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The MedZEB Protocol: a Powerful Tool for Fostering Deep Renovation in the Mediterranean Area

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The market uptake of deep energy retrofitting represents a significant challenge in the EU Mediterranean countries, due to specific bottlenecks which lead to a low level of trust. In order to meet these challenges, the H2020 HAPPEN Project has developed the MedZEB Protocol, a tool conceived for enhancing the quality management of the overall renovation process, and tailored for the residential sector of the Mediterranean Area. The Protocol is based on a holistic approach aimed at maximizing the added value generated by retrofitting interventions, as well as on standardized procedures which allow fostering a deeper integration among the actors involved, relying on higher technical expertise and enhancing the market transparency. The paper describes the main features of the MedZEB Protocol, its architecture, the indicators and the actors/procedures involved in each phase. The results of a feasibility analysis are also presented, which show the sustainability of the Protocol adoption, thus highlighting its potential role as a reference framework for fostering deep energy retrofitting in the Mediterranean area.

1. Introduction

In the Mediterranean area, energy renovation is hampered by specific market-related bottlenecks, namely lack of transparency and of trust in the reliability of the whole process, as well as low awareness of the potential benefits of improved energy efficiency. Moreover, achieving high-quality standards throughout the renovation process is made difficult by the fragmentation of the supply chain in small and non-integrated local operators. This framework requires a strategy that goes beyond the physical and technological aspects of buildings, so as to integrate social, entrepreneurial, financial, technical, regulative and environmental issues, as a mean to deal successfully with the complexity of the Mediterranean living spheres, and the behaviour of their communities. The MedZEB approach (Mediterranean Zero-Energy Building) developed within the H2020 HAPPEN project will pursue the following main objectives (Padula et al., 2018):

- reconnecting the fragmented value chain in the retrofitting market;
- rebuilding a framework of trust in the deep-and-beyond retrofitting market;
- increasing the overall appeal and cost effectiveness of the retrofitting interventions.

In order to achieve these goals, the H2020 HAPPEN Project has developed the MedZEB Protocol, a tool intended as the implementation framework for the MedZEB approach, and aimed at enhancing the quality management of the overall renovation process. The Protocol is based on a holistic approach that includes and integrates all the key aspects of deep retrofitting by providing:

- a retrofitting approach specifically tailored for the residential built stock of the Mediterranean Area;
- effective and integrated technical and financial support mechanisms;
- transparency in the retrofitting process;
- building renovation roadmaps.

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The novelty of the MedZEB Protocol is double-fold: i. it assesses the quality of both the renovation process itself as well as of the achieved results, and ii.it introduces a renovation roadmap tailored for each specific case, thus making the renovation feasible even in challenging situations.
The paper describes the main features of the Protocol, its structure and holistic set of indicators, the actors and the procedures involved in each phase. Moreover, the results of a feasibility analysis are presented, with the aim of showing the sustainability of the Protocol adoption in the renovation process, thus highlighting its potential role as a reference framework for fostering deep energy retrofitting in the Mediterranean area.

2. MedZEB Protocol features

This paragraph provides the description of the MedZEB Protocol, its definition and objectives, and focusing on its relevant features and main constituent parts.

2.1 Definition and objectives

The MedZEB Protocol is a guarantee scheme that sets the quality conditions for the good execution of the renovation process along the whole value chain. The main objectives of the Protocol are as follows:

- defragmenting the retrofitting supply chain by involving all the relevant actors, from homeowners to building companies, in the guarantee framework;
- implementing a holistic approach for deep retrofitting, by addressing all the key issues of renovation (energy, environment and well-being);
- covering all the phases of the renovation process, from the preliminary analysis carried out before the interventions to the monitoring of the performance at the end of the renovation works.

The MedZEB Protocol is a flexible tool that must be signed by all the stakeholders involved in each retrofitting project, and which can be customized on the basis of the following features:

- primary energy consumption reduction target ranging from a minimum of 60% up to the nZEB (nearly Zero-Energy Building) standard;
- choice between step-by-step and single-step renovation, made by clients according to their needs;
- three different levels of analysis (LoA) - i.e. standard, intermediate and advanced – designed to coherently and effectively assess energy efficiency and comfort performances throughout the renovation process, according to the needs and financial resources of the investors. The choice between the LoA is made at the very beginning of the renovation process, and it affects its whole implementation; e.g. the initial energy audit will be carried out in a progressively more thorough way according to the LoA chosen: in case of an advanced LoA, a short-time consumption monitoring is also envisaged (Dall'O', 2013).
- MedZEB Voluntary Certification Scheme (VCS) associated with the Protocol, and customized on the basis of the LoA and of the client's choice between step-by-step and single-step retrofitting.

A wide range of energy and comfort Key Performance Indicators (KPIs) has been designed and included in the Protocol in order to quantify the benefits of the renovation in an increasingly comprehensive way according to the selected LoA (Figure 1). In particular, each LoA takes into account a progressively more thorough set of KPIs to be monitored throughout the renovation process (Figure 1). The energy-related KPIs assess the performances of the envelope and HVAC systems as well as the integration of renewable energy sources. As for indoor environmental quality (IEQ), the KPIs are selected (Fabbri, 2016) so as to address comfort, behavioural and well-being aspects (Antonucci, 2019).

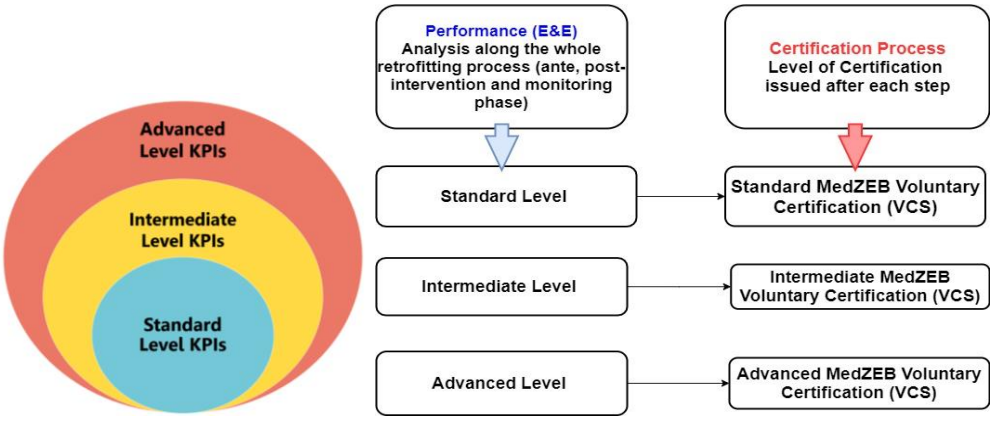

Figure 1: Key Performance Indicators (KPIs), Levels of Analysis (LoA) and certification process

2.2 Main constituent parts of the MedZEB Protocol

The main constituent parts of the MedZEB Protocol are:

- KPIs tables, which describe the different sets of KIPs to be considered, estimated and monitored according to each LoA.
- Energy Performance Certificate (EPC) of the building, issued on the basis of national regulations;
- Building Renovation Roadmap (BRR), developed in compliance with the new European Directive – 2018/844. The HAPPEN BRR is aimed at planning long-term, step-by-step renovation interventions by considering the building as a whole, so as to avoid lock-in effects. The BRR is based on a wide set of Packages of cost-Optimal Solutions (POS) developed by HAPPEN both in a single-step and a step-by-step configuration. These POS are tailored for the Med climates and building typologies, and are based on a cost-optimal methodology aimed at minimizing the Life-Cycle Cost of deep renovation over 30 years, in compliance with the EU regulations (Capogrosso et al., 2021).
- Business Plan (BP) based on the Versatile Energy Loan (VEL) financial solution developed by HAPPEN (Capogrosso et al., 2021), which allows managing both single-step and step-by-step renovation plans, and which is designed to be fully integrated with the POS.
- Design drawings (from draft to final design) for each step of the Renovation Project; these drawings are essential to identify technical contents and boundary conditions.
- MedZEB Voluntary Certification Scheme (VCS), aimed at assessing that the results set in the Protocol have been achieved on completion of each renovation step. To this end, ad-hoc post-intervention and post-occupancy monitoring and evaluation of real performances are carried out after each step, and only after a positive assessment the VCS is issued, thus certifying the full compliance of the interventions with the BRR. The VCS provides a specific scoring system which takes the following aspects into account:
  - energy savings achieved (primary energy demand reduction),
  - comfort conditions achieved (IAQ level),
  - intervention typology (one–step or step-by-step approach),
  - LoA (standard, intermediate or advanced).

Five levels of primary energy demand reduction are envisaged and shown through different shades of colour, representing the relative savings achieved after each step in comparison with the initial condition of the building “as-it-is” (Figure 2).

Figure 2: Five levels to assess primary energy demand reduction; the last step (nZEB Standard) stands for “nearly Zero-Energy Building”, that is a building with a primary energy consumption near zero

3. Actors involved

Two specialized professional figures, the MedZEB Expert and the MedZEB Auditor, have been envisaged in order to effectively manage the Protocol. The MedZEB Expert is a consultant/professional specifically trained in the MedZEB tools like the Protocol, POS and VEL. He/she coordinates the retrofitting design, guides and supports the client, engages the actors to be involved, supervises and manages all the phases of the renovation process both for Single-Family (SFH) and Multi-Family Houses (MFH). Due to the lack of a national quality systems in many Mediterranean countries, the creation of a dedicated independent figure, the MedZEB Auditor, was proposed so to guarantee the impartiality and transparency of the MedZEB certification process.The MedZEB Expert and Auditors receive the same type of training, but the Auditor must also be qualified to conduct «on-field» and energy audits in compliance with the relevant international and European standards (ISO 50001, ISO 19011, EN 16247 parts 2 and 5). The main role of the MedZEB Auditor is to check and validate all the documentation produced along the retrofitting process, and to perform on-site visits according to the

requirements of the selected LoA of the Protocol. While the Expert can be apppointed directly by the client, the Auditor is appointed by the “MedZEB Committee”, so as to guarantee the third-party role of the Auditor. The MedZEB Committee is a technical and management body devised in the framework of the HAPPEN project, with the task of issuing the VCS on the basis of the Auditor’s validation.

4. MedZEB Protocol process scheme

The MedZEB Protocol consists of a preliminary phase followed by four operational phases, as shown in Figure 3. The overall process is facilitated by the HAPPEN Platform, a digital environment specifically designed to support the deep renovation markets of the Med area with dedicated tools and services, fully integrated within the Protocol framework.

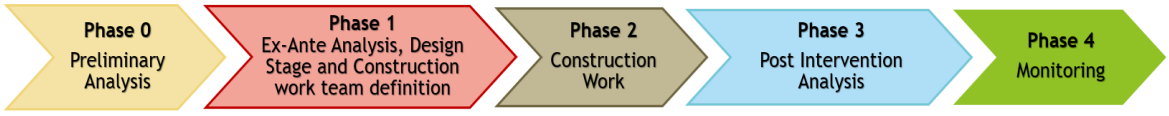

Figure 3: MedZEB Protocol Process Scheme

In the beginning, the client, after accessing the HAPPEN Platform and running a basic tool for analyzing the renovation potential of his/her home, chooses a MedZEB Expert, who carries out a preliminary analysis of the building, and collects the client’s inputs and needs. The Expert illustrates the different Protocol options, and helps the client select the most suitable renovation layout (e.g. energy savings, single-step or multistep, LoA, etc.). On the basis of these inputs, the Expert develops a dedicated renovation solution by using an “expert configurator“ hosted on the Platform, which allows him/her to customize the pre-calculated POS according to specific design parameters, thus providing significant support in speeding up the preliminary design choices. After the decision to start the renovation has been formalized by the client, phase one begins, and the Expert carries out the energy audit of the building “as it is”, according to the selected LoA. The MedZEB Expert draws up the energy audit report, issues the ex-ante EPC, the BP and the BRR. Then, the final design stage is developed (coordinated or directly implemented by the Expert) according to the targets set in the Protocol. At this point, the construction work team is selected, depending on the kind of project: according to tender procedures for public clients, or to direct appointments for private ones (in this case, the Expert should also select the construction work team). After the final renovation design is completed and all the actors are involved, the MedZEB Protocol is signed by these actors, and the project is submitted to the local authorities for formal approval.
In phase two, the MedZEB Expert supervises and manages the construction works, and submits the periodical progress reports to the MedZEB Auditor, who checks and validates the documents. If an intermediate or advanced LoA was chosen, the Auditor also carries out on-field audits.
In phase three, post-intervention analyses and verifications are carried out according to the LoA chosen and the complexity of the renovation project. The Expert submits the final report to the Auditor, who checks and validates it. Moreover, the Expert submits to the MedZEB Auditor the final documents (s.a. inspection report, conformity declaration, certificate of proper execution), according to the local legislation. On completion of the validation process by the Auditor, the MedZEB Committee issues the VCS post-renovation work, based on the LoA chosen. In phase four, monitoring of the building in use is implemented on the basis of the MedZEB “Monitoring Protocol” (MP) developed by HAPPEN, and according to the LoA chosen. The MedZEB MP was designed in order to achieve the following main objectives:

- assessing the performances of the building in terms of energy saved and comfort parameters;
- fostering the improvement in the user’s behaviour towards energy consumption reduction.

This MP is also based on three LoAs - standard, intermediate, and advanced - fully reflecting the LoAs at the basis of the MedZEB Protocol and VCS. The Auditor supervises and manages all the monitoring procedures, verifies the savings and comfort performances, and draws up the monitoring report concerning energy and comfort aspects. On completion of the monitoring phase, in case of positive assessment (i.e energy savings and comfort improvement within a tolerance of 15% for the standard LoA, and of 5% for the intermediate and advanced LoA), the VCS is issued by the MedZEB Committee. In case of unsuccessful assessment, an energy audit is carried out according to the selected LoA, and corrective measures are implemented in order to achieve the design targets, according to the guarantee framework of the Protocol.

The Protocol has been developed and tested in simulation case studies. By the completion of the HAPPEN Project, or immediately after, the Protocol and the VCS will also be tested on the real case studies of the HAPPEN pilot sites, so as to evaluate and validate the results obtained in the simulations.

5. MedZEB Protocol sustainability assessment

This paragraph describes the evaluation of the economic sustainability of the MedZEB Protocol by illustrating a case study of the MedZEB Protocol adoption for an SFH.

5.1 Assumptions and boundary conditions

The economic sustainability of the MedZEB Protocol adoption was evaluated by applying it to two different case study simulations (SFH and MFH), and by comparing the costs of the conventional process (benchmark) with those required by the application of the Protocol. The renovation interventions were designed so as to achieve a target of at least 60% of primary energy savings; in both cases, the interventions concerned the envelope, the HVAC systems, the electric plants and RES installation. The benchmark data concerning the costs of interventions were evaluated on the basis of the authors' consolidated experience in deep renovation projects, especially in projects compliant with the current Italian legislation (i.e. projects designed to access the "Superbonus 110%" tax incentive scheme). It was assumed that the Protocol application across the stages of the process does not affect the cost of renovation interventions: it only influences the professional fees, which were calculated on the basis of the Italian legislation (i.e. Ministerial Decree - DM 17/06/2016). In addition, when assessing the cost of professional services, an overhead of around 20% was considered. Finally, costs were evaluated on the «upper spending limits» to provide for the worst scenario of the Protocol incidence. For the sake of brevity, only the SFH case study and the relevant results are reported in this paper.

5.2 Case study: Single-Family House

The renovation interventions were designed considering a useful surface area of 100-120 m^2, according to the costs shown in Table 1.

Table 1: Amount of work for an SFH to achieve primary energy savings of at least 60%

Amount of work	Envelope	HVAC Systems	Electrical Plants, PV Panels BACS	Total amount of the renovation work
[€]	50,000	30,000	11,000	91,000

Table 2 shows the impact of professional costs (design and supervision) on the benchmark process (Protocol not applied). The supervision costs are the highest, and include the following tasks: i.) managing the renovation work; ii.) supervising, providing technical assistance, monitoring the execution of works and drawing up progress reports; iii.) keeping constant communication with all the other actors and the client, taking everyone's needs into account; iv.) managing safety aspects. Professional fees affect total renovation costs by .ca16%.

Table 2: Professional and consultancy costs of the conventional renovation process without the MedZEB Protocol application (benchmark process)

Professional /Consultancy Costs	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Total Prof.cost	Total cost of works [€]	Total renovation costs [€]	Prof./Total costs (%)
[€]	-	6,630	10,500	150	-	17,280	91,000	108,280	15.96%

The cost impact of the MedZEB Protocol was evaluated in Table 3 the three LoAs, considering both the tasks of the MedZEB Expert and of the MedZEB Auditor in the different phases. The ΔCosts column in Table 3 quantifies the impact of the Protocol compared to the benchmark process (Table 2). As the standard LoA is regarded, the incidence is very low and concentrated in phase 3, where the MedZEB Expert draws up the final inspection report, the MedZEB Auditor carries out the final check, and the MedZEB Committee issues the post-renovation VCS. At the intermediate and advanced LoA, the incidence increases especially in phase 1, due to the energy audit. In phase 2 the incidence is significant at an advanced LoA, due to a larger number of inspections and checks. In phase 4, costs increase according to the different LoA: in the standard LoA only basic parameters (like temperature, humidity and CO_2 concentration) are monitored, and energy consumption is monitored through bills. In the intermediate LoA, energy consumption is monitored through protocols such as the IPMVP. In the advanced LoA, pollutants such as VOC and NO_x are also monitored and post-occupancy assessment is carried out. Table 4 shows the incidence of the additional professional costs compared to the benchmark process. To sum up, in the SFH case study, the MedZEB Protocol based on the standard LoA shows an increase in costs of about 2.5% compared to the benchmark process, which rises up to a maximum of 12.4% in the advanced LoA. As expected, lower increases were observed in the MHF case.

Table 3: Professional and consultancy costs (€) of the MedZEB Procol for the three LoA, and their incidence - Δcosts (€) - compared to the total costs of the benchmark process reported in Table 2

Level of Analysis	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Total Prof. costs	Total Costs	Prof./Total costs (%)	Δcosts (€)
Standard	740	6,630	10,500	1,620	480	19,970	110,970	18.00%	2,690
Intermediate	740	10,630	12,420	1,620	672	26,082	117,082	22.28%	8,802
Advanced	740	13,980	13,450	1,620	960	30,750	121,750	25.26%	13,470

Table 4: Incidence of professionals costs for the three LoA (€) compared to the benchmark process (Table 2).

Level of Analysis	Professional costs	Total costs without Protocol	Professional/Total costs (%) (SFH)
Standard	+2,690	108,280	+2.48%
Intermediate	+8,802	108,280	+8.13%
Advanced	+13,470	108,280	+12.44%

6. Conclusions

The paper describes the MedZEB Protocol as a valuable tool for fostering deep retrofitting in the Mediterranean Area. The Protocol represents an effective opportunity to guarantee the overall quality of the whole renovation process and the achievement of the performance targets set by the project in terms of energy savings, comfort levels and environmental sustainability. The novelty of the MedZEB Protocol lies in the fact that it assesses both the quality of the renovation process and of the building performances, and that it introduces a renovation roadmap tailored for each specific case, thus aimed at maximizing the economic sustainability of the interventions. Thanks to these features, the MedZEB Protocol, with the associated VCS, represents a strong policy instrument for increasing cooperation among the different renovation actors, and for defragmenting the local renovation supply chains. The results of the economic assessment confirm the sustainability of the Protocol adoption in the renovation process, with an increase in costs ranging from 2.5% to 12.4% in the SFH case (even lower in MHF). The availability of three different LoA allows investors to select the most appropriate Protocol layout on the basis of their actual financial resources and quality targets. Provided the great added value connected to the availability of an affordable “standard” guarantee mechanism, the choice of more advanced LoAs allows a progressively stronger guarantee and protection for the investor, connected to higher quality design targets, thanks to a more articulated set of KPIs and associated monitoring systems, and to a more thorough on-site control by the MedZEB Auditor. On the basis of these features, the MedZEB Protocol allows bridging the gap between design and actual renovation performances, thus enabling more reliable, viable and effective deep renovation processes.

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References

Antonucci D. 2019, Key Performance Indicators (KPIs) and needed data, D3.1, ExCEED Project, H2020 program, G.A.723858.

Capogrosso R., De Aloysio G., Laghi L., Malvezzi R., Menconi E., Padula M., Pecchia F., Ruìz Cruceira A., Salmeròn Lissén J.M., Scala P.L., 2021, Deep Energy Retrofit of Residential Buildings in the Mediterranean Area: The MedZEB Approach, In: Bisello A., Vettorato D., Ludlow D., Baranzelli C. (Eds), Smart and Sustainable Planning for Cities and Regions. Results of SSPCR 2019. Springer, Cham.

Dall’Ò G., 2013, Green Energy Audit of Buildings, A guide for a sustainable energy audit of buildings, Springer-Verlag, London.

Fabbri M., De Groote M., Rapf O., 2016, Building Renovation Passports. Customized roadmaps towards deep renovation and better homes, BPIE documents. Accessed Jan 2020.

Padula M., Picenni F., Malvezzi R., Laghi L., Salmeròn Lissén J.M., Sanchez de la Flor F.J., Mateo-Cecilia C., Soto-Francés L., Niki Assimakopoulos M., Karlessi T., 2018, MedZEB: a new holistic approach for the deep energy retrofitting of residential buildings, TECHNE, Special Issue 01, 127-13