



Advanced Design For Manufacturing of Integrated Sustainability “Off-Shore” and “Off-Site” Prototype - MVP “S2_HOME”

Nava Consuelo ^{a*}

^a *Researcher, Mediterranea University, Via dell'Università 25, 89124 Reggio Calabria, Italy.*

Received 04 June 2020; Accepted 13 August 2020

Abstract

The "S2_Home" research project - double safety home - the double safety of living (seismic and social/environmental), pursues the development and research strategy of the De Masi Mechanical Industries of Antonino De Masi, on the themes of innovation related to technologies of automated mechanics, applied to the realization of systems and components at the service of health and quality of life of users. S2_Home pursues the integrated sustainability model between "off-shore" and "off-site" processes. "Off-site" because it applies solutions inspired by robotic automation and advanced manufacturing for the components of a building system between machine shops and off-site. a laboratory for the assembly of systems and services; "off-shore" because it initiates processes of "energy transition" for small and medium-sized user communities. The design process transfers the housing energy-environmental performance of the standard module to the whole integrated supply system, up to the realization of a superior energetic functional model entrusted to the "smart grid". The S2_Home housing module is realized through mobile and self-mounting living systems, that meet the demand for emergency settlements, focusing on the quality of living, the efficiency of operation and usage, and the versatility of construction for different climates and sites sensitive, to the innovation of technological systems and supplies, that are able to characterize the module and make it available to aggregation settlement systems. To realize the economic value through optimizing energy and service operations, as well as the economy of scale on the production chain, using techniques and processes of the company's machine shops.

Keywords: Double Safety; “Off-shore” e “Off-site”; Integrated Design; Prototype/MVP.

1. Introduction

The possible technology and commercial competitiveness of the market to produce "innovation" that is attractive to the demands of users, is the process addressed with an open and progressive approach for the development of the S2_Home – *offshore and offsite*. The ambition of the S2_Home type is in fact to become a model that triggers an innovation of a “sustainable chain on advanced manufacturing industrialization”. It's measured on the typological and settlement proposal, able to provide design and technology, innovative products, interceding with a new local market, competitive at national and international levels.

The sustainable project is always, by its very nature, a "total design", able to find moments of compatibility with other structural dimensions of the environment. Such as those more relevant to the landscape and the device's efficiency system, even including its installations. In regimes of hyper sustainability, including short- medium- and long term, and encompassing the verification and measurement of economic feasibility and the evaluation of viable strategies, there is no longer a real need to distinguish between a sustainable approach to the project and a

* Corresponding author: cnava@unirc.it

 <http://dx.doi.org/10.28991/cej-2020-03091580>



© 2020 by the authors. Licensee C.E.J, Tehran, Iran. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (<http://creativecommons.org/licenses/by/4.0/>).

conventional way of thinking about cities, buildings, and innovative living service products. This is a historical moment in consciousness that presents the only possible way to limit the consumption of exhaustible resources, to renew those of the local and super-local biophysical system. Thinking univocally about the same system's capacity to produce a comprehensive quality of life, in physical, material and performance aspects, for the environment and other non-urban areas. The question of "total quality" is answered by the definition of "total design"; *"using advanced techniques involving preplanning. One must know what has to be done before doing it, so that one can organise the work properly. The key to a building operation ought to be what one might call the total design - which foresees and plans every stage in the operation. This total design must nowadays be the work of many people, each contributing his particular knowledge, and this team should be controlled by a strong leader, now an executive team with power to decide priorities and reconcile conflicting claims"*[1]. We adopt the term "advanced design" rather than project, in order to favour a particular approach. As a concept related to innovation, a *design-driven formula*, which provides the necessary space for interpretation and communication, in the projected life context, between those who must bear the fruit of the project in its production and those who must use and consume them in post-production. The collective laboratory for each process is defined as a "design discourse", in which those who operate the project always assume the role of interpreter/researcher and give various contributions. *"Companies that produce design-driven innovations place great value on their interactions with the interpreter network. These companies know that they are immersed in a collective research laboratory through which companies, designers, artists and schools are carrying out their exploration. These researchers are involved, explicitly and implicitly, in an ongoing dialogue: they exchange insights, interpretations and proposals in the form of studies, conversations, prototypes, images and products. They test the robustness of their assumptions and share their visions. This process of 360-degree research into the possible meanings of things is design discourse"* [2]. For this reason and as discussed, the declination of the project is addressed whilst considering the characterizations and reasons of the "advanced design form". The definition of the equivalent adjective announces its purpose: impact design, high performance design, and cybernetic design. It works to trigger a projective process, which can translate procedures of "total design" and is comparable to proposed sustainable inter-scalar operations that have the ability to control the same definitions of the project [3]. With the aim of configuring a possible commentary on the quality produced in architectural landscapes, a conscious use of technologies can enable an understanding of the functioning life-cycle and the relational energetic conditions among all the biophysical and socio-economic systems that react to a certain "level of turbulence". This is indicative of all building environmental dimensions involved in fast, innovative, complex projects.

The "total sustainable design" is therefore charged with a methodical task of knowing how to effectively manage innovation through a generative, multi-level design model (from strategic planning to the open design of the system/object). To govern the ways in which the activities of the processes affect the technical and performance aspects and to express all levels of useful knowledge about the operating systems involved. Such a definition allows the project to assume an "exploratory", multidisciplinary, non-sectoral or specialized character, but even more a narrative and dedicated role to illustrate paradigmatic issues of interest, of which a possible definition guided by innovation must be found. An approach that although it preserves that projective character of the project, by axiom it leaves room for a fertile state of design thinking, even without its need to achieve a transformation of the building environment. *"On the one hand, the project, precisely as an anticipation, refers as a temporal horizon to the future: that is, the project is inseparably linked to the affirmation of the idea of the future. On the other hand, the design activity must necessarily confront the category of the possible. This clarification puts the project away from deterministic interpretations, but at the same time leaves room for the possibility of thinking about design activity outside of an effective desire to transform the present"* [4].

The mission of the company that commissioned the project-research is not limited at the realization of patentable prototypes nor the results of "experimental development". The project intends to create industrial systems able to position themselves on innovation markets thus activating innovative sectors on the issues of environmental and social security, in accordance with the rules and processes typical of manufacturing industrialization to other content of innovation and enabling technologies. Moreover, the level of specialization necessary to realize the S2_Home, is realised through works in the machine shop. To transfer that typical approach of innovation processes, we are able to experiment but also technical practices, thanks to the transfer of knowledge of its operators at all levels.

The S2_Home research project is described in the paragraphs of this study, presenting the research methodology (Sec.2), on the themes of design driven innovation, with the measure of innovation of the research project S2_Home: self-assessment of the TRL. The results and discussion (Sec.3) of scientific research activities are proposed in their ability to respond to the production demand for the prototype of the housing module, in all its design levels and definitions of sustainable building performance. In conclusion (Sec.4), a review of some of the essential characteristics, in terms of advancement for experimental research, measured through two aspects: the integrated design and sustainability assessment and the facilitated building site.

2. Research Methodology

2.1. The Customer's Request

The housing module S2_Home, is then realized through the thorough study of mobile and self-elevating systems to answer to the growing housing demand for the emergency settlements or in any new living scenarios. Aiming for a high quality of living, the versatility of the building and its efficiency of operations and usage allows it to be located in different climates and other sensitive sites. The project is always responding to all levels of necessary requirements namely the innovation of technological systems and supplies thus characterizing the module and making it available for aggregative systems in geographically different scenarios and specific responses of the module's performance.

This is the economic strategy for realization made possible through optimizing the processes of thus saving energy operations and services for the module, as well as using techniques and possible processes in the company's machine shops can produce a feasible and sustainable economic scale. The necessary properties of the module is to have a sustainable and effective means of mobility. The S2_home can be transported using everyday trucks because it's has the same dimensions as a shipping containers.

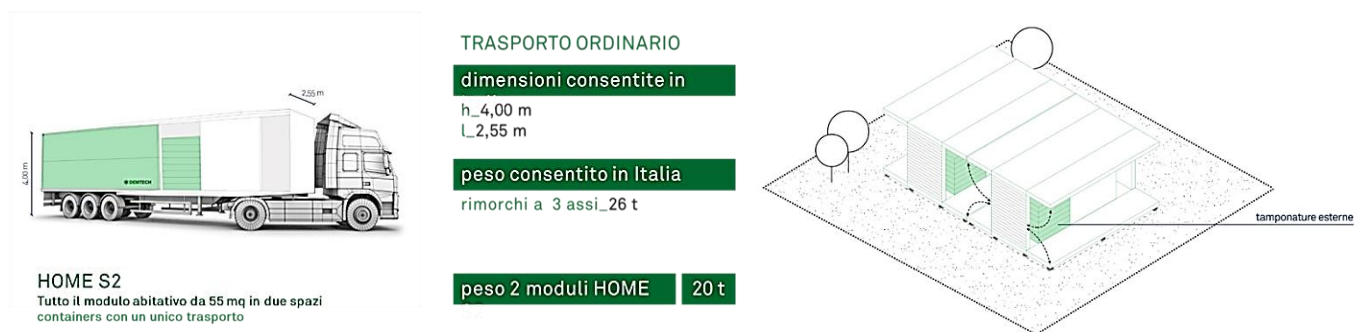


Figure 1. Ordinary transport on three-axis trailer and opening diagram of the modules (Design: Procopio 2017)

Taking into consideration the advancement and uploads of aluminium frames by Safety Cell (patent by De Masi), we have used envelope and steel panels for the configuration of the structural box

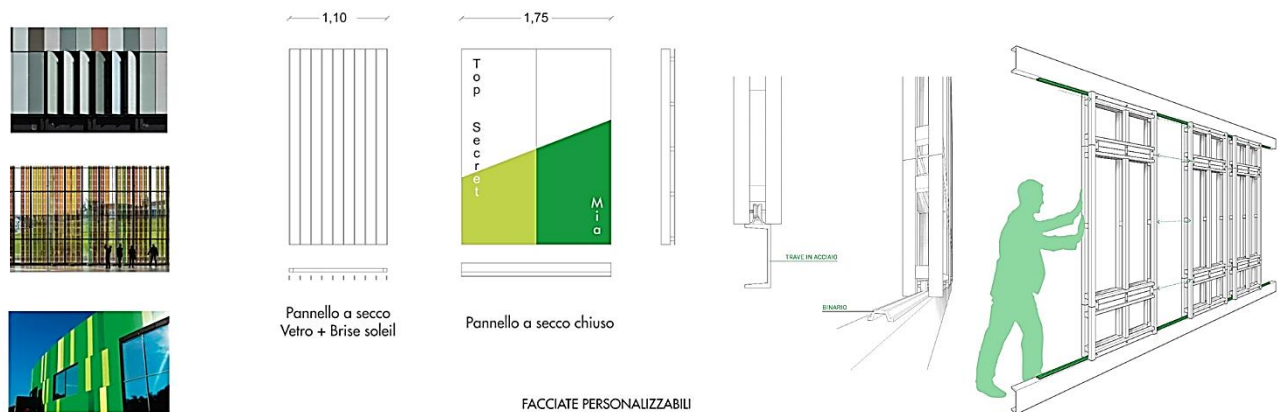


Figure 2. Envelop, structure and coating system (Design: Sgaramella and Procopio 2017)

2.2. S2_Home – Design Driven Innovation

S2_Home is the product of a high-specialization innovation and development process that has identified three important steps for the definition of activities and products:

Step 1: Concept & Innovation Process/design Project

- Definition of innovative concept and process/project illustration;
- Activities of technical-design definition (architectural and functional aspects; technological and systems-engineering; aseismic construction; pre-engineered and engineered);
- Pre-manufacturing Activities (selection of supplies and preparation of site/prototype activities).

Step 2: Manufacturing and Marketing

- Prototyping and Simulations (construction site);
- Post-production Activities (technical and commercial information);
- Communication and marketing activities on a prototype (on programme).

Step 3: Branding and dissemination

- Experimental development and market positioning of the commercial prototype (patent);
- Dissemination and industrialization programme.

The transition between step 1 and step 2, "from concept to prototyping", has affected the engineering activities of the project, which see their conclusion in July 2019, then start the activities in the workshop with the realization of the prototype/MVP and are scanned in two times:

TIME I: A. Concept and Innovation Design (definition, project, pre-manufacturing); B. Manufacturing Envelope; (Prototyping, envelope testing, manufacturing); C. Report and dissemination results.

TIME II: D. Project revision and selection of the typological module I phase; E. Engineering of the structural module and the hybrid systems; F. Engineering of the project with drawings of factory and fabrication; G. Process engineering with pre-prototyping and eco-design, components, models/manufacturing in the company and sensoring testing for envelop and skin; H. Report and dissemination results.



Figure 3. Envelop: additive manufacturing models (Design: Procopio 2019)

These activities, in fact, are built on the prototype model chosen that corresponds to the type MVP-minimum viable product: “(...) an MVP allows you to accelerate your learning about a possible solution whilst using minimal resources. It does this by testing only the essential core of your concept (rather than the full solution) with real users in practice. This means that you can find out early on if there is an actual need or demand for the solution, what is working and what isn't, and make any adjustments accordingly (this is called pivoting in the lean-startup scene). MVPs are often associated with technology, and aren't currently common in public innovation, but may have great potential for situations that deal with a fast-paced political development cycle or require ongoing improvement of public services and public policies. MVPs are about using fewer resources and minimal effort to gather insights and obtain feedback on potential changes” [5].

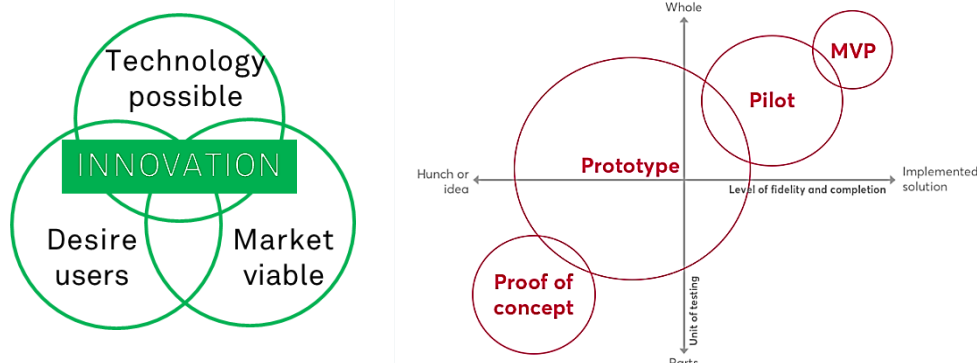


Figure 4. Relationship Process (Nava 2017) - Highlighting the differences/product (Nesta 2018)

Home S2 as prototype-MVP wants to position its solution in the innovation market with one of its possible configurations (85 sq. m.), opening the solutions foreseen for the integration of innovative products on some manufacturing characteristics and non-structural affecting systems, envelope coatings, enabling technologies to increase the energy-environmental reactivity of the skin of the envelope (reactive skin/cybernetic skin). Moreover, this possibility allows to act by integrating new components, as on a catalog system and it is realized, for the planned configuration of its aggregative scenarios, different for climate conditions, landscape, utility, functionality, energy efficiency, and durability.

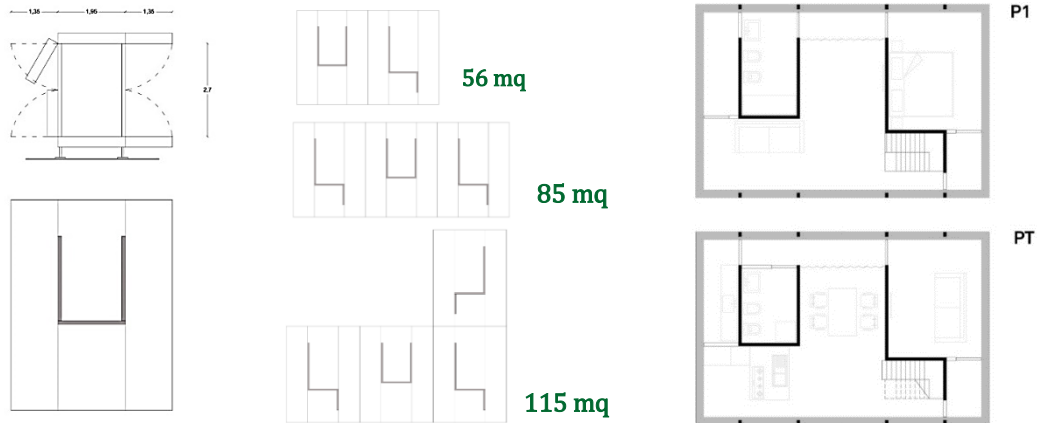


Figure 5. Modularity of different types and distribution on two floors (Design: Sgaramella 2017)

2.3. The Measure of Innovation of the Research Project S2_Home: Self-Assessment of the TRL

Among the ambitions of the research project for the S2_Home module, that of positioning all the work produced in the innovation ecosystem, in which the exploitation of the results of scientific research can take place through an industrial validation process, with a definition of the process of high added value industrialization. As anticipated in the introduction, this work, moreover, can be placed in specialist areas related to the Industry 4.0 system, referring to the Horizon 2020 ket's to process/product technologies on "advanced manufacturing systems" and "advanced materials" and in the production context of Strategy Regional Smart - S3 Calabria, for the trajectories of "Sustainable Building" and "Smart Manufacturing".

The measure of innovation of the research project by the team that operated in phase I and II, can be tested on an evaluation method that refers to the concept of "technological maturity", testing the process as defined by the TRL, Technology Readiness Level "on a scale of values from 1 to 9, as specified by the European Commission in the Program *Horizon 2020 – Work Programme 2018-2020 General Annexes – Extract from Part 19 – Commission Decision C (2017)7124*.

The references on which to compare their applications to evaluate this level of innovation are:

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

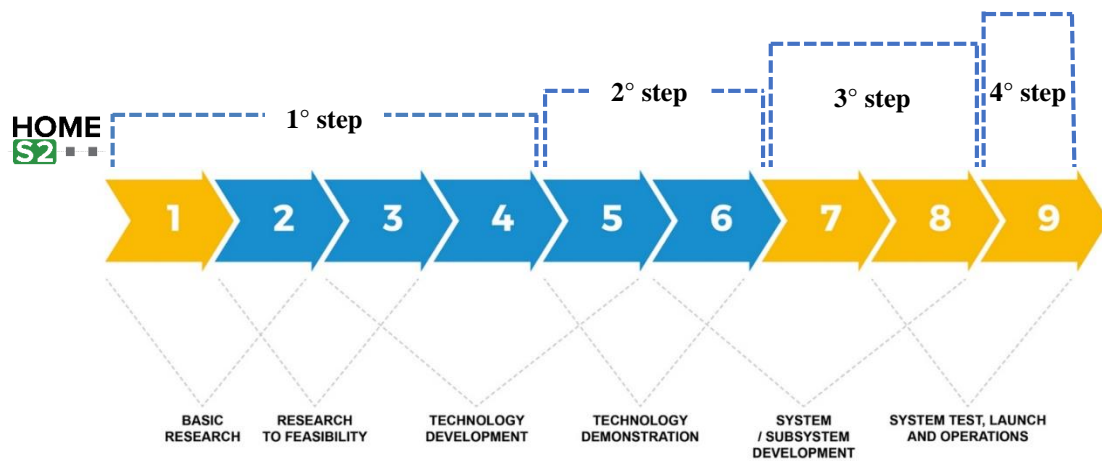


Figure 6. S2_Home diagram implemented on NDA model (Nava 2019); Source: Guide to Technology Readiness Levels for the NDA Estate and its Supply Chain

Table 1. Details of the S2_Home activities with reference to the TRL model are given below

TRL	Step S2_Home	Advanced Design S2_Home
TRL 1 – Basic principles observed	1° step	Process / project construction: design driven innovation. - Process innovation from proof of concept to MVP prototype - Innovation between executive design and factory design - Innovation of the compatibility of the materials for the envelope towards the prototype
TRL 2 – Technology concept formulated	1° step	Concept and design (1): - Integrated off shore and off site sustainability - Housing module between architecture and landscape
TRL 3 – Experimental proof of concept	1° step	Concept e design (2): - Energy model and energy-environmental performance for climate scenarios - Structural model and its typological-technological configuration - Design, technologies and materials of the mounting systems: casing; coverage Feasibility scenarios: - Construction of the smart grid at the settlement aggregation scale: systems, operations, architecture and network performance efficiency - Definition of aggregation scenarios and environmental landscape performances - Definition of cost scenarios and comparison with similar innovative products, assessment of impacts and conveniences
TRL 4 – Technology validated in lab	1° step	To Officine De Masi, Laboratori Enea Trisaia, PMopenlab - Realization of the panel module at the factory - Testing and aging on the scale panel module, discussion of the results - Modeling and automation design of the panel module and the housing module
TRL 5 – Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)/	2° step	Product and process technologies: engineering phase - Executive drawing of the envelope and the buffer system - Executive drawing of the plants on the hybrid model - Executive design of structures, assembly and automation systems Process technologies: assessment of sustainability - Smart grid requirements and type of settlement models in transition - Design and evaluation of the sustainability performances of the cases on the scenarios Start of industrial validation process.
TRL 6 – Tecnologia convalidata in ambiente industrialmente rilevante	2° step	To PMopenlab, Officine De Masi Integreted Design and Maufacturing: - Ecodesign, Modeling and Control of the technical solution in pre-prototyping - Energy-environmental performance monitoring and cybernetics with Arduino technology on the facade system: pre-feasibility
TRL 7 – System prototype demonstration in operational environment	3° step	Prototyping phase to Officine De Masi: - verification of the engineering phase and factory drawings: technological definition of the S2_home module

		<ul style="list-style-type: none"> - Activities on the prototype / MVP (industrial symbiosis) - Full-scale prototype engineering - Performance monitoring activities (full-scale tests and tests)
TRL 8 – System complete and qualified	3° step	Industrialization phase: - Communication, branding and patenting activities - Evaluation and competitive activity
TRL 9 – Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)	4° step	Industrialization and marketing phase

3. Results and Discussion

3.1. S2_Home – Concept of Integrated Sustainability “Off-shore” e “Off-site”

S2_Home pursues the model of integrated sustainability between "off-shore" performance and "off-site" process.

High standards of energy efficiency through “offshore” models capable of making settlements autonomous and starting of "energy transition" processes for small and medium-sized user communities and advanced "off-site" building processes that realize all the components of a system construction between machine shop and off-site and reduce the site a workshop for the assembly of systems and services. But "off-site" also means interest in design processes with digital control and experimentation with industrialization 4.0, with solutions and applications inspired by robotic automation and advanced manufacturing.

The "offshore" system is realized through the design process that transfers the energy-environmental performance of the standard module and entrusts the technological characteristics to its envelope, to the entire integrated system of high efficiency supplies up to the realization of an energy functional model higher level with the "smart grid". This system becomes the guiding matrix for the organization proposed with the multi-scenarios realized through the housing of the S2_Home type, but also with the network of energy services and landscape corridors, which produce outdoor spaces and the quality at the urban scale. Also in the proposal S2_Home module, this process highlights its economic and environmental affordability, its competitive ability to be realized the innovative construction industry and the green yard.

The construction site-laboratory as a place that carries out some of its activities already in the construction phase of open prefabricated systems, to then find the assembly stages on the site, also meets the speed up the realization of the works and of configuration of settlements (especially for emergency scenarios), as well as the ability to check out-of-built the integrated energy services and immediately conceive them as a condition of quality and effective functioning of the entire system building. Furthermore, the level of specialization necessary to realize the S2_Home type, through works of realization in the machine shop, transfers the typical approach of innovation processes, capable of becoming experimental practices but also a new process of products "made in Calabria", thanks to the transfer of the knowledge of its operators at all levels.

3.2. Performance Levels

The project-design of the housing module has transferred the requests of the client (*performance on the application*) into the integrated concept of S2_Home, with a process of meta-projective process that has become the program of the study activities and the reference of integrated design for the transition from the "concept" step to the "definition of the type" step. Already in the concept phase the planning in started for a logic about the spaces-environment; of the filter spaces; of the logic of the structure; of the logic of the envelope; about the logic of the roofing (*performance on the definition of integrated requirements*).

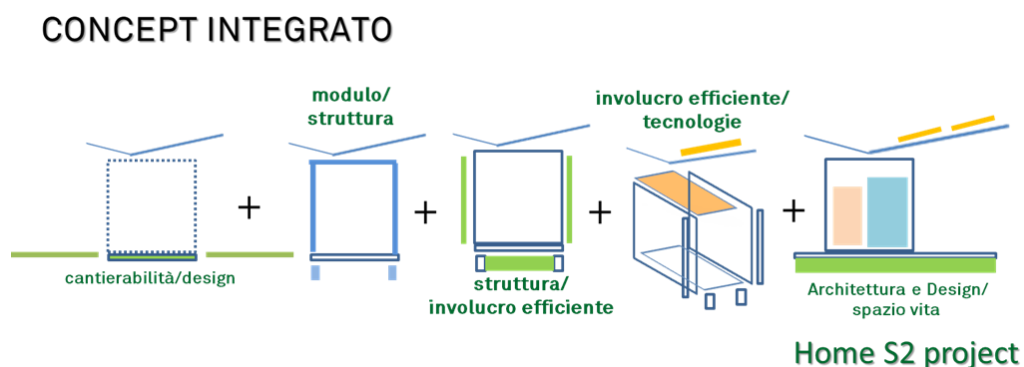


Figure 7. Integrated Concept (Design: Nava 2017)

Also in this experience it is a matter of proceeding according to the trajectory of sustainability served by a "total design" approach. *The sustainable project is always a "total design" capable of rediscovering moments of compatibility with other dimensions of the structures of the environment, those more related to the landscape and to the devices for the efficiency of the systems, to its plants, up to the verification and measurement of the economic feasibility and evaluation of the strategies that can be pursued, in short-term and long-term and medium-term hypersustainability regimes. There is no longer a real need to distinguish between a sustainable project approach and a conventional way of thinking about settlement systems, buildings, and the innovation of living service products [6, 7].*

3.3. Level 0: Performance on the application of the prototype/MVP

Through the level 0 design process, the targets of requirements are defined on the prototype/MVP application for:

- *A structure for sensitive contexts:* beyond an "emergency" structure for a housing system for "sensitive contexts" and "off shore", responding with the transition or the energy-environmental autonomy, in addition to the settlements already served by networks.
- *A flexible modular living system:* according to requests of the clients referable to the structural aseismic project and to the morphological and distribution type of the environments, for a different type of use (couple, family, disabled/elderly) with a basic module 55 sqm and making types from mq. 85/112/170 to one/two floors.
- *For a network metabolism:* with a module of a settlement system that optimizes some relationships with the networks, while configuring its corresponding aggregation, with the possibility of having architectural and operating variants (districts in transition and smart grid operation).
- *A competitive economic system:* a sustainable system also from an economic point of view with the cost of the fully equipped basic module, from a minimum of Euro 1400/sqm to a max of 1600 Euro/sqm.
- *Through an advanced industrialization – Advanced metalmechanics and sensing:* with a module made from an experimental prototype/MVP on a project designed for its industrialization with a dry construction system and innovative reactive envelope systems, with the possibility of integrating Arduino technologies to the skin of the casing. A transportable kit system, to be assembled in situ completely, with stages in self-assembly partly with automation and partly in operational assembly.

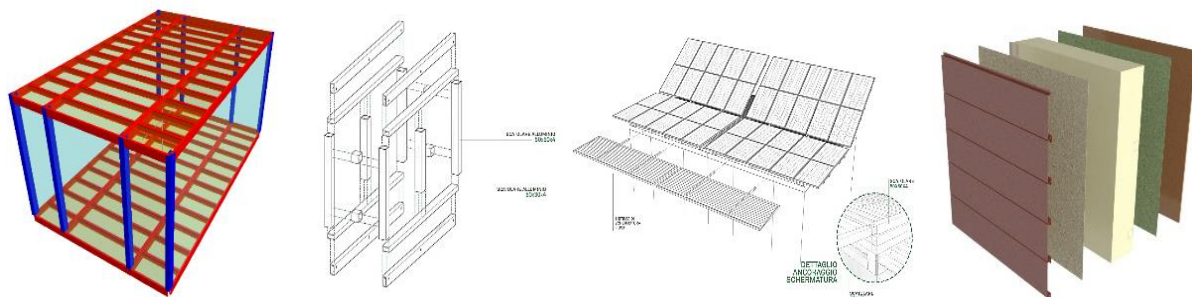


Figure 8. Built-in "off-site" assembly systems. (Design: Astorino and Procopio)

The structural box, entirely in steel type S 235, are made with four corner posts of adequate section to which are connected some transverse beams (arranged in correspondence of the floor of trampling and covering). Statically, the structure is of the single-span frame type, in both directions, which will be placed on a foundation structure, also in steel, specially sized according to the destination site. In the structural sizing, carried out in compliance with the technical standards in force, in addition to the permanent, structural and no permanent actions, the effects produced by the earthquake, wind and snow loads were taken into account. The connections between the structural elements are of the type welded with a corner bead [8].

3.4. Level 1: Performance on the Integrated Requirements Of Safety, Energy And Material Innovation

Through the level 1 design process, we define the targets of integrated requirements for safety, energy and materials innovation for

- *A Kit, safe system "agile to assemble":* with a box mountable with wall sections and shelves and integrated systems, such as an intelligent "kit" of structural wall sections, partition walls and closing on the box-type structure, made of steel and aluminium. With automation systems on the elements that cannot be moved manually

and reduced connection systems to the maximum (low maintenance). An anti-seismic module on support feet of the entire housing module, on a base prepared for the purpose.

- *Integrated roofing system*: a structural cover, which can be integrated for solar and photovoltaic technologies, and which can be oriented with mechanical handling systems and more efficient orientation.
- *A functional base plate*: with a foundation plenum and support system for the assembly of the structure and the closing border, able to contain all the systems, complete with all the equipment also for monitoring and the structural support of the foundation. A network of distribution of the networks to the elevated and supply systems for the services and supplies of the module.
- *A low consumption house*: with a reactive envelope, capable of thermoregulating the module at cold and hot temperatures, sized to perform efficiently for different climatic zones (from A to F) and with the same insulation system, with triple-stratified panels in recycled polyester and with modules inserted in a curtain wall. A model of a home that can be certified energetically and also on some national and European protocols (itaca/leed), a low / zero energy consumption house (energy class A4).
- *A system connected to an energy grid*: for a house powered by solar technologies and water recycling systems (services and kitchen). The coverage of energy needs starts at 96.4% from PV and 3.6% from diesel for solar batteries, with a 2-day module autonomy, isolated from network supplies or smart grid operation. An energy node in a smart-grid, capable of governing the transition of production, storage and distribution for an entire cluster with the 9 living modules connected to the network as energy poles.
- *An ecological, innovative and produced house of a circular economy model*: energetically performing materials, ecological, compatible with a dry construction and coming from recycling processes and chains. The levels of functioning as an isolated system or networked with settlement services, realizes the performance of a system that responds to circular economy models: consumption, production, recycling, innovation. A durable home tested for the impacts of climate change and aging (energy and aging tests conducted by Enea for the Home S2 project).



Fig. 3 – taglio profili scatolari



Fig. 4 – taglio piastre



Fig. 7 – taglio rivestimento interno e barriere



Fig. 8 – pannelli isolanti



Fig. 5 – piegatura a 90°



Fig. 6 – realizzazione fori con trapano verticale



Fig. 9 – fase di saldatura dei profili



Fig. 10 – telaio assemblato

Figure 9. Envelope System: 1. Indoor cladding (e.g. fire wood panels), 2. Vapour Barrier, 3. Thermo-acoustic insulation in polyester fibres recycled on aluminium frames, 4. Windproof barrier, 5. External skin (e.g. boxed slats in varnished aluminium). Project and assembly prototype for workshop testing De Masi machine shops. (Nava, Astorino and Procopio, 2017).

The building envelope is made up of modular elements (panels) that can be mounted manually through a rail system on the external perimeter of the housing module and then completed with the external and internal coverings. The panel, depending on the position inside the enclosure system (on the shorter or longer side of the housing module), is prepared in two modularity for the width and different for the height based on its specific function (opaque panel, transparent with window, transparent / opaque for door).

The composition of the sub-modules gives rise to a diversification of the morphology of the casing as a function of their combination with the sole constraint of the transparent surface dimension that must not exceed 17 square meters for the 60 square meter housing module of commercial surface (proportional increase for the other compositions of the housing module). The modules consist of a structure in aluminium box to form a frame capable of accommodating the layering (thermo-acoustic insulation panels in 100% recycled polyester fibers and the external wind and inner barrier protections to steam) or the window components.

The vertical closure will then be completed through the laying of the coatings (of various types and materials) inside (for example in wood) and outside (for example in painted aluminium), with morphological and material alternatives on different settlement scenarios. The integrated roofing system is designed not only to respond to the

need for protection from atmospheric agents and from the external microclimate but also to accommodate an innovative system for the integration of photovoltaic panels and solar thermal collectors, mounted with a steel box structure which is laid and fixed in special seats on the finished top in steel corrugated sheet; the technological system, therefore, can be tilted according to the optimal orientation to be given to the solar sensors through appropriate electric actuators [9].

3.5. Level 2: Performance on Multi-scenario Settlement Models: Energy Clusters and Smart Grids

Through the level 2 design process, the classes of requirements (targets) are defined for the multi-scenario settlement models described below.

- *The configuration of an energy cluster.*

The housing module HOME S2 self-sufficient, at the aggregative level configures that an “energy block” or energy cluster, realizing in it the concept of modularity: by combining different blocks / energy clusters you go to compose an aggregative structure at the level of the neighborhood to build pieces of cities self-sufficient and disconnected from network operation; the only network will be constituted by the system of connections between housing modules and between energy clusters with the possibility of being able to be connected to an extranet system (connection to already existing network systems). Isolates dimensioned on the needs of 20,000 KWh, served by micro wind and photovoltaic. Housing systems tested on 360 in / 9 modules, 695b / 17 modules, 220 in / 5 modules, for climate zones from A to F. The energy cluster structures not only energy connections but also those for the recovery of environmental resources (recovery rainwater and / or wastewater) on the model of energy-environmental smart grids (phyto-purification, PV, wind, park green). Furthermore, CO2 storage tanks, as far as each type unit is able to save in energy terms with highly efficient hybrid operating models.

- *Smart grid and energy landscape and possible scenarios.*

These scenarios can also refer to the need to create new neighborhoods and new territories settled in different site and landscape conditions. These are new landscape units, but also new stable environmental systems, capable of producing for themselves all the service they need and thus ensuring users from an environmental and social point of view. But it is also a new settlement geography, able to find optimal localizations from the bioclimatic point of view and better accessibility in their relationship with filter and external spaces.

The references to the different climatic zones, allow to show the performances obtainable in different latitudes, but also to test the typological-technological model of S2_home, conceived as "adaptive" to the different climates, with a reactive shell capable of changing skin and giving itself a new morphological configuration and scenery with the landscape that hosts it, with high permeability settlements. In the multi-scenario functional hypotheses, the aggregations could serve settlements in case of emergency (post-earthquake or migration); districts with the transfer of the built-up area during major urban transformations (post-demolition regeneration plans, new satellite districts); villages for intended use, such as employees in urban construction sites, large and small investments in agricultural production sectors with settlements of communities in transition.

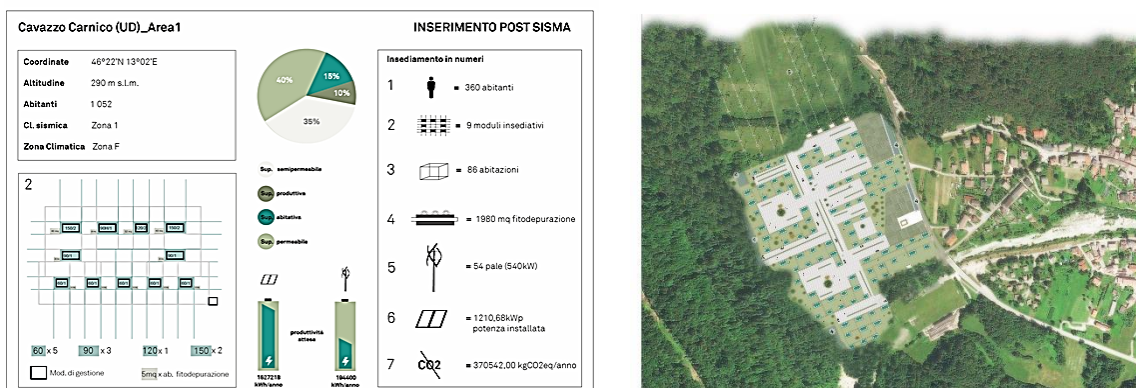


Figure 10. Smart grid system (Design: Sgaramella 2017) and hybrid housing model (Astorino 2017)

The energy model was designed and dimensioned not only with respect to the concept of off-shore smart grid, but also following the performance and energy and capacity that an entire block must guarantee in terms of energy production, organizing the settlement structure on display of the modules and construction of the smart grid. The compositional settlement model, basically observes two criteria: the minimum distance between the buildings and the north positioning of the two-level modules. A minimum distance of 12 m must be guaranteed for each building. The distance doubles in the case of multi-level modules. The general layout can create a free central space, inside the

block, which acts as a public area on which to work for the definition of main neighborhood services. For the disposal of waste water, a phytodepuration system will be used whose minimum areas to be guaranteed refer to the number of inhabitants of each module considered. For schematic convenience of representation of the individual modules, in the two settlement compositions the minimum corresponding phyto-purification surface will be shown, next to each module, to be envisaged at a minimum distance of 10 m [10].



Figure 11. Vision Agro-scenarios (Design: Zinghini 2019)

4. Conclusions

In conclusion, a review of some of the essential characteristics of the concept-idea, which in the integrated design phase are defined and designed to verify their feasibility, in their transfer from "demand for expected performance" to "typological, technological choices", skills that they must be transformed into attributes and characteristics for systems and components and in their compatibility with the industrialized processes of factory and construction site.

4.1. Integrated Design and Sustainability Assessment

Already from the concept phase towards integrated design, it was possible to translate the express needs for the qualification of the housing module with double environmental and seismic safety, into classes of corresponding requirements, through the analysis and development of technological systems, through work evaluation of elements and parameters to arrive at the definition of the type selected for the purpose of manufacturing the prototype / MVP. All the concepts examined were "multidimensional", like all evaluations sought through strategies used in their complexity. Each decision, on structure, materials, technologies, was the result of considerations translated into a design dedicated to the realization phase in the workshop and on the construction site.

"(...) the ability to define the objectives and requirements of a project, include the relevant aspects and assess the interactions between them, calls for different perceptions and ways of seeing the issues from everyone involved in the process. The challenge in controlling planning and design is to bring together the different points of view arising out of the different perceptions at the problem (...)" [11].

Through the "off-site" construction methods, the construction site becomes lighter, an experimental laboratory in which to tackle the assembly and assembly activities of the designed systems. The relationship between factory and site has direct repercussions on quality, comfort and safety. Likewise, the engineering process down to factory drawings approaches a concept of advanced industrialization, which has a lot to do with digital and manufacturing, for the control of technical solutions [12-14]. The five recognizable elements for off-site construction are also guiding trajectories for the S2_Home project: digital infrastructure, productivity, different production scales, environmental sustainability, quality and safety together. Last but not least, in terms of the industrialized production chain, the reliability of the products, the traceability of the components, the programmable maintenance, as well as the containment of energy costs. They become very important targets for controlling the life cycle of the housing module such as its economic sustainability over time.



Figure 12. Vision Agro-scenarios (Design: Zinghini 2019)

4.2. Facilitated Building Site

With reference to the construction site, the design had to reconnect the requirements for transportability, with the definition of the casing systems, joints, structures and systems dimensioned on the 85 square meter module on one level. On the need to think these systems as aggregated in the workshop, to be transported and assembled on site. The modularity of systems has pursued a medium level of unification, because the implementation of the solutions, for example on the functioning of the hybrid energy-environmental model, have however required a diversification between the fronts and therefore a consequent diversification of the systems of the shell structure and the relationship between opaque and transparent surface, as well as for the type of fixtures. Despite this necessary expression of quality, it can be said that the control of the integrated system design and the off-site in the workshop make operational assembly easier on site.

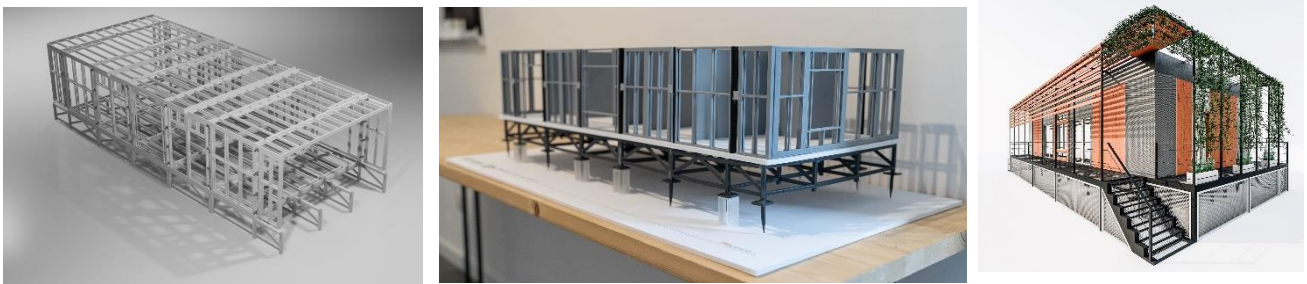


Figure 14. Digital design form manufacturing (Design: PMopenlab 2019)

Also the research project Home S2, starts an interesting field of experimentation on the themes of the relationship between process innovation concerning the circular economy and project innovation, through enabling technologies, for the definition of functioning models based on smart technology grid. In this theoretical and application scenario, the Home S2 module certainly takes on a value that exceeds the size of the product and expresses all its innovative features as an agile and active resilience device for the settlement scenarios to which it provides its service, “ (...) advanced design is a double-bind environment, characterized by contrasting aspect, like two faces of the same coin, which show different ways of tackling the project. In this double connotation, there is a shared root: an Advanced Design which is synonymous with innovation” [15].

5. Acknowledgements

Project- research credits

CLIENT

Antonino De Masi

TECHNICAL_SCIENTIFIC TEAM

Sustainability and Innovation Design /Process

Prof.ssa Arch. Consuelo Nava (Team Manager)

Arch. Giuseppe Mangano (Assistant)

Hybrid Model (Envelope, Energy Systems)

Arch. Raffaele Astorino

Structural Model

Ing. Francesco Astorino

Additive Manufacturing, Pre-prototyping, Modelling e Sensing - PMopenlab

Arch. Andrea Procopio, Arch. Francesca Autelitano,

Arch. Antonio Popone, Veronica Bruzzaniti, Rocco Zinghini

Architecture and Landscape (I fase) - Università di Trento

Prof. Arch. Mosè Ricci, Ing. Arch. Gaia Sgaramella

Engineering Design (II fase)

dArTe – Università Mediterranea degli Studi di Reggio Calabria

Prof. Arch. Alberto De Capua, Prof.ssa Arch. Francesca Giglio,

con Arch.tti Valentina Palco e Alessia Leuzzo

Integrated Communication - PMopenlab srls

Arch.tti Danilo Emo e Alessia R. Palermi con Arch. Giusy Arena

Consultants

Angelo Marra, ENEA Trisaia (I fase).

6. Conflicts of Interest

The authors declare no conflict of interest.

7. References

- [1] Ove Arup. "Teams for Total Design", in Chipperfield. David, Long K., Bose S. "Common Ground", Marsilio edizioni, Venezia, (2012):129-131.
- [2] Verganti, Roberto. Design-Driven Innovation–Cambiare le regole della competizione innovando radicalmente il significato dei prodotti e dei servizi. Etas, Milano, (2009).
- [3] Nava. Consuelo, "Edifici Sostenibili", DEI edizioni, Roma, (2012).
- [4] Campioli. Andrea, "Le culture del progetto", in Nardi G., (a cura), "Aspettando il progetto", F. Angeli ed., Milano, (1997).
- [5] Leurs. Bas, Duggan. Kelly, 2018, "Proof of concept, prototype, pilot, MVP what's in a name". Available online: <https://www.nesta.org.uk/blog/proof-of-concept-prototype-pilot-mvp-whats-in-a-name/> (Accessed on 15 July 2020).
- [6] Nava. Consuelo, "Design Driven Innovation "off-shore" e "off-site" in SID Series, Aracne edizioni, Roma, (2019).
- [7] Nava. Consuelo, "S2_Home – concept della sostenibilità integrate "off-shore" e "off-site", "Design Driven Innovation "off-shore" e "off-site" in SID Series, Aracne edizioni, Roma, (2019).
- [8] Astorino. Francesco, Procopio A. "Il Disegno esecutivo delle strutture, dei sistemi di assemblaggio e automazione, parte V, "Design Driven Innovation "off-shore" e "off-site" in SID Series, Aracne edizioni, Roma (2019): 124-129.
- [9] Nava. Consuelo, Astorino R., Procopio A., "Realizzazione in fabbrica del pannello e del modulo abitativo", part II, "Design Driven Innovation "off-shore" e "off-site" in SID Series, Aracne edizioni, Roma (2019): 53-57.
- [10] Nava. Consuelo, Sgaramella G., 2017, "Definizione degli scenari aggregative e prestazioni ambientali e di paesaggio", parte III. "Design Driven Innovation "off-shore" e "off-site" in SID Series, (2019): 84-89, Aracne edizioni, Roma.
- [11] Drexler. Hans, El Khouli. Sebastian, "Holistic Housing – Concepts, Design Strategies and Processes", Detail ed., Munich, (2012).
- [12] Nava. Consuelo, "Ipersostenibilità e Tecnologie abilitanti. Teoria, Metodo e Progetto". Applicazione V, Aracne ed., Roma, (2019): 625-640.
- [13] Onyelowe, Kennedy C, George Alaneme, Duc Bui Van, Manh Nguyen Van, Charles Ezugwu, Talal Amhadi, Felix Sosa, Francis Orji, and Benjamin Ugorji. "Generalized Review on EVD and Constraints Simplex Method of Materials Properties Optimization for Civil Engineering." Civil Engineering Journal 5, no. 3 (March 19, 2019): 729. doi:10.28991/cej-2019-03091283.
- [14] Khorramshahi, Mohammad Reza, and Ali Mokhtari. "Automatic Construction by Contour Crafting Technology." Emerging Science Journal 1, no. 1 (July 8, 2017): 28. doi:10.28991/esj-2017-01113.
- [15] Celi. M., "Advanced Design Cultures. Long-Term Perspective and Continuous Innovation", Springer, SW, (2010).