TIMEPAC

Towards Innovative Methods
for Energy Performance Assessment and Certification of Buildings

Deliverable 4.9

Guidelines for EPC enhancement at EU level through TIMEPAC Academy

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Executive summary

This deliverable summarizes the outcomes and guidelines developed under Task 4.9 “Guidelines for EPC enhancement at EU level“. It consolidates insights gained from extensive deployment, verification, and training activities conducted across the TIMEPAC partner EU countries. The proposed guidelines support the adoption of dynamic, data-driven approaches to building energy management across Europe and outline a strategic framework for modernizing Energy Performance Certificates (EPCs). Key focus areas include data integration, interoperability, and the inclusion of smart readiness and sustainability indicators. By leveraging technologies such as Building Information Modelling (BIM), Building Energy Modelling (BEM), Renovation Passports (RP), and data integration, TIMEPAC promotes a more holistic and accurate approach to assessing energy performance assessment.

The focus of TIMEPAC is to create a continuous data flow throughout the entire certification process—spanning generation, storage, analysis, and utilization—by enhancing the integration of databases, energy audit reports, and BIM models. This supports the development of a Digital Building Logbook (DBL) to centralize all relevant building data. To achieve this, TIMEPAC proposes a combination of energy certification activities, including energy audits, smart readiness assessments, and sustainability ratings, backed by integrated data solutions. This approach enables a more accurate, dynamic, and comprehensive assessment of building performance, moving beyond traditional, static certification methods. However, several challenges to EPC enhancement have been also identified, namely the integration of operational data, ensuring interoperability between different data systems and the incorporation of smart and sustainability indicators. Recommendations include improving data exchange standards, promoting the use of open data formats, and addressing cost and complexity barriers to the wider adoption of the certification.

Training professionals in certification methods and skills is a crucial factor in the effective implementation of the TIMEPAC energy certification enhancement vision. The TIMEPAC Academy, established as part of this project, serves as a centre for continuous learning by offering a training programme focused on advanced EPC methodologies. This programme can continue post-project, providing practical skills, real-world applications, and a multidisciplinary curriculum on topics such as energy performance assessment, smart readiness evaluation, and digital data management. By connecting project partners and stakeholders beyond the project’s lifetime, the TIMEPAC Academy has the potential to foster ongoing collaboration, ensuring that advancements from the TIMEPAC project continue to shape energy performance certification practices across the EU. Future initiatives, such as webinars, workshops, and partnerships with other EU-funded projects, can further establish the Academy as a leader in professional development for energy performance assessment.

Sustaining the TIMEPAC vision over the long term will depend on the success of future collaborations between project partners, stakeholders, and new training providers. This continued engagement will be crucial for the promotion of a greener, more energy-efficient built environment. Given the rapid evolution of energy technologies and advanced techniques, it will also be essential to regularly update training materials and further develop standardized content to keep the TIMEPAC Academy’s offerings current and impactful.

The key findings and recommendations outlined in this document align with the latest recasts of the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED), supporting the EU’s broader goals of improving energy efficiency and sustainability in the building sector.

1 Introduction

1.1 Purpose and target group

This report presents the outcomes and guidelines developed under Task 4.9 “Guidelines for EPC enhancement at EU level“ of the TIMEPAC project. The guidelines are derived from the extensive deployment of five Transversal Deployment Scenarios (TDSs), four Verification Scenarios (VSs), and six Training Scenarios (TSs) carried out across participating countries, incorporating real-world performance data and insights hands-on applications. The aim is to provide a strategic framework that addresses key areas such as data integration, interoperability, and the inclusion of smart readiness and new sustainability indicators to modernize EPCs and enhance their functionality.

A core aspect of these guidelines is the emphasis on combining diverse activities related to building energy assessment (energy auditing, energy performance certification, and smart and sustainability rating) and data integration, including the use of energy consumption data and sensor technology, with the objective of achieving a more accurate and dynamic representation of a building's performance. Furthermore, enhancing interoperability through the integration of Building Information Modelling (BIM), Building Energy Modelling (BEM) and Renovation Passports (RP) is critical to creating a seamless and cohesive approach to building energy management across Europe. In addition to technical improvements, the guidelines outline that enabling the interoperability between existing databases, previously developed models (such as BIM or BEM), and past energy-audit reports, is crucial to providing a more holistic view of building performance over the building’s lifetime. This information should be accessible to building professionals (such as energy and facility managers, energy performance certifiers, architects, engineers, etc.) in a way that allows enhanced EPCs to build upon previous data. This approach is in line with the recommendations of the latest EPBD and the recognised need to create the Digital Building Logbook (DLB) that will aggregate all the relevant data about a building, ensuring that authorised people can access accurate and reliable information about its performance.

An important outcome of the project is the TIMEPAC Academy, envisioned as a long-term hub connecting project partners beyond the project’s lifetime. The Academy will serve as a centre for continuous learning, training, and knowledge sharing, supported by research and technological development partners, technology providers, and certification bodies. In this capacity, the TIMEPAC Academy will facilitate ongoing education, dialogue, and collaboration, contributing to the enhancement of EPCs at both national and EU levels. By acting as a central point of engagement, the Academy will ensure that the knowledge developed during the TIMEPAC project continues to influence EPC enhancement, foster the integration of new technologies, and drive forward the adoption of dynamic, data-driven energy performance assessments.

1.2 Deliverable structure

This deliverable is organized into five main sections. Section 1 serves as the introduction, covering the purpose of report (1.1), the deliverable structure (1.2), the contribution of the TIMEPAC partners (1.3), and the relationships with other project activities (1.4). Section 2 presents the TIMEPAC vision for enhanced EPC and continuous data flow. Section 3 discusses recent developments and implementation challenges, considering the new EPBD and existing practices across countries. Section 4 presents the main findings and guidelines for effective education and training. Section 5 presents the conclusions and future challenges drawn from the findings and outcomes of TDSs, VSs and TSs.

1.3 Contribution of partners

The work conducted under Task 4.9 was coordinated by the JSI. FUNITEC was tasked with defining TIMEPAC's vision for enhanced EPC and continuous data flow. POLITO led discussions on recent developments and implementation challenges, considering the new EPBD and existing practices across various countries. JSI outlined future education and training activities, focusing on the future of the TIMEPAC Academy, which is envisioned as a long-term hub for connecting project partners beyond the project's lifetime. The other consortium members contributed comments and recommendations for EPC enhancement, creating a roadmap for national policymakers, energy agencies, and other stakeholders to effectively adopt and implement these improvements. JSI also took responsibility for compiling the report.

1.4 Relations to other project activities

The goal of this task is to draw conclusions from the implementation of TDSs, VSs and TSs. This analysis will serve as a foundation for the envisioned activities beyond the TIMEPAC project lifetime. Additionally, the findings will provide a baseline for Deliverable 5.12 "Final Exploitation Plan".

2 TIMEPAC vision for enhanced EPC and continuous data flow

The TIMEPAC vision promotes a holistic approach to the entire EPC data lifecycle, encompassing continuous data flow through four key stages: generation, storage, analysis, and exploitation (Figure 1). This perspective shifts away from static, one-time certifications toward a more dynamic and integrated assessment, treating the building as a living structure interconnected with the built environment and connected to transport and energy generation systems.

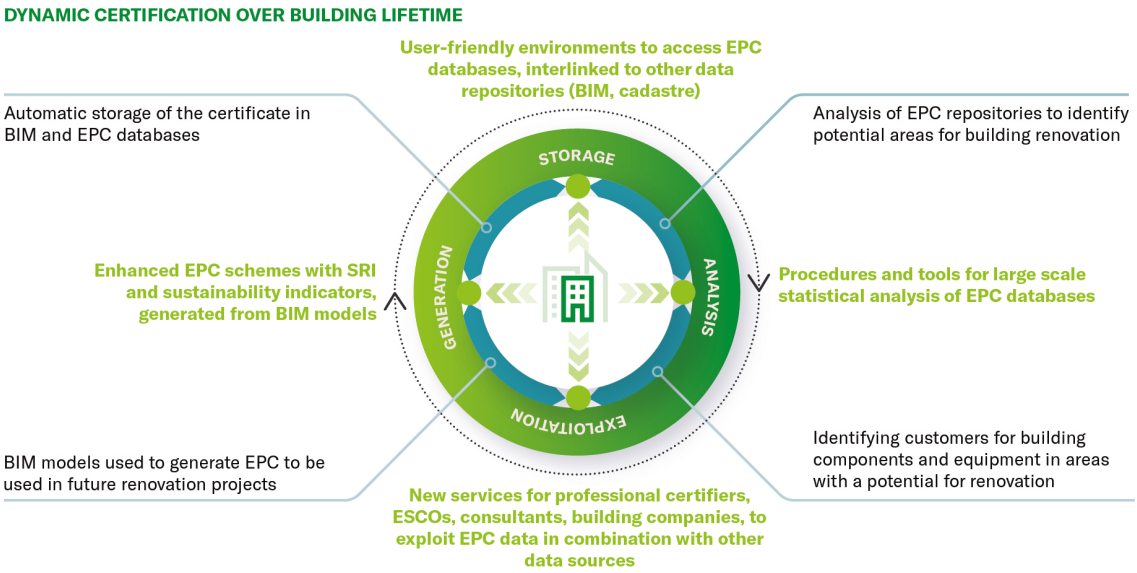

Figure 1. Seamless and continuous data flow of the building certification data

In the work conducted in the TIMEPAC project, we analysed the feasibility of the data flow in the partner countries using the available methods and tools, applying a scenario-based methodology (see Transversal Deployment Scenarios reports). This analysis has revealed existing gaps and deficiencies in the four stages of the data flow and helped us formulate directions to address these issues in the future, in line with the recommendations of the latest EPBD.

2.1 Generation of enhanced and improved EPCs

Generating EPCs from data derived from BIM models can help enhance their accuracy and reliability. BIM models can provide a comprehensive and detailed digital representation of a building's physical and functional characteristics, including geometry, materials, systems, and performance data. This data can be used as input for EPC calculations, reducing the reliance on potentially outdated, inaccurate, or incomplete information often found in traditional EPCs.

Despite the potential benefits, several challenges persist, particularly in the interoperability between various modelling and simulation tools. A significant hurdle lies in exchanging non-geometric data —such as mechanical, electrical, and plumbing information (MEP) — between software systems. Common limitations were observed in nearly all case studies of the TIMEPAC project, with some EPC software unable to fully interpret BIM models or specific components. To address these issues, guidelines have been produced to outline how existing technologies can be used to calculate EPCs from BIM models. These guidelines aim to standardize and improve protocols for using BIM in energy performance certification across the European Union. They focus on extracting key data from BIM models—such as building geometry, material properties, and system information—and converting it into inputs for EPC calculation tools. Additionally, they include recommendations for software developers, policymakers, and industry stakeholders to boost

software compatibility and address challenges in the seamless integration of BIM into energy certification processes (See Deliverable D2.1).

Currently, several barriers hinder the widespread adoption of BIM-based EPC generation, including the perceived cost and complexity of BIM modelling, data availability challenges, and the need for improved interoperability between BIM and EPC software. To address these obstacles, it is necessary to promote BIM training and education, develop simplified approaches to incorporate essential MEP data into EPC calculations, and advocate standardised data exchange formats.

To improve the accuracy of EPCs, it is essential to compare the calculated energy performance with metered energy consumption, as recommended in the latest EPBD, Annex I. Enhancing the EPC with operational data allows for the inclusion of a new set of indicators for a comprehensive building assessment applicable across EU countries, among them: standard energy performance assessment, tailored energy performance assessment, calibration against monitored data, economic evaluation of energy efficiency measures, indoor environmental quality (IEQ) evaluation and Building Automation and Control System (BACS) impact assessment (see Deliverable D2.2).

2.2 Storage and exchange of data

According to the latest EPBD recast, Member States are required to establish “a national database for the energy performance of buildings which allows data to be gathered on the energy performance of individual buildings and on the overall energy performance of the national building stock“, which might consist of “a set interconnected databases” (Art. 22). Current practices, where building-related data is used only for single/dedicated purposes, are unsustainable and cannot result in an enhanced EPC. It is crucial to enable the interoperability between existing databases, previously developed models (such as BIM or BEM), and past energy-audit reports.

At present, building data is often fragmented across different systems and databases of various public agencies. An audit of the EPC databases carried out within TIMEPAC (see Deliverable 1.2) revealed that the number of databases that are interconnected in the six participating countries is insufficient. This highlights the need for improved interoperability, which would enable a continuous data exchange between EPC databases and other key sources such as BIM repositories, cadastral records, geographical databases, registers of PV plants, operational data and utility databases, and more.

Ensuring the quality of EPC data stored in regional and national databases is fundamental. To achieve this, it is necessary to implement data quality checks in EPC generation, storage in databases, and the data exchanges between different EPC tools and databases. These checks may include data type validation, range checks, consistency checks, and plausibility checks to identify and rectify potential errors or inconsistencies. By establishing these quality control procedures across Europe, it will be possible to steadily improve the reliability and trustworthiness of EPCs and other building-related data (see Deliverable D2.5).

The latest EPBD introduces the “Digital Building Logbook (DBL)”, that is, “a common repository for all relevant building data, including data related to energy performance such as energy performance certificates, renovation passports and smart readiness indicators, as well as data related to the life-cycle GWP”, which will facilitate “informed decision making and information sharing within the construction sector, and among building owners and occupants, financial institutions and public bodies” (Art. 2). Moreover, the logbook needs to be interoperable with the national energy performance database (Art. 22.7) and include the renovation passport (Art. 12.8).

In order to meet the EPBD requirements, the DBL can be configured as a single source of truth that encompasses EPCs, BIM data, Renovation Passports (RP), energy audit reports, operational data from building systems, and other pertinent information (see Figure 2). This centralized approach ensures that stakeholders have access to accurate and up-to-date information regarding a building's energy performance and its relevant characteristics. Furthermore, the data stored in the DBL can be reused to carry out the different stages of the building renovation passport roadmap. For

example, reusing BIM data not only makes the renovation process more efficient but also enables informed decision-making at each stage, ultimately leading to more effective building upgrades that enhance energy performance and sustainability.

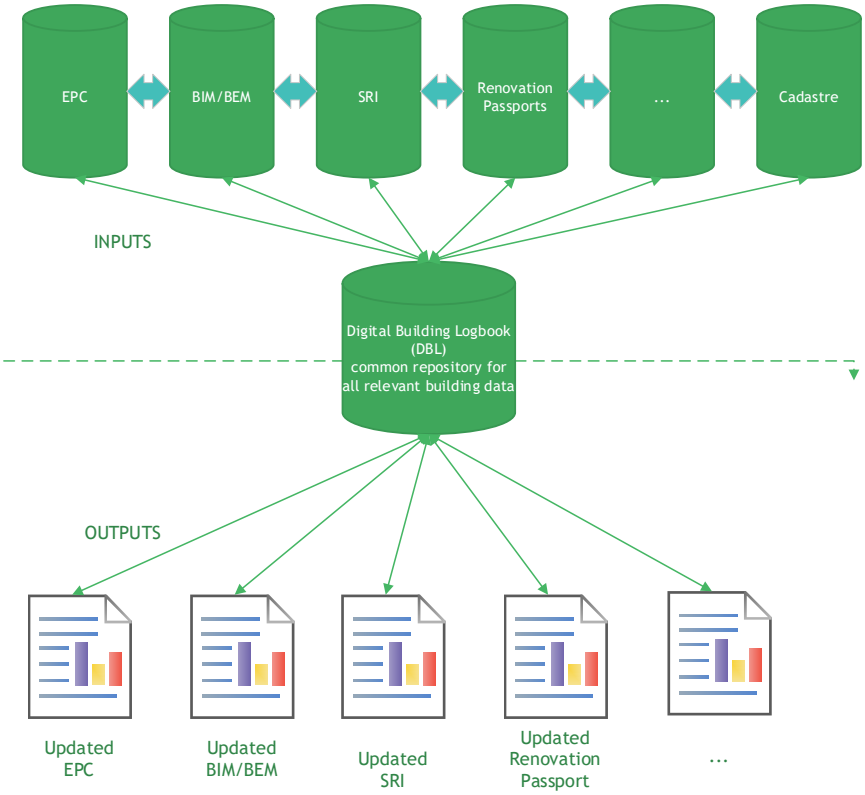

Figure 2. Digital Building Logbook as a central element of the future interoperability between different databases and envisaged dataflow

DLB can act as a community platform, offering different grades of complexity depending on the user's role and the level of data restriction. For instance, citizens might benefit from simplified access, where the system provides straightforward recommendations for improving energy use, reducing consumption, and understanding available incentives or government support for energy-efficient upgrades. This could help homeowners or tenants make informed decisions about how to enhance the energy efficiency of the buildings and dwellings. On the other hand, professionals, such as energy assessor's and researchers, might require more detailed and technical data, such as real-time energy consumption or advanced performance metrics. Public administrators could use aggregated data to identify trends in energy usage and environmental impacts, allowing them to shape local policies or implement community-wide energy-saving initiatives. Importantly, by monitoring building energy consumption over time, these databases enable the creation of more reliable energy scenarios for cities, which are critical in forecasting future energy demands and informing infrastructure planning, including renewable energy integration or grid capacity enhancements.

At a broader level, the harmonisation of EPC databases across EU countries is essential for fostering greater alignment in how energy performance is tracked and reported. Currently, each Member State may use slightly different building data collection standards. However, establishing a unified approach, as devised in TIMEPAC, would facilitate cross-border comparability, allowing for more accurate benchmarking of energy efficiency across different regions. This harmonisation would support a more effective management of the energy transition and reduce carbon emissions at EU level, ensuring that information on buildings is accurate, reliable, and updated.

2.3 Analysis of integrated data

At TIMEPAC, an analysis of EPC databases has been carried out to inform decisions related to improving the energy efficiency of buildings through large-scale renovation programmes. The methodologies developed in previous EU research projects, such as TABULA and EPISCOPE, play a key role in this process by providing a foundation for harmonizing building typologies and monitoring building stocks (see Deliverable D2.5).

The availability of national building energy performance databases can facilitate the assessment of the building stock's condition and the formulation of comprehensive renovation plans at various scales, including district, municipal, regional, and national. However, a quality check of the EPC data is a prerequisite for developing building stock energy models and conducting accurate refurbishment scenario analyses.

Through the analysis of the EPC integrated data, it is possible to carry out energy balances of building stocks using representative buildings, or archetypes. These archetypes are "virtual" representations of buildings that capture the average technological characteristics of specific building stock segments, considering climatic zone, building use, construction period, among other. They can be derived through statistical analyses of EPC data and serve as inputs for determining building stock energy efficiency, ultimately guiding improvements to the built environment.

Guidelines, developed within the TIMEPAC project, establish a shared, harmonized and flexible methodology for the creation of these archetypes based on EPC data. This set of tools and methods provides stakeholders with a better understanding of the potential energy savings and emission reductions achievable through various renovation measures.

2.4 Exploitation of data through new services

The exploitation of data through innovative services in TIMEPAC has shown how the understanding and management of energy and environmental performance of building stocks can be improved. These services are mainly based on data processing through statistical analysis to deepen knowledge about the characteristics of the building stock, ultimately improving the effectiveness of renovation scenarios. The success of these advancements heavily rely on several factors—data availability, data accessibility, and data quality—which are essential for ensuring that the information collected is reliable, timely, and useful. Additionally, these services provide benefits to various stakeholders, including building owners, occupants, renovation professionals, policymakers, and energy service companies (ESCOs).

To harness the power of data, local and regional EPC databases play a crucial role. These databases store core information about the energy performance of buildings. By enriching the available data and improving the quality of these databases, more accurate predictions of building energy characteristics can be made, enhancing the ability to plan future building stock energy performance. As demonstrated within TIMEPAC, firstly, one way to improve these databases is by introducing additional indicators across various fields—economic, environmental, and social—which expand the applicability of the data beyond energy efficiency alone. For example, economic indicators might include the cost-effectiveness of energy-saving measures, while social indicators could account for the energy poverty levels within certain regions. This broadens the relevance of the database, making it a powerful tool for multiple stakeholders, from government policymakers to urban planners, researchers, and even individual property owners. Secondly, a data quality checking procedure embedded within these EPC databases is essential for ensuring that the information stored is accurate, consistent, and reliable over time.

Data availability refers to the extent to which relevant data about building energy performance is collected and accessible for analysis. Some data is mandatory, while other data can be collected on a voluntary basis. However, without comprehensive data, understanding of the building stock performance remains limited, making it difficult to draw meaningful conclusions or make improvements. Data accessibility involves determining who can access this data, and under what

conditions. Different target groups such as private citizens, public authorities, researchers, or technicians may require varying levels of access depending on their needs and their technical proficiency. This is often tied to particular legal or privacy restrictions, especially when it comes to sensitive data such as energy consumption. Lastly, data quality is crucial because inaccurate or inconsistent data can lead to faulty analyses and misguided decisions. Proper validation and verification procedures are essential to ensure that the data feeding into these systems is robust and trustworthy.

EPCs enhanced with additional indicators (e.g. economic, indoor environmental quality (IEQ), building automation and control systems (BACS)) can provide ESCOs with critical insights needed to assess investment strategies. This way, energy managers could evaluate building improvements while considering user needs and economic feasibility. Such advancements would empower end-users to make informed decisions and support the work of energy auditors, ultimately resulting in more consistent and trustworthy certification practices. Additionally, on-site audits conducted by experts can provide valuable information for EPC and SRI certification, as well as for the RP.

Data integration including EPC, BIM, energy audits, and measured consumption into RPs would offer building owners a comprehensive roadmap for energy-efficient renovations. The building renovation roadmap would include recommended measures, estimated costs, potential energy savings, and the expected improvements in building performance.

In addition, personalized energy efficiency recommendations can be derived from the analysis of integrated data such as occupancy patterns, user behaviour, and building system performance. Understanding past performance based on the available data is necessary to identify building-specific measures to improve both energy efficiency and flexibility. These recommendations would be tailored to building occupants, offering advice on energy-saving practices, optimal settings for building systems, and insights into energy consumption patterns. This way, it would be possible to raise awareness and encourage behavioural changes that support energy efficiency.

The potential of data-driven building management systems to analyse building performance and determine improvement measures offer new opportunities for the creation of new services. By integrating EPC data, BIM/BEM models, and operational data, these systems can significantly optimize real-time building operations. This integration enables a range of functionalities, including predictive maintenance, automated adjustments based on occupancy patterns and environmental conditions, and continuous monitoring of energy performance. Such capabilities would facilitate the swift identification and resolution of potential issues, leading to improved operational efficiency. Furthermore, access to this integrated information could pave the way for performance-based contracts with ESCOs that are directly tied to the actual energy savings achieved. This approach would not only incentivize high-quality work but also ensure that building owners achieve the energy efficiency improvements they expect. Nevertheless, a significant challenge remains in developing such services for residential buildings, particularly in multi-proprietary contexts, where diverse ownership and management structures can complicate the implementation of effective building management systems.

3 Implementation challenges

In the context of an enhanced EPC, there are several implementations challenges that future users and policymakers will need to address. The three most significant areas presenting the most intriguing challenges are: the integration of operational data, the interoperability between BIM and RP, and the inclusion of smartness and sustainability indicators in the EPC framework.

These areas are crucial for advancing EPCs beyond their current capabilities, but they also require thoughtful approaches to data management, technological integration, and policy alignment.

3.1 Integration of operational data

Operational data is essential for enhancing EPCs. New and enhanced EPCs have potential to support informed decision-making, facilitate continuous improvement of the building performance, ensure regulatory compliance, and promote stakeholder engagement.

Within the procedures proposed in the TIMEPAC-enhanced EPC framework, operational data is primarily intended for use in calibration processes and can also contribute to assessing indoor environmental quality (IEQ). The calibration method involves comparing monitored energy consumption with the results of a building energy model. This comparison aims to improve the accuracy of the energy model by reducing discrepancies between the model's predictions and the actual building’s components and energy use. The potential of EPCs as dynamic tools for verifying energy savings over time is also examined, shifting from static snapshots to support ongoing energy management and improvements. This vision will be further developed through dialogues with the relevant stakeholders across all participating countries, ensuring that the proposed enhancements align with national requirements and stakeholder needs beyond the TIMEPAC project lifetime.

However, while this method is both useful and effective, it also introduces certain procedural challenges. The first challenge relates to data collection. In some cases, measured data may not be available for the building under consideration. Even when data is available, energy consumption may be aggregated across different building services, making it difficult to accurately disaggregate the data (e.g., a heat pump used for heating may have its electricity consumption aggregated with lighting and appliance usage). To address this, incentivizing the installation of metering systems—ideally separate for each energy service (e.g., heating, cooling, lighting)—is crucial. Alternatively, establishing clear methodologies at the European or national level for disaggregating measured energy consumption across services could also prove beneficial.

A second challenge involves the technical feasibility of applying calibration procedures to large or complex buildings. As demonstrated in TIMEPAC's findings, calibration requires an iterative approach, which can significantly increase processing time. To manage this, it may be advisable to limit these procedures to buildings with specific size characteristics or those with a high likelihood of model inaccuracies, such as older buildings where information about building components is lacking.

Finally, a third issue to consider is the calibration indicator thresholds. Although the limits used in the project analyses were derived from the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) recommendations, it could be beneficial to establish new, variable limits based on the building’s use and size.

For the IEQ assessment integrated into the EPC, the proposed methods rely on calculated parameters. Some of these parameters, such as indoor operative temperature, can also be measured, along with other indicators relevant to environmental quality, like pollutant concentration for air quality. However, these measurements should not be mandatory, as they are often expensive and inconvenient for users, particularly in the case of long-term measurement campaigns.

3.2 Interoperability with BIM and RP

BIM facilitates the creation, management, and exchange of digital building representations; however, information exchange between different tools remains challenging. For instance, transferring BIM data from design software such as Autodesk Revit to energy performance simulation software like EnergyPlus can result in the loss of critical information.

There are two options for transferring BIM data between software: proprietary and open standard formats. While proprietary formats may offer seamless integration within specific software ecosystems, they can create barriers to data exchange with tools outside of those environments. Open standard formats, on the other hand, promote interoperability but can face challenges in preserving all necessary information during the transfer process. Using open formats, such as IFC, can lead to data loss during export, validation, and import processes, requiring manual re-entry of information into EPC tools. This data loss can also hinder the visualization of information within the IFC model.

The guidelines developed within TIMEPAC aim to enhance open interoperability between BIM and EPC tools, promoting standardized protocols for using BIM data in EPC calculations across the EU. However, the effectiveness of these guidelines may be limited if the EPC software tools have direct connections with BIM software through proprietary exchange formats, as many of the problems addressed by the guidelines are already solved by software developers in those cases. Relying on these proprietary solutions can limit the flexibility of users who may not be able to utilize specific software tools due to cost or other factors.

The lack of standardization in BIM methodology presents challenges for data exchange among professionals. To achieve seamless integration, it is essential to involve all stakeholders throughout the building's lifecycle and provide training to improve data management and BIM integration into business models.

The RP, a tool conceived to track renovation progress, connects the EPC process with architectural and engineering work, implementing renovation measures included in the renovation roadmap. However, it requires the issuance of a new EPC, highlighting the need for integration between the EPC calculation software and other tools to avoid repetitive data entry. Aligning BIM parameters with the EPC software libraries can streamline data input, reduce manual errors, and improve user experiences, thereby encouraging wider adoption of EPC software among BIM practitioners.

Finally, achieving interoperability between BIM, RP, and EPC processes requires addressing challenges related to data exchange formats, standardization of procedures, stakeholder engagement, and the development of comprehensive software solutions that can handle the diverse data needs of these interconnected processes.

3.3 Smartness and sustainability

The enhancement of EPCs with smart and sustainability indicators is a relatively new approach introduced in the latest recast of the EPBD. Further testing and adaptations of the proposed methodology will be necessary to fully realize its potential.

The activities within TIMEPAC project confirmed that the SRI has the potential to become an important policy instrument that supports the transformation of the building sector towards more energy-efficient and user-centric models. By assessing a building's readiness for smart technologies, promoting the deployment of digital infrastructures, empowering consumers, and supporting the transition to demand-response energy models, the SRI serves a critical role in shaping a more sustainable, efficient, and comfortable built environment for the future. As the importance of energy efficiency and smart buildings continues to grow, the SRI will undoubtedly become an increasingly valuable tool in shaping the buildings of the future. TIMEPAC has also demonstrated that utilizing simulation tools and software is advantageous for modelling a building's energy consumption and assessing the impact of various smart technologies and strategies on the SRI.

However, several barriers have also been identified, which might affect the smooth integration of these indicators with EPCs. These include its complexity of use, problems with the subjectivity of the auditor and potential problems with the price for the final users. TIMEPAC experiences clearly confirmed that in order to make the SRI rating useful, specific and tailored recommendations for performance improvements must be provided to the final user. This means that in order to be cost-effective, the SRI and sustainability rating should be combined with energy auditing and energy-performance assessments. Also, it would be beneficial to explore the benefits of including facility management as an additional domain in the calculation of the SRI. Special attention must be given to the proper explanation of the SRI score. The SRI score cannot just be a percentage of smartness. The SRI and sustainability auditor should always emphasis on the potential energy-efficiency and flexibility-improvement measures when explaining explain his/her findings. Furthermore, it is essential to properly address the high cost of smartness and develop a set of measures to promote and inform the public about the benefits of smart and flexible technologies.

The testing of the Level(s) based sustainability indicators in the scope of TIMEPAC project revealed that for many of the indicators a detailed lifecycle inventory of data is needed, which cannot be directly retrieved from the architectural plans or documents. A complete assessment of all the indicators on Levels 1-3 requires a considerable amount of time. To reduce the time efforts, it is recommended to establish or improve the links with national tools (e.g., the current link with EPB-software for the Level(s) indicator Use-stage energy performance). Default values are seen as a second way to reduce time-related efforts.

The objective of the Level(s) based sustainability assessment is to provide a common reference point for the performance assessment of buildings across Europe. The sustainability assessment moreover provides general insights into the various environmental impacts, energy use and costs that their design is causing. However, it does not permit the evaluation of the sustainability level of particular project as reference values are not available to compare and a detailed hotspot analysis is not possible. In order to increase the added value of the assessment for practitioners, measures such as the integration of such reference values (benchmarks) or more detailed reporting in the future are recommended.

To promote the use of the SRI and sustainability indicators, the TIMEPAC Code of Conduct for Smart Readiness and Sustainability Rating has been created. It represents a set of guidelines, values and principles that are considered fundamental for the successful, professional, and transparent calculation of the SRI and selected sustainability indicators. The Code of Conduct is generated based on experiences gained through the implementation of the project activities in six countries participating in TIMEPAC.

4 Education and training

Training and capacity building are essential to equip professionals with the skills needed to implement TIMEPAC's vision for enhancing energy certification. Continuous professional development will be essential to incorporate the methods and tools derived from enhanced EPC and to ensure a continuous data flow throughout all stages of the certification process. The TIMEPAC Academy can play an instrumental role in this regard, by providing training programmes focused on analysing and visualizing BIM and EPC data, collecting, and utilizing EPC data, and implementing advanced methods for building assessment and sustainable renovation practices.

The educational and training activities conducted at the TIMEPAC Academy have confirmed that a comprehensive understanding of all the factors involved in developing a cohesive certification process across the stages of generating, storing, analysing, and utilizing EPC data is essential. This need for training is particularly critical when EPCs are combined with smart readiness assessments, sustainability evaluations, energy auditing, and re-commissioning—practical skills and hands-on experience, and a multidisciplinary approach are essential.

The TIMEPAC Academy incorporates a comprehensive curriculum that integrates various fields of knowledge and expertise (see D4.2 Training programme). It covers key aspects such as energy performance assessment, smart readiness evaluation, sustainability, digitalization, and data management. By involving experts from different disciplines and fostering cross-sector collaboration, the TIMEPAC Academy will be able to equip participants with the diverse skills and knowledge necessary to address the complexities of energy performance certification and related fields effectively.

4.1 Vision of the TIMEPAC Academy

The TIMEPAC consortium is confident that the experience gained through the implementation of the training programme will help establishing a sustainable TIMEPAC Academy after the project's conclusion. Figure 3 illustrates the envisioned structure of the TIMEPAC's educational and training activities.

The TIMEPAC Academy aims to create a comprehensive, flexible, and future-oriented training platform designed to support and empower professionals involved in energy performance certification, energy auditing, assessment of smart readiness, sustainability auditing, and building re-commissioning (Re-Co). In a rapidly evolving energy landscape, where sustainability and efficiency are becoming critical imperatives, the Academy's vision is to equip professionals across Europe with both foundational knowledge and advanced skills.

One of the primary challenges that the TIMEPAC Academy has addressed during the project lifetime is the varying national regulations surrounding the training of EPC assessors. Acknowledging the diverse regulatory environments, particularly in countries where EPC assessor training is not mandatory, the Academy seeks to address this gap by offering a voluntary, high-quality training solution that adds significant value to participants' professional capabilities. While in some countries formal training and certification are mandatory, others, such as Spain, do not require EPC assessors to undergo any form of structured education. The Academy's main purpose, therefore, is to provide voluntary but highly valuable training that offers assessors the opportunity to enhance their expertise and differentiate themselves in the marketplace.

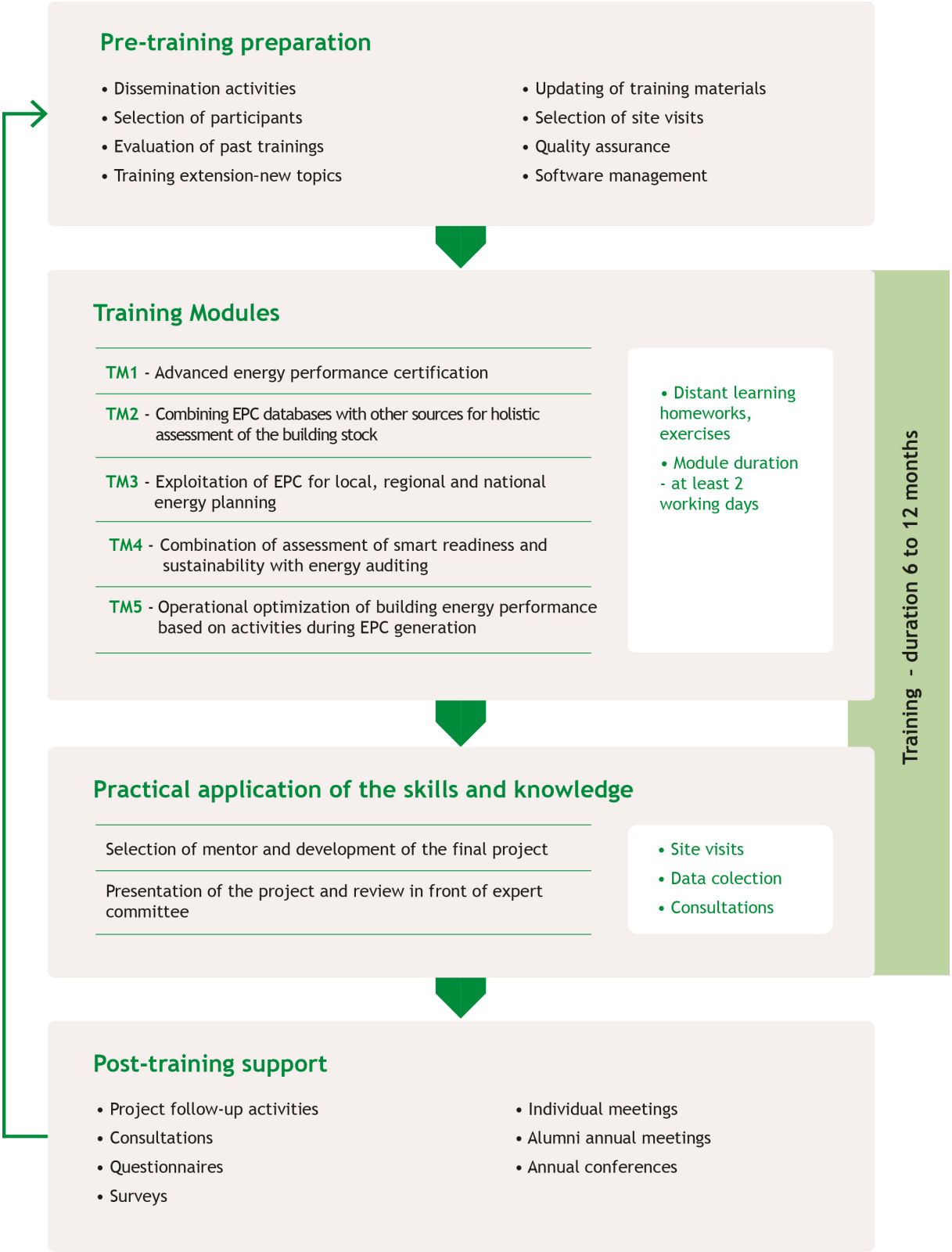

Figure 3. Concept of TIMEPAC educational and training activities after the project completion

Figure 3 illustrates the pathway to achieving superior performance, with a focus on developing advanced skills that enable assessors to offer more comprehensive and insightful services to clients. Specifically, the future TIMEPAC training activities will cover the following topics:

- **Advanced energy performance certification**: Providing comprehensive training on the technical and regulatory aspects of EPC generation, including the integration of BIM to generate EPCs for both new buildings and any successive renovation stages throughout their lifespan. The focus is on practical cases that demonstrate the capabilities of available technologies.
- **Combining EPC databases with other sources for holistic assessment of the building stock:** Using open data from EPCs in Catalonia as an example, TIMEPAC experts can learn how the integration of EPC databases with other sources can be used for a comprehensive analysis of the built environment, including population statistics, renewable energy production, and public amenities.
- **Exploitation of EPC for local, regional and national energy planning: Exploring** the potential to use EPC databases to develop an archetype-based urban building energy model, as devised in the TIMEPAC project. The focus is in statistical analysis of the EPC database, with the goal of leveraging it for benchmarking initiatives.
- **Combination of assessment of smart readiness and sustainability with energy auditing:** Equipping participants with strategies for conducting in-depth energy audits that go beyond compliance to identify cost-saving opportunities and improve building sustainability. Explore the synergies between energy performance certification, technical system inspections, and energy auditing. The main objective is to streamline the process of generating EPCs by identifying essential elements for efficient data extraction from various sources, ensuring their accuracy and reliability.
- **Operational optimization of building energy performance based on activities during EPC generation:** Teaching participants how to fine-tune building systems to ensure optimal performance over time, highlighting the potential for real energy savings and operational efficiency improvements. Re-commissioning (Re-Co) can be particularly appealing for building owners, as it provides long-term benefits such as enhanced comfort for users, reduced operational costs, and improved energy flexibility. Participants should gain the necessary knowledge and skills to provide cost effective optimization advice based on activities during EPC generation.

Previously performed training activities confirmed that there are synergies between the TIMEPAC Academy, professional bodies and industry associations in terms of providing voluntary accreditation. The credential from TIMEPAC Academy training could serve as a mark of excellence, giving certified professionals a competitive advantage in markets where formal training is not mandatory. Additionally, recognition from the Slovenian and Croatian Chambers of Engineers, adds significant value to the Academy. This recognition not only enhances the credibility of the training but also encourages broader participation by offering tangible benefits for professionals seeking to advance their qualifications. Furthermore, this initiative could serve as a compelling example for other engineering chambers and professional organizations to emulate, potentially broadening the Academy's reach and influence.

The TIMEPAC Academy will prioritize practical, hands-on learning to ensure that participants can immediately apply the concepts and techniques acquired in their professional work. Positive responses received from participants during webinars and in-class sessions organized in all six TIMEPAC countries underscore the audience's confidence in the potential of the enhanced EPC to boost the renovation of the building stocks, contributing to more efficient energy use and advancing decarbonization efforts. Participants from diverse professional backgrounds expressed strong interest in leveraging EPC data to carry out energy analyses of building technical systems and identifying feasible energy efficiency and flexibility measures. This feedback affirms that the TIMEPAC Academy's initial orientation—emphasizing real-world cases and hands-on exercises that

would enable participants to engage with actual data, assess building performance, and implement meaningful energy efficiency improvements—was indeed a step in the right direction.

By emphasizing the practical benefits of energy performance improvements, the TIMEPAC Academy appeals to professionals seeking to offer added value to building owners, tenants, and other stakeholders. In particular, future training activities will focus on how assessors can use data from various domains and systems to propose energy efficiency and flexibility measures, providing real-world solutions for optimizing building performance.

The TIMEPAC Academy will strive to offer both on-line and in-person training options, with hybrid learning pathways to cater for professionals across Europe. Previous training activities have confirmed that this flexible approach makes it possible to reach a broader audience, including professionals in countries where training is not mandatory. On-line sessions have been recognized as a convenient option for professionals who may lack the time or resources to attend in-person training. However, in-person or hybrid sessions will focus on delivering hands-on content, such as site assessments, building inspections, and system calibration exercises. Additionally, it is also clear that future training courses will need to address issues related to the life-cycle cost assessment and multi-criteria decision making.

4.2 Synergies with another initiatives

It is important to highlight that the vision of the TIMEPAC Academy aligns with the new EPBD (European Commission, 2024) and the Energy Efficiency Directive (EED) (European Commission, 2023). Both the EPBD and EED stress the need for competent professionals who can conduct energy audits, manage building performance, and ensure compliance. By prioritizing up-to-date training and educational activities, the Academy will address the key objectives outlined in both directives.

The TIMEPAC Academy provides training on energy performance certification, SRI and sustainability assessments, in line with the EPBD's emphasis on improving the energy efficiency of buildings and encouraging sustainable construction practices. In accordance with the EPBD's push for digital tools and smart technologies, the TIMEPAC Academy incorporates modules on digitalization, data management, and the use of smart technologies for energy monitoring, control, and optimization, promoting smart readiness in buildings. Reflecting the EED's goal of increasing energy efficiency, the TIMEPAC Academy covers topics such as building renovation strategies, energy auditing, and re-commissioning, enabling participants to gain practical insights into improving the energy performance of existing building stock.

Learning experiences from Croatia, Slovenia and Cyprus during the project have confirmed that a key component of the TIMEPAC Academy’s curriculum should be a thorough exploration of Re-Co, which involves the fine-tuning building systems to ensure optimal performance throughout the building’s lifecycle. Although often overlooked in building management, Re-Co presents significant opportunities for enhancing energy efficiency and lowering operational costs. Future training activities will place a strong emphasis on the financial and operational advantages of Re-Co. By effectively implementing Re-Co strategies, building owners and operators can substantially reduce energy bills, extend equipment lifespan, and improve the comfort of building occupants. This positions Re-Co as a valuable service for assessors, creating new market opportunities. By equipping assessors with the knowledge to integrate Re-Co into their EPC services, the TIMEPAC Academy will enable them to provide more comprehensive building performance assessments.

Additionally, training in Re-Co should emphasize how to monitor and optimize system performance, identify peak energy consumption periods, and propose energy flexibility measures, all of which are essential to achieving long-term energy savings. These insights are vital for professionals operating in markets where energy efficiency is becoming increasingly prioritized by both regulators and building owners.

In Croatia, the TIMEPAC Academy can be integrated into standardized educational programmes that all designers or energy auditors must complete to maintain their certification. This integration helps address the gap that educational gaps that will arise from the EPBD recast and future changes in the EPC process, including the implementation of BRP, SRI, and other initiatives.

In Cyprus, the training outcomes will provide a valuable foundation to enhance energy certification and building optimization practices. The insights and methodologies from the executed training will be used to inspire curriculum update, with potential integration into academic courses on energy management. Additionally, the knowledge gained from the training will be utilized to support local municipalities and public authorities in adopting low-cost energy efficiency measures and Re-Co practices within their facilities. The principles of Re-Co will also be incorporated into ongoing consultancy services and future projects of all participating companies, helping to bridge gaps in the EPC process and align with the requirements of the EPBD recast, including the implementation of RP and SRI.

4.3 Follow-up activities

The training activities already conducted have clearly confirmed that the TIMEPAC Academy has the potential to function as a hub for continuous professional development and a community for energy performance experts.

In an industry where technologies, regulations, and best practices are constantly evolving, it is essential to provide professionals with access to up-to-date information and ongoing learning opportunities. By offering regular webinars, workshops, and updates, the TIMEPAC Academy can contribute to fostering a dynamic learning environment that encourages professionals to stay informed about the latest trends and innovations in energy performance. Additionally, by focusing on voluntary excellence, practical application, flexibility, and real-world benefits, the training programme can attract a diverse range of professionals from across Europe. Thus, it can play a critical role in advancing the skills of energy assessors, ensuring they are equipped to meet the challenges of a rapidly evolving industry. In doing so, the TIMEPAC Academy will not only support individual career growth but also contribute to the broader goals of sustainability, energy efficiency, and the implementation of comprehensive energy renovation projects.

The TIMEPAC Academy is also open to collaboration with educational institutions, vocational training centres, and organizations with experience in energy performance certification of buildings, as well as EPC professionals interested in becoming TIMEPAC training partners.

Becoming a TIMEPAC training partner involves a few steps, including meeting specific criteria, adhering to guidelines, and submitting an application. Potential new partners and TIMEPAC training providers must demonstrate experience in the assessment of building energy performance and have qualified personnel to cover all the envisioned topics. Additionally, they must demonstrate the availability of infrastructure and resources to deliver both the theoretical and practical components of TIMEPAC training.

The TIMEPAC Academy's alignment with the deployment of the new Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED) will be further developed through upcoming activities and collaborative efforts with the BUILD UP platform. An initial example of this collaboration was the webinar Advancing Energy Performance Certification: Integrating Data, Smart Readiness, and Renovation Strategies, held on November 5, 2024. Through this cooperation, we aim to expand the Academy's outreach and promote knowledge-sharing across Europe by engaging a broader community of professionals, policymakers, and stakeholders in the building sector.

The planned presentation on the BUILD UP platform will highlight how the TIMEPAC Academy addresses key priorities of integrating data from various sources, evaluating smart readiness, and creating renovation strategies, emphasizing its multidisciplinary approach, focus on digitalization, and commitment to enhancing energy efficiency.

TIMEPAC Academy will also try to engage in appropriate future joint initiatives such as webinars, workshops, and knowledge-sharing sessions with other EU funded projects and working groups, further supporting the development of skills and competencies among energy professionals. This will help ensure that stakeholders are equipped with the necessary expertise to navigate the evolving regulatory landscape, drive energy performance improvements, and contribute to the EU's goals of decarbonization and sustainability.

5 Conclusion and next steps

The TIMEPAC project has made significant strides in advancing the concept of enhanced EPCs by tackling key challenges related to data integration, interoperability, and the incorporation of smart readiness and sustainability indicators. Its emphasis on continuous assessment throughout the building's lifetime —including the generation, storage, analysis and exploitation of EPC data—has laid the foundations for a dynamic, real-time approach to building performance management, moving away from traditional static methods. Through a collaborative, multidisciplinary approach, the project has developed guidelines that pave the way for a more accurate and data-driven assessment of building energy performance. These outcomes not only align with the latest EPBD and EED directives but also support the EU's broader goals of improving energy efficiency, sustainability, and decarbonization of building stock.

Outcomes of TIMEPAC project, especially those related with the interoperability between different data systems, were essential for planning the creation of a national database that would house all building-related and energy performance data in Slovenia. This database would facilitate better data sharing and decision-making for energy efficiency upgrades, ensuring that insights from TIMEPAC were effectively integrated into the national energy system. Key findings from the TIMEPAC project will be further exploited during the full-scale development and deployment of a centralized energy data platform. This process has a significant replicability potential and could be offered as a service in other EU countries and regions.

The establishment of the TIMEPAC Academy as a central hub for continuous training and knowledge sharing is one of the project's most significant achievements. The Academy will seek to continue to build on the foundations laid by the project, offering comprehensive and practical training to energy professionals, and fostering collaboration across sectors. This ongoing educational effort is essential to ensure that the skills and expertise developed during the project persist and adapt to future regulatory changes and technological advancements. Also, by connecting project partners and stakeholders beyond project lifetime, the TIMEPAC Academy has a potential to foster ongoing dialogue and cooperation, ensuring that the advancements made during the TIMEPAC project continue to influence and shape energy performance certification practices across the EU.

Moving forward, the TIMEPAC Academy's collaboration with the BUILD UP platform marks a strategic step towards expanding its reach and influence. This webinar which took place on November 5, 2024 served as an opportunity to evaluate the potential of the Academy to reach professional audiences after the project completion. Future joint initiatives, including webinars, workshops, and partnerships with other EU-funded projects, have a potential to further enhance the Academy's role as a leader in professional development for the evaluation of energy performance of buildings.

The envisioned future collaboration between project partners, stakeholders, and eventual new training providers will be crucial in ensuring the long-term sustainability and success of the TIMEPAC vision, ultimately contributing to a greener, more energy-efficient built environment. Since the energy technologies and state-of-the-art techniques are changing very rapidly, extra efforts will have to be dedicated to the training-material updates and the further development of the TIMEPAC Academy content and standardized education and training materials.

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