TIMEPAC

Towards Innovative Methods
for Energy Performance Assessment and Certification of Buildings

Deliverable 4.2

Training programme

Lead Beneficiary: Jožef Stefan Institute (JSI)

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Executive Summary

This deliverable summarizes the work carried out in Task 4.2 “Training Programme,” included in Work Package 4 (WP4) of the TIMEPAC project. The objective of the training programme is to inform the various stakeholders involved in energy performance certification, the procedures and know-how derived from the Transversal Deployment Scenarios (WP2), as well as the lessons learned from the Verification Scenarios (WP3). The outcomes from WP2 aim to improve the current energy performance certification in line with the principles outlined in the latest recast of the EPBD. All lecturing materials (presentations, tools, guidelines, etc.) will be published on the TIMEPAC platform.

The main output of this task has been the design of the overall TIMEPAC training programme, which includes a description of the lectures and exercises that will be delivered within the framework of the Training Scenarios (TSs). Additionally, this deliverable provides a timetable for delivering the envisioned TSs in an organized manner in all six TIMEPAC partner countries (Austria, Croatia, Cyprus, Italy, Slovenia, and Spain). The training programme has been designed for two types of users: general building experts and professionals. All training activities will be free of charge for both target groups, i.e. general building experts and professionals.

Training dedicated to general building experts interested in technical and methodical details about energy certification and potential exploitation of EPC data will be organized as online events, which will be considered as pre-training for the building professionals. It is expected that around 1,500 experts will participate in the online training sessions (i.e. webinars) managed by the consortium. To attract a wider audience from non-TIMEPAC countries, webinars will be delivered in English. Participants will receive a certificate of attendance. Other components of the training programme, such as on-site courses, will be delivered in local languages as well.

Unlike training for general building experts, training dedicated to professionals who want to test the TIMEPAC approach in practice will receive a TIMEPAC certification. These professionals will be introduced to the TIMEPAC approach in a theoretical (lectures) and practical way (exercises). It is expected that at least 100 professionals will receive a TIMEPAC certificate through these extended TIMEPAC training courses managed by the consortium. Training for building professionals will be delivered in national languages and English. Partners will be responsible for translating the selected lecturing materials into their national languages.

This report also provides a description of the implementation plan and quality assurance of the training activities, and includes an indicative timeline to monitor planned activities. Participants who plan to attend multiple training courses can use this timeline to organize their activities accordingly. Before the actual implementation of the training courses, a quality assurance team will be created to support the partners responsible for delivering the courses.

1 Introduction

1.1 Purpose and target group

This deliverable is the result of Task 4.2 "Training Programme" of the TIMEPAC project. The goal of this task was to design the overall TIMEPAC training programme, including mapping the links between Transversal Deployment Scenarios (TDSs), Verification Scenarios (VSs), and Training Scenarios (TSs). The preliminary work required a detailed analysis of existing training and educational activities in all six participating countries in relation to the knowledge, skills, and competences of experts dealing with energy efficiency in buildings and the requirements of the Energy Performance of Buildings Directive (EPBD) concerning Energy Performance Certificates (EPCs). This work focused on identifying topics that should be addressed within the envisioned TSs.

Furthermore, this document provides a description of all envisioned lectures and exercises and a timetable to deliver the courses in an organized manner in all six TIMEPAC partner countries: Austria, Croatia, Cyprus, Italy, Slovenia, and Spain. The primary target groups are the energy experts, independent energy performance certifiers, urbanists and planners, local/regional/national administration bodies, energy agencies, energy service companies (ESCOs), professionals and experts dealing with energy efficiency in buildings, such as architects, engineers, contractors, developers, building owners, and others dealing with EPC generation, exploitation, analysis, and storage. Potential participants in training courses will also be identified in the partner countries with the help of the organizations supporting the project. Links with existing education channels, such as European Energy Manager (EUREM) and LIFE IP Care4Climate, to exploit synergies will be explored.

This deliverable provides an overall structure of the training programme which will be further refined and elaborated after the Transveral Depolyment Scenarios (WP2) and Verification Scenarios (WP3) are completed and implemented. This deliverable provides an overall structure of the training programme which will be further refined and elaborated after the Transveral Depolyment Scenarios (WP2) and Verification Scenarios (WP3) are completed and implemented. The objective of the training programme is to convey to the various stakeholders involved in energy performance certification, the procedures and know-how derived from the Transversal Deployment Scenarios, as well as the lessons learned from the Verification Scenarios. These aim to improve the current energy performance certification in line with the principles outlined in the latest recast of the EPBD.

Lecturing materials (presentations, tools, guidelines, etc.) will be published on an online platform and will be available free of charge. The concept of the TIMEPAC training platform, which will serve as a central hub for distributing training materials, is described in Deliverable 4.1 "Implementation of TIMEPAC training platform".

1.2 Deliverable structure

In addition to the introductory chapter, this document consists of nine additional chapters where the following topics are presented:

- Training activities in the framework of the TIMEPAC project
- Training Scenario 1 - Analysis and visualisation of EPC data and development of innovative energy services
- Training Scenario 2 - EPC data collection, validation and exploitation
- Training Scenario 3 - Advanced methods and tools for holistic energy renovation of buildings
- Training Scenario 4 - Exploitation of EPC for local, regional and national energy planning
- Training Scenario 5 - Combining EPC databases with other sources for energy savings opportunities

- Training Scenario 6 - Operational optimisation of building energy performance based on activities during EPC generation
- Implementation plan and quality assurance

Chapters dealing with the Training Scenarios provide a description of their structure and a short description of the lectures and learning outcomes, including teaching methods and tools, key questions that will be addressed, short CV of the lecturers, and references and recommended readings.

The Conclusion provides a summary of the key findings that will further utilised in creation of the TIMEPAC Academy. The TIMEPAC Academy will serve as a hub to connect project partners after the project lifetime. RTD partners will maintain the training platform and update training materials. Technology providers will be responsible for the updating of tools and the national/regional certification bodies, with the support of energy agencies, will be responsible for the promotion and organisation of the TIMEPAC trainings.

1.3 Contribution of partners

The design of the overall training programme carried out in the framework of Task 4.2 was coordinated by the Jožef Stefan Institute (JSI). With the support of the Training Scenario leaders (TS1, EIHP; TS2, JSI; TS3, CYPE; TS4, POLITO; TS5, FUNITEC; and TS6, JSI), the structure of each TS has been created and lectures have been proposed based on their expertise.

The alignment of the training programme (Task 4.2) with the online training platform (Task 4.1) has been achieved through collaboration with FUNITEC.

1.4 Relations to other project activities

The TIMEPAC training programme is the first step towards the future TIMEPAC Academy. This Academy aims to serve as a reference source for innovation in energy building certification. After the overall training programme provided in this report, the lecturing materials, implementation of courses and assessment of the results will be carried out in Tasks 4.3 to 4.8. Lectures and exercises that are briefly described in this deliverable will be generated based on the lessons learned in the implementation of TDSs and verified in VSs to help target audiences to implement in practice the enhanced elements of future EPCs. Moreover, the dissemination of the TIMEPAC project will be facilitated through the online training platform that hosts this training programme. To achieve this, targeted communication campaigns will be conducted to announce the upcoming courses in the following months. Finally, the successful implementation of training programme in participating countries, will inform the exploitation strategy that will outline how we plan to exploit the TIMEPAC Academy after the end of the project.

2 Training activities in the framework of the TIMEPAC project

The TIMEPAC project is centred around a new holistic approach to Energy Performance Certification that covers all stages of the certification process, including generation, storage, analysis, and exploitation. Innovative procedures are being developed in TIMEPAC to enhance each of these stages and facilitate the seamless flow of data across them throughout the building's lifecycle. This will be achieved through the five Transversal Deployment Scenarios (TDSs) that will provide new knowledge, skills, and competencies. The effectiveness of these TDSs will be verified in Verification Scenarios (VSs) and then shared through Training Scenarios (TSs).

The first activity in the creation of the training programme was a SWOT analysis that was the result of comprehensive sets of discussions within the consortium and with the representatives of different stakeholders groups, such as professional certifiers, energy managers, representatives of ESCOs and individual energy experts. A valuable source of information for the initial SWOT analysis was also the survey conducted in the framework of Task 1.1 "EPC generation" and Task 1.4 "Exploitation of EPC data". The results of the initial SWOT analysis are provided in the Table 1.

Table 1. Initial SWOT analysis of the envisioned TIMEPAC training activities

	Internal	External
POSITIVE	**Strengths** • Customized training materials evolved from the previous experiences of project partners involved in EPC generation, storage, analysis, and exploitation, as well as newly acquired knowledge, skills, and competences through the implementation of TDSs; • All relevant energy topics are covered; • The main focus is on how to do things and how to connect future EPC with the implementation of energy efficiency measures; • Real life exercises and case studies derived from TDSs as a central element of the learning process; • Diverse knowledge among the TIMEPAC consortium partners - experienced and practice-proven lectures are available among project partners;	**Opportunities** • Shortage of qualified energy experts in buildings and a growing need for energy efficiency professionals; • Development of practical and applicable knowledge and skills – there is no training provider that systematically covers continuous EPC data workflow connecting various stages (generation, storage, analysis and exploitation) and stakeholders in multiple ways; • Software developers are embracing interoperability between BIM and EPC tools based on open standards; • In line with the recast of EPBD;
NEGATIVE	**Weaknesses** • Large amount of learning materials and tools – significant amount of time is needed for the customization to the local conditions; • Targeted and quality-oriented marketing strategy is required – already available	**Threats** • Unclear future role of the EPC; • Potentially low interest in the public sector due to the lack of experts dealing with energy efficiency in buildings; • Strong technical background is requested –

	training courses dealing with energy efficiency in buildings are shorter and less demanding; • Limited adoption of BIM in the industry and high diversity of tools in architecture, HVAC design, and energy certification;	limited target groups; • There is no unified EU approach regarding the qualification of EPC experts;

The results of the SWOT analysis clearly indicate the potential of the envisioned TIMEPAC training activities. The framework for an effective training programme must be built with the support of practitioners dealing with developing and implementing energy efficiency solutions in buildings. This is also a clear confirmation of the appropriateness of the TIMEPAC approach, which is built around the five TDSs and verified in four VSs.

2.1 Purpose

This report offers a general overview of the TIMEPAC training program, which will be further developed and expanded on following the completion of the TDSs in WP2 and the VSs in WP3. It includes a description of 83 lectures and exercises, with a total duration of envisioned courses of 90 hours (or 120 teaching hours).As such, the initial description of the courses outlined in this document will be subject to review and refinement in Tasks 4.3 to 4.8. These tasks will include the development and delivery of training materials and the implementation of the courses. Throughout the project lifecycle, the experience gained from implementing these courses will form the foundation for the establishment of the TIMEPAC Academy.

The training programme has been designed for two types of users: general building experts and professionals. All training activities will be free of charge for both target groups, general building experts, and professionals.

Training dedicated to general building experts interested in technical and methodical details about energy certification and potential exploitation of EPC data will be organized as webinars, which will be considered as pre-training for the building professionals. It is expected that around 1,500 experts will participate in online training sessions managed by the consortium. To attract a wider audience outside non-TIMEPAC countries, webinars will be delivered in English. Participants will receive a certificate of attendance. Other components of the training programme, such as on-site courses, might be delivered in local languages as well.

Unlike training for general building experts, training courses dedicated to professionals who want to apply the TIMEPAC approach in practice will receive a TIMEPAC certification. These professionals will be introduced to the TIMEPAC approach in a theoretical (lectures) and practical way (exercises). The programme of these activities for all envisioned courses is presented in the next sections. The final part of the training courses for the building professionals will be a presentation of practical work in front of a multidisciplinary jury composed of TIMEPAC partners and guest experts. A positive evaluation will be necessary for the successful completion of the TIMEPAC training and to receive the certificate. The practical work will include a clear definition of measures for reducing the energy performance gap and an objective elaboration of opportunities to improve energy performance and smart readiness. It is expected that at least 100 professionals will receive a TIMEPAC certificate through these extended TIMEPAC training courses managed by the consortium.

Training courses for building professionals will be delivered in national languages and English. Partners will be responsible for translating the selected lecture materials into their national languages. Guest experts from the sister projects of the Next Gen EPCerts cluster will be invited to present and explain the outcomes of their projects in specific training sessions. This will help establish the TIMEPAC Academy as a hub of reference for the next generation of building energy performance certification.

2.2 Limitations

Although the presented training programme has been created by partners representing only six EU Member States, some of the TIMEPAC partners are also involved in various other initiatives such as Concerted Actions EPBD (MzI, SERA, POLITO), EED (MzI, JSI) and RES (MzI, JSI), as well as the European Energy Network – EnR (EIHP) and the European Energy Managers (JSI). Their participation in these initiatives will provide valuable insights into the training needs of specific target groups.

2.3 Links between Transversal Development Scenarios, Verification Scenarios and Training Scenarios

In order to generate the knowledge, skills and competences which are necessary for the enhanced EPC, five TDSs are implemented in all six partner countries. Each TDS encompasses various stages of the EPC workflow (generation, storage, analysis, and exploitation), involving multiple stakeholders (research groups, energy agencies, and energy experts, among other) and resources (data, tools, and methods). The outcomes from the TDSs will be verified in the VSs, in real settings with specific target groups involved in the certification process, in all six partner countries. Thus, the knowledge, skills and competences developed in the TDSs and verified in the VSs will then be shared through TSs (Figure 1).

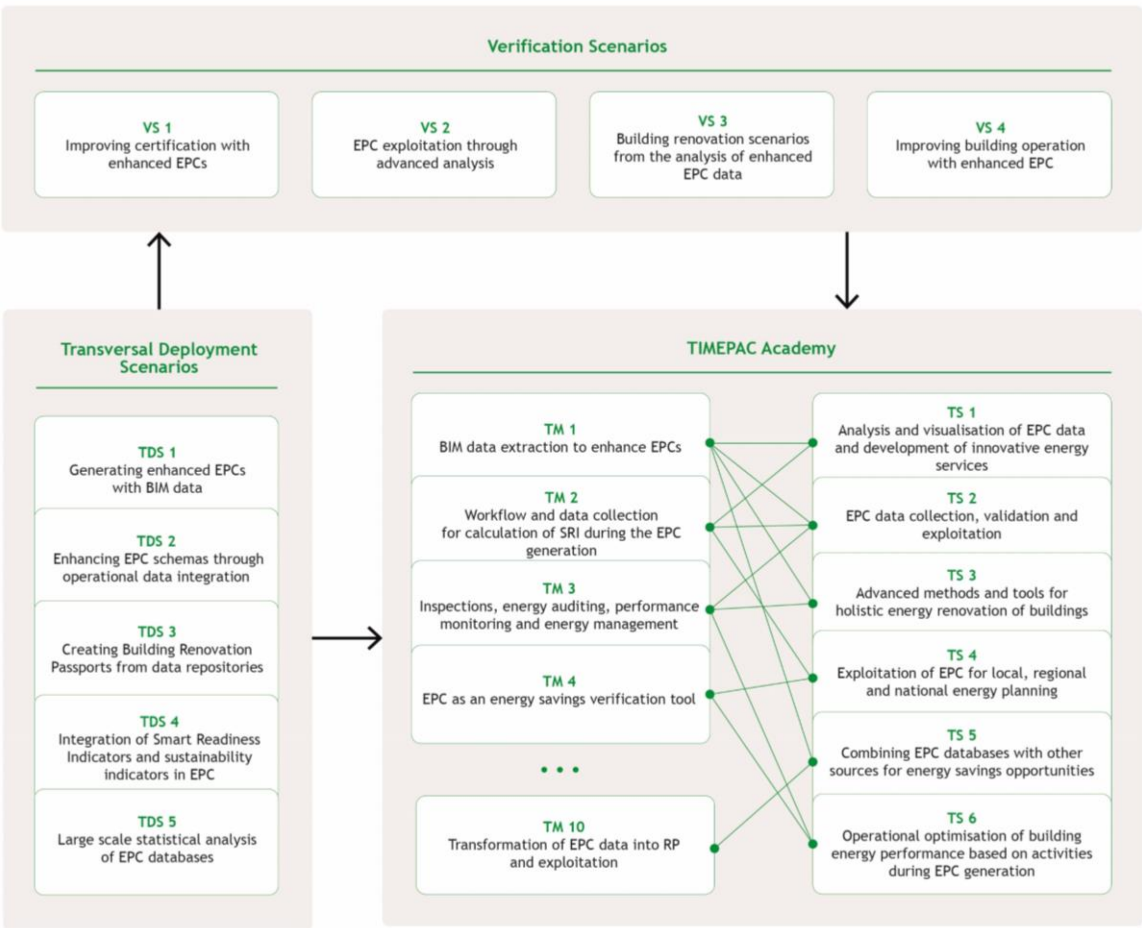

Figure 1. Mapping links between TDSs, VSs, TMs and TSs

In order to satisfy the specific needs of different target groups and to implement the innovative elements developed in the TDSs in current practices, during the project lifetime and beyond in the further development of the TIMEPAC Academy, the TIMEPAC learning paths are organized into ten Training Modules (TMs) (Table 2). TMs are being built on knowledge, skills and competences extracted from the different TDSs and lessons learned from VSs to connect different stages of the EPC data flow (generation, storage, analysis, and exploitation of EPCs).

Table 2. Training modules and links with EPC data flow, TDSs and VSs

Training module	Stages of EPC data flow	Related TDSs	Related VSs
TM 1 - BIM and EPC integration	Generation, Storage and Analysis	TDS 1	VS 1
TM 2 – Workflow and data collection for calculation of SRI during the EPC generation	Generation, Analysis and Exploitation	TDS 4	VS 1, VS 2, VS 4
TM 3 – Inspections, energy auditing, performance monitoring and energy management systems in buildings as a supporting activities and data sources for the EPC generation	Generation, Storage, Analysis and Exploitation	TDS 2, TDS 3	VS 1, VS 2, VS 4
TM 4 – EPC as an energy savings verification tool	Analysis and Exploitation	TDS 2, TDS 5	VS 1, VS 3, VS 4
TM 5 – Integration of sustainability indicators in the EPC	Generation, Analysis and Exploitation	TDS 4	VS 1, VS 2, VS 4
TM 6 – Re-commissioning activities during EPC generation	Generation, Analysis and Exploitation	TDS 3, TDS 4	VS 4
TM 7 – Storage of EPC data and combination with other data sources	Generation, Storage, Analysis and Exploitation	TDS 2, TDS 5	VS 1, VS 2, VS 3, VS 4
TM 8 – Advanced analysis of EPC data as a support tool for local, regional and national energy planning	Storage, Analysis and Exploitation	TDS 5	VS 2, VS 3
TM 9 – Tips and tools for quality checks of the EPC data	Storage and Analysis	TDS 2, TDS 5	VS 1, VS 2
TM 10 – Transformation of EPC data into Renovation Passport and exploitation of the EPC data for deep energy renovation projects and projects based on energy performance contracting	Analysis and Exploitation	TDS 2, TDS 3	VS 2, VS 3

The overall training programme is structured in 10 Training Modules which encompass the relevant issues dealing with the upgrade and enhancement of the building energy certification processes, as envisioned in the TIMEPAC holistic approach and aligned with the recommendations of the EPBD recast (in the process of final approval at the moment of writing). This modular structure enables learners to design their own learning, by combining lectures and exercises from various training modules.

Creating and delivering all ten modules in all six participating countries would be impossible due to the time limits of the project. To overcome this challenge, we have developed training scenarios (TSs) that could be delivered in all participating countries during the project's lifetime. Using the modular structure of the TIMEPAC learning path, we propose six TSs that could be delivered throughout the project's duration by combining lectures and exercises from various training modules. This strategy enable us to implement and verify all the proposed lectures and exercises drawn from different training modules and deliver them to all participating countries via specific TSs. This way, in the implementation of the training programme during the project lifetime, each lecture can be presented to the targeted audience at least once and in at least one participating country.

The envisioned TSs aim to offer specific training to selected target groups involved in the EPC workflow, teaching them how to diminish the energy performance gap, enrich EPCs with accurate and customized energy efficiency measures, exploit enhanced EPC data, and execute high-quality (deep renovation of buildings) projects in buildings. The TIMEPAC consortium is confident that the experience gained through the implementation of the training programme will help to establish a financially sustainable TIMEPAC Academy after the project's conclusion. Figure 2 illustrates the concept of TIMEPAC's educational and training activities following the completion of the programme.

Our ultimate goal is for TIMEPAC Academy to become the premier institution for European EPC experts. Upon successful completion of all training modules, participants will be awarded a certificate as a European EPC expert. In this context, a TIMEPAC expert (or European EPC expert) is an individual who possesses a comprehensive understanding of EPC throughout its entire lifecycle, which includes the generation, storage, analysis, and utilization of building energy certification data

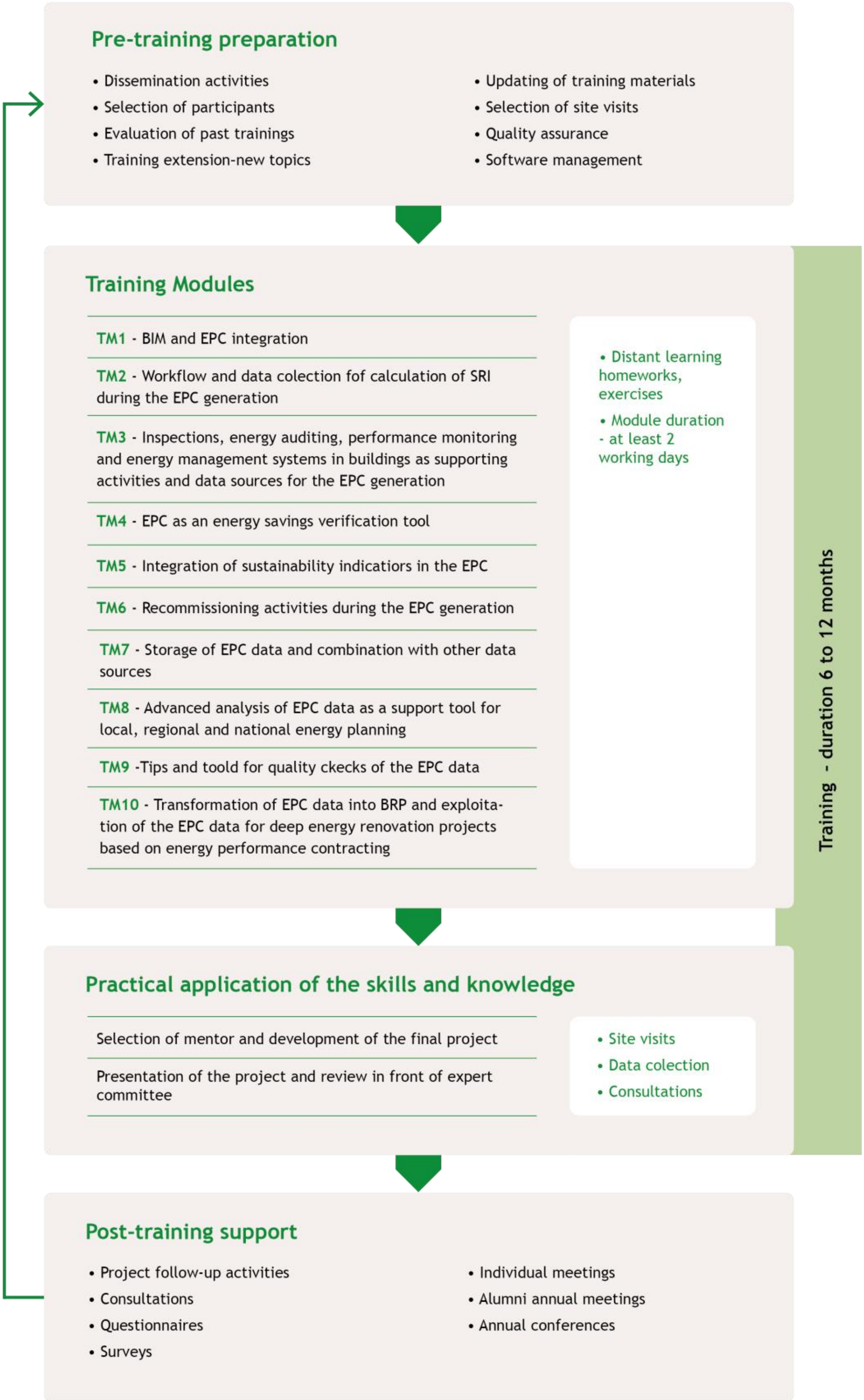

Figure 2. Concept of TIMEPAC educational and training activities after the project lifetime

3 Training Scenario 1 - Analysis and visualisation of EPC data and development of innovative energy services

3.1 Structure of the Training Scenario 1

Training Scenario 1 (TS1) aims to empower general building experts and professionals to properly extract and visualise EPC data and to utilise that data for the creation of innovative energy services. Training materials related to the building information modelling (BIM), dynamic simulation of energy demand, extraction of data from various sources, connecting EPC with real consumption data and monitoring and verification of energy savings will be provided. Special attention will be put on the preparation of training materials related with the transformation of EPC data into a Renovation Passport and the exploitation of the EPC data for the preparation of deep energy renovation projects and projects based on innovative energy services to foster deep energy renovation programs.

TS1 is organised into four teaching hours of training (in total 180 minutes) for the general building experts, which will be organised in the form of a webinar, and sixteen teaching hours of training (in total 720 minutes) held in-person for the professionals carried out through in-class lectures and exercises.

3.2 Envisioned lectures and exercises

Table 3 provides information about all lectures and exercises, with the indication of their duration, that will be delivered in the framework of the TS1. Also, it provides an information from which TMs these lectures and exercises are extracted.

Table 3. Outline of the TS1

Training for the general building experts (webinar)		
Title of the lecture	Duration (min.)	Training Module
Key elements of BIM	25	TM1
Dynamic simulation of energy demand	30	TM1
Comparison of the modelled and real consumption data	25	TM3
The concept of Renovation Passport - in comparison with EPC recommendations - as a stand-alone instrument or integrated in enhanced EPC - including strengths and weaknesses	25	TM10
Identification of cost-optimal investments and creation of renovation scenarios based on the Energy Performance Certificate and other data repositories	25	TM10
How to make an EPC a dynamic tool for verification of energy savings – connecting EPC with real consumption data	25	TM4
Reporting, monitoring and verification of energy savings	30	TM4

Training for the professionals (in-class)		
Title of the lecture/exercise	Duration (min.)	Training Module
Visualisation of EPC data and analysis of energy performance with BIM	90	TM1
Exercise 1: Extracting information from BIM model – case study office building	90	TM3
Exercise 2: Calibration of dynamic energy consumption model with real data – case study office building	120	TM3
Exercise 3: Identification of energy measures and renewable energy system integration	120	TM3
Exercise 4: Implementation of identified measures on a calibrated dynamic model – case study office building	120	TM4
Exercise 5: Transformation of EPC data and other data into Renovation Passport for the deep renovation of the building - case study residential building	90	TM10
Exercise 6: Creation of measurement and verification plan – case study office building	90	TM10

TS1 is therefore organised into seven theory lectures for the general building experts, and one theory lecture and six exercises for the building professionals.

For each envisioned lecture and exercise of the TS1, a short description of learning content and expected outcomes, target groups, a short CV of the envisioned lecturer, teaching methods and tools, and main references are provided from Section 3.2.1 to Section 3.2.14.

3.2.1 Key elements of BIM

Short description of the lecture and learning outcomes:

The lecture focuses on the essential aspects of the BIM (Building Information Modelling) methodology for construction project management.

First, participants will learn that BIM is a methodology for integrating all the information of a construction project into 3D digital models. These models contain detailed information on all components of the project, from architectural design, structure and technical building systems.

Furthermore, the advantages of using BIM in project management will be highlighted, such as reducing errors and increasing efficiency and productivity. The ability of BIM to facilitate decision-making and improve the quality of design and construction will also be presented.

Finally, the lecture will emphasise the importance of BIM education and BIM training for all members of a construction project team, as well as the need to adopt standards and protocols to ensure interoperability between different BIM platforms and to guarantee the quality of the model information.

The expected duration of the lecture is 25 minutes.

Target groups:

The target group of the lecture includes professionals and experts in the construction industry, such as architects, engineers, contractors, developers, building owners and others interested in the use of BIM technology in the planning, design and construction of building projects.

Furthermore, the lecture may be of interest to those involved in project management, decision making and strategic planning in the construction industry, as BIM technology has the potential to improve efficiency, collaboration and quality in project construction.

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in the development of CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as the compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What is BIM and what is its importance in the construction industry?
- What are the key components of the BIM model and how are they related to each other?
- How are BIM models created and managed and what is the role of the different construction professionals involved in the project?
- How is BIM used for coordination and collaboration between different disciplines and teams?
- What are the best practices for effectively implementing BIM in a construction project?
- What are the current and future trends for using BIM in the construction industry?

References and recommended reading:

1. CYPE Architecture. User’s Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. CYPETHERM EPlus. User’s manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf

3.2.2 Dynamic simulation of energy demand

Short description of the lecture and learning outcomes:

One of the more frequently used ways of reducing energy consumption inside the building and choosing the optimal technical solution for improving energy efficiency is conducting dynamic simulations on the building. The focus of the lecture is to acquaint the participants with the possibilities of dynamic energy modelling and dynamic simulation of energy demand and different varieties of software to be used for such analysis.

The focus of the lecture will be put on explanatory possibilities of dynamic simulation of energy demand using the software EnergyPlus. In this context, all above-mentioned activities must provide answers to the following questions:

- What is dynamic modelling of energy demand in a building?
- What are the benefits of dynamic simulation?
- What software are most used to perform dynamic simulations of energy demand?

- What are the possibilities of using EnergyPlus?

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts of dynamic modelling of buildings and performing dynamic simulations of energy demand, most commonly used software packages and, basic knowledge of using EnergyPlus to perform dynamic simulations of energy demand. The expected duration of the lecture is 30 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for anyone else who wants to acquire basic knowledge about dynamic simulations.

Short CV of the envisioned lecturer:

Marko Biščan is a researcher at the Energy Institute Hrvoje Požar, where he holds a master's degree in electrical engineering from the University of Zagreb. His main areas of expertise include energy management, environmental management, decision support for buildings and industries, modelling and optimisation of energy processes, and holistic energy planning. He is also a lecturer for energy manager training under the EUREM program, as well as for public sector energy advisers and associates, providing training to experts conducting energy audits and/or energy certification of buildings. With extensive practical experience, he has been involved in numerous domestic and international projects as a coordinator or team member, particularly in energy efficiency. He has also conducted over 50 energy audits in industrial and building settings.

Teaching methods and tools:

Lecture with passive participation of participants. It will be conducted as a webinar. It includes theoretical explanations of the possibilities of using the tools for dynamic modelling of energy demand, an overview of different software, and basic knowledge of using EnergyPlus to perform dynamic simulations.

Key questions that will be addressed:

- How are dynamic simulations of energy demand performed?
- Which software is the most commonly used for dynamic modelling of building consumption?
- What are the possibilities for reducing energy consumption by conducting dynamic simulations of energy demand in buildings?

References and recommended reading:

1. Crawley, D.B., Lawrie, L.K., Pedersen, C.O., Liesen, R.J., Fisher, D.E., Strand, R.K., Taylor, R.D., Winkelmann, R.C., Buhl, W.F., Huang, Y.J., Erdem. A.E. (1999). ENERGYPLUS, A New-Generation Building Energy Simulation Program. Proceedings of Building Simulation'99,Volume 1: 81-88
2. Crawley, D.B., Pedersen, C.O., Lawrie, L.K., Winklemann, F.C. (2000). EnergyPlus:Energy Simulation Program, ASHRAE Journal
3. https://bembook.ibpsa.us/index.php?title=History_of_Building_Energy_Modeling
4. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
5. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
6. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
7. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA
8. US Department of Energy: EnergyPlus Version 8.9.0 Documentation, 2018

3.2.3 Comparison of the modelled and real consumption data

Short description of the lecture and learning outcomes:

It is of paramount importance to monitor the buildings' energy consumption to understand their energy behaviour and identify possible energy-saving opportunities. However, the monitoring requires the installation of (expensive) sensors and meters and discrete expertise. On the other hand, building energy simulation is an effective alternative to real consumption data monitoring. However, since energy simulations often fail to fully capture the actual energy behaviour of buildings, accurate energy performance predictions can be achieved only by using a calibrated energy model. Therefore, the calibration of building energy models is a key step towards correctly evaluating of building energy performance and, eventually, energy savings achievable through retrofit in existing buildings.

This lecture will deepen the issues and the opportunities related to the comparison between real and simulated energy consumption; the methods for the comparison and the main influencing parameters will be presented. Moreover, the concept of building energy model calibration will be discussed, and the existing methodologies for model calibration will be presented, highlighting the related pros and cos. The issues related to model calibration will be discussed as well, including:

- Uncertainties in the building models, such as boundary conditions, operating conditions model assumptions and simplifications, the accuracy of monitored data
- Absence of a shared building energy model calibration methodology
- Lack of unique solutions for the calibration procedure

The knowledge that aquired at the end of the lecture is related to the main steps required to compare real and simulated energy consumptions, the calibration of a building energy model, and the opportunities in using a calibrated energy model to identify possible energy saving scenarios. Discrete knowledge of building physics and building energy modelling is required. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone involved in evaluating the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts) and everyone who wants to acquire basic knowledge for efficient data collection and analysis.

Short CV of the envisioned lecturer:

Franz Bianco Mauthe Degerfeld is an Engineer whograduated in Building Engineering from Politecnico di Torino. He is currently a PhD student at the Politecnico di Torino, Department of Energy “Galileo Ferraris”. His research activity is part of the research program "Internal Environment and Energy of Buildings" (acronym IIEB), with a specific focus on dynamic energy simulation of buildings, model validation, as well as energy and economic optimization of new building projects and redevelopment. His work contributes to advancing the field of building physics and energy systems through innovative research on energy-efficient building design and optimization strategies.

Teaching methods and tools:

The lecture will be conducted as a webinar and involves primarily theoretical concepts. Lecture notes, material, slides, and technical standards references will be distributed through the TIMEPAC platform.

Key questions that will be addressed:

- What are the opportunities related to the analysis of monitored energy consumption?
- Which are the main issues related to the building energy model calibration?
- Which are the existing building energy model calibration methodologies?

References and recommended reading:

1. American Society for Heating Refrigerating Air-conditioning Engineers (ASHRAE), Guideline 14—Measurement of Energy, Demand, and Water Savings, (2014)
2. Angelotti, A., Ballabio, M., Mazzarella, L., Cornaro, C., Parente, G., Frasca, F., Prada, A., Baggio, P., Ballarini, I., De Luca, G., Corrado, V. (2019). Dynamic simulation of existing buildings: Considerations on the model calibration. Proceedings of the 16th International Conference of Building Performance Simulation Association, 4165–4172 https://doi.org/10.26868/25222708.2019.210439.
3. Coakley, D., Raftery, P., Keane, M. (2014). A review of methods to match building energy simulation models to measured data. Renewable and Sustainable Energy Reviews, 37, 123-141. https://doi.org/10.1016/J.RSER.2014.05.007
4. Reddy, T.A. (2006). Literature review on calibration of building energy simulation programs: Uses, problems, procedure, uncertainty, and tools. ASHRAE Transactions, 112, 226–240
5. Reddy, T.A., Maor, I., Panjapornpon, C. Calibrating Detailed Building Energy Simulation Programs with Measured Data—Part I: General Methodology (RP-1051). (2007). HVAC&R Research, 13, 221–241. https://doi.org/10.1080/10789669.2007.10390952

3.2.4 The concept of Renovation Passport - in comparison with EPC recommendations - as a stand-alone instrument or integrated in enhanced EPC - including strengths and weaknesses

Short description of the lecture and learning outcomes:

The Renovation Passport contains a renovation roadmap with a plan for a staged renovation over time. Compared with the EPC recommendations, the main purpose of this approach is to avoid lock-in effects. The renovation roadmap can be a stand-alone document or part of an enhanced EPC.

In this context, answers to the following questions are needed:

- What is the difference between EPC and a Renovation Passport?
- What is the difference between a renovation roadmap and EPC recommendations?
- What are the requirements regarding data quality, depending on the purpose?
- What is the importance of energy efficiency measures addressing the building envelope compared with measures addressing the Technical Building Systems (TBS)?
- How to deal with district approaches (TBS at the district level instead of the building level)?

Competencies of the participant who successfully completes the learning module will include an understanding of the concept of renovation roadmap and renovation passport, in comparison with the Energy Performance Certificate and recommendations for improving energy efficiency.

The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone who is involved in building renovation. The lecture provides an overview of basic concepts and is also useful for non-technical staff of the administration and companies owning large buildings.

Short CV of the envisioned lecturer:

Susanne Geissler is the owner and director of SERA Institute, an environmental engineer with a background in law, and a trained energy advisor entitled to issue Energy Performance Certificates (EPCs). With years of experience, she has been actively involved in activities related to the implementation and further development of EPC-related concepts. She holds a doctoral degree in Sustainable Construction from the University of Natural Resources and Life Sciences Vienna, showcasing her expertise in the field of sustainable construction and energy performance assessment. Susanne Geissler's work focuses on promoting energy efficiency and sustainability in the built environment, with a particular emphasis on EPC-related practices and concepts.

Teaching methods and tools:

Lecture-based on Knowledge map; possibility for participants to ask questions.

Key questions that will be addressed:

- What are the strengths and weaknesses of the EPC with regard to increasing the renovation rate?
- What are the strengths and weaknesses of the Renovation passport with regard to increasing the renovation rate?

References and recommended reading:

1. European Commission (2021): iBroad - Individual Building (Renovation) Roadmaps. EU Project 754045 under Horizon 2020 https://cordis.europa.eu/project/id/754045/de and https://ibroad-project.eu/results/reports/
2. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) COM/2021/802 final
3. Volt, Jonathan; Toth, Zsolt; Glicker, Jessica; De Groote, Maarten; Borragán, Guillermo; De Regel, Sofie et al. (2020): Definition of the digital building logbook: report 1 of the study on the development of a European Union framework for buildings' digital logbook. European Union: Publications Office https://data.europa.eu/doi/10.2826/480977

3.2.5 Identification of cost-optimal investments and creation of renovation scenarios based on the Energy Performance Certificate and other data repositories

Short description of the lecture and learning outcomes:

This lecture is designed to acquire private companies in the energy sector, decision-makers in the public sector, universities, and individuals in the building sector with the skills to identify cost-effective investment opportunities and create renovation scenarios using the enhanced EPC. The learning module will describe key concepts, methods, and planning tools for identifying and assessing cost-optimal investments and creating building renovation scenarios.
The following learning outcomes are foreseen:

- to understand the principles and benefits of identifying cost-optimal investments in building renovation
- to learn how to identify and assess cost-optimal investments using different methods and tools
- to be able to create renovation scenarios according to the new EPC and meet cost-optimal requirements
-

The expected duration of the lecture is 25 minutes.

Target groups:

The target groups are individuals who work in the building sector and are involved in identifying and assessing cost-optimal investments in building renovation. This includes building designers, engineers, construction managers, energy auditors, and other professionals in the building industry.

Short CV of the envisioned lecturer:

Savvas Savva is an Electrical Engineer who graduated from the School of Electrical and Computer Engineering at the University of Cyprus in 2011. He specialises in the production, transmission, and distribution of energy, as well as biomedicine. With experience as an Electrical Engineer and Procurement Engineer in large-scale organisations in Cyprus, he has been involved in the supply and installation of photovoltaic systems and the traffic safety sector. Savva is also a certified installer of photovoltaic systems and a member of the Scientific and Technical Chamber of Cyprus and the

Electromechanical Service. In November 2021, he became a member of the Cyprus Energy Agency as an Electrical Engineer in the Department of Energy Efficiency and Renewables.

Teaching methods and tools:

The online lecture will be delivered using presentation slides, discussion and interactive activities to help learners to understand and implement the main purpose of the course. Through the TIMEPAC platform, participants will have access to tools such as cost-benefit analysis templates, planning tools related to renovation scenarios.

Key questions that will be addressed:

- What are the initiatives and benefits of identifying cost-optimal investments in building renovation?
- What methods and tools can be used to identify and assess cost-optimal investments in building renovation?
- How to create a cost-optimal renovation scenario following the enhanced EPC principles?

References and recommended reading:

1. European Commission. (2010). Energy Performance of Buildings Directive (2010/31/EU). Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:en:PDF
2. European Commission. (2020). Renovation Wave Strategy. Retrieved from https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave-strategy_en
3. International Energy Agency. (2020). Energy Efficiency 2020. Retrieved from https://www.iea.org/reports/energy-efficiency-2020

3.2.6 How to make an EPC a dynamic tool for verification of energy savings - connecting EPC with real consumption data

Short description of the lecture and learning outcomes:

Taking the EPC of today and expanding data with new initiatives like SRI or real consumption, there are possibilities to increase the reliability of EPC usage. In most cases, EPC in the EU is calculated and derived from standardised usage patterns, making data comparable between buildings but not in line with real, metered consumption. The focus of the lecture is to show the participants how real consumption can be linked to EPC and what calculation changes must be introduced. The basis for this are defined by international standards such as ISO 50001, ISO 50002, ISO 50015 or a series of EPB Standards (EN 15193, EN 15316, EN 52016 etc.) and international measurement and verification protocol. In this context, all above-mentioned activities must provide answers to the following questions:

- What are the differences between real energy consumption and calculated EPC energy consumption?
- What are the most common methods to calibrate the EPC model with the real consumption data?
- How to calculate energy savings from calibrated EPC model?
- How to use an EPC as a dynamic tool for verification of energy savings?

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to calibration between EPC, real consumption data and how to calculate energy savings in line with real consumption data. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone involved in evaluating of energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge in energy savings calculations.

Short CV of the envisioned lecturer:

Marko Bišćan is a researcher at the Energy Institute Hrvoje Požar, where he holds a master's degree in electrical engineering from the University of Zagreb. His main areas of expertise include energy management, environmental management, decision support for buildings and industries, modelling and optimisation of energy processes, and holistic energy planning. He is also a lecturer for energy manager training under the EUREM program, as well as for public sector energy advisers and associates, providing training to experts conducting energy audits and/or energy certification of buildings. With extensive practical experience, he has been involved in numerous domestic and international projects as a coordinator or team member, particularly in the field of energy efficiency. He has also conducted over 50 energy audits in both industrial and building settings.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and examples with overview of calibration and calculation methods.

Key questions that will be addressed:

- What are the differences between real energy consumption and EPC?
- Where are the key discrepancies in calculation assumptions?
- What methods are there to calibrate the EPC model with real consumption data?
- How to calculate energy savings from a calibrated EPC model?

References and recommended reading:

1. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
2. European Committee for Standardisation (CEN). (2017). EN 15193: Energy performance of buildings - Energy requirements for lighting
3. European Committee for Standardisation (CEN). (2017). EN 15316: Method for calculation of system energy requirements and system efficiencies
4. European Committee for Standardisation (CEN). (2017). EN 16798: Energy performance of buildings – ventilation for buildings
5. European Committee for Standardisation (CEN). (2017). EN 15232: Energy performance of building
6. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
7. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
8. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
9. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
10. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
11. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA

3.2.7 Reporting, monitoring and verification of energy savings

Short description of the lecture and learning outcomes:

Measurement and Verification (M&V) is the process of planning, measuring, collecting and analysing data to verify and report energy savings within a facility or facilities resulting from implementing energy efficiency measures. Savings cannot be directly measured since they represent the absence of energy consumption and/or demand, which is why we need M&V protocol. It has the potential to improve engineering design and building operation and maintenance.

This lecture focuses on the following four main areas:

- Definition of the baseline period
- Creation of the metering and monitoring plan
- Data verification procedure
- Reporting requirements – periodic M&V reports

The competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the reporting, monitoring and verification of energy savings. The expected duration of the lecture is 30 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge in reporting, monitoring and verification of energy savings.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The lecture will be conducted as a webinar, and it foresees the passive participation of participants. It includes theoretical explanations and examples with an overview of the M&V Protocol.

Key questions that will be addressed:

- What is the measurement and verification of energy savings?
- Why do we need an M&V protocol?
- What is a periodic M&V report?

References and recommended reading:

1. Efficiency Valuation Organisation. (2019). EVO 10300 - 1: Measurement & Verification - Issues and Examples
2. Efficiency Valuation Organisation. (2022). EVO 10000 - 1: International Performance Measurement and Verification Protocol (IPMVP) – Core Concepts

3. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
4. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
5. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
6. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
7. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations

3.2.8 Visualisation of EPC data and analysis of energy performance with BIM

Short description of the lecture and learning outcomes:

This lecture focuses on two main areas: visualising energy performance certification data and analysing energy performance using Building Information Modelling (BIM).

In the first part of the lecture, participants will be taught how to visualise and analyse energy performance certification data using data visualisation tools. Different types of data visualisations, such as BIMserver.center reports and 3D models, will be explored and best practices for visualising energy performance data will be discussed.

In the second part of the lecture, participants will learn how to use BIM to analyse the energy performance of buildings. Different types of energy simulations will be explored and best practices for building modelling in BIM will be discussed. Topics such as assessing the energy efficiency of existing buildings and optimising energy performance in new buildings will also be covered.

The expected duration of the lecture is 90 minutes.

Target groups:

The target audience of the lecture includes a wide range of people interested in the construction and renovation of buildings, such as the following:

1. Architects and designers, to visualise proposed changes to a building and how they can be easily shared with clients and other members of the construction team.
2. Engineers, to assess and optimise the energy performance and efficiency of existing and proposed systems.
3. EPC quality assurance companies.

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar. The following steps will be used for training:

- Training in software for energy simulation with BIM (CYPETHERM EPlus) and the CDE, BIMserver.center, to view the results in 3D

- Case studies: Users will study examples to understand how this technique can be applied in real projects

Key questions that will be addressed:

- How can building energy performance certification data be visualised and analysed?
- What types of data visualisations are most effective for presenting energy performance data?
- How is BIM used to analyse the energy performance of buildings?
- What types of energy simulations can be performed with BIM and how are the results interpreted?
- How can energy performance certification data and energy performance analysis be used with BIM to improve the energy efficiency of buildings?

References and recommended reading:

1. CYPE Architecture. User’s Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration. https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. CYPETHERM EPlus. User’s manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2. https://www.cype.net/documents_en/manuals/termint_09.pdf

3.2.9 Exercise 1: Extracting information from BIM model - case study office building

Short description of the exercise and learning outcomes:

This exercise is a practical activity designed to enable participants to apply their information extraction skills to a realistic project using a BIM model of an office building.

In this exercise, participants will extract relevant information from a BIM model of an office building. The information to be extracted includes the reference of the building materials used, the dimensions of the rooms, the mechanical and electrical systems and the energy efficiency of the building.

Once the information has been extracted, participants should use it to analyse the building's performance and efficiency and make recommendations on how the building's energy efficiency and functionality can be improved. Participants should also present their findings and recommendations in a detailed report.

This exercise will allow participants to apply the knowledge and skills they have acquired in the information extraction course of the BIM model to a realistic case study.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of the exercise includes a wide range of people interested in construction via BIM models, such as the following:

1. Architects and designers, to create architectural BIM models
2. Engineers, to improve the design of facilities and structures with a BIM workflow

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The following steps will be used for training:

- Training in software for the architectural BIM model (CYPE Architecture), quantities model, Open BIM Quantities and the CDE, BIMserver.center, to view the results in 3D
- Case studies: Users will study examples to understand how this technique can be applied in real projects

Key questions that will be addressed:

- What are the key steps for extracting relevant information from a BIM model of an office building?
- What tools and techniques can be used to extract relevant information from a BIM model of an office building?
- How can the information extracted from the BIM model and the resulting recommendations be effectively presented and communicated to other members of the construction team and those interested in the project?
- What challenges can arise when extracting information from a BIM model and how can they be overcome?
- How can the accuracy and quality of the information extracted from the BIM model be guaranteed?
- How can BIM models be used in larger and more complex construction projects, such as office buildings?

References and recommended reading:

1. CYPE Architecture. User’s Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. CYPETHERM EPlus. User’s manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf

3.2.10 Exercise 2: Calibration of dynamic energy consumption model with real data - case study office building

Short description of the exercise and learning outcomes:

Building energy models and simulations provide an opportunity to explore and improve energy-saving designs, equipment and operational strategies before using them in buildings. However, discrepancies between modelled and actual building performance are common, which is the reason why we have to perform model calibration to ensure an accurate representation of a building’s physical attributes, equipment, schedules, energy use and user influence.

The focus of the exercise is to acquaint the participants with methods for calibration of the dynamic energy consumption model with real data and model analysis. The focus of the lecture will be put on preparatory activities, the creation of building calibration model, discussion of the most influential parameters, and correcting appropriate parameters like schedules to achieve minimal model error. In this context, all above-mentioned activities must provide answers to the following questions:

- What are the aims, needs and expectations concerning the data collection process for the calibration model?
- Which data is necessary to create calibrated energy consumption model?
- What is the starting (baseline) consumption of energy?
- What are the starting costs of energy?

- What are the impacts of different parameters of building systems on the model calibration accuracy?
- What is the extent of user influence on energy consumption?

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts of calibration of energy consumption model with real data, knowledge of different calibration tools and methods. Participants will also acquire basic practical knowledge that is necessary for calibration of energy consumption with real data and evaluation of energy consumption at the level of the building and addressed technical building system. The expected duration of the exercise is 120 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire knowledge for calibration of the building energy model.

Short CV of the envisioned lecturer:

Marko Bišćan is a researcher at the Energy Institute Hrvoje Požar, where he holds a master's degree in electrical engineering from the University of Zagreb. His main areas of expertise include energy management, environmental management, decision support for buildings and industries, modelling and optimisation of energy processes, and holistic energy planning. He is also a lecturer for energy manager training under the EUREM program, as well as for public sector energy advisers and associates, providing training to experts conducting energy audits and/or energy certification of buildings. With extensive practical experience, he has been involved in numerous domestic and international projects as a coordinator or team member, particularly in energy efficiency. He has also conducted over 50 energy audits in industrial and building settings.

Teaching methods and tools:

Exercise with the active participation of participants. It includes theoretical explanations, discussion, performing step-by-step calibration of office building model with real data, analysis of calibrated model and interpretation of results, model error analysis.

Key questions that will be addressed:

- What are the key elements of calibration of the energy consumption model with real data?
- What are the key parameters influencing calibration model accuracy?
- What are the key elements of the data collection process?
- How to assess the accuracy of the calibration of the energy consumption model with real data?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2015). EN 16247: Energy audits - Part 5: Competence of energy auditors
2. Valentina Monetti, Elisabeth Davin, Enrico Fabrizio, Phillippe Andre, Marco Filippi: Calibration of building energy simulation models based on optimization: a case study, Science Direct, 2015
3. Jose Eduardo Pachano, Carlos Fernàndez Bandera: Multi-step building energy model calibration process based on measured data, Elsevier, 2015
4. Khee Poh Lam, Jie Zhao, Jihyun Park: An energyplus whole building energy model calibration method for office buildings using occupant behaviour data mining and empirical data, ResearchGate
5. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)

6. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
7. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom
8. Thollander, P., Karlsson, M., Rohdin, P., Wollin, J., Rosenqvist, J. (2020). Introduction to Industrial Energy Efficiency - Energy Auditing, Energy Management and Policy Issues. Academic Press, Elsevier, London, U
9. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA

3.2.11 Exercise 3: Identification of energy measures and renewable energy system integration

Short description of the exercise and learning outcomes:

After systematic inspection and analysis of energy use and energy consumption of a building and technical building systems completion, identification of possibilities to improve energy efficiency and RES integration has to be conducted. The focus of the exercise is to acquaint the participants with methods for determination of energy efficiency measures (including on-site renewable energy generation). How to recognize energy efficiency potential and how to calculate achievable savings are key outcomes of this exercise.

The basis for this exercise will be international standards such as ISO 50015, Energy Management Handbook and related professional literature with international measurement and verification protocol. In this context, all above-mentioned activities must provide answers to the following questions:

- What are typical energy efficiency measures?
- What is renewable energy production potential?
- What is the interrelation between energy consumption and generation?
- How to calculate energy savings?

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to energy efficiency, savings calculations and renewable energy generation. The expected duration of the exercise is 120 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about energy efficiency measures and calculation methods.

Short CV of the envisioned lecturer:

Marko Bišćan is a researcher at the Energy Institute Hrvoje Požar, where he holds a master's degree in electrical engineering from the University of Zagreb. His main areas of expertise include energy management, environmental management, decision support for buildings and industries, modelling and optimisation of energy processes, and holistic energy planning. He is also a lecturer for energy manager training under the EUREM program, as well as for public sector energy advisers and associates, providing training to experts conducting energy audits and/or energy certification of buildings. With extensive practical experience, he has been involved in numerous domestic and international projects as a coordinator or team member, particularly in energy efficiency. He has also conducted over 50 energy audits in industrial and building settings.

Teaching methods and tools:

Exercise with the active participation of participants. It includes a theoretical introduction to typical energy efficiency measures and RES generation. Afterwards, exercise includes explanations, discussion, solving real-life energy problems and calculation methods for selected components of the energy system in the building.

Key questions that will be addressed:

- What are typical energy efficiency measures?
- What is renewable energy production potential?
- What is the interrelation between energy consumption and generation?
- How to calculate energy savings?
- What methods are to be used?

References and recommended reading:

1. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings
2. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
3. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
4. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
5. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom
6. Thollander, P., Karlsson, M., Rohdin, P., Wollin, J., Rosenqvist, J. (2020). Introduction to Industrial Energy Efficiency - Energy Auditing, Energy Management and Policy Issues. Academic Press, Elsevier, London, UK
7. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA

3.2.12 Exercise 4: Implementation of identified measures on calibrated dynamic model - case study office building

Short description of the exercise and learning outcomes:

The implementation of measures on a calibrated dynamic model (adjusted to the real usage schedules) can serve as a basis for making decisions about investing in energy efficiency measures of a specific building. In the introductory part of the exercise, the calibration of the dynamic model according to the real way of usage will be presented with the advantages of such a process. This part of the exercise includes the transfer of theoretical knowledge to the participants on this topic, which will later be applied in practical exercises.

Practical exercises will include the implementation of energy efficiency measures on the example of a selected calibrated dynamic model of a real building. In this part, the energy efficiency measures that will be analysed on the selected building will be clearly defined, according to the following division:

- Energy efficiency measures in the construction part – analysis of different insulation thicknesses of the outer envelope of the selected building
- Energy efficiency measures in the mechanical part – analysis of different HVACs
- Energy efficiency measures in the electrotechnical part – analysis of different lighting systems

All the mentioned measures will be combined with each other, and for the purposes of this exercise, only a few measures will be combined in order to carry out the analyses in the given time frame. The results of the analysis will be the technical potential of implementing each combination of energy efficiency measures. Finally, the obtained results will be interpreted in a technical and economic context and can serve the decision-makers of deep energy renovation of buildings to select the optimal combination that, in addition to the technical requirements, also considers the cost-effectiveness of the implementation of the energy efficiency measures. Ultimately, the investor makes the final decision, which can be based only on technical potential, economic potential or their combination.

In this context all above mentioned activities must provide answers to the following questions:

- What is the goal of calibrating dynamic models according to actual usage?
- What tools can be used for this purpose?
- What data are needed to carry out such analyses?
- How to implement energy efficiency measures?
- What is the optimal solution for deep energy renovation of buildings?

Competencies of participants who successfully complete the learning module will include an understanding of basic concepts related to the implementation of energy efficiency measures on a calibrated dynamic model, and guidelines for finding optimal solutions for deep energy renovation of buildings, which includes the implementation of technical and economic potential analyses. The expected duration of the exercise is 120 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about the implementation of identified measures and influence on the dynamic model.

Short CV of the envisioned lecturer:

Marko Bišćan is a researcher at the Energy Institute Hrvoje Požar, where he holds a master's degree in electrical engineering from the University of Zagreb. His main areas of expertise include energy management, environmental management, decision support for buildings and industries, modelling and optimisation of energy processes, and holistic energy planning. He is also a lecturer for energy manager training under the EUREM program, as well as for public sector energy advisers and associates, providing training to experts conducting energy audits and/or energy certification of buildings. With extensive practical experience, he has been involved in numerous domestic and international projects as a coordinator or team member, particularly in energy efficiency. He has also conducted over 50 energy audits in industrial and building settings.

Teaching methods and tools:

Exercise with the active participation of participants. It includes theoretical explanations, discussion, analysis of collected data, implementation of identified measures on calibrated dynamic model and calculations of energy efficiency for selected component of the energy system in the addressed building.

Key questions that will be addressed:

- What is the goal of calibrating dynamic models according to actual usage?
- What tools can be used for this purpose?
- What data are needed to carry out such analyses?
- What is the optimal solution for deep energy renovation of buildings?

References and recommended reading:

1. Agliardi, E., Cattani, E., Ferrante, A. (2018). Deep energy renovation strategies: A real option approach for add-ons in a social housing case study. Energy and Buildings, 161, 1–9. doi:10.1016/j.enbuild.2017.11.044
2. Bac, U., Alaloosi, K.A.M.S., Turhan, C. (2021). A comprehensive evaluation of the most suitable HVAC system for an industrial building by using a hybrid building energy simulation and multi criteria decision making framework. Journal of Building Engineering, 37, 102153. doi:10.1016/j.jobe.2021.102153
3. Budim, R., Dergestin, D., Knezovic F., Bacan, I. (2022). Method for selection of the optimal solution for deep energy renovation of a building, 20th International Conference on Thermal Science and Engineering of Serbia, SimTerm2022
4. Cholewa, T., Balaras, C.A., Nižetić, S., Siuta-Olcha, A. (2020). On calculated and actual energy savings from thermal building renovations – Long term field evaluation of multifamily buildings. Energy and Buildings, 223, 110145. doi:10.1016/j.enbuild.2020.110145
5. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
6. Dodoo, A., Gustavsson, L., Tettey, U.Y.A. (2017). Final energy savings and cost-effectiveness of deep energy renovation of a multi-storey residential building. Energy, 135, 563–576. doi:10.1016/j.energy.2017.06.123
7. Economidou M., Atanasiu B., Despret C., Maio J., Nolte I., Rapf, O. Europe's buildings under the microscope. A country-by-country review of the energy performance of buildings. Build Perform Inst Eur (BPIE) 2011:35–6
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9. IEA OECD Report, Transition to Sustainable Buildings. Strategies and Opportunities to 2050 OECD/IEA July 2013 (612013151P1), ISBN:978-92-64-20841-2
10. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations.
11. Jradi, M., Veje, C., Jørgensen, B.N. (2017). Deep energy renovation of the Mærsk office building in Denmark using a holistic design approach. Energy and Buildings, 151, 306–319. doi:10.1016/j.enbuild.2017.06.047
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13. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom
14. Semprini, G., Gulli, R., Ferrante, A. (2017). Deep regeneration vs shallow renovation to achieve nearly Zero Energy in existing buildings. Energy and Buildings, 156, 327–342. doi:10.1016/j.enbuild.2017.09.044
15. Shi, H., Chen, Q. (2020). Building Energy Management Decision-Making in the Real World: A Comparative Study of HVAC Cooling Strategies. Journal of Building Engineering, 101869. doi:10.1016/j.jobe.2020.101869
16. Tettey, U.Y.A., Gustavsson, L. (2020). Energy savings and overheating risk of deep energy renovation of a multi-storey residential building in a cold climate under climate change. Energy, 202, 117578. doi:10.1016/j.energy.2020.117578
17. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA
18. Washim Akram, M., Hasanuzzaman, M., Cuce, E., Mert Cuce, P. (2021). Global technological advancement and challenges of glazed window, facade system and vertical greenery-based energy savings in buildings: A comprehensive review. Energy and Built Environment. doi: 10.1016/j.enbenv.2021.11.003

19. Zhang, Lili; Liu, Zu'an; Hou, Chaoping; Hou, Jiawen; Wei, Dong; Hou, Yuyao (2019). Optimization analysis of thermal insulation layer attributes of building envelope exterior wall based on DeST and life cycle economic evaluation. Case Studies in Thermal Engineering, 14(), 100410–. doi:10.1016/j.csite.2019.100410

3.2.13 Exercise 5: Transformation of EPC data and other data into Renovation Passport for the deep renovation of the building - case study residential building

Short description of the exercise and learning outcomes:

The staged renovation is based on a renovation roadmap that shows the energy-related measures in the correct sequence. This exercise takes the audience through the steps of creating a renovation roadmap for deep renovation, based on the Energy Performance Certificate and other sources of information such as a Building Information Model. The focus is on residential buildings, considering that the major share of buildings belongs to the residential sector.

In this context, answers to the following questions are needed:

- What is the procedure for developing a renovation roadmap?
- Which tools are available?
- What are the advantages and disadvantages of the different data sources?
- How to deal with a lack of data?
- Is an on-site visit needed?
- What is the interface with the usual maintenance and repair plan?

Competencies of the participant who successfully completes the learning module will include an understanding of how to develop a renovation roadmap and how to cope with difficulties concerning data availability and data quality that might occur during the process.

The expected duration of the exercise is 90 minutes. Input is 45 minutes, the remaining time is devoted to discussion with participants.

Target groups:

The exercise is intended for everyone who is involved in building renovation. The exercise provides an overview of contents, procedures, and tools, and is also useful for technical and non-technical staff of the administration and companies owning large buildings.

Short CV of the envisioned lecturer:

Susanne Geissler is the owner and director of SERA Institute, an environmental engineer with a background in European law, and a trained energy advisor entitled to issue Energy Performance Certificates (EPCs). With years of experience, she has been actively involved in activities related to the implementation and further development of EPC-related concepts. She holds a doctoral degree in Sustainable Construction from the University of Natural Resources and Life Sciences Vienna, showcasing her expertise in the field of sustainable construction and energy performance assessment. Susanne Geissler's work focuses on promoting energy efficiency and sustainability in the built environment, with a particular emphasis on EPC-related practices and concepts.

Teaching methods and tools:

Exercise based on PPT presentation; demonstration of tools; possibility for participants to ask questions; discussion with participants.

Key questions that will be addressed:

- What are the minimum requirements a useful renovation roadmap must meet?
- How to deal with the challenge of data quality and data availability?

References and recommended reading:

1. European Commission (2021): iBroad - Individual Building (Renovation) Roadmaps. EU Project 754045 under Horizon 2020 https://cordis.europa.eu/project/id/754045/de and https://ibroad-project.eu/results/reports/
2. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) COM/2021/802 final
3. Volt, Jonathan; Toth, Zsolt; Glicker, Jessica; De Groote, Maarten; Borragán, Guillermo; De Regel, Sofie et al. (2020): Definition of the digital building logbook: report 1 of the study on the development of a European Union framework for buildings' digital logbook. European Union: Publications Office https://data.europa.eu/doi/10.2826/480977

3.2.14 Exercise 6: Creation of measurement and verification plan - case study office building

Short description of the exercise and learning outcomes:

Performance improvement starts with measurements which are aimed at quantifying past action in order to determine current performance. Only when performance is quantified, meaningful discussion about possible improvements may begin. This exercise provides an example of how to create a reliable and realistic measurement and verification plan for an office building recently renovated. In this context, it is crucial that the proposed metrics are simple and understandable to key stakeholders, energy managers and facility managers. Through this, the exercise participants will create the measurement and verification plan and discuss in groups about possible improvements. Each measurement and verification plan will be assessed, and it will be checked does it provide answers to the following questions:

- Why do we need the proposed measurement?
- What are the performance improvement measures that will be monitored and verified by the proposed measurement?
- What energy indicators will be calculated based on the proposed measurement?
- What is the appropriate data recording frequency?

Participants will also learn how to specify and establish the data handling routines in order to assure data adequacy. In that respect, the data handling protocol created for an office building will be given as an example. The main elements of the data verification procedures will be presented and participants will have to do the exercise and discover which recorded values are correct.

Competencies of the participant who successfully completes the learning module will include an understanding of the reporting, monitoring and verification of energy savings which includes the creation of measurement and verification plan. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge in reporting, monitoring and verification of energy savings. Participants will learn how to create realistic measurement and verification plan.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

Exercise with active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of metering plans, analysis of collected data and verification of achieved energy savings.

Key questions that will be addressed:

- What is the measurement and verification plan?
- Why do we need an M&V protocol?
- What are the main M&V activities?
- What are the options for measurement and verification?
- What are the key questions to which the metering plan must provide answers?

References and recommended reading:

1. Beggs, C. (2010). Energy: Management, Supply and Conservation. Routledge – Taylor & Francis Group, United Kingdom
2. Braga, L.C., Braga, A.R., Braga, C.M.P. (2013). On the characterization and monitoring of building energy demand using statistical process control methodologies. Energy and Buildings, 65, 205-219
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-7
4. Efficiency Valuation Organisation. (2019). EVO 10300 - 1: Measurement & Verification - Issues and Examples
5. Efficiency Valuation Organisation. (2022). EVO 10000 - 1: International Performance Measurement and Verification Protocol (IPMVP) – Core Concepts
6. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
7. International Energy Agency. (2013). Transition to Sustainable Buildings – Strategies and Opportunities to 2050. OECD/IEA, Paris, France
8. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
9. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
10. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI).
11. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
12. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
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4 Training Scenario 2 - EPC data collection, validation and exploitation

4.1 Structure of the Training Scenario 2

Training Scenario 2 (TS2) aims to empower general building experts and professionals to identify essential elements for successful and efficient EPC data collection, validation, and exploitation, including necessary skills of accredited energy certifiers, data collection procedures, calculation methodology, and risk management in each phase. Training materials related to proper planning and site visits, including tips for efficient data collection, validation, and exploitation, and data extraction from multiple sources, will be provided. Special attention will be put on preparing training materials related to the data collection and calculation of the smart readiness indicator (SRI), including the main steps of an SRI audit and calculating sustainability indicators based on building energy performance.

TS2 is organized into four teaching hours of training (in total 180 minutes) for general building experts, which will be organized in the form of a webinar, and sixteen teaching hours of training (in total 720 minutes) held in person for professionals carried out by means of in-class lectures and exercises.

4.2 Envisioned lectures and exercises

Table 4 provides information about all lectures and exercises, with the indication of their duration, that will be delivered in the framework of the TS2. Also, it provides information from which TMs these lectures and exercises are extracted.

Table 4. Outline of the TS2

Training for the general building experts (webinar)		
Title of the lecture	Duration (min.)	Training Module
Key elements of proper planning and site visit	25	TM2
Tips for efficient EPC data collection, validation and exploitation	25	TM9
Data extraction from the multiple sources	25	TM3
Strengths and weaknesses of the BIM models	25	TM1
Quality assessment of the EPC database contents	25	TM9
Calculating smart readiness indicator	30	TM2
Calculating sustainability indicators based on a building's energy performance	25	TM5

Training for the professionals (in-class)		
Title of the lecture/exercise	Duration (min.)	Training Module
Preparatory activities, data collection plan, metering plan and site visit	60	TM2
Exercise 1: Data collection and verification – case study office building	90	TM9
Exercise 2: Data extraction from the energy management system and other monitoring systems	60	TM3
Exercise 3: Creating a BIM model – case study educational building	90	TM1
Exercise 4: Comparing modelled and measured energy performance with the emphasis on energy performance indicators	90	TM3
Dynamics of EPC process – utilising data collection process for optimisation of energy systems and recommissioning activities	90	TM4
Exercise 5: Calculating smart readiness indicator and extracting potential energy and flexibility measures from collected data – case study different types of buildings belonging to the educational sector	90	TM2
Exercise 6: Data collection and calculation of sustainability indicators – case study municipal building	90	TM5
Exercise 7: Creation of the implementation action plan and presentation of results to the end-users	60	TM3

TS2 is organised into seven theory lectures for the general building experts, and two theory lectures and seven exercises for the professionals.

For each envisioned lecture and exercise of the TS2, a short description of learning content and expected outcomes, target groups, a short CV of the envisioned lecturer, teaching methods and tools, and main references are provided from Section 4.2.1 to Section 4.2.16.

4.2.1 Key elements of proper planning and site visit

Short description of the lecture and learning outcomes:

An energy performance assessment of a building, if conducted systematically and comprehensively, is a powerful tool for evaluating current or past energy and environmental performance and management practice. Planning and preparation is crucial for any activity related to the energy performance assessment. Planning includes at least the following:

- Lay out a timetable and scope of all activities
- Set up the project team and assign specific tasks
- Establish a relationship with the building owner/users and, in the case of larger buildings with personnel dealing with energy and maintenance

- Establish effective lines of communication and coordination between the project team and owner/users/technical personnel
- Initiate data gathering
- Kick off the project successfully

The planning activities should be documented in the form of a work plan, which should also be shared with the owner/users before visiting the building to carry out the intended work. The work plan must outline which part of the building is to be visited, the purpose of the visit, the documentation and data required, and the personnel to be involved.

This lecture focuses on the following two main areas:

- Planning a site visit
- Planning and preparation for data collection

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the planning a site visit, communication during the energy performance assessment and data collection. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about proper planning, communication, site visit and data collection.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The lecture will be conducted as a webinar, and it foresees the passive participation of participants. It includes theoretical explanations and examples of proper planning.

Key questions that will be addressed:

- What is the purpose of planning a site visit and how is it conducted?
- What are the key steps of successful planning?
- Why do we need honest communication and co-operation between different experts during the assessment of a building’s energy performance?
- What needs to be agreed upon with the owner/users before the site visit?
- Which data needs to be collected by the energy assessor during the site visit?

References and recommended reading:

1. Baechler, M.C. (2011). A Guide to Energy Audits. PNNL-20956
2. Cai, L., Zhu, Y. (2015). The Challenges of Data Quality and Data Quality Assessment in the Big Data Era. Data Science Journal, 14
3. Chism, M. (2022). From Conflict to Courage How to Stop Avoiding and Start Leading. Berrett-Koehler Publishers, USA

4. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
5. European Committee for Standardisation (CEN). (2014). EN 16247-2:2014: Energy audits - Part 2: Buildings
6. Fowler, S. (2014). Why Motivating People Doesn't Work . . . and What Does: The New Science of Leading, Energizing, and Engaging. Berrett-Koehler Publishers, USA
7. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
8. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
9. Loehr, J., Schwartz, T. (2003). The Power of Full Engagement: Managing Energy, Not Time, Is the Key to High Performance and Personal Renewal. The Free Press – A Division of Simon & Schuster, Inc., New York
10. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom

4.2.2 Tips for efficient EPC data collection, validation and exploitation

Short description of the lecture and learning outcomes:

Data without processing is useless; only valid data processing provides relevant information. Therefore, in this lecture, the focus will be on data processing related to EPCs. In this context, attention will first be drawn to the goal and purpose of data collection, and then to the relevant data needed to achieve those goals. After defining the final goal and the necessary input data, certain tips will be given on how to get this data and how to process it. On the example of several EPCs from different countries, the conclusions that can be made based on data processing from EPCs will be presented. The aforementioned will be conveyed to the participants through analysis and examples of good practice examples. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about EPCs.

Short CV of the envisioned lecturer:

Marko Bišćan is a researcher at the Energy Institute Hrvoje Požar, where he holds a master's degree in electrical engineering from the University of Zagreb. His main areas of expertise include energy management, environmental management, decision support for buildings and industries, modelling and optimisation of energy processes, and holistic energy planning. He is also a lecturer for energy manager training under the EUREM program, as well as for public sector energy advisers and associates, providing training to experts conducting energy audits and/or energy certification of buildings. With extensive practical experience, he has been involved in numerous domestic and international projects as a coordinator or team member, particularly in energy efficiency. He has also conducted over 50 energy audits in industrial and building settings.

Teaching methods and tools:

The lecture will be conducted as a webinar showing examples of good practice in EPC data processing through an interactive discussion with participants.

Key questions that will be addressed:

- What to pay attention to during data collection and processing?
- How to make data collection easier and less time-consuming process?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2017). EN 15193: Energy performance of buildings - Energy requirements for lighting
2. European Committee for Standardisation (CEN). (2017). EN 15316: Method for calculation of system energy requirements and system efficiencies
3. European Committee for Standardisation (CEN). (2017). EN 16798: Energy performance of buildings – ventilation for buildings
4. European Committee for Standardisation (CEN). (2017). EN 15232-1: Energy performance of buildings. Part 1: Impact of Building Automation, Controls and Building Management
5. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
6. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
7. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
8. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA

4.2.3 Data extraction from the multiple sources

Short description of the lecture and learning outcomes:

The lecture will provide a comprehensive overview of the data collection process in building energy performance certification, including the tools used to gather and verify the accuracy of data obtained from multiple sources. Participants will learn how to enhance energy performance certificates (EPCs) by ensuring consistency with EPC requirements in accordance with standard procedures.

The lecture will also address the challenges of extracting data from multiple sources, such as incomplete data sets, data inconsistency, and missing data points. Best practices for dealing with these issues will be explained, equipping participants with the skills and knowledge necessary to ensure that the data used for an EPC is accurate and meets the required standards.

By the end of the lecture, participants will have a thorough understanding of the data collection process in building energy performance certification and will be able to apply their knowledge to effectively obtain and verify data to enhance EPCs. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is designed for individuals involved in the evaluation of energy performance in buildings or technical building systems, such as auditors, energy managers, facility managers, and EPC experts.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What are the different data sources that can be used for an EPC, and how can they be accessed and extracted?
- What potential challenges and issues can arise when extracting data from multiple sources, and what strategies can be employed to overcome them?
- What are the implications of inaccurate or incomplete data for the validity and reliability of an EPC?

References and recommended reading:

1. TIMEPAC D2.1 Report on technical specification of TDS 1. Guidelines to assess tools that can be used to extract BIM data to enhance EPCs.
2. TIMEPAC D2.2 Report on technical specification of TDS 2. Procedures and services addressing the enhancement of EPC schemas through operational data integration.
3. TIMEPAC D2.4 Report on technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools.

4.2.4 Strengths and weaknesses of the BIM models

Short description of the lecture and learning outcomes:

This lecture focuses on understanding the strengths and weaknesses of Building Information Modelling (BIM) models. Participants will learn how BIM can improve building performance, project coordination and decision-making, and the importance of data management and quality control in BIM models.

The first part of the lecture will cover the strengths of BIM, including its ability to improve accuracy in planning and design, its ability to improve project coordination and communication between construction teams, and its ability to improve efficiency in project management. Participants will also learn how BIM can improve decision-making and risk assessment in construction.

The second part of the lecture will address the weaknesses of BIM, including the complexity of the software and the need for specialised skills for its effective use, as well as the challenges in connecting applications and data management and quality control of BIM models. Participants will also learn how these weaknesses can be minimised by implementing of effective data management and quality control processes.

Overall, this lecture provides participants with a solid understanding of the strengths and weaknesses of BIM models and how to use them effectively to improve performance and effectiveness in construction.

The expected duration of the lecture is 25 minutes.

Target groups:

The target group of the lecture includes professionals and experts in the construction industry, such as architects, engineers, contractors, developers, building owners and others interested in the use of BIM technology in the planning, design and construction of building projects.

BIM can also be useful for architecture, engineering and construction participants looking for a deeper understanding of BIM models and its use in the construction industry.

Furthermore, the lecture may be of interest to those involved in project management, decision making and strategic planning in the construction industry, as BIM technology has the potential to improve efficiency, collaboration and quality in project construction.

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations, discussions, as well as an explanation of workflows.

Key questions that will be addressed:

- What are the main strengths of BIM?
- How can BIM improve accuracy in the planning and design of construction projects?
- How can BIM improve project coordination and communication between construction teams?
- How can BIM improve efficiency in project management?
- How can BIM improve decision-making and risk assessment in construction?
- What are the main weaknesses of Building Information Modelling (BIM)?
- How can we overcome the complexity of the software and the need for specialised skills to use it effectively?
- How can we address the challenges in data management and quality control of BIM models?
- What are the best practices for using BIM effectively in construction?
- How can BIM models' strengths and weaknesses affect construction efficiency and effectiveness?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2018). EN 19650-1: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles
2. European Committee for Standardisation (CEN). (2018). EN 19650-2: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 2: Delivery phase of the assets
3. European Committee for Standardisation (CEN). (2020). EN 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 3: Operational phase of the assets

4.2.5 Quality assessment of the EPC database content

Short description of the lecture and learning outcomes:

To achieve the EU 2030 and 2050 GHG emission reduction goals, the renovation of building stock goes through the reliable creation of the urban building's energy models. In this regard, the energy certificate represents a crucial data source for building urban energy analysis. The EPC information should be enhanced, real-time upgradeable, implemented, and made interoperable. It is essential to perform the quality assessment of the EPC database contents to have energy certificates free of inaccuracies and be valuable for making appropriate policy decisions, building performance benchmarking, and energy efficiency upgrades. This lecture aims to use a method for quality-checking procedures, providing the score attribution to parameters and values in the energy certificates after defining validity rules and thresholds. Groups of rules include data types of checks, physical impossibility checks, and consistency checks. The primary outcomes of the lecture are:

- Determine a methodology for EPC database contents quality assessment
- Recognize the strengths and weaknesses of current EPC data content
- EPC data innovative handling techniques

- Best practices identification, overcoming obstacles to quality and dependability and maximizing the benefits of the EPC data content

The expected duration of the lecture is 30 minutes.

Target groups:

The lecture is intended for everyone involved in evaluating the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts) and everyone who wants to acquire basic knowledge for efficient data collection and analysis.

Short CV of the envisioned lecturer:

Mamak P. Tootkaboni is a research fellow at Politecnico di Torino, Department of Energy. She holds a PhD in Energetics from Politecnico di Torino, and her research focuses on energy efficiency, climate resilience, building energy performance modelling, future weather data creation, adaptation and mitigation to climate change, and statistical analysis. She has authored several scientific articles published in international and Italian journals and conferences, showcasing her expertise in the field of building physics and energy systems. Mamak P. Tootkaboni's work contributes to advancing the understanding and application of sustainable and resilient building practices in the face of climate change challenges.

Teaching methods and tools:

Lecture with passive participation of participants. It includes theoretical explanations, discussion, and investigation of different quality assessment and scoring methods of EPC data contents. The outcomes of the X-tendo project will be presented and discussed. The instructor will provide participants with lecture materials, presentations, and references.

Key questions that will be addressed:

- What are the contents of EPC data, and why is quality assessment crucial?
- How can various rules and thresholds be identified, quantified, and assessed in an EPC database?
- What kinds of data quality problems might be present in an EPC database?
- How can the EPC database's quality be improved using the scoring method's results?

References and recommended reading:

1. Anagnostopoulos, F., Arcipowska, A., Mariottini, F. (2015). Energy Performance Certificates as tools to support and track renovation activities. Repéré sur le site du Buildings Performance Institute Europe
2. eXTENDing the energy performance assessment and certification schemes via a mOdular approach (X-tendo). (2022). Implementation guidelines and replicability potential of the innovative features for the next generation EPCs.126 pages
3. eXTENDing the energy performance assessment and certification schemes via a mOdular approach (X-tendo). (2022). D4.4 description of methodologies and concepts for the technical implementation of each feature regarding improved handling and use of EPC data in selected implementing countries
4. Pagliaro, F., Hugony, F., Zanghirella, F., Basili, R., Misceo, M., Colasuonno, L., Del Fatto, V. (2021). Assessing building energy performance and energy policy impact through the combined analysis of EPC data–The Italian case study of SIAPE. Energy Policy, 159, 112609.
5. THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS (2020). Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020SC0176

4.2.6 Calculating smart readiness indicator

Short description of the lecture and learning outcomes:

Successful sustainable and climate-friendly development strategies of urban areas must be adaptive and rely on empirical data. It is clear that new challenges also need new indicators. In this context, the inclusion of the Smart Readiness Indicator (SRI) concept into the framework of a building's energy performance assessment has a vast potential to enable sustainable change of current development practices and transformation of existing building stock into the biggest energy generating entity. The amended Energy Performance of Buildings Directive introduced the SRI in 2018 and its subsequent regulations (Delegated Regulation and Implementing Regulation), triggering an optional implementation phase by EU countries. Several EU countries interested in the SRI scheme have already started by launching a non-committal test phase.

However, there are no specific guidelines from the European Commission for the SRI implementation according to regulation 2156/2020. This enables the national governing bodies of each Member State to have the freedom and the ability to modify the SRI tool for their own testing phase.

This lecture focuses on the following three main areas:

- Assessment methodology
- Format of the SRI certificates
- Assessment process and data collection

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the SRI, assessment process and data collection. The expected duration of the lecture is 30 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about SRI and its elements.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The lecture will be conducted as a webinar, and it includes theoretical explanations and examples of SRI calculation.

Key questions that will be addressed:

- What are the key elements of the SRI calculation methodology?
- Which data needs to be collected for a calculation of SRI?
- How to properly understand SRI rating?

References and recommended reading:

1. European Commission: The Smart Readiness Indicator (SRI) for rating smart readiness of the European building stock https://energy.ec.europa.eu/system/files/2022-04/SRI-Factsheet-v6_0.pdf
2. TIMEPAC D2.4 Report on the technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools
3. Waide P., Verbeke, S., Dourlens S., Decorme, R., Kubicki, S. (2023). Smart Readiness Indicator (SRI) - Provisional guidance on the implementation of the SRI. SRI support team: VITO (Belgium), Waide Strategic Efficiency Europe (Ireland), Research to Market Solution (France) and Luxembourg Institute of Science and Technology (Luxembourg)

4.2.7 Calculating sustainability indicators based on building's energy performance

Short description of the lecture and learning outcomes:

The role of any indicator is to make complex systems understandable or easily comprehensible. The situation with the evaluation of sustainability is even more complex and an effective sustainability indicator or a set of indicators must help determine the current position against established sustainability objectives. Different countries around the world have adopted different strategies for sustainability framework application. Some have adopted already established certification systems, e.g. LEED, BREEAM, while some have decided to transpose Level(s) and adapt it to local and national conditions. This lecture provides an overview of the sustainability indicators from the Level(s) framework. Special emphasis will be put on those sustainability indicators that have been recognized by the TIMEPAC project with the potential to add value to the enhanced EPC:

- Use stage energy performance
- Indoor air quality
- Life cycle costs

The main goal of the selected sustainability indicators is to enable monitoring and evaluation of applied energy and environmental performance improvement measures on the overall sustainability of the assessed building.

This lecture focuses on the following two main areas:

- The purpose of each selected sustainability indicator (use stage energy performance, indoor air quality, life cycle costs)
- Data collection, roles and responsibilities for each assessment

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the Level(s) framework, data collection and calculation of selected indicators. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about sustainability indicators included in Level(s) framework.

Short CV of the envisioned lecturer:

Gašper Stegnar is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Civil Engineering from the University of Ljubljana, and his areas of expertise include simulation modelling of the thermal response of buildings, implementation of BIM methodology, and detailed simulation modelling of energy-efficient building renovations. His research focuses on developing energy consumption models and projections in the building sector, with a special emphasis on energy efficiency and renewable energy sources in buildings. Gašper is also involved in designing and modelling energy systems, as well as conducting analyses to support decision-making in climate and energy policies. He actively participates in international research and application projects, particularly those related to energy efficiency. Furthermore, Gašper is gaining valuable experience as an energy consultant in the ENSVET energy consulting network, providing expert advice on buildings and energy management.

Teaching methods and tools:

The lecture will be conducted as a webinar and it foresees passive participation of participants. It includes theoretical explanations and examples of the calculation of sustainability indicators.

Key questions that will be addressed:

- How do we measure/evaluate sustainability?
- Why do we need sustainability indicators?
- What is Level(s)?
- What data do we need to calculate selected sustainability indicators?

References and recommended reading:

1. TIMEPAC D2.4 Report on the technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools.

4.2.8 Preparatory activities, data collection plan, metering plan and site visit

Short description of the lecture and learning outcomes:

The first and basic step for any company or organization that wants to improve energy efficiency and reduce energy supply costs is to conduct a systematic inspection and analysis of energy use and energy consumption of a building and technical building systems to identify energy flows and the potential for energy efficiency improvements and report them. The focus of the lecture will be put on preparatory activities, the creation of a data collection plan, metering plan and site visit requirements that are defined by international standards such as ISO 50001, ISO 50002, ISO 50015 or the EN 16247 series of standards (EN 16247-1, EN 16247-2 and EN 16247-5). In this context, all above-mentioned activities must provide answers to the following questions:

- What are the aims, needs and expectations concerning the data collection process?
- What is the starting (reference) consumption of energy and water?
- What are the starting costs of energy and water?
- What are the impacts of addressing technical building systems on the environment, and are they in accordance with legal regulations?
- Which data is necessary to create EPC and which data is necessary to propose reliable energy efficiency measures that are economically justified and which interventions need to be carried out to meet legal requirements?

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the preparation of the site visit, creation of the metering plan, knowledge of modern methods for collecting and analysing data on energy and water use, and the ability to use these methods independently Participants will also acquire basic practical knowledge necessary for active monitoring and evaluation of energy consumption at the building level and addressed technical building system. The expected duration of the lecture is 45 minutes.

Target groups:

The lecture is intended for everyone involved in evaluating of energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge for efficient data collection and analysis.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

Lecture with the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of metering plans, analysis of collected data and calculations of energy efficiency for a selected energy system component in the addressed building.

Key questions that will be addressed:

- What are the key questions to which the metering plan must provide answers?
- What are the key elements of the data collection process?
- What are the most important changes that have been introduced in energy auditing by the standards (ISO 50001, ISO 50002 and EN 16247)?
- Why should we keep good records on where, how and what has been measured during the data collection process?

References and recommended reading:

1. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
2. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
3. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
4. European Committee for Standardisation (CEN). (2015). EN 16247: Energy audits - Part 5: Competence of energy auditors
5. International Energy Agency. (2013). Transition to Sustainable Buildings – Strategies and Opportunities to 2050. OECD/IEA, Paris, France
6. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
7. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
8. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
9. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
10. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
11. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom

12. Thollander, P., Karlsson, M., Rohdin, P., Wollin, J., Rosenqvist, J. (2020). Introduction to Industrial Energy Efficiency - Energy Auditing, Energy Management and Policy Issues. Academic Press, Elsevier, London, UK
13. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA

4.2.9 Exercise 1: Data collection and verification - case study office building

Short description of the exercise and learning outcomes:

The data collection phase is the activity propaedeutic to the building performance analysis. According to EN 16247-1, the data collection phase should be preceded by a preliminary contact with the organization define the aim and the expectations, the boundary conditions, the criteria for the assessment, etc. During this phase, a site inspection with the involvement of the responsible for the building and building facility is necessary for collecting the building data to be elaborated for further analysis.

The exercise is aimed at showing, through a case study approach, methods for data collection and verification and site visit requirements, according to the related technical standards.

A real office building is presented and the list of input data to be collected for the overall performance assessment is analysed, providing tips for the data collection, for involving the participation of the building experts (e.g. building manager, facility manager), for data verification, visualization and elaboration for the subsequent performance analysis.

The exercise provides answers to the following questions:

- How to proceed in practice with the preparation of the site inspection?
- How to proceed in practice with a data collection process?
- What are the data to be collected for the overall performance evaluation (energy, economics, occupants' comfort, smartness of the building and building sustainability)?
- How to elaborate and visualize the collected data to be further elaborated?

Competencies of the participant who successfully completes the learning module will include an understanding of the practical concepts related to the preparation of the site visit and the data collection for performing an overall building assessment. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in evaluating building performance (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge for data collection for the overall evaluation of the building performance going beyond the mere energy evaluation.

Short CV of the envisioned lecturer:

Alice Gorrino is a Building Engineer and currently works as an Internationalization Consultant at Edilclima S.r.l. since January 2021. She holds a PhD in Technological Innovation for the Built Environment from Politecnico di Torino, Department of Energy, where she previously worked as a grant researcher until 2017 and as an external lecturer until September 2021. Her research activities have primarily focused on building energy performance calculation methods in accordance with technical standards, as well as data analysis and building energy management systems. She has authored approximately 35 scientific, technical, and didactic publications, with a particular focus on energy performance dynamic simulation, energy performance of building envelopes (including thermal bridges, sunspaces, green roofs, vented opaque envelopes, and transparent active façades), energy management strategies, and Decision Support Systems. In addition to her research work, Alice Gorrino has been actively involved in energy audits of hospitals, banks, and municipal buildings, conducting around 40 audits as an energy consultant.

Teaching methods and tools:

The exercise requires the active participation of attendants making use of a case study-approach. The activity is structured into a brief theoretical part and a practical exercise and includes a practical guideline for the data collection.

Key questions that will be addressed:

- What are the key aspects to be defined with the building manager during a site inspection?
- What are the steps of the data collection process?
- According to EN 16247-1, what are the building data to be collected?
- What information is required for a holistic assessment of building performance?

References and recommended reading:

1. European Commission: The Smart Readiness Indicator (SRI) for rating smart readiness of the European building stock https://energy.ec.europa.eu/system/files/2022-04/SRI-Factsheet-v6_0.pdf
2. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
3. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Building
4. European Committee for Standardisation (CEN). (2015). EN 16247: Energy audits - Part 5: Competence of energy auditors
5. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
6. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
7. European Committee for Standardisation (CEN). (2015). EN 16247: Energy audits - Part 5: Competence of energy auditors
8. European Committee for Standardisation (CEN). (2012). CSN EN 16231: Energy efficiency benchmarking methodology
9. TIMEPAC D2.4 Report on the technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools.
10. Waide P., Verbeke, S., Dourlens S., Decorme, R., Kubicki, S. (2023). Smart Readiness Indicator (SRI) - Provisional guidance on the implementation of the SRI. SRI support team: VITO (Belgium), Waide Strategic Efficiency Europe (Ireland), Research to Market Solution (France) and Luxembourg Institute of Science and Technology (Luxembourg)

4.2.10 Exercise 2: Data extraction from the energy management system and other monitoring systems

Short description of the exercise and learning outcomes:

In many modern buildings, different monitoring and control systems are used, but the majority of them are not directly connected with energy consumption optimisation. This exercise provides an example of how to identify appropriate data that is necessary for the energy performance assessment and that can be extracted from the energy management system or any other monitoring system that is already installed in the building. Also, through this exercise participants will be acknowledged with the advanced techniques for real-time analysis of data streams, such as pattern matching algorithms. Participants will learn how to evaluate extracted data and identify potentials for energy efficiency improvements. They will also have to identify good and bad practices and to create lists of potential alarms due to extensive energy consumption. Each proposal will be assessed, and participants will have to demonstrate that they properly understand the reasons for deviations. Additionally, participants will learn how to assess existing energy management procedures and practices, on-site metering and control equipment and their quality.

Competencies of the participant who successfully completes this learning module will include an understanding of the data extraction techniques and evaluation of energy savings opportunities based on the extracted data. The expected duration of the exercise is 60 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge about energy management or any other performance monitoring system. Participants will learn how to identify the data that is already measured and how to extract it for existing systems.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The exercise requires active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, analysis of extracted data and identification of opportunities to improve energy efficiency of existing technical building systems.

Key questions that will be addressed:

- What is the energy management system?
- Why do we need contextual information to understand energy performance?
- What is SCADA?
- Which performance aspect needs to be monitored and what related values are measured?

References and recommended reading:

1. Braga, L.C., Braga, A.R., Braga, C.M.P. (2013). On the characterization and monitoring of building energy demand using statistical process control methodologies. Energy and Buildings, 65, 205-219
2. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
3. Efficiency Valuation Organisation. (2019). EVO 10300 - 1: Measurement & Verification - Issues and Examples
4. Efficiency Valuation Organisation. (2022). EVO 10000 - 1: International Performance Measurement and Verification Protocol (IPMVP) – Core Concepts
5. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
6. International Energy Agency. (2013). Transition to Sustainable Buildings – Strategies and Opportunities to 2050. OECD/IEA, Paris, France
7. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
8. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use

9. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
10. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
11. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
12. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom
13. Vikhorev, K., Greenough, R., Brown, N. (2013). An advanced energy management framework to promote energy awareness. Journal of Cleaner Production, 43, 103-112

4.2.11 Exercise 3: Creating a BIM model - case study educational building

Short description of the exercise and learning outcomes:

In this exercise, participants will have to use BIM modelling software to create a model of an educational building. The building should include several floors and classrooms, laboratories, administrative offices, common areas and toilets.

Participants should apply BIM modelling principles to create an accurate and detailed model of the building, including information such as building geometry, location of walls, windows, doors, mechanical and electrical systems, and other important building elements.

Once the model is complete, participants should extract relevant information from the BIM model, such as the amount of material used, the dimensions of the rooms and the technical specifications of the building systems. Participants should then present their findings and explain how the extracted information can be used to inform the decision-making in the construction of the building.

In short, this exercise allows participants to apply the knowledge acquired in the course to create a detailed BIM model and extract valuable information from it. Furthermore, participants will have the opportunity to work in teams and improve their communication and presentation skills by presenting their findings to the class.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of the lecture includes a wide range of people interested in construction via BIM models, such as the following:

1. Architects and designers, to create architectural BIM models
2. Engineers, to improve the design of facilities and structures with a BIM workflow

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The following steps will be used for training:

- Training in software for the architectural BIM model (CYPE Architecture), and the CDE, BIMserver.center, to visualise the results in 3D.
- Case studies: Users will study examples to understand how this technique can be applied in real projects.

Key questions that will be addressed:

- What are the key steps in creating a detailed BIM model of an educational building?
- What information is important to include in a BIM model of an educational building?
- How can a BIM model be used to inform the decision-making in the construction of an educational building?
- What tools and techniques can be used to extract relevant information from a BIM model of an educational building?
- How can the information extracted from the BIM model be effectively presented and communicated to other members of the construction team and those interested in the project?

References and recommended reading:

1. CYPE Architecture. User's Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. CYPETHERM EPlus. User's manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf

4.2.12 Exercise 4: Comparing modelled and measured energy performance with the emphasis on energy performance indicators

Short description of the exercise and learning outcomes:

This exercise provides examples of modelled and measured energy performance of a building with a focus on energy performance indicators and clear explanations of reasons for the performance gap. More precise methods offer opportunities to optimize energy designs and systems in new construction and renovation. For less detailed methods, the results must be treated more conservatively and be aware of the impact on the energy balance if the results are to show the real situation.

The process of energy planning the renovation of two office buildings will be analysed via two different methods and compared with actual measured energy consumption after the completed renovation works. Progress in the development of methods for calculating energy use have changed the attitude towards treating reference energy consumption/energy balances. The basic calculation methods are seasonal, monthly, simple hourly and detailed simulation methods. More accurate methods work on the basis of a smaller time step and thus allow better treatment of energy flows. The main choice between a monthly or hourly calculation method is at level of calculation of heating and cooling needs and indoor temperature (EN ISO 52016-1).

The hourly method in EN ISO 52016-1:

- Is transparent, robust and reproducible (fit for use in the context of building regulations)
- Is tailored to the goal: to consider dynamic interactions
- Requires not more input data from the user than the monthly method
- Can be used to validate or find the limits of a monthly method

- Provides a bridge to interactive system performance calculation (e.g. via the “system specific calculation mode”, via exchanging input and output to/from system standards on hourly basis)

Participants will compare modelled and measured energy consumptions and have to create a list of energy performance indicators suitable for the future target setting. The proposed list of energy performance indicators will be assessed and will be checked for answers to the following questions:

- Why do we need the proposed indicator?
- What are the performance improvement measures that will be monitored and verified by the proposed indicator?
- What is the appropriate data recording frequency?

Participants will learn how to identify the reasons for deviations between modelled and measured energy consumption. They will also learn how to normalise and contextualise measured energy consumption in order to compare it with the modelled consumption.

Competencies of the participant who successfully completes the learning module will include an understanding of the differences between modelled and measured energy performance with an emphasis on energy performance indicators. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge about comparing modelled and measured energy performance. Participants will learn how to create comprehensive list of energy performance indicators.

Short CV of the envisioned lecturer:

Gašper Stegnar is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Civil Engineering from the University of Ljubljana, and his areas of expertise include simulation modelling of the thermal response of buildings, implementation of BIM methodology, and detailed simulation modelling of energy-efficient building renovations. His research focuses on developing energy consumption models and projections in the building sector, with a special emphasis on energy efficiency and renewable energy sources in buildings. Gašper is also involved in designing and modelling energy systems, as well as conducting analyses to support decision-making in climate and energy policies. He actively participates in international research and application projects, particularly those related to energy efficiency. Furthermore, Gašper is gaining valuable experience as an energy consultant in the ENSVET energy consulting network, providing expert advice on buildings and energy management.

Teaching methods and tools:

The exercise requires the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, analysis of collected data, comparison of modelled and measured energy performance with an emphasis on energy performance indicators and identification of potential energy efficiency performance opportunities.

Key questions that will be addressed:

- Which energy performance calculation method can be chosen for different building types?
- What are the actual benefits of BIM?
- What are the most influencing factors when choosing an appropriate calculation method?
- What are the key steps of the successful implementation approach?
- Why do we need a data verification procedure?
- What is a digital twin?

References and recommended reading:

1. Ballarini, I., Corrado, V., Madonna, F., Paduos, S., Ravasio, F. (2017). Energy refurbishment of the Italian residential building stock: energy and cost analysis through the application of the building typology. Energy Policy, 105, 148–160
2. Buso, T., Becchio, C., Corgnati, S.P. (2017). NZEB, cost- and comfort-optimal retrofit solutions for an Italian Reference Hotel. Energy Procedia, 140, Beyond NZEB Buildings, 217–230
3. International Organization for Standardization (ISO). (2017). ISO 52016 Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads
4. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
5. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
6. International Organization for Standardization(ISO). (2017). ISO 15686 - Buildings and constructed assets -- Service life planning -- Part 5: Life-cycle costing
7. Koulamas, C., Kalogeras, A.P., Pacheco-Torres, R., Casillas, J., Ferrarini, L. (2018). Suitability analysis of modelling and assessment approaches in energy efficiency in buildings. Energy and Buildings, 158, 1662–1682
8. Silenzi, F., Priarone, A., Fossa, M. (2018). Hourly simulations of an hospital building for assessing the thermal demand and the best retrofit strategies for consumption reduction. Thermal Science and Engineering Progress, 6, 388–397

4.2.13 Dynamics of EPC process - utilising data collection process for optimisation of energy systems and re-commissioning activities

Short description of the lecture and learning outcomes:

This lecture deals with the dynamics of the EPC process and it provides examples of how it can be connected with re-commissioning activities. In this context, re-commissioning (Re-Co) activities are seen as elements of a quality-oriented process for achieving, verifying, and documenting whether the performance of a building's systems and equipment still meet originally defined objectives and criteria. Participants will learn how they can utilise the data collection process to understand cause-effect relationships between various systems and how to properly interpret collected, calculated and measured data and evaluate performance. To develop an understanding of the cause-effect relationship, participants will have to analyse provided data samples and compile a list of individual influencing factors relevant to the energy performance. They will also learn how to identify potential Re-Co measures that can be applied to improve energy performance, reduce costs and improve end-user comfort.

Throughout the lecture, participants will learn how to create the EPC implementation plan, including Re-Co activities, and discuss in groups about possible improvements. Plans will have to correspond, for example to the following cases:

- Building Type 1: Small size building with a simple HVAC system
- Building Type 2: Medium size building with independent HVAC units
- Building Type 3: Medium size building with a simple HVAC system

Competencies of the participant who successfully completes the learning module will include an understanding of the Re-Co and how it can be combined with EPC generation process and identification of energy savings which includes the creation of an implementation action plan. The expected duration of the exercise is 90 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge of how to effectively utilise data collection process for optimisation of energy systems and re-commissioning activities. Participants will learn how to create a realistic list of re-commissioning measures.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The lecture requires the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of Re-Co implementation plans, analysis of collected data and verification of achieved energy savings.

Key questions that will be addressed:

- What are the typical energy-saving measures triggered by Re-Co activities?
- What are the main techniques for continuous performance monitoring?
- What is the typical scope of Re-Co activities?
- Which data needs to be collected to assess on-site metering and control equipment?
- How Re-Co can be applied during the process of generation of EPC?
- What are the main benefits of combining two different activities (Re-Co and generation of EPC)?

References and recommended reading:

1. European Commission: The Smart Readiness Indicator (SRI) for rating smart readiness of the European building stock https://energy.ec.europa.eu/system/files/2022-04/SRI-Factsheet-v6_0.pdf
2. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
3. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
4. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
5. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
6. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
7. TIMEPAC D2.4 Report on the technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools
8. Waide P., Verbeke, S., Dourlens S., Decorme, R., Kubicki, S. (2023). Smart Readiness Indicator (SRI) - Provisional guidance on the implementation of the SRI. SRI support team: VITO (Belgium), Waide Strategic Efficiency Europe (Ireland), Research to Market Solution (France) and Luxembourg Institute of Science and Technology (Luxembourg)

4.2.14 Exercise 5: Calculating smart readiness indicator and extracting potential energy and flexibility measures from collected data - case study different types of buildings belonging to the educational sector

Short description of the exercise and learning outcomes:

This exercise provides examples of how to collect necessary data for the calculation of the SRI and how to further utilize that data for the extraction of potential energy and flexibility measures. An introduction to the exercise will include a short overview of the SRI methodology and the main steps of the SRI audit. The main elements of the assessment of smart-ready services (the level of smart functionality) within nine technical domains (heating, cooling, domestic hot water, ventilation, lighting, dynamic building envelope, electricity, electric vehicle charging, and monitoring and control) will be presented to the participants.

Participants will be divided into groups, and they will have to assess different buildings and calculate the SRI using both assessment methods: a detailed assessment method and a simplified assessment method. The simplified method (Method A) uses a reduced set of services, which requires less effort and expertise to conduct the assessment. It will be used as a baseline to compare the smart readiness of buildings assessed by different groups.

In the final stage of the exercise, the detailed method (Method B) will be utilized, and it will employ a use-case approach that focuses on the following end-users:

- Demand Side Management (DSM) aware facility manager
- Cost-conscious facility manager
- Sustainability supporting owner
- Informed tenant
- Informed ESCO
- Informed utility

A use-case approach is a methodology used to capture the potential benefits of a tested tool from the end-user's perspective. This includes a role-play exercise, and each group will have to act as potential users or beneficiaries of the SRI tool. In this phase, assessors will need to act as end-users and perform the SRI calculation while keeping in mind the main needs of the adopted end-user role. All comments that are entered into the SRI calculation spreadsheet will be used to extract potential energy efficiency and flexibility measures.

Competencies of the participant who successfully completes the learning module will include an understanding of the calculation of the smart readiness indicator, extracting potential energy and flexibility measures from collected data, reporting, monitoring, and verification of energy savings. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge about the calculation of SRI. Participants will learn how to extract potential energy and flexibility measures from collected data.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of metering plans, analysis of collected data and verification of achieved energy savings.

Key questions that will be addressed:

- What are the main steps of SRI calculation methodology?
- What measures can be extracted from the SRI?
- What are the main elements of efficient data collection?
- What are the key factors that influence energy performance and SRI rating?

References and recommended reading:

1. European Commission: The Smart Readiness Indicator (SRI) for rating smart readiness of the European building stock https://energy.ec.europa.eu/system/files/2022-04/SRI-Factsheet-v6_0.pdf
2. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
3. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
4. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
5. TIMEPAC D2.4 Report on the technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools
6. Waide P., Verbeke, S., Dourlens S., Decorme, R., Kubicki, S. (2023). Smart Readiness Indicator (SRI) - Provisional guidance on the implementation of the SRI. SRI support team: VITO (Belgium), Waide Strategic Efficiency Europe (Ireland), Research to Market Solution (France) and Luxembourg Institute of Science and Technology (Luxembourg).

4.2.15 Exercise 6: Data collection and calculation of sustainability indicators - case study municipal building

Short description of the exercise and learning outcomes:

Building energy certification is mandatory and aims to inform citizens about the level of energy efficiency of buildings. However, the upcoming European Directive on the energy efficiency of buildings will require the life-cycle Global Warming Potential (GWP) of new buildings to be calculated by 2030 under the Level(s) framework. This poses a challenge on combining Energy Performance Certificates (EPCs) and sustainability indicators to achieve a more comprehensive understanding of building performance beyond energy-related issues.

The exercise will explore how to apply Level(s) in the certification process of a municipal building, and participants will understand the basic concepts related to this process. Moreover, it is will include an overview of the sustainability indicators considered in Level(s) and how they can be integrated with EPCs to achieve a more comprehensive building performance assessment. By the end of the lecture, participants will be equipped with the knowledge and skills necessary to incorporate Level(s) into their certification process, thus contributing to promoting sustainable building practices.

The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is targeted towards individuals involved in evaluating energy performance in buildings or technical building systems, such as auditors, energy managers, facility managers, and EPC experts. Specifically, the exercise is tailored towards technicians responsible for assessing and monitoring the performance of municipal buildings.

Short CV of the envisioned lecturers:

Ainhoa Mata is an architect at the ETSAB-UPC (Escola Tècnica Superior d'Arquitectura de Barcelona - Universitat Politècnica de Catalunya), with a master's degree in building control and sustainable architecture from URL (Universitat Ramon Llull). She is also a lecturer at the Catalan Chamber of Architects. Since 2015, Ainhoa has been responsible for the buildings unit at ICAEN (Institut Català d'Energia), where her tasks include organising conferences, managing the register of energy efficiency certificates, and overseeing grants for energy efficiency in buildings. Before her role at ICAEN, Ainhoa worked in architectural offices, specialising in sustainable architecture. Her expertise lies in energy efficiency and sustainable architecture, and she is actively involved in promoting sustainable building practices and energy-efficient solutions in the built environment.

Marta Chàfer holds a PhD in engineering from a joint programme between the University of Perugia and the University of Lleida. She is also an architect (2017) from the University of Rovira i Virgili, and a building engineer (2010) from the University of Lleida. She is a co-author in the IPCC Working Group III, specifically in chapter 9 on Buildings. In 2022, she joined ICAEN to work on EU research projects. She actively contributes to creating new opportunities and preparing proposals within the framework of European and international R&D programmes.

Teaching methods and tools:

The exercise will be delivered in person and is designed to actively engage participants through theoretical explanations, discussions, and practical problem-solving related to sustainability indicators and their application in building design and evaluation.

Key questions that will be addressed:

- What are the sustainability indicators included in the Level(s) framework?
- How is the embodied energy of construction materials calculated, and why is it important for building sustainability?
- What criteria should be considered when selecting building materials, such as renewability, recoverability, and recyclability?
- What are some strategies for optimizing water consumption in buildings and reusing rainwater?
- How can building design address thermal, acoustic, and lighting comfort for occupants?
- What measures can be taken to adapt buildings to climate change impacts, such as drought, heavy rain, or extreme heat?

References and recommended reading:

1. European Commission: Level(s), European framework for sustainable buildings https://environment.ec.europa.eu/topics/circular-economy/levels_en

4.2.16 Exercise 7: Creation of the implementation action plan and presentation of results to the end-users

Short description of the exercise and learning outcomes:

In December 2021, the European Commission published its proposal for revising the Energy Performance of Buildings Directive (EPBD). This revision is a full recast, with many provisions either introduced or modified and covering a broad set of issues. The EPBD must be considered a pivotal element of the Fit for 55 Package as it is the key legislative tool to deeply renovate and fully decarbonise the building stock in a way that brings benefits to all citizens and protects the most vulnerable.

Although still under discussion, the directive introduces concrete steps targeting the full decarbonisation of the building stock. The proposed measures will increase the rate of renovation, particularly for the worst-performing buildings in each country.

The revised directive will modernise the building stock, making it more resilient and accessible. It will also support better air quality, the digitalisation of building energy systems and the roll-out of infrastructure for sustainable mobility. Crucially, the revised directive facilitates more targeted financing to investments in the building sector, complementing other EU instruments supporting vulnerable consumers and fighting energy poverty.

A key element is that the Directive would require EPC class G buildings to be renovated and improved to at least energy performance class F by 2027 and to at least class E by 2030, and the worst-performing residential buildings to at least class F by 2030 and to at least class E by 2033.

The exercise will provide a presentation of the EPBD recast in terms of renovation targets to be achieved in the National context. Besides, a comparison between the actual EPC scheme and the enhanced one will be provided, highlighting the level of information available for the creation of the renovation action plan needed. The presentation of case studies with energy and economic assessment of the planned renovation interventions will complement the exercise.

Finally, a discussion about implementation constraints and potentialities (quality of the building, quality of the EPC, architectural constraints, etc.) of such enhanced EPC scheme will be performed.

The expected duration of the exercise is 60 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge for efficient creation of the implementation action plan and presentation of results to the end-users.

Short CV of the envisioned lecturer:

Giovanni Nuvoli is a member of the Sustainable Energy Sector of the Piemonte Region staff since 1992. He evaluates regional and EU funded projects aimed at improving efficiency and renewable energy use. He was involved in the legislation process of transposing the EU Directive on energy performance (2002/91 EC and 20190/31 EU) into the Italian and regional laws. He is responsible for of the Piemonte's EPC repository (SIPEE) and for the regional thermal plants cadastre (CIT). He also collaborates in the drafting of the Regional Energy Plan for the energy efficiency sector with a specific target on energy savings, refurbishment and renovation of the building stock, residential and commercial. He works on the development of Smart Energy Communities and sustainable buildings design.

Teaching methods and tools:

The exercise requires the active participation of participants. It includes theoretical explanations, discussion solving real-life energy problems and presentation of case studies.

Key questions that will be addressed:

- What are the main targets and challenges that the new EPBD Directive will introduce?
- What are the key elements of the enhanced EPC?
- How to create an implementation action plan for the full decarbonization of the buildings?
- How to present the results of the renovation action plan to the end-users?

References and recommended reading:

1. Edifici altamente isolati come elemento indispensabile di smart cities, bilanciamento della rete e potenziale di accumulo per le rinnovabili (Knauf, Politecnico di Milano - https://bit.ly/3L2nCSV)
2. Portale Nazionale sulla Prestazione Energetica degli Edifici (PnPE2, https://pnpe2.enea.it)
3. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) COM/2021/802 final
4. Report Monitoraggio POR FESR 2014-2020 (https://bit.ly/3ymdZqz)
5. Strategia per la riqualificazione energetica del parco immobiliare nazionale (https://bit.ly/3mCutrL)

5 Training Scenario 3 - Advanced methods and tools for holistic energy renovation of buildings

5.1 Structure of the Training Scenario 3

Training Scenario 3 (TS3) aims to empower general building experts (professional certifiers, architects, contractors, energy agencies, facility managers, etc.) to integrate BIM technology with EPC. The current state of the art of BIM will be shown, as well as the possible interactions at the level of energy efficiency, sustainability, GIS and facility management. Training materials will be prepared to understand BIM technology and objectively present implementation challenges. The implementation will improve the generation of EPC, the design of the deep renovation of buildings and the connection with other specialities.

TS3 is organised into four teaching hours of training (in total 180 minutes) for the general building experts, which will be organised in the form of a webinar, and sixteen teaching hours of training (in total 720 minutes) held in-person for the professionals carried out by means of in-class lecture and exercises.

5.2 Envisioned lectures and exercises

Table 5 provides information about all lectures and exercises, with the indication of their duration, that will be delivered in the framework of the TS3. Also, it provides information from which TMs these lectures and exercises are extracted.

Table 5. Outline of the TS3

Training for the general building experts (webinar)		
Title of the lecture	Duration (min.)	Training Module
Strengths and weaknesses of the BIM models	25	TM1
The role of the BIM model in the deep renovation of existing buildings	15	TM1
Implement the BIM methodology in projects and organizations	15	TM1
Data extraction of the BIM model focused on EPC	25	TM1
How to use BIM models to generate EPC and analyse energy performance data	25	TM2
How to use 3D models in the framework of the EPC generation	25	TM4
Providing benefits for the end users by integrating different BIM models and calculating sustainability indicators (lighting, ventilation, HVAC systems, …) in the EPC	25	TM5
BIM and smart buildings, smart neighbourhoods and cities	25	TM8

Training for the professionals (in-class)		
Title of the exercise	Duration (min.)	Training Module
Exercise 1: Creating a realistic BIM model – case study educational building	90	TM1
Exercise 2: Data extraction from the BIM model	90	TM1
Exercise 3: Comparing modelled energy performance with an emphasis on measures	90	TM3
Exercise 4: Calculating energy savings based on BIM model	90	TM4
Exercise 5: Applying BIM to achieve sustainability throughout a building life cycle	90	TM5
Exercise 6: Use of BIM for facility management and preventive maintenance control	90	TM3
Exercise 7: Creating a realistic BIM model – case study municipal building	90	TM1
Exercise 8: BIM and GIS integration - value for Smart Cities	90	TM8

TS3 is therefore organised into eight theory lectures for the general building experts, and eight exercises for the professionals.

For each envisioned lecture and exercise of the TS3, a short description of learning content and expected outcomes, target groups, short CV of the envisioned lecturer, teaching methods and tools, and main references are provided from Section 5.2.1 to Section 5.2.16.

5.2.1 Strengths and weaknesses of the BIM models

Short description of the lecture and learning outcomes:

This lecture focuses on understanding the strengths and weaknesses of Building Information Modelling (BIM) models. Participants will learn how BIM can improve building performance, project coordination and decision-making, and the importance of data management and quality control in BIM models.

The first part of the lecture will cover the strengths of BIM, including its ability to improve accuracy in planning and design, its ability to improve project coordination and communication between construction teams, and its ability to improve efficiency in project management. Participants will also learn how BIM can improve decision-making and risk assessment in construction.

The second part of the lecture will address the weaknesses of BIM, including the complexity of the software and the need for specialised skills for its effective use, as well as the challenges in connecting applications and data management and quality control of BIM models. Participants will also learn how these weaknesses can be minimised by implementing effective data management and quality control processes.

Overall, this lecture provides participants with a solid understanding of the strengths and weaknesses of BIM models and how to use them effectively to improve performance and effectiveness in construction.

The expected duration of the lecture is 25 minutes.

Target groups:

The target group of the lecture includes professionals and experts in the construction industry, such as architects, engineers, contractors, developers, building owners and others interested in the use of BIM technology in the planning, design and construction of building projects.

BIM can also be useful for architecture, engineering and construction participants looking for a deeper understanding of BIM models and its use in the construction industry.

Furthermore, the lecture may be of interest to those involved in project management, decision making and strategic planning in the construction industry, as BIM technology can potentially to improve efficiency, collaboration and quality in project construction.

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations, discussions, solving real problems, as well as an explanation of workflows.

Key questions that will be addressed:

- What are the main strengths of BIM?
- How can BIM improve accuracy in the planning and design of construction projects?
- How can BIM improve project coordination and communication between construction teams?
- How can BIM improve efficiency in project management?
- How can BIM improve decision making and risk assessment in construction?
- What are the main weaknesses of Building Information Modelling (BIM)?
- How can we overcome the complexity of the software and the need for specialised skills to use it effectively?
- How can we address the challenges in data management and quality control of BIM models?
- What are the best practices for using BIM effectively in construction?
- How can the strengths and weaknesses of BIM models affect the efficiency and effectiveness of construction?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2018). EN 19650-1: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles
2. European Committee for Standardisation (CEN). (2018). EN 19650-2: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 2: Delivery phase of the assets
3. European Committee for Standardisation (CEN). (2020). EN 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 3: Operational phase of the assets

5.2.2 The role of the BIM model in the deep renovation of existing buildings

Short description of the lecture and learning outcomes:

This lecture focuses on the role of the BIM model in the deep renovation of existing buildings. Participants will learn about the methodologies and techniques for creating BIM models of existing buildings, as well as the software tools and processes for planning and executing deep renovations using BIM.

The first part of the lecture will present the concept of the deep renovation of buildings and discuss the challenges and opportunities associated when applying BIM. Attendees will learn about techniques for data collection and the creation of BIM models of existing buildings, as well as how to use these models to analyse the energy performance and efficiency of building systems.

The second part of the lecture will discuss the design and analysis processes of deep renovation using BIM. Attendees will learn how BIM models can be used to develop renovation strategies and to simulate different design options and cost assessments. Best practices for data management and collaboration in the deep renovation process will also be discussed.

Overall, this lecture provides attendees with a solid understanding of the BIM model's role in the deep renovation of existing buildings. They will acquire skills and knowledge that will enable them to use BIM effectively in the deep renovation process and improve the energy efficiency and sustainability of existing buildings.

The expected duration of the lecture is 15 minutes.

Target groups:

The target audience of the lecture includes a wide range of people interested in the construction and renovation of buildings, such as the following:

1. Architects and designers, to visualise the proposed changes to a building and how they can be easily shared with clients and other members of the construction team
2. Engineers, to assess and optimise the energy performance and efficiency of existing and proposed systems
3. Contractors, to improve coordination of the different stages of the project, to identify and resolve potential problems before they occur and to reduce the overall costs of the renovation
4. Owners and developers, to assess the energy performance and efficiency of existing buildings and to identify improvement opportunities that can result in long-term energy and cost savings

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations, discussions, solving real problems about deep renovation and the use of BIM technology. Furthermore, the most advanced workflows for modelling, design and energy analysis of a deep renovation will be described.

Key questions that will be addressed:

- What is a BIM model and how is it applied in the deep renovation of existing buildings?
- What are the main benefits of a BIM model in the renovation of existing buildings?
- What are the key challenges when using a BIM model in the renovation of existing buildings and how can they be overcome?
- How can a BIM model help to improve the energy efficiency of existing buildings during their renovation?
- How can a BIM model be used to improve project management and coordination between teams involved in the renovation of existing buildings?
- What is the BIM model's role in the communication and collaboration with building owners during the deep renovation process?
- How can a BIM model be used to ensure safety and compliance in the renovation of existing buildings?
- What are the best practices when implementing a BIM model in the deep renovation of existing buildings?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2018). EN 19650-1: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles
2. European Committee for Standardisation (CEN). (2018). EN 19650-2: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 2: Delivery phase of the assets
3. European Committee for Standardisation (CEN). (2020). EN 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 3: Operational phase of the assets

5.2.3 Implement the BIM methodology in projects and organizations

Short description of the lecture and learning outcomes:

This lecture aims to provide participants with the knowledge and skills needed to implement the Building Information Modelling (BIM) methodology in construction projects and organisations related to the construction industry.

This lecture will focus on the fundamental concepts of BIM, such as creating and managing 3D models, multidisciplinary coordination, information management and collaboration between the different construction professionals involved in a construction project.

It will also cover topics such as the implementation of BIM in different project lifecycle phases, the selection of BIM tools and technologies, change management and staff training, standardisation and normalisation of processes, and the evaluation of the benefits and return on investment of BIM implementation.

At the end of the lecture, participants will be prepared to lead the implementation of BIM in their organisations and projects, enabling them to improve the efficiency, quality and profitability of their construction projects.

The expected duration of the lecture is 15 minutes.

Target groups:

The target audience of the lecture includes a wide range of construction professionals and individuals interested in the implementation of the BIM methodology, such as the following:

1. Project managers and directors, to implement the BIM methodology into their organisation and how they can evaluate the results
2. Engineers and architects, to implement BIM methodology into their everyday work and how they can improve their performance
3. Contractors and subcontractors, to implement BIM methodology in their work and see how they can improve their efficiency
4. Policymakers and regulators, to establish policies and regulations that encourage the implementation of BIM methodology in construction projects

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modelling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations, discussions, an explanation of real implementation cases, as well as an explanation of tools and workflows for using BIM technology in projects and organisations.

Key questions that will be addressed:

- What are the fundamental concepts of BIM methodology and how are they applied in construction projects?
- How can BIM be implemented in different phases of the project lifecycle and what benefits can it offer in each phase?
- What tools and technologies are available for BIM implementation and how can the most suitable ones be selected for each project?
- How can change management and staff training be managed to ensure that BIM is implemented effectively in an organisation?
- How can BIM processes be standardised and normalised in an organisation and how can the return on investment of BIM implementation be evaluated?
- How can multidisciplinary collaboration and coordination between the different professionals involved in a construction project be encouraged through BIM methodology?
- How can information generated by the BIM methodology be used to improve the efficiency, quality and profitability of construction projects?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2018). EN 19650-1: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles
2. European Committee for Standardisation (CEN). (2018). EN 19650-2: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 2: Delivery phase of the assets

3. European Committee for Standardisation (CEN). (2020). EN 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 3: Operational phase of the assets

5.2.4 Data extraction of the BIM model focused on EPC

Short description of the lecture and learning outcomes:

In this lecture, the primary focus will be on the use of Building Information Modelling (BIM) to extract data for Energy Performance Certificates (EPCs) in building renovation projects. The lecture will cover the different types of data that can be extracted from a BIM model for EPCs, such as building geometry, materials, and equipment. Additionally, the lecture will address the challenges associated with data extraction from BIM models and strategies for overcoming them. Furthermore, the lecture will discuss the use of software tools and methodologies for processing the data extracted from BIM models for EPCs.

The importance of accuracy and reliability in the data extracted from BIM models for EPCs will also be highlighted, and guidance on how to ensure the accuracy and reliability of the data will be provided. Finally, the implications of using BIM for data extraction in building renovation projects will be discussed, including the potential benefits for energy savings and the challenges associated with integrating different BIM models and calculating sustainability indicators in the EPC.

Participants will better understand the types of data that can be extracted from BIM models for EPCs, as well as the importance of accuracy and reliability in the data.

The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for professionals in building renovation and energy performance assessment, including architects, engineers, energy consultants, and project managers. Additionally, the lecture is suitable for professionals involved in implementing EPCs, such as energy assessors and energy auditors.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- How can BIM be effectively utilized to extract accurate data for Energy Performance Certificates (EPCs) in building renovation projects?
- What are the potential advantages and drawbacks of implementing BIM for data extraction in building renovation projects, and what measures can be taken to overcome any challenges?

References and recommended reading:

1. TIMEPAC D2.1 Report on the technical specification of TDS 1. Guidelines for the generation of EPCs from BIM models

5.2.5 How to use BIM models to generate EPC and analyse energy performance data

Short description of the lecture and learning outcomes:

In this lecture, attendees will learn how Building Information Modelling (BIM) can be leveraged to enhance data collection and generation of Energy Performance Certificates (EPCs). The lecture will begin with an overview of the role of BIM models in the generation process and highlight the importance of accurate data collection for EPCs. It will cover different data types typically collected during EPC generation process, including building geometry, materials, and equipment.

The lecture will then delve into the specific ways BIM models can be used to collect and organise EPC-related data more efficiently and effectively. Attendees will learn about the software tools and methods available for processing the data collected during EPC generation using BIM models. Additionally, the benefits of using BIM models for EPC generation, such as improved accuracy, reduced costs, and increased speed will be addressed.

The lecture will provide practical insights into how BIM models can be used to streamline the generation process, making it easier for professionals to collect and analyse energy performance data. Through real-world examples and interactive discussions, attendees will gain a practical understanding of how to use BIM models to generate EPCs and analyse energy performance data. This will equip attendees with the skills and knowledge needed to implement successful energy renovation projects and comply with building regulations.

The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is designed for professionals who work in the field of building renovation and energy performance assessment. This includes architects, engineers, energy consultants, and project managers who are involved in energy renovation projects. Additionally, professionals who are responsible for the implementation of EPCs, such as energy assessors and energy auditors, can benefit from this lecture.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What are the challenges associated with generating EPC of buildings using traditional methods?
- How can BIM models streamline the process of analysing a building's energy performance?

References and recommended reading:

1. Hsieh, S.-H., Tsai, Y.-H. (2016). Process Modelling of a BIM-enabled Construction Inspection Approach with BPMN. International Conference on Innovative Production and Construction (IPC 2016)
2. TIMEPAC D2.1 Report on technical specification of TDS 1. Guidelines for the generation of EPCs from BIM models

3. Tsai, Y.-H., Hsieh, S.-H., Kang, S.-C. (2014). A BIM-Enabled Approach for Construction Inspection. International Conference on Computing in Civil and Building Engineering, 721-728. doi: 10.1061/9780784413616.090

5.2.6 How to use 3D models in the framework of the EPC generation

Short description of the lecture and learning outcomes:

The elaboration of the building model is not only the drawing of the building but it's the transposition of the geometrical technical components of the building (opaque envelope, transparent envelope and thermal bridges) as well as the building surroundings, allowing the proper calculation of the building energy performance.

There are many tools allowing the creation of buildings 3D models through a BIM approach but, regardless of the tool you intend to use, the very important lesson to learn is which part of the building envelope needs to be modelled, avoiding redundant or misleading information.

As an example, walls should be composed by layers, each of them characterised by thermo-physical properties; windows should be properly modelled, paying attention to their geometry; it is essential to properly model the zones and spaces, otherwise the EPC tool, whatever it would be, will never recognise the thermal zones for the energy modelling.

Integrating these characteristics from the architectural model creation would be advisable to avoid subsequent reworking and consequent errors.

During this lecture, an example of creating a building 3D model is provided through the use of a BIM tool, Revit, and the exchange of information with an EPC tool through IFC file is shown.

The lecture provides answers to the following questions:

- How to create the proper 3D model?
- How to set IFC properties?
- How to export IFC file?
- How to import and complete IFC file through EPC tool?

Competencies that the participants acquire will include understanding of the basic concepts related to the 3D modelling of the building envelope through a BIM approach and its interoperability with an energy simulation tool for EPC purposes. Participants will also acquire basic practical knowledge to set IFC properties and to export an IFC file.

The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (designers, auditors, energy managers, facility managers, EPC experts etc.), as well as for everyone else who wants to acquire basic knowledge for building 3D modelling for energy performance analysis.

Short CV of the envisioned lecturer:

Beatrice Soldi is a Building Engineer who has been working as a software analyst at Edilclima S.r.l. since May 2017. Her main responsibilities include the introduction of Building Information Modelling (BIM) methodology in calculation software, the creation of graphical inputs, and the implementation of sustainability calculations in accordance with technical standards. She is actively involved in working groups related to UNI 11337 (Building and civil engineering works - Digital management of informative processes). She has authored numerous technical publications and serves as a lecturer for various courses on how to use BIM for energy and acoustic calculations using IFC standards.

Teaching methods and tools:

Lecture with the active participation of participants through the use of a case study-approach. It includes a practical guideline for the elaboration of the 3D model of a building.

Key questions that will be addressed:

- How to properly model an opaque building component?
- How to properly model a building zone or space?
- How to set IFC properties?
- How to export an IFC file?

References and recommended reading:

1. Liebich, T. (2009). IFC 2x Edition 3 Model Implementation Guide (Version 2). buildingSMART International, Modeling Support Group. https://standards.buildingsmart.org/documents/Implementation/IFC2x_Model_Implementation_Guide_V2-0b.pdf
2. AUTODESK Inc. (2018). Revit IFC manual - Detailed instructions for handling IFC files. https://damassets.autodesk.net/content/dam/autodesk/draftr/2528/180213_IFC_Handbuch.pdf

5.2.7 Providing benefits for the end users by integrating different BIM models and calculating sustainability indicators (lighting, ventilation, HVAC systems, …) in the EPC

Short description of the lecture and learning outcomes:

This lecture focuses on integrating different BIM models and calculating sustainability indicators based on lighting, ventilation and HVAC systems to provide benefits to end users when generating the EPC. Participants will learn how to integrate different BIM models, such as the architectural model, structural model, energy simulation model, etc., to calculate energy performance indicators for lighting, ventilation and HVAC systems.

The course will include practical examples with software tools for integrating different BIM models and calculating energy performance indicators. At the end of the course, participants will have a solid understanding of how BIM models can be used for EPC generation, enhanced with the design of lighting, ventilation and HVAC systems. The expected duration of the lecture is 25 minutes.

Target groups:

The target audience of the lecture includes a wide range of professionals and interested parties, such as the following:

1. Building owners and facility managers, to improve the life quality of building occupants and reduce the building's carbon footprint
2. Engineers and architects, to use the information provided by BIM models and sustainability indicators to design more efficient lighting, ventilation and HVAC systems
3. Contractors and developers, to use the information provided by BIM models and sustainability indicators to optimise construction and reduce construction costs

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations, discussions, solving real problems, as well as an explanation of workflows for using BIM technology in projects and their connection with lighting, ventilation, HVAC systems and EPC generation.

Key questions that will be addressed:

- What types of BIM models are needed to calculate energy performance indicators for lighting, ventilation and HVAC systems?
- How is energy efficiency in buildings assessed and what methods are used to do so?
- What software tools are available for integrating different BIM models and calculating energy performance indicators?
- How can BIM models and energy performance indicators be used to benefit end-users in terms of energy efficiency?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2018). EN 19650-1: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles
2. European Committee for Standardisation (CEN). (2018). EN 19650-2: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 2: Delivery phase of the assets
3. European Committee for Standardisation (CEN). (2020). EN 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 3: Operational phase of the assets
4. ISO 15686-4: 2014. Building Construction — Service Life Planning — Part 4: Service Life Planning using Building Information Modelling

5.2.8 BIM and smart buildings, smart neighbourhoods and cities

Short description of the lecture and learning outcomes:

The lecture focuses on exploring the role of Building Information Modelling (BIM) in creating sustainable and energy-efficient buildings, neighbourhoods, and cities. This lecture will cover the integration of BIM models with smart technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Building Automation and Control Systems (BACS) to create smart buildings and cities.

The lecture will delve into the concept of smart buildings and how BIM models can be used to optimize the building's energy consumption, including lighting, ventilation, and HVAC systems. It will also cover how BIM models can be used to analyse and monitor the building's performance, including real-time data collection and analysis of energy usage.

Moreover, the lecture will discuss the use of BIM models in creating smart neighbourhoods and cities, highlighting the advantages of using BIM models in urban planning and development. It will cover how BIM models can be used to integrate various sustainability indicators such as carbon footprint, water usage, and waste management to create sustainable and liveable communities.

Overall, this lecture will provide participants with an in-depth understanding of the role of BIM models in creating smart buildings, neighbourhoods, and cities, and the benefits of integrating BIM models with smart technologies to create more sustainable and energy-efficient built environments. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture targets professionals and participants in the fields of architecture, engineering, construction management, and urban planning, who are interested in staying updated with the latest trends and technologies in sustainable and energy-efficient building design and urban development.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What are the benefits of using BIM models in creating smart buildings, neighbourhoods, and cities?
- How can BIM models and smart technologies be used to support urban planning and development initiatives, such as the creation of smart neighbourhoods and cities?
- What are the potential impacts of using BIM models and smart technologies on the future of the building sector and the built environment as a whole?

References and recommended reading:

1. Ghaffarianhoseini, A., AlWaer, H., Ghaffarianhoseini, A., Clements-Croome, D., Berardi, U., Raahemifar, K., Tookey, J. (2018). Intelligent or smart cities and buildings: a critical exposition and a way forward. Intelligent Buildings International, 10(2), 122-129. https://doi.org/10.1080/17508975.2017.1394810
2. Goyal, L.K., Chauhan, R., Kumar, R., Rai, H.S. (2020). Use of BIM in Development of Smart Cities: A Review. IOP Conference Series: Materials Science and Engineering, 955(1), 012010. https://doi.org/10.1088/1757-899X/955/1/012010
3. Pal, A. K., Hsieh, S.-H. (2021). A trend review on BIM applications for smart cities. CRC Press EBooks. https://doi.org/10.1201/9781003191476-54

5.2.9 Exercise 1: Creating a realistic BIM model - case study educational building

Short description of the exercise and learning outcomes:

The "BIM to EPC guidelines" developed by TIMEPAC will be presented and discussed. As part of the exercise, attendees can create a realistic BIM model of an educational building selected from a pre-defined list. To enhance the learning experience of the exercise, advanced tools and methods for holistic energy renovation of buildings will be applied to the model.

Participants will utilize the data provided, including floor plans, elevations, sections, materials, and construction systems, as well as information on the building's mechanical and electrical systems, such as HVAC, lighting, and ventilation. Using these inputs, they will create a highly detailed and accurate BIM model of the selected educational building, incorporating advanced tools and methodologies to ensure the model's completeness and accuracy. Also, participants will be able to apply best practices and innovative strategies to achieve optimal energy performance while considering factors such as cost-effectiveness, sustainability, and occupant comfort.

The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is specifically targeted towards professionals who are involved in the fields of building renovation and energy performance assessment. This includes architects, engineers, energy consultants, and project managers who are interested in staying up-to-date with the latest developments and technologies in these areas. In addition, professionals responsible for implementing EPCs, such as energy assessors and building inspectors, can also benefit from attending this lecture.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The exercise requires the active participation of participants. It includes theoretical explanations, a discussion on how to solve real-life energy problems and a presentation of case studies.

Key questions that will be addressed:

- What is the purpose of using BIM models for energy renovation, and what are some of the benefits and challenges associated with this approach?
- How can BIM models be used to facilitate communication and collaboration among different stakeholders in energy renovation projects, such as architects, engineers, and building owners?

References and recommended reading:

1. TIMEPAC D2.1 Report on the technical specification of TDS 1. Guidelines for the generation of EPCs from BIM models

5.2.10 Exercise 2: Data extraction from the BIM Model

Short description of the exercise and learning outcomes:

The exercise aims to identify and collect relevant information from the BIM model of a building. A BIM model is a detailed digital representation of a building that includes information about its geometry, components, materials, systems and construction processes.

To extract data from the BIM model, specialised software tools are used to access the model information in a structured and automated way. Software tools may vary depending on the type of information required and the complexity of the BIM model.

An explanation will be given on how the following data can be extracted from the BIM model:

- Geometric information: such as the location, dimensions and shape of building elements like walls, ceilings, floors, doors and windows
- Material information: such as the type, quantity and properties of the materials used in the construction of the building
- System information: such as the location and specifications of HVAC systems

Extracting data from the BIM model is a highly valuable technique for many professionals involved in the construction, maintenance and management of buildings. Architects will be able to use the information extracted from the BIM model to optimise building design and improve energy efficiency. Engineers will design more accurate and efficient mechanical and electrical systems. Building owners and managers can use the information to plan maintenance and upgrades of building systems.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience for the BIM model data extraction exercise may include the following groups:

1. Construction and engineering professionals: including architects, mechanical and electrical engineers, contractors and other professionals involved in the design, construction and maintenance of buildings
2. Building owners and managers: including commercial and residential building owners, property managers, facility managers and anyone else responsible for the management and maintenance of buildings
3. Regulators and local authorities: including government agencies, planning committees and other bodies responsible for setting and enforcing construction and energy efficiency standards for buildings
4. Manufacturers and material suppliers: including manufacturers of building materials, suppliers of mechanical and electrical systems, and other suppliers of construction-related products and services

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The following steps will be used for training:

1. Software training: Extracting data from the BIM model requires the use of specialised software. Therefore, users should be trained in the use of BIM modelling software tools, such as Open BIM Quantities and others
2. Case studies: Users will study examples of BIM model data extraction to understand how this technique can be applied in real projects

Key questions that will be addressed:

- What specific data should be extracted from the BIM model?
- Which BIM model data extraction software and tools will be used?
- How will the data be extracted from the BIM model?
- How will the data extracted from the BIM model be used?
- How will the data extracted from the BIM model be stored and managed?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2018). EN 19650-1: Organization and digitization of information about buildings and civil engineering works, including building

information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles
2. European Committee for Standardisation (CEN). (2018). EN 19650-2: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 2: Delivery phase of the assets
3. European Committee for Standardisation (CEN). (2020). EN 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Information management using building information modelling - Part 3: Operational phase of the assets

5.2.11 Exercise 3: Comparing modelled energy performance with an emphasis on measures

Short description of the exercise and learning outcomes:

This exercise is a practical activity designed to enable participants to evaluate and compare the modelled energy performance of buildings, identify potential performance gaps and propose measures to improve the energy efficiency of buildings.

Once the differences in performance have been identified, participants should propose measures to improve the energy efficiency of buildings and compare the costs and benefits of each proposed measure.

This exercise will improve their data analysis and presentation skills and will allow them to understand how energy efficiency measures can improve building performance.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of the exercise addresses the following groups:

1. Construction and engineering professionals: including architects, mechanical and electrical engineers, contractors and other professionals involved in the design and construction of buildings
2. Building owners and managers: including commercial and residential building owners, property managers, facility managers and anyone else responsible for the management and maintenance of buildings
3. Regulators and local authorities: including government agencies, planning committees and other bodies responsible for setting and enforcing construction and energy efficiency standards for buildings

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The following steps will be used for training:

1. Training in energy simulation software (CYPETHERM EPlus) and improvement measures (CYPETHERM Improvements Plus).
2. Case studies: Users will study simulation examples and improvement measures to understand how this technique can be applied in real projects.

Key questions that will be addressed:

- How can the modelled energy performance of two buildings be assessed and compared?
- What tools and techniques can be used to analyse the modelled energy performance results and detect possible performance gaps between two buildings?
- What measures can be proposed to improve the energy efficiency of buildings identified with performance gaps and how can the costs and benefits of each proposed measure be compared?
- How can findings and recommendations be effectively presented in a detailed report?

References and recommended reading:

1. CYPETHERM EPlus. User's manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf
2. International Organization for Standardization (ISO). (2017). ISO 52000-1:2017. Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures

5.2.12 Exercise 4: Calculating energy savings based on BIM model

Short description of the exercise and learning outcomes:

The energy savings calculation exercise based on a BIM model involves using a building information model (BIM) to analyse the energy consumption of a building and determine how it can be reduced. To carry out this exercise, the following steps can be followed:

1. Create a BIM architectural model of the building in question using specialised software. This model should contain detailed information on the geometry, materials and systems of the building
2. Generate an analytical model from the BIM architectural model
3. Use energy simulation software to analyse the energy consumption of the building in its current state
4. Identify areas of the building where energy improvements can be made
5. Use the BIM model to simulate the proposed changes and determine the energy savings that can be achieved
6. Present the results of the analysis to the client or building owner so that they can make informed decisions on the implementation of energy improvements

In short, the energy savings calculation exercise based on a BIM model involves the use of a detailed model of the building to identify areas for energy improvement and simulate the proposed changes to determine the energy savings that can be achieved.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of the exercise addresses the following groups:

1. Construction and engineering professionals: including architects, mechanical and electrical engineers, contractors and other professionals involved in the design and construction of buildings

2. Building owners and managers: including commercial and residential building owners, property managers, facility managers and anyone else responsible for the management and maintenance of buildings

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The following steps will be used for training:

- Training in software for the architectural BIM model (CYPE Architecture), analytical model (Open BIM Analytical Model), energy simulation (CYPETHERM EPlus) and improvement measures (CYPETHERM Improvements Plus)
- Case studies: Users will study simulation examples and improvement measures to understand how this technique can be applied in real projects

Key questions that will be addressed:

- What kind of information should be included in a BIM architectural model to carry out the energy savings calculation?
- How is energy simulation software used in the energy savings calculation exercise and what results can be obtained?
- What are the main areas of the building to consider when energy improvements are identified?
- What types of changes can be simulated in the BIM model to determine the energy savings that can be achieved?
- How can the results of the analysis be effectively presented to the client or building owner?
- How can the results of energy savings calculations based on a BIM model help building owners and designers make informed decisions on energy improvements?

References and recommended reading:

1. CYPE Architecture. User’s Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. CYPETHERM EPlus. User’s manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf

5.2.13 Exercise 5: Applying BIM to achieve sustainability throughout a building life cycle

Short description of the exercise and learning outcomes:

This exercise focuses on sustainable design practices, building life cycle management, and how to use BIM to improve energy efficiency and environmental sustainability throughout all stages of a building's life cycle.

The exercise will cover the fundamental concepts of sustainability in construction and how they apply to the design and construction of buildings. Participants will learn how to use BIM to model and visualise a building's construction system, energy system and environmental system, and how they can be optimised to improve energy efficiency and reduce environmental impact.

In the exercise, the software tools available for the application of BIM to sustainability and life cycle management of buildings will be covered. At the end of the exercise, participants will have a solid understanding of how to apply BIM to achieve sustainability throughout the life cycle of a building and how benefits can be provided in terms of energy efficiency, costs and environmental impact.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of the exercise addresses the following groups:

1. Construction and engineering professionals: including architects, mechanical and electrical engineers, contractors and other professionals involved in the design and construction of buildings
2. Building owners and managers: including commercial and residential building owners, property managers, facility managers and anyone else responsible for the management and maintenance of buildings

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The following steps will be used for training:

- Training in software for the architectural BIM model (CYPE Architecture), analytical model (Open BIM Analytical Model), energy simulation (CYPETHERM EPlus) and bills of quantities (Open BIM Quantities)
- Case studies: Users will study examples of sustainability with the building's energy analysis and bill of quantities, including a life cycle analysis of materials

Key questions that will be addressed:

- What is BIM and how can it be used to achieve sustainability throughout the life cycle of a building?
- How can BIM be used to optimise energy efficiency and reduce the energy consumption of a building?
- How can BIM help reduce the environmental impact of construction?
- What are the challenges associated with implementing BIM to achieve sustainability in construction?

References and recommended reading:

1. CYPE Architecture. User’s Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. CYPETHERM EPlus. User’s manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf

5.2.14 Exercise 6: Use of BIM for facility management and preventive maintenance control

Short description of the exercise and learning outcomes:

The exercise is a practical activity designed to help participants understand how Building Information Modelling (BIM) is used for facility management and planned preventative maintenance in buildings.

In this exercise, participants will analyse an existing building and create a detailed BIM model of the building. Participants will use BIM modelling tools to add facility and equipment information to the building geometry.

Once the BIM model has been created, participants will use facility maintenance management software tools to import the BIM model and link facility and equipment information to the corresponding locations in the model.

Participants will also learn how to use the BIM model for facility management, including space assignment, asset management, scheduling of cleaning and maintenance tasks, and troubleshooting.

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of this exercise consists of professionals and experts in the field of facility management and preventive maintenance, as well as those who are interested in learning about the use of BIM (Building Information Modelling) for planned preventive maintenance and facility management. This may include engineers, architects, contractors, facility managers, maintenance managers, building owners, as well as participants and academics interested in the subject.

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The following steps will be used for training:

- Training in software for the architectural BIM model (CYPE Architecture), maintenance model via BIMserver.center and Open BIM Quantities
- Case studies: Users will study simulation examples and improvement measures to understand how this technique can be applied in real projects

Key questions that will be addressed:

- How can we create a detailed BIM model of an existing building and add facility and equipment information to the model?
- How can facility maintenance management software tools be used to import the BIM model and link facility and equipment information to the corresponding locations in the model?

References and recommended reading:

1. CYPE Architecture. User’s Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf

2. CYPETHERM EPlus. User's manual - Modelling and simulation of buildings with EnergyPlus™. version 22.2 https://www.cype.net/documents_en/manuals/termint_09.pdf

5.2.15 Exercise 7: Creating a realistic BIM model - case study municipal building

Short description of the exercise and learning outcomes:

The exercise will present and discuss the "BIM to EPC guidelines" developed by TIMEPAC, with a focus on their application in energy renovation projects for municipal buildings. Through an exercise, participants can apply their knowledge and skills by creating a realistic BIM model for a municipal building. The building should be a real-world example and be sufficiently complex to demonstrate the participants' proficiency in using advanced methods and tools for holistic energy renovation. Participants will develop a detailed and accurate BIM model using the data provided in the lecture, including floor plans, elevations, sections, materials, constructive systems, and the building's mechanical and electrical systems (including HVAC, lighting, and ventilation) of the selected building. The aim is to produce a model that can support a comprehensive energy renovation plan, and attendees will be encouraged to use advanced tools and methodologies to achieve this.

The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is specifically targeted towards professionals who are involved in the fields of building renovation and energy performance assessment. This includes architects, engineers, energy consultants, and project managers who are interested in staying up-to-date with the latest developments and technologies in these areas. In addition, professionals responsible for implementing EPCs, such as energy assessors and building inspectors, can also benefit from attending this lecture.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The exercise with active participation of participants. It includes theoretical explanations, discussion solving real-life energy problems and presentation of case studies.

Key questions that will be addressed:

- What is the purpose of using BIM models for energy renovation, and what are some of the benefits and challenges associated with this approach?
- How can BIM models be used to facilitate communication and collaboration among different stakeholders in energy renovation projects, such as architects, engineers, and building owners?

References and recommended reading:

1. TIMEPAC D2.1 Report on technical specification of TDS 1. Guidelines for the generation of EPCs from BIM models

5.2.16 Exercise 8: BIM and GIS integration - value for Smart Cities

Short description of the exercise and learning outcomes:

This exercise aims to combine the information and capabilities of Building Information Modelling (BIM) and Geographic Information Systems (GIS) to improve the planning and management of cities.

This exercise involves the integration of BIM and GIS data and models to provide a comprehensive view of the city, including detailed information about buildings, infrastructure and public spaces. This can help urban planners make informed decisions about the planning, design and management of the city.

The main steps of the BIM and GIS integration exercise for smart cities include the following:

1. BIM and GIS data collection and storage: This includes the collection of detailed data on the city's infrastructure, buildings and public spaces. This data is stored in a central database
2. BIM and GIS data integration: BIM and GIS data are integrated to provide a complete view of a city area. This is done by linking BIM data with GIS data to create a 3D city model
3. Analysis and simulation: Once the city model has been created, analyses and simulations can be carried out to assess the impacts of different urban planning and building design scenarios in the city
4. Decision-making: the results of analyses and simulations are used to make informed decisions on city planning, design and management

The expected duration of the exercise is 90 minutes.

Target groups:

The target audience of the exercise addresses the following groups:

1. Construction and engineering professionals: including architects, mechanical and electrical engineers, contractors and other professionals involved in the design and construction of buildings
2. Building owners and managers: including commercial and residential building owners, property managers, facility managers and anyone else responsible for the management and maintenance of buildings
3. Regulators and local authorities: including government agencies, planning committees and other bodies responsible for setting and enforcing construction and energy efficiency standards for buildings

Short CV of the envisioned lecturer:

Benjamín González is an Industrial Engineer who graduated from the Polytechnic University of Valencia (Spain) and holds an MBA from UNED. He currently serves as the Corporate Development Director at CYPE. With a career spanning since 2003 at CYPE, he has played a key role in developing CYPE's thermal study suite, overseeing the calculation of thermal loads and HVAC systems, as well as compliance with thermal regulations in Spain, France, Portugal, and Morocco. He has also been involved in projects related to the acoustic and energy calculations of buildings using EnergyPlus. In recent years, he has been actively promoting research project initiatives, particularly in the integration of thermal models with the BIM (Building Information Modeling) workflow.

Teaching methods and tools:

The following steps will be used for training:

- Training in software for the GIS model with Open BIM Site and the BIM model with CYPE Architecture. Subsequently, they will be visualised and managed in BIMserver.center.
- Case studies: Users will study examples of GIS and BIM models to understand how this technique can be applied in real projects.

Key questions that will be addressed:

- What is BIM and what is GIS?
- How are BIM and GIS integrated in smart cities?
- What are the benefits of BIM and GIS integration in smart cities?
- What are the challenges associated with BIM and GIS integration, and how can they be addressed?

References and recommended reading:

1. CYPE Architecture. User's Manual - 3D architectural modelling software, specifically designed for multidisciplinary collaboration https://www.cype.net/documents_en/manuals/cype_architecture_09.pdf
2. International Organization for Standardization (ISO). (2021). ISO/TS 19166:2021 Geographic information - BIM to GIS conceptual mapping (B2GM)

6 Training Scenario 4 - Exploitation of EPC for local, regional and national energy planning

6.1 Structure of the Training Scenario 4

Training Scenario 4 (TS4) offers comprehensive training in statistical analysis of Energy Performance Certificate (EPC) databases, with the goal of leveraging the vast building stock database for benchmarking initiatives. This training equips participants with the skills to create energy renovation plans at both the individual building scale and broader building stock levels, such as neighbourhood, district, or city levels. The training materials cover the workflow of statistical analysis on EPC databases, quality control activities for EPC data, and the utilization of building typologies for benchmarking activities and the development of renovation plans.

TS4 is organised into four teaching hours of training (in total 180 minutes) for the general building experts, which will be organised in the form of a webinar, and sixteen teaching hours of training (in total 720 minutes) held in-person for the professionals carried out by means of exercises.

6.2 Envisioned lectures and exercises

Table 6 provides information about all lectures and exercises, with the indication of their duration, that will be delivered in the framework of the TS4. Also, it provides information from which TMs these lectures and exercises are extracted.

Table 6. Outline of the TS4

Training for the general building experts (webinar)		
Title of the lecture	Duration (min.)	Training Module
Introduction to national and EU legislation and goals	25	TM8
Identification and collection of relevant data from EPC databases to map the energy status of the building stock	25	TM7
Tips and control activities on the EPC data to evaluate the reliability of certificate information	25	TM9
Data clustering techniques (building typology) to define representative buildings	25	TM7
Overview of building stock energy models using EPC data as a support tool	20	TM8
Application of a bottom-up model to predict the building energy demand at different scales	20	TM8
Creation of a renovation roadmap – link to the Renovation Passport	20	TM10
Energy saving assessment in building stock deep renovation scenarios through EPC data	20	TM4

Training for the professionals (in-class)		
Title of the exercise	Duration (min.)	Training Module
Exercise 1: Extraction of relevant EPC data for energy large-scale analysis	90	TM7
Exercise 2: Creation of clusters for the building typologies definition	120	TM7
Exercise 3: Application of EPC data quality checking procedure	90	TM9
Exercise 4: Statistical analysis to generate representative buildings (archetypes)	120	TM8
Exercise 5: Application of a bottom-up model to predict the building energy demand at different scales	120	TM8
Exercise 6: Transformation of EPC data and other data into Renovation Passport for the deep renovation of the building - case study residential building	90	TM10
Exercise 7: Application of recommended energy efficiency measures for the creation of the building stock renovation scenarios	90	TM4

TS4 is therefore organised into eight theory lectures for the general building experts, and seven exercises for the professionals.

For each envisioned lecture and exercise of the TS4, a short description of learning content and expected outcomes, target groups, a short CV of the envisioned lecturer, teaching methods and tools, and main references are provided from Section 6.2.1 to Section 6.2.15.

6.2.1 Introduction to national and EU legislation and goals

Short description of the lecture and learning outcomes:

This lecture provides an overview of the legislative context and requirements for the deep renovation of the EU building stock, which has been included in National Energy and Climate Plansand National Long-Term Renovation Strategies. However, the primary focus will be on Slovenia, and the lecture will provide comprehensive insights into the national policy instruments, major barriers, and future challenges. Slovenia has adopted a long-term energy renovation strategy, which defines a comprehensive set of measures to decarbonize the national building stock until 2050. The two most ambitious goals of the Slovenian NECP regarding buildings are to reduce greenhouse gas emissions in buildings by at least 70%, and for renewable energy sources to account for at least two-thirds of energy use in buildings by 2030. According to the Long-term energy renovation strategy, 74% of single-family homes and 91% of multi-apartment buildings should be renovated. The 2050 vision is to come close to net-zero emissions in the building sector by using low-carbon and renewable materials in renovation and by focusing on heating with renewable technologies.

The lecture will also provide an overview of activities conducted in the framework of the project Concerted Action EPBD (CA EPBD). It deals with various elements of the Energy Performance of Buildings Directive (EPBD) and aims to contribute to the reduction of energy use in European buildings through the exchange of knowledge and best practices in the field of energy efficiency and energy savings between all 27 EU Member States, plus Norway.

The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for general building experts, public authorities and energy agencies.

Short CV of the envisioned lecturer:

Erik Potočar works at the Energy Directorate at the Ministry of the Environment, Climate, and Energy. He holds a Bachelor of Science degree in Mechanical Engineering and has also earned a Master's Degree from the Faculty of Mechanical Engineering, specialising in wind turbines. With expertise in energy certificates, Erik has played a key role in implementing this measure at the governmental level. He has successfully managed multiple studies, strategies, and international projects on a European scale, including those related to energy efficiency, renewables, and innovative energy technologies, such as the IEE and FP programs. In his current role at the Ministry of Infrastructure, Erik is responsible for the implementation of Renewable Energy Sources (RES), Energy Efficiency Directive (EED), and Energy Performance of Buildings Directive (EPBD) measures.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and an overview of the legislative context and requirements for the deep renovation of the EU building stock.

Key questions that will be addressed:

- What are key measures that are envisioned in NECPs for the improvement of the energy performance of existing buildings?
- What are the key energy policy challenges connected with the deep renovation of buildings?
- What are the main challenges connected with the implementation of the EPBD?

References and recommended reading:

1. Long-term renovation strategies https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en
2. National energy and climate plans https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en
3. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) COM/2021/802 final

6.2.2 Identification and collection of relevant data from EPC databases to map the energy status of the building stock

Short description of the lecture and learning outcomes:

In this lecture, the primary focus is on identifying and collecting relevant data from EPC databases, which is a crucial step in mapping the energy status of the building stock. The lecture will cover different types of data available in EPC databases and the techniques used for data extraction. The challenges and limitations associated with using EPC data to map the energy status of the building stock will also be discussed, including issues related to data quality, reliability, and the need for data standardization and harmonization to facilitate data collection and analysis.

The lecture will also provide an overview of data visualization techniques, including the use of GIS and other mapping tools to create energy maps. Additionally, the importance of collaboration and data sharing among different stakeholders involved in large-scale building renovation programmes, including local and national governments, energy companies, and building owners, will be highlighted. The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for public authorities and energy agencies.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What types of data are available in EPC databases, and how can this data be used to map the status of the building stock?
- How EPC data can be integrated with other data sources to have a comprehensive view of the status of the building stock?
- What techniques and tools are available for visualizing and analysing EPC data to inform decision making in building renovation?

References and recommended reading:

1. TIMEPAC D2.5 Report on the technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

6.2.3 Tips and control activities on the EPC data to evaluate the reliability of certificate information

Short description of the lecture and learning outcomes:

In order to provide an accurate picture of the building's energy performance, it is necessary to focus on the quality of Energy Performance Certificates and the reliability of their information. This lecture gives participants a thorough overview of the methods (tips and control activities) for assessing the accuracy of EPC. The following factors are reviewed, contributing to EPC data's accuracy and reliability: sustainability indicators, data interoperability, database control activities, cost adaptation, and independent control reinforcement. The EPC data types and the variables affecting this data's correctness are covered. Knowledge is also provided on the numerous control activities that can be used to assess the reliability and consistency of EPC data, including site visits, energy audits, and data consistency and accuracy assessments.

At the end of the lecture, participants will learn about the EPC reliability criteria activities and develop the skills and knowledge necessary to guarantee the accuracy of EPC data. More particularly, the primary outcomes of the lecture are:

- Recognize the significance of quality controls for EPC data
- Determine the elements that may have an impact on the reliability of EPC data
- Use tips and control activities to assess the accuracy of EPC data
- Create plans to increase the EPC data's accuracy

The expected duration of the lecture is 25 minutes.

Target groups:

The lecture is intended for public authorities and validation bodies, and everyone involved in evaluating the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as who wants to acquire basic knowledge for efficient data collection and analysis.

Short CV of the envisioned lecturer:

Mamak P. Tootkaboni is a research fellow at Politecnico di Torino, Department of Energy. She holds a PhD in Energetics from Politecnico di Torino, and her research focuses on energy efficiency, climate resilience, building energy performance modelling, future weather data creation, adaptation and mitigation to climate change, and statistical analysis. She has authored several scientific articles published in international and Italian journals and conferences, showcasing her expertise in the field of building physics and energy systems. Mamak P. Tootkaboni's work contributes to advancing the understanding and application of sustainable and resilient building practices in the face of climate change challenges.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations, discussion, investigation of different tips and control activities for the EPC evaluation procedure, preparation of control plans, and analysis of collected data in the addressed EPC.

Key questions that will be addressed:

- What are some of the elements that could impact the reliability of EPC data?
- What tips and control activities can be employed to assess the validity of EPC data?
- How are inconsistencies in EPC data found and fixed?
- What steps must be taken to integrate quality checks for EPC data into building energy performance?
- What obstacles must be overcome to guarantee the accuracy of EPC data?
- How can the practical accuracy of EPC data be increased?

References and recommended reading:

1. Arcipowska, A., Anagnostopoulos, F., Mariottini, F., Kunkel, S. (2015). *Energy Performance Certificates across the EU*. https://www.researchgate.net/publication/314151888.
2. Durier, F., Geissler, S., Wouters, P. (2017). Source book for improved compliance of Energy Performance Certificates (EPCs) of buildings. QUALICHeCK project (www. qualicheckplatform.eu).
3. European Parliament. (2010). Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0031&from=EN.
4. European Parliament. (2018). Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=IT.
5. Marinosci, C., Morini, G.L. (2014). Check-in and control activities on the energy performance certificates in Emilia-Romagna (Italy). *Energy Procedia*. Elsevier Ltd, 434–442. https://doi.org/10.1016/j.egypro.2014.01.047

6.2.4 Data clustering techniques (building typology) to define representative buildings

Short description of the lecture and learning outcomes:

The building archetypes are crucial elements for the energy performance assessment of the building stock. The uncertainties related to the urban building energy model (UBEM) regarding the collection of data are an open issue. The creation of a national or regional building archetypes library or building typology matrix plays an important role in large-scale energy analysis especially to reduce this uncertainty. It means identifying per each climatic zone the adequate number of average buildings to cover the entire building stock. Archetype buildings are virtual buildings representative of the average thermophysical properties and characteristics of the cluster to which they are referred.

This lecture is based on assigning to an urbanised area real or theoretical residential and non-residential building, with known characteristics and energy indicators to assess the energy and environmental performance at a large scale. The main clusters recognised by the scientific community (climatic zone, building use category, construction periods, building size and shape, and other KPIs) will be discussed. The sources of data (local, regional, or national databases, statistical surveys, technical standards) to collect the information to create the clusters will be introduced. Among the data sources, the EPC database will be considered as the main source.

The skills and knowledge expected at the end of the lectures include identifying the clusters to group buildings with similar thermophysical properties of the opaque and transparent building envelope and comparable technical building systems characteristics. Basic knowledge of mathematics and building physics is required.

The expected duration of the lecture is 25 minutes.

Target groups:

This lecture is dedicated to research bodies, policymakers, and public administrations willing to cluster the building stock to create the building archetypes to reduce the uncertainties related to urban building energy model development.

Short CV of the envisioned lecturer:

Matteo Piro graduated in Building Engineering at Politecnico di Torino with a thesis based on the methodologies and tools to assess urban energy and environmental performance. He is currently a PhD participant in Energetics at Politecnico di Torino – Department of Energy. The research topic is focused on methodologies and tools for the enhancement of urban-scale energy modelling through the reduction of input data uncertainties.

Teaching methods and tools:

The lecture will be conducted as a webinar. It involves the theoretical concepts and explanation preparatory to the exercise. The outcomes of several European projects (TABULA, EPISCOPE, and TIMEPAC) will be presented and discussed.

Key questions that will be addressed:

- What are the criteria behind the creation of the regional or national building typology matrix?
- Why does clustering assume a crucial role in large-scale energy analysis?
- Why can the criteria associated to the building typology matrix change from country to country?

References and recommended reading:

1. Ballarini, I., Corgnati, S. P., Corrado, V. (2014). Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273-284. https://doi.org/10.1016/j.enpol.2014.01.027.

2. Ballarini, I., Corrado, V. (2017). A New Methodology for Assessing the Energy Consumption of Building Stocks. Energies, 10, 1102. https://doi.org/10.3390/en10081102.
3. BUILD_ME. (2018). BUILD_ME: Towards a Low-Carbon Building Sector in the MENA Region - Building typology database. Retrieved November 26, 2022 https://www.buildings-mena.com/typologies.
4. Department of Energy (DOE) of United States of America. (2013). Prototype Building Models. Retrieved November 26, 2022 https://www.energycodes.gov/prototype-building-models.
5. European Committee for Standardisation (CEN). (2017). EN ISO 52000-1: Energy performance of buildings —Overarching EPB assessment — Part 1: General framework and procedures.
6. IEE-EPISCOPE Project. (2016). Retrieved November 26, 2022 http://episcope.eu.
7. TABULA WebTool. (2012). Retrieved November 26, 2022 https://webtool.building-typology.eu/#bm.

6.2.5 Overview of building stock energy models using EPC data as a support tool

Short description of the lecture and learning outcomes:

Different sources can be used to get information about the energy performance of national and regional building stocks. Among these sources, the Energy Performance Certificates (EPC) are promising since the information is mainly relying on investigations by energy experts and the number of EPCs issued since the past years is rather large, due to the implementation of the EPBD and its recast (Directives 2002/91/EC and 2010/31/EU).

The lecture is focused on presenting some approaches to exploit the EPC database as a support instrument to identify the energy performance of the building stock and to create building stock energy models. Some preconditions in the use of the database are drawn; it can be stated that the EPC database should have a homogeneous structure containing not only general but also detailed information about buildings and supply systems. In addition, the structure should be harmonised between the EU countries so that the developed energy model could be easily applied to each territory. In addition, it would also be important to verify the completeness of the information by means of a preliminary check of the data contained in the EPCs in order to pick out field data errors. At this regard, the lecture will take advantage from the outcomes of the lecture “Tips and control activities on the EPC data to evaluate the reliability of certificate information”, as a starting point to address the development of building stock energy models.

The skills and knowledge that are expected at the end of this lecture include the capability to select and apply proper methods to exploit the EPC data for carrying out building stock energy models.

The expected duration of the lecture is 20 minutes.

Target groups:

This lecture is dedicated to research bodies, policymakers, and public administrations willing to use the EPC database to perform data processing and statistical analysis useful to investigate the energy performance of building stocks.

Short CV of the envisioned lecturer:

Ilaria Ballarini holds a Master's Degree in Architecture and a PhD in "Technological Innovation for the Built Environment" from Politecnico di Torino in Italy. She is an Associate Professor in building physics and energy systems at the Department of Energy of Politecnico di Torino. She teaches in Bachelor and Master of Science degree programs in Architecture, Building Engineering, and Energy Engineering, and also leads the course on "Energy and Environmental Assessment of Building Stocks" in the PhD program on Energetics at Politecnico di Torino. Her primary research focuses on building physics and building energy systems, with expertise in energy modelling of buildings and building stocks, procedures and calculation methods for energy performance assessment and cost optimisation, energy audit and certification, and legislation and technical standards in the fields of energy and environment. She has participated in numerous EU research projects, national research projects, and research contracts and has authored over 100 scientific contributions, including papers published in national and international journals, conference proceedings, books, and monographs.

Teaching methods and tools:
The lecture will be conducted as a webinar. It involves theoretical concepts and examples. The outcomes of previous research studies will be used as supporting references (European projects / literature).

Key questions that will be addressed:

- What approaches can be followed to exploit EPCs for assessing the energy performance of building stocks?
- What are advantages and disadvantages in the use of EPC database of a source of data?
- What building stock energy models can be developed from information provided by EPCs?

References and recommended reading:

1. Ballarini, I., Corgnati, S.P., Corrado, V., Talà, N. (2011). Definition of building typologies for energy investigations on residential sector by TABULA IEE-project: application to Italian case studies. Proceedings of Roomvent 2011, Trondheim (Norway), 19-22 June 2011, ISBN: 978-825-1928-12-0
2. Ballarini, I., Corgnati, S.P., Corrado, V., Talà, N. (2011). Improving energy modelling of large building stock through the development of archetype buildings. In: driving better design through simulation. Proceedings of Building Simulation 2011, Sydney (Australia), 14-16 November 2011, pp. 8, Melbourne Victoria (AUS): IBPSA Australasia and AIRAH, ISBN: 978-0-646-56510-1
3. Ballarini, I., Corgnati, S. P., Corrado, V. (2014). Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273-284. https://doi.org/10.1016/j.enpol.2014.01.027
4. Ballarini, I., Corrado, V. (2017). A New Methodology for Assessing the Energy Consumption of Building Stocks. Energies, 10, 1102. https://doi.org/10.3390/en10081102
5. Loga, T., Diefenbach, N., et al. (2012). Use of Energy Certificate Databases as Data Source for National Building Typologies. TABULA Thematic Report N° 1. Darmstadt: Institut Wohnen und Umwelt GmbH https://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_TR1_D7_EPC-DataBase-Use.pdf

6.2.6 Application of a bottom-up model to predict the building energy demand at different scales

Short description of the lecture and learning outcomes:

According to the scientific literature, the building stock energy models are usually classified in function of two different methodological approaches: the *top-down* and the *bottom-up* models. The top-down model is mainly used to predict a future scenario, based on situations from the past time series. The bottom-up, which is also the most common approach, is based instead on disaggregated and extensive data that are acquired by the developer beforehand through analytical, statistical or empirical means, in order to be able to proceed with the subsequent calculation phases.

This lecture will provide insights on the different bottom-up models used to predict the energy demand of building stocks, with a specific focus on the *engineering models*, like UBEMs (Urban Building Energy Models). Most of them exploit the concept of the building typology that can serve as a basis for analysing the energy balance of the regional/national building sector. The lecture will provide examples of application showing how building typologies (by means of a set of representative buildings) can be a helpful tool for modelling the energy consumption of building stocks and for carrying out energy refurbishment scenario analysis.

The quality of future model calculations will depend very much on the availability of statistical data. For reliable scenario analysis information is necessary about the current state of the building stock and about the current trends. The availability and regular update of the relevant statistical data will be an important basis for the development and evaluation of national climate protection strategies in the building sector. In this context, the EPC database and census data will serve as a basis to perform this activity.

The expected duration of the lecture is 20 minutes.

Target groups:

This lecture is dedicated to research bodies, policymakers, and public administrations willing to perform building stock energy assessments and energy refurbishment scenarios analysis useful for energy planning purposes.

Short CV of the envisioned lecturer:

Ilaria Ballarini holds a Master's Degree in Architecture and a PhD in "Technological Innovation for the Built Environment" from Politecnico di Torino in Italy. She is an Associate Professor in building physics and energy systems at the Department of Energy of Politecnico di Torino. She teaches in Bachelor and Master of Science degree programs in Architecture, Building Engineering, and Energy Engineering, and also leads the course on "Energy and Environmental Assessment of Building Stocks" in the PhD program on Energetics at Politecnico di Torino. Her primary research focuses on building physics and building energy systems, with expertise in energy modelling of buildings and building stocks, procedures and calculation methods for energy performance assessment and cost optimisation, energy audit and certification, and legislation and technical standards in the fields of energy and environment. She has participated in numerous EU research projects, national research projects, and research contracts and has authored over 100 scientific contributions, including papers published in national and international journals, conference proceedings, books, and monographs.

Teaching methods and tools:

The lecture will be conducted as a webinar. It involves theoretical concepts and examples.

Key questions that will be addressed:

- What are the main differences between building stock energy models?
- What are the main advantages and disadvantages in the use of *bottom-up* models?
- In which way can the *bottom-up* models be used to assess the energy performance of building stocks and to carry out energy renovation plans?
- How to assess the reliability of the building stock energy models?

References and recommended reading:

1. Abbasabadi, N., Ashayeri, M. (2019). Urban energy use modeling methods and tools: A review and an outlook. Building and Environment, 161, 106270
2. Ballarini, I., Corgnati, S. P., Corrado, V. (2014). Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273-284. https://doi.org/10.1016/j.enpol.2014.01.027
3. Ballarini, I., Corrado, V. (2017). A New Methodology for Assessing the Energy Consumption of Building Stocks. Energies, 10, 1102. https://doi.org/10.3390/en10081102
4. Ballarini, I., Corrado, V., Piro, M. (2021). Building Stock Energy Models and ICT Solutions for Urban Energy Systems. In: Del Giudice M.; Osello A. Handbook of Research on Developing Smart Cities Based on Digital Twins. chapter 22, p. 490-514, Hershey: IGI Global, ISBN13: 9781799870913, EISBN13: 9781799870937, doi: 10.4018/978-1-7998-7091-3.ch022

5. Corrado, V., Corgnati, S.P., Ballarini, I., et al. (2012). Application of Building Typologies for Modelling the Energy Balance of the Residential Building Stock. TABULA Thematic Report n° 2. Darmstadt: Institut Wohnen und Umwelt, ISBN: 978-3-941140-23-3 https://episcope.eu/fileadmin/tabula/public/docs/report/TABULA_TR2_D8_NationalEnergyBalances.pdf
6. Johari, F., Peronato, G., Sadeghian, P., Zhao, X., Widén, J. (2020). Urban building energy modeling: State of the art and future prospects. Renewable and Sustainable Energy Reviews, 128, 109902
7. Kavgic, M., Mavrogianni, A., Mumovic, D., Summerfield, A., Stevanovic, Z., Djurovic-Petrovic, M. (2010). A review of bottom-up building stock models for energy consumption in the residential sector. Building and Environment, 45, 1683-1697
8. Swan, L. G., Ugursal, V. I. (2009). Modeling of end-use energy consumption in the residential sector: A review of modeling techniques. Renewable and Sustainable Energy Reviews, 13, 1819-1835

6.2.7 Creation of a renovation roadmap – link to the Renovation Passport

Short description of the lecture and learning outcomes:

The renovation roadmap links energy efficiency measures with building maintenance, repair and improvement measures, instead of doing a deep renovation in one go. For example, if the roof needs substantial repair or renewal in around 10 years, this intervention will be combined with improving the energy efficiency and the installation of a PV system. The future development of a building needs to be discussed together with the owner, because adaptations to future needs such as changing the floor plans and adding extensions also need to be considered. In this context, answers to the following questions will be provided:

- What are the advantages of a renovation in one go and a staged renovation based on a renovation roadmap?
- Which data sources can be used?
- How to consider the general building condition (maintenance & repair, renewal)?
- How is the renovation roadmap connected with the building logbook?
- How to make sure that information about the roadmap and the interventions already done, are accessible, for example in case of a change in building ownership?
- How to deal with the long-term perspective of development of costs and technologies?
- How to make sure the implementation of energy-related improvement measures can be tracked?

Competencies of the participant who successfully completes the learning module will include understanding how to develop a renovation roadmap and the crucial aspects for effective implementation. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in building renovation. The lecture provides an overview of contents, procedures, and tools, and is also useful for technical and non-technical staff of the administration and companies owning large buildings.

Short CV of the envisioned lecturer:

Susanne Geissler is the owner and director of SERA Institute, an environmental engineer with a background in European law, and a trained energy advisor entitled to issue Energy Performance Certificates (EPCs). With years of experience, she has been actively involved in activities related to the implementation and further development of EPC-related concepts. She holds a doctoral degree in Sustainable Construction from the University of Natural Resources and Life Sciences Vienna, showcasing her expertise in the field of sustainable construction and energy performance assessment. Susanne Geissler's work focuses on promoting energy efficiency and sustainability in the built environment, with a particular emphasis on EPC-related practices and concepts.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- When and how to develop a renovation roadmap?
- What are the key elements to make the renovation roadmap effective?

References and recommended reading:

1. European Commission (2021): iBroad - Individual Building (Renovation) Roadmaps. EU Project 754045 under Horizon 2020 https://cordis.europa.eu/project/id/754045/de and https://ibroad-project.eu/results/reports/
2. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) COM/2021/802 final
3. Volt, Jonathan; Toth, Zsolt; Glicker, Jessica; De Groote, Maarten; Borragán, Guillermo; De Regel, Sofie et al. (2020): Definition of the digital building logbook: report 1 of the study on the development of a European Union framework for buildings' digital logbook. European Union: Publications Office https://data.europa.eu/doi/10.2826/480977

6.2.8 Energy saving assessment in building stock deep renovation scenarios through EPC data

Short description of the lecture and learning outcomes:

Proper modelling of the current energy performance of the existing building stock is necessary to pursue the great potential for energy savings related to its refurbishment. To this purpose, it is possible to perform statistical analysis of the data contained in the EPC repositories aimed at identifying reference buildings (or archetypes) and creating a Building Typology matrix.

The lecture describes the whole process, including the following three steps: (1) definition of a knowledge-base on the current state of the building stock, (2) investigation of refurbishment scenarios considering energy efficiency measures and retrofit rates, and (3) comparison of the achievable CO_2 reductions with the climate protection targets in short and middle term.

A focus is made on the EPC data that should be processed, such as climatic data, use categories, geometric features, envelope’s thermal characteristics and HVAC systems types, and energy performance indicators.

Basic knowledge of mathematics and building physics is required. The expected duration of the lecture is 20 minutes.

Target groups:

This lecture is addressed to research bodies, energy planners, policymakers, and public administrations willing to investigate building stock refurbishment trends and establish new energy plans.

Short CV of the envisioned lecturer:

Vincenzo Corrado is a civil engineer and a full professor of "Building Physics and Building Energy Systems" at Politecnico di Torino, Department of Energy. He has over 30 years of professional experience in research and development (R&D) in the fields of building physics, technical building systems, building energy performance modeling, energy audit and certification procedures, thermal comfort, indoor environmental quality, legislation, and technical standards related to energy and environmental issues. For more than 15 years, he has served as the Italian delegate of CEN TC 89 "Thermal performance of buildings and building components" and ISO TC 163 "Thermal performance and energy use in the built environment". He has also been a member of the working group of the

Italian Ministry of Economic Development entrusted with the national implementation of the European Directive on the energy performance of buildings. He has held scientific responsibility for numerous competitive national and international research projects awarded through a peer-review process. He is the author of over 300 scientific papers, didactic volumes, and editorials.

Teaching methods and tools:

The lecture will be conducted as a webinar. It involves the application of the theoretical concepts presented in the literature. The outcomes of some European projects (TABULA, EPISCOPE, and TIMEPAC) will be presented and discussed.

Key questions that will be addressed:

- What are the criteria behind the creation of the regional or national building typology matrix?
- What models can be adopted to perform energy refurbishment scenario analyses of the building stock?

References and recommended reading:

1. Ballarini, I., Corgnati, S. P., Corrado, V. (2014). Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273-284. https://doi.org/10.1016/j.enpol.2014.01.027
2. Ballarini, I., Corrado, V. (2017). A New Methodology for Assessing the Energy Consumption of Building Stocks. Energies, 10, 1102. https://doi.org/10.3390/en10081102
3. Corrado V., Ballarini I. (2016). Refurbishment trends of the residential building stock: analysis of a regional pilot case in Italy. Energy and Buildings, Towards an energy efficient European housing stock: monitoring, mapping and modelling retrofitting processes, vol. 132, 15 Nov. 2016, p. 91-106, ISSN: 0378-7788, https://doi.org/10.1016/j.enbuild.2016.06.022.
4. European Committee for Standardisation (CEN). (2017). EN ISO 52000-1: Energy performance of buildings —Overarching EPB assessment — Part 1: General framework and procedures
5. Piro, M., Ballarini. I., Corrado, V. (2020). Use of Energy Performance Certificates data repositories in Urban Building Energy Models. AiCARR Journal, vol. 64, n. 5, p. 44-48, ISSN: 2038-2723, October-November 2020, doi:10.36164/AiCARRJ.64.05.03

6.2.9 Exercise 1: Extraction of relevant EPC data for energy large-scale analysis

Short description of the exercise and learning outcomes:

Understanding energy use at a large scale can support the planning and the design of energy efficiency policies in cities; in fact, it allows one to observe existing profiles of energy use in cities and, consequently, to forecast and predict future urban energy demand and supply. Energy large-scale analysis can be performed by applying bottom-up models, generally built up from extensive data derived from different databases, such as the Energy Performance Certificate (EPC) database.

This exercise will present and apply a methodology to extract relevant data in the EPCs to perform large-scale energy analysis. The proposed methodology consists in:

1. Identification of the data required to perform the large-scale analysis (according to the tool selected to perform the analysis). Generally, these are geometrical information, data on the building envelope and technical building systems, and energy performance indicators
2. Verification of the availability of the required relevant data in the EPC scheme, and their extraction from the database
3. Derivation of missing data from other databases (i.e., regional or national databases), technical standards, and/or scientific community

The proposed methodology will be applied to the EPC database of one of the TIMEPAC country partners, and will consider a specific building stock (e.g., residential).

The skills and knowledge that are expected at the end of the lecture include the competence to identify the relevant data to be extracted from the EPC database for a large-scale energy analysis and to select the appropriate alternative databases to extract missing data.

Basic knowledge of mathematics and building physics is required. The expected duration of the exercise is 90 minutes.

Target groups:

This exercise is dedicated to research bodies, policymakers, and public administrations willing to perform large-scale energy analysis to forecast and predict future energy demand and refurbishment scenarios.

Short CV of the envisioned lecturer:

Franz Bianco Mauthe Degerfeld is an Engineer, graduated in Building Engineering at the Politecnico di Torino. He is currently a PhD student at the Politecnico di Torino, Department of Energy "Galileo Ferraris". His research activity is part of the research program "Internal Environment and Energy of Buildings" (acronym IIEB), with a specific focus on dynamic energy simulation of buildings, model validation, as well as energy and economic optimisation of new building projects and redevelopment. His work contributes to advancing the field of building physics and energy systems through innovative research on energy-efficient building design and optimisation strategies.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussions on solving real-life energy problems and a presentation of case studies.

Key questions that will be addressed:

- Which are the opportunities related to a large-scale energy analysis?
- Which are the relevant data to be extracted from an EPC database to perform a large-scale energy analysis?
- Which are the alternative databases to be considered for relevant data missing from the EPC database?

References and recommended reading:

1. Abbasabadi, N., Ashayeri, M. (2019). Urban energy use modeling methods and tools: A review and an outlook. Building and Environment, 161, 106270 https://doi.org/10.1016/j.buildenv.2019.106270
2. Hedegaard, R. E., Kristensen, M. H., Pedersen, T. H., Brun, A., Petersen, S. (2019). Bottom-up modelling methodology for urban-scale analysis of residential space heating demand response. Applied Energy, 242, 181-204. https://doi.org/10.1016/j.apenergy.2019.03.063.
3. Reinhart, C. F., Cerezo Davila, C. (2016). Urban building energy modeling – A review of a nascent field. Building and Environment, 97, 196-202 https://doi.org/10.1016/j.buildenv.2015.12.001
4. Sola, A., Corchero, C., Salom, J., Sanmarti, M. (2018). Simulation Tools to Build Urban-Scale Energy Models: A Review. Energies, 11, 3269. https://doi.org/10.3390/en11123269
5. Sola, A., Corchero, C., Salom, J., Sanmarti, M. (2020). Multi-domain urban-scale energy modelling tools: A review. Sustainable Cities and Society, 54, 101872 https://doi.org/10.1016/j.scs.2019.101872
6. TIMEPAC D2.5 Report on the technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

6.2.10 Exercise 2: Creation of clusters for the building typologies definition

Short description of the exercise and learning outcomes:

The building archetypes are crucial elements for the energy performance assessment of the building stock. The uncertainties related to the urban building energy model (UBEM) regarding data collection are an open issue. The creation of a national or regional building archetypes library or building typology matrix plays an important role in large-scale energy analysis, especially in reducing this uncertainty. It means identifying the adequate number of average buildings per climate zone to cover the entire building stock. Archetypes building are virtual buildings representative of the climatic zone. They represent averagely the thermophysical properties and characteristics of the cluster to which they are referred.

This exercise is based on the application of the methods and tools presented in the theoretical lesson (“Data clustering techniques (building typology) to define representative buildings”) in order to identify between two real buildings belonging to the same climatic zone, building use category, and construction period and which one is the closest to the characteristics of the archetype building. Statistical analysis on crucial KPIs will be carried out to make the right choice.

The skills and knowledge that are expected at the end of the lectures include the competence to establish appropriate criteria to conduct clustering techniques on the building stock and to adopt the most effective statistical analysis to represent the parameters.

Basic knowledge of mathematics and building physics is required. The expected duration of the lecture is 120 minutes.

Target groups:

This exercise is dedicated to research bodies, policymakers, and public administrations willing to cluster the building stock to create the building archetypes to reduce the uncertainties related to urban building energy model development.

Short CV of the envisioned lecturer:

Matteo Piro graduated in Building Engineering at Politecnico di Torino with a thesis based on the methodologies and tools to assess urban energy and environmental performance. He is currently a PhD participant in Energetics at Politecnico di Torino – Department of Energy. The research topic is focused on methodologies and tools for the enhancement of urban-scale energy modelling through the reduction of input data uncertainties.

Teaching methods and tools:

The exercise foresees the active participation of participants. It also involves the application of the theoretical concepts presented in the lecture (“Data clustering techniques (building typology) to define representative buildings”). The outcomes of several European projects (TABULA, EPISCOPE, and TIMEPAC) will be presented and discussed.

Key questions that will be addressed:

- What are the criteria behind the creation of the regional or national building typology matrix?
- Why does clustering assume a crucial role in large-scale energy analysis?
- Why can the criteria associated to the building typology matrix change from country to country?
- What are the main KPIs that can be considered for cluster analysis?

References and recommended reading:

1. Ballarini, I., Corgnati, S. P., Corrado, V. (2014). Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273-284. https://doi.org/10.1016/j.enpol.2014.01.027

2. Ballarini, I., Corrado, V. (2017). A New Methodology for Assessing the Energy Consumption of Building Stocks. Energies, 10, 1102. https://doi.org/10.3390/en10081102
3. BUILD_ME. (2018). BUILD_ME: Towards a Low-Carbon Building Sector in the MENA Region - Building typology database. Retrieved November 26, 2022, from https://www.buildings-mena.com/typologies
4. Department of Energy (DOE) of United States of America. (2013). Prototype Building Models. Retrieved November 26, 2022, from https://www.energycodes.gov/prototype-building-models
5. European Committee for Standardisation (CEN). (2017). EN ISO 52000-1: Energy performance of buildings —Overarching EPB assessment — Part 1: General framework and procedures

6.2.11 Exercise 3: Application of EPC data quality checking procedure

Short description of the exercise and learning outcomes:

The renovation of the existing building stock involves accurately producing urban building energy models to fulfil the EU's 2030 and 2050 GHG emission reduction goals. In this sense, the energy performance certificate (EPC) is an essential data source for constructing urban energy analyses. Concentrating on the quality of energy performance certificates and the accuracy of the data they contain is essential. The EPC data should be improved, implemented, real-time upgradeable, and made interoperable. To ensure that the given database contents are correct and beneficial for making proper policy decisions, benchmarking building performance, and energy efficiency upgrades, it is crucial to undertake the quality assessment of the EPC database contents and have energy certifications free of inaccuracies.

This exercise is based on the methods and techniques presented in the lecture "Quality assessment of the EPC database contents." It would involve providing sample sets of EPC data and asking participants to apply skills, knowledge, and competencies to establish appropriate criteria to establish suitable, high-quality data analysis of the EPC data content and identify best practices.

The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for public authorities and validation bodies, and everyone involved in evaluating the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as who wants to acquire basic knowledge for efficient data collection and analysis.

Short CV of the envisioned lecturer:

Mamak P. Tootkaboni is a research fellow at Politecnico di Torino, Department of Energy. She holds a PhD in Energetics from Politecnico di Torino, and her research focuses on energy efficiency, climate resilience, building energy performance modelling, future weather data creation, adaptation and mitigation to climate change, and statistical analysis. She has authored several scientific articles published in international and Italian journals and conferences, showcasing her expertise in the field of building physics and energy systems. Mamak P. Tootkaboni's work contributes to advancing the understanding and application of sustainable and resilient building practices in the face of climate change challenges.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes the application of quality assessment and scoring methods of EPC data contents and analysis of results in the addressed EPC. The findings will be discussed to decide on reasonable criteria for thoroughly examining the EPC data content and identifying best practices.

Key questions that will be addressed:

- What are the most critical data quality checks for EPC data, and how may they be used successfully?
- What standards and regulations need to be considered while validating EPC data?
- What typical problems or discrepancies could occur in EPC data, and how can they be fixed?
- How may the outcomes of the quality assurance procedure be applied to enhance EPC evaluations and building energy efficiency measures?

References and recommended reading:

1. Anagnostopoulos, F., Arcipowska, A., Mariottini, F. (2015). Energy Performance Certificates as tools to support and track renovation activities. Repéré sur le site du Buildings Performance Institute Europe
2. Arcipowska, A., Anagnostopoulos, F., Mariottini, F., Kunkel, S. (2015). *Energy Performance Certificates across the EU*. https://www.researchgate.net/publication/314151888.
3. Durier, F., Geissler, S., Wouters, P. (2017). Source book for improved compliance of Energy Performance Certificates (EPCs) of buildings. QUALICHeCK project (www. qualicheckplatform.eu)
4. European Parliament. (2010). Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0031&from=EN
5. European Parliament. (2018). Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=IT
6. eXTENDing the energy performance assessment and certification schemes via a mOdular approach (X-tendo). (2022). Implementation guidelines and replicability potential of the innovative features for the next generation EPCs.126 pages
7. eXTENDing the energy performance assessment and certification schemes via a mOdular approach (X-tendo). (2022). D4.4 description of methodologies and concepts for the technical implementation of each feature regarding improved handling and use of EPC data in selected implementing countries
8. Marinosci, C., Morini, G.L. (2014). Check-in and control activities on the energy performance certificates in Emilia-Romagna (Italy). *Energy Procedia*. Elsevier Ltd, 434–442. https://doi.org/10.1016/j.egypro.2014.01.047
9. Pagliaro, F., Hugony, F., Zanghirella, F., Basili, R., Misceo, M., Colasuonno, L., Del Fatto, V. (2021). Assessing building energy performance and energy policy impact through the combined analysis of EPC data–The Italian case study of SIAPE. Energy Policy, 159, 112609.
10. THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS (2020). Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020SC0176
11. TIMEPAC D2.5 Report on technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC’s databases

6.2.12 Exercise 4: Statistical analysis to generate representative buildings (archetypes)

Short description of the exercise and learning outcomes:

The building archetypes have to reflect the most common geometrical characteristics, technical specifications of the building envelope, and technical building system typology, representing the average situation in a market segment. They represent 'virtual' residential and non-residential buildings for a specific climatic zone, building use category, and construction period. The generation of the building archetypes is achievable in presence of a large amount of data.

This exercise focuses on extracting the most probable data to generate representative buildings for the specific climate zone. An example of EPC database will be used. The basic data categories to be selected are (1) the geometrical data (e.g., compactness ratio, thermally heated/cooled floor area, heated/cooled volume, windows-to-wall ratio, etc.), (2) the thermophysical properties of the opaque and transparent building envelope (e.g., mean thermal transmittance of the opaque building envelope, mean thermal transmittance of the transparent building envelope), and (3) the typologies and energy performance of the technical building system. The analysis will be conducted for the input and output derived from the energy certificate data. The statistical analysis provides the calculation of median and interquartile ranges ($Q_3 - Q_2$ and $Q_2 - Q_1$) for the selected parameters.

The skills and knowledge that are expected at the end of the lectures include the competence to effectively select the KPIs to generate, through statistical analysis, the representative buildings for the specific climate zone.

Basic knowledge of mathematics and building physics is required. The expected duration of the exercise is 120 minutes.

Target groups:

This exercise is dedicated to research bodies, policymakers, and public administrations willing to create the building archetypes to reduce the uncertainties related to urban building energy model development.

Short CV of the envisioned lecturer:

Matteo Piro graduated in Building Engineering at Politecnico di Torino with a thesis based on the methodologies and tools to assess urban energy and environmental performance. He is currently a PhD participant in Energetics at Politecnico di Torino – Department of Energy. The research topic is focused on methodologies and tools for the enhancement of urban-scale energy modelling through the reduction of input data uncertainties.

Teaching methods and tools:

The exercise with active participation of participants. It includes practical application of newly acquired knowledge, skills and competences and solving real-life energy problems.

Key questions that will be addressed:

- What statistical methods can be used for generating building archetypes?
- What are the KPIs to define a building archetype?

References and recommended reading:

1. Ballarini, I., Corgnati, S.P., Corrado, V., Talà, N. (2011). Improving energy modeling of large building stock through the development of archetype buildings. Proceedings of Building Simulation 2011: 12th Conference of International Building Performance Simulation Association, pp. 2874 - 2881
2. Ballarini, I., Corgnati, S.P., Corrado, V. (2014). Use of reference buildings to assess the energy savings potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273–284. https://doi.org/10.1016/j.enpol.2014.01.027

3. Brandão de Vasconcelos, A., Duarte Pinheiro, M., Manso, A., Cabaço, A. (2015). A Portuguese approach to define reference buildings for cost-optimal methodologies. Applied Energy, 140, 316-328. https://doi.org/10.1016/j.apenergy.2014.11.035
4. Dascalaki, E., Balaras, C., Zavrl, M.Š., Rakuščček, A., Corrado, V., Corgnati, S., Ballarini, I., Renders, N., Vimmr, T., Wittchen, K.B., et al. (2012). Application of Building Typologies for Modelling the Energy Balance of the Residential Building Stock. TABULA Thematic Report No. 2; Institut Wohnen und Umwelt GmbH: Darmstadt, Germany
5. Dascalaki, E., Balaras, C.A., Droutsa, K., Kontoyiannidis, S., Zavrl, M.Š., Rakuščček, A., Corrado, V., Corgnati, S., Ballarini, I., Roarty, C., et al. (2012). Typology Approach for Building Stock Energy Assessment. Main Results of the TABULA Project. Final Project Report; Institut Wohnen und Umwelt GmbH: Darmstadt, Germany
6. Dascalaki, E.G., Droutsa, K.G., Balaras, C.A., Kontoyiannidis, S. (2011). Building typologies as a tool for assessing the energy performance of residential buildings—A case study for the Hellenic building stock. Energy and Buildings, 43, Issue 12, 3400-3409 https://doi.org/10.1016/j.enbuild.2011.09.002
7. Department of Energy (DOE) of United States of America. (2013). Prototype Building Models. Retrieved November 26, 2022, from https://www.energycodes.gov/prototype-building-models
8. Filogamo, L., Peri, G., Rizzo, G., Giaccone, A. (2014). On the classification of large residential buildings stocks by sample typologies for energy planning purposes. Applied Energy, 135, 825–835. https://doi.org/10.1016/j.apenergy.2014.04.002
9. Kavgic, M., Mavrogianni, A., Mumovic, D., Summerfield, A., Stevanovic, Z., Djurovic-Petrovic, M. (2010). A review of bottom-up building stock models for energy consumption in the residential sector. Building Environment, 45, 1683–1697 https://doi.org/10.1016/j.buildenv.2010.01.021
10. IEE-EPISCOPE Project. (2016). Retrieved November 26, 2022, from http://episcope.eu.
11. Mata, É., Sasic Kalagasidis, A., Johnsson, F. (2014). Building-stock aggregation through archetype buildings: France, Germany, Spain and the UK. Building Environment, 81, 270–282. https://doi.org/10.1016/j.buildenv.2014.06.013
12. TABULA WebTool. (2012). Retrieved November 26, 2022, from https://webtool.building-typology.eu/#bm
13. TIMEPAC D2.5 Report on the technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

6.2.13 Exercise 5: Application of a bottom-up model to predict the building energy demand at different scales

Short description of the exercise and learning outcomes:

This exercise aims at performing an example of application of a bottom-up energy model to predict the energy demand of a building stock. It will show the applicability of the theory presented in the lecture titled "Application of a bottom-up model to predict the building energy demand at different scales". The application will be based on the development of an Urban Building Energy Model (UBEM) and will adopt a set of reference buildings (archetypes) representative of a subset of the building stock (e.g., residential use) that serve as a basis for analysing the energy balance of the regional/national building sector. For each archetype, its annual energy intensity – expressed in kWh/m^2 – will be multiplied by the amount of the actual building stock floor area represented by that archetype, in order to derive the overall energy demand of the building stock. To carry out the exercise, a set of archetypes of a region/country will be taken as an example; their energy intensity will be derived from the EPC database, while their frequency in the stock will be provided by regional/national data sources (e.g., census).

The expected duration of the exercise is 120 minutes.

Target groups:

This exercise is dedicated to research bodies, policymakers, and public administrations willing to perform building stock energy assessments and energy refurbishment scenarios analysis useful for energy planning purposes.

Short CV of the envisioned lecturer:

Ilaria Ballarini holds a Master's Degree in Architecture and a PhD in "Technological Innovation for the Built Environment" from Politecnico di Torino in Italy. She is an Associate Professor in building physics and energy systems at the Department of Energy of Politecnico di Torino. She teaches in Bachelor and Master of Science degree programs in Architecture, Building Engineering, and Energy Engineering, and also leads the course on "Energy and Environmental Assessment of Building Stocks" in the PhD program on Energetics at Politecnico di Torino. Her primary research focuses on building physics and building energy systems, with expertise in energy modelling of buildings and building stocks, procedures and calculation methods for energy performance assessment and cost optimisation, energy audit and certification, and legislation and technical standards in the fields of energy and environment. She has participated in numerous EU research projects, national research projects, and research contracts and has authored over 100 scientific contributions, including papers published in national and international journals, conference proceedings, books, and monographs.

Teaching methods and tools:

The exercise involves the application of the theoretical concepts already presented. An Excel spread-sheet will be used to perform the calculation.

Key questions that will be addressed:

- What are the main input data to carry out a *bottom-up* energy model to assess the energy balance of the building stock?
- What are the main data source and format to perform the analysis?
- What are the model assumptions needed to close the monitoring information gaps?

References and recommended reading:

1. Ballarini, I., Corgnati, S. P., Corrado, V. (2014). Use of reference buildings to assess the energy saving potentials of the residential building stock: The experience of TABULA project. Energy Policy, 68, 273-284. https://doi.org/10.1016/j.enpol.2014.01.027
2. Ballarini, I., Corrado, V. (2017). A New Methodology for Assessing the Energy Consumption of Building Stocks. Energies, 10, 1102. https://doi.org/10.3390/en10081102
3. IEE-EPISCOPE Project. (2016). Retrieved November 26, 2022, from http://episcope.eu.
4. TABULA WebTool. (2012). Retrieved November 26, 2022, from https://webtool.building-typology.eu/#bm
5. TIMEPAC D2.5 Report on technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

6.2.14 Exercise 6: Transformation of EPC data and other data into Renovation Passport for the deep renovation of the building - case study residential building

Short description of the exercise and learning outcomes:

The staged renovation is based on a renovation roadmap that shows the energy-related measures in the correct sequence. This exercise takes the audience through the steps of creating a renovation roadmap for deep renovation, based on the Energy Performance Certificate and other sources of information such as a Building Information Model. The focus is on residential buildings, considering that the major share of buildings belongs to the residential sector.

In this context, answers to the following questions are needed:

- What is the procedure for developing a renovation roadmap?
- Which tools are available?
- What are the advantages and disadvantages of the different data sources?
- How to deal with a lack of data?
- Is an on-site visit needed?
- What is the interface with the usual maintenance and repair plan?

Competencies of the participant who successfully completes the learning module will include an understanding how to develop a renovation roadmap and how to cope with difficulties concerning data availability and data quality that might occur during the process.

The expected duration of the exercise is 90 min. Input is 45 min, the remaining time is devoted to discussion with participants.

Target groups:

The exercise is intended for everyone who is involved in building renovation. The exercise provides an overview of contents, procedures, and tools, and is also useful for technical and non-technical staff of the administration and companies owning large buildings.

Short CV of the envisioned lecturer:

Susanne Geissler is the owner and director of SERA Institute, an environmental engineer with a background in European law, and a trained energy advisor entitled to issue Energy Performance Certificates (EPCs). With years of experience, she has been actively involved in activities related to the implementation and further development of EPC-related concepts. She holds a doctoral degree in Sustainable Construction from the University of Natural Resources and Life Sciences Vienna, showcasing her expertise in the field of sustainable construction and energy performance assessment. Susanne Geissler's work focuses on promoting energy efficiency and sustainability in the built environment, with a particular emphasis on EPC-related practices and concepts.

Teaching methods and tools:

The exercise with active participation of participants including demonstration of tools and discussion with participants.

Key questions that will be addressed:

- What are the minimum requirements a useful renovation roadmap must meet?
- How to deal with the challenge of data quality and data availability?

References and recommended reading:

1. European Commission (2021): iBroad - Individual Building (Renovation) Roadmaps. EU Project 754045 under Horizon 2020 https://cordis.europa.eu/project/id/754045/de and https://ibroad-project.eu/results/reports/
2. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) COM/2021/802 final
3. Volt, Jonathan; Toth, Zsolt; Glicker, Jessica; De Groote, Maarten; Borragán, Guillermo; De Regel, Sofie et al. (2020): Definition of the digital building logbook: report 1 of the study on the development of a European Union framework for buildings' digital logbook. European Union: Publications Office https://data.europa.eu/doi/10.2826/480977

6.2.15 Exercise 7: Application of recommended energy efficiency measures for the creation of the building stock renovation scenarios

Short description of the exercise and learning outcomes:

In order to reach the European goals for decarbonisation, it is of utmost importance to improve the whole building stock, moving from a high pollutant to a zero-emission one. In order to evaluate possible enhancement, the first step is the analysis of the current state of the building stock. A possible way is to analyse the existing EPC database to define the main energetic deficiencies and therefore the possible improvements that can be applied.

The two main groups of energy efficiency measures, related to the envelope and to the technical building systems, are presented as well as the possible influences in the energy and emission reduction. In this exercise, a case study is presented and the main phases to define and apply the renovation scenarios for a building stock are explained.

The competencies of the participants who successfully complete the learning module will include the ability to define renovation scenarios for both single buildings and building stock.

The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in evaluation of energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who is involved in formulating policies.

Short CV of the envisioned lecturer:

Franz Bianco Mauthe Degerfeld is an Engineer, graduated in Building Engineering at the Politecnico di Torino. He is currently a PhD student at the Politecnico di Torino, Department of Energy “Galileo Ferraris”. His research activity is part of the research program "Internal Environment and Energy of Buildings" (acronym IIEB), with a specific focus on dynamic energy simulation of buildings, model validation, as well as energy and economic optimisation of new building projects and redevelopment. His work contributes to advancing the field of building physics and energy systems through innovative research on energy-efficient building design and optimisation strategies.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes brief theoretical explanations, practical exercises, discussion, and solving real-life energy problems in view of defining and applying energy efficiency measures for the creation of the building stock renovation scenarios.

Key questions that will be addressed:

- What are the main recommended energy efficiency measures that can be applied to a building stock in the perspective of a renovation?
- What are the procedures to define the best energy efficiency measure for a building stock renovation?
- How can the effectiveness of these measures be assessed?

References and recommended reading:

1. Christensen, C., Anderson, R., Horowitz, S., Courtney, A., and Spencer, J. (2006) BEoptTM Software for Building Energy Optimization: Features and Capabilities, Golden, Colorado (USA): U.S. Dep. of Energy, National Renewable Energy Laboratory
2. Corrado V., Ballarini I. (2016). Refurbishment trends of the residential building stock: analysis of a regional pilot case in Italy. Energy and Buildings, Towards an energy efficient European housing stock: monitoring, mapping and modelling retrofitting processes, vol. 132, 15 Nov. 2016, p. 91-106, ISSN: 0378-7788, https://doi.org/10.1016/j.enbuild.2016.06.022

3. Fernandez-Luzuriaga, J., Portillo-Valdes, L. d. and Flores-Abascal, I. (2021) Identification of cost-optimal levels for energy refurbishment of a residential building stock under different scenarios: Application at the urban scale, Energy and Buildings vol. 240
4. IEE-EPISCOPE Project. (2016). Retrieved November 26, 2022, from http://episcope.eu.
5. Kephalopoulos, S., Geiss, O., Barrero, J., D'Agostino, D. and Paci, D. (2017) Promoting healthy and energy efficient buildings in the European Union: National implementation of related requirements of the Energy Performance Buildings Directive (2010/31/EU), Publications Office of the European Union, Luxembourg
6. TABULA WebTool. (2012). Retrieved November 26, 2022, from https://webtool.building-typology.eu/#bm

7 Training Scenario 5 - Combining EPC databases with other sources for energy savings opportunities

7.1 Structure of the Training Scenario 5

Training Scenario 5 (TS5) aims to equip participants with the necessary skills to effectively utilize EPC databases and apply their knowledge to building renovation and policy development work. The lectures cover various topics related to EPC databases, including database auditing to identify limitations and obstacles to adopting new EPC schemes, the use of open data portals to retrieve and analyse EPC data, and the quality assessment of EPC databases to ensure their accuracy. Additionally, the training highlights the use of EPC data in combination with a socio-economic, cadastre, and other data sources to assess the current status of an urban area and its potential for renovation. The lectures also cover the planning and evaluation of the impact of different renovation scenarios based on multiple criteria, such as energy savings, CO_2 emissions reduction, cost-effectiveness, and social acceptance. Attendees will learn how to combine EPC databases with other data sources to identify energy savings opportunities in buildings and promote energy efficiency. During the training course, participants will engage in various exercises to deepen their understanding of using EPC databases for building renovation and policy development. Through these exercises, participants will compare the current EPC with the enhanced EPC and identify the differences; consult an EPC database and assess the quality of the data it contains; extract data from the database and combine it with other sources; identify areas in a city that are most in need of building renovation and apply analysis methods at multiple scales to pinpoint potential areas for intervention.

TS5 is organised into four teaching hours of training (in total 180 minutes) for the general building experts who will be organised in the form of a webinar, and sixteen teaching hours of training (in total 720 minutes) held in-person for the professionals carried out by means of exercises.

7.2 Envisioned lectures and exercises

Table 7 provides information about all lectures and exercises, with the indication of their duration, that will be delivered in the framework of the TS5. Also, it provides information from which TMs these lectures and exercises are extracted.

Table 7. Outline of the TS5

Training for the general building experts (webinar)		
Title of the lecture	Duration (min.)	Training Module
Challenges of the new energy performance of buildings directive	36	TM7
Querying open data about EPCs	36	TM8
Quality assessment of the EPC database contents	36	TM9
EPC data combination for multi-dimensional analysis	36	TM4
Advanced analysis of EPC data as a support tool for local, regional and national energy planning	36	TM8

Training for the professionals (in-class)		
Title of the exercise	Duration (min.)	Training Module
Exercise 1: To make a comparison between the current EPC and the enhanced EPC	150	TM4
Exercise 2: Making queries and analysis on EPC databases	150	TM8
Exercise 3: To make a quality assessment of EPC data	150	TM9
Exercise 4: To extract data from EPC databases to combine with other sources	150	TM4
Exercise 5: To identify vulnerable areas of a city at multiple scales	120	TM8

TS5 is therefore organised into five theory lectures for the general building experts, and five exercises for the professionals.

For each envisioned lecture and exercise of the TS5, a short description of learning content and expected outcomes, target groups, a short CV of the envisioned lecturer, teaching methods and tools, and main references are provided from Section 7.2.1 to Section 7.2.10.

7.2.1 Challenges of the new energy performance of buildings directive

Short description of the lecture and learning outcomes:

This lecture will introduce the new instruments and requirements of the recast Energy Performance of Buildings Directive (EPBD), a crucial part of the EU "Fit for 55" package, which aims to achieve a zero-emission building stock by 2050. The Climate Action Plan has identified the EPBD as a key legislative instrument to deliver on the 2030 and 2050 decarbonization objectives.

In 2030, all new buildings will be required to be zero-emission. To achieve this goal, the Global Warming Potential (GWP) of buildings must be evaluated by calculating their total emissions throughout their lifecycle, following the European Level(s) framework. This includes the embodied energy of materials, transport, energy use, and end-of-life disposal/recycling. In addition to the GWP, the Smart Readiness Indicator (SRI) must also be considered. This indicator will assess the capabilities of a building or building unit to adapt its operation to the needs of occupants and the grid, and to improve its energy efficiency and overall performance.

For existing buildings, the renovation passport (RP) will help to plan the renovation measures needed to achieve zero-emission buildings by 2050. The EC proposal for the recast EPBD specifies that buildings will be required to achieve minimum energy performance standards (MEPS), and renovation will be mandatory for the first time. This will also affect the energy rating scale, with the A rating corresponding to buildings with zero emissions and the G rating representing 15% of buildings with the worst energy performance.

The expected duration of the lecture is 36 minutes.

Target groups:

This lecture is intended for all stakeholders in the building sector, including professionals such as architects, engineers, certifiers, and energy auditors, as well as public authorities such as energy agencies; market operators such as energy service companies, real estate agencies, construction companies, and energy-related product companies, and regional and local public authorities.

Short CV of the envisioned lecturer:

Ainhoa Mata is an architect at the ETSAB-UPC (Escola Tècnica Superior d'Arquitectura de Barcelona - Universitat Politècnica de Catalunya), with a master's degree in building control and sustainable architecture from URL (Universitat Ramon Llull). She is also a lecturer at the Catalan Chamber of Architects. Since 2015, Ainhoa has been responsible for the buildings unit at ICAEN (Institut Català d'Energia), where her tasks include organising conferences, managing the register of energy efficiency certificates, and overseeing grants for energy efficiency in buildings. Before her role at ICAEN, Ainhoa worked in architectural offices, specialising in sustainable architecture. Her expertise lies in energy efficiency and sustainable architecture, and she is actively involved in promoting sustainable building practices and energy-efficient solutions in the built environment.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What are the main challenges expected to be faced by implementing the recast EPBD?
- How will the certification process be affected by the new EPBD, and what changes can be expected in terms of requirements and procedures?
- How will existing EPC databases be adapted to the new EPBD?
- What will be the relationship between the EPC and the building renovation passport (BRP)?

References and recommended reading:

1. BPIE (Buildings Performance Institute Europe) (2022). EPBD Recast: New provisions need sharpening to hit climate targets https://www.bpie.eu/publication/epbd-recast-new-provisions-need-sharpening-to-hit-climate-targets/
2. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast)

7.2.2 Querying open data about EPCs

Short description of the lecture and learning outcomes:

EPC databases contain valuable information that can assist various stakeholders within the construction and renovation industry. In the TIMEPAC project, EPC databases from participating partners were audited to identify limitations, deficiencies, and obstacles that may impede the adoption of new EPC schemes. This lecture will present the results of the audit of these EPC databases, with a special focus on the findings related to the ICAEN (Catalan Energy Institute) database.

The lecture will also showcase an open data portal, which stores public EPC data. Participants will learn how to query and process the portal to obtain EPC data for basic analysis alongside other data sources, such as socio-economic data. By attending this lecture, participants will gain knowledge on how to effectively use the open data portals to retrieve and analyse EPC data.

The expected duration of the lecture is 36 minutes.

Target groups:

This lecture is designed for all the stakeholders in building sector, such as professionals (architects, engineers, certifiers, energy auditors), public authorities (energy agency, public authority) and market operators (energy service company, real estate agency, construction company, energy-related product company).

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and

ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- How can information about EPCs in a city or region be extracted from the database?
- How can the extracted data be used to conduct analysis for specific purposes?
- How can the data extracted from the database be related to other public data for specific purposes?

References and recommended reading:

1. ICAEN 2023. Certificats d'eficiència energètica d'edificis – Dades obertes Catalunya. https://analisi.transparenciacatalunya.cat/Energia/Certificats-d-efici-ncia-energ-tica-d-edificis/j6ii-t3w2
2. TIMEPAC D1.2 Comprehensive analysis of data storage in the participating countries. https://timepac.eu/reports/comprehensive-analysis-of-data-storage-in-the-participating-countries Deliverable 1.2 "Comprehensive analysis of data storage in the participating countries"

7.2.3 Quality assessment of the EPC database contents

Short description of the lecture and learning outcomes:

In this lecture, an overview will be provided on the quality assessment of energy performance certificates (EPCs) databases. The importance of accurate EPC data and the implications of incorrect data for energy efficiency initiatives will be discussed. The factors affecting the EPC data quality, including data collection methods, data management practices, and data verification procedures, will be explored. Different quality assessment techniques that can be used to evaluate the accuracy of EPC databases, such as statistical analysis, data profiling, and data cleaning, will be examined. Throughout the lecture, examples of how EPC data quality assessment is used in practice.

By the end of the lecture, participants will have gained an understanding of the importance of high-quality EPC data and the techniques used to assess its accuracy. They will also have a broader understanding of the role of data quality in energy efficiency initiatives and how this can contribute to a more sustainable future.

The expected duration of the lecture is 36 minutes.

Target groups:

This lecture aims to provide valuable insights to a diverse range of professionals involved in municipal planning, urban design, and building energy performance evaluation. Specifically, the target audience includes energy agencies, regional and local public authorities, and private sector urban designers who work in collaboration with public authorities to develop urban planning strategies.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

Lecture will be conducted as a webinar.

Key questions that will be addressed:

- How to verify that an EPC is reliable?

References and recommended reading:

1. TIMEPAC D2.5 Report on the technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases.

7.2.4 EPC data combination for multi-dimensional analysis

Short description of the lecture and learning outcomes:

This lecture will provide an overview of the Retabit project, co-funded by the Spanish Ministry of Science and Innovation, which aims to promote energy efficiency and sustainability in urban areas by supporting residential building retrofitting programmes at the municipal level. The lecture will focus on the use of the Retabit platform, which integrates EPC databases with other sources such as cadastre, socio-economic data, to assist various stakeholders, including building owners, managers, public authorities, energy service companies, and financial institutions, in evaluating the current status of an urban area and its potential for renovation. The lecture will also cover the planning and assessment of the impact of different renovation scenarios based on multiple criteria, such as energy savings, CO_2 emissions reduction, comfort improvement, cost-effectiveness, and social acceptance.

Attendees will have a deeper understanding of challenges connected with data combination from EPC databases with other sources such as cadastre or socio-economic data, service platform's key features, and the importance of fostering energy efficiency and sustainability in urban areas and residential building retrofitting programmes at the municipal level.

The expected duration of the lecture is 36 minutes.

Target groups:

This lecture is designed for individuals involved in municipal planning such as Energy agencies, Regional and Local Public Authorities, as well as urban designers in the private sector who provide support to public authorities in developing urban planning. Additionally, it is intended for those involved in evaluating the energy performance of buildings, including Professional Certifiers, Architects, and Engineers.

Short CV of the envisioned lecturers:

Leandro Madrazo is a leading researcher of the ARC Engineering and Architecture La Salle research group, and holds a full professorship at the School of Architecture La Salle. He holds a PhD in Architecture from ETH Zürich, and his research interests primarily revolve around architecture, construction, and energy efficiency. Over the years, he has successfully led various national and European research projects, including BARCODE HOUSING SYSTEM, OIKODOMOS, REPENER, OIKONET, SEMANCO, among others. He has also actively participated as a partner in other projects such as INTUBE, OPTIMUS, ENERSI, and OPTEMAL. He is currently the coordinator for several European projects, including A-Place, which is co-funded by the Creative Europe programme, RE-DWELL, a Marie Skłodowska-Curie Action, TIMEPAC, co-financed by the H2020 programme, and Retabit, a project funded by the Spanish RDI plan.

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- How can data be extracted and combined to aid in the implementation of measures aimed at increasing the renovation rate?
- How can data extraction and combination be used to implement measures focused on reducing energy poverty?

References and recommended reading:

1. Galimshina, A., Moustapha, M., Hollberg, A., Padey, P., Lasvaux, S., Sudret, B., Habert, G. (2020). Robust and resilient renovation solutions in different climate change scenarios. IOP Conference Series Earth and Environmental Science, 588. doi: 10.1088/1755-1315/588/3/032042
2. Gkatzogias, K., Crowley, H., Veljkovic, A., Pohoryles, D. A., Tsionis, G., Bournas, D. (2022). Building renovation in the EU: scenarios and impact assessment. doi: 10.2760/04574
3. TIMEPAC D2.5 Report on technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

7.2.5 Advanced analysis of EPC data as a support tool for local, regional and national energy planning

Short description of the lecture and learning outcomes:

One of the objectives of the local, regional and national authorities is to develop urban and energy planning and improve decision-making, which allow prioritizing actions to support people's needs. The lecture focuses on presenting tools that can be used by the public authorities to analyse the energy performance of the building stock in the selected area. Public authorities will be able to relate energy performance of the building stock in the selected area with the socio-economic situation of the users and develop energy planning.

Competencies of the participant who successfully completes the learning module will include an understanding of enhanced EPC on a large scale, analysis of their data, and the relationship of the enhanced EPC with the Renovation Passport.

The expected duration of the lecture is 36 minutes.

Target groups:

This lecture is designed for individuals involved in municipal planning such as Energy agencies, Regional and Local Public Authorities, and urban designers in the private sector who support public authorities in developing urban planning. Additionally, it is intended for those involved in evaluating the energy performance of buildings, including Professional Certifiers, Architects, and Engineers.

Short CV of the envisioned lecturer:

Ainhoa Mata is an architect at the ETSAB-UPC (Escola Tècnica Superior d'Arquitectura de Barcelona - Universitat Politècnica de Catalunya), with a master's degree in building control and sustainable architecture from URL (Universitat Ramon Llull). She is also a lecturer at the Catalan Chamber of Architects. Since 2015, Ainhoa has been responsible for the buildings unit at ICAEN (Institut Català d'Energia), where her tasks include organising conferences, managing the register of energy efficiency certificates, and overseeing grants for energy efficiency in buildings. Before her role at ICAEN, Ainhoa worked in architectural offices, specialising in sustainable architecture. Her expertise lies in energy efficiency and sustainable architecture, and she is actively involved in promoting sustainable building practices and energy-efficient solutions in the built environment.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- Where are the best locations to prioritize building renovations based on various multidimensional factors such as income and building status?
- How can vulnerable citizens suffering from energy poverty be identified at different scales?
- What strategies can be implemented to establish funds for renovating buildings located in vulnerable areas?

References and recommended reading:

1. Galimshina, A., Moustapha, M., Hollberg, A., Padey, P., Lasvaux, S., Sudret, B., Habert, G. (2020). Robust and resilient renovation solutions in different climate change scenarios. IOP Conference Series Earth and Environmental Science, 588. doi: 10.1088/1755-1315/588/3/032042
2. Gkatzogias, K., Crowley, H., Veljkovic, A., Pohoryles, D. A., Tsionis, G., Bournas, D. (2022). Building renovation in the EU: scenarios and impact assessment. doi: 10.2760/04574
3. TIMEPAC D2.5 Report on the technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC’s databases

7.2.6 Exercise 1: To make a comparison between the current EPC and the enhanced EPC

Short description of the exercise and learning outcomes:

In this exercise participants will compare the current Energy Performance Certificate (EPC) with the enhanced EPC developed by TIMEPAC. Participants will work in small groups, and each group will be assigned a scenario developed in the TIMEPAC project, which includes using Building Information Modelling (BIM), operational data, building renovation passports, and new indicators such as the Smart Readiness Indicator (SRI) and the Level(s) framework, to carry out a certificate.

After completing the scenarios, the groups will compare their findings with current EPC practices. They will then share their insights with the rest of the participants and facilitate a group discussion to identify the main advantages and limitations of the enhanced EPC and how it can support the goals of the Energy Performance of Buildings Directive (EPBD) recast.

Through this exercise, participants will gain a hands-on experience of the enhanced EPC and be able to critically evaluate its potential benefits and challenges. They will also learn about the progress made in the TIMEPAC project in terms of new certification processes.

The expected duration of the exercise is 150 minutes.

Target groups:

This exercise is intended for all stakeholders in the building sector, including professionals such as architects, engineers, certifiers, and energy auditors, as well as public authorities such as energy agencies; market operators such as energy service companies, real estate agencies, construction companies, and energy-related product companies, and regional and local public authorities.

Short CV of the envisioned lecturers:

Leandro Madrazo is a leading researcher of the ARC Engineering and Architecture La Salle research group, and holds a full professorship at the School of Architecture La Salle. He holds a PhD in Architecture from ETH Zürich, and his research interests primarily revolve around architecture, construction, and energy efficiency. Over the years, he has successfully led various national and European research projects, including BARCODE HOUSING SYSTEM, OIKODOMOS, REPENER, OIKONET, SEMANCO, among others. He has also actively participated as a partner in other projects such as INTUBE, OPTIMUS, ENERSI, and OPTEMAL. He is currently the coordinator for several European projects, including A-Place, which is co-funded by the Creative Europe programme, RE-DWELL, a

Marie Skłodowska-Curie Action, TIMEPAC, co-financed by the H2020 programme, and Retabit, a project funded by the Spanish RDI plan.

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

In-person exercise that encourages active participation from the attendees.

Key questions that will be addressed:

- What are the advantages and limitations of enhanced EPCs in comparison to current EPCs?
- What are the challenges associated with implementing enhanced EPCs?
- What kind of training or support would be needed for stakeholders to adopt enhanced EPCs?

References and recommended reading:

1. TIMEPAC D2.1 Report on the technical specification of TDS 1. Guidelines to assess tools that can be used to extract BIM data to enhance EPCs
2. TIMEPAC D2.2 Report on the technical specification of TDS 2. Procedures and services addressing the enhancement of EPC schemas through operational data integration
3. TIMEPAC D2.3 Report on the technical specification of TDS 3. Procedures to monitor building refurbishment using multiple data sources
4. TIMEPAC D2.4 Report on the technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools

7.2.7 Exercise 2: Making queries and analysis on EPC databases

Short description of the exercise and learning outcomes:

This exercise will demonstrate how to query and process a portal to extract Energy Performance Certificate (EPC) data and conduct basic analysis with other data sources, such as socio-economic data. Participants will engage in exercises that involve querying an open data portal that stores public EPC data for Catalonia. They will learn to use filtering, aggregation, and sorting to analyse the EPC data at multiple scales.

The exercises will provide participants with hands-on experience in combining EPC data with other data sources and conducting data analysis to gain insights. After querying the database, participants will export the resulting data in Excel format and integrate it with a socio-economic dataset provided by the lecturers. With this integrated dataset, participants will conduct a multi-dimensional analysis.

Through these exercises, participants will gain practical experience in working with real-world EPC data and develop skills in manipulating and analysing large datasets. They will also learn how to integrate EPC data with other socio-economic datasets, enabling them to draw more comprehensive conclusions and insights.

The expected duration of the exercise is 150 minutes.

Target groups:

This exercise is designed for individuals involved in municipal planning, such as energy agencies, regional and local public authorities, as well as urban designers in the private sector who provide support to public authorities in developing urban planning. Additionally, it is intended for those involved in evaluating the energy performance of buildings, including professional certifiers, architects, and engineers.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

In-person interactive session that encourages active participation from the attendees. It includes theoretical explanations and hands-on exercises on using open data portals from ICAEN and basic data management tools such as spreadsheets.

Key questions that will be addressed:

- What methods can be used to extract EPC data for my city or region?"
- What are the basic steps to perform an analysis of EPCs for a city or region?"

References and recommended reading:

1. ICAEN 2023. Certificats d’eficiència energètica d’edificis – Dades obertes Catalunya https://analisi.transparenciacatalunya.cat/Energia/Certificats-d-efici-ncia-energ-tica-d-edificis/j6ii-t3w2
2. TIMEPAC D1.2 Comprehensive analysis of data storage in the participating countries

7.2.8 Exercise 3: To make a quality assessment of EPC data

Short description of the exercise and learning outcomes:

In this exercise, participants will learn how to conduct a quality assessment of EPC data from their respective cities. Each participant will get a dataset of EPCs specific to their city from the open data portal storing public EPC data (e.g., for Catalonia the data portal will be provided by ICAEN). Using the TIMEPAC methodology, they will assess the quality of the data by considering various factors such as data collection methods and data verification procedures. After conducting the quality assessment, participants will share their findings with the rest of the group. They will discuss the strengths and weaknesses of the EPC database in their city, as well as any implications of incorrect data for energy efficiency initiatives. Finally, the group will then engage in a discussion to identify potential strategies for improving the quality of EPC data and the role of data quality in achieving a more sustainable development of the building stock.

Through this exercise, participants will gain hands-on experience in conducting quality assessments of EPC data and apply the TIMEPAC methodology to real-world datasets specific to their city. They will also develop critical thinking skills and gain a deeper understanding of the importance of high-quality EPC data in energy efficiency initiatives.

The expected duration of the exercise is 150 minutes.

Target groups:

This exercise is designed for individuals involved in municipal planning such as energy agencies, regional and local public authorities, as well as urban designers in the private sector who provide support to public authorities in developing urban planning. Additionally, it is intended for those involved in evaluating the energy performance of buildings, including professional certifiers, architects, and engineers.

Short CV of the envisioned lecturer:

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

In-person interactive session that encourages active participation from the attendees. It includes theoretical explanations and hands-on exercises on using open data portals and data quality checking methodology developed in the TIMEPAC project.

Key questions that will be addressed:

- How can the reliability of an EPC be verified?
- What are the different quality assessment techniques that can be used to evaluate the accuracy of EPC databases, such as statistical analysis, data profiling, and data cleaning?
- How can participants use the findings from the quality assessment to identify potential strategies for improving the quality of EPC data in their city?

References and recommended reading:

1. TIMEPAC D2.5 Report on technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

7.2.9 Exercise 4: To extract data from EPC databases to combine with other sources

Short description of the exercise and learning outcomes:

The attendees will engage in an exercise that involves extracting data from EPC databases and integrating it with other sources of information to assess the potential for residential building retrofitting in a specific urban area. The participants will be grouped and assigned a specific urban area to focus on. Using the Retabit platform and the EPC database for their assigned area, each group will extract relevant data related to building energy performance, such as building age, insulation, heating and cooling systems, and renewable energy installations.

After extracting the EPC data, each group will integrate it with other sources of information, such as socioeconomic data, land registry data, and urban planning data, to assess the current status of their assigned urban area and identify potential opportunities for residential building retrofitting. Finally, each group will present their findings to all participants and discuss the importance of combining EPC data with other sources of information.

Through this exercise, attendees will gain practical experience in using the Retabit platform and extracting data from EPC databases. They will also develop critical thinking skills and gain a deeper understanding of the importance of integrating EPC data with other sources of information to support decision-making to promote energy efficiency and sustainable development of the building stock.

The expected duration of the exercise is 150 minutes.

Target groups:

This exercise is designed for individuals involved in municipal planning such as energy agencies, regional and local public authorities, as well as urban designers in the private sector who provide support to public authorities in developing urban planning. Additionally, it is intended for those involved in evaluating the energy performance of buildings, including professional certifiers, architects, and engineers.

Short CV of the envisioned lecturers:

Leandro Madrazo is a leading researcher of the ARC Engineering and Architecture La Salle research group, and holds a full professorship at the School of Architecture La Salle. He holds a PhD in Architecture from ETH Zürich, and his research interests primarily revolve around architecture, construction, and energy efficiency. Over the years, he has successfully led various national and European research projects, including BARCODE HOUSING SYSTEM, OIKODOMOS, REPENER, OIKONET, SEMANCO, among others. He has also actively participated as a partner in other projects such as INTUBE, OPTIMUS, ENERSI, and OPTEMAL. He is currently the coordinator for several European projects, including A-Place, which is co-funded by the Creative Europe programme, RE-DWELL, a Marie Skłodowska-Curie Action, TIMEPAC, co-financed by the H2020 programme, and Retabit, a project funded by the Spanish RDI plan.

Álvaro Sicilia is a leading researcher of the ARC Engineering and Architecture La Salle research group. He holds a PhD in Computer Science from Ramon Llull University and is a professor of the databases course at La Salle engineering school. With active participation in numerous national and European projects such as INTUBE, REPENER, SEMANCO, OPTIMUS, ENERSI, OPTEEMAL, TIMEPAC, and ACCORD, Álvaro has gained extensive experience in the management and analysis of energy-related data for buildings, particularly utilising Semantic Web technologies. He currently co-coordinates the national research project Retabit, while actively participating in the TIMEPAC and ACCORD projects.

Teaching methods and tools:

In-person interactive session that encourages active participation from the attendees. It includes theoretical explanations and consultations on the EPC database of Catalonia. Additionally, the Retabit platform will be introduced as a resource for planning.

Key questions that will be addressed:

- How can the combination of EPC data with other sources of information help identify potential opportunities for building retrofitting in a specific urban area?
- What are the key challenges and opportunities associated with the use of EPC data in building retrofitting projects?
- How can the findings from the exercise be used to promote energy efficiency and sustainable development of the building stock?

References and recommended reading:

1. Galimshina, A., Moustapha, M., Hollberg, A., Padey, P., Lasvaux, S., Sudret, B., Habert, G. (2020). Robust and resilient renovation solutions in different climate change scenarios. IOP Conference Series Earth and Environmental Science, 588. doi: 10.1088/1755-1315/588/3/032042
2. Gkatzogias, K., Crowley, H., Veljkovic, A., Pohoryles, D. A., Tsionis, G., Bournas, D. (2022). Building renovation in the EU: scenarios and impact assessment. doi: 10.2760/04574
3. TIMEPAC D2.5 Report on technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

7.2.10 Exercise 5: To identify vulnerable areas of a city at multiple scales

Short description of the exercise and learning outcomes:

Local, regional, and national authorities aim to develop urban and energy planning and improve decision-making to better support people's needs. The purpose of this exercise is to provide tools to public authorities for understanding the energy performance of their building stock, and how it relates to the socio-economic situation of their users, in order to develop effective energy planning strategies.

The session will be structured into two case studies. The first case study will involve consulting the Catalan energy certificate database to gather information on building renovations. Additional databases, such as grants and population statistics, may also be utilized to supplement this data.

In the second case study, the energy certificate register database will be consulted to analyse the socioeconomic level of the different areas studied in relation to their energy performance. This will provide valuable insights for developing effective energy planning strategies.

Through these two exercises, the participants will learn how to consult the EPC databases and incorporate the results in planning energy renovation measures at the municipal level, with particular attention to situations of energy poverty.

The expected duration of the exercise is 150 minutes.

Target groups:

This exercise is designed for individuals involved in municipal planning such as energy agencies, regional and local public authorities, and urban designers in the private sector who support public authorities in developing urban planning. Additionally, it is intended for those involved in evaluating the energy performance of buildings, including professional certifiers, architects, and engineers.

Short CV of the envisioned lecturers:

Ainhoa Mata is an architect at the ETSAB-UPC (Escola Tècnica Superior d'Arquitectura de Barcelona - Universitat Politècnica de Catalunya), with a master's degree in building control and sustainable architecture from URL (Universitat Ramon Llull). She is also a lecturer at the Catalan Chamber of Architects. Since 2015, Ainhoa has been responsible for the buildings unit at ICAEN (Institut Català d'Energia), where her tasks include organising conferences, managing the register of energy efficiency certificates, and overseeing grants for energy efficiency in buildings. Before her role at ICAEN, Ainhoa worked in architectural offices, specialising in sustainable architecture. Her expertise lies in energy efficiency and sustainable architecture, and she is actively involved in promoting sustainable building practices and energy-efficient solutions in the built environment.

Marta Chàfer holds a PhD in engineering from a joint programme between the University of Perugia and the University of Lleida. She is also an architect (2017) from the University of Rovira i Virgili, and a building engineer (2010) from the University of Lleida. She is a co-author in the IPCC Working Group III, specifically in chapter 9 on Buildings. In 2022, she joined ICAEN to work on EU research projects. She actively contributes to creating new opportunities and preparing proposals within the framework of European and international R&D programmes.

Teaching methods and tools:

In-person exercise with an active role of the participants. It includes theoretical explanations and consultations on the EPC database of Catalonia as a resource for planning.

Key questions that will be addressed:

- What insights can be gained from analysing the relationship between energy performance and socioeconomic level?
- How can energy rehabilitation measures be planned at the municipal level to address energy poverty?

References and recommended reading:

1. Galimshina, A., Moustapha, M., Hollberg, A., Padey, P., Lasvaux, S., Sudret, B., Habert, G. (2020). Robust and resilient renovation solutions in different climate change scenarios. IOP Conference Series Earth and Environmental Science, 588. doi: 10.1088/1755-1315/588/3/032042
2. Gkatzogias, K., Crowley, H., Veljkovic, A., Pohoryles, D. A., Tsionis, G., Bournas, D. (2022). Building renovation in the EU: scenarios and impact assessment. doi: 10.2760/04574
3. TIMEPAC D2.5 Report on the technical specification of TDS 5. Procedures and services to undertake large-scale statistical analysis of EPC's databases

8 Training Scenario 6 - Operational optimisation of building energy performance based on activities during EPC generation

8.1 Structure of the Training Scenario 6

Training Scenario 6 (TS6) aims to empower participants with the necessary knowledge and skills to provide cost-effective optimisation advice based on activities during EPC generation. The lectures and exercises will cover various topics related to various aspects of the Re-Commissioning (Re-Co) process, starting from planning to implementation and verification of savings. Additionally, the training highlights the use of operational data to assess the energy performance of building and its technical systems.

TS6 is organised into four teaching hours of training (in total 180 minutes) for the general building experts, which will be organised in a form of a webinar, and sixteen teaching hours of training (in total 720 minutes) held in-person for the professionals carried out by means of exercises.

8.2 Envisioned lectures and exercises

Table 8 provides information about all lectures and exercises, with an indication of their duration, that will be delivered in the framework of the TS6. Also, it provides information from which TMs these lectures and exercises are extracted.

Table 8. Outline of the TS6

Training for the general building experts (webinar)		
Title of the lecture	Duration (min.)	Training Module
Re-Commissioning - Creating Awareness and Common Understanding	20	TM6
Distinguishing Re-Co from Energy Audits and Retrofits	20	TM6
Re-Co in the Building Life Cycle	20	TM6
Re-Co and EPC	20	TM6
Planning Re-Co activities	20	TM6
Re-Co and BACS	20	TM6
Re-Co and HVAC	20	TM6
Re-Co and electrical lighting	20	TM6
Re-Co and energy management	20	TM6

Training for the professionals (in-class)		
Title of the exercise	Duration (min.)	Training Module
Exercise 1: Selection of appropriate buildings for Re-Co activities - trend analysis and utility bill analysis	45	TM6
Exercise 2: Creation of realistic Re-CO implementation plan - case study educational building	90	TM6
Exercise 3: Data collection and inspection of energy management systems	90	TM6
Exercise 4: HVAC Re-commissioning - improving indoor environmental quality	90	TM6
Exercise 5: Electrical system re-commissioning - improving equipment performance	90	TM6
Exercise 6: Analysis of the context of energy and water consumption - proper benchmarking	90	TM6
Exercise 7: Calculation and verification of energy savings based on Re-Co activities - case study nursery home	90	TM6
Exercise 8: Calculation of SRI based on Re-Co activities and extracting energy efficiency and flexibility measures	90	TM2
Exercise 9: Creation of short and long-term plans for implementing improvements	45	TM6

TS6 is therefore organised into nine theory lectures for the general building experts, and nine exercises for the professionals.

For each envisioned lecture and exercise of the TS6, a short description of learning content and expected outcomes, target groups, a short CV of the envisioned lecturer, teaching methods and tools, and main references are provided from Section 8.2.1 to Section 8.2.18.

8.2.1 Re-Commissioning - Creating Awareness and Common Understanding

Short description of the lecture and learning outcomes:

Recommissioning or Re-Co is the process of re-optimizing existing buildings that have already been commissioned or retro-commissioned. It aims to ensure that building equipment and systems are operating at their best to meet the current needs of occupants. The process involves a thorough investigation to identify problems and integration issues, with a focus on finding "low cost/no cost" solutions to improve comfort and energy efficiency. Re-Co can be done independently or in conjunction with a retrofit project.

This lecture deals with creating awareness and enabling a common understanding of re-commissioning activities. In order to facilitate the effective implementation of Re-Co, it is essential to have the full and wholehearted cooperation of the building owner and his technical team. Everyone involved in implementation should understand what Re-Co is intended to provide and how it should be executed. Everybody should be motivated to make the best possible use of it. This ideal state of affairs can only be approached if the awareness and motivation process starts at the beginning of Re-Co implementation. Re-Co, if conducted in a systematic and a comprehensive manner, is a powerful tool for evaluating current or past energy and environmental performance and management practice.

This lecture focuses on the following topics:

- Providing participants, with an overview of the Re-Co process
- Providing participants with an understanding of important factors influencing current energy performance
- Stimulating participants to identify and share their views on all open issues related to the energy use in their buildings
- Communicating Re-Co activities and expected savings
- Planning and support during the implementation of the first project

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to re-commissioning, communication during the energy performance assessment and data collection. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about creating awareness and common understanding of Re-Co activities.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and examples of creating awareness and a common understanding of re-commissioning activities.

Key questions that will be addressed:

- What is the purpose of Re-Co activities?
- What are the key steps of Re-Co?
- Why do we need to re-evaluate the energy performance of existing and “well-functioning” technical building systems?
- Why is target setting crucial for the overall success of any energy efficiency project?
- Why do we need trainings and how do we initiate awareness-raising activities?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers

3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
6. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
7. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
8. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
9. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. IOP Conf. Series: Earth and Environmental Science 290
10. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
11. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany

8.2.2 Distinguishing Re-Co from Energy Audits and Retrofits

Short description of the lecture and learning outcomes:

Energy audit, almost universally, aims at identifying opportunities to reduce energy and water costs. According to the EN 16247–1, energy audit is a systematic inspection and analysis of energy use and energy consumption of a site, building, system or organisation with the objective of identifying energy flows and the potential for energy efficiency improvements and reporting them. It starts from understanding processes at the level of a building as whole and recognizing issues that are relevant for energy consumption. From that analysis, the energy auditor defines what has to be investigated in more details in order to quantify performance of current energy consumption. Main findings of energy audit are energy efficiency measures grouped in energy retrofitting action plans where each retrofitting proposal is evaluated in terms of investment cost and energy savings.

In the context of energy auditing, Re-Co activities can be considered as part of energy audit where the main emphasis is on identification of low-cost energy efficiency measures which can be implemented during the implementation of energy audit. Inspection of the on-site metering system is a direct connection between Re-Co and energy auditing. On-site metering is important because it provides first-hand information on energy performance. Both Re-Co expert and energy auditor needs to check the following issues:

- How energy consumption is metered and monitored?
- How operation of the equipment/processes is controlled and who is responsible for defining operational parameters of main equipment?
- Accuracy and reliability of existing metering equipment.

Depending on the extent of reliable on-site metering, both experts has to define metering plans in order to get a complete picture of energy consumption at the location. Combining Re-Co and energy audit can provide extra benefits to the end-users since low-cost measures are already implemented and supervised by experienced experts. In this context, early achievement of visible energy saving based on Re-Co activities can be considered as a building of trust between energy auditor and the owner/user of building. Examples of typical cost saving measures are shown below:

- Equipment operation settings and adjusting the operating schedule to actual needs
- Control Valves, Sensors, Controllers, VFDs, often included
- Repair of thermal insulation of heat – cold distributions
- HVAC Control System Modifications

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to re-commissioning, energy auditing and target setting. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about energy auditing, re-commissioning, target setting, site visit and data collection.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and provides clear instructions how to distinguish Re-Co from Energy Audits.

Key questions that will be addressed:

- What is the main difference between Re-Co and energy audits?
- Why is it important to identify and, if it is possible even to achieve the first energy savings during the conducting the energy audit?
- What are the main elements of Re-Co implementation action plan?
- What are the techniques for verifying performance improvements?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
6. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines

7. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
8. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
9. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. IOP Conf. Series: Earth and Environmental Science 290
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11. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany
12. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom

8.2.3 Re-Co in the Building Life Cycle

Short description of the lecture and learning outcomes:

Re-Co is a periodic activity and it should be applied throughout the whole life of the building. Experience has shown that the savings range is between 5% and 15%. However, the primary obstacles that are preventing the adoption of re-commissioning as a routine process for all buildings throughout their life cycle are mostly connected with the lack of awareness about potential benefits and fear of change/desire to preserve the status quo.

This lecture provides a set of examples of Re-Co measures that can be applied through the building life cycle. Participants will also be informed about the content of the Re-Co report. The exact content of the report shall always be adjusted based on the complexity of the inspected and evaluated systems. The main purpose of the final report is to convince the owner of the building to start with the implementation of proposed performance improvement measures and projects and to prove that these measures can compete with other investment opportunities in terms of their own return on investment. Re-Co activities should be executed in a regular time intervals in order to check that the operation of main and energy most intensive systems continue to fulfil initially set requirements.

This lecture focuses on following three topics:

- Re-Co and energy auditing
- Re-Co and seasonal testing
- Re-Co and monitoring and targeting

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the role of re-commissioning activities within the building life cycle. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about the role of re-commissioning activities within the building life cycle.

Short CV of the envisioned lecturer:

Gašper Stegnar is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Civil Engineering from the University of Ljubljana, and his areas of expertise include simulation modelling of the thermal response of buildings, implementation of BIM methodology, and detailed simulation modelling of energy-efficient building renovations. His research focuses on developing energy consumption models and projections in the building sector, with a special emphasis on energy efficiency and renewable energy sources in buildings. Gašper is also involved in designing and modelling energy systems, as well as conducting analyses to support decision-making in climate and energy policies. He actively participates in international research and application projects, particularly those related to energy efficiency. Furthermore, Gašper is gaining valuable experience as an energy consultant in the ENSVET energy consulting network, providing expert advice on buildings and energy management.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and examples of Re-Co activities throughout building life cycle.

Key questions that will be addressed:

- What is the purpose of the re-commissioning within the building life cycle?
- What are the typical energy saving measures triggered by Re-Co activities?
- What are the main techniques for continuous performance monitoring?
- What is the typical scope of Re-Co activities?
- Which data needs to be collected to assess on-site metering and control equipment?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissionin
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
6. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
7. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
8. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
9. International Organization for Standardization(ISO). (2017). ISO 15686 - Buildings and constructed assets -- Service life planning -- Part 5: Life-cycle costing
10. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. IOP Conf. Series: Earth and Environmental Science 290
11. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
12. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany
13. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom

8.2.4 Re-Co and EPC

Short description of the lecture and learning outcomes:

This lecture will outline how the EPC generation process can be connected with re-commissioning activities. In this context, re-commissioning activities are seen as elements of a quality-oriented process for achieving, verifying, and documenting whether a building's systems and equipment's performance still meets originally defined objectives and criteria. Participants will learn how to utilise the data collection process and identify performance improvement opportunities from the collected and calculated data. Participants will also learn how to use the Re-Co checklist to ensure that critical performance opportunities are effectively identified. Also, it will be provided with examples of how the data from building control systems can be used in the framework of Re-Co and EPC generation process.

This lecture focuses on the following three main areas:

- Planning and preparation for data collection
- Calculation and benchmarking
- Identifying main factors influencing performance and proposing Re-Co measures

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the re-commissioning and how to connect it with the activities during the generation of EPC. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about Re-Co activities that can be combined/executed during the process of obtaining the data for the EPC generation.

Short CV of the envisioned lecturer:

Gašper Stegnar is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Civil Engineering from the University of Ljubljana, and his areas of expertise include simulation modelling of the thermal response of buildings, implementation of BIM methodology, and detailed simulation modelling of energy-efficient building renovations. His research focuses on developing energy consumption models and projections in the building sector, with a special emphasis on energy efficiency and renewable energy sources in buildings. Gašper is also involved in designing and modelling energy systems, as well as conducting analyses to support decision-making in climate and energy policies. He actively participates in international research and application projects, particularly those related to energy efficiency. Furthermore, Gašper is gaining valuable experience as an energy consultant in the ENSVET energy consulting network, providing expert advice on buildings and energy management.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and examples of Re-Co activities that can be combined with the generation of EPC.

Key questions that will be addressed:

- What are the most common performance improvement opportunities that can be identified during the site visit and data collection process in the framework of the EPC generation?
- Which Re-Co activities can be combined with the activities during the generation of EPC?
- Which data needs to be collected by energy assessor during the site visit and how it can be connected with Re-Co?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
6. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
7. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*
8. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 200
9. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany

8.2.5 Planning Re-Co activities

Short description of the lecture and learning outcomes:

For any activity related to the energy performance assessment - planning and preparation are a crucial phases. Planning includes at least the following:

- Lay out a timetable and scope of all activities
- Set up the project team and assign specific tasks
- Establish a relationship with the building owner/users and, in the case of larger buildings with personnel dealing with energy and maintenance
- Establish effective lines of communication and coordination between the project team and owner/users/technical personnel
- Initiate data gathering
- Kick off the project successfully

The planning activities in the framework of the Re-Co should be documented in the form of a work plan, which should also be shared with the owner/users prior to visiting the building to carry out the intended work. The work plan must outline which part of the building is to be visited, the purpose of the visit, the documentation and data required, and the necessary personnel to be involved. This lecture focuses on the following main areas:

- Planning a site visit
- Planning and preparation for data collection
- Planning of measurement to verify the current performance
- Planning for implementation of Re-Co measures/corrective actions
- Planning of measurement to verify achieved savings

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the planning re-commissioning activities, site visit and data collection. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about proper planning of Re-Co activities, communication, site visit and data collection.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and examples of Re-Co activities.

Key questions that will be addressed:

- What is the purpose of Re-Co, and how is it conducted?
- What are the key steps of a successful planning of Re-Co activities?
- Why do we need honest communication and co-operation between different experts during the assessment of a building’s energy performance?
- What needs to be agreed upon with the owner/users before the site visit?
- Which data needs to be collected during the site visit?
- What are the main systems and end-user equipment that need to be checked during the Re-Co activities?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
6. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
7. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*

8. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 200
9. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany

8.2.6 Re-Co and BACS

Short description of the lecture and learning outcomes:

The term 'Building Automation and Control System' (BACS) refers to centralized systems that monitor, control, and record the functions of various building systems. Building facilities monitored and controlled by a reliable BACS tend to maintain the building environment more efficiently and reduce the building's environmental impact and energy costs. Automation can affect several aspects of a building’s daily operations, but it most commonly controls HVAC and electrical systems.

This lecture will outline how to assess existing on-site sensors, metering and control equipment in the framework of Re-Co. Participants will learn how to identify performance improvement opportunities based on the settings of the existing control systems. Participants will also learn how to assess existing BACS systems with the goal that neither too many nor too few measurements are taken.

This lecture focuses on the following main areas:

- How to connect operational settings of building’s systems with actual energy consumption,
- Interpretation of energy data pattern
- Quantifying performance opportunities and proposing Re-Co measures connected with the functioning of BACS
- Connecting existing monitoring and metering devices with performance targets

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to the re-commissioning and assessment of on-site sensors, metering and control equipment. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge about Re-Co activities and BACS.

Short CV of the envisioned lecturer:

Jure Čižman holds a Master of Science degree from the University of Ljubljana Faculty of Mechanical Engineering. His primary areas of work are research and applicative projects related to energy efficiency and renewable energy consumption. He has recently been focusing on the utilisation of GIS tools in the energy sector. Jure is actively involved in international projects and serves as a member of the Education & Training Working Group of the international technological platform DHC+, established within the framework of Euroheat&Power. In 2013, he joined Jožef Stefan Institute as an expert consultant. Before that, he worked as a secretary at the public institute Slovenian Accreditation, where he held roles such as a leading and expert assessor, an evaluator in the European conformity assessment system, and led assessor training courses. From 1999 to 2001, he worked as the head of inspection bodies at the Metrology Institute of the Republic of Slovenia. His first employment was at the Faculty of Mechanical Engineering, where he worked as an assistant and obtained his Master's degree in 1998.

Teaching methods and tools:

The lecture will be conducted as a webinar. It includes theoretical explanations and examples of Re-Co activities connected with BACS.

Key questions that will be addressed:

- What does BACS stand for, and which standard is responsible for its definition?
- From which systems did BACS actually evolve?
- What do we need to consider before proposing new sensors and metering devices to be installed?
- How to connect existing monitoring and metering devices with performance targets?
- What is the sufficient frequency of measurements?
- Who acts on alarms, and what do they do?

References and recommended reading:

1. Aghemo, C., Blaso, L., Pellegrino, A. (2014). Building automation and control systems: A case study to evaluate the energy and environmental performances of a lighting control system in offices, Automation in Construction, 43, 10-22
2. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
3. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
4. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
6. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
7. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
8. International Organization for Standardization (ISO). (2017). ISO 16484: Building Automation and Control Systems (BACS) – Part 5: Data communication protocol
9. International Organization for Standardization (ISO). (2020). ISO 16484: Building Automation and Control Systems (BACS) – Part 6: Data communication conformance testing
10. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*
11. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
12. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany
13. Van Thillo, L., Verbeke. S. Audenaert, A. (2022). The potential of building automation and control systems to lower the energy demand in residential buildings: A review of their performance and influencing parameters. Renewable and Sustainable Energy Reviews, 158.
14. Yan, C., Wang, S., Fu, X., Gao, D. (2015). A multi-level energy performance diagnosis method for energy information poor buildings. Energy, 83, 189-203

8.2.7 Re-Co and HVAC

Short description of the lecture and learning outcomes:

Re-Commissioning is a methodical process of testing an existing facility's HVAC systems and equipment to make sure they are still functioning according to the original design intent or to adjust and correct any deviation from the original design. This process also checks for any inefficiencies that could be improved. Re-Co is often necessary to perform within 5-7 years of construction completion. Even buildings that were thoroughly commissioned at the time of the original design can develop issues over time, also because HVAC systems often experience changes in operation and occupancy which compromise the performance.

Th lectures are based on most widespread standards and guidelines, such as ASHRAE Guideline 0.2-2015 and CanmetENERGY Recommissioning Guide.

The lecture will comprehensively describe a systematic quality-oriented process that improves the performance and sustainability of existing facilities, including planning, assessing, investigating, implementing, verifying, and documenting performance to meet defined and optimized operational requirements. The step-by-step process for getting the best effectiveness from facilities for the lowest investment and ensuring durable benefits will be described. Common best practices will also be presented. The following phases of the re-commissioning process will be described: planning, investigation, implementation, and persistence.

The documents produced in the re-commissioning process, such as the surveys on the status of certain devices and a report on the verification of maintenance efficiency, will be presented. The contents of the periodic report, including suggestions and proposals, estimate of any costs to be incurred, evaluation of the amortization period and estimate of the savings obtained in terms of both consumption and money, will be outlined.

The competencies of the participants who successfully complete the learning module will include basic knowledge on the re-commissioning process of an HVAC system.

Basic knowledge of HVAC systems design, construction supervision, testing and calibration of systems, is required. The expected duration of the lecture is 20 minutes.

Target groups:

This lecture is primarily addressed to all professionals involved in building design, management and operation. It is also intended to be addressed to owners, facility decision-makers and commissioning providers who are focused on optimizing the operation of their facilities and systems. The following specific categories can be interested in this topic: director or chief of engineering, property or facility manager, property management firms, operation and maintenance staff, control technicians and building automation supervisors, recommissioning service providers, consultants in energy management, professors and participants in building science and engineering.

Short CV of the envisioned lecturer:

Vincenzo Corrado is a civil engineer and a full professor of "Building Physics and Building Energy Systems" at Politecnico di Torino, Department of Energy. He has over 30 years of professional experience in research and development (R&D) in the fields of building physics, technical building systems, building energy performance modeling, energy audit and certification procedures, thermal comfort, indoor environmental quality, legislation, and technical standards related to energy and environmental issues. For more than 15 years, he has served as the Italian delegate of CEN TC 89 "Thermal performance of buildings and building components" and ISO TC 163 "Thermal performance and energy use in the built environment". He has also been a member of the working group of the Italian Ministry of Economic Development entrusted with the national implementation of the European Directive on the energy performance of buildings. He has held scientific responsibility for numerous competitive national and international research projects awarded through a peer-review process. He is the author of over 300 scientific papers, didactic volumes, and editorials.

Teaching methods and tools:

The lecture will be conducted as a webinar, and it involves the description of the theoretical concepts and procedures presented in the most widespread standards and guidelines.

Key questions that will be addressed:

- How can a systematic quality-oriented process improve the performance and sustainability of existing facilities?
- What are the phases of the road map to meet defined and optimized operational requirements?
- How can owners and facility managers get the best effectiveness from their facility for the lowest investment and be sure that those benefits last for the life of the building?
- Is it possible to define best practices in HVAC systems recommissioning?

References and recommended reading:

1. ASHRAE (2015). Guideline 0.2-2015 -- Commissioning Process for Existing Systems and Assemblies
2. ASHRAE (2019). Guideline 1.2-2019 -- Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies
3. CanmetENERGY (2008). Recommissioning Guide for Building Owners and Managers (First Edition), Portland Energy Conservation Energy Inc.
4. U.S. Department of Energy/PIER (2003). Strategies for Improving Persistence of Commissioning Benefits

8.2.8 Re-Co and electrical lighting

Short description of the lecture and learning outcomes:

Lighting systems play a crucial role in creating a comfortable working environment. However, over time, all lighting systems become less efficient. While some losses in efficiency are inevitable, such as a decrease in light output due to ageing equipment, other losses, like malfunctioning controls, dirt accumulation on fixtures, and lumen depreciation, can be prevented through regular maintenance. One of the main goals of re-commissioning lighting systems is to improve energy efficiency. This can be achieved by identifying and addressing issues such as over-lighting, optimizing lighting control, and the use of outdated or inefficient lighting technologies.

Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to Re-Co in connection to electrical lighting. The lecture will go through all the main steps of Re-Co lighting systems: assessing existing lighting systems, identifying opportunities for improvement, developing a plan of action, implementing changes, monitoring and evaluating performance, regular maintenance, and creating documentation. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge of recommissioning in buildings.

Short CV of the envisioned lecturer:

Matej Pahor is a mechanical engineer with a University Degree in Energy and Process Engineering from the University of Ljubljana. His work primarily focuses on monitoring, targeting, and energy accounting, as well as the elaboration of energy performance certificates. He is also experienced in feasibility studies, technical documentation elaboration, building energy audits, and has participated as a technical expert in various projects such as ELENA, ENERJ, and TIMEPAC. Matej Pahor is also a certified European Energy Manager (EUREM), obtaining his certification in 2014, showcasing his expertise and commitment to energy management and sustainability.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What are the primary focus areas of a Re-Co process for lighting systems?
- What are the steps involved in a lighting system Re-Co?
- How much energy savings can be triggered by Re-Co of a lighting system?

References and recommended reading:

1. International Organization for Standardization (ISO). (2020). ISO/TS 21274: Light and lighting – Commissioning of lighting systems in buildings.
2. Portland Energy Conservation, Inc., adapted by canmetEnergy. (2008). Sustainable Building Operation and Maintenance Guideline.
3. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA.
4. U.S. Environmental Protection Agency (EPA) and Energy Star program. (2007). Building Upgrade Manual: Recommissioning.

8.2.9 Re-Co and energy management

Short description of the lecture and learning outcomes:

Unless energy data is measured, it is almost impossible to know where to direct performance improvement efforts. A metering system provides the vital ingredient to successful energy management. Performance improvement targets can be set only from the position of knowledge of actual performance based on measured data.

The commissioning process for existing buildings has multiple terms and various adaptations. Depending on the budget and owner requirements, a practitioner may implement the process differently in different buildings. Re-Co focuses on enhancing the overall control and operation of a building's systems to meet current facility needs. It does not ensure that the systems function as originally designed but ensures that the building and systems operate optimally to meet the current requirements. During the lecture, the audience will be taken through the various phases involved in the re-commissioning process of an energy management system that has been implemented in a municipality.

Also, participants will be informed on how to use Re-Co and actively look for new insights from available performance data. The focus will be put on the following elements of Re-Co:

- Review of an operational event with substandard performance
- Reconstruction of what happened
- Agreement on corrective actions
- Corrective actions implemented
- Monitoring of the effects and confirmation of performance improvement

The competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to recommissioning process in existing buildings. The expected duration of the lecture is 20 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge of recommissioning in buildings.

Short CV of the envisioned lecturer:

Matej Pahor is a mechanical engineer with a University Degree in Energy and Process Engineering from the University of Ljubljana. His work primarily focuses on monitoring, targeting, and energy accounting, as well as the elaboration of energy performance certificates. He is also experienced in feasibility studies, technical documentation elaboration, building energy audits, and has participated as a technical expert in various projects such as ELENA, ENERJ, and TIMEPAC. Matej Pahor is also a certified European Energy Manager (EUREM), obtaining his certification in 2014, showcasing his expertise and commitment to energy management and sustainability.

Teaching methods and tools:

The lecture will be conducted as a webinar.

Key questions that will be addressed:

- What are the main steps of are-commissioning process in connection with the settings of an energy management system?
- What are the parameters that can be extracted from the energy management system and how can we use them during the re-commissioning?
- What are the phases of Re-Co implementation process?

References and recommended reading:

1. Portland Energy Conservation, Inc., adapted by canmetEnergy. (2008). Sustainable Building Operation and Maintenance Guideline
2. Turner, W.C., Doty, S. (2006). Energy Management Handbook, Sixth Edition. Fairmont Press. Atlanta, Georgia, USA
3. U.S. Environmental Protection Agency (EPA) and Energy Star program. (2007). Building Upgrade Manual: Recommissioning

8.2.10 Exercise 1: Selection of appropriate buildings for Re-Co activities - trend analysis and utility bill analysis

Short description of the exercise and learning outcomes:

This exercise provides guidelines and examples of how to select appropriate buildings for the Re-Co activities. Ideally, all variability in energy use should be explained by its fundamental relationship to the activity within the building. The dynamic nature of building use and various influencing factors will result in energy variability greater than the one granted by pure variability of activities with in the building. The first two steps in the selection of appropriate buildings for Re-Co activities are trend analysis and utility bill analysis.

In the context of this exercise, participants will be provided with data samples from which they will have to perform trend analysis and utility bill analysis. Participants will also learn how to justify why certain buildings are suitable candidates for the Re-Co activities and how to rank them.

Competencies of the participant who successfully completes the learning module will include an understanding of the main criteria for the selection of appropriate buildings for Re-Co. Participants will also learn how to conduct trend analysis and utility bill analysis. The expected duration of the exercise is 45 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge about the selection of appropriate buildings for Re-Co activities.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, discussion about criteria for selection of appropriate buildings for Re-Co activities and analysis of collected data.

Key questions that will be addressed:

- What is the trend analysis?
- Why do we need to understand the tariff system, and what are the most common improvement opportunities that can be extracted from that analysis?
- What are the main criteria for the selection of appropriate buildings for Re-Co activities?
- Who is responsible for the data collection?
- What data can be obtained directly from the energy suppliers/utilities and what has to be measured?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
5. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
6. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
7. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*
8. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
9. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany

8.2.11 Exercise 2: Creation of realistic Re-Co implementation plan - case study educational building

Short description of the exercise and learning outcomes:

This exercise provides guidelines and examples of how to create a realistic Re-CO implementation plan. Participants will be informed about the main elements of a realistic Re-Co implementation plan with a focus on educational buildings. Additionally, they will learn how to incorporate measurement and verification activities within the Re-Co implementation plan. Participants will have to create a Re-Co implementation plan and discuss in groups possible improvements. Each implementation plan will be assessed, and it will be checked does it provide answers to following questions:

- What are the main steps of implementing Re-Co project?
- What are the main benefits of proposed Re-Co measures?
- What are the performance improvement measures that will be monitored and verified by the proposed measurement?
- What energy indicators will be calculated for verification purposes?
- What is the appropriate data recording frequency?

Competencies of the participant who successfully completes the learning module will include an understanding of the realistic planning and implementation Re-Co activities, reporting, monitoring and verification of energy savings triggered by Re-Co activities. The expected duration of the exercise is 90 minutes.

Target groups:

The lecture is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge how to effectively utilise data collection process for optimisation of energy systems and re-commissioning activities. Participants will learn how to create a realistic plan for the implementation of proposed re-commissioning measures.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of re-commissioning plans, analysis of collected data and verification of achieved energy savings.

Key questions that will be addressed:

- What are the main elements of a realistic Re-Co implementation plan in educational buildings?
- What are the most energy-intensive appliances and technical systems in educational buildings?
- Why do we need to analyse operation hours and settings of HVAC?
- What is the purpose of a detailed inspection of the building, and what answers should be given?
- Why is it necessary to verify the savings achieved?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings

2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Efficiency Valuation Organisation. (2019). EVO 10300 - 1: Measurement & Verification - Issues and Examples
5. Efficiency Valuation Organisation. (2022). EVO 10000 - 1: International Performance Measurement and Verification Protocol (IPMVP) – Core Concepts
6. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
7. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
8. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
9. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
10. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
11. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*
12. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
13. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, German
14. Natural Resources Canada, www.nrcan.gc.ca, Recommissioning (RCx) Case Study (available online)
15. Oregon Office of Energy prepared by Portland Energy Conservation, Inc. (PECI). (2001). Retrocommissioning Handbook for Facility Managers
16. U.S. Department of Veterans Affairs prepared by RetroCom Energy Strategies, Inc. (2014). Retro-Commissioning Process Manual

8.2.12 Exercise 3: Data collection and inspection of energy management systems

Short description of the exercise and learning outcomes:

To measure energy performance and improvements in an Energy Management System (EnMS), it is necessary to collect data on key factors affecting energy performance. Data collection can pose a challenge in EnMS implementation. Accordingly, planning for data collection and implementing a system of reliable data acquisition at planned intervals, including agreements to regularly obtain data from within and from outside the organization, is an important task best undertaken during early stages of the implementation of an EnMS. As an organization starts to plan for EnMS development and implementation, it can record each type of data used and its source. This recording should continue throughout the EnMS development process, including data used to identify the Significant Energy Use (SEUs), Energy Baselines (EnBs), measurement of energy performance and changes in energy performance, Energy Performance Indicators (EnPIs), and other indicators of operational control or performance.

The focus of the exercise is to acquaint the participants with the data collection process. Competencies of the participant who successfully completes the learning module will include an understanding of the basic concepts related to identifying all energy sources that are consumed within the scope and boundaries, identifying energy uses, identifying relevant variables that potentially affect the energy consumption, developing and implementing a data collection plan, ensuring measurements and metering are conducted accurately and are repeatable and determining appropriate analysis methods. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge for data collection and energy management systems.

Short CV of the envisioned lecturer:

Matej Pahor is a mechanical engineer with a University Degree in Energy and Process Engineering from the University of Ljubljana. His work primarily focuses on monitoring, targeting, and energy accounting, as well as the elaboration of energy performance certificates. He is also experienced in feasibility studies, technical documentation elaboration, building energy audits, and has participated as a technical expert in various projects such as ELENA, ENERJ, and TIMEPAC. Matej Pahor is also a certified European Energy Manager (EUREM), obtaining his certification in 2014, showcasing his expertise and commitment to energy management and sustainability.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussion, preparation of a data collection plan, and analysis of collected data.

Key questions that will be addressed:

- What are the key elements of the data collection process?
- How to make data collection plan?
- What are the variables that can affect energy consumption?
- Which data analysis methods can be used?

References and recommended reading:

1. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
2. International Organization for Standardization (ISO). (2020). ISO 50004: Energy management systems - Guidance for the implementation, maintenance and improvement of an ISO 50001 energy management system
3. United States Department of Energy and Lawrence Berkeley National Laboratory. 50001 Ready Navigator: Section: Planning., https://navigator.lbl.gov/project/4529/task/8/download

8.2.13 Exercise 4: HVAC Re-commissioning - improving indoor environmental quality

Short description of the exercise and learning outcomes:

The main aim of the re-commissioning procedure applied to HVAC systems is to evaluate if the system is working properly and, in case of a building refurbishment, if the system is still suitable for the building's needs. The exercise will analyse, starting from a measured set of data related to a technical building sub-system and comparing it with both the technical sheet properties and the building needs. The aim is to exploit the re-commissioning best practices highlighting the possible building energetic and economic enhancement.

Alongside energy and economic evaluations, it is of utmost importance to analyse the well-being of the building occupants. A second exercise is focused on the assessment of the indoor environmental quality, analysing the different aspects such as thermal, acoustic, and lighting comfort.

Competencies of the participants who successfully complete the learning module will include the ability to apply a re-commissioning analysis of an HVAC system, including the knowledge to assess and improve the indoor environmental quality of a building. Participants will also acquire the ability to perform specific assessment procedures and methodological procedures for a broad range of applications.

The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in evaluation of energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire basic knowledge on the HVAC Recommissioning procedures and indoor environmental quality improvement application as well.

Short CV of the envisioned lecturer:

Franz Bianco Mauthe Degerfeld is an Engineer, graduated in Building Engineering at the Politecnico di Torino. He is currently a PhD student at the Politecnico di Torino, Department of Energy "Galileo Ferraris". His research activity is part of the research program "Internal Environment and Energy of Buildings" (acronym IIEB), with a specific focus on dynamic energy simulation of buildings, model validation, as well as energy and economic optimisation of new building projects and redevelopment. His work contributes to advancing the field of building physics and energy systems through innovative research on energy-efficient building design and optimisation strategies.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes brief theoretical explanations, practical exercise, discussion, solving real-life energy problems, analysis of collected data to perform a HVAC re-commissioning and an evaluation of the indoor environmental quality in view of an improvement in the addressed building.

Key questions that will be addressed:

- How can a re-commissioning procedure be applied to a HVAC system?
- What are the best practices for performing a re-commissioning procedure?
- What is the main goal of a re-commissioning procedure?
- What is the procedure for evaluating the indoor environmental quality?
- How can the indoor environmental quality be improved?

References and recommended reading:

1. ASHRAE (2015). Guideline 0.2-2015 -- Commissioning Process for Existing Systems and Assemblies
2. ASHRAE (2019). Guideline 1.2-2019 -- Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies
3. CanmetENERGY (2008). Recommissioning (RCx) Guide for Building Owners and Managers (First Edition), Portland Energy Conservation Energy Inc.
4. European Committee for Standardisation (CEN). (2019). EN 16798-1, Energy performance of buildings. Ventilation for buildings. Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics. Module M
5. European Committee for Standardisation (CEN). (2021). EN 12464-1, Light and lighting - Lighting of work places - Part 1: Indoor work places
6. Kubba, S. (2016). LEED v4 Practices, Certification, and Accreditation Handbook (Second Edition), 167-220

8.2.14 Exercise 5: Electrical system re-commissioning - improving equipment performance

Short description of the exercise and learning outcomes:

This exercise provides examples of how to conduct Re-Co activities connected with the electric power system in order to improve the performance of the equipment and system as a whole. Performance assessment of a building's electric power systems should not focus only on the efficiency of individual devices because, in such a case, most of the opportunities for performance improvement will remain undetected. In this context, Re-Co represents a systematic approach which takes into consideration not only the performance of individual equipment and machines but their performance within a system where these machines deliver specific work or function. This brings us to the simple fact that the largest savings of electricity in buildings will come from the basic principle or so-called golden rule of Re-Co: Turn off all electrical appliances when you don't need them. This is the simplest, easy and cost-free energy efficiency measure, but in spite of this too often neglected. There is no building where we cannot find machines idling, lights left on, fans running, pumps pumping etc., without an apparent need.

In this exercise, participants will be provided with data samples from which they will have to identify unnecessary electricity consumption. The exercise will tackle the following performance improvement opportunities:

- Tariff system analysis
- Load management and demand control
- Power factor correction
- Power quality indicators

Participants will also learn how to construct a load duration diagram which indicates not only the peak load but also the duration of peak loads over the observed time interval, which is important for the consideration of demand control strategies. Participants will gain knowledge on how to identify the common cases of so-called 'false' fixed demand when certain loads are operated as fixed, although, in reality, such operation is not required.

Competencies of the participant who successfully completes the learning module will include an understanding of the Re-Co activities that are connected with electric end-user equipment, estimation of the energy-saving potential and reporting. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge how to effectively supervise the re-commissioning activities connected with the electric power systems and appliances in buildings. Participants will learn how to create a realistic list of re-commissioning measures.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The Exercise with active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of metering plans, analysis of collected data and verification of achieved energy savings.

Key questions that will be addressed:

- What are the main components of building electric power systems?
- Why do we need to analyse the tariff system?
- What is the power factor, and how can we improve it?
- What are the options for demand control?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Efficiency Valuation Organisation. (2019). EVO 10300 - 1: Measurement & Verification - Issues and Examples
5. Efficiency Valuation Organisation. (2022). EVO 10000 - 1: International Performance Measurement and Verification Protocol (IPMVP) – Core Concepts
6. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
7. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
8. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
9. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
10. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
11. International Energy Agency. (2013). Transition to Sustainable Buildings – Strategies and Opportunities to 2050. OECD/IEA, Paris, France
12. International Organization for Standardization (ISO). (2018). ISO 50001: Energy management systems
13. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
14. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)
15. International Organization for Standardization (ISO). (2014). ISO 50015: Energy management systems — Measurement and verification of energy performance of organizations
16. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*
17. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and

Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 200
18. Morvay, Z.K., Gvozdenac, D.D. (2008). Applied Industrial Energy and Environmental Management. IEEE Press and John Wiley & Sons, Chichester
19. Moss, K.J. (2005). Energy Management in Buildings. Routledge – Taylor & Francis Group, United Kingdom
20. Natural Resources Canada, www.nrcan.gc.ca, Recommissioning (RCx) Case Study (available online)
21. Oregon Office of Energy prepared by Portland Energy Conservation, Inc. (PECI). (2001). Retrocommissioning Handbook for Facility Managers
22. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany
23. U.S. Department of Veterans Affairs prepared by RetroCom Energy Strategies, Inc. (2014). Retro-Commissioning Process Manual.

8.2.15 Exercise 6: Analysis of the context of energy and water consumption - proper benchmarking

Short description of the exercise and learning outcomes:

In order to design and propose the proper retrofitting strategies (for both refurbishments and optimization of the building systems), a robust baseline of the building shall be defined and presented to buildings' owners and managers.

According to EN 16247-1:2022, the energy baseline is defined as *quantitative reference(s) providing a basis for comparison of energy performance*, meaning setting the building's current performance by energy use and sources for determining its potential for improvements. To identify the baseline for both energy and water consumption, an audit shall be performed. According to EN 16247-1:2022, the energy audit is defined as the *systematic inspection and analysis of energy use and energy consumption of a site, building, system or organization with the objective of identifying energy flows and the potential for energy efficiency improvements and reporting them*.

The exercise is aimed at proposing for a real building, through a case study approach, the baseline definition for the energy and water consumption as a chronological sequence of steps according to EN 16247-1 and EN 16247-2 from the data collection phase to the report elaboration, and the comparison against the proper benchmarks. The exercise focuses on the quality check of input data, calculation assumptions for simulating the building performance, visualization and communication of the analysis output.

The lecture provides answers to the following questions:

- What is the baseline and benchmarking analysis in practice?
- What tools and methods do you need for the baseline analysis?
- What input data do you need for calculating the building energy (and non-energy) baseline?
- What is the proper trade-off between input data accuracy and simplification?
- How to perform the calibration procedure for setting the proper baseline?
- What output do you need to show to the buildings' owners and managers?

The competencies of the participant who successfully completes the learning module will include an understanding of the practical procedures for the elaboration of a robust baseline related to energy and water consumption. The participants will acquire practical knowledge of data collection and verification procedures, modelling assumptions, creation of the building energy modelling, output elaboration and visualization. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (designers, auditors, energy managers, facility managers, EPC experts, ESCOs), as well as for everyone else who wants to acquire practical knowledge for the calculation of an energy and water consumption baseline as the starting point for the designing of the proper retrofitting strategies.

Short CV of the envisioned lecturer:

Alice Gorrino is a Building Engineer and currently works as an Internationalization Consultant at Edilclima S.r.l. since January 2021. She holds a PhD in Technological Innovation for the Built Environment from Politecnico di Torino, Department of Energy, where she previously worked as a grant researcher until 2017 and as an external lecturer until September 2021. Her research activities have primarily focused on building energy performance calculation methods in accordance with technical standards, as well as data analysis and building energy management systems. She has authored approximately 35 scientific, technical, and didactic publications, with a particular focus on energy performance dynamic simulation, energy performance of building envelopes (including thermal bridges, sunspaces, green roofs, vented opaque envelopes, and transparent active façades), energy management strategies, and Decision Support Systems. In addition to her research work, Alice Gorrino has been actively involved in energy audits of hospitals, banks, and municipal buildings, conducting around 40 audits as an energy consultant.

Teaching methods and tools:

The exercise foresees the active participation of attendants making use of a case study-approach. It is structured into a brief theoretical part and a practical exercise through the use of an energy performance simulation tool (Edilclima's EC700) coupled with Excel spreadsheets for further analysis.

Key questions that will be addressed:

- What are, in practice, the steps of a baseline evaluation?
- What documentation should I collect during the site inspection?
- What is, in practice, a calibration procedure?
- What are the main outcomes of the baseline analysis that are relevant for buildings' owners and managers?

References and recommended reading:

1. European Committee for Standardisation (CEN). (2012). EN 16231: Energy efficiency benchmarking methodology
2. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
3. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
4. European Committee for Standardisation (CEN). (2015). EN 16247: Energy audits - Part 5: Competence of energy auditors
5. https://www.efficienzaenergetica.enea.it/servizi-per/imprese/diagnosi-energetiche/indicazioni-operative.html
6. International Organization for Standardization (ISO). (2014). ISO 50002: Energy audits - Requirements with guidance for use
7. International Organization for Standardization (ISO). (2014). ISO 50006: Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)

8.2.16 Exercise 7: Calculation and verification of energy savings based on Re-Co activities - case study nursery home

Short description of the exercise and learning outcomes:

This exercise provides an example of how to calculate and verify energy savings triggered by Re-Co activities. Participants will learn how to conduct a reliable and realistic calculation and verification of energy savings that were triggered by Re-Co activities in a nursery home. Based on the provided data sample, we will have to define the baseline period. They will also have to create the measurement and verification plan and discuss in groups possible improvements. Each measurement and verification plan will be assessed, and it will be checked does it provide answers on the following questions:

- Why do we need the proposed measurement?
- What are the performance improvement measures that will be monitored and verified by the proposed measurement?
- What energy indicators will be calculated based on the proposed measurement?
- What is the appropriate data recording frequency?

Participants will also learn how to specify continuous re-commissioning using energy management system functionalities.

Competencies of the participant who successfully completes the learning module will include an understanding of the calculation and verification of energy savings triggered by Re-Co activities which include the creation of a measurement and verification plan. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in the evaluation of the energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge how to effectively utilise data collection process for optimisation of energy systems and re-commissioning activities. Participants will learn how to calculate and verify energy savings based on Re-Co activities.

Short CV of the envisioned lecturer:

Marko Pečkaj is a mechanical engineer at Jožef Stefan Institute - Energy Efficiency Centre, specialising in energy management systems for industry and buildings, as well as sustainable transport. With extensive experience in managing and participating in various projects, Marko has expertise in energy audits, municipal energy planning, feasibility studies, energy system modelling, software development, and measurements in industrial and building settings. In addition to his role at Jožef Stefan Institute, he serves as a lecturer at EUREM (European Energy Manager) training and is also proficient in GHG (Greenhouse Gas) emissions verification. Marko Pečkaj's dedication to advancing sustainable practices and technologies in the field of energy efficiency is evident through his work and expertise in these areas.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, preparation of re-commissioning plans, analysis of collected data and verification of achieved energy savings.

Key questions that will be addressed:

- What are the most energy-intensive appliances and technical systems in nursery homes?
- Why do we need to analyse operation hours and settings of HVAC?
- What are the main factors influencing boiler performance?
- What are the options for demand control in nursery homes?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings
2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. Efficiency Valuation Organisation. (2019). EVO 10300 - 1: Measurement & Verification - Issues and Examples
5. Efficiency Valuation Organisation. (2022). EVO 10000 - 1: International Performance Measurement and Verification Protocol (IPMVP) – Core Concepts.
6. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning
7. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information
8. Environmental Protection Agency, Facilities Management & Services Division, Office of Administration & Resources Management. (2009) EPA building commissioning guidelines
9. European Committee for Standardisation (CEN). (2012). EN 16247: Energy audits - Part 1: General requirements
10. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
11. Kong, K.W., Lam, K.W., Chan, C., Sat, P. (2019). Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings. *IOP Conf. Series: Earth and Environmental Science 290*
12. Mills, E. Norman Bourassa, N., Mary Ann Piette, M.A., Hannah Friedman, H., Tudi Haasl, T., Tehesia Powell, T., Claridge, D. (2005). The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings, National Conference on Building Commissioning: May 4-6, 2005
13. Plesser, S., Görtgens, A., Ahrens-Hein, N. Houschka, D. (2014). RE-Commissioning of Complex Commercial Buildings - Management Summary. Energydesign braunschweig GmbH, Braunschweig, Germany
14. Natural Resources Canada, www.nrcan.gc.ca, Recommissioning (RCx) Case Study (available online)
15. Oregon Office of Energy prepared by Portland Energy Conservation, Inc. (PECI). (2001). Retrocommissioning Handbook for Facility Managers
16. U.S. Department of Veterans Affairs prepared by RetroCom Energy Strategies, Inc. (2014). Retro-Commissioning Process Manual

8.2.17 Exercise 8: Calculation of SRI based on Re-Co activities and extracting energy efficiency and flexibility measures

Short description of the exercise and learning outcomes:

This exercise deals with the dynamics of the data collection for the calculation of the SRI and it provides examples how it can be connected with the re-commissioning activities. In this context, re-commissioning activities are seen as elements of a quality-oriented process for achieving, verifying, and documenting whether the performance of a building's systems and equipment still meet originally defined objectives and criteria. Participants will learn how they can utilise the data collection process for calculation of SRI to understanding cause-effect relationships between various systems and how to properly interpret collected, calculated and measured data and evaluate performance. To develop understanding of the cause-effect relationship, participants will have to analyse provided sample of data from metering and sensor infrastructure and compile a list of individual influencing factors relevant to the energy performance. They will also learn how to identify potential Re-Co measures that can be applied to improve energy performance, reduce costs and improve end-user comfort.

Participants will learn how to collect necessary data for calculation of the SRI and how to further utilise that data for the extraction of potential energy and flexibility measures which includes Re-Co activities and discuss in groups about possible improvements.

Participants will be divided in groups and they will have to assess different buildings and calculate SRI. They will have to use both assessment methods: a simplified assessment method (Method A) and a detailed assessment method (Method B). All comments that are entered to the SRI calculation spreadsheet will be used to extract potential energy efficiency and flexibility measures.

Competencies of the participant who successfully completes the learning module will include an understanding of the SRI auditing and how it can be connected with Re-Co activities. The expected duration of the exercise is 90 minutes.

Target groups:

The exercise is intended for everyone who is involved in evaluation of energy performance of buildings or technical building systems (auditors, energy managers, facility managers, EPC experts), as well as for everyone else who wants to acquire comprehensive knowledge to effectively utilise SRI data collection process and combine it with Re-Co activities. Participants will learn how to calculate SRI based on Re-Co activities and how to extract energy efficiency and flexibility measures from SRI data collection sheet.

Short CV of the envisioned lecturer:

Boris Sučić is a researcher at Jožef Stefan Institute - Energy Efficiency Centre. He holds a PhD in Electrical Engineering from the University of Zagreb. His main areas of expertise include energy management, environment management, support in decision-making in buildings and industry, modelling and optimisation of energy processes, and holistic planning in energy. As the leader of energy manager training following the EUREM programme, Boris has extensive experience in conducting training programs. He has authored numerous scientific articles published in international and domestic journals and conferences and handbooks for various seminars and training courses. Boris has gained practical experience by implementing several domestic and international projects as a coordinator or team member, focusing on energy efficiency. He has also conducted over 100 energy audits in industry and buildings, further showcasing his expertise in the field.

Teaching methods and tools:

The exercise foresees the active participation of participants. It includes theoretical explanations, discussion, solving real-life energy problems, calculation of SRI, analysis of collected data and extraction of energy efficiency and flexibility measures.

Key questions that will be addressed:

- What are main factors that are influencing SRI rating and can be connected with Re-Co?
- How do we construct load duration diagram?
- What are the main options for the load management?
- How can we utilise existing emergency diesel generators to improve overall performance of building?
- What are the key flexibility measures that can be extracted from SRI?

References and recommended reading:

1. California Commissioning Collaborative. (2006). California Commissioning Guide: Existing Buildings

2. Canmet ENERGY in collaboration with the Office of Energy Efficiency (OEE) and under the ecoENERGY for Buildings Program of Natural Resources Canada. (2008). Recommissioning Guide For Building Owners and Managers
3. Colmenar-Santos, A., Terán de Lober, L.N., Borge-Diez, D., Castro-Gil, M. (2013). Solutions to reduce energy consumption in the management of large buildings, Energy and Buildings, 56, 66-77
4. D2.4 Report on technical specification of TDS 4. Procedures and services for the integration of SRI and environmental sustainability indicators in existing EPC tools
5. European Commission: The Smart Readiness Indicator (SRI) for rating smart readiness of the European building stock https://energy.ec.europa.eu/system/files/2022-04/SRI-Factsheet-v6_0.pdf
6. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning.
7. Energy Efficiency Office, Electrical & Mechanical Services Department (EMSD), Hong Kong. (2018). Technical Guideline on Retro-commissioning, Supplementary Information.
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10. European Committee for Standardisation (CEN). (2014). EN 16247: Energy audits - Part 2: Buildings
11. Waide P., Verbeke, S., Dourlens S., Decorme, R., Kubicki, S. (2023). Smart Readiness Indicator (SRI) - Provisional guidance on the implementation of the SRI. SRI support team: VITO (Belgium), Waide Strategic Efficiency Europe (Ireland), Research to Market Solution (France) and Luxembourg Institute of Science and Technology (Luxembourg).

8.2.18 Exercise 9: Creation of short and long-term plans for implementing improvements

Short description of the exercise and learning outcomes:

This exercise is designed to provide hands-on experience in creating short and long-term plans for implementing improvements in building energy efficiency using enhanced EPC. The following learning outcomes are foreseen:

1. Understand the key components and considerations involved in creating short and long-term plans for implementing improvements in building energy efficiency,
2. Develop skills in collaborative planning and problem-solving,
3. Learn how to use the enhanced EPC to identify and prioritize energy efficiency improvements in a building.

Participants will be provided with a case study of a specific building prior to the exercise. Two case studies are pre-selected and involve public school and private residential buildings.
Case studies will provide participants with real-world scenarios to apply the knowledge and skills gained from TDS 2, TDS 3 and TDS 4. Participants will have to identify and prioritize energy efficiency improvements and create two renovation scenarios that consider the specific needs and constraints of the case study. Participants will have 75 minutes to complete each exercise, and the lecturer will monitor their progress and provide feedback as needed. The last 15 minutes will be used for the discussion.

Target groups:

The target groups for this exercise are individuals who work in the building sector and are involved in planning and implementing energy efficiency improvements in buildings. This includes architects, engineers, construction managers, energy auditors, and other professionals in the building industry.

Short CV of the envisioned lecturer:

Alexandros Charalambides is a full-time Associate Professor at the Department of Chemical Engineering of the Cyprus University of Technology and used to serve on the Board of Directors of the International Solar Energy Society (ISES). While working at the CUT, he has successfully supervised 2 Ph.D. Participants and currently running two more; he has worked/is working on more than 20 Research Programs as principal investigator/ lead participant. He has always favoured promoting entrepreneurship and bringing research and innovation to the industry. He is one of the founders of Chrysalis LEAP, the first cleantech accelerator in Cyprus.

Teaching methods and tools:

The exercise foresees the active participation of participants.

Key questions that will be addressed

- What are the key components and considerations involved in creating short and long-term plans for implementing improvements in building energy efficiency?
- How can the new EPC be used to identify and prioritize energy efficiency improvements in a building?
- What are the best practices for collaborative planning and problem-solving in the building sector?

References and recommended reading

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9 Implementation plan and quality assurance

9.1 Implementation plan

In order to enable knowledge sharing and practical application of the enhanced approaches for EPC, TIMEPAC will deliver the six previously described TSs in a systematic and organized manner. To facilitate the monitoring of the planned activities, an indicative time plan for the next year and a half (by the end of the project's lifetime) is presented in this chapter. The indicative time plan is dedicated to monitoring the planned activities and is also intended to enable participants who want to attend several different training courses to plan their activities accordingly.

The initial plan is to organize training courses to familiarize energy certifiers and all other target groups from the building sector with the TIMEPAC approach. Envisioned training courses include an introductory workshop (webinar), after which a classic in-class training course will be organized with lectures about country-specific regulatory and market conditions, and selected topics from previously presented TIMEPAC courses. All webinars will be organized in English to reach the expected audience of 1,500 participants. A certificate of attendance will be issued to all participants attending a webinar.

After the in-class training, participants will have approximately one month to conduct practical work on a selected case (building) using elements of the TIMEPAC approach. During this process, participants will be guided and tutored by mentors from the organizations participating in the TIMEPAC consortium. The final part of the TIMEPAC training is the presentation of practical work in front of a multidisciplinary jury. A positive evaluation of the presentation is a precondition for the successful completion of the TIMEPAC training and receiving a TIMEPAC certificate. The practical work will include a clear definition of measures for reducing the energy performance gap and an objective elaboration of opportunities for the improvement of energy performance and smart readiness.

It is envisioned that during the project's lifetime, TIMEPAC courses will be organized in six countries (Austria, Croatia, Cyprus, Italy, Slovenia, and Spain), and that approximately 100 experts (13 experts per country, except Croatia and Slovenia where it is expected that two training courses will be organized resulting in 24 experts per country) will receive a TIMEPAC certificate.

For the success of the training programme, it is important to have a clear understanding of the needs and expectations of each stakeholder group involved in building energy performance certification. With this purpose, the training content and approach will be discussed with the key stakeholders at the workshops that are planned in all participating countries in the framework of WP3, which will be implemented during September and October 2023. These workshops will help to discover some of the obstacles in the implementation of enhanced certification procedures and the gaps in existing training programmes. Moreover, the ongoing survey on “Getting ready for the building Renovation Wave” launched as part of the Exploitation Plan (WP5) will also provide insights about the training gaps that exist in order to improve building energy certification at the European level. The interactions between different WPs are shown in Figure 3.

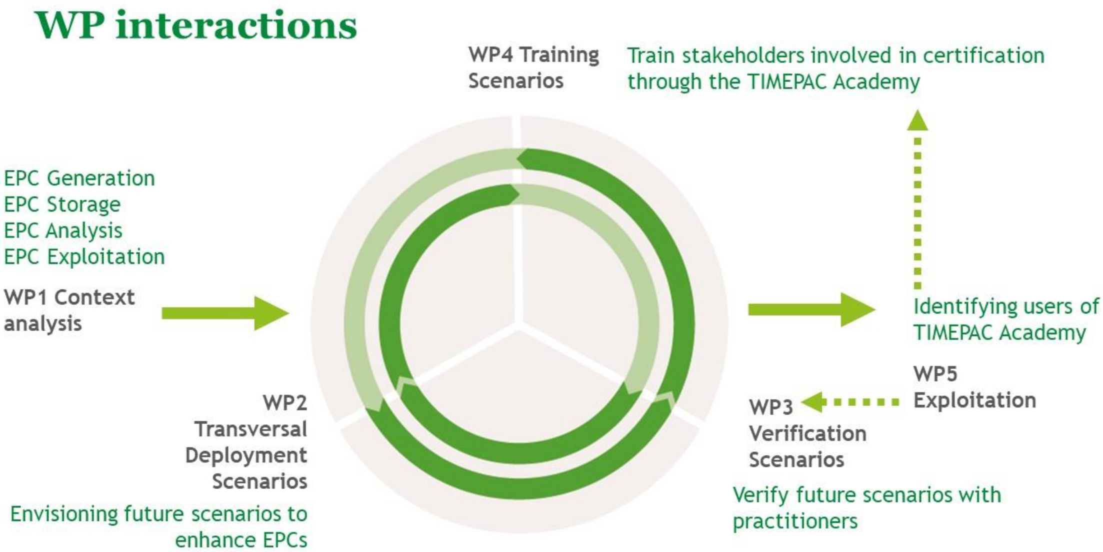

Figure 3. Interaction between different WPs

The implementation of the training courses will start in November 2023. A tentative time plan for the implementation of the training programme is presented in Table 9.

Table 9. Time plan of training activities

Ref.	Month of implementation	Type of training	Training course
1	November – December 2023	Webinar	All training courses
2	January - February2024	In class	Selected training courses in six TIMEPAC countries, starting with Croatia and Slovenia and continuing in Austria, Cyprus, Italy and Spain
3	February – March 2024	Webinar	All training courses
4	March – April 2024	In class	Training Course 1 (Analysis and visualisation of EPC data and development of innovative energy services) in Croatia and Training Course 6 (Operational optimisation of building energy performance based on activities during EPC generation) in Slovenia
5	April 2024	Webinar	All training courses

By the end of the project, our goal is to have defined a clear structure for the pan-European TIMEPAC Academy, which will continue delivering training after the project's completion. Formal organizational bodies of the TIMEPAC Academy, such as the head, management board, technical committee, scientific committee, etc., will be established during the project's lifetime.

9.2 Quality assurance

In order to ensure the desired level of quality for all foreseen training courses in different countries and environments (on-line and in-class), a quality assurance team will be created before actual start of the training campaign. Each consortium member will appoint one representative to the quality assurance team.

Course participants will have the possibility to rate every lecture and practical exercise, and lecturers will be informed of this feedback information in order to motivate them to constantly improve the content of their courses and the performance of the participants. Feedback from the participants will guide us not only in terms of reaching the initial objectives, but also in refining and redefining the respective training activities. The process of obtaining feedback regarding lecturing activities and evaluation will be based on the customized questionnaire as the main feedback mechanism for each tailor-made activity, like an in-class lecture, webinar or a practical exercise. The questionnaires and the analysis of the responses will be included in the corresponding deliverables for each course.

For each lecture and exercise the respondents will indicate their level of satisfaction with the topics, the teaching methods, the training materials, the methods and tools and the overall presentation by the lecturer using a 5-point Likert scale ("Not satisfied at all", "Mostly unsatisfied", "Neither satisfied or unsatisfied", "Mostly satisfied", "Very satisfied"). Additionally, the respondents will indicate the importance and applicability of the contents using a 3-point Likert scale ("Prefer less", "Right level", "Prefer more"). The questionnaire will also be used to evaluate the implementation of the training, including the location, premises, and use of pedagogical tools. The evaluation of the first round of training courses will help to identify necessary improvements in both the methodology and the training format and contents.

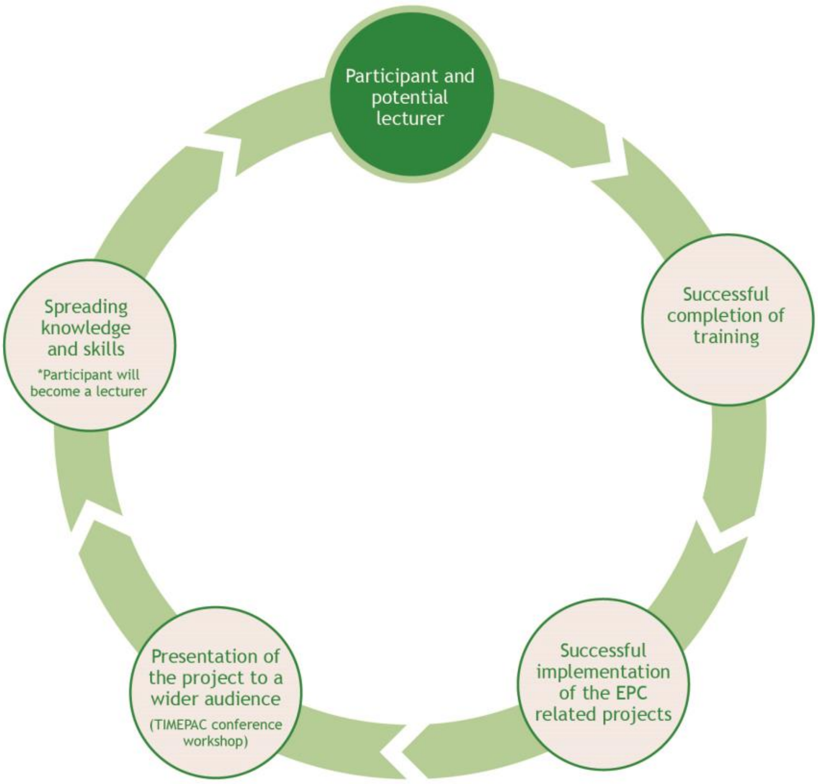

Figure 4. Knowledge sharing and inclusion of former participants in a network of lecturers

The training activities have been methodically designed with a participant-centred pedagogical approach in mind, such as in-class exercises and problem-based learning. Emphasis will be placed on knowledge sharing and the inclusion of former participants in a network of potential lecturers, which will continue to grow through ongoing learning. All participants will have the opportunity to become lecturers, provided that, they successfully complete the training, implement an EPC-related projects in practice, and present their work at a future TIMEPAC conference or workshop (Figure 4).

The risk factors affecting the implementation of envisioned training courses are listed in Table 10.

Table 10. Risks and mitigation measures

Description of risk	Likelihood	Impact	Proposed risk-mitigation measures
The selected group of lecturers does not meet expectations	Low	Medium	The group of lecturers is selected based on their technical knowledge, high qualifications, and individual lecturer experience. Quality assurance assessment (questionnaire) is carried out immediately after each lecture and is also used to assess the performance of ongoing activities and implementation. Participants in the training will evaluate each lecture and practical exercise, and the information will be sent to the lecturers, thus encouraging them to continuously improve their lectures and their delivery.
Quality of training materials is not appropriate	Low	High	The entire two years of the project are dedicated to the identification of shortcomings in the existing educational and training activities, implementation of Transversal Deployment Scenarios and verification of the proposed approaches in Verification Scenarios. Strengthened and harmonised training materials will be collaboratively developed by all members of the TIMEPAC consortium. The training materials will have a clear focus on practical application of the how to-do approach in resolving existing problems in energy performance certification.
Successful implementation of training requires much more learning materials and additional tools then initially anticipated.	Low	Medium	A comprehensive training programme must be developed early enough to enable the successful implementation of envisioned courses. The entire second year of the project is dedicated to the implementation of Transversal Deployment Scenarios and development of learning materials and additional tools that are essential for the successful implementation of the planned training courses. A quality assurance group will be established and it will closely monitor the implementation of courses and act on the identified strengths and weaknesses.

Insufficient number of participants in target trainings, difficulties in implementing on-line or in-class trainings due to low interest for selected target groups and the lack of adequate personnel dealing with energy and environmental issues in public sector.	Low	Medium	During the implementation of the Verification Scenarios, special and quality-oriented workshops will be organised to promote envisioned trainings. In addition, regular discussions will be held with selected target groups. The main goal of these discussions is to identify the main obstacles in implementing envisioned training activities in practice and to explore how the training program can be improved in terms of content and organization.

10 Conclusion

The work carried out in Task 4.2 of the TIMEPAC project has focused on developing the overall TIMEPAC training programme. The output of this task is the present deliverable, which provides a detailed description of all planned educational activities and outlines a timetable for delivering the envisioned training courses in an organized fashion across all six TIMEPAC partner countries (Austria, Croatia, Cyprus, Italy, Slovenia and Spain).

The TIMEPAC consortium recognizes that the successful execution of energy efficiency projects in buildings requires interdisciplinary knowledge encompassing energy performance evaluation, energy management, renewable energy sources, energy auditing, building and facility management, and other related areas. To identify the training needs of the various stakeholders involved in building energy certification, and to apply the comprehensive approach suggested in TIMEPAC, a series of discussions were held among all project partners. The objective was to determine the present state of EPC-related activities in each participating country or region, as well as to identify any limitations or obstacles that may impede the implementation of new training courses.

This training programme focuses not just on current, but also on future needs of EPC professionals. Enhanced EPC professionals will be empowered with new knowledge, skills and competences that will help them to close the gap between theory and practice and to provide the necessary background and help for decision-makers when they are dealing with energy-related issues in buildings. As the consortium partners are strongly embedded in various disciplines of the energy performance assessment sector, TIMEPAC training courses will take advantage of this large network of experts.

The main focus of the envisioned in-class training courses will be on real-life cases and exercises that will be extracted from experiences related to the implementation of TDSs. We believe that interactive in-class teaching by experienced trainers and professionals will give the participants an opportunity to gain relevant practical experience or update their existing knowledge, skills and competences.

With the aim of multiplying the knowledge gained through sharing good practices and networking, the TIMEPAC consortium will continue working after the project lifetime through TIMEPAC Academy to further exploit the innovative elements of EPC enhancement methods and tools and the training materials used in the project. The main beneficiaries of the TIMEPAC Academy will be professional certifiers, national and regional standardisation bodies, and energy and EPC experts. The Academy will in the first stage take advantage of the interdisciplinary and international expertise of the consortium partners themselves and in a later stage, expand its offerings with the involvement of other actors and resources. The main findings and lessons learned from implemented training courses will be summarised through the work in Tasks 4.3 to Task 4.8.

At the conclusion of the project, our objective is to have established a well-defined framework for the pan-European TIMEPAC Academy that will provide ongoing training beyond the completion of the project. To achieve this, formal organizational bodies for the TIMEPAC Academy, such as the head, management board, technical committee, scientific committee, etc., will be established during the project's duration.