

A Digital Environment for Empowering the Main Actors of the Deep Energy Retrofitting Value Chain

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The H2020 HAPPEN project has defined a new approach to tackle significant unsolved bottlenecks affecting the energy renovation markets of the residential built stock in the Mediterranean area: the MedZEB approach (Mediterranean way to nearly Zero Energy Building), which backbone is the HAPPEN ICT Platform. The paper describes firstly the MedZEB concept as a holistic, flexible and cost-optimal approach especially tailored for the Med area. It then presents the HAPPEN Platform in terms of general architecture, workflows, resources and tools aimed at fostering the spread of the MedZEB approach by integrating technical, financial, environmental and operational aspects. A critical assessment on the state-of-the-art highlights the novelty of the HAPPEN Platform as a comprehensive and effective framework for empowering the evolution of the Med renovation markets, as means for fostering the progressive uptake of deep energy retrofitting in the Med area.

1. Introduction

Deep renovation markets of the Med area share complex unsolved challenges, related e.g. to the fragmentation of the market, the high ratio of private ownership, peculiar climatic and environmental conditions, socio-economic backgrounds, and low trust in deep renovation. As an answer, the H2020 project HAPPEN (Holistic Approach and Platform for the deep renovation of the Med residential built Environment) has developed the MedZEB approach (the Mediterranean way to nearly Zero Energy Buildings; Padula et al., 2018), a homogeneous and holistic renovation framework devoted at enhancing (Capogrosso et al., 2021):

- economic sustainability: “Packages of Optimal Solutions” (POS) (Salmeron et al., 2013) have been pre-calculated by minimizing Life Cycle Cost (LCC) at 30 years according to the amending Energy Performance of Buildings Directive (EPBD; 844/EU 2018); the latter has been investigated in BPIE (2010) and tested in the case of global retrofitting (Brandao et al., 2016) and of a comparative ‘deep vs nZEB’ retrofitting (Becchio et al. 2015);
- adaptability: the HAPPEN POS foresee the possibility of both a single-step and a step-by-step implementation approach (Fabbri et al., 2016);
- viability: the Versatile Energy Loan (VEL), a dedicated financial solution fully integrated with the POS, has been developed in order to minimise the initial investments of step-by-step renovations;
- transparency: the MedZEB Protocol and the Voluntary Certification Scheme (VCS) guarantee the quality management of the process, and include holistic key performance indicators (KPIs) addressing energy, comfort and well-being (Fabbri et al., 2016), environmental and behavioural (Antonucci, 2019) aspects;

- capacity building: dedicated training contents on the MedZEB approach (MedZEBinars), and, more in general, on deep renovation have been produced and made available for stakeholders.

The HAPPEN Platform (medzeb-happen.eu), integrates the solutions presented above, thus shaping an assisted digital marketplace aimed at matching demand and offer of the Mediterranean (Med) deep energy retrofitting market of the residential built stock (where 'deep' is intended as >60% of primary energy savings, Fabbri et al., 2016), as well as at supporting them through the whole renovation process, especially in the initial decision-making phase. The solutions have been developed also through the activation of 10 Pilot Sites in 7 Med countries, where. In each pilot area, the Living Labs (LLs) performed allowed to involve actors from the demand and supply sides (e.g. owners, tenants and managers, technicians, providers and builders), who provided valuable points of view, insights on local issues, and feedback on the project's approach and outputs, thus feeding their development into effective instruments.

2. Platform novelty assessment

The HAPPEN Platform concept takes into account the main barriers encountered in previous experiences (D'Oca et al., 2018) and the MedZEB approach leverages on the lessons learned from previous projects on the multiple benefits of deep renovation (D'Oca et al., 2019) for accelerating the renovation rate in the Med area (Vavallo et al., 2019). A state-of-art review on more than 50 H2020 projects and studies confirmed the HAPPEN Platform as the first holistic renovation framework tailored for the Med area. Current renovation approaches mostly focus on advanced (e.g. RESSEEPE) or key-enabling technologies (REZBUILD); they presuppose evolved networks of actors (RECO2ST), rely on industrial (4RinEU) or plug&play processes (RenoZEB) and mainly address late design phases (BIM-SPEED); they offer highly engineered tools for process (DESIGN4ENERGY) and workflow management (BIM4REN) or for decision support at the district scale (ECODISTR-ICT), also automated (OptEEmAL). These approaches pursue a "technology-push innovation" (Norman and Verganti, 2014) which is suitable for well-structured and organized economic areas, but not for the Med markets, characterized by low tendency to innovation, poor cooperation, weak economies, low skills and capacity. HAPPEN, therefore, pursues a "meaning-driven innovation" aimed at fostering a systemic and evolutionary upgrade of the renovation markets under the framework of the MedZEB approach. In particular, the HAPPEN platform integrates traditional (low-tech) and advanced (high-tech) renovation solutions in order to handle multiple "grip points" for delivering the best possible innovation to each local situation. From a technical point of view, most EU platforms propose benchmarked (e.g. STUNNING) or limited sets of renovation measures (EASEE), non-specific for the Med area (INFINITE); multi-KPI simulators for the evaluation of scenarios (ENCORE) and design options (EEEMBEDDED), as well as decision-support tools (e.g. Dalla Mora et al., 2018), quality evaluation tools (Domjan et al., 2020) or concept studies (Kharseh et al., 2019). These solutions do not embed large and comprehensive libraries of cost-optimal solutions, and mostly rely on inputs from the designers. On the contrary, the HAPPEN Platform offers seamless sets of reference buildings (n. 42), climatic zones (n. 13) and renovation measures (.ca 160) which are specific for the Med area; they constitute a library 546 POS designers can refer to in the initial decision-making phase of a renovation process. Each POS includes 12 different renovation solutions to allow a comparison among multiple design options based, as well, on users' affordances (de Feijter and van Vliet, 2021), thus stimulating interactive design (Baedeker et al, 2020). Moreover, the HAPPEN Platform offers open access and integrated POS and VEL calculators which: i. provide detailed energy needs simulations; ii. include measures for ventilation, air tightness, thermal bridges, and shading; iii. allow to customise the POS library according to multiple parameters (e.g. costs, orientation, systems, etc.); iv. support single-step and step-by-step renovation schemes; v. enable developing Building Renovation Roadmaps (Fabbri et al., 2016). As compared to other projects (e.g. 4RinEU), the HAPPEN Platform gives its users the possibility to enrol to training courses – the MedZEBinars - in order to get certified as MedZEB Experts. In addition, the availability of a tested LL approach empowers the Experts to foster engagement and collaboration also in complex situations, such as multi-family houses or district-scale projects. Thanks to the deep integration among its tools and services, the HAPPEN Platform can be considered as a "digital One-Stop-Shop prototype" (OSS) fully complying with the business models "OSS supported by digital tools" and "OSS supported by a step-by-step approach" proposed by STUNNING (2018), and providing substantial updates for overcoming the weaknesses and threads there detected. Finally, the flexible architecture of the Platform facilitates the integration of new modules aimed at further supporting the evolution of Med renovation markets in the future. Among these, it is worth mentioning the innovative potential of combining the HAPPEN cost-optimal approach with Life Cycle Assessment (LCA; Janjua et al., 2019) and Multi-Criteria Analysis (MCA; Ongpeng et al., 2020) for expanding the capacity of the MedZEB framework to support an aware decision-making process and to maximize the achieved impacts.

3. Customised workflows

The HAPPEN Platform connects actors interested in undertaking retrofitting actions; professionals, technicians and enterprises operating in the renovation market; policymakers and other institutional actors, respectively labelled “owners”, “makers”, and “influencers” in the MedZEB framework.

The Platform’s main structure is implemented in the WordPress Content Management System, whose functionalities have been extended with both official plug-ins and ad-hoc components. The HAPPEN outputs were developed as stand-alone tools and then the logic has been implemented server-side in PHP 7; the underlying MySQL database has been abstracted through the Eloquent Object-Relational Mapping implementation; the user interface runs as a React app embedded in WordPress.

The overall Platform users’ workflow is based on the so-called HAPPEN Program, i.e. the go-to-market strategy developed for the MedZEB approach. The Program encompasses three main stages, each characterized by actions, tools and services tailored for the three main target groups:

- Engaging owners to get in touch with a MedZEB Expert to go deeper in the possible solutions for their dwellings and Makers to complete the training course to become certified MedZEB Experts;
- Convincing owners to undertake the intervention through an iterative solutions’ customisation process performed by the MedZEB Expert;
- Performing the intervention downstream of the subscription HAPPEN Protocol by all the actors involved in the process in order to guarantee the post-intervention performance and compliance to the approach.

All the actors of the renovation value chain have the opportunity to exchange knowledge, to share good practices and success stories, and to foster mutual recognition, thus creating a MedZEB Community. Each of them can take profit of customized workflows, empowered by dedicated tools and services.

3.1 Owners

They are offered free informative and interactive material to deepen their understanding of deep retrofitting:

- ePills: a collection of 20 short videos tagged and categorized on the basis the subject discussed;
- HAPPEN Tips&Tricks: a sub-section of the HAPPEN Knowledge base collecting dissemination and informative material about energy saving tips;
- Success stories: a set of use cases about successful implementation of the MedZEB approach;
- Basic MedZEBinars: courses on deep retrofitting hosted in the e-learning section of the Platform (if desired, owners can also take a test to verify their proficiency after the course);
- Owners’ forum: dedicated digital space where owners can exchange their opinions on both the contents offered and, more in general, on deep retrofitting issues;
- Basic POS Calculator: web tool through which they can identify a set of standard POS answering to their renovation needs, both in a single or in a step-by-step arrangement; To this end, the user is asked to enter basic information about their dwelling (e.g. climatic zone, typology, year of construction, etc.) and the system will provide a preview of the savings potential and of the associated standard POS.

Owners may get in touch with one of the suggested MedZEB Experts to get more information and, if interested, to activate the design of a customized solution. Registered owners can look up for MedZEB experts in a subset populated on the basis of the geographical proximity and needed/ offered skills.

3.2 Makers

Makers have access to training courses on the MedZEB approach granting - after a number of tests and a final exam – the certification of MedZEB Experts and, therefore, the inclusion in the Platform’s Experts Database. A dedicated dashboard will allow Experts to manage their renovation projects and owners’ data thanks to the following tools and services:

- Detailed overview of renovation solutions: in-depth analysis of contents and parameters (technical and a financial) of the abacus of POS developed by HAPPEN;
- Expert POS Calculator: MedZEB Experts can adjust a subset of POS and VEL parameters, in order to develop customized and integrated optimal solutions (technical and financial);
- MedZEB Protocol generation: once the definitive design has been developed on the basis of the customized optimal solution, the related Protocol is produced;
- MedZEB Voluntary Certification Scheme generation, certifying that the design objectives are achieved;
- Success stories generation: the Expert can edit a new “success story” to be published on the Platform.

Makers can also access open services for knowledge transfer made available to owners, the HAPPEN Knowledge Base, which collects both scientific and informative materials, a Forum specifically dedicated to MedZEB experts, and to usage statistics on registered owners.

3.3 Influencers

This user category can access the HAPPEN Knowledge Base and a dedicated forum, and is provided with a Dashboard showing the trends emerged by the automatic analysis of the Owners' and Makers' Platform usage, thus giving them an overview on the renovation processes activated according to the MedZEB approach. This privileged view provides them with useful information as support to decision-making .

4. The Platform main tools

The Platform offers three main tools which can be accessed at different complexity levels according to the user typology: the POS Calculator (technical), the VEL Calculator (financial), and the e-Learning section (training). The POS calculator can identify sets of renovation measures deemed as optimal in terms of LCC, primary energy consumption and CO₂ emissions minimisation (Figure 1). Each set is defined as an optimal solution and includes renovation measures for: façades, glazing, roofs, floors, thermal bridges, ventilation systems, shading elements, and HVAC systems. A POS consists of 12 different optimal renovation solutions, each composed of 12 renovation measures: this offers a number of heuristic solutions high enough to get as close as possible to the optimum. The POS Calculator is based on a set of 32 pre-calculated packages of optimal solutions obtained by simulating the combination of each renovation measure on 4 reference buildings in 4 climate zones, with the main façades N-S and E-W oriented. This accounts for a total of 213.840 simulated combinations for a single building in one climate zone. The 4 reference buildings were selected based on their geometry, typology, use, compactness, and thermal characteristics appearing more frequently in the countries under study. The 4 climates selected are the most frequent in the Med area. This allowed to evaluate, for each combination of reference building and climate zone, the energy needs of heating and cooling of all the spaces of the building, taking considering the transient effect in walls, roofs, floors, windows, the heat losses and gains through thermal bridges, the effect of airtightness and ventilation, and shadings over the windows or other elements of the building envelope. The calculator can compute the cost of the interventions, the energy consumption and the CO₂ emissions and can as well split the renovation interventions and their cost into more steps. The POS Calculator is available to owners and makers, with different user interfaces giving access, respectively, to basic and expert usage functionalities. Experts have access to the "POS customization" functionalities and can edit parameters s. a. energy prices, renovation measures costs, orientation of the building, HVAC systems.

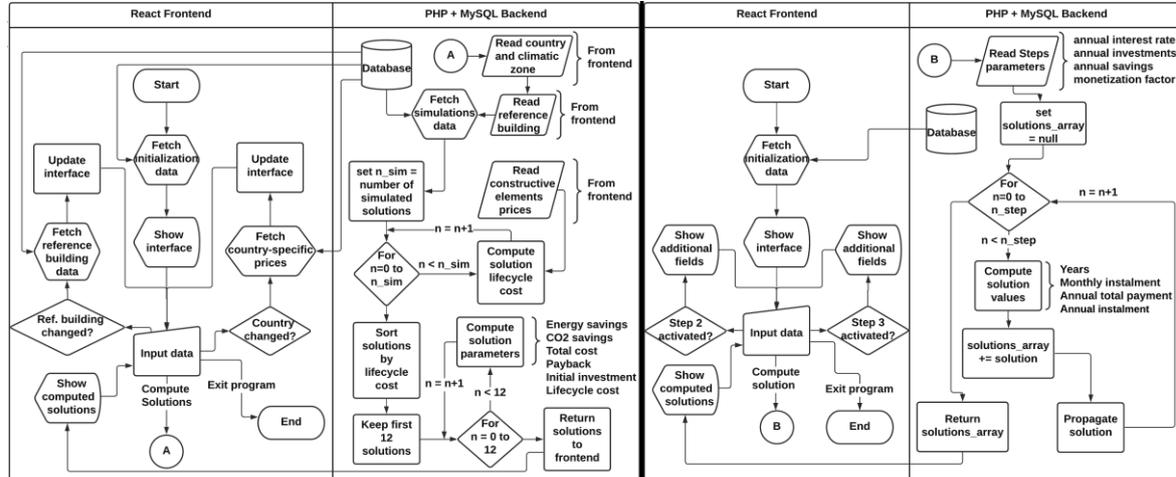


Figure 1: The flowchart diagrams related to the POS tool (left) and VEL tool (right), subdivided between frontend and backend sub-processes

The VEL Calculator implements a repayment plan with fixed instalments allowing users to specify a "monetisation factor", i.e. the amount of savings they wish to re-invest in the repayment plan, thus shortening the reimbursement period. It allows owners and makers to get a clearer idea of the investment's payback time required for implementing the POS, thus allowing to gain higher awareness on the overall sustainability conditions of their renovation.

Besides, if a step-by-step solution is chosen, the tool provides indications on how to split the steps basing on their individual payback time: in this way, a renovation roadmap can be planned with an integrated business plan aimed at maximising the economic sustainability of the interventions.

Thanks to the POS and VEL calculators the Platform can support makers to define customized feasibility studies for tailoring residential buildings deep retrofitting interventions to the owners' needs (Table 1).

Table 1: The HAPPEN Platform as a digital advisor

Owners	Makers
<ul style="list-style-type: none"> ▶ Orientation and training services contribute to the engagement of the subject with a view to a preliminary opening to the idea of embarking on a deep retrofitting path; ▶ This is done on the basis of pre-calculated solutions, both in the "one single step" and "two steps" configuration, to which a standard financial solution is associated, realized by the POS and VEL Configurators. 	<ul style="list-style-type: none"> ▶ Specific services are provided to develop the pre-calculated solution into a customized solution (POS Calculator); ▶ These services generally concern the possibility of inserting customized costs and parameters both in reference to "single step" and "two steps" solutions, to compare technical solutions for different macro-climatic ranges, and to develop specific financial solutions for the retrofitting; ▶ Information is also provided, for example concerning the behaviour of the inhabitants.

A Learning Management System (LSM) is integrated with the platform – by using the Sensei LMS WordPress plug-in – to provide an e-Learning service to both the general public and professionals. The general public avails of a set of introductory materials related to the HAPPEN project and the MedZEB approach, as well as an array of training resources on deep renovation. Professional training, instead, is aimed at building capacity on the adoption of the MedZEB approach, tools and services: a Massive Open Online Course (MOOC) based on 11 MedZEBinars was produced and divided in 5 deep-training modules, each one addressing one relevant aspect of the MedZEB framework, for a total of 15 notional learning hours of self-training. Makers can freely choose to take either only the MedZEBinars they are interested in or the complete training and whether to take the related tests or not. In case they successfully pass all the tests, they are awarded with the MedZEB Expert certificate. Aizpurua et al. (2018) showed that strategies encouraging social interaction and collaboration among peers aid in the development of cognitive skills such as creative thinking and problem solving. All the Platform tools are currently under final testing in the "HAPPEN Incubators", i.e. extensions of the Living Labs aimed at creating clusters of stakeholders interested in the project outputs' exploitation.

6. Conclusions

The HAPPEN Platform constitutes the main exploitation instrument for the widest diffusion of the MedZEB concept, intended as the first holistic retrofitting approach specifically tailored for the Mediterranean area. The Platform offers an easy-to-use access point to a large set of tools, services and solutions intended to support the actors of the local renovation value chains in the quality management of the retrofitting processes carried out on the residential built stock, with a special reference to the decision-making phase.

The integration of technical, financial, environmental and operational aspects makes the HAPPEN Platform an effective framework for actively promoting the evolution of the renovation supply and value chains, as means for enhancing the uptake of the deep renovation markets in the Med area. Respect to the state-of-the-art researches and solutions, often based on a "technology-push innovation", the HAPPEN Platform rather pursues a "meaning-driven innovation" aimed at laying the ground for a progressive gain of trust between all the market actors, thanks to capacity building and process support tools aimed at increasing the overall transparency, convenience and reliability of the renovation process.

The integration with the MedZEB Protocol as a guarantee framework contributes to reduce the gap between design and actual performances after renovation, and to nudge potential investors in favour of positive decision making. Moreover, the Platform stresses the relevance of non-energy related added values, e.g. inner comfort and well-being, thus increasing also the overall appeal of deep renovations.

For all these reasons, the HAPPEN Platform acts as a digital One-Stop-Shop pursuing a capillary spread of the MedZEB tools and solutions across the Med area. Further technical developments are planned before and after the end of the project, s.a. the fine-tuning of POS and VEL tools based on the results achieved from the renovation of actual buildings in the HAPPEN pilot sites.

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