Architectural Technology responds to the environmental crisis: participatory design in an emergency context

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Key words: Architectural technology, environmental crisis, participatory planning, emergency modules, hydrogeological risk

Abstract

Within the framework of the research and innovation strategy RIS3 "Sustainable Living" (POR-FSE, funded by the Veneto Region), for the improvement of the resilience and adaptation capacity of the Veneto territory to environmental crises and emergencies, the subject of the contribution returns the results of the participatory experimentation of the project H.E.L.P. Veneto ' High-efficiency Emergency Living Prototypes Veneto - Sustainable adaptive residences for temporary stay in environmental emergencies. The research concerns the design of a minimum flexible emergency living module, replicable on a large scale, multifunctional, sustainable, powered by off-grid systems and integrated into the built environment. The housing unit uses timber, a material linked to the local building tradition, whose prefabricated modular reversibility follows principles of circular reuse. Moreover, the constructive adaptability of the interior spaces is reflected in a "liquid space" capable of transforming itself according to the needs of the occupants. The paper introduces a form of participatory design of the emergency housing module, based on the engagement of small and large companies, related to different segments of the construction market, a leading sector in the economy of Veneto. The participatory approach borrows from Architectural Technology the tools needed to understand the characteristics of the settlement system, the potential of the project and the value of scientific stakeholder engagement in the process. Using the Soft System Methodology, direct investigation protocols have been constructed relating to the performance of the living unit. Using Strategic Options Development and Analysis (SODA), the results of the experimented survey (large-scale questionnaires) were decoded, interpreted and systematised. The processing of the answers allowed the stakeholders to validate the potential of the proposed module and, at the same time, to be informed about its characteristics. The innovation of the method lies precisely in the modelling phase, which makes it possible to integrate the results of the hard and soft data analyses and to make it clear how participation plays an essential role in the process of designing and validating the proposed module.

1. INTRODUCTION

The contribution is carried out in the framework of the research and innovation strategy RIS3 ``*Sustainable* Living" (Veneto Region, 2021). The latter represents an Intelligent *Specialisation* Strategy that, since 2014, has been guiding the Regions and the member countries of the European Union in identifying the objectives and actions to be taken to *maximise* the effects of investments in research and innovation. This tool allows the optimization of resources in the areas of *specialisation* characteristic of each territory through the construction of paths of sharing between the territorial stakeholders (world of research, public administration, businesses and communities of citizens). This area of research allows for the identification of new solutions capable of preparing the territories in which they operate for the challenges of our time. Specifically, the Intelligent Specialization Strategy aims to achieve the objectives of the research and sustainable development through scientific experimentation related to environmental and pandemic emergency conditions due to COVID-19. These scenarios push research to renew the approaches and development models of the territories in which it operates, starting from the collaboration of all the *stakeholders* involved in the experimentation processes at different scales. The push for involvement derives from the need to find concrete answers linked to the latest regional (Sustainable Veneto and Veneto towards 2030), national (PNRR) and European (Green Deal, Next Generation EU) guidelines. Within the RIS3 "Sustainable Living" planning, development addresses have been framed, related to the areas with the highest growth potential concerning both the resources present in the region. This identification was based not only on economic capital but also on human capital, infrastructure, innovation of territorial research bodies, national competencies and the quality of the built environment. These potential resources have been related to the vulnerabilities dominating the territory of experimentation concerning the labour market change, population ageing and environmental changes. This made it possible to identify the areas of Smart Agrifood, Smart Manufacturing, Creative Industries and Sustainable Living. These themes represented the regional development trajectories on which programme actions were based in order to leverage the available FESR funds. These directives were implemented by the Veneto Regional Council on 28 February 2017, through measure no. 216. The latter approved the Document "Fine Tuning Path" *which contained* further 39 development trajectories selected regarding the four previously identified areas of *specialisation*. For these reasons, the object of the contribution falls within the POR-FSE funded by the Veneto Region and is aimed at improving the resilience and adaptability of the Veneto region in case of crises and environmental emergencies. Specifically, the experimentation is known under the acronym of H.E.L.P. Veneto High-efficiency Emergency Living Prototypes Veneto - Sustainable adaptive residences for temporary living in environmental emergencies. In the introductory section, the contribution describes the legislative, economic and emergency context of the latest regional, national and European guidelines in which the experimentation proposal is placed. This is followed by a section dedicated to the restitution of a state of the art on a regional scale of the need to intervene because of the existing and *expected* emergency scenario. This section of the contribution focuses on the participatory approach, borrowed from the Technology of Architecture, to achieve, through its analysis tools, the understanding of the characteristics of the settlement system, the potential of the project and the value of scientific engagement of stakeholders in the process. The third section concerns the methodological approach, describing how, employing the Soft System Methodology, direct investigation protocols have been constructed combining the performance knowledge of settlement processes in the environmental unit. Through the Strategic Options Development and Analysis (SODA) the results of the experimented survey (large scale questionnaires) were decoded, interpreted and *systematised*. The elaboration of the responses allowed the expert knowledge of the stakeholders to validate the potential of the proposed module while at the same time informing themselves on its characteristics. The fourth section concerns the design of a flexible, replicable large-scale, multifunctional, sustainable minimum emergency housing module with off-grid systems and integrated into the built environment. The housing unit uses wood, a material linked to the local building tradition, whose prefabricated modular reversibility follows principles of circular reuse. Furthermore, the constructive adaptability of the interior spaces is reflected in a "liquid space" capable of being transformed according to the needs of living. The fifth section concerns the discussion of the outcomes of the experimentation of a form of participatory design of the emergency housing module. It was based on the engagement of small and large companies, related to different segments of the construction market, the leading sector of the Veneto Region. Finally, the last section proposes new advancement scenarios, illustrating how the innovation of modelling makes it possible to integrate the results of hard and soft data analysis and to make clear how participation plays an essential role in the process of animation and validation of the proposed module.

2. THE H.E.L.P MODULE BETWEEN EMERGENCY AND SUSTAINABILITY

2.1 Vulnerability, exposure and response requirements

The need to intervene in the Veneto Region territory arises from the necessity to mitigate the three types of environmental risks *characterising* this territory: seismic risk, wildfires risk and hydrogeological risk. The first type of risk finds in the territory of Veneto Region a relevant vulnerability so that the area of the high Treviso/low Belluno, adjacent to the Friulian region (Fig. 1), has a high hazard and a high exposure to seismic risk (CNR, 2020).

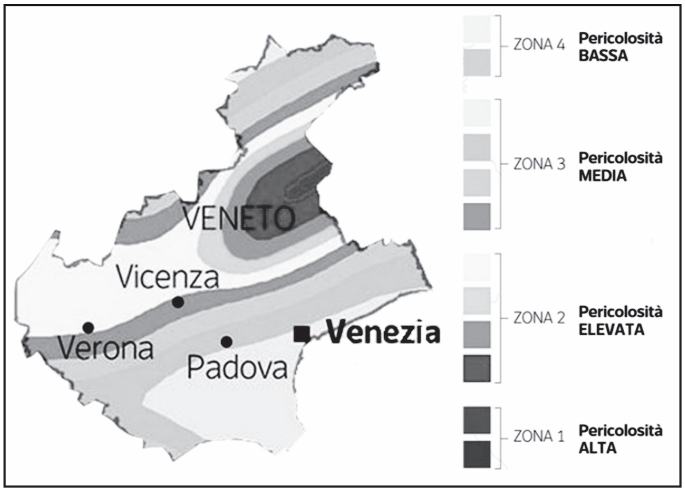


Figure 1 - *Seismic Hazard Map of the National Territory - Veneto, National Institute of Geophysics and Volcanology, April 2004.*

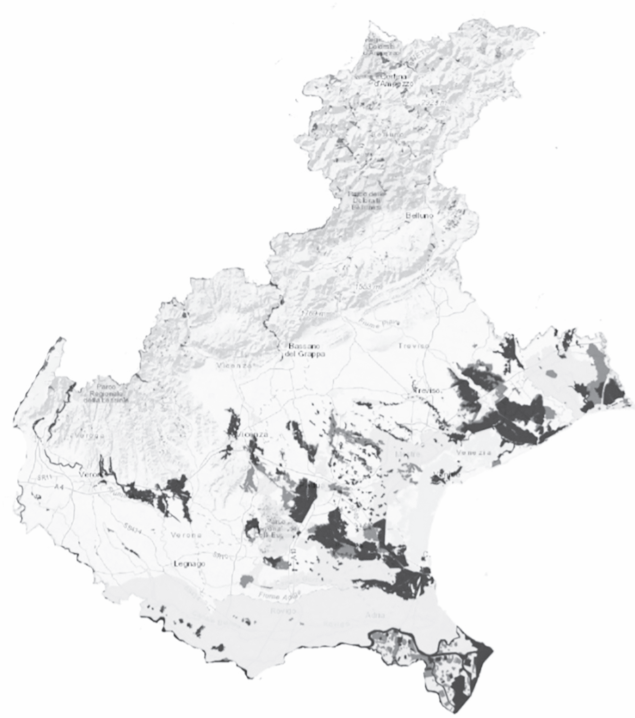
The second typology, the one inherent to wildfire risk, reveals that the areas subjected to a high probability of danger are well defined and refer to sites previously affected by historical fire phenomena. These areas cover about 20% of the regional area, of which 15% have high exposure and the remaining 5% very high (Veneto Region, 2017).

The third typology, hydrogeological instability, represents the dominant environmental risk as it affects the major provinces of the region (Fig. 2). The *urbanisation* and the expansion of the consolidated city in the urban surroundings of the territory have determined an increase in the built environment which is poorly monitored and maintained, making it lacking in preventive planning for the mitigation of catastrophic events linked to emergencies. On the one hand, landslide phenomena whose main causes are to be found both in short and intense atmospheric precipitations and in persistent precipitations that often determine the landslides of surface soils. Particularly, the provinces of Belluno and Vicenza are the areas with the highest landslide criticality (ISPRA, 2018). On the other hand, flooding *phenomena are* due to the increase of impermeable surfaces and in the loss of natural areas of absorption and containment of such disasters. Given the historical repetitiveness of these phenomena, it is possible to trace the provinces of Venice and Padua as the most affected by floods. The reasons are linked to the morphological, topographical and anthropic characteristics of the territories (CNR, 2020).

The activity of desk research capitalization about the vulnerability of Veneto Region gives back an exposure framework based on the relation between the surface of the area at risk and the population and the enterprises located in it. The total area at risk is 105,6 sqkm, involving besides the resident population also 268 enterprises distributed on the territory. Specifically, the exposure for the Province of Belluno is 71,62 sqkm with 2.677 exposed citizens; for the Province of Vicenza it is 17,95 sqkm with 2.315 exposed inhabitants; for the Province of Venice it is 413,575 sqkm with 131.682 exposed citizens and for the Province of Padova it is 245,777 sqkm with 117.679 exposed inhabitants. In this context of an emergency, described by the identified vulnerabilities and their relative levels of exposure, it is essential to identify the requirements necessary to fulfil the criticalities that emerged from the analysis. It is necessary, therefore, to mitigate the identified vulnerabilities through the correspondence of the territorial needs regarding the latent availability of emergency housing sites.

Veneto - Frane: Pericolosità e indicatori di rischio

Indice	Territorio	Popolazione	Famiglie	Edifici	Imprese	Beni culturali
P4	47,663 (0,259%)	2.253 (0,046%)	981 (0,049%)	1.275 (0,104%)	268 (0,061%)	63 (0,263%)
P3	57,954 (0,315%)	4.431 (0,091%)	1.925 (0,097%)	2.295 (0,187%)	268 (0,061%)	42 (0,175%)
P2	30,363 (0,165%)	5.712 (0,118%)	2.501 (0,126%)	2.313 (0,188%)	350 (0,079%)	38 (0,158%)
P1	25,802 (0,14%)	3.241 (0,067%)	1.444 (0,073%)	1.249 (0,102%)	302 (0,069%)	26 (0,108%)
AA	265,608 (1,443%)	6.268 (0,129%)	2.691 (0,135%)	1.249 (0,252%)	415 (0,094%)	102 (0,425%)



Veneto - Alluvioni: Pericolosità e indicatori di rischio

Indice	Territorio	Popolazione	Famiglie	Edifici	Imprese	Beni culturali
P3	1.231,069 (6,688%)	333.052 (6,857%)	141.597 (7,126%)	72.299 (5,89%)	31.616 (7,175%)	4.034 (16,824%)
P2	1.713,422 (9,309%)	460.668 (9,484%)	193.397 (9,733%)	102.551 (8,355%)	44.512 (10,102%)	4.397 (18,338%)
P1	4.635,328 (25,183%)	1.245.610 (25,645%)	524.013 (26,372%)	297.079 (24,202%)	110.033 (24,972%)	7.036 (29,344%)

Figure 2 - *Floods Directive 2007/60/EC map - CNR, 2020.*

According to the provisions of the decree-law 14 August 2013 n.93, coordinated with the conversion law 15 October 2013 n.119, which updates the law n.225 of 24 February 1992 - Establishment of the National Service of Civil Protection, at article 3 specifies how the Regions have both the task of implementing the risk forecasting and prevention programs and of providing structures and means necessary to support the activities and tasks of civil protection regarding the protection of the integrity of life, property, settlements and the environment from damage resulting from calamitous events. The success factors of the response lie both in the regular morphological identification of a flat area and in the easy accessibility with large vehicles as well as in the reachability of the same through its positioning near communication routes. These areas must also be provided with the primary infrastructural services of water, sewage, electricity and telecommunications. These areas must also be equipped with external spaces for parking vehicles. Finally, the entire area must be able to accommodate housing units corresponding to a population to be settled of between 100 and 500 people.

The main objective of this type of intervention is to guarantee the effective and immediate use of the resources needed to overcome the emergency and return to normal living conditions (Mango and Guida, 1988). The management of emergencies is strictly dependent on the procedures for dealing with a calamitous event, the right location of the areas for sheltering the population and the type of facilities used to house the evacuees (Cascone et. al., 2018). The latter can vary depending on the time of utility in three typologies. The first typology concerns existing structures, which are usually referred to as public and/or private buildings (such as military facilities, hotels, schools, sports centres, campsites, housing, etc.). This type of structure is used to host the population temporarily for a few days or a few weeks. The purpose of the short stay is to allow the population to return to their homes or to settle in the community by renting and/or assigning other homes. The second type refers to the tent city, usually equipped with services consisting of prefabricated modules that are less comfortable but can be set up very quickly. This type of structure is used to host the population for a medium-long period of up to 3 months. Finally, the third and last type is that of emergency housing settlements (prefabricated and/or modular systems). This solution is referred to in case of a prolonged period of emergency crisis for annual periods. This system is designed to allow the displaced population to cushion the psychological impact of the loss of their homes by positioning the structures close to the territory. This type of structure is attentive to the material-constructive, morphological-dimensional and perceptual-cultural constraints (Pinto, 2004) to guarantee to the users the custody of the memory and better standards of liveability than the other two solutions.

This scenario returns the necessity to focus the design attention not only on the requirements of the area at urban scale but also at building scale. Therefore the emergency modules are required to behave, in terms of performance of modularity and high flexibility, both in the structural *realisation* of the prefabricated element and in its very transportability. They will therefore have to consist of light material elements, easy to assemble with an estimated average assembly time of a few hours. This structural flexibility will also have to be reflected in the functional model of the emergency structure, which will have to guarantee a variability of the number of beds available and internal distribution of the rooms that responds to the different needs linked to the relative phases of the emergency. This flexibility determines *the environmental* quality of the module, a *mixture* of the conditions of contemporary well-being and safety, *allowing the building of* a new housing consciousness in a state of emergency. The possibility of *compartmentalising* spaces in case of infection, supports the improvement of the well-being of the entire community of the housing module. This determines a social well-being that supports the health and safety of users, an essential requirement in an era of urban crisis in which it is necessary to contribute to the well-being of the community, trying to obtain greater awareness and control over the changes that develop in them. The architectural requirements must therefore guarantee the presence of minimum habitable and covered living spaces, guaranteeing 3.5 m2/person for tropical climates and 4.5-5.5 m2/person for cold climates (United Nations Refugee Agency, 2020). This metric provision must, in turn, be able to offer a minimum number of beds corresponding to the average value linked to the climatic circumstances of the site and the demographic structure of the resident community. In the case of the Veneto Region, the size is about 4.5 square metres/person, since the average family size is 3/4 members and the climate is mild (temperate zone), neither tropical nor cold, in relation to the world situation.

The discretisation of the urban and architectural requirements for responding to the emergency makes it possible to identify the main subsystems in which to intervene to enhance territorial animation. The incidence dimension of the potential stakeholders to be involved fell on the technological subsystem, *finalising* the info-dissemination to the exposure of the potential of the emergency module. The latter, being adaptive, minimally flexible, replicable on a large scale, multifunctional, sustainable and integrated, with an improved capacity of resistance and adaptation to the urban and natural territory of the Veneto region, is envisaged to define the future directions of research and development.

2.2 Structural reversibility, DfD and end-of-life value retention

The response to the vulnerability parameters analysed has been realised in the design of an emergency module, adaptive and flexible. The H.E.L.P. module incorporates solutions that allow to adapt the usability of the spaces to the uses requested by the occupants, in order to ensure a quality living comfort both in the long and in the short term. To allow geographical adaptability, the module presents the possibility of modifying the stratigraphy of the thermal cladding in order to achieve (standard) thermal performance parameters differentiated by location at variable altitudes. Both aspects of spatial and performance flexibility are a direct application of some of the tools of reversible design (Durmisevic, 2019). This resulted in the development of a construction system suitable for the production of the structural components of the module in a standardised manner. This factor privileged the aspects of physical interchangeability of the structural elements, ensuring their easy disassembly even for repeated cycles of use, as envisaged by the methods of Design for Disassembly (DfD) in the combination of the use of hybrid wood-steel connections (Durmisevic, 2019). This aspect of the solution gives additional potential to the module in the emergency setting, as it combines the ability to reuse the structure for multiple time cycles that cannot be determined at the design stage. This provides the H.E.L.P. project with optimal characteristics for the implementation of the aspects of the Circular Economy declined in the development of the module, both from a technical and participatory point of view (Wastling, Charnley et al., 2018). In particular, Circular Economy applied to Architecture focuses on conceiving the building as a "bank of materials", a storage of building components inserted in a functional context from which to recover and reconfigure them according to the functions required by the users. This determines the mitigation of the impacts of the built environment, transforming the waste into a resource and intervening simultaneously on the relationships between the individual parts and the whole structure (Bosone and Ciampa, 2021). The circularity inherent in adaptive reuse makes it possible to treat the emergency module as a dynamic system of complex elements that can be replaced over time according to the performance required. The circular economy borrows from recovery a systemic vision of multiple life cycles to be extended through the knowledge of material culture (Nocca dn Fusco Girard, 2018).

The application of circularity to emergency structures returns the complexity of interrelationships between technological, architectural, environmental and management aspects, related to Life Cycle Assessment (Iodice et al., 2021). The module responds to this need through the innovation of the usual design practices related to a linear economy, in favour of a recursive and 'circular' decision-making process, in which the stakeholders of the process have been involved since the early stages of design. The aspect of participation has been fundamental for the identification of valid and shared solutions not only by designers but by the whole construction chain. The engagement process involved decision-makers (Administrations and Civil Protection) for issues related to the use and logistics of the emergency modules, and stakeholders (companies from the Veneto production chain of the wood sector, components and systems for domestic use) to support aspects of the production and construction of the H.E.L.P. module. In this specific case, the involvement of stakeholders in the design process implemented the steps suggested by Mulhall, Braungart and Hansen for the implementation of a building with a positive impact (Mulhall et al. 2019).

The centrality of stakeholders in the process (Fig. 3) restores the order of importance for determining key objectives and performances in a circular design, or more appropriately in designing the positive impact of buildings in the built environment.

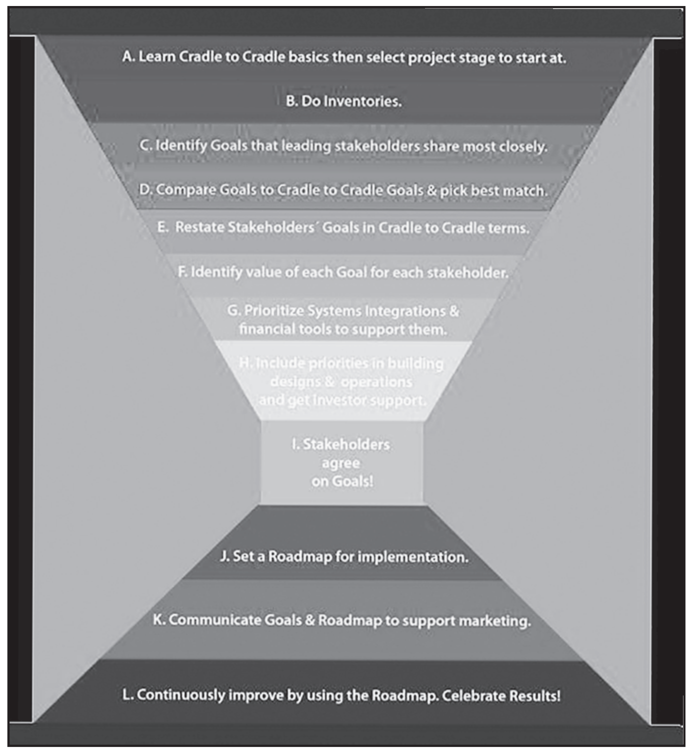


Figure 3 - *Representation of the proportion of material ready for reuse at each life cycle allowed by reversible or DfD design (Mulhall et al. 2019).*

This highlights the need for circular and multidisciplinary strategies that assist the designer in the implementation of modules whose expected performance is capable of responding to the needs of widespread users, increasing the retention of the value of the resources employed.

The involvement extended to the stakeholders in the design process increases awareness of the value of reuse and makes the user responsible for more sustainable choices, educating them about the need for circular approaches. This last aspect returns an effective implementation of the performance levels of the H.E.L.P. module that meet the requirements of the widespread users. This constitutes the prerequisite for the construction of value retention strategies (Vermeulen et al. 2018), which is configured as a fundamental assumption from which the totality of the choices made in the design phase are derived. In this sense, architectural flexibility and structural reversibility are to be interpreted as the implementation tools that allow preserving the value of the raw materials used in the construction of the artefact through the extension of the useful life of the module both on the functional level (flexibility of use) and on the physical level (reuse), determining a scenario of open life in which the decomposition of the module does not determine the disposal (landfill) of its components. Through the design of reversible connections, the preservation of the mechanical characteristics of the wooden structural elements is favoured. Therefore, the retention of the useful value of these elements lasts well beyond the life limit that a traditional construction system would allow. It should be noted that at the basis of the design of the H.EL.P. module the concept of reuse (Pinto, 2004) is declined in its adaptive expression, as this approach involves the maximisation of the use of existing resources, which from potential waste become a resource of the new life cycle of the module replicated in other contexts. This characteristic gives the H.E.L.P. module the ability not to require further transformations at the end of its useful life cycle, implementing the 4Rs of circular design (Recycle, Repair, Recovery, Reuse), especially with reference to Reuse as a privileged tool for value retention. In this adaptive framework, the H.E.L.P. module is consistent with the latest Design For Disassembly addresses, following a design aimed at disassembly (DfD), repair and regeneration (European Commission 2020, Hopkinson et al. 2020, Joensuu et al. 2020, Minunno et al. 2020, Pomponi and Moncaster 2017, Ness and Xing 2017, Benachio et al. 2020). As the wood comes from renewable sources (Campbell 2019), the realisation of the H.E.L.P. module is reversible and projected towards a high degree of circularity (Durmisevic 2019), considering that the connections between the components allow the reuse of the parts (Fivet 2019, Durmisevic 2006, Brütting et al. 2021).

The impact of reversibility is appreciable in terms of retention of the value of the module, considering that this feature affects the end-of-life scenario. The latter remains "open" through the ability to reuse disused materials, removing them from landfill disposal. In this sense, it appears immediately how through reversible design the reuse of materials and the preservation of their value is promoted on a longer time scale than the one that building regulations provide for most residential buildings, i.e. 50 years (NTC, 2018). In the case of the H.E.L.P. module, the need for continuous disassembly and reassembly, forced by the project development context, necessitated the identification of a method to extend the use of the module above the average of the ordinary time scale. However, since the project was based on the use of immediately usable and available technologies, it was also necessary to consider the inevitable irreversible deterioration of the materials (therefore of their value) due mainly to:

- deterioration of mechanical properties over time;
- accidental damage during disassembly.

It is possible to trace the H.E.L.P. module within a renewed end-of-life perspective (Fig. 4) through the relationship between material deterioration and the number of disassembly cycles within the static strength limit of the element employed (Camerin et al. 2020).

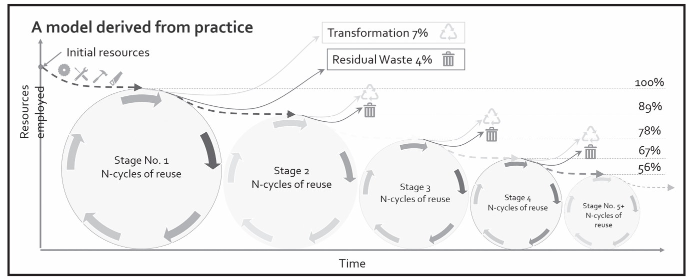


Figure 4 - *Representation of the share of material ready for reuse at each life cycle allowed by reversible design or DfD (author: Francesco Incelli).*

This relationship shows that the progression of disassembly cycles determines a decrease in the amount of material that can be directly used. In this respect, the design reversibility characteristic of the residual material confers an increase in the extension and value of the previous life cycle, evolving according to the scheme proposed below (Fig. 5).

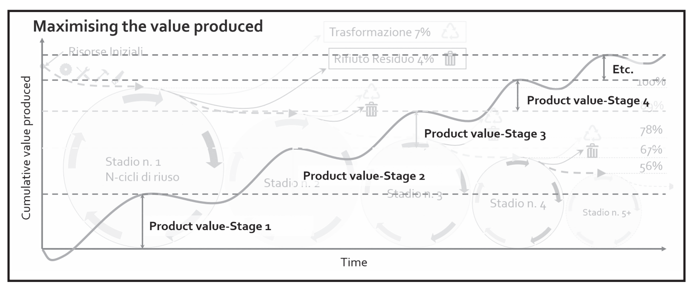


Figure 5 - *Qualitative assessment of the value accumulated in successive life cycles thanks to structural reversibility (author: Francesco Incelli).*

However, the extension of the useful life of the materials beyond the end of life of the standard modules allows further value implementation compared to a linear scenario.

3. METHODS AND MATERIALS

In the different stages of the built environment recovery process, Architectural Technology deals with the involvement of different stakeholders through participatory strategies and tools (Pinto et al. 2016). This is done in order to foresee transformations of the built environment based on performance that is responsive and appropriate to the needs of the users involved (Viola, 2012). This approach allows the development of a sharing platform of the project outcomes during both implementation and management phases (Caterina, 2013). In fact, the engagement of the community in the processes of rehabilitation of the built environment consolidates, over time, the potential for redistribution of decision-making power to all types of stakeholders involved. This entails the sharing of information, objectives and actions that influence and determine a new way of inhabiting the built environment (Arnstein, 1969). Specifically, the identification of appropriate requirements for the architectural design of emergency structures cannot disregard the participation of the stakeholders in the process as they are linked to the set of activities aimed at supporting the achievement and development of new shared solutions. This allows in the decision-making process to implement a cognitive activity aimed at increasing the awareness of the problem, the design choice and the integrable solution (Dell'Anna and Dell'Ovo, 2022).

Participatory design in emergency contexts is based on complex approaches aimed at integrating the level of quality of mitigation actions with the responsiveness of the modular housing solution. This feedback derives from the alignment between the needs of the stakeholders, understood as design requirements, and the offer of the systemic solution, represented by the expected performance (Ciampa, 2021).

Stakeholder participation reveals the degree of user satisfaction and acceptance of the design proposal, allowing for the testing of new investigative approaches aimed at responding to the emerging demand framework to produce an efficient experimental solution (Viola, 2012).

This supports the importance of nurturing processes of stakeholder participation within emergency design processes, describing the need to promote greater awareness not only of future scenarios but also of habitable solutions for the mitigation of possible events.

Participation represents the innovative fulcrum of the design and *organisational* process of the form and development of the model (Antonini, 2005). Participation can provide concrete answers to contemporary challenges through the support of expert skills capable of interpreting the manifestation of real needs in order to trace characteristics adherent to the mitigation of vulnerabilities.

In particular, the demand for land use in the event of an emergency must compensate for the disruption of the state of crisis, associating the engagement of processes with the necessary planning guidelines. Participation makes it possible to verify the design choices of intervention through their correspondence to the elaboration of compatible perceptions (Costantini, 2005). This determines the potential development of shared scenarios between design in an emergency state and its evolution in the field of market experimentation.

Participation affects, in fact, both the evolutionary level of the product and the process as it affects respectively the management and the technology and maintenance of the *hypothesised* solution. This pushes research towards a multi-disciplinary culture that involves different stakeholders capable of influencing the process at all levels of action (Norsa, 2005).

For this reason, the scientific dissemination activity has been elaborated through a participatory methodology proper to the Technology of Architecture, equipped with knowledge tools that allow understanding the characteristics of the settlement system, the potential of the project and the value of the scientific engagement of stakeholders in the process (Torricelli, 2004).

Stakeholder mapping is the first phase necessary for participatory experimentation. This selection is substantiated through an information matrix (Munda, 2004) that allows for the identification of the *stakeholders* linked to the systemic discretization of the settlement system. The latter is done, in turn, through the analysis of risk exposure, key vulnerabilities and requirements for action and recovery (Mayer et al., 2004).

For these reasons, after having discretised the types of *stakeholders* to be identified for the process and, therefore, outlined the profiles of the stakeholders involved directly and indirectly in the dynamics of the project, it is necessary to establish the methods of participation and, therefore, of investigation of the stakeholders.

The tools are varied and diverse, ranging from direct digital communications for disseminating information to animation through large-scale participatory survey tools. The first tools act in support of the second, offering the possibility of supporting descriptive protocols of introduction to the survey. The latter consists of the preparation of questions linked to the identification of the project benefits – identified by the previous phases (requirements) – and the performances expected by the stakeholders.

These questions are supported by a graphic communication section of the project aimed at stimulating stakeholder involvement. This phase consisted of the choice of a central image representative of the project and descriptive logos (as many as the potentialities previously found in the research and the market).

The circular figure attributed to the infographic (Fig. 3) is aimed at drawing the stakeholder's attention both to facilitate its reading and to communicate the equal and synergic approach of the single potentials within the same module.

The choice of colours fell on those that could stimulate attention and therefore induce curiosity in filling out the questionnaire. This strategy is aimed at overcoming the cognitive bias of potential stakeholders. This form of graphic kit allows to enhance the animation and dissemination phases of the emergency housing solution.

Using the Soft System Methodology (Checkland, 2001) the participatory protocols of the survey were decoded. The latter combine the performance knowledge of the settlement processes in the environmental unit for the discretization of each of the knowledge involved. This discretization of dissemination outcomes, carried out according to processes attentive to the type of stakeholders to be involved, is evaluated according to the extent of animation on a territorial scale (Reza et al. , 2012).

This step is essential to the success of the objective of territorial animation. The tool of the questionnaire has an ambivalent action: on the one hand, it stimulates the participation of stakeholders who are asked to express – and therefore support – expert knowledge about the potential of the project; on the other hand, in the act of questioning induces the stakeholder to assimilate notions and knowledge about the project and the results obtained from it (Wiek and Walker, 2009).

Such ambivalence guarantees a type of participation that supports the expression of expert knowledge in response to the survey, contributing to the validation of the dominant features of the project (Del Nord, 2006).

The methodological path pays particular attention to the decoding, interpretation and *systematisation* of the results of the questionnaires through the SODA approach - Strategic Options Development and Analysis (Eden and Simpson, 1989).

This determines the need to obtain an optional range of digital protocols to be adopted for the transformation of qualitative data from the questionnaires into quantitative data through the construction of a process of analysis and graphical restitution of the outcomes on a ranking basis (Kusumaningrum et al., 2019).

The latter flows into a system of pie charts that consider the complexity of different stakeholder views, interests and preferences.

The innovation of the method lies in the modelling phase, which allows to integrate the results of the analysis, converting hard data into soft data, and making clear how participation plays an essential role in the process of animation and validation of the proposed module.

This is evident in the ranking phase which integrates the views of the different experts, identifying the main issues on which the views overlap because they are recognised by the majority as relevant.

The orders allow, therefore, to give a different weight to the issues that emerge, consistent with the lines of intervention proposed by the modules of project experimentation.

Figure 6 - *Project potential mapping, infographic tool to support participatory protocol surveys, 2021.*

This phase allows identifying the priority characteristics of the project, identifying for each of them a precise evaluation essential to the construction of emergency modules for the mitigation and management of territorial vulnerabilities.

3.1 Operational phases

The first one is related to the formation of a cognitive framework within the emergency structures present in the territory of the Veneto Region. The construction of the state of the art was structured in four steps, each of them consisting of a main topic, an objective, its own methodology and a system of expected results then found (Fig. 7).

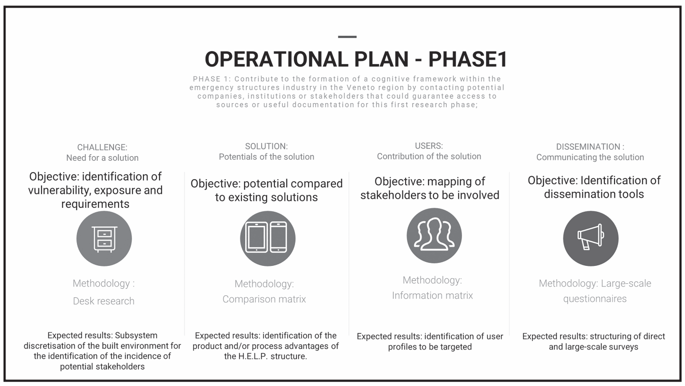


Figure 7 - *Operational phase 1: the four steps consisting of themes, objectives, methodologies and expected results (author: Francesca Ciampa).*

- The first step refers to the framing of the problem and to the research of the necessity of the solution within current and foreseen scenarios. This step, in fact, is moved to the objective of identifying vulnerability, exposure and project requirements through a desk research methodology aimed at the subsystemic discretization of the built environment. This last aspect is significant in order to identify the incidence dimensions of the stakeholders to be involved in the participatory process in emergency contexts.
- The second step refers to the identification of the potential of the solution. This step aims to establish the potential compared to existing solutions through the construction of a comparison matrix, able to return the advantages of the proposed design module.
- The third step refers to the ability of the solution to contribute to the sector scenario in which it is located. This aims to draw a map of stakeholders to be involved in the process through the construction of a matrix of information of potential stakeholders, aimed at establishing the profiles of users to be involved.
- The fourth step refers to the dissemination and communication of the project solution in order to identify the most suitable tools for the dissemination of the results. This leads to establishing a large-scale survey supported by a protocol of questions scientifically inferred from the previous steps.

The second phase refers to raising awareness among the potential project recipients, the main subjects that deal with the coordination of activities and issues of defence and protection from emergency crises in the territory, through meetings aimed at creating interdisciplinary networks.

- The construction of this awareness-raising phase involves a first step related to a mapping of contacts to be associated with the different potential stakeholders. The latter will be involved to contribute their knowledge to the validation of the proposed project.
- The step refers to the coordination of stakeholder involvement within the process phase. The latter aims, through the participatory survey methodology described above, to disseminate the survey questions to optimise engagement.
- The third step looks at participation through responding to the selected significant sample. This step uses the Soft System Methodology to systematise the results obtained by converting qualitative protocols into quantitative ones. This allows a scientificity to be attached to the graphing of the responses of the expert knowledge involved.
- The fourth step is the implementation of a network of exchange but also of validation of the module by means of feedback with the stakeholders of the sector. This takes place through the Strategic Options Development and Analysis, which makes it possible to verify the degree of correspondence of the potential that emerged from the info-disclosure involvement (Fig. 8).

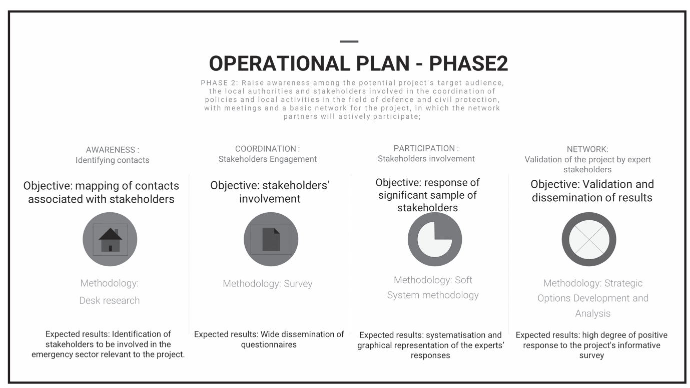


Figure 8 - *Operational phase 2: the four steps consisting of themes, objectives, methodologies and expected results (author: Francesca Ciampa).*

The third and last phase concerns the implementation of dissemination activities of the results both within synergic actions for the diffusion to the widest sectors of the market and society of the Veneto Region, and in the drafting of a final report useful to the territorial governance policies to respond to future emergencies.

- The first step deals with the communication of meetings between research and territory to create multimedia material of a dissemination type, aimed at supporting the dissemination interventions of the designed module. In particular, this phase is necessary to involve the widest possible audience, making communicable technical-graphic languages of the sector to the wide community.

- The second step refers to the events with experts in the sector for the dissemination of scientific research in the market areas. These events refer to national conferences and the "Researchers' Night" - a national event in which research is opened to citizens through public laboratory stations. In this regard, the implementation of Living Labs makes it possible both to generate disciplinary comparisons aimed at strengthening interdisciplinary synergies and to bring theoretical and empirical visions of the built environment closer together.
- The third step aims at structuring support tools and project guidelines with domains that accredit the involvement of stakeholders on a regional scale.
- Finally, the fourth step looks at the outcomes of the whole experimentation of stakeholder involvement through the restitution and communication of the scientific animation (Fig. 9).

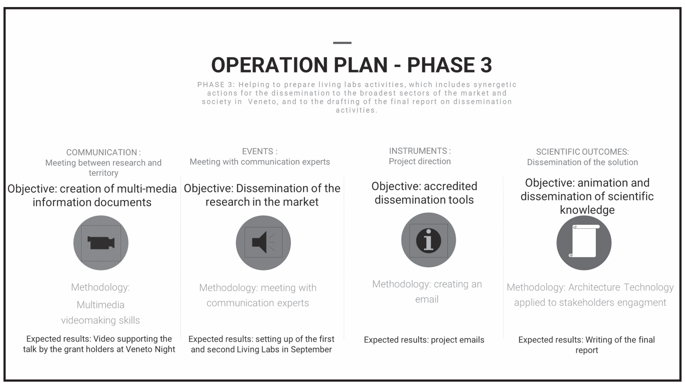


Figure 9 - *Operational phase 3: the four steps consisting of themes, objectives, methodologies and expected results (author: Francesca Ciampa).*

4. DISCUSSION AND RESULTS

The results of the capitalization activity have flowed into the participation tools of the info-dissemination type. The use of Strategic Options Development and Analysis (SODA) allowed us to work on complex problems using questionnaires in order to build a cognitive mapping of individual points of view on the characteristics of the module. Group maps built through the aggregation of individual cognitive maps were used to identify the questions to be submitted in the questionnaires. This has allowed on the one hand to highlight the requirements necessary to meet market demands and on the other the cutting-edge performance of the module in question. The structuring of the questions is developed to disseminate the potential of the model, describing its main requirements for success. The questionnaire involved a sample of 100 companies active in the area in the manufacture of emergency housing modules. Each company answered all the questions in the questionnaire, which was issued to them for a period of two months. In particular, the questionnaire can be divided into five main sections. Therefore, the questionnaire can be divided into five main sections.

The first one refers to the state of the art of knowledge of the project, whose questions correspond to: Are you aware of the project H.E.L.P. Veneto:

1. High-efficiency Emergency Living Prototypes Veneto - Sustainable adaptive residences for temporary living in environmental emergencies? If yes, how did you learn about it?

The second section instead describes the functional and architectural potential of the model in order to disseminate and validate them on the market, whose questions correspond to:

2. The H.E.L.P. Veneto module offers a housing solution of 30sqm, adaptable to a number of people between 1 and 4 without modifying the total volume. Based on your experience, do you believe that having the possibility of varying the number of people is a valid characteristic?
3. The Veneto H.E.L.P. module offers the flexibility of environments through the use of a sliding wall that can be easily moved without the use of tools or specialised personnel. For instance, the structure is equipped with a study/working station that is functionally separated from the rest of the rooms and whose volume can be modified according to the users' needs. Based on your experience, do you think that adapting the internal spaces concerning the functions is a valid solution?
4. The Veneto H.E.L.P. module includes an integrated technical room. Based on your experience, do you think that integrating the technical room inside the structure and away from external weather conditions is a valid solution?
5. The H.E.L.P. Veneto module provides for the integration in the functional layout of both basic services (bathroom and kitchen) and additional services (washing machine and dishwasher). Based on your experience do you think offering additional services is a valid opportunity?
6. The Veneto H.E.L.P. module integrates functional flexibility of the internal spaces utilising concealed services and furniture that can be adapted to the needs of the user (tables of variable size and/or concealed; desk furniture that can be transformed into beds for dual-use during the day and night; etc.). Based on your experience, do you think it is a valid solution to optimise space while safeguarding the mobility and functions of users?

The third section refers to the mechanical and transportability potential of the proposal to validate both its replicability and market convenience. The questions are:

7. The H.E.L.P. Veneto module, being composed of standardised elements, can be both assembled in situ and transported to the site in main parts to be connected without having to make changes to the construction process. Based on your experience, do you think that flexibility of transport is a valid characteristic?
8. The H.E.L.P. Veneto module is made so that it can be disassembled and reused if necessary. Based on your experience, do you think that reversible construction is an advantage?
9. The H.E.L.P. Veneto module is designed to be assembled quickly, even in situ and by non-specialised personnel. Based on your experience, do you think that making assembly as easy and quick as possible is a valid solution?

The fourth section describes the energy potential of the module in order to validate in the market the possibility to advance in the sector in a sustainable way.

10. The H.E.L.P. Veneto module offers the possibility of placing sustainable energy sources (photovoltaic panels) both on the ground and on the roof. Based on your experience, do you believe that the flexibility of the placement of energy sources is a valid feature to maximise the yield of the system in relation to the final orientation of the building or other needs (including architectural)?
11. The H.E.L.P. Veneto module offers the possibility of installing, without requiring any modifications, different external finishing panels according to requirements. Based on your experience, do you believe that the possibility of customising the appearance and/or thermo-hygrometric performance in relation to the site where it is located (mountains or plains) is a valid feature?

The fifth section refers instead to the possible involvement of the corporate stakeholder in direct contact with the module designers, aimed at the implementation of third mission synergies desired by the latest national guidelines.

The results of the scientific dissemination flow into the graphic significance of their elaboration. Through a system of pie charts it is possible to return the value of excellence that companies active in the sector (stakeholders) recognize to the module proposed by the project.

The stakeholders did not know the project (87.5% did not know it and the remaining part learned of its existence through the questionnaire or the conferences organised in the dissemination activities). This data is significant because it reinforced even more the informative value of the questions that, through the questioning of expert knowledge, disseminated the potential of the project exposing it to the stakeholders involved (Fig. 10).

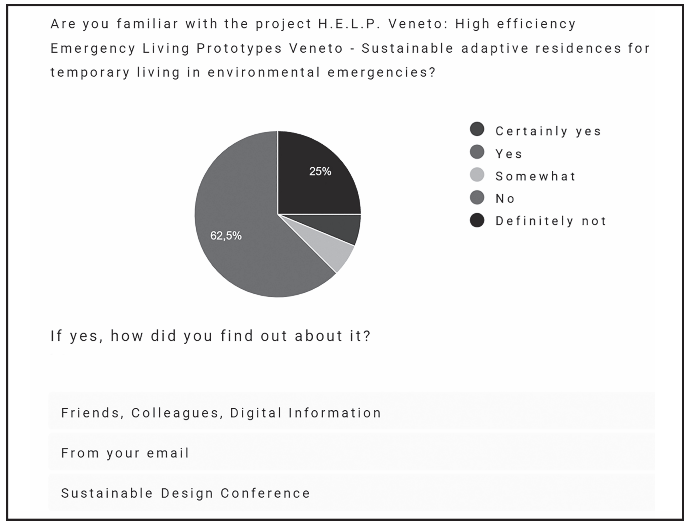


Figure 10 - *Results of the preliminary cognitive survey.*

Stakeholders (100%) considered as an essential and valid feature the possibility to vary the number of people accommodated in the module, which offers a housing solution of 30sqm adaptable to a number between 1 and 4 people without changing the total volume of the project. Equally valid was the high flexibility of the environments of the module (93.8%), obtained through the use of a sliding wall to be easily moved without the use of tools or specialised personnel. Particular recognition was given to the provision of a study/working station functionally separated from the rest of the environments and whose volume could be modified according to the needs of users. Also appreciated (62.6%) was the presence of a technical room integrated within the structure and far from external weather conditions (Fig. 11).

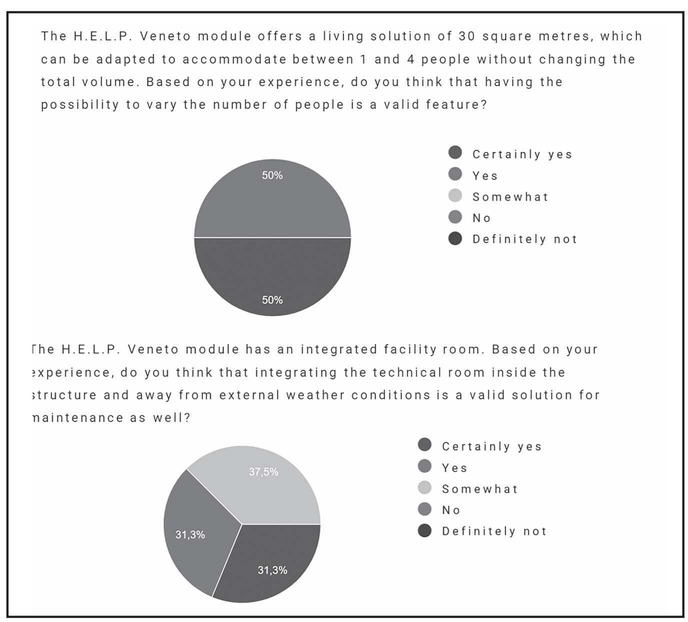


Figure 11 - *Results of the survey in the functional area, part I.*

A feature of excellence was then recognized (93.8%) for the integration in the functional layout of both basic services (bathroom and kitchen) and additional ones (washing machine and dishwasher). Similarly, the functional flexibility of the interior spaces through furniture that can be adapted to the needs of the user – such as tables of varying size and/or that can be folded away; desk furniture that can be transformed into beds for dual-use during the day and night, etc. – was judged positively (100%) (Fig. 12).

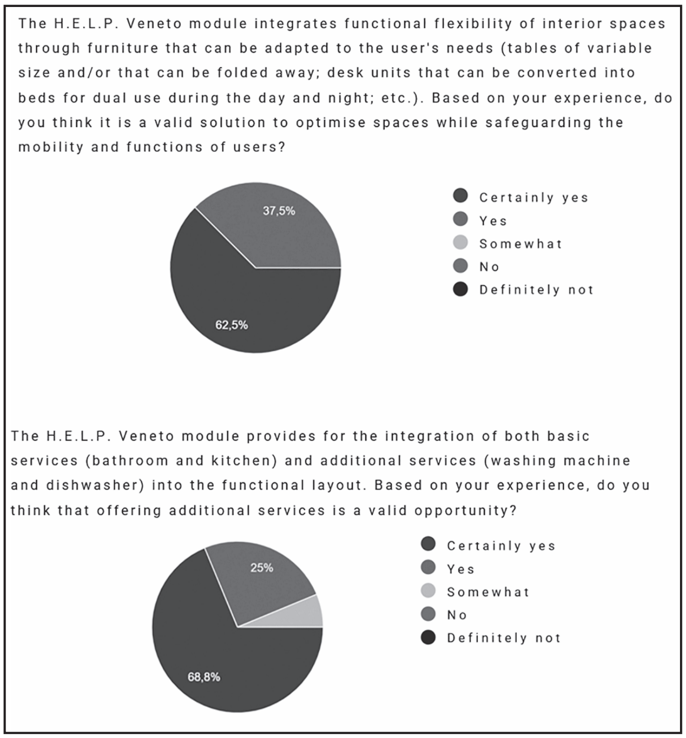


Figure 12 - *Results of the survey in the functional area, part II.*

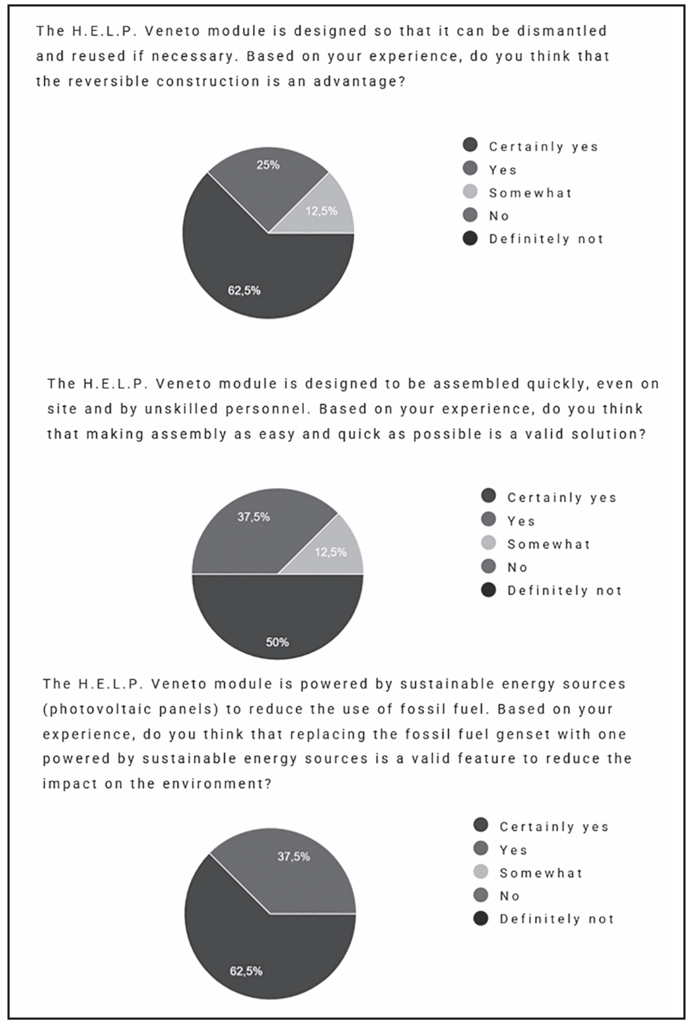


Figure 13 - *Results of the transportability survey, part III.*

A further aspect of excellence was acknowledged (93.8%) to the ability to assemble in situ standardised elements that can be transported on site and connected without implementing changes to the construction process of the module, as well as the ability to disassemble and reuse as a factor of constructive reversibility offered by the module (87.5%). A further advantage (87.5%) was recognized in relation to the ability to quickly assemble the module on site even by unskilled personnel (Fig. 13).

A factor of excellence is the powering of the module with sustainable energy sources (photovoltaic panels) to reduce the use of fossil fuel by replacing the fossil fuel generator (100%). This valid feature is also associated with further excellence (93.3%) referred to as the ability to place these energy sources both on the ground and on the roof, maximising the yield of the system in relation to the final orientation of the building or other needs including architectural. Finally, it has been positively validated (93.8%) the possibility to install, without requiring any changes, different external finishing panels according to the aesthetic and/or thermo-hygrometric performance requirements related to the site where the module is placed (Fig. 14).

The degree of satisfaction with this communication and involvement was so high that some of the stakeholders stated that they would visit the project site (25%), that they were glad to have participated (50%) and that they would try to ask for an interview with the module project technicians. The most notable finding lies in the absence of negative perceptions of the project characteristics by expert knowledge (Fig. 15).

On the one hand, the methodological path set out and its results provide a process innovation that looks to the involvement of stakeholders as a functional element for the success of the participatory planning. On the other hand, product innovation obtains the validation of expert knowledge through the empirical recognition of the participants. Participation is functional to the development and testing of the module within the market of emergency residential structures in a sustainable way. The recognition of the module's potential through a

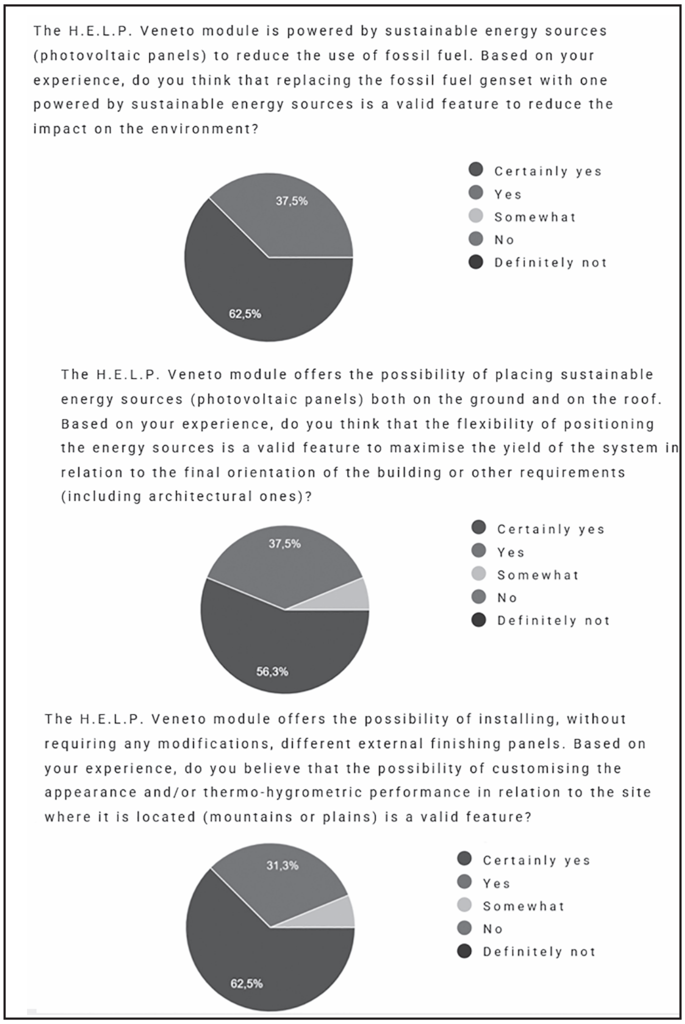


Figure 14 - *Results of the energy sustainability survey, part IV.*

validation of the functional, logistical and energy aspects, allows it to evolve towards more sustainable land management scenarios.

5. CONCLUSIONS AND RESEARCH PERSPECTIVES

The participation of the stakeholders in the emergency

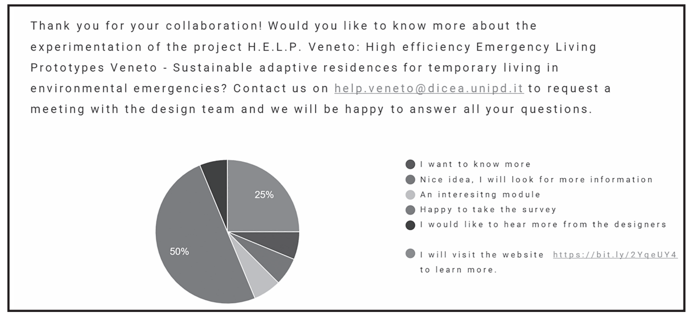


Figure 15 - *Results of the energy sustainability survey, part IV.*

process allows projecting the research towards new integrated strategies able to recover and regenerate the built environment employing multi-dimensional and multi-stakeholder methodologies. This supports a holistic and interdisciplinary design, attentive to the needs of the entire stakeholder chain for the shared resolution of dysfunctions of the built environment. The search opens towards a new design scenario, which by making a shift on the methodological level, evolves from an object-centred to a system-centred vision (Gaziulusoy, Brezet 2015; Manzini, Vezzoli 2003), based on the transversality of roles and knowledge of the project life cycle (Bakker 1997; Joore, Brezet 2015; Sumter, Bakker et al. 2018). In the design experience of the module H.E.L.P., the satisfaction of the needs of well-being and usability of the users, attentive to the last fragilities of the pandemic period experienced, is preponderant. In this case, the consultation of stakeholders (decision-makers) belonging to the industrial environment of Veneto constitutes a tool for assessing the quality of the proposed solution, allowing the identification of key features of a virtuous emergency module. The circularity, declined as physical reversibility of the structural and non-structural components, is a factor of the H.E.L.P. module consistent with the guidelines of the European Commission about the need to produce resilient projects and high value (Green Deal, Next Generation EU). This opens up new research perspectives, in the perspective of participatory design, highlighting the need to extend the attention on the areas of participatory life cycle assessment towards the transition of models of shared and conscious management of the emergency.

Acknowledgments

We would like to thank the Veneto Region and the Research Assistants involved in the project Andrea Piccinato, Francesco Pozzobon and Milica Mitrovic.

Authors contributed

Conceptualization, F.C.; Introduction, F.C., Theoretical Background and Literary Review, F.C., Methodology, F.C.; Validation, F.C.; Investigation, F.C.; Resources, F.C. and F.I.; data curation, F.C. and F.I., writing-initial drafting, writing-review and editing, F.C. and F.I.; writing-review and editing, F.C. and F.I. All authors have read and agreed to the published version of the manuscript.

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