO NZEB LEVELS**
Academic hours	1 hour lecture and/or 1-2 hours practical lessons per week Total: 36 hours - 12 hrs lectures and 24 hrs practical lessons
Type of discipline	Elective (facultative)
EQF level	3 - 5
	Control and evaluation - ongoing assessment and examination
Credits ECTS	
Acquired knowledge	Comprehensive, specialised, factual and theoretical knowledge on: (a) deep energy retrofit process (b) principles and practices of the deep energy retrofit (c) overview of the basic deep energy retrofit details and their implementation during building renovation
Acquired skills	Comprehensive range of cognitive and practical skills on: (a) overall organization of building renovation design process (b) implementation of electrical services and energy supply during renovation with regard to key aspects of building construction: thermal bridges insulation, air tightness, fixing of thermal insulation, windows assembling etc.
Targeted responsibility and autonomy	Responsibility for: (a) read and process the planning documents of the main stages of the design and construction process in deep energy retrofit (b) reading the necessary drawings regarding the retrofit
Preliminary requirements	The students are expected to have general knowledge on: electrical services and energy supply, building physics & construction basics.
Exam procedure	Midterm test and final written exam (incl. drawings done on site) and an oral examination.
Technical secure (hardware and software)	• White board; • Multimedia facility; • Demonstration models; • Practical training models; • Samples of components and materials, suitable for deep renovation; • Demonstration videos.
Leading lectors	Lecturers will be nominated per countries.

2.3. Distribution of lectures and practical lessons

Development of the educational programme - schedule of lectures and practical lessons[2]

№	Subject	Teaching units	
		Theory	Practice
	Part I **Building envelope**		

1	Basis of building physics, Passive house principles, Optimal solar gains (Topics 1+2)
	• Heat and Heating Energy (Heat Flux/Thermal Conduction)
	• Thermal environments,
	• The 5 Passive House Pillars
	  ○ Thermal envelope
	  ○ Windows
	  ○ Airtightness
	  ○ Thermal Bridges
	  ○ Mechanical Ventilation System
		2	2

2	Comfort, health and safety requirements in buildings, incl. indoor air quality (Topic 11) • 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	2
3	Thermal insulation (Topic 3.1) • 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	2	2
4	Thermal bridges (Topic 3.2) • thermal bridges • prevention and minimisation of thermal bridges • thermal bridge optimised window installation • cross-crafting	2	2
5	High performance building components, highly efficient windows: products and installation (Topic 3.3) • general requirements for windows (airtight, thermally insulating (U-value), transparent, possibility of opening and providing shade when necessary)	2	2

[2] The programme itself will consist in a selection of topics as listed in Task 2.3, spread within a general framework of 36 teaching units (12 hours theoretical lectures and 24 hours of practical training).

	• window installation in a thermal bridge minimised/free manner, • airtight window installation		
6	Airtightness, vapour and moisture movement, windtightness (Topic 5) • Key psychometric concepts relating to (1) temperature (dry-bulb, wet-bulb and dew-point) and (2) vapour (relative humidity, humidity ratio and absolute humidity) and ability to interpret a simplified psychometric chart; • Sources of vapour in dwellings (generated internally and externally); • Vapour pressure and vapour drive in different climates and the optimal location for positioning the vapour control layer (internal, central or external); • Conditions that favour mould growth and condensation; • Understanding the term 'breathable' construction as it related to vapour diffusion; • Sd (or Perm) rating for different materials and best practice use according to different site conditions (vapour closed, vapour permeable / semi-permeable, vapour open and vapour variable); • Metrics used in airtightness testing including air changes per hour (h-1) as well as air permeability (m3/hr.m2) and targets for deep retrofitting, including 1.0 h-1 for EnerPHit; • Hands-on airtightness installation at key junctions, penetrations and connections for different construction types and using different materials (membranes, plaster, wooden boards (plywood), tapes, caulks and so forth); • Airtightness testing methods for local code compliance as well as Passive House / EnerPHit (considering pressure differences, testing direction (negative and / or positive), exterior weather conditions (temperature and wind speed)); • Airtightness demonstration test, including volume calculation, identification and fixing of leaks and re-testing; • Wind-tightness and its influence on interior comfort and performance of the insulation layer; • Materials used for achieving wind-tightness; • Cross-crafting and quality assurance issues, including risks of failure.	2	2
7	"Step-by-step" renovation. The EnerPHit standard (Topic 12) • potential for energy savings assessment • renovation standards; certification of the energy performance • details, products and materials • RES • economic efficiency of the different steps		2
8	Site visit – renovation of existing building		3

	Part II **Project management and planning and optimization instruments**		
9	Conservation of historic building fabric, Renovation of buildings, monuments of culture (Topic 7) • 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		2
10	NZEB neighbourhoods, Energy cooperatives (Topic 4) • Nearly Zero Energy Neighbourhood - concept; • Impact and benefits of the distributed electrical energy generation grid integration; • Legal framework for energy management, tariffs and inter-connection and inter-operability of energy systems; • Cooperatives energy management systems and correlation with new business opportunities.		2
11	Project management, Quality assurance (Topic 16) • Introduction – basic principles; • Necessary legislation; • Executing, monitoring and controlling; • Basic investment efficiency; • Energy efficiency principle; • Energy efficiency documents.		1
12	Economic efficiency of existing buildings energy renovation up to the level "passive house" and "nZEB" (Topic 9) • EED and EPBD II • What is Life Cycle Assessment – LCA, LCC • Economic Calculations of Return on Investment • Prices of construction materials, bill of quantities • Energy savings and operational costs - Energy efficiency measures – construction		2
	TOTAL	**12**	**24**

The curriculum defined the "Electrical Engineering and Energy Sector" professional direction has a certain flexibility regarding the number of hours and can be modified to fit the national requirements for the definition of educational plans (for professional high schools and technical colleges to adapt the programme to the duration of the specific year in which the program is approved and/or considering the number of weeks for theoretical and practical modules in the applicable national professional qualification standards).

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