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Sustainable Built Environment Conference

May 16th - 17th 2019, Scilla

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SBE19 SCILLA

Sustainable Built Environment Conference

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ITACA

MedCités MedCities

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

CESBA Common European Sustainable Building Assessment

Interreg Mediterranean CESBA MED

Supporters

UN environment United Nations Environment Programme

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Global Alliance for Buildings and Construction

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Policies and programs

Sustainable neighborhoods and cities

Assessment methods and tools - Building scale

FOREWORD

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Andrea Moro
President of iiSBEE Italia

Policies play a key role in starting and promoting the movement towards a more sustainable built environment. Public authorities at all government levels are developing and implementing policy instruments to improve the performance of existing and new buildings and urban areas. Sustainability requirements are adopted in green public procurement, building codes, funding programs, subsidies and incentives, urban plans, authorization processes. Public buildings are assuming the role of frontrunner projects to show the feasibility of sustainable building in practice. But policies alone aren't enough. To reach the target, a synergy among all the actors of the building sector is necessary. A public – private partnership is needed. Professionals, workers and construction companies must improve their skills and knowledge. Research organisations must provide new cost-effective materials and solutions. Users must change behaviour in using buildings.
At transnational level, Sustainability Development Goals (SDGs) were set in the United Nations Agenda 2030. The European Union issued common directives, communications and programs concerning SDGs, circular economy, energy efficiency, etc. Following the principle of "Think globally, Act locally", a harmonization among actions implemented at local level is necessary to meet the global common targets. Objectives need to be aligned, common methodologies and indicators must be set up for facilitating the exchange of best practices and to measure the overall progress and results achieved. The outputs of research projects must be effectively exploited and capitalised in practice.
In this context, sustainability assessment and rating systems are recognized to be a useful tool to promote the movement of the building sector towards a better sustainability. Their adoption in policies allows public authorities to fix objective, measurable and reliable performance targets. In the same time, sustainability certifications systems allow to recognize and valorise high performance buildings in the market. Also in this case, a harmonization among the assessment systems is necessary to allow the comparison of assessment results at transnational level.
The SBE19 Scilla conference addressed all the above-mentioned topics, focusing on policies, programs and action plans targeted to improve the sustainability of the built environment. Particular attention was given to the integration of assessment systems in policies and decision-making processes in relation to all spatial levels: buildings, urban areas, cities and territories. Strategies for the harmonization of public assessment systems at building, urban and territorial levels were also discussed. Several thematic sessions were organised with relevant organisations. UN Environment/MAP and MEDCities organised a session concerning planning and management of sustainable cities in the Mediterranean. The Government of Catalonia managed a session on architecture, energy efficiency and housing in the framework of the 2030 agenda. In collaboration with the DG Environment of the European Commission, a session focused on the Level(s) system for the harmonization of assessment systems used by public authorities was organised involving scheme operators from different countries. A session devoted to the European research was organised with the MEDNICE project that manages the Efficient Building Community of the Interreg MED Programme. Always in the field of research, the project CESBA MED: Sustainable Cities showed the first international assessment system for measuring the sustainability of neighbourhoods developed in collaboration with 9 European cities. The Euro-Mediterranean Center on Climate Change (CMCC) organised a session devoted to policies and strategies for Climate Change adaptation in the Mediterranean. The Energy Cities network organised a session to discuss the opportunities for energy efficiency of public buildings in Italy in relation to the new European Directive. Beside the Thematic sessions, 9 paper sessions took place dealing with building design and operation, decision making and assessment tools at building and urban scale, education and training, policies and programs, sustainable neighborhoods and cities. Representatives from 17 countries and 4 continents participated, sharing experiences and creating the conditions for future collaborations and projects.

BUILDING DESIGN AND OPERATION

A new interpretation of local materials: innovations, technologies, researches

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Abstract
The concept of material and sustainability are constantly evolving areas; they have become the key factors of different sectors, disciplines and researches. In particular, the construction sector, it is always stronger the need to interrelate skills and identify new scientific methods of research approach, in order to face the complexity and often the contradiction between the theme "materials and consumption of resources" and "sustainability". For this purpose, the present paper deal with theoretical reflections derived from the research group, following the preparation of ITACA Protocol. In specific, attention was focused on the study of bio-materials criteria regarding residential field, with attention on local materials manufactured in Calabria. Moreover, the paper highlights the critical nature and evolution of the concept of local material and innovative technologies in the choice of constructive techniques to be use in building sector. These aspects are analyzed through researches carried out on case studies.

1. Introduction

The paper deal with the researches campaign carried out by the authors on the occasion of the PARCO project (Project Housing Policies for Sustainable Construction) aimed consider new design patterns for the construction of housing to zero energy, eco-cities and certified buildings; a new design model for sustainable construction for the economic benefit, social and environmental, with sustainable innovations such as eco- cities and eco-homes. This project involved two Calabrian universities (Mediterranea University of Reggio Calabria and University of Calabria) together with the Calabria Region; in a process of regulation of aspects related to environmental sustainability in the construction sector. Specifically, the results of the research project led to the preparation of the residential ITACA Procotol for the Calabria Region, missing until a few years ago.
"ITACA Protocol" of the Calabria Region is an integral part of the Regional Law n.41/2011 (and s.m.i.), "Norms for Sustainable Living", and it is adopted in order to obtain the "Certificate in Environmental Sustainability ". In particular, the authors worked on the study and analysis of the "Eco-friendly materials" criteria within Area B - Resource Consumption. This study has led to critical considerations regarding the specificity of the Calabrese territory and its peculiarity in terms of productive activities, natural resources available, local microeconomics to be safeguarded and even optimized, in a logic of circular economy for the regional and national territory. For these purpose, firstly, the paper deals with a general framework on the problems related to the consumption of materials and reuse of resources in the construction sector, after that some critical considerations on the new ways were defined and finally "local" materials and on developments were outlined, highlighting future research prospects, through the description of experimental research experiences conducted during the years.

2. Material consumption and resource reuse for building sector

The European economy is highly dependent on natural resources. The main drivers of consumption in Europe are economic growth, technological developments and changing consumption and production. The availability of any material on the market can be translated into the "Hubbert curve concept", developed thinking of oil, but actually applicable to anything. First, the annual production of the raw material of the day grows luxuriantly, then, once a maximum has been reached, it inexorably begins to decline (Schultze 2013). The problem of the question of resources is, however, a topic characterized not only by the observation that the production cycles and constructives consume raw materials and energy, but also from the production of waste from these processes. About a third of the resources used are transformed into waste and emissions. The continuous production of waste is irreversibly reducing the capacity to bear the environment, the carrying capacity of the planet Earth. Having as a social, economic, productive goal, to live respecting the limits of nature, has created the conditions for a new resource policy, which could encourage the transition from a society that uses non-renewable resources to one that uses renewable resources through the rethinking the way to manage the global resources heritage. The largest waste streams in Europe originate from construction and demolition activities, together with manufacturing activities. Most municipal waste in the European Union continues to be destined for landfill (45%). However, more and more municipal waste is now subjected to recycling or composting (37%) or to incineration with energy recovery (18%)i. Following the Europe 2020 flagship initiative on resource efficiency, which promotes the development of a strategy to set medium and long-term efficiency targets and the means to achieve them, in 2011 it was launched the roadmap towards an efficient Europe, which proposes ways to increase productivity and disaggregate economic growth from the use of resources and its impact on the environment. The roadmap and the circular economy package should change this trend, turning the EU economy into a sustainable economy by 2050. To overcome this challenge, the European

Union has introduced a series of policies and initiatives aimed at ensuring sustainable consumption and growth. These policies should improve the overall environmental performance of products throughout their entire life cycle, stimulate demand for better products and production technologies and help consumers make informed choices. The "2030 climate package", with the new objectives 40-27-27 (percentages of CO2 reduction, energy efficiency and use of energy from renewable sources) that replace the previous 20-20-20 to 2020 is an example of this. These are concepts that totally involve the ever-growing sector of materials. A sector that is suffering, albeit slowly, from the need to operate with the aim of reducing costs - consumption - energy through a broader and deeper reflection of the implications that production processes have on man and the environment. The study of the culture of materials is, indeed, today more than ever, a sector in full evolution, in which the need to "innovate" the sector by introducing new technologies and materials with advanced performances, with the need to reduce consumption of non-renewable natural resources and with attention to the environmental context. The progressive innovation that involves, alongside traditional materials, new technologies and materials with advanced performance, results in emerging technologies (Ket- Key Enabling Technologies) that invest, among the six main trajectories, the field of advanced materials. Defined as such because they are able to change the traditional concepts of both material and use of the same and by identifying themselves with recycled, photocatalytic materials, with a change in density depending on the temperature to be reached, etc. their ability to improve project performance by reducing the consumption of resources and energy and very often reproducing nano structuring levels proposed by nature in the effect of chlorophyll photosynthesis, the lotus effect, and other adaptive functional behaviors.
The need for sustainability manifests itself in the need to modify production processes to provide materials that consume less resources and produce less waste, with a view to protecting the environment, but it also manifests itself through the need to modify construction processes, using materials, techniques , technologies that make sustainability a performance of the building organism to achieve high conditions of well-being.
The technological implications in the design of the new energy envelope performances are manifested in all aspects of the process:
- design: through the satisfaction of new requirements such as substitutability, recoverability, disassembly, the separability of the components;
- production: through the use of certified products with low environmental impact, with a recycled content, with the ability to increase thermal inertia and reduce the transmittance of the envelope;
- constructive: through the use of prefabricated, light construction systems, which favor the speed of installation through dry connections, lightness of components, modularity, ease of reuse / recycling of components.

A constant search for innovation exists more and more in architecture. therefore, a "silent" revolution is underway in which attention to the context, control of environmental qualities, technical experimentation, formal research, become paradigms of a new constructive era.
Technological innovation has greatly expanded the possibilities offered to architects, giving rise to new expressive and functional solutions that result in the methodologies of Eco-design, Design for sustainability - D4S or Life Cycle Design, which integrate environmental sustainability considerations with the principles aesthetic-functional typical of Design. These can mitigate the impact of production and contribute to
improving the overall environmental performance of products during their life cycle, increasing the demand for more advanced production technologies.

3. A new concept of local material and innovation technologies bio-materials criteria for residential field with ITACA Protocol experience

In their broadest expression, "materials" are always connected to change: of an era, of a technology, of a process, of a language. As "means" for the language of functions, the materials tell what is immediately perceptible in an artifact but also what has undergone major changes of course over time, by virtue of the advancement of technological innovation and socio-cultural changes. From the material, to the material, to the product, the transformative evolution of any material always starts from a percentage, more or less large, of natural resource. This is the cardinal principle around which even the construction sector has been involved for almost 40 years in a process of rethinking, changing, identity crisis. The industrial revolution has determined a net gap in the distortion of the relationship between natural resources and construction. The use of few materials, by virtue of their availability, connected to the environmental and climatic knowledge of the places, led to the construction, sometimes even spontaneous, of building typologies realized with the surrounding environment, advocate of lighting, cooling and natural heating, outlining architectural scenarios recognizable by materials, form and function. The post-industrial revolution period has never ended, continuing to feed on itself through the most negative concept of the term impact, leaving behind a particularly energy-intensive building heritage, made with materials whose characteristics are not always known and inattentive to the place where it's built. A premise this, which has no will to be nostalgic for an "Architecture without architects" (B. Rudofsky 1987, J. May, A. Reid 2010), but a duty to understand the motivations, needs and objectives of a new cultural orientation. The awareness of the culture of the limit on the one hand and the material culture of the project on the other is a dichotomy that involves all the actors and the phases of the construction process and in this scenario, the presence of guiding tools that can accompany the change is a first significant step, among many others to accomplish.
In this sense, the Eco-friendly materials area, within the wider category Consumption of resources, was structured in the ITACA

Protocol of the Calabria Region, in collaboration with the two universities, through choices that could be representative of a regional situation not particularly characterized by industrial realities and even less by significant productive activities in this sense. The main objectives concern primarily the re-use of existing real estate assets, to be enhanced in terms of material, cultural and social resources. With respect to the material choices we want to orientate towards the use of materials from renewable sources, recovered and/or recycled materials with appropriate environmental labeling (type I, II, III environmental declarations), materials that derive from local or assembled production chains in the local area, also encouraging processes of economic and social sustainability, as well as circular economy. A vision of the project that looks at the relationship between time and construction in a different way, proposing dry layered technologies, which favor the disassembly and disassembly of individual components, in order to favor their reusability/recoverability/recyclability, in other production cycles. The crucial point, however, which has led to various critical considerations and comparisons, concerns local materials. Those materials / components, produced or assembled within a radius of 300 km from the site of intervention, were considered "locally produced" in order to facilitate the economic system of the micro-SMEs and Calabrian SMEs and encourage the use of local resources, contributing also to reduce emissions caused by journeys in terms of kilometers traveled longer.
Encouraging the use of local materials, both for the building envelope and for the structural components, is a theme that introduces multiple aspects, not always easily conjugated relating to the need to reduce the consumption of resources on the one hand and to the needs of encouraging reality local territorial production on the other, to which is associated the need to reaffirm a renewed recognizability of places through material aspects that strongly characterize the places themselves. The general objective was to facilitate compatible choices, in terms of use of materials, with all the constructive and technological strategies adopted, both with respect to the structure of the building and its envelope, in line with the principles of "sustainable" choices with respect to a circular economy, linked to the surrounding area, the specificity of the places and the reduction of the environmental impact due to transport. The choice of local products and materials cannot be separated from an overall assessment of the congruence and compatibility between the various criteria and, therefore, between the aspects linked to environmental, economic and performance factors. The choice of a criterion, therefore, is strongly connected to the choice of other criteria, with the final objective of proposing functional technical solutions to the overall behavior of the building, in relation to the type of activity performed and, consequently, to the constructive strategies designed depending on the orientation of the building and its overall energy behavior.

4. Developments and future perspectives for experimental research

The new construction fields for the design phases, with particular reference to materials, cover two very different but both relevant areas. On the one hand, research is advancing in the field of biomimicry, that is, in the study of biological and biomechanical processes of nature, reproposed in particularly performing materials and components, which adapt to climate change and improve the reactivity of the casings. On the other hand, the research investigates the experimentation of new materials with a natural matrix through the exploitation of plant biomass, new raw materials based on renewable sources. The study of natural fibers as reinforcing fibers for biocomposite materials guarantees a lower environmental impact compared to composites based on synthetic fibers, thanks both to reinforcing fibers (of vegetable and / or mineral origin) and to the matrix.
Fabric-reinforced cementitious matrix (FRCM) composites have emerged as a new material for repairing and strengthening of masonry elements. From an environmental point of view, the use of natural fabrics to produce FRCM composites could significantly help solving several problems of sustainability in the construction industry. For this reason, researchers have directed their attention toward the study of new materials based on natural fibers and renewable resources.
Old masonry structures, exhibit excellent compression strength. However, their response to tensile or out-of- plane loads is very limited, or even could be neglected. To improve the mechanical behaviour of these structures, strengthening techniques such as externally bonded fibre-reinforced polymer (FRP) composites, steel plates and reinforced concrete (RC) have been very popular among designers and engineers, but some drawbacks appear when the structures are subjected to special environmental conditions. By using a composite produced with a cementitious matrix, the compatibility with masonry substrates is improved. Furthermore, the performance of the strengthening system is not affected when the structures are subjected to severe conditions of temperature and humidity. Several studies have been conducted by the authors, to demonstrate the efficacy of FRCM composites to strength concrete and masonry structures, in which fabrics of traditional or synthetic fibres such as glass, carbon, polyparaphenylene benzobisoxazole (PBO) and aramid have been used.
During different experimental campaign the authors have examined various natural materials, in specific flax, hemp, jute, sisal and coir. All of these materials have been analysed carrying out experimental tests. Firstly, tensile tests on single yarns and non-impregnated fabrics. Each single yarn was measured and weighed in order to compute the linear density (Tex) and tenacity (N/tex) of the different materials. Analysing the first results on the single yarns, it was possible to observe that flax and hemp are the materials that present higher values in terms of tensile strength, followed by sisal, jute and coir (figure 1). Moreover, it was observed that the tensile strength of the fiber is inversely proportional to the linear density, in fact the coir fibers with a linear density equal to 2887 Tex is characterized by a tensile strength of 52 MPa, on the contrary to 198 MPa of flax fibers (figure 1). The failure modes of the yarns observed were non homogeneous; this is due to the fact that the specimens are characterized by non-uniform diameters and above all they are natural materials. Consequently, in order to obtain 5 good results, with a failure mode

in the middle of the specimens, a number between 10-15 specimens, for each type of material, were tested.

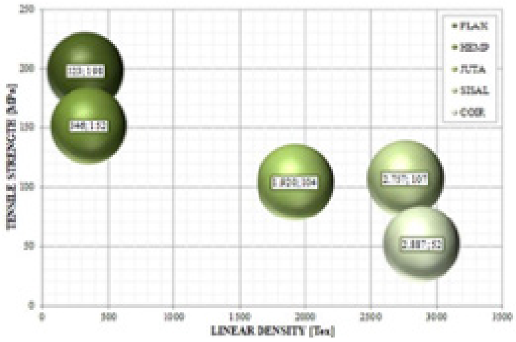


Figure 1 Linear density -Tensile strength diagram of single yarns of natural materials

From the results obtained by the tensile tests on non-impregnated fabrics, it was possible to observe that flax is the material with higher mechanical properties, followed by jute and sisal. In this part of the experimental
program, a total of seven bi-directional woven fabrics have been analyzed, two of these were "mixed fabrics" with the presence of different type of materials in warp or weft direction. Non-impregnated fabrics were studied both in warp and weft direction, in order to research the most resistant direction of the fabrics (figure 2).

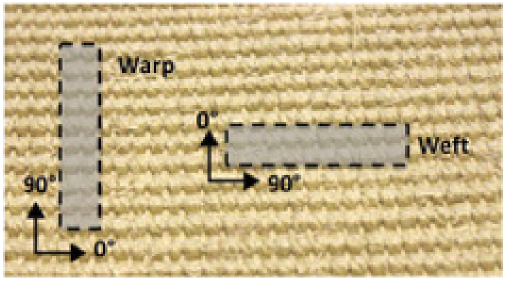


Figure 2 Preparation of the specimens: cutting direction of non-impregnated fabrics

The results have showed that the stronger direction of the fabrics is the warp (90°) for all types of materials (table 1).

<table>
<tr><th></th><th></th><th>JUTE[1]</th><th>JUTE[2]</th><th>JUTE[3]</th><th>SISAL[1]</th><th>SISAL[2]</th><th>HEMP</th><th>FLAX</th></tr>
<tr><td>ε_{peak}</td><td>warp</td><td>4,8% (9%)</td><td>8,6% (1%)</td><td>6% (7%)</td><td>4,4% (3%)</td><td>4% (7%)</td><td rowspan="2">7,5% (2%)</td><td rowspan="2">4% (4%)</td></tr>
<tr><td>[%]</td><td>weft</td><td>3,3% (4%)</td><td>6,2% (3%)</td><td>1,7% (5%)</td><td>7,2% (4%)</td><td>54% (2%)</td></tr>
<tr><td>f_t</td><td>warp</td><td>32,91 (14%)</td><td>31,41 (5%)</td><td>55,20 (17%)</td><td>17,73 (11%)</td><td>9,94 (6%)</td><td rowspan="2">46,68 (8%)</td><td rowspan="2">68,81 (7%)</td></tr>
<tr><td>[MPa]</td><td>weft</td><td>22,83 (19%)</td><td>34,5 (6%)</td><td>30,68 (29%)</td><td>7,43 (9%)</td><td>15,34 (18%)</td></tr>
<tr><td>E</td><td>warp</td><td>691,49 (11%)</td><td>364,74 (5%)</td><td>863,33 (15%)</td><td>402 (9%)</td><td>239,23 (10%)</td><td rowspan="2">618,65 (7%)</td><td rowspan="2">1746,91 (10%)</td></tr>
<tr><td>[MPa]</td><td>weft</td><td>699,48 (21%)</td><td>554,29 (6%)</td><td>178,87 (30%)</td><td>103,6 (7%)</td><td>28,25 (18%)</td></tr>
</table>

In addition to the experimental tests carried out in order to analyze the mechanical and physical properties of natural fibers such as reinforcement fibers for FRCM composite materials, the authors have produced different types of FRCM in the laboratory. Three manufacturing methods were used to produce NFRP (based-epoxy resin matrix and based-polyester resin matrix) or NFRG (based-grout matrix): manual lay-up, vacuum infusion process and traditional technique with the use of steel formworks. The vacuum infusion process is the best manufacturing method for composites materials, especially because it is possible to achieve a uniform thickness of the composite and a uniform distribution of the matrix into the fibers. The manual lay-up is, most probably, the easier and faster method, but it is more difficult to obtain a uniform configuration of the composite. Regarding, instead, the composite materials mortar-based matrix, the use of the steel formworks represents the manufacturing method mostly used in civil engineering field. From the results achieved from tensile tests on the three typologies of composites produced, it is clear that (figure 3): impregnated fabrics with epoxy resin (NFRP) increase considerably the mechanical properties of composite systems based on natural fibers, presenting a tensile strength greater than the polyester resin, so consequently it can be stated that the epoxy resin is most suitable as a matrix of natural fiber composite materials. Concerning the fabrics with the mortar-based matrix (NFRG) further studies are still needed, especially regarding the thickness of the mortar that has to be applied to the specimen and the quantities of the water to consider in the composition of the mortar. However, during the tests it was possible to observe a good bond between natural materials and the different types of matrixes.

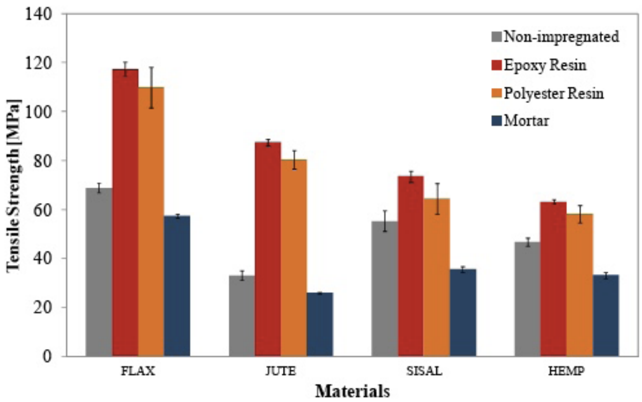
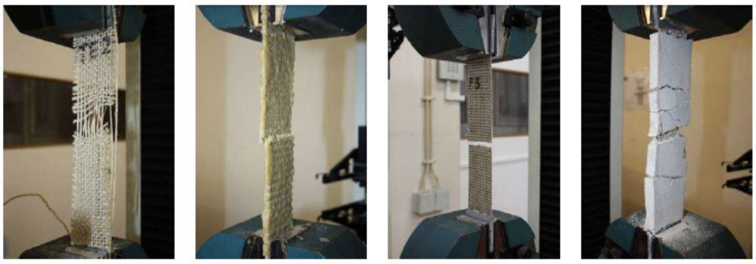


Figure 3 Tensile strength - Materials diagram

In addition, it is possible to say that natural fiber-based composite materials have a wide variety of mechanical properties. This is a consequence of the fact that the properties of natural materials are influenced by several variables, as the type of fiber, the diameter of the fibers, the environmental conditions and possible methods of fiber treatment. This is also confirmed by the variety of the results obtained and shown in this work, especially in the case of tensile tests (figure 3). However, the first data obtained, confirms the significant development that the natural materials are acquiring in function of their biodegradability, low cost, low relative density, adequate specific resistance and renewable nature.

To sum up, figure 6 highlights all the results achieved from the tensile tests carried out on the fabrics and composites cut in the warp direction. Initially all seven fabrics are tested in their non-impregnated configuration and with epoxy resin-based matrix, both in warp and weft direction. Afterwards, analyzing the results obtained and having prepared a list depending on the more resistant material, in terms of maximum load capacity and tensile strength, the composites based on the mortar and polyester resin were only produced with the four strongest materials. That is why in the figure sisal and jute fabrics were not considered in the second part of the experimental plan.



a) b) c) d)

Figure 4 Failure mode: Non-impregnated fabrics (a); NFRPepoxy (b); NFRPpolyester (c); NFRG (d).

Finally, for the different strengthening systems used, it's of primary importance to discuss of failure modes of the specimens.

In the case of non-impregnated specimens there is a reduction of area of the individual yarns that make-up the fabric (figure 4.a), while in the impregnated specimens with the polymer matrix, epoxy (figure 4.b) and polyester (figure 4.c), it's possible to notice an instantaneous and uniform break of the specimen. Finally, in the case of cement-based composite, the failure mode occurs slowly marked by the rupture of mortar at the beginning and follow the break/stretching of single yarns that make-up the fabric (figure 4.7d). During the tests it was possible to observe a good bond between natural materials and the different types of matrixes.

5. Conclusions

The concept of local material that is difficult to define absolutely, is being modified and evolved thanks to experimental research. If until a few decades ago, local materials were closely connected to the consumption of material resources of a specific place, currently these two concepts can also be parallel, without being in conflict with each other, in relation to consumption and the resulting impacts. An aspect that, of course, varies with respect to the specificity of contexts, places, construction techniques and local economies. The study of the criteria to be adopted for the Calabrese territory, with respect to the choice of materials within the ITACA Protocol, in parallel with experimental studies on fiber-reinforced composite materials with vegetable fibers, an index to broaden the future perspective on the potential of the Calabrian territory. The potential is to become the place of production chains of natural fibers of which it has a centennial history and which could configure new local economies. Natural fibers represent, together with other natural renewable materials, the extension of the concept of local material for a specific context and, at the same time, a response to the environmental problems connected to the consumption of soil and resources. Therefore, a dynamic concept of "local" materials, which looks to a future change in production, construction and implementation methods through the advancement of research on natural materials and from renewable sources.

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[i] The "Hubbert curve" applied to world production indicates that the peak was reached in 2000 and is already at the height of the descending curve.
[i] A central conception of the analysis of the Worldwatch Institute, the most authoritative point of observation on the environmental trends of the planet is found in the ecological concept of Carrying Capacity that is the number of individuals of a population that resources of a habitat are able to sustain.
[i] EEA European Environment Agency, 2016

Building energy and environmental performance of high-rise residential buildings with a newly developed cladding

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Keywords: energy, environmental performance, cladding, residential building, thermal characteristic

Abstract
There are demands of spatial plans for responding to the demographic change and more residents' needs for a variety of family types and residential types. In this aspect, housing-space flexibility and easy maintenance are required to high-rise residential buildings in South Korea. In order to respond to housing flexibility effectively and to secure easy repair of an old building, it is absolutely necessary to systemize building materials as flexible components and thereby to make them interactive. A cladding to provide spatial flexibility and improve the performance of external walls was developed. The purpose of this study was to analyze thermal performance of a newly developed cladding. Simulation tools were used to scrutinize energy and environmental performance of residential building with the cladding. In addition, this study assessed unsteady-state thermal characteristics, linear thermal transmittance, and effective thermal transmittance of the cladding. In the energy results, heating load of the residential building with the cladding was lower 2.6% than that of the existing building and the cooling load was 0.4% higher. Consequently, some measures for preventing from heat loss of joints were needed.

1. Introduction

According to statistical data in 2017, South Korea had 17.12 million housing units and 10.37 million (approximately 61%) of them were residential building units. Due to mass supply of residential complexes in a relatively short period of time, only a limited number of fixed and standardized planar designs have been used in South Korea. Because 95% of residential buildings have bearing wall system, residents are not allowed to change their residential space. In addition, it is not easy to maintain and repair facilities. Apartments built 30 years ago or less are being demolished for rebuilding due to degradation of facilities and external walls. Bearing wall systems rather than column-beam systems are often used to construct residential buildings due to their economic advantages, although column-beam systems are also considered for spatial flexibility. In recent years, South Korea has witnessed an increase in residential buildings built with column-beam system that enables long-term usage through a structure with spatial flexibility, easy maintenance, and easy repair.

For an effective design of flexible space and easy repair for future building improvement, it is essential to systemize building components and develop mutually compatible systems. It is possible to use buildings for a long term and in an efficient way by developing a cladding system as a complexed-external wall with easy repair ability and improved performance of envelopes. With this background, this study developed a cladding system that could be detached and attached as a novel alternative to provide spatial flexibility and improve the performance of external walls. The cladding was developed for external insulation to minimize thermal bridging effects and its module systems could provide easy constructability.

Cladding design and selection of its materials are important elements of the building envelope. Cladding is a non-structural material, a protective covering that is fixed on the outdoor surface of a building, and to protect against moisture and thermal variations while providing aesthetic purposes. The cladding of a building is a factor that has the greatest influence on the environment inside the building. The cladding separates the indoor environment that is air-conditioned by heating and cooling systems from the external environment that is not air-conditioned. It protects indoor space from weather condition and large fluctuations in temperature. The cladding of a building provides thermal comfort for occupants and conserves building energy at the same time.

Therefore, the purpose of the present study was to evaluate thermal performance of the cladding system developed in this study and to analyse and to compare the energy performance of the residential unit with the developed cladding system and conventional unit in South Korea. A simulation analysis was carried out to examine thermal characteristics of the cladding system. For analysis, the thermal-analysis program 'PHYSIBEL TRISCO' and the dynamic energy program 'EnergyPlus' were used.

2. Cladding systems in this study

Conventional envelopes of residential buildings are concrete walls and doors & windows. Almost external walls are not structural ones, but are constructed at the same time of concrete casting for easy construction, water penetration and air

leakage. The developed cladding system in this study is comprised of Floor Unit and Unit as shown in Figure 1. The Floor Units are installed in upper slab and lower slab, and Units are installed in each floor in the vertical direction. The cladding system can be assembled in the indoor side of each floor in tilt-in way, and can be attached and detached easily if necessary. The cladding system is produced in a factory and is assembled on site, and features attachability & detachability for easy construction. From the perspective of long-term usage, it has a standardized unit model form that makes it possible to respond to building deterioration for replacement, and to accept a variety of flexibility. To install, disassemble, and transport the cladding systems, indoor small equipment is taken into account as shown in Figure 2.
From the outside to the inside, the EWP consisted of a 30 mm of extruded cement panel, a 25 mm insulation board, and an aluminum frame for the exterior side, followed by 2 sheets of 85 mm glass wool, another 10 mm insulation board, and a 9.5 mm of a gypsum board for the interior side.

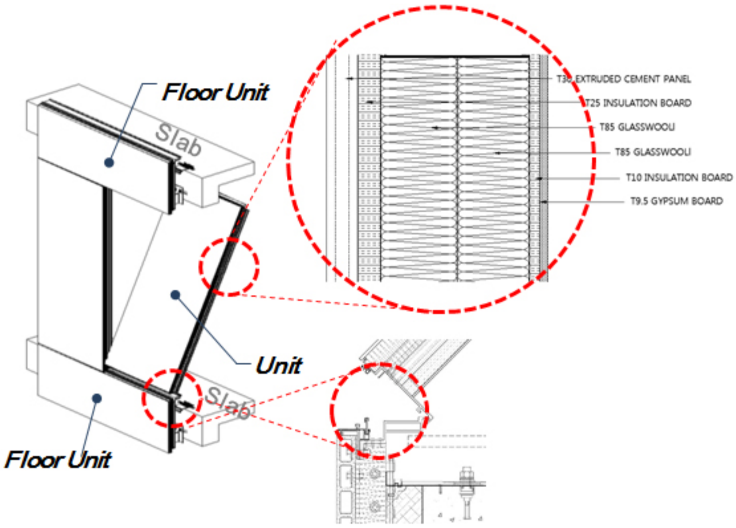


Figure 1 The developed cladding system in this study

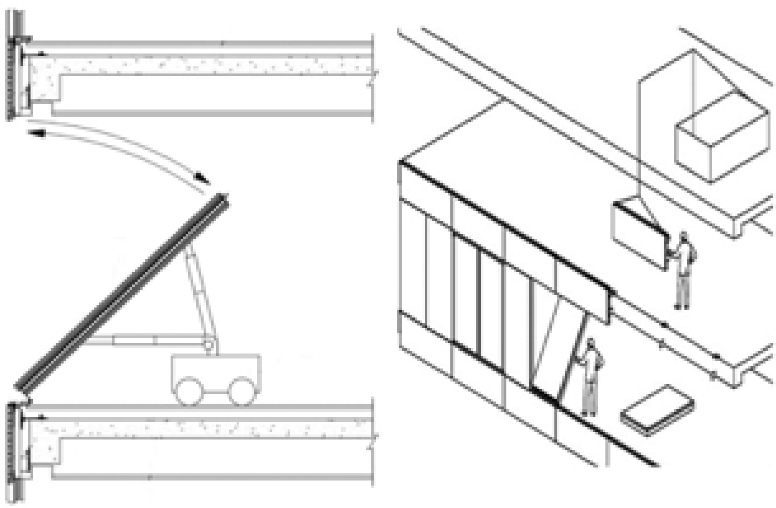
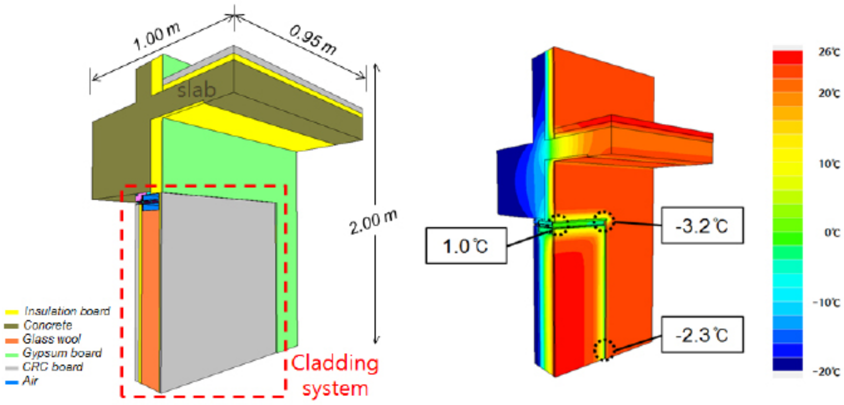


Figure 2 Image of installation

3. Thermal characteristic of the cladding system
3.1. Model and Method
3.1.1. Modelling
Figure 3 (a) shows a simulation model to evaluate thermal properties. It shows that the ceiling part is joined with the cladding and the insulated-concrete wall of an adjacent household. The insulated-concrete wall had 140 mm concrete, 110 mm insulation materials with a thermal conductivity of 0.03 W/mK, and 9.5 mm gypsum board.
Surface temperature of the interior side of the cladding was assessed through this analysis model. PHYSIBEL TRISCO program was used for steady state 3-dimensional heat transfer analysis.



(a) Model for simulation *(b) Surface temperature for thermal property*

Figure 3 Model and temperature distribution for thermal performance

3.1.2. Condition for simulation

Table 1 shows boundary conditions for simulation. Outdoor temperature and indoor temperature were set at -20°C and 25°C, respectively, in accordance with the Korean Design Standard for Preventing Condensation in residential buildings.

Table 1 Boundary Conditions

	Set-point Temperatures	Set-point Relative Humidity	Surface Heat Transfer Coefficient
Outdoor	-20℃	-	23.25 W/㎡K
Indoor	25℃	50%	9.09 W/㎡K

3.2 Results

Figure 3 (b) shows results of thermal performance analysis. The whole indoor surface temperature was estimated at a relatively high temperature of approximately 22°C due to the use of insulation materials on the interior side. However, the indoor surface temperature at connection parts of the cladding was relatively much lower. Because connection parts were installed with only three layers of weather strip silicone gaskets without any insulation, these joints showed the lowest indoor surface temperature of -3.2°C, -2.3°C, and 1.0°C, respectively. Because boundary conditions were set at an indoor temperature of 25°C, an indoor humidity of 50%, and a dew point temperature of 13.9°C, condensation was expected to occur during winter, indicating the need for improvement of insulation performance. According to the analysis model, heat loss of the cladding was measured at 68W. Its thermal transmission was estimated to be 0.72 W/m^{2}K by considering linear thermal transmission rates at connection parts.

4. Energy Performance

4.1. Model and Condition

One residential unit to which the cladding system would be applied was selected as the target subject to evaluate energy performance. The household is located in the center of the middle floors so that its front and back sides are exposed to the outdoor. It has 59m^2 in size, and three rooms, two bathrooms, one living room, and kitchen. Figure 4 shows the sketch-up modeling for energy analysis. Based on the design code of Korean residential building's condensation prevention (Ministry of Land, Infrastructure, and Transport Notification No. 2016-835, 2016.12), the temperature distribution of the parts to which the cladding system was applied was examined as shown in Figure 3 (b).

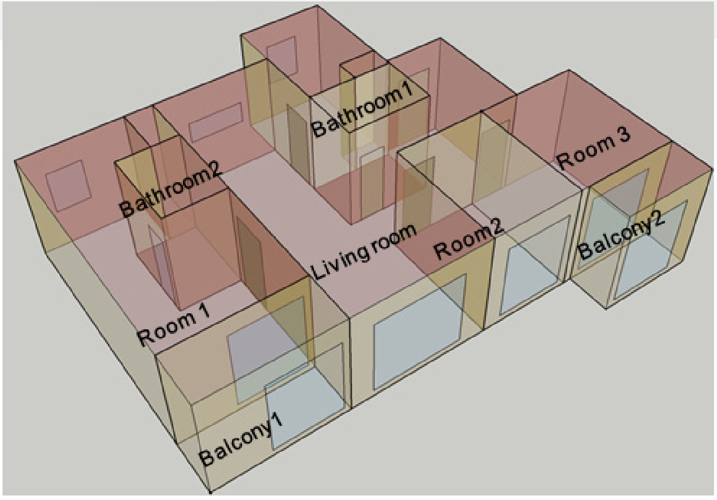


Figure 4 Model for analysing heating and cooling load

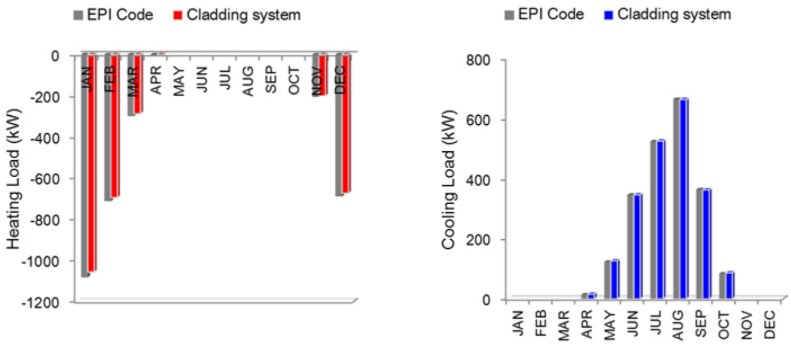
With the EnergyPlus developed by the US DOE(Department of Energy), heating and cooling load of the household was analyzed. The conventional wall to compare with has 200mm of concrete, 120mm of internal insulation, and 0.21W/m^{2}K of thermal transmittance according to Energy Performance Index Code(EPI Code, Ministry of Land, Infrastructure, and Transport Notification No. 2017-71). The window as double glazing sizes 22mm, and its thermal transmittance is 1.2W/m^{2}K. The features of the window are equal to those of the window in the household with the cladding system. However, the thermal transmittance between conventional wall and the cladding system was different.
For input data, infiltration rate was 0.2 air change per hour(ACH), ventilation rate was 0.5 ACH (Regulations of Building Facility Standards, Etc., 2013). For the input values of internal heat gains (people, lighting, and miscellaneous), ASHRAE code was referred to. Setpoint temperature for heating was 20°C and cooling temperature to 28°C. Roof and floor were supposed to have no heat transfer, and bathroom, balcony space, and shaft space were set as unconditioned space for analysis. Detailed input conditions are presented in Table 2.
For weather data, the Seoul weather data offered by EnergyPlus was used. In order to observe heating and cooling load, Ideal load of the program was executed.

Table 2 Condition of input data

Contents		EPI Code	Cladding System
Thermal Transmittance	Wall	0.21 W/㎡K	0.14 W/㎡K
	Window	1.2 W/㎡K (SHGC:0.4) (5+12Air+5low-e / 5+12Air+5)	
Infiltration		0.2 ACH	
Ventilation		0.5 ACH	
Internal Heat Gain	People	100 W/person	
	Lighting	10 W/㎡	
	Miscellaneous	2 W/㎡	
Setpoint Temperature		20℃ (heating) / 28℃ (cooling)	
Partition Wall		Concrete 200mm	
Weather Data		Seoul_ISO-TRY.epw	

4.2 Results

With household with the conventional internal insulation wall with thermal transmittance of EPI Code and the same unit with the developed cladding system for evaluation, monthly heating load and cooling load were analyzed as shown in Figure 5. Up to now, heating energy of residential building was researched mostly in Korea, but this study looked into monthly cooling and heating load. It is important to find energy saving factors by analyzing heating and cooling load of a household.
The annual heating load of the conventional system based unit was 2,993 kW, and that of the residential unit with the developed cladding system was 2,915 kW, about 2.6% lower heating load. On contrary, the annual cooling load of the conventional system based the unit was 2,120 kW and that of the unit with the developed cladding system was 2,130kW, about 0.4% or 10kW higher. The annual cooling load was more than 2,000kW which was more than 65% of the annual heating load. Therefore, it is important to analyze the cooling energy of residential units.
In the condition where the insulation thickness, the thermal transmittance, and internal heat gains were different, the cladding system had 2.6% lower heating load, and 0.4% cooling load higher. Due to heat loss of joints as thermal bridge, the difference of energy performance is little. Consequently, some measures for preventing from heat loss of joints were needed.



(a) Heating load *(b) Cooling load*

Figure 5 Monthly Heating and Cooling Load According to Two Cases

5. Conclusion

This research introduced the newly developed cladding system. To assess its application possibility to real residential building unit, this study carried out simulation to analyze thermal properties of the cladding. This study also evaluated the energy load of the household with cladding. Although heating and cooling load of two units were almost same, some measures for preventing from heat loss of cladding joints were needed.

6. Acknowledgement

This study was made possible by financial support from part of results a major research project conducted by the Korea Ministry of Land, Infrastructure and Transport, Residential Environment Research Project in 2019 (Project No.: 19RERP-B082173-06).

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Design of integrated sustainability "off-shore" and "off-site". Prototype-mvp "S2_Home" by Demasi mechanical industries

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Keywords: double safety; off-shore e off-site; integrated design; prototype/MVP

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.
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.
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".

1. Innovation and Development Process for a prototype/MVP
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.
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. 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 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 it's 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 contaneirs

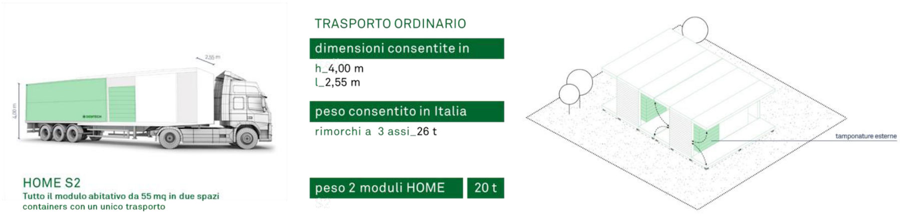

Figure 1 Ordinary transport on three-axis trailer and opening diagram of the modules. (design: A.Procopio, 2017)

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

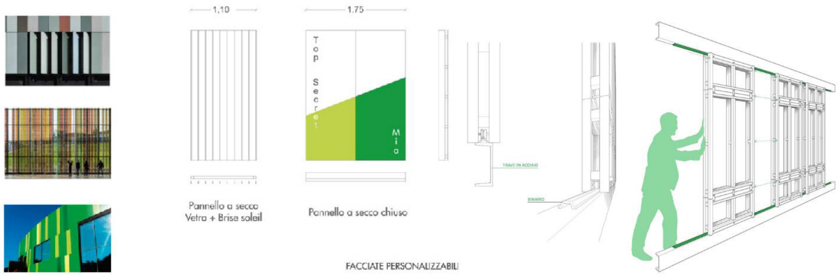

Figure 2 Envelop, structure and coating system (design:G.Sgaramella, A.Procopio,2017)

1.1 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; aseismatic 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

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*" (B.Leurs, K.Duggan,2018)

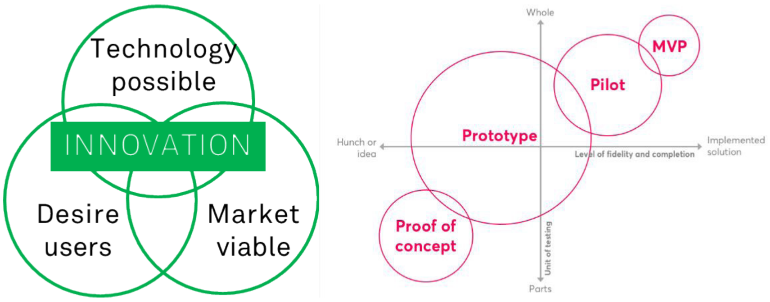

Figure 3 Relationship Process (C.Nava, 2017) - Highlighting the differences/product (Nesta, 2018)

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, durability.

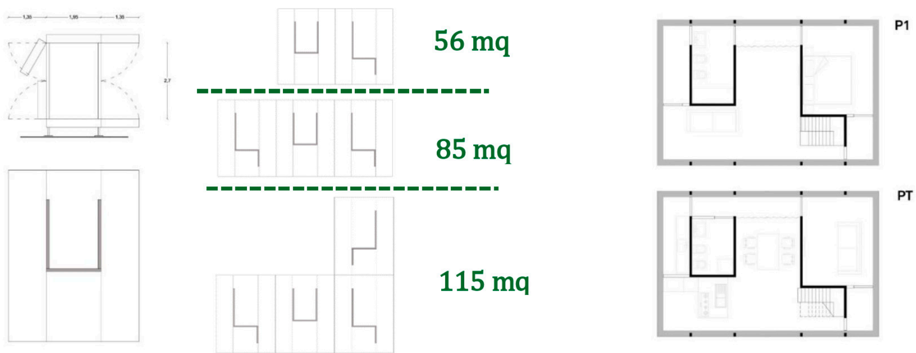

Figure 4 Modularity of different types and distribution on two floors (design: G.Sgaramella, 2017)

2. 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 a 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. Furthemore, 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.

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 metaprojective 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).

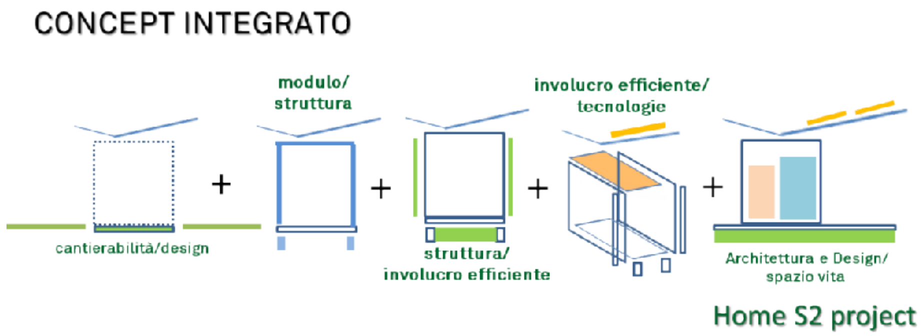

Figure 5 Integrated Concept (design: C.Nava, 2017)

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. (C.Nava, 2018).

2.1. 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 smq 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 sensoring: 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.

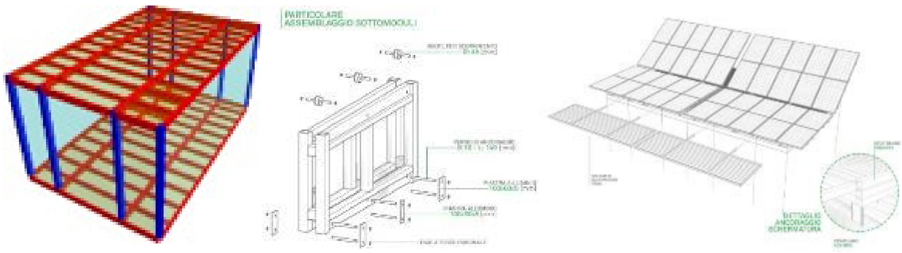

Figure 6 Built-in "off-site" assembly systems. (Design. F.Astorino, A.Procopio, R.Astorino)

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 non 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. (F.Astorino, 2017)

2.2 Level 1: Performance on the integrated requirements of safety, energy and material innovation

Through the level 1 design process, we define the targetsof 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).

Figure 7 Envelope System: 1. Indoor cladding (e.g. fir 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. (C. Nava, R. Astorino, A. 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 aluminum 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 aluminum), 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.. (C. Nava, R. Astorino, A. Procopio, 2017).

2.3 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, CO_2 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.

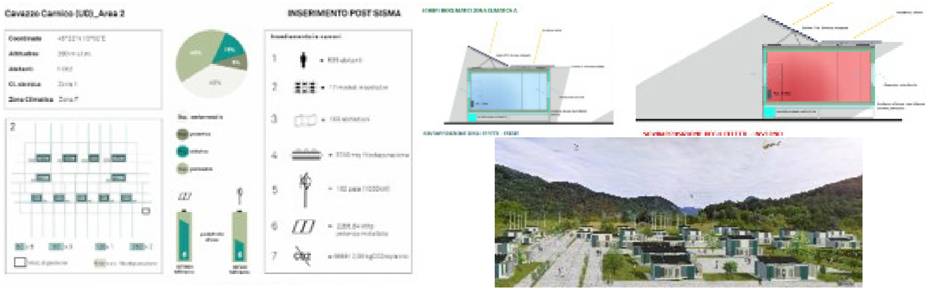

Figure 8 Smart grid system (design: G. Sgaramella, 2017) and hybrid housing model (R.Astorino, 2017)

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. (C.Nava, 2018).

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. (C.Nava, G.Sgaramella, 2017)

3. Conclusions

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.

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Video: https://www.youtube.com/watch?v=yvuMVMtprmM

Project- research credits

CLIENT

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Use of generalised additive models to assess energy efficiency savings in buildings using smart metering data

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keywords: building energy retrofit, energy efficiency measures evaluation, data driven approach, generalized additive models, gaussian mixture models.

Abstract
Buildings and construction together are estimated to account for 36% of global final energy use and 39% of energy-related carbon dioxide emissions globally [8]. Increasing energy efficiency in the building sector has become a priority worldwide and especially in the European Union, although it is clear that the energy efficiency potential that lies in buildings is far from being harnessed. Given the relatively low turn-over rate of the building stock, energy efficiency retrofit appears to be a fundamental step in reducing the energy consumption and CO2 emissions in existent buildings. In this study, a framework for the evaluation of the impact of energy retrofitting measures, with a statistical learning approach, is proposed. The research was developed to enhance the data analytics system at the core of European projects SHERPA and EDI-Net, with the main goal of facilitating energy consumption monitoring in buildings and allowing analysis and evaluation of applied energy efficiency measures (EEM). An innovative approach considering user behaviour in the evaluation of EEM impact is proposed, based on a combination of Gaussian Mixture Models and Generalized Additive Models (GAM). The method was tested in three pilot buildings in the framework of projects SHERPA and EDI-Net through the analysis of hourly smart meter consumption data and weather data. The results show the viability of this quick and cost-effective approach to evaluate the impact of applied EEM and open to further research to verify the method's scalability to a district, city or national level when applied in a big data environment.

1. Introduction

Poor energy performance of the building stock is one of the main challenges to reach the European energy efficiency targets and needs to be addressed by high quality energy renovation, maintenance and energy management [4,5]. Poor building performance is related to the building design and construction, the building materials, the mechanical and electrical systems and the control and operation of the buildings. In the case of commercial and public buildings, the application of energy efficiency measures (EEM) and retrofitting actions has a substantial impact, but no standardized method has been adopted yet, to evaluate this impact. A wide range of technologies is now available to improve the energy performance of existing buildings, but it is still a major challenge to identify the most effective retrofit measures, according to the building characteristic, as Ma et al. pointed out [10]. For this reason, this study proposes a data-driven approach that makes use of big data analytics to evaluate energy retrofit impact on tertiary buildings. The method stands in the framework of the International Performance Measurement and Verification Protocol (IPMVP) and makes use of smart meters and weather stations data.

The method presented in this study makes use of advanced statistical models, such as Generalized Additive Models (GAM), that are able to process hourly and sub-hourly consumption data and evaluate dependence on different exogenous variables, with the goal of assessing the impact of applied EEMs. The successful application of such a method opens several interesting possibilities, as it allows an easy and low-cost evaluation of EEM impact relying only on the continuous collection of energy consumption data from the utility smart meters, without the need of any simulation software or energy audits. Applied in a big data environment over large quantity of buildings, the analysis would allow to detect which measures have the highest impact and on which kind of buildings, extracting valuable conclusions for future application of EEMs. Furthermore, this analysis could be integrated with machine learning algorithms generating recommendations for the most suited EEMs to apply to each building.

2. Pilot buildings

For the purpose of this study, three pilot buildings from the projects SHERPA and EDI-Net were selected and analysed. These buildings were selected for having three years of historical hourly consumption data available and one or more EEM applied during a period long enough to evaluate their effect. Two of the buildings are located in Leicester (UK), while the third is located in Barcelona (ES). In each of these 3 buildings, one or more energy efficiency measures were applied during the last three years, statistical models have been applied in order to analyse the data collected from the smart meters and to evaluate effect and savings of the EEM. A short description of the different pilots and the measures applied follows.

2.1. Pilot 1: Highfields Library (UK)

This building is located in the city of Leicester (UK) and has the following characteristics:

- Building type: public library
- Total building area: 506 m^2
- Average annual electricity consumption: 40 702 KWh
- Average annual electricity consumption per square meter: 80.44 KWh / m^2

The model was run using electricity consumption data sampled every 30 minutes and starting 01-01-2016. Since 2016, only one EEM was applied, its details are described in Table 1

Table 1. EEMs applied in Highfields Library

Date	Source	Description	Investment (€)
27/04/2018	Lighting	Light bulb replacement	12083

2.2 Pilot 2: Mellor Primary School (UK)

This building is located in the city of Leicester (UK) and has the following characteristics:

- Building type: primary school
- Total building area: 4425 m^2
- Average annual electricity consumption: 287 920 KWh
- Average annual electricity consumption per square meter: 65.07 KWh / m^2

The model was run using electricity consumption data sampled every 30 minutes and starting 01-01-2016. Since 2016, only one EEM was applied, its details are described in Table 2.

Table 2. EEMs applied in Mellor Primary School

Date	Source	Description	Investment (€)
12/02/2018	Lighting	Light bulb replacement	15000

3. Pilot 3: Seu Central de l'Agència de l'Habitatge de Catalunya (ES)

This building is located in the city of Barcelona (ES) and has the following characteristics:

- Building type: office building
- Total building area: 5857 m^2
- Average annual electricity consumption: 693 898 KWh
- Average annual electricity consumption per square meter: 118.47 KWh /m^2

The model was run using electricity consumption data sampled every hour and starting 29-01-2016. Since 2016, two different EEMs were applied, their details are described in Table 3.

Table 3. EEMs applied in Seu Central de l'Agència de l'Habitatge de Catalunya

Date	Source	Description	Investment (€)
30/09/2016	Electrical appliances	Efficiency improvement	16952
02/01/2018	Management	Opening time reduction	0

3. Methodology

This section describes the methodology used in this research, from the data cleaning and pre-processing phases until the model application and savings estimation. The different steps of the analysis performed are presented in detail and mathematical explanations of the statistical models used are provided.

3.1. Data cleaning

Data cleaning in the energy domain is the process of detecting, diagnosing, and editing faulty data in consumption time series. In the methodology developed, this is a critical step because the analysis is made based on the raw electricity consumption time series. As shown in [1], there are multiple approaches to detect outliers in energy consumption time series. In this study, the selected approach is a non-recursive elimination of extreme scores based on a Z-score of one-week sliding window population in order to detect outliers when their value is above eight (eight standard deviations from the mean). The Z-score is the signed number of standard deviations by which the value of an observation or data point is above the mean value of what is being measured.

3.2. Data pre-processing

In this section, the steps taken in order to prepare the data set to perform the analysis are introduced. Two main techniques are described: the creation of dummy variables to track the applied measures and the calculations operated on the temperature vectors to take into account the buildings' thermal capacity and resistance.

3.2.1. Dummy variables

Dummy variables are used in the model to indicate the period of application of energy efficiency measures over time. For every EEM m_i that is eligible for evaluation, a dummy variable m_i is added to the dataset, having value 0 before the measure application date and value 1 after the measure application date. m_i is an essential variable to differentiate the section of the timeseries where the EEM is not applied and the one where it is, it can be described as:

$$m_i = \begin{cases} 0 \; if \; measure \; i \; is \; not \; applied \\ 1 \; if \; measure \; i \; is \; applied \end{cases} \qquad (1)$$

In addition to m_i, another variable m is added to the dataset, which indicates the total number of EEM applied to the building at each instant of the time series:

$$m = \sum_{i=1}^{n} m_i \qquad (2)$$

The m and m_i are then added to every observation of the dataset, marking which measures were applied (and which were not) on any given day of the timeseries.

2. Temperature vectors

To take into account the building heat dynamics in the model, a first order low-pass filter is applied to the outdoor temperature time-series [2]. The reason for this is that the building energy consumption is not directly dependent on the short-term outdoor temperature variations because of the building's thermal capacity and resistance; the low pass filter ignores the fluctuations and considers only the longer-term trend.

$$T_{lp}(t) = T(t-1)\,\alpha + T(t)\,(1-\alpha) \qquad (3)$$

Where $T(t)$ and $T_{lp}(t)$ are the average outdoor temperature and the low pass filtered temperature at hour t, while $T(t-1)$ is the average outdoor temperature at hour $t-1$. The optimal α is calculated for every building, according to its characteristics, by running the savings evaluation model described in section 3.4 with different α values and choosing the one that minimizes the RMSE (root-mean-square-error) of the model. Once the low pass filter is applied, the difference T_b between T_{lp} and the balance temperature of the building $T_{balance}$ is calculated. In this way we obtain that when T_b is close to zero, the fraction of the building consumption directly dependent on the outdoor temperature will also be close to zero.

$$T_b = T_{lp} - T_{balance} \quad (4)$$

Finally, taking into account T_b and the dummy variables, additional vectors T_{bmi} are calculated. These are only calculated in case of application of more than one EEM and are used in the model to obtain a more accurate evaluation of the effect of an individual measure on the building energy consumption.

$$T_{bm_i} = \begin{cases} 0 & when\ i\ \neq 1\ and\ m_{i-1} = 0 \\ T_b & when\ i = 1\ or\ i\ \neq 1\ and\ \ m_{i-1} = 1 \end{cases} \quad (5)$$

3.3 Modelling

After the phases of data cleaning and pre-processing, the dataset is ready to be analysed. First, a clustering algorithm is applied, in order to identify the consumption patterns of each day of the time-series. Then, the model described in paragraph 3.3.2 is run on each cluster separately, in this way the model is applied only on days having a specific pattern of consumption and provides better fit and prediction.

3.3.1. Clustering algorithm

In order to identify the building consumption patterns, representing the user behaviour in different days of the year, a clustering algorithm is applied. The different days of the time-series are classified into clusters C_k of similar daily behaviour, using as input the building's energy consumption values, sampled every hour. The clusters are identified using a Gaussian Mixture Model and the optimal number of clusters is chosen according to the Bayesian Information Criterion (BIC) of the model [3, 11]. Once the algorithm identifies the different patterns of consumption, a filter is applied in order to exclude clusters containing days of unusual behaviour and small overall relevance. To do this, the mean within cluster variation is calculated for every cluster C_k, defined as:

$$W(C_k) = \frac{1}{n_k} \sum_{x_i \in C_k} (x_i - \bar{x}_k)^2 \quad (6)$$

where n_k is the number of observations in the kth cluster, $\bar{x}_k$ is the mean of cluster C_k (or cluster centroid), and $x_1, \dots, x_N$ is the set of observations [9]. After calculating this value for all the C_k, the clusters having W higher than 1.5 times the average W of all clusters ($\overline{W} = \frac{1}{K}\sum_{k=1}^{K} W(C_k)$) are excluded from the analysis; the days belonging to these clusters are classified as having atypical behaviour and are not used for model fitting and savings calculation.

3.3.2. Generalized Additive Models

Although attractively simple, the traditional linear models often fail in many situations, since in real life effects are often not linear. Among the different possible statistical models, it was decided to work with generalized additive models (GAM), a specific method for supervised learning, originally developed by statisticians Trevor Hastie and Robert Tibshirani [7]. GAMs are flexible statistical methods that can be used to identify and characterize nonlinear effects. In the regression setting, a generalized additive model has the form:

$$g\big(E(Y)\big) = \beta_0 + f_1(X_1) + f_2(X_2) + \cdots + f_p(X_p) \quad (7)$$

where X_F, $X_\&$, ... , X_l represent the predictors and Y is the outcome; the f_n may be functions with a specified parametric form (polynomial or un-penalized regression spline, for example), or unspecified `smooth' functions, to be estimated by non-parametric means. This means that the model allows for rather flexible specification of the dependence of the response on the covariates.

The GAM developed in the framework of this research aims to represent daily electricity consumption as a function of outdoor temperature, day of the week, sun altitude and wind speed. Then, supposing that an EEM application caused a change in the building energy behaviour, the model attempts to evaluate the EEM effect by analysing how the dependency of the building consumption on the exogenous variables previously described changed. Equation (8) represents the GAM applied in this study to evaluate the energy savings in the selected pilot buildings. The different terms of the equation are also explained in details.

$$g\big(E(E_d\,)\big) = B_l + f(T_b) + \sum_{i=1}^{n} \alpha_i m_i + \sum_{i=1}^{7} d_i \delta_i + \sum_{i=0}^{n} (m_i \cdot (\,f(S_{alt,i}) + f(W_{s,i}))) + \sum_{i=1}^{n} (\,f_0(T_{bmi}) + f_1(T_{bmi})) \qquad (8)$$

Where:

$E(E_d\,)$ is the estimator of the daily electricity consumption,

B_l is the base load of the building,

$f(T_b)$ is the outdoor temperature smooth term (as described in section 3.2.2),

n is the total number of measures applied in the building,

m_i are the dummy variables that are equal to 1 when the measure i is effective, 0 elsewhere. m_0 is considered 1 when there are no measures applied and 0 elsewhere,

d_i are the dummy variables indicating the day of the week (d_1 is equal to 1 on Mondays and 0 on any other day, d_2 is equal to 1 on Tuesdays and 0 on any other day etc.),

$\sum_{i=1}^{n} \alpha_i m_i$ is the term representing the direct effect of applied measures m_i. m_i are the dummy variables defined above, while α_i are the weight coefficients calculated by the model,

$\sum_{i=1}^{7} d_i \delta_i$ is the term representing the influence of the day of the week on the consumption. d_i are the dummy variables as defined above, while δ_i are the weight coefficients calculated by the model,

$\sum_{i=0}^{n}(m_i \cdot (\,f(S_{alt,i}) + f(W_{s,i})))$ are the sun altitude and wind speed smooth terms, according to the status of the building (before first EEM application, between first and second application, before second and third etc.)

$\sum_{i=1}^{n}(\,f_0(T_{bmi}) + f_1(T_{bmi}))$ are the temperature smooth terms according to the measure applied, where f_0 and f_1 represent the two states when the measure is not applied $f_{[m_i=0]}$ and when the measure is applied $f_{[m_i=1]}$

3.4. EEM savings evaluation

Once calculated, the results of the models introduced in the previous section are then used to estimate savings, following the procedure presented in this paragraph. The savings calculation technique is based on the concept that the building behaves differently depending on its `status', that is to say depending on the measures that are applied at a given point of the time-series. The GAM in equation (8) is trained with the whole time-series of the building, and is therefore able to capture the different behaviours of the building and to represent them with the smooth terms described in the previous section.

Before the model application, the whole time-series is divided in n + 1 sections (T_k, T_F, ... T_D), where n is the total number of measures applied in the building, in the period of time under analysis. In order to calculate the savings provided by an individual EEM, in a specific period of time T_4, the model predicts what would be the energy consumption during that period of time if the behaviour of the building would still be the one the building had in the previous section of the time-series T_{4WF}, (before the measure application). This prediction is realized by applying the GAM with the parametric coefficients and smooth terms the model fit for section T_{4WF}, but with all the exogenous variables (outdoor temperature, sun altitude, wind speed, etc.) of period T_4. The result is then compared with the actual energy consumption, during the same period of time T_4. If the measure had an effect on the consumption of the building, the GAM predicted consumption for the period will be higher than the actual one, and by calculating the difference we can evaluate the savings. In formula, the savings S_4 for period T_4 can be described as:

$$S_i = \sum_{t \in T_i} E_{d,t} - \sum_{t \in T_i} g(E(E_{d,t}|i = i-1))$$

$\sum_{t \in T_i} E_{d,t}$ is the real energy consumption monitored during period T_i

$\sum_{t \in T_i} g(E(E_{d,t}|i = i-1))$ is the GAM estimated consumption for period T_i given the condition that the model parameters are the ones fit for $i = i-1$

4. Main results and discussion

As first step of the analysis, the clustering algorithm was run, for all the three buildings, identifying three different consumption patterns for pilot 1 and 3, while pilot 2 appeared to have four different patterns. Once the patterns were identified, different models were fit, one per every cluster, that were then applied to calculate the expected behaviour of the building after the application of the measure, had the measure not been applied. Finally, the savings were calculated following the procedure described in section 3.4. The model estimates savings as a probability density function (pdf), in Table 4 results for every pilot are summarized in terms of pdf average (μ) and standard error (*SEM*) and percentage of consumption reduction with 95% confidence interval [9]. The 95% confidence interval concept is related to the probability density function definition, for instance pilot 1 has a consumption reduction of 21.3%, with a 95% confidence interval of 4.1%, meaning that there is a 95% probability that the consumption reduction for this building is between 17.2% and 25.4%. In the results table, the coefficient of variation of the root mean square error CV(RMSE) is also shown, this parameter is a measure of the difference between values predicted by a model and values observed and is frequently used to represent the accuracy of statistical models. ASHRAE Guideline 14

"Measurement of Energy and Demand Savings", one of the bases of the International Performance Measurement and verification protocol (IMPVP), details that models calibrated to estimate whole building energy savings should have CV(RMSE) < 25% [6].
Model results show how measures applied in pilot 1 and 2 resulted in significant savings, while no noticeable change was detected for pilot 3. Figure 1 and 2 show how the model fit the whole timeseries (above) and the difference between the real consumption and the forecasted consumption after the application of the measure (below) for pilot 2 and pilot 3. Note how in Figure 2 there are three graphs, as two different measures had to be evaluated. In the graphs, the black line represents the real consumption data, while the red line represents the model prediction. It's possible to observe the good fit of the model for both buildings and how the estimated savings are quite evident for pilot 2, while pilot 3 does not show any noticeable improvement following the measures application.
The models described in this section were realized using R, a programming language widely used for data analysis and statistical computing.

Table 4. Savings estimation results

Pilot building	Average daily consumption after the measure (kWh)	Average daily estimated savings μ (kWh)	Average daily estimated savings SEM (kWh)	Consumption reduction (95% confidence interval)	CV(RMSE)
Highfields Library	94.5	25.5	4.9	21.3 ($\pm$ 4.1) %	7.3%
Mellor Primary	633.1	225.6	54.1	26.3 ($\pm$ 6.3) %	10.68%
Seu Central Habitatge (measure 1)	1924.1	15.2	95.1	0.79 ($\pm$ 4.9) %	6.83%
Seu Central Habitatge (measure 2)	1839.3	-23.1	98.5	-1.27 ($\pm$ 5.43) %	6.83%

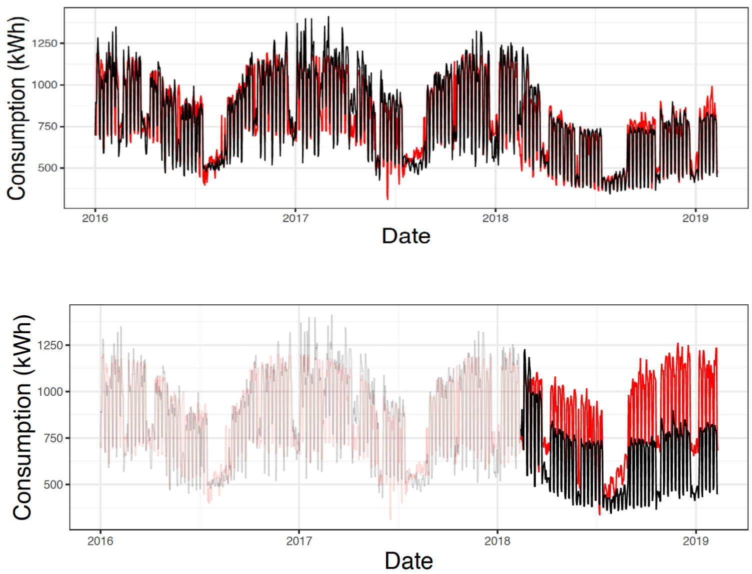

Figure 1 Pilot 2 overall model fit (top) and savings evaluation (bottom)

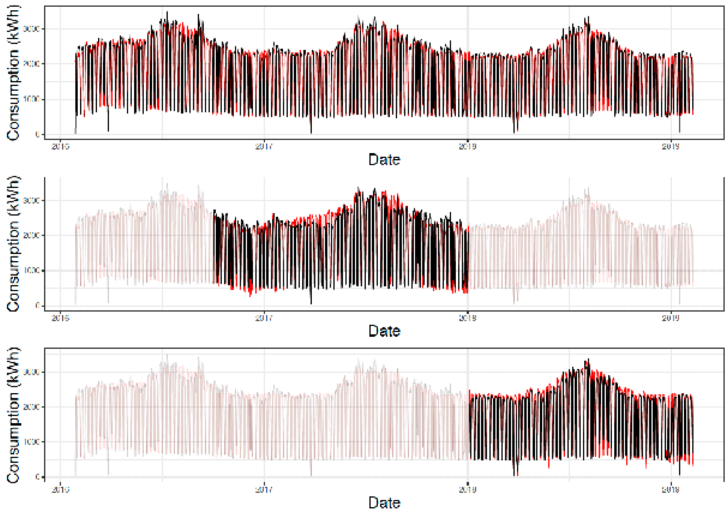

Figure 2 Pilot 3 overall model fit (top) and savings evaluation for measure 1 (center) and 2 (bottom)

5. Conclusions

The research presented in this paper is focused on the evaluation of energy savings in buildings, by using a statistical learning method that analyses hourly or sub-hourly energy consumption data. The proposed approach combines Gaussian Mixture Model clustering, used to detect user behaviour patterns, and Generalized Additive Models, used to predict the energy performance of analysed buildings in different scenarios.

The two main advantages granted by this approach are:

- the possibility of considering user behaviour as part of the model, leading to a substantial improvement of the predictions, especially in case of unusual behaviour changes,
- the possibility of easily and flexibly evaluating the nonlinear dependence of the buildings' energy consumption on several different variables, allowing the differentiation between actual savings and consumption reductions due to erratic changes of exogenous variables.

The method was applied to evaluate EEM applied in three different pilot buildings: in two of the pilots a single measure was applied, while in the third pilot the effects of two different measures, applied at roughly one-year distance from one another, were analysed. The models reported good fitting, reaching accuracy similar to more complicated deterministic and grey-box models developed for the same purpose. Furthermore, the proposed approach shows high robustness in not detecting any savings when EEM do not have substantial effects (pilot 3).

The approach proved to be a valid option to easily and cost-effectively assess energy retrofit impact, although further work and development is necessary. Next steps will include testing of the algorithm using synthetic data generated by deterministic models, using energy simulation software such as EnergyPlus, and further validation of the algorithm on various building typologies with different occupancy characteristics, applying complex combinations of EEM.

Acknowledgements

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Energy efficiency measures uncoupled from human perception: the control of solar shading systems in residential buildings

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Keywords: Smart Solar Shading, Energy Saving, Venetian Blinds

Abstract
Glazing surfaces strongly affect the building energy balance considering heat losses, solar gains and daylighting. Appropriate management of screens is required to control the incoming solar radiation, preventing internal overheating but assuring visual comfort. Consequently, in the building design phase solar control systems have become crucial devices to achieve high energy standards, to be exploited also in the refurbishment of existing buildings, especially in warm climates. Automated systems guarantee additional energy efficiency because of a model of use and operation of the shielding independent of the personal choices of the users. Usually, these choices are guided by personal perception and beliefs, often conflicting with common sense, and not by the search and optimization of environmental comfort. Instead, management based on well-defined control strategies can help reduce cooling consumption and ensure natural lighting. Among the control parameters to be monitored, there may be the intensity of solar radiation, the external and internal air temperature, the level of internal natural light and the occupancy. The greater the degree of automation and control of the sunscreen, the greater becomes its effectiveness in ensuring the level of expected solar and light control. The present study aims at investigating the effect of different screening strategies on the energy consumption of a high-performance building designed in the Mediterranean climate. The screen type consisting of blinds with horizontal slats is examined at the variation of its position with respect to the glazed surface and according to different control parameters.

1. Introduction

Due to the compelling need of tackling climate change, many countries around the world are trying to implement measures for reducing energy consumption. In the wake of this trend, European policies have identified energy efficiency in buildings as one of the key action for limiting greenhouse gas emissions (Directive 2010/31/EU). The use of shielding devices is among the contemplated interventions for energy conservation. An effective design of solar-control systems allows to reduce energy for cooling, by preventing the transmission of direct-solar radiation in summer, and either energy for heating, allowing the maximum solar gains in winter. Moreover, solar-control systems can help to reduce electricity for artificial lighting, and to ensure adequate visual comfort, trying to take the most advantage of the healthy natural light. Shielding systems can be divided into fixed and mobile systems (Kirimtat et al. 2016). The first category includes overhangs, external horizontal and vertical louvers, and egg-crates. The second category comprises venetian blinds, vertical blinds and roller shades. In addition, according to the type of control, the mobile systems can be further distinguished in manual control, central up-down commands and fully automated control (Kuhn 2017). Several studies have investigated the effect of shading systems on thermal and daylighting performance of buildings. For example, (Palmero-Marrero & Oliveira 2010) (Lau et al. 2016) (Freewan 2014) focused on the use of fixed systems and demonstrated that solar shadings are essential to reach internal comfort conditions and allow achieving significant energy savings for space cooling. (Kim et al. 2012) and (Yao 2014) analyzed the application of movable solar shadings proving that the adjustment of the slat angle can enhance the overall performance and reduce the risk of uncomfortable conditions. However, as observed by (Kim et al. 2009), manual or motorized control are limited in their ability to reduce energy consumption and to provide internal comfort, because an operation of the shielding by the occupants themselves is expected. Instead, the use of automated systems allows to more fully exploit the benefits of the shading systems. The authors carried out thermal and

visual experiments in a real scale test room and collected reports by the occupants of the dwelling in summer, confirming the potential energy savings and the comfort enhancement when using automated blinds. Also (Hashemi 2014) and (Touma & Ouahrani 2018) explored the effectiveness and potential savings in energy spaces demand and energy consumption for artificial lighting, achievable through the installation of automated sunshades and application of lighting and shading controls. Several authors have analysed the interaction of the occupants with shields and artificial light, trying to understand the influence of the level of automation and the possibility of handling by users, on environmental and energy performance and the degree of user satisfaction. A field study of human interactions with motorized roller shades and dimmable electric lights in a high performance office building is presented in (Sadeghi et al. 2016). The analysis revealed a preference for customized indoor climate with consequently different energy impacts. (Meerbeek et al. 2016) reported two experiments investigating the effect of the level of automation and the type of system expressiveness on users' satisfaction with an automated blinds system. They found out that the use of an expressive interface communicating the status and intentions of the blinds system could favour users' acceptance and satisfaction level, reducing the sense of losing control when decisions on environmental control are made by technology.
The analysed literature highlighted the benefits brought by the application of solar shades both in terms of energy saving and internal comfort. Moreover, the improvement of the shielding operation can also bring advantages from an economic point of view, since it reduces the waste of energy for air-conditioning. However, what requires a more in depth analysis is the activation and setting of these systems in order to maximize their performance. The objective of the present work is to evaluate the effect of the smart-control of a shielding system consisting of internal venetian blinds with horizontal slats on the energy consumption of a building. In particular, the study aims at designing an advanced control strategy based on the identification of the optimal slat angle, able to better exploit the available solar radiation. This implies reducing the incoming solar radiation when it represents an undesired thermal load and allow it to enter when there is a heating demand. The management of these actions also takes into account the occupants' comfort, seeking to guarantee a suitable minimum level of natural lighting and avoid direct exposure to solar radiation. The control strategy is based on IoT technology, requiring the use of "cognitive" objects consisting of sensors and actuators, able to detect the environmental data, process information, and implement the most appropriate actions needed to achieve the desired conditions.

2. Venetian Blinds and sensors

Venetian blinds represent a solution often adopted to allow the user to modify the incoming solar energy based on external weather conditions and his own sense of visual pleasure. They consist of small horizontal slats that can be manually oriented. The following characteristic parameters are defined for this type of shielding (Figure 1): distance between two consecutive slats d; slat depth L; slat inclination (angle between the normal to the surface of the slat and the horizontal plane) Slat.

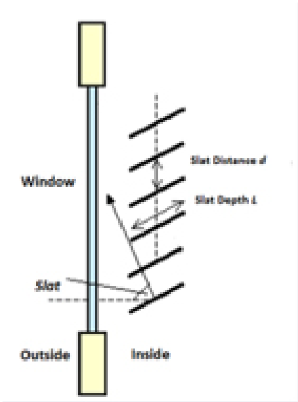

Figure 1 Schematization of venetian blinds

To automate the opening of the blinds, it is necessary to modify the angle of inclination by means of an actuator to obtain the desired shielding. To evaluate the optimal inclination in every moment of the day, information from indoor and outdoor environments must be received. In particular, an internal temperature sensor T and a presence detection sensor are required for each room.
In correspondence of each wall containing a glazed surface, a solarimeter is placed on the outside with the task of measuring the global radiation incident on a vertical surface.
In order to assess the presence of direct radiation, two solarimeters are used: one for measuring global radiation on a horizontal surface G, and another one with a shading ring for measuring scattered radiation on a horizontal surface D. The difference

between the two measured quantities allows to discern between the two types of day: clear or cloudy.

3. Control Method

The shields are managed based on the outputs supplied by the sensors. First of all, it is necessary to distinguish two different operating conditions, relative to the presence or absence of occupants inside the environment.
If there is no occupant inside the room, the operation depends on the internal temperature detected:
• In the case of temperatures below the set-point value of 21 °C, the maximum solar radiation must be introduced into the environment, without worrying about the glare of the occupants.
The optimal angle of inclination varies if the surface is exposed or not to direct solar radiation. In the negative case the Slat value is 110°, which allows to maximize the transmitted diffused solar radiation. In the positive case, in which there is direct radiation incident on the glass surface, the slats of the venetian blinds are arranged in a direction parallel to the sun's rays. The slats' inclination is, therefore, defined by the projection of the sun in the vertical plane perpendicular to the surface. Figure 2 shows the sun profile angle β that the sun projection forms with the horizontal plane.

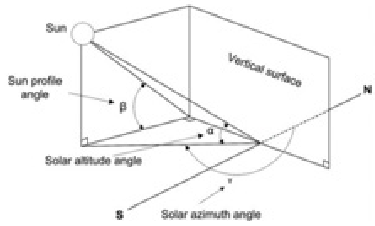

Figure 2 Relationship between sun profile angle, solar azimuth angle and solar altitude angle

β is obtained as a function of the azimuth of the surface γw, of the solar altitude α and of the solar azimuth γ according to the following relation:

$$\beta = \arctan\left(\frac{\tan(\alpha)}{\tan(\gamma - \gamma_w)}\right) \qquad (1)$$

If β is lower than 65°, the optimal Slat angle is fixed equal to β+90°, such as to keep the lamellas parallel to the solar rays. Otherwise:
if G>300 W/m2 direct component is high and the optimal Slat angle is still β+90°;
if G<300 W/m2 direct radiation has a lower energy contribution than diffuse radiation, so the Slat angle to be set must be such as to maximize the entry of the latter. It is given by the following correlation:

$$Slat = 120° - \frac{2}{3} \cdot \alpha \qquad (2)$$

• In the case of temperatures above the set-point value of 25 °C, the shields must be completely closed since it is not necessary to guarantee natural illumination inside the environment.
• Finally, if the temperature is between 21-25 °C, Slat is fixed to 80° (there is no need to exploit the solar contribution or even to shield).
In the presence of occupants, three different cases can be distinguished again.
• If the temperature is lower than the set-point value of 21 °C, solar radiation, which in this case is a free contribution, must be used as much as possible.
• The presence of direct radiation could cause visual discomfort on the work surface to people. In this case the optimal configuration shields the sun's rays by keeping the lamellas as open as possible. The requirement that guarantees this condition is that the vertex A of the lower lamella, the vertex B of the upper lamella and the point representation of the sun are on the same line (Figure 3). The angle of inclination that identifies this position of the lamella is indicated in Figure 3 with the name of Slat*. In fact, if these points are aligned, certainly the sun's rays do not reach the work surface and the slats are the most open possible.

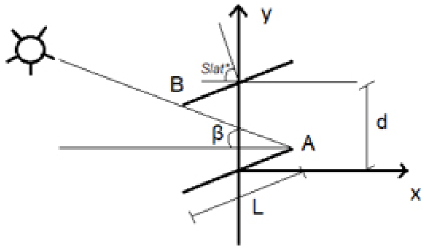

Figure 3 Limit inclination for direct radiation blocking

With reference to Figure 3, the coordinates of points A and B are the following:

$$\begin{cases} x_A = \frac{L}{2}\sin(Slat*) \\ y_A = \frac{L}{2}\cos(Slat*) \end{cases} \qquad \begin{cases} x_B = -\frac{L}{2}\sin(Slat*) \\ y_B = d - \frac{L}{2}\cos(Slat*) \end{cases} \tag{3}$$

Therefore, it is necessary that points A and B form the angle β with respect to the horizontal:

$$-\tan\beta = \frac{y_B - y_A}{x_B - x_A} = \frac{d - \frac{L}{2}\cos(Slat*) - \frac{L}{2}\cos(Slat*)}{-\frac{L}{2}\sin(Slat*) - \frac{L}{2}\sin(Slat*)} \tag{4}$$

After some mathematical steps, Slat* results:

$$Slat* = 2\cdot\arctan\left(\frac{\tan(\beta) + \sqrt{\tan^2(\beta) - \left(\frac{d}{L}\right)^2 + 1}}{1 + \frac{d}{L}}\right) \tag{5}$$

• If the direct solar radiation does not affect the walls, then the configuration that allows the maximum diffuse solar radiation to enter is Slat equal to 110°.
• For temperatures above the set-point value of 25 °C, it is necessary to shield the solar radiation, but not completely, guaranteeing a minimum of natural illumination, obtained with slat equal to 45°.
• If the temperature is between 21°C and 25 °C, the operation depends on the exposure to direct solar radiation: in the negative case, Slat is 80°; while in the case of exposure to direct solar radiation, the optimal angle is determined by equation (5) to avoid glare to the occupants.

4. Definition of Simulation Environment

The actual energy saving and operation of control method are simulated on Energy Plus. The climatic parameters set refer to a year, registered in Cosenza. The building consists of a 25 m2 square room designed to have a window for each exposure (Figure 4). The transmittances of the vertical surfaces, the floor and the roof covering are respectively: 0.38, 0.34, 0.27 W/m2K. The stained glass windows represent the 15% of the total walls and are composed of double glass and air space (4-12-4) with transmittance 1.91 W/m2K. The number of occupants is zero from 8.00 a.m. to 2.00 p.m. and it is two during the rest of the day. The lighting system, equipped with linear control, is active from 7.00 a.m. to 8.00 a.m. and from 2.00 p.m. to 11:00 p.m. and ensure 500 Lux on the work surface, placed at 0.75 meters from the ground. Finally, temperature control is managed by a fan coil system, always on, set at 20°C for winter days and 26°C for summer days.

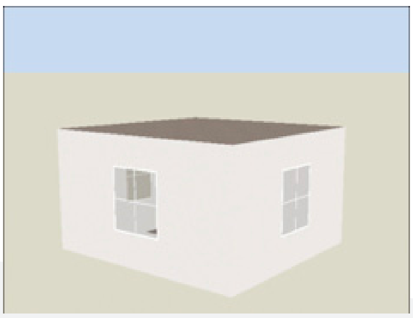

Figure 4 Test Building

5. Analysis of Results

In order to analyze the effects of smart shielding devices, the solar radiation transmitted with the dynamic control is compared with the same transmitted in the case of fixed shielding with an inclination angle of 80 °.

Figure 5 shows the trends of the global external radiation incident on the vertical surface Gv, of the solar radiation transmitted both with the Tadj orientable shields and with the fixed Tfixed shields for the different exposures. In the Figures, moreover, the lamellas inclination angle Slat, in case of activated control is reported. The simulations are conducted with reference to a typical day in the winter period (January 4th). In Figure 5.a, relative to the East exposure, the gain deriving from the use of mobile shields emerges. In the early hours, they help to provide a greater solar contribution. The same considerations also applies to the Southern exposure (Figure 5.d), in which Slat=β+90°, with β determined by the Equation (1). In the morning hours, for the North and West exposures, not directly illuminated by the sun, Slat is equal to 110°, such as to maximize the incoming diffuse solar radiation. From the west exposure graph (Figure 5.c) emerges, instead, how dynamic control is implemented to ensure visual comfort in the presence of the occupants. The solar radiation transmitted, therefore, is limited from 15:00 to 17:00 by the control described by equation (5).

For the southern exposure, which is exposed to solar radiation for long periods of the day, the double effect of the mobile shielding emerges. In the first part of the day, they enhance the incoming solar radiation while, in the second part of the day, they optimize the amount of solar radiation that can be transmitted in conjunction with the visual comfort of the occupants. Under the simulated conditions, the daily heating demand is 2.05 kWh with the smart logic control and 5.38 kWh with the fixed slat angle, obtaining a reduction of 62%.

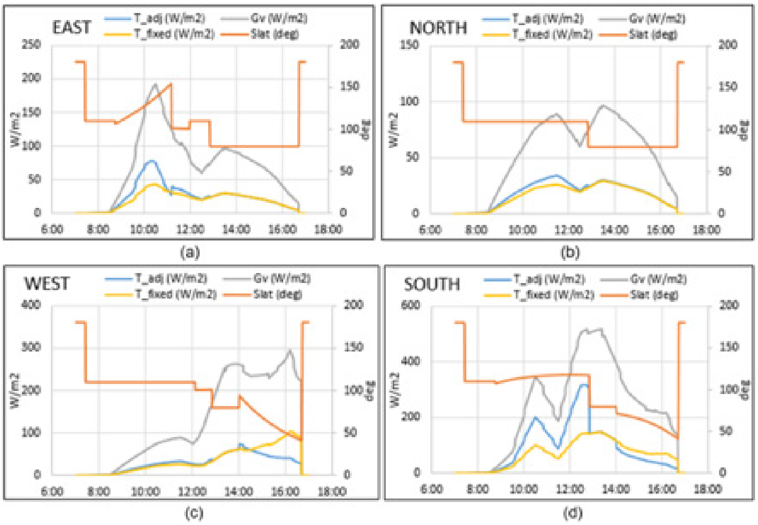

Figure 5 Winter day type simulations for different exposures

In Figure 6, instead, the same quantities are shown with reference to a typical day in the summer period (July 18th).

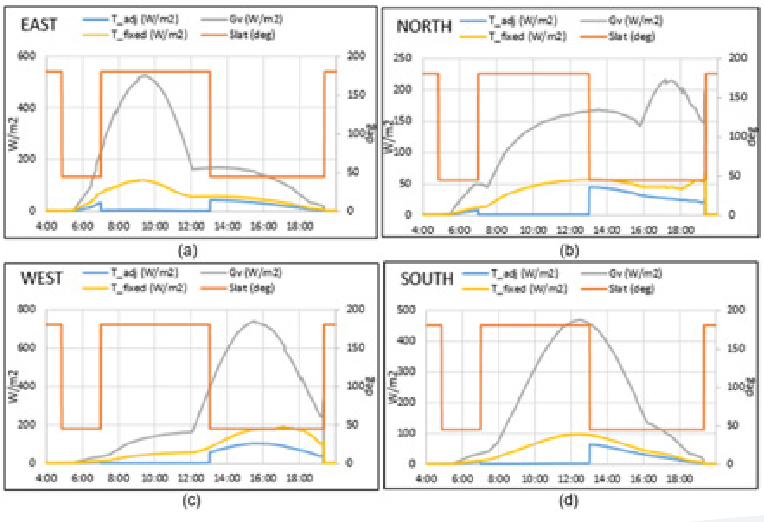

Figure 6 Summer day type simulations for different exposures

In the conditions of clear day and high outdoor temperature, the solar radiation transmitted through the windows must be shielded as much as possible and, therefore, the thermal load on the cooling system can be reduced. The graphs in Figure 6 show how the control, set up to keep the shields completely closed in the absence of occupants and at an angle of 45 ° in the presence of occupants, guarantees its effectiveness by introducing into the environment a much smaller amount of solar radiation than would be the case with fixed shielding. The daily cooling energy demand is 11.5 kWh with the smart logic control and 12.9 kWh with the fixed slat angle, achieving a reduction of 10.8%.
Figure 7 shows the monthly requirements deriving from the sum of energy consumption related to heating, cooling and lighting. In every month there is a tangible reduction in consumption thanks to the application of intelligent control of shielding systems. The percentage saving is between 30% and 60% in the winter months and between 10% and 20% in the summer months. On an annual level, total saving is around 15%.

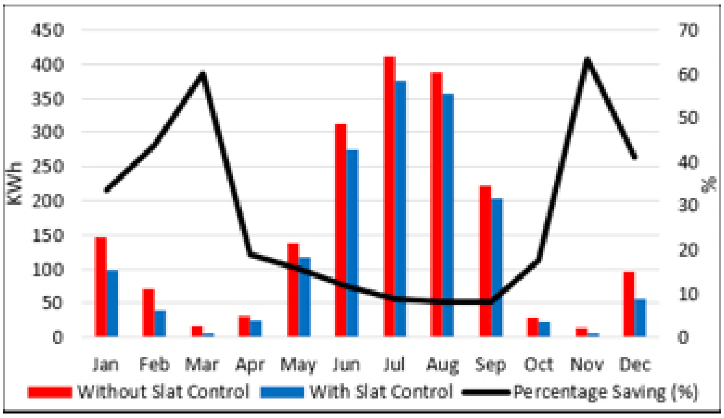

Figure 7 Monthly energy demand and percentage saving

6. Conclusions

The study focuses on the energy effects deriving from the use of a system of internal mobile shields controlled with a precise control method, in order to determine any benefits on the energy needs of a residential building model for a specific location.
The use of mobile shields leads to a reduction in the energy demand for cooling during the summer period and guarantees an aid to the energy needs in the winter period, when solar radiation can help in reducing the energy waste for heating and lighting. Furthermore, the best shielding solution must be such as to protect the visual comfort of the occupants, who could be exposed to glare.
The dynamic control of the shields allows to obtain a considerable energy saving, with significant effects especially in the winter period. In one year, the estimated reduction in energy consumption for the building under study was 15%.
Further developments and improvements on the control logic could concern the parametric study of the geometric characteristics of the slats, in order to identify the optimal configuration to be adopted during installation. It is also interesting to carry out the same study in other locations with different latitudes, in order to assess how much the location can influence the resulting benefits.

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Architectural quality and typological flexibility: the role of buffer spaces in warm climates buildings. An application in a steel and hemp construction system

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Keywords: architectural design, architectural quality, temporary housing, typological innovation and flexibility, buffer spaces

Abstract
This study is part of ongoing research which seeks to define a design method for sustainable temporary houses that could also be built in warm climates. It is based on the current results of the "Ac.Ca. Building. Progettare e Costruire in Sicurezza con l'Acciaio e la Canapa. Tecnologie Innovative per Edifici Ecosostenibili" R&D project, funded within POR Calabria FESR- 2014-2020, which involves a research group of the University of Calabria to which the author belongs.
The prefabricated system presented can assume multiple aggregative and volumetric configurations, starting from a wide range of functional spaces to be arranged for various uses: from temporary houses, to cohousing, to accommodations related to more traditional social housing. All this in a logic of interchangeability, adaptability and reversibility of the various typological schemes thus achievable. Precisely for applications in warm environments, the system envisages, in its own architectural principles, an envelope with several depth orders, with a crown of perimeter spaces that can play the role of buffer spaces with the aim of mitigating the effect produced by solar gains in hot seasons. The formal apparatuses of this envelope are therefore constructed and declined, in the various possible aggregations, through elements useful for this purpose, such as overhangs and shieldings, with different density plots according to the exposures and the possible latitudes. The aim of this work is to present the typological and aesthetical outcomes of this research with specific reference to the characteristics of innovation identified in possible applications in warm climates.

1. Introduction

Today's notion of sustainability, now necessarily and irreversibly extended to economic, social and environmental issues, at least starting from the 1995 United Nations World Summit in Copenhagen, places contemporary architectural research adopting a holistic approach to the theme, in which design choices can act on all these possible variations in an organic and unitary manner. It is as if to say that today there can no longer be an architectural choice that is sustainable from an environmental point of view which cannot be translated into an economically sustainable choice, since this certainly means having also worked towards a consequent social sustainability. The increasingly worrying issues that we must face, and which often require the use of architectural design tools, presuppose it in an increasingly obvious manner. If the concept of sustainability thus understood is currently now so pervasive as to be considered, according to some, as a veritable zeitgeist of the contemporary condition, it could also be said that a sort of new version has now been determined in the approach to the architectural project, a type of new updated version of the albertian concinnitas, where the inseparable balance between the parts and all of that underlying (moreover observed by Leon Battista Alberti in the same nature) corresponds to this specific kind of holistic equilibrium. So much that we could speak today, borrowing from the Latin contemporary ecclesiastical part of a significant neologism, of tolerabilis (progressio) concinnitas. Without therefore wanting to radicalize the linguistic options necessary to achieve such a balance (La Cecla 2008). It is clear that the unexpected need to add a term already adapted to architectural culture - because it is known that it was inspired to Alberti by Cicerone and borrowed from rhetoric - is born from the novelty, manifested "only" in the last fifty years, with the first awareness of the advent of the Anthropocene (Crutzen 2000), of having to consider the built environment a problem rather than a resource. It is in the perspective of overturning this anomaly, restoring the correct original sequence between the two terms (the built as a resource for the human race), that it is essential to adopt this kind of mental habitus in the architectural project. In the awareness, however, that this cannot in any case disregard the implications related to the architectural quality of the result thus achievable, of which the aforementioned particular concinnitas therefore arises as a necessary but not sufficient condition.
This is the underlying philosophy that inspired the methodological and design experimentation presented here, the Research and Development project "Ac.Ca. Building. Progettare e Costruire in Sicurezza con l'Acciaio e la Canapa. Tecnologie Innovative per Edifici Ecosostenibili", funded within the POR Calabria FESR- 2014-2020, and based on a partnership that commits a working group of the Department of Civil Engineering of the University of Calabria, making reference to the Laboratory of Architectural and Technological Design, and the following partners: Metal Carpenteria (steel carpentry and components), Edil Canapa (components for walls, floors and thermal-acoustic insulation based on hemp and lime fibre), and Irenova (plant design).
The Ac.Ca. building project proposes a dry construction system with a steel structure and hemp components, whose implicit

features of environmental and economic sustainability are placed at the service of a wide and versatile typological repertoire, which is entrusted with the objectives of social sustainability, and a formal apparatus that is equally flexible and adaptable to different contexts, climatic and not only, which is also respectful, in a circular manner, of the same evoked principles of sustainability. (Fig. 1)
This paper presents some of the results relating to the ongoing experimentation in its architectural, typological and aesthetic aspects developed by the architectural design team, coordinated by the author of this paper and consisting of the engineers Giuseppe Canestrino and Alessandra Gallo.
Steel was chosen to meet safety requirements, for the increasingly fragile contexts of the Italian territory in which it was imagined that the system could be applied at first and with a view to being able to affect that alarming figure of 6% of global emissions of CO_2 attributable to the production of cement. Hemp was chosen to achieve other sustainability and innovation results, within a project, financed as part of a program aimed at encouraging the adoption of criteria in this sense by SMEs. The project therefore acts as a corollary to a more general initiative of process innovation and industrial research and experimentation.

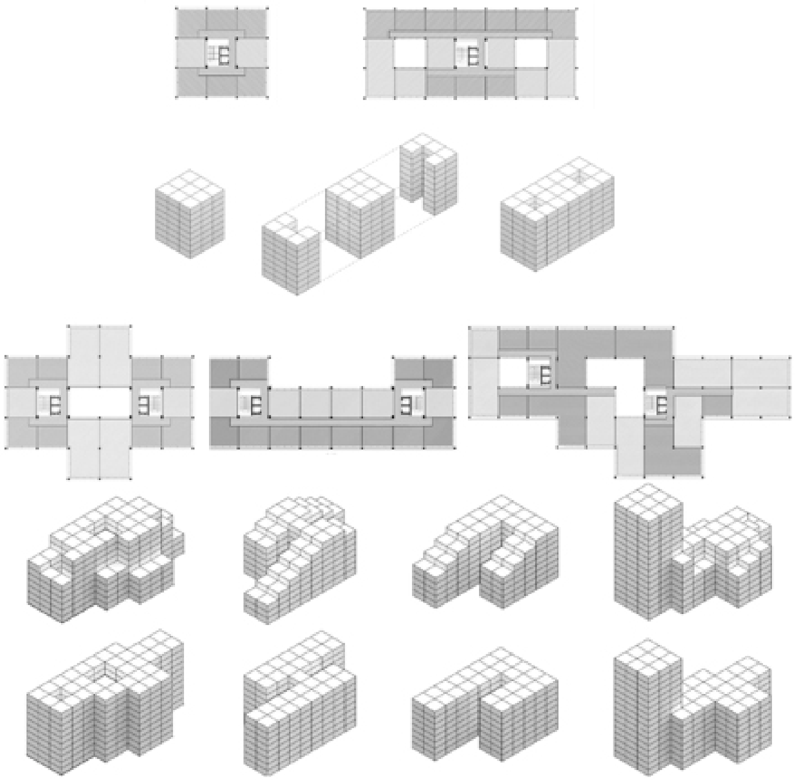


Figure 1 Examples of different typological and volume's combinations for the adaptability to different contexts

The modular stratification typical of dry systems and the possible reversibility of their connections, the latter also assured in the steel structure where bolts are preferred to welds, have determined technological conditions useful in guaranteeing a virtuous behaviour of the buildings configurable with the Ac.Ca. building system for environmental purposes. But, beyond the range of components and wall elements envisaged (whose in-depth study has been entrusted to the specialized group in this area), the applicability of the system to contexts that are theoretically very different from the climatic point of view has imposed functional choices, orienting the project actions aimed at the construction of the envelope system, and in all its different functions: organic, in thermal exchange with the outdoor environment, but also symbolic and therefore figurative and linguistic, in the adaptation to possible different identitary contexts. A three-dimensional apparatus-casing was created, conceived as a permeable limit: from the inside to the outside for the typological adaptations and the complete fulfilment of flexibility and versatility provided at this level, and from the outside to the inside for the graduation of the porosity of the building organism conceived from time to time, in order to allow adequate thermal responses given the anisotropic behaviour of the various possible configurations in each case.

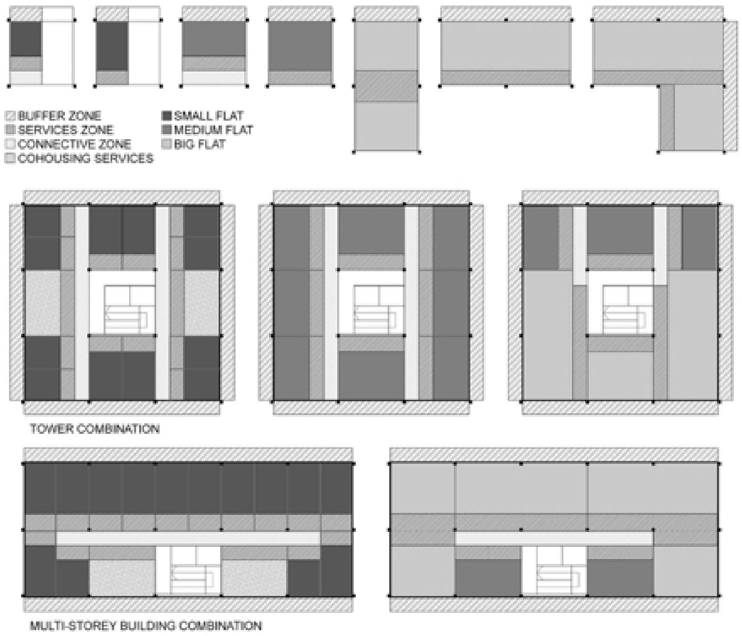


Figure 2 Elementary modules and possible different typological combinations

This perimeter confinement structure is, in some respects, comparable to an exoskeleton (Montuori 2014) and for others to a buffer zone, a crown of those that in the terminology of passive buildings are defined as buffer spaces. This refers to a remote tradition, dating back to the pre-industrial period, before the affirmation of the so-called regenerative model (Banham1984, Lucente 2018), in which the typological and, therefore, volumetric and formal structure of the building introjected useful methods to achieve the best possible mediations with the natural environment and its phenomena (Rudofsky, 1979). In the AcCa building system, the novelty factor is constituted by the versatility of the declination of this buffer space, not only as faces, a significant element of the building, the one in which most of the architectural quality is played, but also as a guarantor space of the various typological solutions achievable in the different context. (Fig. 2)

2. Typological variations in a point of view of complete social sustainability

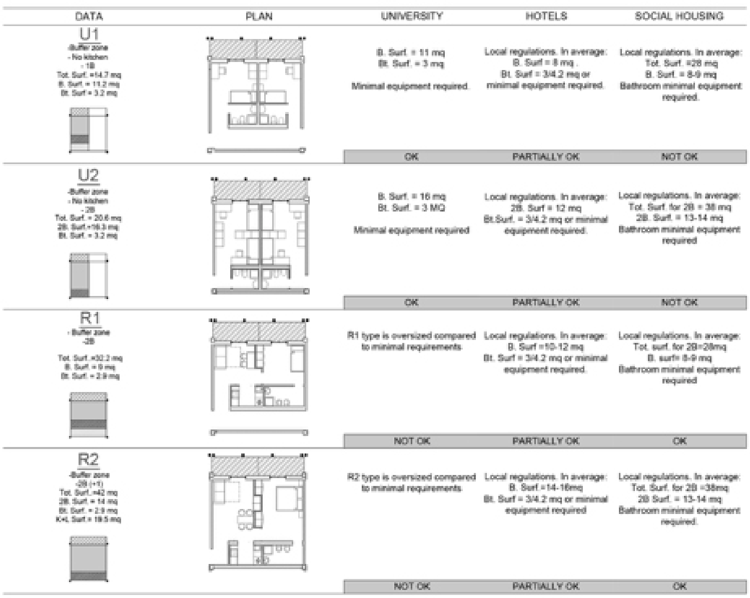
In the already discussed perspective of full social sustainability, the AcCa building system was designed to respond to a residential demand - and not only - that is increasingly diversified and innovative. Therefore, reference was made to housing options that are increasingly spreading as models adaptable to the new social scenarios that we face, following the increase in risk and disaster situations and the expansion and diversification of the range of possible users of these new typological segments. The twentieth century has definitively given us the logic of the existenz minimum, notoriously introduced since the dawn of the century by the Modern Movement, to which periodic updates are still required. And it is in this same time frame that the still available concepts of flexibility (Till, Schneider 2007) and modifiability of the space of the dwelling have also been introduced. The new ways of working typical of the digital era have therefore enriched the residential dimension with other meanings, while the same happened to the traditional places of work and leisure and that, at the same time, society recorded significant changes in traditional family structures and of the dynamics of employment and health of the planet and its inhabitants.

All this has led typological research to favour new areas of experimentation, effectively summarized by key words that sum up the underlying philosophy, replacing the more generic term of flexibility with the concepts of mutability, transformability and mobility (Terporilli 2015), up to to arrive at the terms temporariness and transitoriness, which almost allude to a real dissolution, according to some to the limits of paradox (Campioli 2010), of the traditional meaning of the housing dimension as a permanent and immobile condition. To reach the increasingly widespread and polysemic use of the term resilience, that is to say of adaptability to changes and ability to return to an initial condition following a significant stress.

It is evident that reflections of this magnitude demand us to draw increasingly from the humanistic dimension of architecture, and not only from a disciplinary point of view, requiring the effort to own some mandates of which other disciplines are holders, such as sociology and philosophy, without disregarding the political dimension, to which even the visions of these are finally to be transferred.

But there is a technical level to which architecture is first of all called upon to respond, not without safeguarding that symbolic dimension, of representing the cultural needs of its users, which is likewise entrusted to it in an equally exclusive manner. And

this is the level at which the present experimentation is placed in its typological and symbolic-formal declinations, beyond its technological specifications that, nevertheless, form the necessary preconditions.
The concept of transience implies a revolution in the traditional logic of living. In the most widespread contemporary applications, whose beginnings date back to the 1920s, there is an allusion to a possible radical revision of current residential models, as suggested by the slogan "Contemporary house = temporary home" (Cellucci 2016, p.17), starting from the idea that the concept of durability that is traditionally linked to the constructive dimension, and therefore also to housing, can today be replaced by the concept of evolution (Lucente in press). They are applications that ab origine derive from experiences related to emergency situations, of disaster in the broad sense (Lucente 2014). The intersection of scenarios of this kind with the evolutionary scenarios of contemporary society frames the range of possible users to which the Ac.Ca. building experimentation looks, and which includes, in addition to the unfortunate victims of disasters, single-parent families, self-sufficient elderly, city users, off-site workers and students, non-EU immigrants and native migrants, separated people and extended families. They are users with limited financial resources that could need, in a transitory phase of their life or at defined and limited time intervals, temporary accommodation. However, precisely in the evolutionary perspective being discussed and of the evoked sustainability, also of an economic and environmental nature, the Ac.Ca. building typological experimentation was conceived to provide an answer not only to what has been defined as an "emergency in peacetime", but to adapt to even collateral uses, as long as they have sufficient margins of typological affinity, considered, moreover, the objectives underlying the funding of technology transfer to the companies involved in the project in terms of increasing their innovative competitiveness capabilities.
For this reason, the applicability to some types of special residences, such as hotels, residences for students, senior citizens, and more generally alternative formulas of living such as co-housing was tested, as well as the availability of the system to find applications in the project of advanced contemporary working spaces such as co-working offices and fab-lab was explored.
All this, above all in relation to residential typologies, has brought to the fore the aforementioned question of minimum standards. Because while on the one hand contemporary experimentation projects towards horizons of significant reduction of the current ones - to the point of prefiguring minimal solutions oscillating from Le Corbusier's cabanon to Tiny houses - on the other, the fact remains that in concrete large-scale applications it is, however, still to those same standards that we still have to look at today. For this reason, while preserving the experimental nature of the system, the minimum typological modules have been sized for an aggregability able to meet the current standards relating to the entire range of residential options listed above, without excluding solutions more typically related to the established tradition of social housing. (Figg. 3,4).



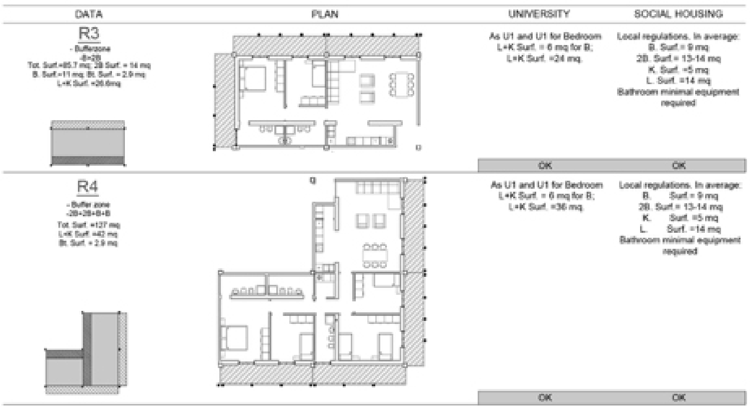


Figure 3 Small typologies abacus with reference to different current regulations and standards
Figure 4 Large typologies abacus with reference to different current regulations and standards

The desire then to guarantee the maximum possible flexibility, given the reversibility of the structures allowed in power by the dry system envisaged for each technical level of construction, has led to choosing the "redundancy" (Cellucci Di Sivo 2016) of the systems and of the entrances as a key to open to interchangeability and reversibility of all the contemplative aggregation solutions.
Therefore, we started from an elementary three-dimensional module sized according to the static conditions guaranteed by the steel structure and designed to house inside a strip within which the services and/or the shared accesses of the housing units will be located, organized therefore at the turn of an intermediate wall containing the system ducts. The typical span, in both directions, has been sized to gain a nett light between the pillars of 6.60 m x 6.60m, starting from a modularity on base of 60 also assumed as a formal key for the design of the casing. From this point of view, the odd number of the modules thus determined has been set as a condition to construct a figurative variability of the facade and to provide, inside, a wall-container module, separating the two minimum environmental units that can be cut out inside of the aforementioned light.

3. Environmental adaptability: the perimeter buffer space
But, above all, the elementary module thus conceived foresees, thanks to the high structural performance of the steel, an overhang with an external projection of every residential unit: that buffer space object of this contribution, depository of different and multiple meanings and roles.
From the point of view of the flexibility and adaptability mentioned, it enriches the various aggregative options - starting from the minimum cell with service for one person, of 16 m2 meters - of a precious outdoor space that is multipurpose and even containable. From the figurative point of view, of the design of the envelope, it becomes the guarantor of all the possible customization options, formal such as adaptation to different climates and contexts. From the bioclimatic point of view, it determines the conditions for the system to find application even in hot climates, in which the greatest problem is notoriously that of protection from excess solar radiation.
In the Ac.Ca. building system, in cold seasons hemp infill panels and inner coating in the same material guarantee a high performance level of the envelope. The absence of mass of this material would theoretically reduce its performance in hot seasons. It is precisely because of this problem, that the system intervenes on two levels. In fact, it foresees a stratification criterion of the drywall which is functional to obtain the maximum possible performance (for these aspects refer to the contribution in this volume by Prof. Laura Greco, coordinator of the technological design team of the project), but above all it is designed to guarantee a significant shading contribution through the overhang, for mitigation of the pervasive effect of the summer solar rays, to which it adds a repertoire of shielding adequate to the orientation, and therefore, diversified in density and direction. (Fig. 5)

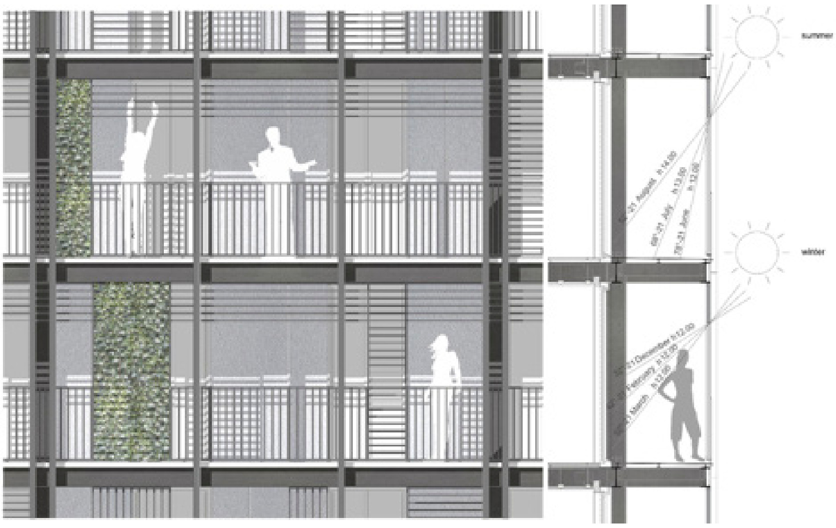


Figure 5 Perimeter buffer space: steel components, forms and screens.

The attached figures and tables exemplify the aggregate logics developed. The choice to leave the steel structure visible, according to a modular "tartan" grid (Staib, Rosenthal, Dörrhöfer 2010), naturally responds to the will of aesthetic characterization of the system, whilst guaranteeing those material discontinuities necessary to avoid any thermal bridges. The projecting frame that defines the perimeter buffer space thus builds - together with the structural metal members and the completion shielding grilles variously oriented for the different exposures - a formal apparatus, consisting of horizontal and vertical wefts that open to various possible declinations.

In particular, in terms of response in environmental terms, the sections reported clarify the behaviour with respect to the solar action of a generic building aggregated according to the AcCa building system by virtue of the aforementioned buffer space, better explaining the meaning of some formal choices. In the southern exposure, for example, it can be seen that the perimeter overhang ensures adequate shading for almost all of the day, in the worst summer weather conditions, while it does not inhibit the access of sunlight during the winter season. A horizontal shielding can therefore intervene, in the south-west orientations, to contribute to the achievement of the optimal result. For the same purpose, in East and West exposures the buffer zone can be equipped with vertical shields, with adjustable slats. Furthermore, the same gratings constructed from the uprights of the parapets and from the vertical plots of the metallic elements that define the external perimeter of the buffer zone giving it a three-dimensional aspect, define a functional plot to support photovoltaic panels, to the South, and to build green walls, to the East and West, to improve the microclimate of housing, to help to avoid the heat island effect, and to mitigate the impact of noise.

More in general, all these elements contribute to construct a minimal but effective architectural vocabulary, made of basic steel components whose different possible combinations pursue both economical and environmental sustainability and aesthetic result.

4. Conclusions

The results of design experimentation so far produced within the R&D project "Ac.Ca. Building. Progettare e Costruire in Sicurezza con l'Acciaio e la Canapa. Tecnologie Innovative per Edifici Ecosostenibili", demonstrate the achievement of full consistency between the objectives of architectural quality and those of environmental, economic and social sustainability, with a view to a holistic design approach that does not intend to ignore any of these four factors. This consistency benefits from the implicit sustainability of the dry construction system and the chosen materials, describing the technological choices in terms of extreme flexibility and adaptability of the typological and formal solutions developed. The applicability of the system conceived even in warm climatic contexts - considered among the objectives of the research project and demonstrated by the nature of the conformation choices of the envelope - will be further proven by the realization of a prototype to be placed in Crotone in climate zone B and scheduled between May and June 2019.

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Experimental results on the thermal properties of reflective materials for building insulation applications

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Keywords: double-skin systems, thermal transmittance, thermo-reflective panel, radiative heat exchange

Abstract
Double-skin systems represent a viable and efficient solution for building refurbishment, producing a noticeable reduction of the thermal losses through the envelope. In order to limit the external encumbrance, the total system thickness has to be contained, however precise values of the thermal transmittance should be achieved. For instance, in the Italian regulation context, requalification interventions by double-skin systems are not classified as a building volumetric growth if the thermal transmittance of the new envelope configuration is lower than a limit value, further decreased of 10%. A less invasive system could be attained by thermo-reflective panels located inside the air-gap formed between the existing wall and the double-skin. Indeed, these materials lead to a noticeable reduction of the radiative thermal losses allowing to use external insulated panels thinner. In this paper, experimental tests carried out on a sample with different types of reflective materials have shown that air-gap thermal resistance can be increased also 9 times than a conventional air-gap. The tests have shown that the radiative thermal exchange contribute is strongly reduced, as well as the convective one. Moreover, these advantages are more evident in presence of limited temperature differences between the wrapping surfaces. In the better case, the application of thermo-reflective materials could produce an insulation thickness reduction in the double-skin system of about 5 cm.

1. Introduction
In light of the last developments in terms of energy saving and environmental sustainability, the refurbishment of existing buildings is planned as a priority target (Directive 2012/27/EU, 2012). The Europe Union promulgated cardinal directives to promote energy savings, by contemplating the requalification of obsolete building-plant systems (Directive 2010/31/EU, 2010). The current building stock is prevalently represented by existing edifices, therefore an actual reduction of the global energy consumptions can be attained by measures addressed on their refurbishment (Oliveti et al.2009, Bruno et al. 2019, Carpino et al. 2017). Among the different interventions, the improvement of the thermal performance of the envelope could produce a noticeable reduction of the building energy requirements (Carpino et al. 2018). The majority of existing edifices, in fact, were built in absence of an appropriate regulation frame to contain energy consumptions, consequently these envelopes are characterized by elevated transmission losses, prevalently due to the absence of insulation. With reference to the Italian situation, about the 93% of the existing edifices were built before 1991 (ISTAT 2001), when the first regulation tool developed to limit the energy consumption in the building sector, represented by the law N°10/91, was emanated (Italian Republic 1991). In order to limit thermal losses through the building envelope, designers look toward solutions able to reduce the thermal transmittance, in the respect of the structural constrains. In this context, double-skin systems, made by insulating panels, distanced from the wall by a supporting frame to form a non-ventilated air-gap (Fig. 1), result particularly interesting (Gratia & De Herde 2007,Kim et al. 2013). These systems are even more considered by designers because, beyond the energy advantages, they are able to improve the building also from other aspects such as aesthetic characteristics, acoustic performances and facilitating the integration of active solar systems. However, in order to contain the global encumbrance, the total thickness of the double-skin systems has not to be excessive. These aspects could impede the achievement of a precise value of thermal transmittance, often imposed by current regulations to achieve suitable energy performance levels. For instance, in accordance with the current Italian regulations, the installation of the double-skin systems is not considered as a building volumetric increment if the thermal transmittance of

the new envelope configuration is lower than a thermal transmittance limit value, further decreased than 10%, with a maximum extra-thickness of 25 cm for vertical
walls (Italian Republic 2014). These limits are differentiated in function of the climatic zone (Italian Republic 2005) and can be attained by an appropriate choice of the insulation thicknesses inside the external panels.

Figure 1 Example of double-skin solution for the refurbishment of building envelopes. *Source: http://www.promoclad.com/xline/

n order to reduce the system encumbrance without compromise thermal transmittance, double-skin thickness could be reduced when proper material are inserted in the air-gap. In this field, the installation of thermo- reflective materials appears a very interesting solution, because allows for the reduction of the infrared radiative thermal exchange, and consequently for a reduction of the thermal transmittance, at parity of occupied space (Lee et al. 2016, Tenpierik & Hasselaar 2013, Hernandez-Perez et al. 2017). In this paper, in order to investigate on these properties, the thermal transmittance of air-gap equipped with thermo-reflective materials installed in the middle point, are investigated. In particular, the thermal resistance of different reflective materials have been quantified in a climatic chamber by means of experimental measures carried out by the thermo-flux meter method on a specimen constituted by an air-gap wrapped by two thin wooden walls. The experiments have confirmed that these materials, compared with the same sample without thermo- reflective panel, are able to increase the thermal resistance of nine times.

2. Operating principles of thermo-reflective materials

Peculiar characteristic of thermo-reflective panels is represented by the presence of at least a surface with a low-emission treatment, allowing for a severe reduction of the infrared radiative exchange inside the air-gap. The thermal energy emitted from the material surfaces is a fraction of the "black-body" energy and this rate depends on characteristics such as colour and surface treatments; this aptitude is quantified by their "emissivity", or surface emission coefficient ε. In the building sector, materials are usually equipped with elevated values of ε, around 0.9 (Oliveti et al. 2012, ASHRAE 2013), therefore the radiative thermal exchange is conspicuous. Regarding an air cavity not equipped with thermo-reflective materials, the radiant thermal flux exchanged between the delimiting surfaces with the same exchange area, supposing an emissivity of 90%, an unitary view factor and internal surface temperatures of 283.15 K (T1) and 273.15 K (T2), is equal to:

$$\Phi = 4 \cdot F \cdot \sigma \cdot T_m^3 \cdot (T_1 - T_2) = 19.97 \left[\frac{W}{m^2}\right] \quad (1)$$

where T_m is the average cavity temperature that, neglecting the convection effects, it can be calculated as the mean of the wrapping surface temperatures, σ is the Stefan-Boltzmann constant (5.67·10-8 W/m²K4) and F is the air-gap emittance, evaluable as:

$$F = \frac{1}{\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1} = \frac{1}{\frac{1}{0.9}+\frac{1}{0.9}-1} = 0.818 \quad (2)$$

When a thermo-reflective panel with a surface emission coefficient (ε2) of 0.1 is inserted in the air gap, a noticeable reduction of the radiative thermal flux can be detected, connected prevalently to a drastic limitation of the emittance that drops to 0.098, and consequently the heat flux calculated by Eq. (1) reduces to
2.41 W/m². Supposing a thermo-reflective panel inserted in the middle of the air gap, a reduced emission coefficient for the surface toward the wall warm side coincides with a reduced longwave absorption coefficient, therefore it has a scarce aptitude to absorb thermal radiation. Consequently, the remaining part is reflected back and it acts as a reflective surface, from which the panel nomenclature. Despite the reduced absorbed thermal radiation, the panel is anyhow subjected to a slight temperature

increment, however this aspect is counterbalanced by the limited emission coefficient of the other surface toward the wall cold side, that reduces the transmitted infrared radiation acting as a low-emission surface. Globally, the thermal resistance of the air- gap increases, producing a decrement of the wall thermal transmittance. Supposing a non-ventilated air-gap, the global thermal resistance can be defined as (CEN 2018):

$$R_{ag} = \frac{1}{h_C + h_R} = \frac{m^2 K}{W} \tag{3}$$

where h_C and h_R are the convective and the radiative heat transfer coefficients. In presence of a horizontal heat flux (vertical walls) the first can be determined in simplified manner as the maximum value between (CEN 2018):

$$h_C = \max\left(1.25; \frac{0.025}{d}\right) = \frac{W}{m^2 K} \tag{4}$$

where "d" is the air-gap thickness, whereas the radiative heat transfer coefficient can be set equal to:

$$h_R = \ 4 \cdot F \cdot \sigma \cdot T_m^3 = \frac{W}{m^2 \cdot K} \tag{5}$$

3. Determination of air-gap thermal resistances by means of experimental results

A sample constituted by an air-gap wrapped by two wooden panels (Fig. 2) was used to measure the thermal resistances by means of a compact climatic chamber developed at the Mechanical, Energetic and Management Engineering Department of the University of Calabria (Italy) (Bruno et al. 2018). The total sample thickness is 11.6 cm with an air-gap of 10 cm, and internal surface emission coefficients (ε1) of 0.91. The conductive thermal resistance connected to each wood panel is equal to 0.067 m^2K/W. Furthermore, a suitable supporting frame is employed to place the reflective panel perfectly in the middle point of the air-gap. The climatic chamber is constituted by two identical sub-chambers maintained at different temperatures in order to determine the materials thermal properties by means of the thermo-flux meter method. A radiant system integrated inside the sub-chambers walls is exploited for the provision and for the removal of thermal powers for the attainment of the set-points temperatures, by using a thermo-cryostat on the warm side, with a temperature stability of ±0.03°C, and a small chiller on the cold one, with a temperature stability of about
±0.5°C. When regime conditions were attained, the external surface temperatures of the sample (TEhot,side and TEcold,side) are measured by four wires RTDs PT100, 1/10 class, with an operation range varying between -50°C and 250 °C and accuracy of ±0.03°C at 0°C and ±0.08°C at 100 °C. Temperatures can not be measured on the internal sides of the sample in order to guarantee the air-gap tightness. The regime thermal flux (ΦM) is measured with an appropriate probe with a measurement range of ± 50 W/m2, accuracy of 5% and operative temperature varying between -30°C and 70°C.

Figure 2 Specimen with a thermo-reflective panel installed in the climatic chamber and its views

The ratio between the measured temperature difference on the sample surfaces and the transmitted thermal flux (in regime conditions) allows for the calculation of the thermal resistance (RT) of the whole specimen:

$$R_T = \frac{T^E_{hot,side} - T^E_{cold,side}}{\Phi_M} = \frac{\Delta T^E}{\Phi_M} = \frac{m^2 \cdot K}{W} \tag{6}$$

The ratio between the measured temperature difference on the sample surfaces and the transmitted thermal flux (in regime conditions) allows for the calculation of the thermal resistance (RT) of the whole specimen:

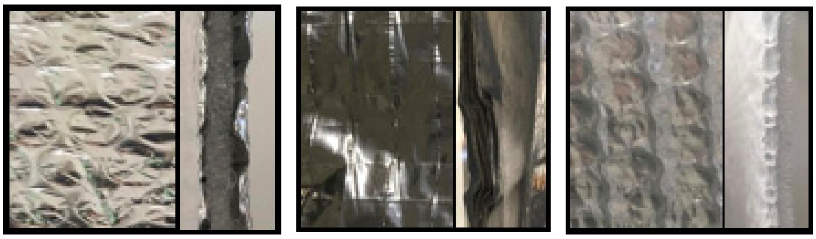
$$R_{ag} = \frac{T^i_{hot,side} - T^i_{cold,side}}{\Phi_M} = \frac{\Delta T^i}{\Phi_M} = \frac{m^2 \cdot K}{W} \tag{7}$$

The climatic chamber operation was validated by other measurement campaigns where the measured thermal resistances on different sample materials were compared with those certified provided by manufactures, obtaining satisfactory results (Bruno et al. 2018). Other tests were carried out by varying the temperature difference between the sample surfaces, in order to investigate on the effects connected with the convective heat transfer. In Tab. 1, the several tests carried out on the sample by varying the typology of thermo-reflective panels with the correspondent emission coefficient and the applied temperature differences, are listed. In Fig. 3, frontal and section views of the three typologies of investigated thermo-reflective materials, are shown.

Table 1 List of the different tests carried out on different thermo-reflective panels, varying the temperature difference (ΔT) between the sample surfaces

N° Test	Description	ΔT	ε_2
1	Measurement of the sample without thermo-reflective material	10	-
2	Measurement of the sample without thermo-reflective material	15	-
3	Measurement of the sample without thermo-reflective material	20	-
4	Measurement of the sample with the thermo-reflective panel N°1	10	0.05
5	Measurement of the sample with the thermo-reflective panel N°1	25	0.05
6	Measurement of the sample with the thermo-reflective panel N°1	30	0.05
7	Measurement of the sample with the thermo-reflective panel N°2	10	0.04
8	Measurement of the sample with the thermo-reflective panel N°2	30	0.04
9	Measurement of the sample with the thermo-reflective panel N°2	35	0.04
10	As the prior but removing the low-ε surface	35	0.04*
11	Measurement of the sample with the thermo-reflective panel N°3	10	0.25*
12	Measurement of the sample with the thermo-reflective panel N°3	25	0.25*
13	Measurement of the sample with the thermo-reflective panel N°3	30	0.25*

*low emission surface only on a panel side



N°1 N°2 N°3

Figure 3 Portions of the thermo-reflective panels tested in the climatic chamber: frontal and section views.

4. Tests results

In Tab. 2, the comparison between the results obtained from the tests N°1, 2 and 3 with a sample not equipped with thermo-reflective panels, is reported. In particular, temperature difference between the sample surfaces (ΔT^E and ΔT^i), transferred thermal flux (Φ_M) and correspondent thermal resistances (RT and Rag), are listed.

Table 2 Results of the samples without thermo-reflective panel, varying the temperature difference

N° Test	ΔT^E (°C)	ΔT^i (°C)	Φ_M (W/m²)	R_T (m²K/W)	R_{ag} (m²K/W)
1	7.97	4.38	26.92	0.296	0.163
2	10.00	5.37	34.75	0.288	0.155
3	12.01	6.35	42.78	0.281	0.149

Clearly, thermal resistance decreases with the temperature difference growth: indeed, the convective effects are more marked with the augment of the temperature difference between the sample surfaces, and consequent major thermal power transferred by convection. However, a temperature difference growth of 10 °C produces a decrement of the air-gap thermal resistance of about 8.6%, confirming the main role of the radiative thermal exchange in absence of thermo-reflective panels. The radiative heat transfer coefficients are of about 2.5 times greater than the convective ones. Indeed, by evaluating the mean air-gap temperatures equal respectively to 15.4°C, 17.7°C and 20.2°C, Eq. (5) with emission coefficients ε1=ε2=0.91 provided:

- $h_{R,1}$ = 4.548 W/m²K;
- $h_{R,2}$ = 4.661 W/m²K;
- $h_{R,3}$ = 4.782 W/m²K.

The convective heat transfer coefficient were calculated by the inverse solution of Eq. (3), obtaining:
- $h_{C,1}$ = 1.591 W/m^{2}K;
- $h_{C,2}$ = 1.808 W/m^{2}K;
- $h_{C,3}$ = 1.952 W/m^{2}K.

therefore the role of the convection exchange becomes more influent with the temperature difference growth. By comparing heat transfer coefficients between Test 1 and Test 3, the convective heat transfer coefficient increased of 22.7%, whereas the radiative one only of 5.1%.

In Tab. 3 the results obtained for the thermo-reflective panel N°1 of Fig. 3, equipped with both low-ε surfaces, are reported. These tests were conducted by setting greater temperature differences than the prior cases, due to the limited thermal flux connected to the presence of the thermo-reflective panel, in order to better investigate on the role of the convective heat transfer. Clearly, thermal resistance values increase: the better case, obtained with the lowest temperature difference and consequently the most limited convection effects, produced an augment of the air-gap thermal resistance of about 9 times than test N°1 (carried out with the same temperature difference). Again, thermal resistances decrease with the temperature difference growth; a slight reduction was detected between test N°5 and N°6 (-5.4%), whereas the deviance between test N°4 and test N°6, differentiated by an augment of ΔT=20°C, was of -25.6%.

Table 3 Results of the samples with the thermo-reflective panel N°1, varying the temperature difference

The convective heat transfer coefficient were calculated by the inverse solution of Eq. (3), obtaining:
- $h_{C,1}$ = 1.591 W/m^{2}K;
- $h_{C,2}$ = 1.808 W/m^{2}K;
- $h_{C,3}$ = 1.952 W/m^{2}K.

therefore the role of the convection exchange becomes more influent with the temperature difference growth. By comparing heat transfer coefficients between Test 1 and Test 3, the convective heat transfer coefficient increased of 22.7%, whereas the radiative one only of 5.1%.

In Tab. 3 the results obtained for the thermo-reflective panel N°1 of Fig. 3, equipped with both low-Δ surfaces, are reported. These tests were conducted by setting greater temperature differences than the prior cases, due to the limited thermal flux connected to the presence of the thermo-reflective panel, in order to better investigate on the role of the convective heat transfer. Clearly, thermal resistance values increase: the better case, obtained with the lowest temperature difference and consequently the most limited convection effects, produced an augment of the air-gap thermal resistance of about 9 times than test N°1 (carried out with the same temperature difference). Again, thermal resistances decrease with the temperature difference growth; a slight reduction was detected between test N°5 and N°6 (-5.4%), whereas the deviance between test N°4 and test N°6, differentiated by an augment of ΔT=20°C, was of -25.6%.

Table 3 Results of the samples with the thermo-reflective panel N°1, varying the temperature difference

N° Test	ΔT^E (°C)	ΔT^i (°C)	Φ_M (W/m^2)	R_T (m^{2}K/W)	R_{ag} (m^{2}K/W)
4	7.11	6.52	4.43	1.605	1.471
5	17.72	15.89	13.72	1.292	1.158
6	21.17	18.87	17.23	1.229	1.095

The radiative heat transfer coefficients calculated with Eq. (5) were determined in:
- $h_{R,4}$ = 0.271 W/m^{2}K;
- $h_{R,5}$ = 0.278 W/m^{2}K;
- $h_{R,6}$ = 0.284 W/m^{2}K.

These values, obtained with the new emittance of 0.049, clearly show that with the temperature difference growth, the radiative heat transfer coefficients increase slightly. The comparison between test 4 and test 1 highlights a reduction of the heat transfer coefficient, at parity of applied temperature difference, of -94%. Despite the augment of the internal temperature difference, the thermo-reflective panel produced also a noticeable decrement of the convective values, respectively equal to:
- $h_{C,4}$ = 0.409 W/m^{2}K;
- $h_{C,5}$ = 0.585 W/m^{2}K;
- $h_{C,6}$ = 0.628 W/m^{2}K.

This decrement is prevalently connected to the presence of the panel in the middle of the air-gap that obstacles the air thermo-circulation. Furthermore, the increment of the internal temperature difference is due to the reduced radiant thermal flux, which usually produces a homogenization of the temperature field inside the air- gap. Finally, the application of the thermo-reflective panel led to the achievement of radiative and convective heat transfer coefficients with the same order of magnitude. With reference to test N°1, the installation of the insulation panel in the test N°4 produced a decrement of the convective heat

transfer coefficient of -68%.
In Tab. 4 the results carried out with the thermo-reflective panel N°2 of Fig. 3, are shown. The tested panel is equipped with both low-ε surfaces, moreover the manufacturer declares a value more limited and equal of
ε_2=0.04, with a correspondent emittance of 0.039. However, the comparison between test N°7 and test N°4 (with the same temperature difference) has not shown a better thermal behaviour of the latter despite the
higher emission coefficient than the first: indeed, test N°7 provided a thermal resistance lower than 1.4%. The analysis of the heat transfer coefficients highlights that the radiative exchange is more reduced, whereas the convective contribution increases and this effect prevails. Indeed, the convective heat transfer coefficient of test N°7 is greater than 15% referred to test N°4, with radiative ones that remain almost constant. Conversely, with the temperature difference growth, a different behaviour was detected: by comparing test N°5 and N°8, the convective heat transfer coefficients were identical, whereas the radiative is more limited in test N° 8, therefore for the latter the air-gap thermal resistance increased. Again, the reduction of the air-gap emittance corresponds to a further increment of the convective heat exchange due to the greater temperature differences inside the cavity (16.11 °C in test 8 against 15.89 °C in test 5). The radiative heat transfer coefficients have been subjected to a further reduction due to the lowest emission coefficient, by calculating the following value:
- $h_{R,7}$ = 0.218 W/m²K;
- $h_{R,8}$ = 0.222 W/m²K;
- $h_{R,9}$ = 0.228 W/m²K;
- $h_{R,10}$ = 0.346 W/m²K

whereas the consequent convective heat transfer coefficients were:
- $h_{c,7}$ = 0.472 W/m²K;
- $h_{c,8}$ = 0.585 W/m²K;
- $h_{c,9}$ = 0.623 W/m²K;
- $h_{c,10}$ = 0.625 W/m²K

Table 4 Results of the samples with the thermo-reflective panel N°2, varying the temperature difference

N° Test	ΔT^E (°C)	ΔT^i (°C)	Φ_M (W/m²)	R_T (m²K/W)	R_{ag} (m²K/W)
7	7.12	6.52	4.50	1.584	1.451
8	17.84	16.11	13.00	1.373	1.239
9	21.37	19.19	16.33	1.309	1.175
10	20.71	18.33	17.79	1.164	1.031

In order to investigate on the role of the panel low-ε surface, the latter was removed in Test N°10 and a new thermal resistance measurement was carried out and compared with Test N°9 (where the same temperature difference was applied). Clearly, the presence of the sole reflective surface led to a worsening of the air-gap thermal properties, as highlighted by the increment of the transmitted thermal flux (+9%), the reduction of the temperature difference between the sample surfaces (-0.7 °C) and the lower air-gap thermal resistance (-12.2%), relevant with the new emittance value F=0.060. Therefore, the role of the low-emission surface cannot be considered negligible. In particular, the radiative heat flux increased (+51%), whereas the convective heat transfer coefficient remained almost constant. The latter confirms that, despite the different temperature difference inside the cavity, the convective exchange mainly depends on the air thermo-circulation influenced by the presence of the thermo-reflective panel.
Finally, the latter tests involved the thermo-reflective panel N°3 of Fig. 3 equipped with a sole reflective surface and an emission coefficient of 0.25, with results listed in Tab. 5. The augment of the radiant exchange, due to the great emittance of 0.244, led to a reduction of the ΔT between the sample surface, and a correspondent major transmitted thermal flux. In particular, comparing tests N°11 and N° 7, where the same temperature difference inside the climatic chamber was set, ΔT decreases of 1.9°C, but thermal flux almost doubled. Consequently, thermal resistance in test N° 11 is almost a third. Regarding the radiative heat transfer coefficient, the latter tested panel has provided the following values:
- $h_{R,10}$ = 1.327 W/m²K;
- $h_{R,11}$ = 1.362 W/m²K;
- $h_{R,12}$ = 1.395 W/m²K;

whereas the convective heat transfer coefficient were:
- $h_{C,10}$ = 0.412 W/m²K;
- $h_{C,11}$ = 0.566 W/m²K;
- $h_{C,12}$ = 0.620 W/m²K;

Again, the augment of the radiative heat flux led to a homogenization of the temperature field inside the air- gap with a consequent slight decrement of the convective heat flux. However, the worsening of the air-gap thermal properties is connected prevalently to increment of the radiative heat exchange, whereas the convective contribute is almost constant.

Table 5 Results of the samples with the thermo-reflective panel N°3, varying the temperature difference

N° Test	ΔT^E (°C)	ΔT^i (°C)	Φ_M (W/m^2)	R_T (m^{2}K/W)	R_{ag} (m^{2}K/W)
11	5.72	4.64	8.08	0.708	0.575
12	14.34	11.41	22.00	0.652	0.519
13	17.22	13.57	27.35	0.630	0.496

In Fig. 7, the thermal resistances detected for the different tests, are reported. In absence of thermo-reflective panel (Tests N° 1, 2 and 3), the radiative contribute is about 3 times than the convective exchange, with the latter that increases slightly with the internal temperature difference growth. In presence of limited temperature differences, the decrement of a percentage point of the emission coefficient (see Test N° 4 and Test N°7) did not lead to a correspondent increment of the air-gap thermal resistances. In this case, the slight reduction of the radiative heat flux was widely counterbalanced by a major increment of the convective exchange. The same behavior was not detected with the temperature differences growth, as highlighted by comparing Test N°8 and N°6. The removal of the low-ε surface (N° 10) produced a thermal resistance decrement of 0.144 m^{2}K/W. In the better case, the highest measured thermal resistance was detected in Test N° 4 with a temperature difference of 10 °C, observing a thermal resistance increment of 9 times than the Test N° 1.
Obviously, the worst case is represented by the sample without thermos-reflective material with the highest temperature difference.

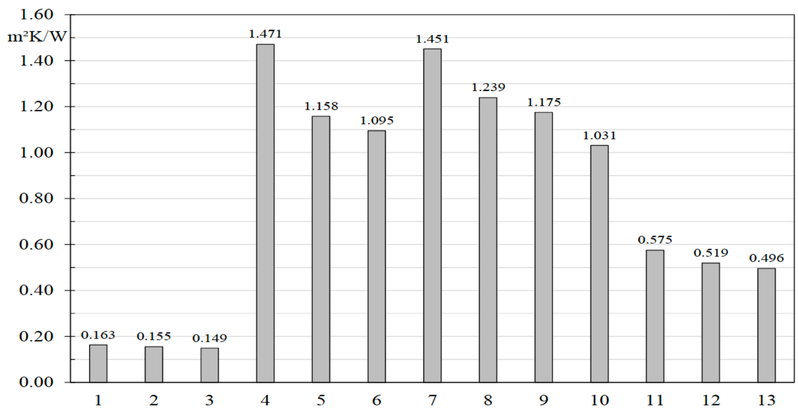


Figure 6 Synoptic frame of the air-gap thermal resistance carried out with the 13 experimental tests.

5. Conclusions

Different types of thermo-reflective panels to employ for the reduction of thermal losses in non-ventilated air- gap, were tested in a climatic chamber. These systems led to a noticeable reduction of the thermal flux delivered by radiative exchange, which is prevalent in traditional air-gap. Consequently, these materials seem to be suitable for the refurbishment of existing buildings with double-skin systems, because they can be inserted in the air-gap to reduce the insulation thicknesses without occupy additional spaces, making the whole system less invasive. Preliminary tests have shown that thermo-reflective panels, in presence of an external temperature difference of 10°C, can increase the air-gap thermal resistance also more of 9 times. In particular, the advantages are more evident when reduced temperature difference are applied. The same tests have shown that these materials reduce both the radiative and the convective exchanges. Despite an increment of the internal temperature difference, in fact, the convective contribution decrease because the presence of the same panel in the middle point obstacles the air thermo-circulation inside the air-gap. Obviously, the thermal resistances increase with the emission coefficient decrement, however sometime the reduction of the radiative exchange could be counterbalanced by a simultaneously increment of the convective rate, and consequently the air-gap thermal resistance decreases. Furthermore, thermo-reflective materials allow for the attainment of radiative and convective heat transfer coefficients with the same order of magnitude. By comparing tests characterized by the same temperature differences with and without thermo-reflective panels, the measured thermal resistance growth corresponds to that attainable with an insulation thickness of 5 cm, supposing the latter with a thermal conductivity of 0.038 W/m·K. By applying the procedure of the international standard EN ISO 6946 in order to separate the radiative and the convective rates, the latter seem to assume the values suggested by the standard only if the air-gap is not equipped with thermo-reflective panels. Furthermore, the convective heat transfer coefficient should increase with air-gap thickness lower than 2 cm, whereas the application of the panel (and consequently the reduction of the air-gap thickness) has provided a noticeable reduction. Moreover, the test results carried out on a specimen with an air-gap thick 10 cm and an internal thermo-reflective panel, have provided convective heat transfer coefficients ranging between 0.409 W/m^2K and 0.628 W/m^2K, about 4 times lower than the same coefficients determined in absence of internal panels. Regarding the radiative heat transfer coefficient, the thermo-reflective panel allows for a drastic reduction of about 17 times.

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The role of thermal inertia in wooden buildings

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Abstract
For the next future, European Directives impose the realization of nZEB whose design process requires particular envelope characteristics. Among them, the thermal inertia has to be considered carefully, especially in Mediterranean climates, in order to reduce energy requirements in summer. The building thermal inertia is connected with the use of heavier and denser materials in order to increase the heat storage capacity. Of particular interest appears the study of thermal inertia in wooden buildings, more lightweight when compared with traditional structures, which are spreading worldwide due to their attitude to respect sustainability aspects. Recently, building manufacturer are implementing timber structures mainly adopting the platform frame system, where nailed OSB (Oriented Strand Board) panels are used in "sandwich" walls to constitute a lightweight envelope. The aim of this study is to assess the influence of thermal inertia on the energy behaviour of such system. The study will focus on the introduction of massive materials in the wall layering, in particular loose sand, for the realization of heavier wooden buildings. Dynamic simulations were carried out in the TRNSYS environment, by paying particular attention to the position of the massive layers in the structure, in order to evaluate the building energy consumptions and the attained indoor thermal comfort conditions.

1. Introduction
In light of the last developments in terms of energy saving and environmental sustainability, the design of low emission buildings is planned as a priority target (Directive 2012/27/EU, 2012), by imposing the construction of near Zero Energy Buildings (nZEB) starting from 2021. Furthermore, if the involved building belongs to the public sector, the deadline is anticipated to 2019, as reported by the 2010/31/UE Directive (EPBD recast) where the nZEB concept was marked for the first time (Directive 2010/31/EU, 2010). The latter represents a building-plant configuration characterized by a small amount of energy demands, both for heating and for cooling, to satisfy possibly by employing renewable sources. The nZEB model represent the result of a careful design process where different parameters have to be analysed carefully. Among these design parameters, in the Mediterranean climatic context thermal inertia of the building fabric plays a crucial role for the attainment of high-energy performances. In winter, it can be used to store the transmitted solar gains through glazed surfaces, whereas in summer it has to contrast the transfer of the thermal wave through the opaque walls and the indoor overheating. In order to limit annual energy consumptions, the best compromise between the conflicting winter and summer needs has to be found (Verbeke and Audenaert, 2018; Arcuri et al., 2016). For instance, high insulation levels are desirable in winter to reduce thermal losses, but they can favour the rise of indoor air temperature in summer, whereas fixed shading devices allow for contain solar irradiance in summer, but they compromise winter solar gains. Furthermore, the building thermal mass can be managed opportunely to achieve energy savings (Li et al., 2019; Bruno et al., 2019a) by exploiting the structure as a "sui generis" thermal storage system (Navarro et al., 2016). For instance, the charge and the discharge of thermal energy from the building fabric can be regulated by using radiant emitters (Bruno et al., 2019b; Bruno et al., 2018), due to the radiative exchange that allows for the transfer or the removal of thermal power from the in view opaque structures. Traditional nZEB solutions, developed for continental climatic contexts, are designed with high insulation thickness and large glazed surfaces facing South to maximize solar gains. However, if the same approach is used in Mediterranean climatic context, the summer energy performances are strongly penalized (Bruno et al., 2015). This issue could be overcome if the building fabric is characterized by high thermal mass in order to attenuate and to delay the thermal wave transmitted through the walls. The augment of the wall

specific weight on the inner side also allows for the absorption of the transmitted solar radiation through the windows, delaying the indoor air overheating. Indeed, if the cooling peak loads are time shifted during night, the nocturnal free cooling can be used to transfer the stored thermal energy outward (Bruno et al., 2017; Ascione et al., 2016). However, the wooden nZEBs are lightweight and consequently do not allow the attainment of the mentioned targets. Furthermore, these typologies of nZEB are becoming widespread due to the employment of natural resources usually available in proximity of the construction site and the possibility to recover them during the building disposal, making the whole structure more sustainable (Peris Mora, 2007). In this paper, feasible wooden nZEB designed specifically for the Mediterranean area, have been investigated. The general aim of the present work is the definition of a new building model contextualized to the particular climatic zone, which addresses the major challenges connected with the achievement of appropriate thermal masses in presence of lightweight envelopes. In particular, different wall layering, that include the use of loose sand as massive material, have been studied to quantify the effects on the building fabric thermal inertia. Regarding a reference wooden nZEB, the actual energy performances at annual level were determined by TRNSYS 18 with different technical solutions, by evaluating the corresponding energy needs (VV.AA., 2017). Moreover, the different wall layering have been analysed in conjunction with different free cooling strategies and several operation modes of the shading devices.

2. Simulations Process

TRNSYS simulations were carried out on a single-storey family house depicted in Fig.1, 115 square meters of net indoor surface, consisting in eight conditioned rooms: living and dining rooms, kitchen, wildcard room, three bedrooms and two toilettes. Backroom and corridor are non-conditioned spaces, whereas dining and living rooms have been simulated as two divided thermal nodes, split up by a virtual surface. Every room has at least one external window, therefore these are naturally lighted and ventilated. The building was located in the Italian locality of Cosenza (Lat. 39.3°C, Long. 16.2 °E) and it was designed in order to obtain adequate thermal comfort conditions; indeed, orientation follows the natural sun path with service's room in the north and daily used room in the south. In the same Figure 1, a description of the different external wall layering considered in this work, is shown.

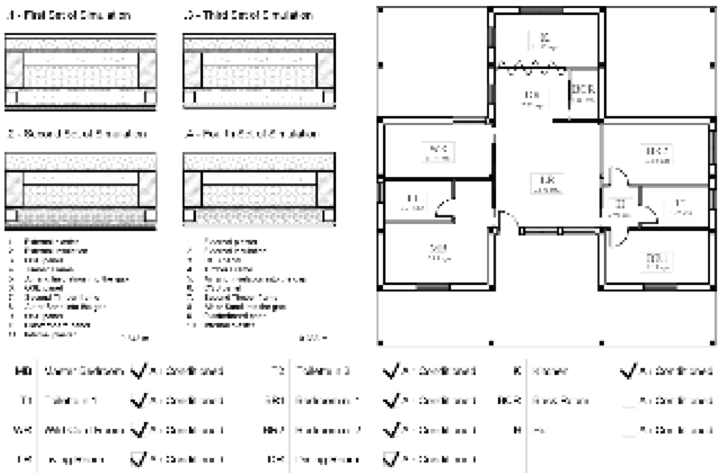

Figure 1 Building planimetry and particular of the different layering solutions considered for the envelope

In the reference-building configuration, external walls from the external to the internal side, neglecting external and internal plaster, present the following layers:

- External insulation,0.050 m
- OSB panel, 0.015 m
- Bitumen waterproof and vapour barrier, 0.0006 m
- Timber frame with external air cavity and mineral insulation into the gap, 0.160 m
- OSB panel, 0.015 m
- Second order timber frame, internal air gap, 0.050 m
- OSB panel, 0.015 m
- Plasterboard panel, 0.0125 m.

The wall is well-insulated in light of the attained thermal transmittance of 0.245 W/m^2K, but extremely lightweight due to the specific mass equal to 46.7 kg/m^2. In order to evaluate the role of thermal inertia, the study deals with dynamical simulations of the considered building through different combinations of vertical wall stratigraphies, but at parity of thermal transmittance. In particular, four different external wall layering and three different types of natural ventilation and shading devices operation modes, were considered. Preliminarily simulations consisted in the replacement of the internal air cavity with a massive layer made by loose sand that allowed for the augment of the wall specific mass. In other two sets of simulations, the replacement of the internal OSB panel was provided in order to facilitate the storage of thermal energy inside the wall. Because the latter obviously produced an increment of the thermal transmittance, a consequent augment of the external insulation layer was operated from 0.050 m to 0.055 m in order to maintain a constant heat loss coefficient. Three different conditions for the thermal indoor environments were considered for dynamics simulations, see Table 1: in every case, radiant panels are used for the room air-conditioning. For the evaluation of energy requirements, a limit case, without natural ventilation and solar protection, was considered (C0), whereas in the second one the sole contribute of the natural ventilation was implemented (C1). Finally, in the last one the activation of solar shading devices in conjunction with the natural ventilation, was taken into account (C2).

Table 1 List of the different conditions implemented for the indoor environments in order to determine the energy requirements in function of the investigated external wall layering

		CONTROL PARAMETERS
C 0	Combination # 0	Heating and Cooling conditioning through active layer on the floor powered by pumps. No free cooling. No solar protections.
C 1	Combination # 1	Heating and Cooling conditioning through active layer on the floor powered by pumps. Overnight free cooling in Summer, 0.5 ACH from 00:00 to 05:00. No solar protections.
C 2	Combination # 2	Heating and Cooling conditioning through active layer on the floor powered by pumps. Overnight free cooling in Summer. 50% solar protections depending on indoor thermal conditions.

1. Dynamic simulations results

Regarding the different modes to conduce the reference building in terms of natural ventilation and solar protection, in Table 2 the energy requirement for heating and cooling (in kWh) are reported for each considered envelope configuration. Clearly, the inclusion of loose sand on the inner side of vertical walls produces a reduction of energy demands, both in winter and in summer, and the highest savings in percentage term was detected for the combination (C0). In particular, with reference to the base layering described with the internal OSB panel, an energy saving of 18% combining heating and cooling was achieved by filling the vertical walls by sand. Moreover, similar energy savings can be observed both in winter and in summer, with a slight prevalence of the first. When a more conductive plasterboard layer replaces the internal OSB panel, the storage properties are furthermore improved, especially in summer, reaching at annual level a percentage reduction of 31%. This effect is justified by the possibility to transfer more thermal power inside the building fabric due to the higher thermal conductivity of the plasterboard than the OSB panel. Similar energy savings in percentage results have been detected by adding the nocturnal free cooling (C1), observing an equalization of the results between winter and summer with the internal OSB removal. In every case, the natural ventilation produced an evident worsening of the heating demands, whereas an imperceptible improvement was detected in summer. However, the heavyweight envelope configuration allows for the augment of the energy savings, therefore the natural ventilation exalts the exploitation of the thermal mass. Finally, the addition of the solar protection of the indoor environment, produced a reduction of the percentage energy savings due to the noticeable decrement of the cooling requirements. Indeed, external shading devices, that reduce the incident solar radiation of 50% when indoor overheating risks occur, produce an evident decrement of the cooling requirements that prevails on the slight increment of the heating ones. Again, the solution with the internal

plasterboard layer wrapping the sand layer thick 5 cm on the inner side, produced the best building envelope configuration by attaining the lowest energy demands.

Table 2 Heating and cooling requirements in function of the investigated external wall layering and for the different conditions considered for the air-conditioned rooms

Free Cooling		OFF	Solar Protection		OFF	Combination # C0			
0.1	OSB + Plasterboard + Air		0.2	OSB + Plasterboard + Sand					
0.3	Plasterboard + Air		0.4	Plasterboard + Sand			GAIN / LOSS		%
0.1	Heating Demand	Cooling Demand	0.2	Heating Demand	Cooling Demand	0.1.2	Heating Demand	Cooling Demand	GAIN
	-3250.11	4439.66		-2485.04	3789.62		765.06	650.04	18%
	7689.76			6274.66			1415.10		
	kWh			kWh			kWh		
0.3	Heating Demand	Cooling Demand	0.4	Heating Demand	Cooling Demand	0.3.4	Heating Demand	Cooling Demand	GAIN
	-3521.18	4847.00		-2353.09	3453.27		1168.10	1393.73	31%
	8368.18			5806.36			2561.82		
	kWh			kWh			kWh		
Free Cooling		ON	Solar Protection		OFF	Combination # C1			
1.1	OSB + Plasterboard + Air		1.2	OSB + Plasterboard + Sand					
1.3	Plasterboard + Air		1.4	Plasterboard + Sand			GAIN / LOSS		%
1.1	Heating Demand	Cooling Demand	1.2	Heating Demand	Cooling Demand	1.1.2	Heating Demand	Cooling Demand	GAIN
	-4191.99	4441.72		-3367.21	3724.72		824.78	716.99	18%
	8633.70			7091.93			1541.77		
	kWh			kWh			kWh		
1.3	Heating Demand	Cooling Demand	1.4	Heating Demand	Cooling Demand	1.3.4	Heating Demand	Cooling Demand	GAIN
	-4617.83	4887.75		-3176.79	3410.94		1441.03	1476.81	31%
	9505.58			6587.73			2917.85		
	kWh			kWh			kWh		

Free Cooling		ON	Solar Protection		ON	Combination # C2			
2.1	OSB + Plasterboard + Air		2.2	OSB + Plasterboard + Sand					
2.3	Plasterboard + Air		2.4	Plasterboard + Sand			GAIN / LOSS		%
2.1	Heating Demand	Cooling Demand	2.2	Heating Demand	Cooling Demand	2.1.2	Heating Demand	Cooling Demand	GAIN
	-4774.83	3082.61		-4397.07	2733.53		377.76	349.08	9%
	7857.43			7130.59			726.84		
	kWh			kWh			kWh		
2.3	Heating Demand	Cooling Demand	2.4	Heating Demand	Cooling Demand	2.3.4	Heating Demand	Cooling Demand	GAIN
	-4921.69	3197.98		-4224.52	2523.42		697.17	674.56	17%
	8119.67			6747.94			1371.73		
	kWh			kWh			kWh		

2.2 Dynamic indoor air temperature trends

With the aim to evaluate the transient thermal behaviour of the different building configurations, dynamic analysis involving the indoor air temperature of the BR1 room, have been considered. This room was selected because its unfavourable South exposition increases the risk of summer overheating and it is equipped with the wider storage surface, which means more evident effects connected to the thermal inertia. Analysis relate to thermal behaviour of BR1 for four different layer's combinations and for two different conductions of indoor environments (C0 and C1). Figure 2 shows the indoor air temperature trends for three consecutive days during winter (1-3 January) and summer (1-3 August). In January, the initial temperature for every heated room was set to 10°C. For every graph, the two trends refer to the layering equipped with sand and for the same layering in the lightweight configuration. Table 3 lists the stratigraphy characteristics specifying the layer thicknesses, the thermal transmittance, the periodic thermal transmittance and the specific surface mass of the wall. It is interesting to highlight that the application of the loose sand inside the layering produces an increment of the surface mass of 192% for stratigraphy 2 and of 244% for the stratigraphy 4.

Table 3 Description of the layering considered in the energy analysis with the correspondent values of thermal transmittance (U), periodic thermal transmittance (Y_{IE}) and specific surface mass (SF)

.1 Stratigraphy	.2 Stratigraphy	.3 Stratigraphy	.4 Stratigraphy
• *External insulation,0.050 m* • *OSB panel, 0.015 m* • *Bitumen water and vapour control sheet, 0.0006 m* • *Timber frame with external air cavity and mineral insulation into the gap, 0.160 m* • *OSB panel, 0.015 m* • *Second order timber frame, internal cavity full of **AIR**, 0.050 m* • *OSB panel, 0.015 m* • *Plasterboard panel, 0.0125 m*	• *External insulation,0.050 m* • *OSB panel, 0.015 m* • *Bitumen water and vapour control sheet, 0.0006 m* • *Timber frame with external air cavity and mineral insulation into the gap, 0.160 m* • *OSB panel, 0.015 m* • *Second order timber frame, internal cavity full of **SAND**, 0.050 m* • *OSB panel, 0.015 m* • *Plasterboard panel, 0.0125 m*	• *External insulation,0.050 m* • *OSB panel, 0.015 m* • *Bitumen water and vapour control sheet, 0.0006 m* • *Timber frame with external air cavity and mineral insulation into the gap, 0.160 m* • *OSB panel, 0.015 m* • *Second order timber frame, internal cavity full of **AIR**, 0.050 m* • *Plasterboard panel, 0.0125 m*	• *External insulation,0.050 m* • *OSB panel, 0.015 m* • *Bitumen water and vapour control sheet, 0.0006 m* • *Timber frame with external air cavity and mineral insulation into the gap, 0.160 m* • *OSB panel, 0.015 m* • *Second order timber frame, internal cavity full of **SAND,** 0.050 m* • *Plasterboard panel, 0.0125 m*
U = 0.24 W/m^2K	*U = 0.24* W/m^2K	*U = 0.25* W/m^2K	*U = 0.25* W/m^2K
Yie = 0.007 W/m^2K	*Yie = 0.007* W/m^2K	*Yie = 0.009* W/m^2K	*Yie = 0.009* W/m^2K
SF = 46.70 Kg/m^2	*SF = 136.60* Kg/m^2	*SF = 36.90* Kg/m^2	*SF = 126.85* Kg/m^2

In the first two graphs, the advantages consequent the application of the sand during winter are evident due to the reduction of the winter overheating. The temperature peaks are connected to the lacking of the solar control by the shading devices, however these peaks result more attenuated for the heavyweight envelope configuration. Furthermore, the indoor air temperature oscillations are more attenuated, therefore the comfort conditions obviously benefit of such situation. In summer the trends is different, because the heavyweight envelope produce indoor air temperatures greater than the correspondent lightweight configuration. Indeed, during night the latter is subjected to a better cooling, because it is not able to store a significant quantity of thermal energy. Consequently, during the first hours of the day, the heavyweight room starts from higher indoor air temperature, however the increment is less pronounced and the peaks are almost coincident. During the afternoon, especially for the layering N° 4, the sand produces a slower decrement and the air temperature and the difference during night could be greater than 2 °C compared to the correspondent lightweight configuration. Furthermore, it possible to highlight that sand produce a reduction of the temperature peaks, with lower thermal load and correspondent energy savings. Moreover, the presence of hotter vertical surface in summer determines a better exploitation of the radiant emitters that, at parity of inlet temperature, are able to provide a greater cooling load. Again, temperature oscillations are less marked with consequent advantage for the thermal comfort conditions.

The same trends were detected for the room with natural ventilation and solar protection; obviously, the temperature peaks are less pronounced, however the role of the sand to mitigate the indoor air temperatures oscillations and peaks appears more evident than the prior case.

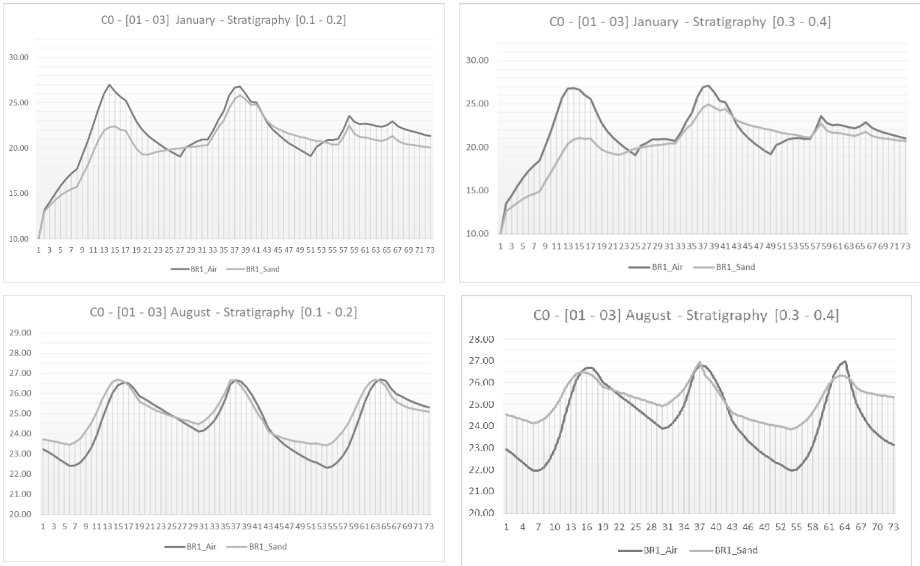

Figure 2 Trends of the indoor air temperature for the room BR1 in winter and summer for the four layering listed in Table 3 for the strategy (C0) for natural ventilation and solar protection

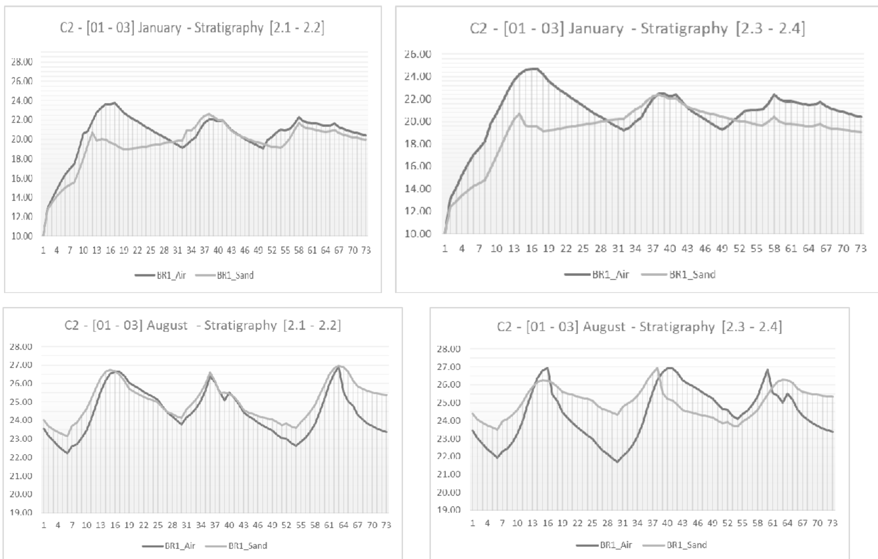

Figure 3 Trends of the indoor air temperature for the room BR1 in winter and summer for the four layering listed in Table 3 for the strategy (C2) for natural ventilation and solar protection

3. Conclusions

nZEBs in the Mediterranean area has to be designed adequately in order to avoid the risk of indoor overheating, especially in summer. For this reason, thermal inertia represents a crucial aspect in order to optimize the thermal performance of the building fabric conciliating the conflicting needs between heating and cooling applications. However, the attainment of adequate thermal mass in wooden nZEB appears a difficult target. In this paper, the hypothesis to increase the thermal inertia of these building with the application of massive layers inside the vertical walls, with the aim to minimize the annual energy consumptions, was investigated. Because external wall often are equipped with internal air-gaps, the possibility to fill these spaces with loose sand to increase the surface specific mass, was explored. Regarding a reference building, different vertical wall layering, with and without sand layers, were studied by evaluating also the role of natural ventilation as well as that of external shading devices. Results provided by the TRNSYS simulation software, in transient conditions and with climatic data of a Mediterranean locality, have shown an improvement of the thermal performances of wooden nZEBs made more heavy by the employment of loose sand. In particular, the application of a layer thick 5 cm, that replace an existing air-gap inside the wall, is able to reduce significantly both heating and cooling requirements. In the worst case, where natural ventilation and envelope solar protection were not considered in the simulated building, the heavyweight configuration was able to reduce heating demand of 765 kWh and cooling demand of 650 kWh. At annual level, the energy savings amounted to a percentage reduction of 18%. By replacing the internal OSB panel, hypothesised in the initial layering of the reference building, with a more conductive plasterboard panel, a noticeable improvement of the results was observed. In particular, heating savings rose to 1168 kWh, whereas cooling demand decreased of 1393 kWh. The plasterboard, in fact, exalts the envelope storage characteristic if equipped with sand because a greater amount of thermal energy was transferred inside the wall. At annual level, the percentage energy saving rose to 31%. Similar results were detected considering the sole natural ventilation; however, with reference to the same building constituted by vertical walls equipped with a plasterboard panel on the inner side, the heating demand decreased of 1441 kWh whereas the cooling savings rose to 1476 kWh. Therefore, the natural ventilation allowed for a better exploitation of the building thermal mass, both in winter and in summer. Finally, a real case including the operation of external shading devices for the control of the transmitted solar radiation inside the indoor environments, was considered. Due to a natural decrement of the cooling demands and of a natural worsening of heating requirements, in the best case the heavyweight envelope led to a reduction of first of about 674 kWh and of 697 kWh for the second. At annual level, a percentage reduction of 17% was quantified by considering the plasterboard panel on the inner side of the vertical walls. The analysis of the indoor air temperature of a reference room, more penalized during summer, proved that the proposed layering with internal sand produced a reduction of the temperature peaks, with consequent energy advantages, as well as an evident limitation of the internal temperature oscillations that surely helped to improve internal thermal comfort.

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DECISION MAKING AND EVALUATION TOOLS

Multi-criteria decision support system for urban energy group planning and decision-making activities

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keywords: Urban Energy Planning (UEP), Multi-Criteria Spatial Decision Support System (MC-SDSS), Interactive Group Decision-Making, Geographic Information System (GIS)

Abstract
The choice among Urban Energy Planning (UEP) scenarios is broadly based on multi aspects. Hence, the Multi Criteria Analysis (MCA) basing on stakeholders-oriented approach plays a fundamental role in implementing the effective strategies. In this regard, the use of proper supportive tools and methods to address the complex interactions of UEP purposes are needed. This study aims at presenting the final result activities of a national Smart City & Communities project, named "EEB-Zero Energy Buildings in Smart Urban Districts", which is the development of a new Multi-Criteria Spatial Decision Support System (MC-SDSS) for UEP. This tool facilitates the group decisional processes for stakeholders by creating "what-if" questions and visualizing "if-then" scenarios on-the-fly. Specifically, the study focuses on the definition of different energy retrofitting scenarios for the built environment, based on stakeholders' preferences. Accordingly, different decision scenarios have been developed representing a set of retrofitting measures basing on the different hierarchy of preferences of the stakeholders as "stakeholders-oriented" scenario. The tool has been applied and tested to a demonstrator case-study, related to a medium-sized city of the metropolitan area of Turin.

1. Introduction

In recent decades, cities are the main energy consumers in the world contributing to carbon dioxide (CO2) emissions and the leading cause of climate change. Many cities are facing enormous challenges in managing rapid urbanization, which is increasing from the beginning of 20th century (UN-HABITAT, 2009). Over half of the world's population currently are settling in urban areas and expecting to have this number increased to 64-69% by 2050 (IPCC, 2014). Moreover, urban sprawl and the way that cities are growing and operating are among the most visible consequences, along with the increasing of substantial detrimental impacts on the environment and its energy demand (Jaeger et al., 2010). Interestingly, urban areas account for about two-thirds of the world energy (United Nations, 2010).

Cities therefore play a significant role in resolving acute challenges related to climate change and energy transition (IEA, 2016). With the increasing importance of urban areas, among the 17 Sustainable Development Goals (SDGs) identified by UN Agenda 2030, goal 11 is completely dedicated to sustainable cities and communities. Particularly, Goal 11 emphasises the better urban planning and management of cities and human settlements with the aim at making them inclusive, safe, resilient and sustainable (UN General, 2015). In fact, cities are the decisive framework for the development of new strategies and approach in facing climate change and energy transition giving concrete and rapid solutions for more sustainable and eco-friendly human development (UN General, 2015). However, most urban planning systems do not have evaluation and monitoring as an integral part of their operations (UN-HABITAT, 2009). Clear indicators are needed to be integrated within each urban planning systems to monitor and evaluate tactics, strategies and processes. Although a larger scale approach is preferable to a building scale, this concept requires considering an all-new set of sustainability variables, and involving numerous new stakeholders, thus extremely complexifying the decision-making activities. In fact, due to many influences and factors in large-scale plans, their impacts are very difficult to be assessed.

For this reason, new tools and methodology are needed in order to plan of more sustainable cities addressing multiple objectives such as reduction of energy consumption, increase in energy efficiency of systems and adaptation of urban areas to climate change at the same time (Brandon and Lombardi, 2011). According to the current trend, it has now been proven that there is a need to rethink energy efficiency measures at a larger scale, considering the built environment as a tile of a wider area, thus better exploiting the potential synergies between buildings, in economic, social and environmental terms (Torabi Moghadam et al., 2017).

The whole process is indispensable to guarantee a future sustainable urban transformation by investing responsibly in alternative consumption patterns and greener strategies and speeding the decision-making process through participation and intuitive visualization.

According to the given background, this study presents the final result activities of a national Smart City & Communities project, named "EEB-Zero Energy Buildings in Smart Urban Districts", which is the development of a new Multi-Criteria Spatial Decision

Support System (MC-SDSS) for Urban Energy Planning (UEP). This tool facilitates the group decisional processes for stakeholders by creating "what-if" questions and visualizing "if-then" scenarios on-the-fly. Moreover, the study focuses specifically on the definition of different energy retrofitting scenarios for built environment, based on stakeholders' preferences. Accordingly, different decision scenarios have been developed representing a set of retrofitting measures basing on different hierarchy of preferences of the stakeholders: "stakeholders-oriented" scenario. The tool has been applied and tested to a demonstrator case-study, related to a medium-sized city of the metropolitan area of Turin, named Settimo Torinese.
The rest of the paper is organized as follows: details of the proposed framework are illustrated in Section 2. Section 3 presents the results which is the application of the proposed methodology to the case study. This application is used for testing the effectiveness of the proposed framework. Finally, conclusive remarks are discussed in Section 4 and future developments are identified.

2. Methodology

This work assembles research outcomes aiming to illuminate innovative solutions bridging the limitations of the current field of research of UEP, which consists in four main phases of planning according to (Mirakyan and De Guio, 2015): (i) Phase I-Preparation and preliminary analysis; (ii) Phase II-Detailed urban buildings energy modelling; (iii) Phase III-Prioritization and decisional process and (iv) Phase IV-Implementation and monitoring. The methodological framework of this study integrates the first three main phases of UEP presented above, where in each phase several steps, tools and methodologies are involved (Cajot et al. 2017). The specific attention is paid to space heating energy consumption of the residential building stock. The research

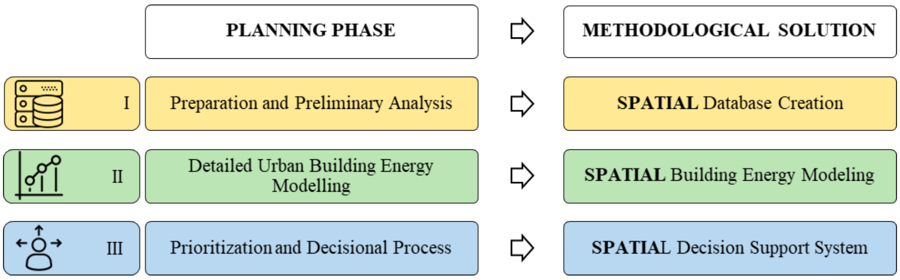

Figure 1 Summary of methodological framework solution for each phase of planning through this study.

The integration of this technical know-how leads to urban energy map evaluating economic, environmental, social and technical indicators resulting from the evaluation of energy saving scenarios. This provides a supportive tool for the urban actors in the group decision making planning processes. Moreover, it allows several stakeholders having different conflicting interests to gather and discuss the issues of several urban saving scenarios (Torabi Moghadam et al., 2019). A new MC-SDSS is an interactive plug-in of ArcGIS 10.3 (www.arcgis.com) environment in order to help dynamically analyze the energy retrofitting scenarios based on the stakeholders' preferences over an urban scale. To this end, in Figure 2 a schematic flowchart of the integrated methodological approach is shown. The methodological approach of this study is presented in a very detailed way in (Torabi Moghadam and Lombardi, 2019).

(i) **Phase I-Spatial database creation**: the study started from collecting the quantitative data and information which led to characterize the building stock and to create a supportive geo-database. This phase is the supportive basis of all next phases (II and III). The GIS database can be continuously updated joining more geo-referenced and non-georeferenced (they need to be geocoded) data into the framework. All the collected data have been then overlapped and integrated into each building polygon in GIS platform. Into this end, the 2D-GIS-database has been created including the several factors, which may effect of the building energy issues. The use of GIS was crucial at the urban scale due to its powerful spatial visualization features and its multiple layers representation.

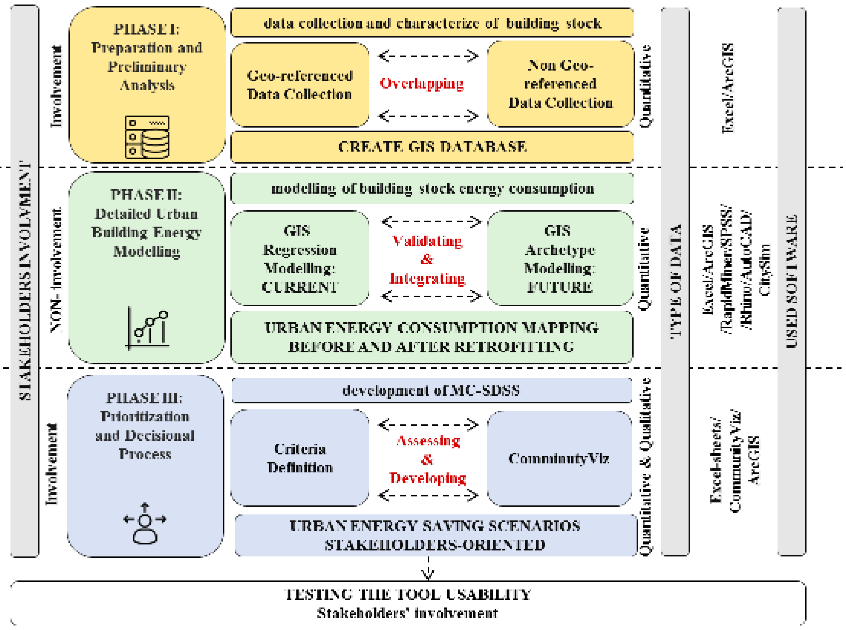

Figure 2 A schematic overview of the methodological approach, elaborated from (Torabi Moghadam and Lombardi, 2019).

(ii) **Phase II-Spatial building energy modelling**: the main goal of this phase was to assess the building stock space heating energy consumption at the current and future city status. The modelling approach is based on the integration of statistical analysis with 2D-GIS (for the current status) and the engineering analysis with 3D-city model (for the future status) (Torabi Moghadam et al., 2018); (Torabi Moghadam et al., 2019); (Mastrucci et al., 2013). In fact, the methodology framework combines both the statistical and engineering approaches to obtain a more robust prediction of the urban energy consumption (Nouvel et al., 2015). The framework is performed in order to assess and to design urban energy saving scenarios. A spatial distribution of urban building energy consumption both in 2D and 3D visualization provides Spatial Decision Support System (SDSS) tool in order to identify the hot-spots zone to make the better decisions and to avoid unnecessary investments.

(iii) **Phase III-Prioritization and decisional process**: the main goal of this phase was first to identify the most relevant evaluation criteria, both qualitative and quantitative through an organizing a workshop involving stakeholders. The definition of evaluation criteria side-by-side the real local stakeholders led to have reliable results that grantee the robustness of planning process. In this study, the "Playing Cards" method is chosen to select the most relevant criteria (Simos, 1990); (Lombardi et al., 2017). Consequently, all the selected evaluation criteria have been assessed and analysed to be implemented in a new MC-SDSS tool. The new MC-SDSS is modelled and coded using an existing interactive plug-in in the GIS environment , called CommunityViz (Kwartler and Bernard, 2001). Since this tool is interactive can provide dynamic feedbacks on changing the assumptions and viewing the influences of changes on the future scenarios in real-time. Furthermore, it engages stakeholders in participative and group decision-making processes through its visualization features in real-time. Finally, a workshop is organized on to test the usability of the tool and to understand its weaknesses and strengths from the stakeholders' point of view.

3. Results

This section demonstrates the tool interface and how it is able to make different dynamic scenarios. All the results and outputs are integrated and assembled to create a new MC-SDSS tool, which came from the introduced phases in Figure 2. The MC-SDSS is an interactive plug-in in GIS environment, which has been adapted from CommunityViz. CommunityViz is an ArcView modular GIS-based decision support system (http://www.communityviz.com) consisting of two main components: (i) Scenario 360 to map and analyse, and (ii) Scenario 3D to visualize (Kwartler and Bernard, 2001).

This dynamic process aids meaningfully in sharing information with the urban actors in a very simple visualization manner providing maps, alerts and charts for such a complex problem as UEP (Wang et al., 2009). Figure 3 shows the interface of Scenario 360 modelled for the specific case study of medium-sized Italian city, Settimo Torinese. Particularly, the tool consists in building dynamic attributes, which are changeable based upon: dynamic data, assumptions (sliders) and indicators.

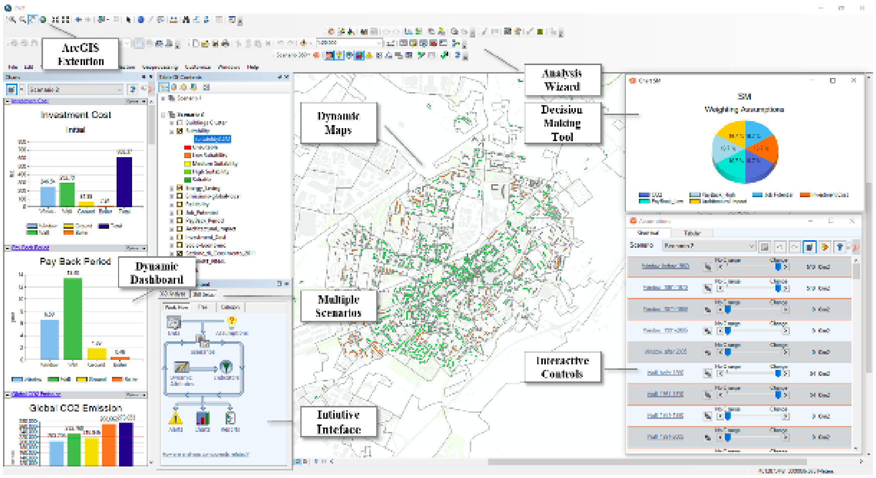

Figure 3 CommunityViz Interface; the case study of Settimo Torinese, source (Torabi Moghadam and Lombardi, 2019)

Moving the sliders bars, the stakeholders can define different dynamic scenarios and visualize the impact of their preferred assumptions. The impact of different scenarios is consequently visible through different charts, maps and indicators. Moreover, the tool provides the ability of comparison among different scenarios and indicators.

Figure 4 shows an example of one of the scenarios defined by stakeholders, so-called "stakeholder-oriented" scenario. In this specific scenario, the stakeholders replaced the glazing ratio windows of older buildings and they isolated the walls and floors of building age 1961-1990; while, they preferred to do not renovate any intervention in terms of energy system. This decision was made because they wanted to see the impact of the envelope system refurbishment that leads to significantly reduce the energy consumption. In this phase of work, the aim of defining different scenarios is not to find the "best" performance scenarios, but it is to test the usability of the tool experimenting it.

As a result, stakeholders can visualize all the criteria related to the following indicators at the urban level both for each retrofit measure and for the total value considering all the measures: (i) total energy consumption (GWh); (ii) energy saving reduction (%); (iii) initial investment costs (M€); (iv) investment cost (€/m2), (v) PBP (year), (vi) CO^2 emissions (tonnes); (vii) CO^2 emissions (tonnes/GWh), (viii) local emissions NO_X (tonnes) (ix) local emissions PM_{10} (kg); (x) job potential (man-day), (xii) architectural impact (rank), and (xiii) reliability of the retrofitting measure (rank).

4. Conclusions

This study integrates different energetical, economical, societal, technical and environmental performances of building retrofitting interventions. The research boundaries are specifically focused on an existing building stock in European context. The relative data and information of the building stock is first collected and geolocated in order to model the energy consumption patterns at the current and future status of the city. The geospatial database was used as the object of multi-criteria analysis assessments. Finally, an interactive MC-SDSS was created to support the decision makers in defining energy saving scenarios in real-time. Within the use of this GIS extension, public administrative users, such as urban energy planners, policymakers and built environment stakeholders can plan, design and manage sustainable cities. This plug-in provides the stakeholders with the ability to visualize interactively and explore a range of possible futures saving scenarios. This methodological approach provides a significant innovative progress in the research field, that is developing an interactive plug-in tool for UEP in the GIS environment.

Figure 4 an example of one of the scenarios defined by stakeholders, so-called scenario 2 "stakeholder-oriented".

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Conflict of Interest Conflicts of Interest
The authors declare no conflicts of interest.

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Eco-efficiency Assessment of Administrative Divisions in 42 Countries Based on Environmental Impact and Gross Regional Product

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Keywords: LCIA method, Endpoint-type, GRP, OECD, Local government

Abstract

In recent years, some international frameworks such as the Sustainable Development Goals (SDGs) and the Paris Agreement, have promoted environmental practices for enterprises around the world. It is important for enterprises in each country to decide their environmental policies after carefully examining their own economic circumstances. Within this context, environmental accounting—a system in which an enterprise reports its environmental activities quantitatively in monetary terms—should be performed not only by private companies but also local governments. However, it may not be easy for government agencies to objectively measure their current environmental impact, and there is currently no internationally standardized methodology of environmental accounting for local governments.

An important concept in life cycle assessment research, is life cycle impact assessment (LCIA), which is the quantitative measurement of environmental impact through the life cycle of products and services. A methodology whereby the environmental loads of several impact categories are integrated into a simple indicator expressed in a monetary unit has already been developed. Thus, this paper attempts to quantify the environmental efficiency of administrative divisions in 42 countries, most of which are OECD members. Here, environmental efficiency is based on both environmental impact, which is calculated by LCIA methods, and gross regional product (GRP). This research is expected to provide new information for local governments around the world to use in environmental accounting.

1. Introduction

In recent years, some international frameworks, such as the Sustainable Development Goals (SDGs) and the Paris Agreement, have promoted environmental conservation in countries around the world. It is important for enterprises around the world to decide their environmental policies after carefully examining their own economic circumstances. Enterprises should therefore seek to build consensus on their future paths based on the relationship between the environment and the economy. Environmental accounting—a system in which an enterprise reports its environmental activities quantitatively in monetary terms—is mainly used in private companies, although there are some examples of local governments which have aggressively introduced this system. For example, the local government of Eurobodalla in Australia publishes annual statistics on the sustention of assets for environmental conservation. The cities of Sabae and Yokosuka in Japan also publish environmental accounting on an annual basis using one-of-a-kind methods. These governments struggle to calculate not only environmental costs but also environmental conservation effects, and it is difficult for local governments to measure the environmental value of their own administrative divisions in an objective way. Therefore, an international standard of environmental accounting for local governments has not been established and these systems have not been implemented worldwide.

An important concept in life cycle assessment research is life cycle impact assessment (LCIA), which is the quantitative measurement of environmental impacts throughout the life cycle of products and services. A methodology has been developed whereby the environmental loads of several impact categories, such as "climate change" and "land use," are integrated into a simple indicator. Several assessment methods that include the theory of integration have already been developed, such as ExternE and EPS. However, there is

no nation that officially incorporates this assessment theory into calculations of environmental conservation effects across all governmental agencies for set periods of time. Some studies have used a scientific methodology to assess the environmental impacts of geographic areas, such as areas of countries or communities; for example, "carbon footprint" and "land footprint". However, standard systems that comprehensively utilize these research outcomes to measure governmental agencies' environmental value have not yet been established. It is therefore possible that LCIA may provide useful knowledge that will help in constructing a unified methodology for the environmental accounting of local governments.

In a previous study using the LCIA method, the authors carried out an environmental impact assessment of 42 countries, most of which are OECD members [1]. The study leveraged the assessment theory of LIME- 3 (Life-Cycle Impact Assessment Method Based on Endpoint Modeling 3), which was developed in 2018 [2- 9]. This endpoint-type and global-scale LCIA method reflects environmental conditions from around the world. Results are calculable in monetary units while integrating the environmental loads of several impact categories. Based on this, the research reported herein attempted to operationalize "eco-efficiency for productivity (unit: dimensionless)" for administrative divisions of 42 countries, dividing the annual value of Gross Regional Product (GRP) (unit: USD) by the annual value of environmental loads (unit: USD). Results are presented on world maps to visually capture spatial heterogeneities in the results. Through comparative consideration of the eco-efficiency of each administrative division based on these indicators, this study seeks to provide new knowledge to inform the decision-making process of public administrators with respect to environmental policies based on economic circumstances, best practices of other local governments, and trends in environmental impact around the world.

2. Assessment Method

2.1. Fundamentals

The assessment period of this study is defined as the fiscal operating period of the local governments in order to avoid confusion between financial and environmental statistics. This is basically defined as one year, with flexibility to account for the availability of information. The assessment scope of this study is defined as all sectors, including industry, consumers, transportation, and households, since local governments are accountable to a wide range of constituencies within their jurisdictions.

2.2. Summary of LIME-3

This study utilizes LIME-3 to measure the total amounts of environmental loads as described above. LIME-3 has several methods of calculation for different countries around the world and is able to assess environmental impact based on their respective environmental conditions. The assessment framework for LIME-3 is shown in Figure 1.

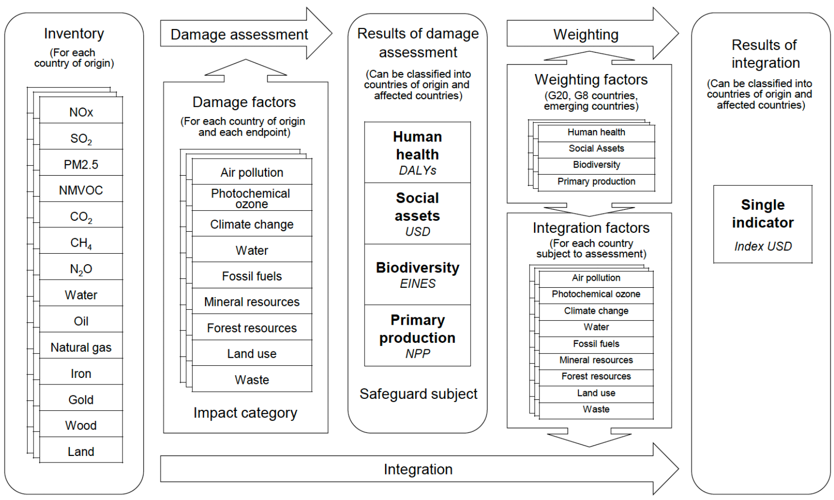

Figure 1. Assessment framework of LIME-3 [2]

The assessment processes of LIME-3 are divided into two steps, the damage assessment and the integration, and each factor list is provided in order to calculate the results for different assessment purposes. This study aims to calculate assessments as an integrated simple indicator in terms of monetary units; the integration factor lists were used accordingly. The integration factors are provided for each of the following: hazardous substances, impact categories, countries of origin, and safeguard subjects. Incidentally, these factors are calculated as a reflection of the causal relationship between the countries of origin and the affected countries for environmental impact. For example, in regard to air pollution, LIME-3 is able to calculate the results while considering the movement of hazardous substances across borders. The assessment results with the simple indicator converted into a monetary value (USD) are obtained by multiplying these factors with corresponding inventory data and summing these values. The calculation formula is described as follows.

$$SI = \sum_{impact} \sum_{X} Inv(X) \times IF^{impact}(X) \qquad (1)$$

SI : Single indicator (Damage amount of environmental impact) [USD]

$Inv(X)$: Inventory of substance X [kg] $IF^{impact}(X)$: Integration factor of substance X [USD/kg]

The framework of LIME-3 has nine impact categories, such as "Climate change" and "Air pollution." Some environmental hazardous substances, such as CO2 and fine particulate matter (PM2.5), are used as inventory items in each impact category. The four safeguard subjects, "Human health," "Social assets," "Biodiversity," and "Primary production," are shown in the corresponding impact category. In the LIME-3 framework, the calculated results of 4 safeguard subjects are weighted by conjoint analysis based on a survey of people's values through the process of the integration. This survey targeted residents of G20 countries. Using this, assessment results converted into monetary value can be calculated as a reflection of each nation's environmental values. Moreover, the average integration factors are provided in order to calculate the assessment results under the same conditions throughout the world. Thus, LIME-3 has several calculation procedures for its various assessment purposes.
There are other global-scale LCIA methods, such as LC-IMPACT, IMPACT World+, and EPS. Based on our requirements, LIME-3 is the most advantageous of the LCIA methods for the assessment of local government policies.

2.3. Definition of Eco-efficiency for Productivity
To measure environmental efficiency for each division systematically, one of the simplest methods is to compare these results with the Gross Regional Product (GRP) for each division around the world. GRP is the total amount of added value for all industries in a certain division in a certain period, expressed in monetary units. Gross Domestic Product (GDP) is a commonly used national economic indicator and GRP is the same indicator for regions within nations. On this basis, this study defined the eco-efficiency for productivity index (unit: dimensionless), dividing the value of GRP (unit: USD) by the value of damage (unit: USD) calculated above.

$$(Eco\text{-}efficiency\ for\ Productivity)\ [-] = \frac{(Gross\ Regional\ Product)\ [\mathrm{USD}]}{(Damage\ amount\ of\ environemtal\ impact)\ [\mathrm{USD}]} \qquad (2)$$

2.4. Targets for Assessment
As this study focuses on countries that belong to the Organization for Economic Co-operation and Development (OCED) [10], we utilize statistical information published by the statistics bureau of the OECD (OECD.Stat). This data was used mainly for assessments of administrative divisions. OECD.Stat aggregates data from the statistics bureaus of some countries, most of which are OECD members, and is a reliable source of information because it publishes uniform information about administrative divisions worldwide. In this study, we target 42 countries, of which 35 are OECD members. Data for seven non-OECD countries (Brazil, China, Colombia, India, Lithuania, Russia, and South Africa), for which information is readily available through OECD.Stat was also included. Required data which was unavailable through OECD.Stat was obtained from other international organizations or statistics bureaus in each respective country.
OECD.Stat defines the area classifications for all countries for which it publishes statistics at two territorial levels (TLs), a higher level (TL2) and a lower level (TL3). TLs are defined mainly according to the population of each unit. A TL2 unit consists of some number of TL3 units, and national land consists of some number of TL2 units. This definition is standardized within countries, and territories generally correspond to the administrative divisions of each country. This study therefore defines the area of assessment according to TL.
From the perspective of data availability, the minimum area unit of assessment was defined as TL3 units within the 35 OECD countries, and as TL2 units within the 7 non-OECD countries. Additionally, in cases that required data for units that were not available, estimated data was used.
2.5 Preparation of Data
First, the availability of LIME-3 inventory data by TL unit about 42 countries was assessed. In this study, the assessment period was the year 2015. In cases in which data for this year was not available, data from the year closest to 2015 was used instead. The availability of data is shown in Table 1. The table describes the availability of inventory data, main references, indicators for assessment of administrative divisions, and the minimum area unit for which data is available by impact category of LIME-3.

Table 1. Availability of inventory data by each impact category

Impact category	Inventory	Main reference	Indicator	Minimum area
Climate change	CO_2	Regional Social and Environmental Indicators by OECD.Stat	Emission amount [kg]	TL3
Air pollution	BCOC (PM2.5)	Air Emission Accounts by OECD.Stat	Emission amount [kg]	Country
Photochemical ozone	NMVOC (O_3)	Air Emission Accounts by OECD.Stat	Emission amount [kg]	Country
Waste	Waste	Regional Social and Environmental Indicators by OECD.Stat	Disposal amount [kg]	TL3
Water consumption	Water	Annual Water Consumption by OECD.Stat	Consumption amount [kg]	Country
Land use	Paddy field	The Global Land Cover by National Mapping Organizations (GLCNMO)	Current area [m^2]	TL3
	Cropland			
	Infrastructure			
Fossil fuels consumption	Fossil energy	Material Resources by OECD.Stat	Consumption amount [kg]	Country
Forest resources consumption	Wood	Material Resources by OECD.Stat	Consumption amount [kg]	Country

BCOC, black carbon/organic carbon; NMVOC, Non-methane volatile organic compounds.

Inventory data for "Land use" was taken from data published by the National Mapping Organization (NMO) [11]. All land use data was converted into TL3 units using ArcGIS (10.5) software. "Land use" in this study is limited to human-made areas, including paddy fields, cropland, and infrastructure, from the perspective of local government responsibility.

In cases where inventory data was not available by TL2 or TL3 unit, the required data was estimated based on proportionate distribution using other related data. The emission amounts of each substance, such as CO2 and SO2, were available only by country unit, and emissions in the industrial sector accounted for most of total emissions. Emission amounts were divided proportionally by TL2 or TL3 unit using data on the number of employees per division. Consumption of water, fossil energy, and wood was also available by country only, with consumption closely related to the lives of the citizenry. Consumption amounts were divided proportionally by TL2 or TL3 unit using population data. The "Mineral resources consumption" category was not included in this assessment because of a lack of detailed data and low estimation accuracy.

In this study the average integration factors above were used to unify the weighting of the 4 safeguard subjects for the same condition throughout the world. GRP data was also taken from OECD.Stat, and data by unit of TL2 and TL3 in a year 2015 was used for assessment.

3. Assessment Results and Discussion

In this section, we first describe the assessment results of environmental impact for administrative divisions in 42 countries. The results are shown using monetary value as an indicator, and this indicator can be interpreted as the annual amount of damage to the environment in each division. This indicator is called "Damage amount of environmental impact (USD)" in this study. Finally, we describe the topic of Eco-efficiency for administrative divisions.

3.1 Damage Amount by TL2

The environmental damage by TL2 unit for 42 countries is described in this section. Here, the damage amount per unit area and per capita for each TL2 was calculated. These results are shown in Table 2, which lists the average for each impact category and safeguard subject. The TL2 averages of total damage amounts per unit area and per capita were calculated as 540,000 USD/km2 and 2,960 USD/capita, respectively. The top three amounts per area unit by each impact category were "Fossil fuels consumption" (237,000 USD/km2), "Land use" (77,600 USD/km2), and "Water consumption" (72,900 USD/km2). The top three amounts per capita by each impact category were "Land use" (1,500 USD/capita), "Fossil fuels consumption" (736 USD/capita), and "Forest consumption" (245 USD/capita). TL2 unit is mainly defined based on the population size for each division, but the area of each division varies greatly. Consequently, the magnitude of the relationship of the average damage amount between per area unit and per capita differed accordingly for each impact category.

Table 2. Assessment results of damage amount by TL2

	Item	Damage amount per area [USD/km^2]	Damage amount per capita [USD/capita]
Impact category	Climate change	3.73×10^4	1.67×10^2
	Air pollution	1.33×10^4	2.51×10^1
	Photochemical ozone	9.76×10^2	2.23×10^0
	Waste	3.87×10^4	1.29×10^2
	Water consumption	7.29×10^4	1.55×10^2
	Land use	7.76×10^4	1.50×10^3
	Fossil fuels consumption	2.37×10^5	7.36×10^2
	Forest resources consumption	6.18×10^4	2.45×10^2
Safeguard subject	Human health	1.08×10^5	2.76×10^2
	Social assets	2.76×10^5	8.64×10^2
	Biodiversity	1.11×10^5	1.44×10^3
	Primary production	4.49×10^4	3.88×10^2
Summation		5.40×10^5	2.96×10^3

Number of samples: 677

3.2 Regionality of Eco-efficiency for Productivity

The assessment results for three indicators (GRP per capita, Damage amount per capita, and "Eco-Efficiency for Productivity") are shown on world maps to illustrate their regionality in the administrative divisions in the 42 sample countries. A world map showing the indicators for each TL is shown in Figures 2-4. Here, these indicators for all divisions are shown so that map colors are shown in 10% increments of cumulative frequency distribution. The median value of "Eco-Efficiency for Productivity" for all divisions was calculated as 13.6; values higher (lower) than this are shown in cold (warm) colors by each administrative division. The area unit of description on the map followed the minimum area of assessment as described above, which was TL3 within the 35 OECD countries, and TL2 within the 7 non-OECD countries.

In examining Figure 4, eco-efficiency tends to be higher in urban areas in each country, and lower in sparsely populated areas. However, detailed trends for each region were diverse, so there are opportunities to reflect on the characteristics of environmental loads within each region. Nest, we will look at each region in the world.

(1) North America: GRP per capita is relatively high in Canada and United States, but so too is the damage amount per capita in the densely populated areas of these countries. As a result, eco-efficiency did not tend to be high in most areas of North America. In detail, the value was lower in desert areas, and higher in urban areas of the West Coast, East Coast, and around the Great Lakes.

(2) South America: Eco-efficiency values tended to be lower in forest areas, and higher in urban areas. Damage amounts per capita were lower in the cities of Rio de Janeiro and Santiago, and the eco-efficiency values reflected these observations.

(3) Europe: Eco-efficiency tended to be high in many divisions. GRP per capita tended to be high in major urban areas of each country, and the value of eco-efficiency was also higher in these areas. Damage amount per capita was lower and GRP per capita was higher across Ireland, Switzerland, and Austria, therefore the value of eco-efficiency was highest level in throughout these countries.

(4) Africa: GRP per capita was reasonably homogenous between different divisions in South Africa. The damage amount per capita was comparatively low in the cities of Johannesburg and Cape Town, so the eco-efficiency values were slightly higher in these areas.

(5) Asia and Russia: Eco-efficiency values tended to be lower in sparsely populated areas in accordance with norms around the world and were higher in densely populated areas in East Asia. Damage amounts per capita tended to be lower, and GRP per capita tended to be higher in South Korea and Japan with eco-efficiency values reflecting these trends.

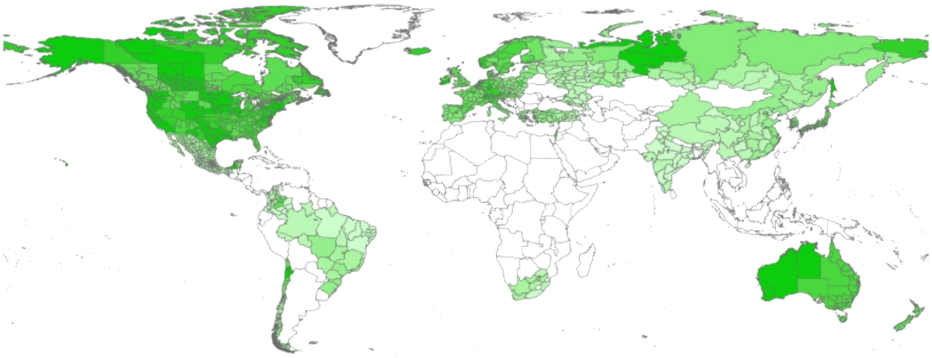

Figure 2. GRP per capita by administrative divisions, global

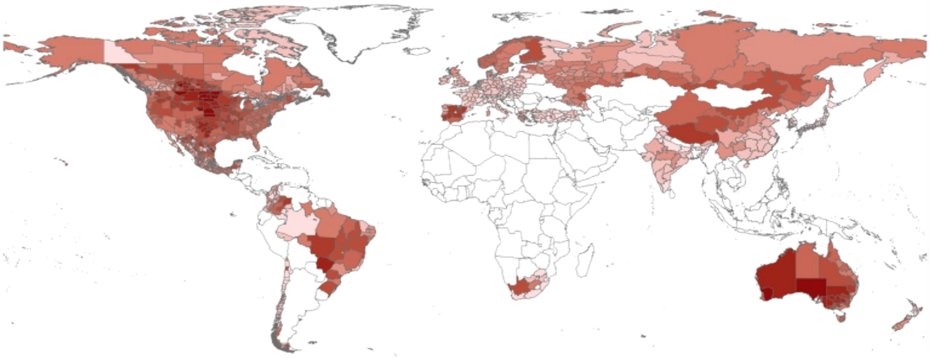

Figure 3. Damage amount per capita by administrative divisions, global

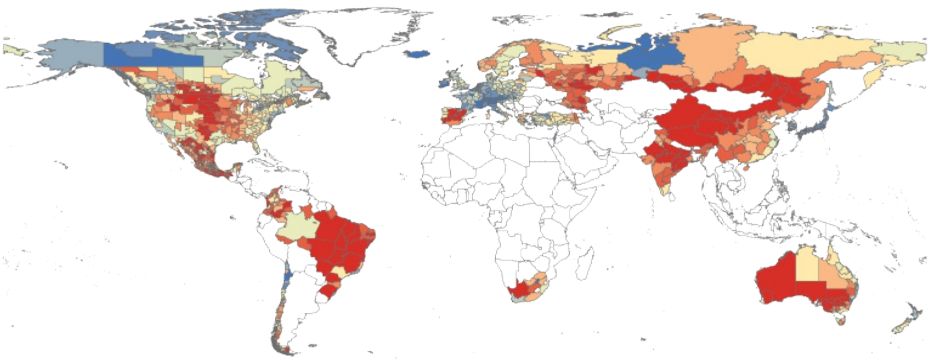

Figure 4. "Eco-efficiency for productivity" by administrative divisions

(6) Oceania: Eco-efficiency tended to be lower in the desert areas of Australia. Damage amounts per capita were lower in urban areas of the east coast of Australia and New Zealand, such as Sydney and Wellington so eco-efficiency values were comparatively high in these areas.

Overall therefore, eco-efficiency is highly regional both within and between countries, and knowledge and understanding of this regionality could provide important input for the effective design and implementation of environmental policies for realizing sustainable development objectives.

3.3 Assessment results for major cities

In recent years, urban populations around the world have continued to grow, and sustainable urban development is recognized as a global challenge. Here, 50 major cities were selected from the 42 sample countries and their assessment results by 3 indicators (GRP per capita, Damage amount per capita, and "eco-efficiency for productivity") are shown in Table 3.

Focusing on GRP per capita, the three most economically developed cities were Paris (112,000 USD/capita), Luxemburg (104,000 USD/capita), and Dublin (96,800 USD/capita). These cities are the national capitals of their respective countries. These results reflect their respective business climates in terms of goods, services, and tourism.

Table 3. Assessment results for 50 major cities

City	GRP per capita [USD/capita]	Damage per capita [USD/capita]	Eco-efficiency [-]	City	GRP per capita [USD/capita]	Damage per capita [USD/capita]	Eco-efficiency [-]
Sydney	4.67×10^4	1.81×10^3	25.8	Dublin	9.68×10^4	1.82×10^3	53.2
Melbourne	4.37×10^4	1.76×10^3	24.8	Reykjavík	4.77×10^4	8.55×10^2	55.8
Vienna	6.20×10^4	8.06×10^2	77.0	Jerusalem	3.65×10^4	7.19×10^2	50.8
Brussels	7.95×10^4	1.66×10^3	47.8	Roma	5.31×10^4	8.74×10^2	60.7
Rio de Janeiro	2.07×10^4	7.75×10^2	26.7	Tokyo	7.27×10^4	1.05×10^3	69.2
Sao Paulo	2.18×10^4	2.18×10^3	10.0	Seoul	3.96×10^4	1.18×10^3	33.7
Toronto	4.25×10^4	1.88×10^3	22.6	Vilnius	3.98×10^4	9.58×10^2	41.6
Vancouver	4.09×10^4	1.86×10^3	22.0	Luxembourg	1.04×10^5	1.89×10^3	55.0
Montreal	3.67×10^4	1.86×10^3	19.8	Riga	4.22×10^4	1.84×10^3	22.9
Zurich	7.58×10^4	7.48×10^2	101.2	Mexico City	3.73×10^4	1.29×10^3	28.8
Santiago	2.75×10^4	1.21×10^3	22.7	Amsterdam	8.50×10^4	1.65×10^3	51.4
Beijing	3.18×10^4	1.45×10^3	21.9	Oslo	8.44×10^4	6.21×10^3	13.6
Shanghai	3.04×10^4	1.39×10^3	21.9	Auckland	3.88×10^4	7.93×10^2	49.0
Bogota	1.24×10^4	1.75×10^3	7.0	Warsaw	7.61×10^4	1.27×10^3	59.7
Prague	7.28×10^4	1.67×10^3	43.5	Lisbon	4.16×10^4	1.79×10^3	23.3
Berlin	4.34×10^4	1.58×10^3	27.6	Moscow	5.37×10^4	1.79×10^3	30.0
Copenhagen	6.75×10^4	2.80×10^3	24.1	St. Petersburg	2.47×10^4	1.68×10^3	14.7
Madrid	4.75×10^4	1.24×10^3	38.4	Bratislava	7.13×10^4	1.29×10^3	55.2
Tallinn	4.08×10^4	4.92×10^3	8.3	Ljubljana	4.58×10^4	1.58×10^3	29.0
Helsinki	5.66×10^4	6.59×10^3	8.6	Stockholm	6.71×10^4	3.39×10^3	19.8
Paris	1.12×10^5	6.20×10^2	181.3	Istanbul	3.52×10^4	1.03×10^3	34.1
London	7.16×10^4	1.92×10^3	37.2	New York	6.89×10^4	2.89×10^3	23.8
Athens	3.48×10^4	9.01×10^2	38.6	Los Angeles	6.17×10^4	2.91×10^3	21.2
Budapest	5.87×10^4	8.28×10^2	70.9	Chicago	5.83×10^4	3.91×10^3	14.9
Delhi	1.55×10^4	7.38×10^2	21.0	Johannesburg	1.89×10^4	4.84×10^2	39.1

Focusing on damage amounts per capita, the bottom three cities were Johannesburg (484 USD/capita), Paris (620 USD/capita), and Jerusalem (719 USD/capita). Johannesburg is being developed as the flagship environmentally conscious city of South Africa, and the local government of Paris promotes sustainable tourism.

The assessment results may reflect the achievement of these efforts. On the other hand, the top three cities in terms of damage were Helsinki (6,590 USD/capita), Oslo (6,210 USD/capita), and Tallinn (4,920 USD/capita). Countries in Northern Europe are often heralded for their advanced environmental policies, but these results appear to reflect large consumption of heating energy because these cities are located in cold regions.

Focusing on eco-efficiency for productivity, the top three cities were Paris (181.3), Zurich (101.2), and Vienna (77.0). These cities are attractive tourist destinations and these results may reflect their active tourist industries with environmental loads which are low compared with their benefits. There could be an array of lessons to be learned from these cities to facilitate the implementation of best practices in other cities which are currently lagging in terms of eco-efficiency.

4 Conclusions

This study carried out an eco-efficiency assessment for administrative divisions of 42 countries in 2015 by use of the endpoint-type and global-scale LCIA method, LIME-3. The required inventory data was sourced mainly from the OECD. Eco-efficiency for productivity was calculated as GRP divided by amount of environmental damage. This study attempted to identify and explore global spatial regionalities in this indicator. Eco-efficiency was high in Ireland, Switzerland, Austria, South Korea, and Japan (country-level) as well as Paris, Zurich, and Vienna (city-level). The results herein are expected to contribute to the adoption of the LCIA method into the environmental accounting practices of local governments. Future research challenges can be identified in terms of collecting more inventory data for environmental impact assessment, and improving/validating methods for calculating eco-efficiency.

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Comparative analysis for the evaluation of sustainable mobility in urban scale environmental certification

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Abstract
The current organization of transport, characterized by the predominance of road traffic, with the use mainly of private vehicles, has strong negative consequences on the environmental, economic and social level.
In this context, the promotion of environmental certification systems is a necessary activity to promote efficient models of land use.
For some years now, we are approaching the development of certification systems on an urban scale (English BREEAM Communities, Japanese CASBEE for urban development, German DGNB NS, American LEED ND, Italian GBC Quartieri and ITACA protocol, even if not yet defined). It is mainly an assessment related to the neighbourhood scale, which represents the most adequate scale of intervention, having sufficiently large dimensions to appeal to the sustainability criteria.
These tools relate, among others, the objectives of sustainable mobility with the goals of territorial modelling; therefore, they are in fact able to give greater assurance about the environmental impact of interventions regarding the territory and human health.
Each of these neighbourhood scale certification systems is characterized by a particular set of evaluation criteria and different methods of analysis, and each focuses attention on some particular aspects.
Starting from a comparative analysis of the methods of approach of these tools to the evaluation of aspects related to mobility, the present work intends to evaluate the strengths and weaknesses of each of them in order to define which one is best suited to the Calabrian context.

1. Sustainable land use models

For several years the European Union has affirmed the role of cities as a central place in which to lay new foundations for the economic recovery of territories (Leipzig Charter, 2007; Declarations of Marseille, 2008, and of Toledo, 2010), indicating urban regeneration as a useful tool to integrate environmental sustainability objectives with those of urban planning, governance, economy and social inclusion (Gandolfi et al., 2014). Urban regeneration processes, in fact, include a series of elements linked to the concept of sustainability ranging from energy and environmental improvement of the urban organism, to the quality of public spaces, to material and immaterial accessibility, to mobility systems, to flexibility of spaces, functional complexity and the ability to respond to the ever-increasing demand for social integration (D'Onofrio et al., 2015).
In particular, the European strategy on urban sustainability considers a general rethinking of urban mobility fundamental to limit the impacts caused by the current transport system on the environment, on man and on the economy (Socco, 2010). Above all, the choice of this topic was dictated by the well-known consideration that transport infrastructures constitute a significant part of land use and a determining factor for sustainability conditions. A project aimed at creating urban environments with a high environmental value therefore requires a holistic approach and an integrated design of buildings and transport infrastructures. The aim must therefore be to promote efficient models of land use that pursue sustainable mobility objectives.
In this framework, cities must take on the task of more consciously promoting environmental re-balancing, strongly rethinking local actions to better qualify urban space and to increase the feasibility of urban transformation interventions (Gandolfi, op.cit.). In this direction, an important role must be played by the planning which must, among other things, identify the best location of the settlements (to encourage urban development in areas that are already heavily populated and linked to basic services), discouraging dependence on the use of private cars and to encourage public mobility (Critelli et al., 2011).
To guide the processes of development and urban transformation, planning must be supported by appropriate methodologies and tools, which are capable of "measuring" urban performance in terms of sustainability and which are based on indicators that also take into account mobility (Devitofrancesco et al., 2015).
In this paper we analyse the most widespread environmental certification systems on the urban scale, with reference to the ways in which they approach the issue of mobility.

2. Mobility as a common element of urban-scale environmental certification systems

The development of sustainability assessment methodologies has been underway for over two decades and has mainly focused on the evaluation of buildings and their components (Bragança et al., 2010). Recent literature (Ameen et al., 2015; Gargiulo et al., 2014) has, however, underlined the importance of going beyond the assessment of the sustainability of individual buildings, also extending it to the urban environment in which they are inserted. This assessment is in fact little explored, not only in our national context, but also internationally; while offering multiple insights, it is still a field to be developed and with great potential for application (Corsi, 2009).

In particular, to maintain a good level of precision with practically constant evaluation elements, the ideal scale for dealing with the assessment of sustainability is the micro urban one, namely the neighbourhood (Mobiglia, 2012). Located between the building and the city, the neighbourhood represents a cross-section of urban reality of a sufficiently large size to appeal to sustainability criteria that are transferable to the city scale. This scale is also linked to quality of life: the project of a sustainable neighbourhood involves the development of communities with environmental considerations and social and economic objectives, in a balanced perspective. Moreover, thanks to its size, the district offers greater ease of coordination between authorities, associations, residents and businesses.

A survey of the environmental certification systems used today has made it possible to identify 6 systems that deal with the development of urban areas, of which 4 are widespread in the international sphere and 2 are related to the Italian sphere (one of which is still being defined) (see Tab.1). These are voluntary application evaluation methods based on a scoring system that leads to the definition of an assessment class of the achieved environmental level, of which a brief overview is given below.

Table 1 Environmental certification systems analysed

Tool/(Country)	Year	Last version	Macro-areas	Criteria
Building Research Establishment Environmental Assessment Method - Communities BREEAM Communities (United Kingdom)	2009	2012	1. Governance 2. Soil use and ecology 3. Resources and energy 4. Social and economic wellbeing 5. Transport and movement	40 (12 are mandatory)
Comprehensive Assessment System for Building Environmental Efficiency for Urban Development CASBEE UD (Japan)	2006	2014	1. Environment (resources, nature, artefacts) 2. Society (impartiality/fairness, security/safety, amenities) 3. Economy (traffic/urban structure, growth potential, efficiency/rationality)	26
Deutsche Gesellschaft fur Nachhaltiges Bauen - Neubau Stadtquartiere DGNB NS (Germany)	2009	2016	1. Environmental Quality 2. Economic Quality 3. Socio-cultural and Functional Quality 4. Technical Quality 5. Process Quality	30
Leadership in Energy and Environmental Design for Neighbourhood Development LEED ND (Usa)	2007	2018	1. Smart Location and Linkage 2. Neighbourhood Pattern and Design 3. Green Infrastructure and Buildings 4. Innovation 5. Regional Priority	56 (12 are mandatory)
Green Building Council Quartieri GBC Quartieri (GBC Districts) (Italy)	2015	2015	1. Localisation and links to the site 2. Organisation and planning of the District 3. Infrastructure and sustainable buildings 4. Project innovation 5. Regional priorities	57 (12 are mandatory)
Protocol Institute for procurement innovation and environmental compatibility on an urban scale ITACA on urban scale (Italy)	2016	2016	1. Governance 2. Urban aspects 3. Urban landscape quality 4. Architectural aspects 5. Public areas 6. Urban functioning 7. Biodiversity 8. Adaptability 9. Mobility/Accessibility 10. Culture and Society 11. Economic aspects	65

BREEAM Communities
This method can be considered as the starting point from which the focus on evaluation of the building energy performance has branched, which has encouraged the worldwide development of numerous other systems. The urban scale protocol was developed to help local authorities and designers from the early planning stages, ensuring the design of sustainable new construction sites, interventions and recovery of degraded areas. The system is applied through the use of a fair number of criteria to be analysed, most of which are optional. This implies that it is possible to choose a specific target to build the final score, even if there are mandatory prerequisites that must necessarily be met to obtain the certification. The criteria are rather clear and explicit, and do not give the possibility for personal interpretation. The possibility of having two or more alternative specifications to obtain a credit makes this system a very complete score, in addition to the fact that it allows the protocol to adapt easily to contexts other than the United Kingdom. The weak point is that the system, although rigorous and precise, is complex as it is based on a system of evaluation of weighted scores criteria. This process makes the calculation less transparent, and transparency is essential for the international market.
CASBEE for Urban Development
This system stems from the need to consider the environment as a whole in relation to technological-constructive and social needs. The certification process is much more complex than other systems, defining a vast quantity of indicators that are then associated with each other and finally reported graphically. This guarantees an immediate reading of the results and a quick comparison of the relative performances, allowing to immediately identify the aspects to be improved to increase performance. However, the difficulty of understanding how to modify the set weighing system makes it difficult to transpose them in a context different from the original one.
DGNB- Neubau Stadtquartiere
This protocol covers all the key aspects of sustainable construction (from energy consumption to maintenance costs, from material selection to indoor comfort), giving them the same weight in the evaluation. This means that it is the only system, among those analysed, that gives equal importance to the economic aspect of sustainable construction and ecological criteria. Furthermore, considering that the process of building an urban neighbourhood extends over a rather long period of time, during which the project may also undergo changes, the system provides for three certifications for the various construction phases: during the urban planning phase, during the plan approval phase and during the advanced stages of implementation. The evaluation is extended even beyond the realization, considering that maintenance and management costs are as important as the investment costs. The strength of the system is its flexibility, which makes it usable also internationally. Moreover, due to the similarity between the German and Italian urban planning regulations, the system is of particular interest to our country.
LEED for Neighbourhood Development
Mainly designed for the planning and development of sustainable neighbourhoods and urban areas, this system is easily integrated into scarcely urbanized fabrics, disused urban areas to be redeveloped, outlying districts and new expansion areas and historical centres. Moreover, it tends to pursue the objective of carrying out projects that take into account the infrastructural and connective requirements existing on an urban scale right from the start (Courses, op.cit.).
According to the LEED ND standard, a neighbourhood must have large public spaces that encourage socialization, and must be designed for pedestrians, so that all services are easily accessible. The LEED ND protocol can be used for different projects, of different sizes and in different phases: from the design phase to the construction phase, up to the actual certification after the completion of the intervention. One of the aspects that makes the system more widespread internationally is the easy calculation method: a checklist makes counting points in relation to the established requirements very easy and transparent. Also in this system there are mandatory prerequisites that must necessarily be met to obtain the certification. Furthermore, the final score is determined by summing the equally important points. This methodology is widely referred to and envisaged in other different certification systems, as it allows the results to be obtained in a simple and readable way. The weak point is determined by the fact that indicators related to the economic aspects are not considered in the evaluation.
GBC Quartieri (GBC Districts)
This is a protocol developed in Italy for the redevelopment or construction of existing or newly built areas. The system was born as an extension of the LEED ND certification system, of which it has the same structure and follows the same calculation methodology. The peculiarity consists in the fact that this system is adapted to the Italian context, as it is aligned with the regulations and the national market.
ITACA on an urban scale
It is a tool connected to different scales that can potentially evaluate and measure, through an indicative numerical score, the level of energy and environmental sustainability of the interventions for the construction of new neighbourhoods, or for the regeneration of existing neighbourhoods. Starting from some specific objectives such as strengthening environmental protection, increasing the quality of life for users and minimizing construction and management costs, a list of 65 evaluation criteria was developed.

Since not all are significant at all scales of application or can be calculated in the same way, the protocol makes it possible to consider the issues of sustainability in a manner consistent with the evaluation scale, assuming from time to time the perspective which is appropriate to the investigation in progress, without neglecting the overview. To date, this system is not yet operational as, for each criterion, the indicators and units of measurement have been defined, but the performance scales have not yet been built.

Table 2 Scope of application and calculation methodology

Tool	Minimum application size	Calculation methodology
BREEAM Communities	Considers projects of different sizes (from 10 units to more than 6000 units).	It foresees the use of a technical manual that contains around 40 criteria to be analysed through the following steps: - for each assessment issue the number of credits awarded by the assessor in accordance with the criteria; - the credits achieved in the assessment issue are then multiplied by the corresponding individual credit weighting. This gives the assessment issue a weighted score; - in order to determine the category score, the individual assessment issue weighted scores for all issues in any category are added together. An additional 1% can be added to the final score of the relevant innovation category (up to a maximum of 7%).
CASBEE UD	It does not put a limit on size, as long as there are buildings on the area that interact with each other and with the outside.	The evaluation criteria have been developed starting from 2 basic themes: the environmental quality within the project (Q-Quality) and the external environmental load (L-Load). The system wants to reduce external impacts and increase internal quality, by relating the project to a reference object, defined according to the characteristics of the project. For the evaluation and classification of the object, the BEE (Building Environmental Efficiency) indicator was created, obtained from the Q / L ratio. The final certification is obtained thanks to the final BEE indicator, resulting from the weighted average of the BEE indicators related to each category.
DGNB NS	Evaluate urban areas that: - extend for at least 2 ha, - are composed of at least two building lots with public space, - have a residential share that varies between 10% and 90% of the gross useful area.	The evaluation is done by assigning to each criterion up to 10 sustainability points on a reference performance scale. Each criterion has a different percentage incidence within its own quality section, and therefore the score achieved is weighed and then aggregated to the other members of the same quality section. The level of sustainability of the quality section is expressed as a percentage of the total points acquired by the criteria with respect to the maximum number of points that can be acquired. Subsequently, the percentages of the quality sections are aggregated considering, also in this case, the incidence within the entire evaluation system. The final percentage obtained determines the rating of the area.
LEED ND	Consider projects with an extension of less than 1.3 sq. Km. For larger surfaces the division of the project is recommended.	To obtain and proceed with the evaluation there are prerequisites that must necessarily be respected. Each credit is assigned a score based on the benefits and the impact that the neighbourhood generates on man and the environment. The sum of all the scores leads to four levels of environmental sustainability reachable from a neighbourhood, where the maximum score is 110. To obtain the LEED ND certification, the candidate project must meet all the prerequisites and reach a minimum number of points to achieve project evaluations.
GBC Quartieri (Districts)	It does not foresee limitations on the size of the urban area, but requires that at least two buildings are present in the area and that it is inserted in a multifunctional context	Similar to LEED ND
ITACA on an urban scale	It refers to three different areas: - isolated, - compartment, - district, without information on size	It is structured according to three hierarchical levels: areas, categories and criteria. Starting from a set of basic assessment items, it aims to provide a final performance score, indicative of the sustainability level of the urban settlement. The constituent elements of the evaluation method can be summarized in a set of criteria and a set of indicators, which make it possible to quantify the performance of the urban area in relation to each criterion.

Among the different macro-areas considered by the certification systems analysed, a common element is related to the issue of transport. This derives from the currently recognized need to provide urban centres with better organization, based on sustainability indicators, through the adoption of sustainable mobility models. These are, in particular, models based on the modernization of intermodal public transport and the strengthening of an alternative mobility system (such as e-mobility, cycle paths and pedestrian areas) integrated with city planning, which reduces land usage and implements climate change strategies. The intention is not to prohibit the use of private cars as a means of transport, but rather to design urban environments in which

citizens think of private cars as a second modal option (Banister, 2008).
Focusing on the specific objectives of each of the systems analysed, it emerges that each one deals with the issue of mobility in depth, albeit with small differences, establishing criteria concerning accessibility, soft mobility, public transport, services and transport system management (see Table 3).

BREEAM Communities (TM)	Transport assessment	To ensure transport and movement strategies reduce the impact of the development upon the existing transport infrastructure and improve environmental and social sustainability through transport.
	Safe and appealing streets	To create safe and appealing spaces that encourage human interaction and a positive sense of place.
	Cycling network	To promote cycling as a leisure activity and as an alternative to vehicle use by providing a safe and efficient cycle network.
	Access to public transport	To ensure the availability of frequent and convenient public transport links to fixed public transport points (train, bus, tram or tube) and local centres.
	Cycling facilities	To promote cycling by ensuring cycling facilities are adequate.
	Public transport facilities	To encourage frequent use of public transport throughout the year by providing safe and comfortable transport facilities.
CASBEE UD (3.1.1)	Development of traffic facilities	- The development of roads, parking lots, bicycles parking areas etc. - Usability of public transportation Distance from railway stations (including LRT/BRT station) or bus stops is evaluated in combination with measures for a comprehensive transportation system (including arrangement of bicycle parking and park-and-ride in cooperation with the road administrators and transport business operator).
	Logistics management	Rationalization, cooperative delivery etc., of logistics (including waste disposal).
DGNB NS (TEC3)	Motorised transportation	To safeguard resources and increase user comfort by means of a sustainable mobility infrastructure for motorised transportation.
	Pedestrians and cyclists	To safeguard resources and increase user comfort by means of a sustainable mobility infrastructure for pedestrians and cyclists.
LEED ND (SLL) (NPD)	Access to quality transit (credit)	To encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health risks associated with motor vehicle use.
	Bicycle facilities (credit)	To promote cycling and transportation efficiency and reduce distances travelled by vehicle. To improve public health by encouraging utilitarian and recreational physical activity.
	Reduced Parking Footprint (credit)	To minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.
	Walkable streets (Prerequisite and Credit)	To promote transportation efficiency and reduce vehicle distance travelled. To improve public health by providing safe, appealing, and a comfortable urban environment that encourages daily physical activity and limits pedestrian injuries.
	Connected and open community (credit)	To conserve land and promote multimodal transportation by encouraging development within existing communities that have high levels of internal connectivity and are well connected to the larger community. To improve public health by encouraging daily physical activity and reducing motor vehicle emissions.
	Transit facilities (credit)	To encourage transit use and reduce vehicle distance travelled by providing safe, convenient, and comfortable transit waiting areas.
	Transportation demand management (credit)	To reduce energy consumption, pollution, and harm to human health from motor vehicles by encouraging multimodal travel.
GBC Quartieri (Districts)	Minimum characteristics for the pedestrian usability of roads (prerequisite)	Promoting transport efficiency, including the reduction of kilometres travelled by private car. Promote walking on foot through the creation of routes in safe, attractive and comfortable urban environments, with the aim of improving public health, reducing accidents involving pedestrians and promoting daily physical activity.

	Accessibility to the public transport system (credit)	Encourage urban development in those areas served by several types of transport or for which reduced use of cars is possible, so as to reduce climate-changing emissions, air pollution and other negative effects on the environment and on public health associated with the use of motor vehicles.
	Cycle mobility (credit)	Promote the use of bicycles and increase the efficiency of travel, also by reducing car use. Improve the population's wellbeing by encouraging physical activity.
	Management of transport demand (credit)	Reducing energy consumption, the pollution produced by motor vehicles and the negative impact on public health by encouraging multimodality in the use of transport systems.
ITACA on an urban scale (8)	Road network connectivity	Multiply the number of possible routes, reduce distances and increase pedestrian accessibility.
	Complexity of the road network in terms of cycling routes	Create multiple possible routes, allowing more fluid traffic.
	Road network scale	Guarantee the possibility of moving on foot or by bike for daily trips.
	Access to public transport	Reduce the use of private vehicles.
	Availability of safe cycling routes	Encourage cycling mobility by improving the continuity and safety of routes.
	Congruity of cycle and vehicular routes	Allow the use of the bicycle as an alternative means of transport.
	Accessibility of pedestrian routes	Ensure maximum accessibility to pedestrian routes.
	Accessibility to shared mobility	Increase the use of shared sustainable mobility systems.

3. The degree of adaptability of the certification systems to the Calabrian context

The systems analysed have many common characteristics in terms of the general objectives and the types of evaluation. However, they highlight differences, in some cases even quite considerable, between the number of categories and criteria considered (see Table 1), between the application size (that ranges from a few buildings to medium-sized cities), the calculation method (see Table 2) and especially in the weighing procedures of the impacts to define the score assigned to each criterion.

Although the number of criteria considered in each system turns out to be quite high, the comparison showed that each of them focuses on some particular aspects, while, in general, the environmental aspect is considered in depth in each while social dynamics aren't as detailed.

The BREEAM Communities system, for example, takes particular account of aspects related to transport, efficient use of resources and business for local companies, while social aspects related to history and tradition are considered only in CASBEE UD. The NS DGNB system also assesses the economic and cost related aspects and those related to the implementation process; unlike the LEED ND system (and GBC Quartieri) which instead, ignoring these aspects, privileges the location with respect to the existing city and the design aspects of the public space. Furthermore, in LEED ND, some criteria can be evaluated with reference to single elements, without analysing either the characteristics or the relationship with the surrounding context (for example, a cycle path can be evaluated without studying the relationship with the transport network) (Frisch, 2015). With reference to the different rating systems, instead, some studies (Zeinal Hamedani et al., 2015) show that DGNB NS is generally the strictest system for project certification, followed by LEED ND and BREEAM Communities. Furthermore, all the protocols have a strong link with the territorial context of origin: they depend, that is, on national regulations, rules, recommendations and standards, as well as on cultural and social aspects.

It follows, therefore, that the differences found are the result of the technical and political debate that accompanied the formation of these evaluation systems in the respective countries and of the consensus that each system was able to form around its own values and methods of analysis. From the point of view of the effectiveness of the certification, a technical comparison of the systems or a discussion on the single strengths and critical points appears to be of little significance if they are not related to the specific territorial context of application and to a precise reference value scale (Frisch, op .cit.).

The objective of the contribution is to relate, also with reference to the aspects linked to mobility, the analysis/comparison of the different systems to the Calabrian context, characterized by a particular geographical-urban situation made up of small to medium cities.

For a long time, these areas seemed to be exempt from the transport problems of big cities, being characterized by lower levels of pollution and congestion and by a better quality of public spaces and services to citizens. In recent decades, however, they too have been affected by the systematic use of private vehicles generally connected to the dispersion of urban activities and to the widespread territorial distribution, which have made local public transport, where existing, decidedly uncompetitive. It should not be overlooked, in fact, that comprehensive public transport systems are present in only about 10 of the 404 Calabrian municipalities, while in the remaining, public transport is limited to linking a few supra-municipal road transport lines and, in the most fortunate cases, in the presence of a railway station. Moreover, in the medium sized cities there are large areas that

are not served by public transport: it is even more so in the historical centres which, in almost all cases, are characterized by narrow and uncomfortable streets. This is also accompanied by an orographic situation that often makes it impossible to use alternative means to individual transport that are widespread in other national and international realities, such as the bicycle.
In this framework, the previous analysis shows that not all certification systems are suitable, or adaptable, to this territory. In general, in fact, it emerges that some systems are very rigid and difficult to apply in such a context (BREEAM Communities and CASBEE UD), while others are more adaptable (DGNB NS, LEED ND, or even better GBC Quartieri, as its adaptation to the Italian context).
A separate discussion is required for the ITACA Protocol on an urban scale, as it is not yet complete nor operational. To make it more usable in different contexts, it would be interesting to be able to review its structure and define its missing aspects (including mainly the performance scale of the individual criteria) also with reference to particular situations such as the Calabrian one. For example, it would be useful to be able to integrate the envisaged application scale (at the moment this relates to the block, sector and neighbourhood) by introducing a variable relating to physical and urban conditions (Municipalities with poorly urbanized areas or areas with reduced population, historic centres characterized by limited infrastructural conditions, etc.).
Moreover, in consideration of the high number of criteria envisaged, the procedure could be streamlined and made more flexible by taking inspiration, for example, from the methodology used by the LEED ND which differentiates the criteria into "mandatory" and "optional". Simplifying the protocol would also direction of increase its competitiveness with respect to other systems of more immediate use.

4. Conclusions

The criticality of the evaluation systems is constituted by the fact that they are the product of a series of preliminary settings (choice of criteria and indicators, weighing, etc.) which, in turn, are influenced by the value systems assumed; however, they are criticalities that can be limited through periodic checks and updates of the same evaluation system. The added value of the certification is, instead, the fact that the indicators are weighed and referred to an evaluation grid. In this way, the individual project is assigned a score or a certification level that makes it comparable to other projects, even if implemented in different contexts and times.
One of the main obstacles to a more extensive application of sustainability assessment tools is the application to different contexts with different needs. Since most indicators and their relative weights have been developed for very specific contexts, the scope of each of the instruments ends up being limited (Macedo et al., 2017).
What emerges from the analysis, and on which it will be necessary to make a particular commitment, is to be able to bridge the identified limits, to universally grasp the concept of sustainability and, above all, to develop a model of certification of urban settlement that goes beyond the context in which it has been formulated and ensures it is applicable in a unique way to the various existing realities.

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Urban scale ITACA protocol

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Keywords: Multicriteria analysis, Evaluating urban scale environmental sustainability, Urban regeneration, Land consumption, Sustainable cities and communities.

Abstract: The need for an "urban-level" ITACA protocol
The need to upgrade buildings and avoid land consumption, especially in urban peripheries, the importance of verifying environmental impact in relation to the effects of climate change and the awareness that re-designing cities can positively reinforce some of the factors that facilitate integration (community comfort and safety, for example) are among the issues that make it necessary to thoroughly re-examine government policy regarding urban planning and regulation. "Sustainable Construction", an inter-regional working group that is part of ITACA[1], has responded to these issues by preparing a specific evaluation protocol for use in urban areas. The objective of this protocol, which will act in synergy with other protocols relating to building sustainability[2] and facilitate appropriate responses to urban regeneration, is to provide a cross-scale assessment that will measure the sustainability level of interventions in urban environments ranging in size from the block to the city. This protocol will be useful for public planning bodies and all those stakeholders in developing or transforming urban areas.

1. The reference scenario, the evaluation and guidance models developed within the Community.
Ever since the Leipzig Charter on Sustainable European Cities (2007), Europe has considered cities as places where the foundations are laid for generate the economic revitalization of their hinterland. The Declarations of Marseille (2008) and Toledo (2010) defined the contents relating to development in urban contexts, identified urban regeneration as a useful context for integrating the complex goals of environmental sustainability, supported the establishment of settlements with non-homogeneous zoning which would allow degraded or under-used urban areas to be reutilised, and expressed a preference for these strategies rather than isolated expansion processes. In this perspective, the Bristol Accord lists the cornerstones of so-called Sustainable Communities[3] which, despite differences dictated by their specific local context, must be:
• active, inclusive, safe, just, tolerant and cohesive;
• well managed with efficient leadership that stimulates citizen participation;
• sensitive to environmental quality.
• well organized and well built, characterised by quality urban and natural environments;
• well connected by efficient transport and communication services between workplaces, schools, health services and dwellings;
• economically thriving with a diversified local economy;
• well served by public, private and voluntary services that are adequate to people's needs and accessible to all;
• fair and capable of welcoming, now and in the future, people from other communities.

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[1] ITACA is the acronym for: l'Innovazione e la Trasparenza degli Appalti e la Compatibilità Ambientale. (Institute for Innovation, Procurement Transparency and Environmental Sustainability). The inter-regional working group is part of the Federal Association of Italian Regions and Autonomous Provinces
[2] The ITACA Protocol is based on the SBTool, an international instrument developed by iiSBE, and it belongs to a European network of certification systems based on the SBMethod which includes Verde (Spain), SB Tool PT (Portugal) and SB Tool CZ (Chech Republic).
[3] See the communication from the Commission to the Council, the European Parliament, the European Social and Economic Committee and the Regional Committee - Towards a Thematic Strategy for the Urban Environment COM/2004/0060 def. And The Bristol Accord (2005).

AMBITI DI APPLICAZIONE					SCALA DI APPLICAZIONE			UTILIZZO		INDICATORE	
Esistente	Progetto	Monitoraggio			Isolato	Comparto	Quartiere	piano, (*masterplan*, *(metaprogetto)*)	progetto (*piano attuativo, prog. Preliminare)*	Scenario	Quantitativo
			1. GOVERNANCE								
	x		1,01	Partecipazione	x	x	x	x	x	x	
	x		1,02	Gestione sociale del cantiere		x	x		x	x	
			2. ASPETTI URBANISTICI								
x	x	x	2,01	Sviluppo e integrazione delle particelle catastali	x	x	x	x			x
x	x	x	2,02	Adiacenza alla città consolidata	x	x	x	x			x
	x	x	2,03	Conservazione del suolo	x	x	x	x			x
	x	x	2,04	Conservazione dell'ambiente costruito	x	x	x	x	x		x
			2 bis. QUALITA' DEL PAESAGGIO URBANO								
	x		2.bis.01	Rapporto con il contesto	x	x	x	x	x	x	
	x		2.bis.02	Rapporto con le aree agricole periurbane	x	x	x	x	x	x	
	x		2.bis.03	Rafforzamento del ruolo urbano	x	x	x	x	x	x	
	x		2.bis.04	Qualificazione del margine urbano	x	x	x	x	x	x	
	x		2.bis.05	Ruolo dello spazio pubblico	x	x	x	x	x	x	
			3. ASPETTI ARCHITETTONICI								
	x		3,01	Modalità di elaborazione del progetto	x	x	x		x	x	
	x		3,02	Qualificazione del gruppo di progettazione	x	x	x		x	x	
	x		3,03	Criteri di gestione	x	x	x		x	x	
	x		3,04	Capacità del progetto di interpretare il contesto utilizzando linguaggi contemporanei	x	x	x		x	x	
	x		3,05	Flessibilità delle opere architettoniche	x	x	x		x	x	
			4. SPAZI PUBBLICI								
x	x	x	4,01	Rilevanza dello spazio pubblico nel progetto	x	x	x	x	x		x
x	x	x	4,02	Illuminazione dei percorsi pedonali	x	x	x		x		x
x	x	x	4,03	Prevenzione dei crimini	x	x	x		x		x
x	x	x	4,04	Strade e spazi pubblici ombreggiati - comfort termico	x	x	x		x		x
			5. METABOLISMO URBANO								
			Acqua								
x	x	x	5,01	Permeabilità del suolo	x	x	x	x	x		x
x	x	x	5,02	Intensità del trattamento delle acque	x			x	x		x
x	x	x	5,03	Gestione delle acque reflue	x	x	x	x	x		x
			Rifiuti								
x	x	x	5,04	Accessibilità alla raccolta differenziata	x	x		x	x		x
			Luce								
x	x	x	5,05	Inquinamento luminoso	x	x	x	x	x		x
			Gas/qualità dell'aria								
x	x	x	5,06	Monitoraggio della qualità dell'aria	x	x	x	x			x
x	x	x	5,07	Intensità di emissioni gas serra	x	x			x		x
x	x	x	5,08	Intensità di emissioni acidificanti	x	x			x		x
x	x	x	5,09	Intensità di emissioni fotossidanti	x	x			x		x
			Energia								
x	x	x	5,10	Energia primaria per la pubblica illuminazione	x	x	x	x	x		x
x	x	x	5,11	Produzione locale di energia rinnovabile	x	x	x	x			x
			6. BIODIVERSITA'								
x	x	x	6,01	Connettività degli spazi verdi	x	x	x	x			x
x	x	x	6,02	Uso di vegetazione locale	x	x	x		x		x
x	x	x	6,03	Disponibilità di spazi verdi	x	x	x	x			x
			7. ADATTAMENTO								
			Mitigazione degli effetti di siccità e carenza idrica								
	x		7,01.1	Manutenzione straordinaria condotte idriche		x	x		x	x	
	x		7,01.2	Riduzione e recupero dell'acqua piovana immessa in fogna	x	x	x		x		x
	x		7,01.3	Utilizzo delle piante xerofite	x	x	x		x		x
			Mitigazione delle ondate di calore in area urbana								
x	x	x	7,02.1	Incremento delle alberature su strade, piazze e parcheggi	x	x	x		x		x
	x	x	7,02.2	Intensificazione della ventilazione urbana naturale	x	x	x		x		x
x	x	x	7,02.3	Comfort termico delle aree esterne - Albedo	x	x	x		x		x
			Adattamento a eventi estremi di pioggia e rischio idrogeologico								
x	x		7,03.1	Riqualificazione della qualità naturale - regreening	x	x	x	x	x		x
x			7,03.2	Riduzione della pressione edilizia	x	x	x	x			x
	x		7,03.3	Riduzione della quantità di acqua piovana immessa in fogna	x	x	x	x	x		x
x	x	x	7,03.4	Rinaturalizzazione dei corsi d'acqua di qualsiasi categoria	x	x	x	x		x	
	x		7,03.5	Riduzione tendenziale dell'esposizione della popolazione al rischio			x	x			x
x	x		7,03.6	Riduzione del danno negli spazi pubblici aperti	x	x					x
			8. MOBILITA'/ACCESSIBILITA'								
x	x	x	8,01	Connettività della rete stradale	x	x	x		x		x
x	x	x	8,02	Complessità ciclomatica della rete stradale	x	x	x		x		x
x	x	x	8,03	Scala della rete stradale	x	x	x		x		x
x	x	x	8,04	Accesso al trasporto pubblico	x	x	x		x		x
x	x	x	8,05	Disponibilità di percorsi ciclabili sicuri (in sede protetta)	x	x	x		x		x
x	x	x	8,06	Contiguità dei percorsi ciclabili e veicolari	x	x	x		x		x
x	x	x	8,07	Accessibilità dei percorsi pedonali	x	x	x		x		x
x	x	x	8,08	Accessibilità alla mobilità condivisa	x	x	x		x		x
x	x	x	8,09	Accessibilità ICT	x	x	x		x		x
			9. SOCIETA' E CULTURA								
x	x	x	9,01	Prossimita' ai servizi principali	x	x	x	x			x
x	x	x	9,02	Prossimita' a strutture per il tempo libero	x	x	x	x			x
x	x	x	9,03	Flessibilità d'uso (Flessibilità degli usi nell'arco della giornata/settimana)	x	x	x	x			x
x	x	x	9,04	Mixité	x	x	x	x			x
x	x	x	9,05	Incidenza degli orti urbani	x	x	x	x			x
			10. ECONOMIA								
			Accesso alla residenza								
x	x	x	10,01	Accessibilità economica alla proprieta' residenziale	x	x	x	x			x
x	x	x	10,02	Accessibilità economica all'affitto residenziale	x	x	x	x			x
x	x	x	10,03	Composizione e varietà dell'offerta abitativa	x	x		x			x
			Accesso all'occupazione								
		x	10,04	Potenziale occupazionale			x	x			x

Figure 1: Framework of the Protocol criteria, with identification of the areas and scale of application.

The objectives outlined in these treaties have been included in national urban development strategies and more importantly, in the revised programming of European Community Structural Funding. Mention should be made of the Urban Agenda[4], the strategic and operational indications for programming structural funding from 2014 until 2020; this Agenda was implemented in

the provisions for sustainable urban development, contained in the Regulation relating to the European Regional Development Fund (ERDF) and in the partnership agreements associated with it, as well as in the National Operational Plan for Metropolitan Cities 2014-2020.
Within this strategic framework, the role the Regions play in governance in the field of urban innovation emerges; regional policies support a greater use of integrated urban development strategies, to facilitate improved coordination between public and private investments and greater citizen involvement. Consequently, the need to reconsider the aspects related to the growth of cities should be seen as an opportunity to interpret the theme of urban regeneration in the widest and most effective way possible.
Numerous experiments have focused on the topic of urban sustainability and methodologies have been developed for assessing sustainability at both neighborhood and city scales. "Sustainable Seattle" (1993) needs to be mentioned as it has been recognized as the first project to develop large-scale sustainability indicators, based on citizens' shared values and the objectives they set for their community[5]. Some of the more significant experiments in Europe are: the EcoQuartier and EcoCitè experience and the research project HQE2R - Sustainable upgrade of buildings for a sustainable urban neighborhood (France), the evaluation tool Sustainable neighborhoods developed by SméO (Switzerland), the CAT-MED project which resulted in the Green Apple (or Manzana Verde) assessment system (Spain) while the Agència d'Ecologia Urbana de Barcelona (BCN) developed El Plan Especial de indicatores de Sevilla.

2. The ITACA Protocol

When applied at the urban scale the ITACA Protocol is a multicriteria analysis system for assessing the sustainability of urban regeneration /transformation with a modular structure. Starting from a set of criteria, the Protocol provides a final performance score which indicates the level of sustainability of the urban-scale intervention. The final performance score is calculated using a procedure that is divided into three phases:
• characterisation: appropriate indicators obtained by calculating specific physical quantities (consumption, emissions, distances, etc.) assess how an urban area performs for each criterion;
• normalisation: the value of each indicator is dimensionalised and then re-graded again within a normalisation range-i.e. a score is assigned based on the value of the indicator and in reference to a performance scale (benchmark);
• aggregation: the scores are combined to produce a compressive score. Aggregation is determined using a weighted sum. Each criterion is characterised by a weight that represents its importance.

Although the objective of the Protocol is to assess the sustainability of urban-scale regeneration using criteria based as much as possible on measurable quantitative elements, some aspects of regeneration work, such as its impact on architectural or landscape quality require so-called "scenery-based" evaluation criteria. These criteria allow the overall assessment to consider issues that are not directly measurable on quantitative value scales by introducing flexible assessment methods that can be more easily contextualized to the reference areas[6].
The constituent elements of the evaluation method can be summarised as follows: A set of evaluation items known as criteria; A set of quantities, known as indicators, which allow the performance of an urban area to be quantified in relation to each criterion; A standardisation method; An aggregation method.
The method adopted allows the Protocol to be contextualised to the specific geographical area where it is to be applied. This is possible because:
- the benchmark value and therefore the performance scale, can be defined for the normalisation phase. This means the score assigned for the various criteria reflects benchmark performance that also takes into consideration local context / best practice;
- the weighted value of the criteria can be adjusted for the aggregation phase so local priorities regarding the issue of sustainability can be taken into consideration.
Given the complexity of urban areas, the Protocol provides for three different application scales which interact with each other; these scales are: the block, the sector, and the neighborhood. In some cases, where appropriate, a reference to the building scale (Building Protocol) or to the entire city is also provided.
In this way, sustainability issues are coherent with the rating scale, and they adopt the appropriate perspective for the area under investigation without neglecting the overall view; this means that not all criteria are significant at all scales of application, nor are they all calculated in the same way.

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[4] Methods and Objectives for an efficient use of European Funding 2014/20 - Document which opened the public debate. It was presented by the Minister for Territorial Cohesion in agreement with the Ministers for Labour, Social Policies, and Food, Agriculture and Forestry.
[5] This project was awarded an "Excellence in Best Performance Indicators" by UNHABITAT, the United Nations Centre for Human Settlement.

To summarise: the Urban Scale ITACA Protocol includes all the parameters, material and immaterial, required for characterising and assessing the sustainability of scale-based regeneration of "scale-based" interventions in the city or in significant parts thereof. The protocol applies with is a cross-scale system (from block to neighborhood). This system's holistic approach allows it to promote a plurality of functions (functional mix) and to avoid land consumption, while ensuring, balanced growth of the the area being regenerated and to assess the area's performance level with respect to the main environmental social and economic problems. This instrument can be used to analyse both potential new urbanisation and existing areas in all phases of their life cycle: design, implementation and monitoring. As mentioned, the definition of the proposed criteria / indicators seeks to include issues related to the development of "sustainable cities", giving priority to criteria that can define (target / evaluate) urban quality in its multiple forms.

GOVERNANCE:	i.e. the management and planning process, which starts with an assessment of economic-financial feasibility / sustainability.
URBAN PLANNING ASPECTS:	which take into consideration the complexity of morphology and urban organization.
LANDSCAPE QUALITY:	obtained by identifying the objectives that help protect, preserve and promote the characteristic aspects of the landscape
ARCHITECTURAL ASPECTS:	architectural quality, accessibility and the preservation of historical-cultural heritage and identity.
PUBLIC SPACES:	ensure comfort, safety, usability and accessibility for pedestrians.
URBAN METABOLISM:	control environmental quality by evaluating flows (air, water, energy, waste)
BIODIVERSITY:	a project for green spaces, re-greening the existing city and protecting nature.
ADAPTATION:	adopt strategies to counter the threat posed by climate change.
MOBILITY / ACCESSIBILITY:	public transport and infrastructure.
SOCIETY AND CULTURE:	social cohesion and integration, cultural aspects related to participation/sharing as well as provision of services (educational, cultural, health/assistance, leisure), and commercial equipment (small/medium structures).
ECONOMY:	analyse the benefits to the urban economy and the creation of work opportunities

Table of criteria

[6] The choice of criteria was made with a view to building a complete, open, rigorous and well performing system. Document verification safeguards the principles of system openness and accessibility. The urban-scale evaluation system followed a set of principles which formed the basis for identifying the evaluation criteria best suited to fully expressing the sustainability of urban regeneration, so the protocol could represent:
- a complete system: the criteria identified represent the vast panorama of the areas, economic and social sustainability; the aspects appropriate for an urban system are cartefully considered;
- an open system: the indicators selected for evaluating the criteria use data obtained from territorial information systems and from public databases;
- an accessible system: the calculation methods adopted are transparent and simple; citizens and public administrations find it easy to interprete and communicate the results;
- a rigorous system: the scientific validity of the system is constantly refined, through continuous experimental work and verification processes conducted in research projects;
- a high-performance system: the evaluation indicators express specific performance aspects, thereby avoiding the definition of a series of rigid design requirements;
- a flexible system: adopt criteria most appropriate to the scale of the area being assessed so as to evaluate its performance as accurately as possible while simultaneously maintaining the connections between the various scales of the urban fabric;
- a contextualised system: once criteria and methodologies appropriate to the specific features of the local and national urban fabric have been selected, the performance ratings are compared with benchmarks relating to the context of the city, so as to capture their specific features and give them a significant characterisation.

For ITACA, therefore, this protocol provides an opportunity for consolidating experience already gained in the context of public building certification protocols, with the aim of providing a tool that can evaluate urban regeneration plans/programes (ex ante evaluation), verify their effectiveness (ex post monitoring), and significantly assist in orienting the design process towards higher quality (the guidelines and environmental criteria to be used for notices and public announcements). The preparation of a national protocol deeply rooted in the territorial context, linked to a system of local customs and laws and to the specific background of the the surrounding area, can also facilitate the drafting of guidelines for settlement quality for use as urban planning tools. The Protocol is an instrument that is intended to meet the needs of both public planning bodies and operators involved in the development or transformation of urban areas. It will be used:

- to define benchmarks during the project phase and as a decision support tool;
- to verify the achievement of sustainability objectives during the construction phase;
- to monitor the overall level of sustainability in the operating phase

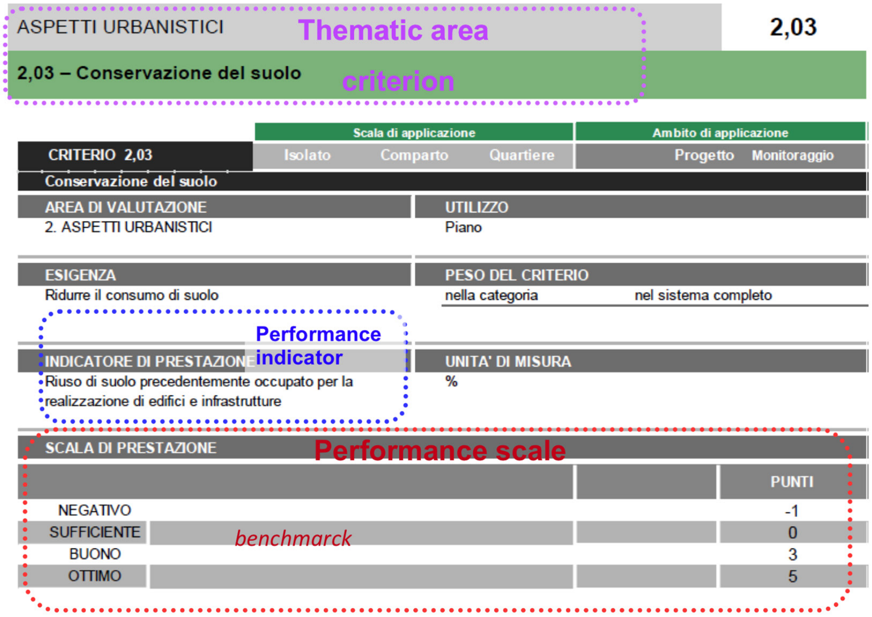
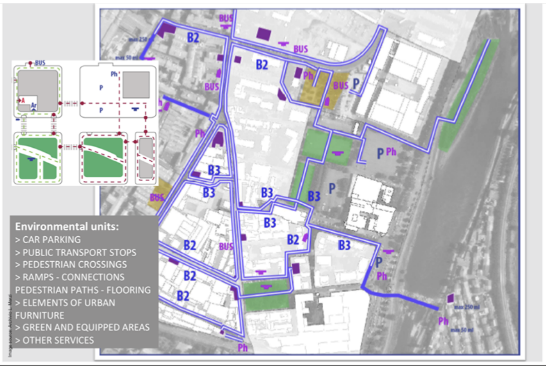


Figure 2: Criterion Sheet

3. Protocol architecture

The protocol is a modular tool designed for homogeneous sections. The 11 thematic areas are divided into 65 criteria (of which 51 are quantitative and 14 qualitative). The Criteria are the evaluation items of the protocol - each criterion is associated with one or more physical quantities that allow the performance of the urban area to be quantified in relation to the criterion being considered by assigning it a numerical value. These quantities are represented by indicators. Each criterion is weighted by its index and identified by its application scale (block, sector or neighborhood) and scope (analysis of existing context, of project context or of monitoring activities).

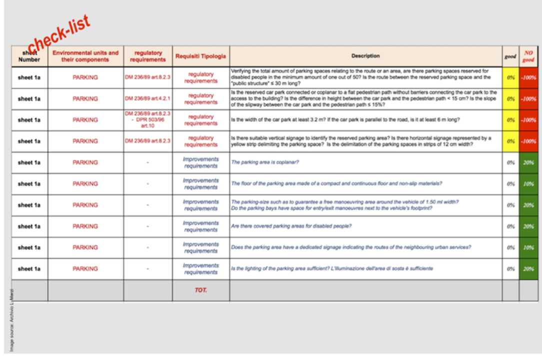
	
Phase 0: Identification of urban Ward (Neighborhood).	Phase 1: Identification urban nodes and connection routes. Identification of urban nodality inside the area and in the immediate proximity.



Phase 2: Insertion of the elements to be evaluated and of the services - facilities present in the network of paths.

Phase 3: Tracking of pedestrian routes and classification of road types, and connection path types

Phase 4: Classification and verification of routes and services identified with check-list verification.



Phase 4: Example of check-list: "Sheet 1A" parking. In the sheet are collected: Regulatory data. Improvement data.

Figure 3: Application example Criteria 8.07: Accessibility of walkways, WalkAbility. The methodology examines the network of pedestrian paths that link access to buildings of particular importance and the services and facilities in the analysis area.

Once the operational framework and the territorial area have been identified, the criterion indicates the application area (thematic area), its use (area of application), the type of requirement and the relative performance indicator as well as the unit of measure and the criterion weight.

The criterion weight ponders (weighs) the score (ranking) obtained on the basis of the performance scale. The score of each criterion is calculated by applying the verification methods and tools.

The techniques used for applying verification methods and tools depend on the characteristics of the indicator. The values obtained, defined at the different urban application scales, are applied to the performance scale in accordance with a comparative framework assessed on 4 reference values (negative - sufficient - good and excellent). The 4 values (performance scale) are common to all 65 criteria. When present, negative values reflect a shortfall in regulatory performance. In this sense the protocol considers that meeting legal requirements is an essential pre-conditon for obtaining a positive score. The scores for each criterion are combined to produce the overall score. The aggregation takes place through a weighted sum. Each criterion is characterized by a weight that expresses its relevance.

The objective of the ITACA Protocol is to formulate a concise assessment of the overall performance of an urban settlement, assigning a summary - score relating to the performance of the urban area under analysis. The overall performance score of this urban area is defined by the sum of all the scores obtained by analyzing the evaluated criteria.

4. Future Developments

Unlike the methodology used in ITACA building protocols, protocols for urban areas are mostly concerned with aspects closely related to regional and municipal regulatory and planning systems. This makes it difficult to identify valid benchmarks for every urban area in Italy. The complexity and diversity of the characteristics and problems of Italian urban centres has made

it advisable to postpone the calibration of the indicators to a later stage. This means creating another in-depth phase which will require further study by the working group.The development of this additional phase will require that the calibration of the criteria, and their relative scores be based on the local characteristics of each regional area of reference in order to make the protocol sufficiently flexible to accommmodate each specific local reality.
This adaptation phase could be developed using digital territorial data management systems. In this perspective, digital evaluation tools could be designed to interconnect with geo-referenced public databases (GIS tools) that correlate cartographic data with numerical-statistical data. This should enable existing data to be used so as to facilitate the evaluation procedure and to enhance (increase) cities' information assets and update their data. Once these systems are fully operational, the protocol for urban areas can function as a control and monitoring tool.

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To download the protocol from the Internet (last log in on date: 10/09/2019): http://www.itaca.org/documenti/news/Protocollo%20ITACA%20Scala%20urbana_211216.pdf

EDUCATION AND TRAINING

Waterworld: Architecture Design Proposals Address Climate Change and Rising Sea Levels

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Abstract

During the spring semesters of 2017 and 2018, graduate students at the University of Hartford, began to consider recent developments within the Fort Point neighborhood in South Boston. Two design studios under the direction of Professors As and Sawruk respectively, were charged with developing architectural proposals for an a) urban redevelopment plan, and b) office, residential, and civic complex on a site along the waterfront. A preeminent concern of the design project research was the consideration of the potential 1.5-3.1 meter (5-10 feet) increase in sea level over the next 25 years.

The "Fan Pier" of the Fort Point neighborhood, located on the low-lying coastline Boston Harbor, was constructed over a century ago of infill. The area was originally conceived to support the conveyance of harbor-to-rail goods. Recently, the area has seen a proliferation of planning and commercial high-rise development. During the construction period of the "Big Dig" (1997-2007), a transportation tunnel under the harbor, the city, state, and local community alike focused on what the redevelopment of Fort Point would and should be in the future. These early planning efforts, including the planning of the Big Dig itself, occurred in awareness of flood zones documented by the US Federal Emergency Management Agency (FEMA), but prior to the acknowledged, critical need for coastal resilience strategies to address rising sea levels.

Planning authorities, have since implemented large-scale studies and planning efforts to address the imminent impact of rising seas on their coastal populations and industries. Julie Wormser, for example, representing the Boston Harbor Association recognized that "today's 100-year flood could be 2050's annual flood and 2100's high tide." (Nov 2014)

The counter-intuitive boom of recent development in this categorical flood plain, however, appears to have been more informed by the financing cycles of traditional development practices than by recognized reality of global sea-level rise. The status quo strategy for "resilience," a sacrificial ground floor, belies the current inadequacy of design solutions (realized parcel by parcel) to address a systemic, regional threat. As such, this paper seeks to present the Academic pedagogy realized within the course and various proposals realized by the students, which seek to address the changing sea level through creative design solutions and responsible urban planning propositions

Introduction

The title of this paper, Waterworld, references the 1995 American science fiction film Waterworld, directed by Kevin Reynolds and co-written by Peter Rader and David Twohy. The film was based on Rader's original 1986 screenplay, and stared Kevin Costner and Dennis Hopper. The time-frame of the film is in the distant future, although no exact date was given in the film itself. However, in this twenty-first century, post-apocalyptic future, the polar ice caps have completely melted, and the sea level has risen over 7,600 m (25,000 feet). Having covered nearly all known land masses, the new earth is an endless sea. While the concept of a world of only water was an ideal pretext for a dystopian drama, it might not be far off from a more serious reality. The evolution of contemporary climate change predictions, propose a significant increase in sea levels, and the potential flooding of endless water front urban centers globally.

NAAB Pedagogy Performance Criteria

Architecture programs in the United States are reviewed and accredited by the National Architecture Accreditation Board (NAAB), consisting of members from professional, academic, and student organizations. The accredited degree program must demonstrate that each graduate possesses the knowledge and skills defined by the criteria set out below. The knowledge and skills are the minimum for meeting the demands of an internship leading to registration for practice. The school must provide evidence that its graduates have satisfied each criterion through required coursework.

In the realm of integrated building practices, Architects are called upon to comprehend the technical aspects of design, systems and materials, and be able to apply that comprehension to their services. Additionally, they must appreciate their role in the implementation of design decisions, and the impact of such decisions on the environment. Students learning aspirations include: a) Creating building designs with well-integrated systems, b) Comprehending constructability, c) Incorporating life safety systems and d) Integrating accessibility, all while applying principles of sustainable design

Architects often take on a leadership role in multi-faceted, sequential projects where multiple design professionals and sub-contractors need to be coordinated. Students must learn to manage, advocate, and act legally, ethically and critically for the good of the client, society and the public. This includes collaboration, business, and leadership skills. Student learning aspirations include: a) Knowing societal and professional responsibilities, b) Comprehending the business of building. c) Collaborating and negotiating with clients and consultants in the design process, d) Discerning the diverse roles of architects and those in related disciplines, and e) Integrating community service into the practice of architecture. Finally, understanding of the relationship between human behavior, the natural environment and the design of the built environment is paramount to the education of architecture students in our contemporary society.

Course: ARC 521, Architectural Studio II

ARC 521 Architecture Studio II is problem-oriented studio offered to second semester, fifth-year students. Introspective problems are intended to broaden and deepen individual understanding of the process, theories, and systems that influence the design of the built environment. Emphasis is on the thorough examination of all aspects of an urban design architectural simulation.

The course, in its current frame-work was initiated by Professor Dariel Cobb (2010-2013). As she stated in her original course introduction, urban design is a complex field of study that brings together a wide variety of disciplines, including architects, landscape architects, and city planners converge around urban issues. Various engineers design and maintain a complex grid of urban infrastructure including intermodal transportation. Beyond those primarily concerned with the city's physical fabric, there are those who study unseen forces, such as economists, political scientists and sociologists probe the organization, growth, and decline of cities—the flow of goods and services, the directions of market forces—and the effect of the urban environment on human behavior—evolving social values, human interaction, and the emigration and exodus of individuals and groups. These larger picture views of communal life in dense urban settings reveal patterns that single snap-shots obfuscate.

In fact, the city is simply a locus, a stage upon which the entire range of human experiences, emotions and events take place. Almost any issue in almost any discipline can be explored in an urban context. However, Americans, with their love of the rural and suburban, are essentially anti-urban. The combination of the Jeffersonian-era ideal of the small independent farmer and the 20th century association of urban life with crime, disease, and poverty has resulted in the unplanned, sprawling configuration of the American landscape today. In turn, more often than not, architects love the city. The intensity of its built fabric is intoxicating, the density and diversity of its cultural life is magnetic, and the layers of history written on its streets inform our understanding of the human-made world. Furthermore, the city represents certain civic values that look kindly upon architecture: tolerance, respect for the past, interest in the future, social altruism, and the appreciation of the arts and free expression.

The city of Boston presents us with great challenges and great opportunities. Let us not mince words: to create change in the city is a difficult task. Developers must navigate the complex rules created by city and state government, look for federal incentives for socially beneficial projects, struggle to get funding from private interests, and hire architects with that rare mix of vision and pragmatism. The city has less control over its destiny than one might suppose. Private interests and private citizens influence the city and its workings far more than city hall, and the city and its region as a whole are subjugated to the greater power of economic forces on the national and international scale. Yet, despite the odds, it is our task to continue to explore ways to improve the city, to ameliorate problems and contribute to civic life.

Spring 2017 Assignment Program Brief

During the spring of 2017, ARC 521 Architecture Studio II was conducted by Assistant Professor Imdat As. The studio, consisting of six students developed individual proposals for urban redevelopment proposals, which specifically addressed an evolving waterfront due to rising sea-levels. These students proposed innovative urban plans, integrating program, structures, and landscape, under an overarching sustainable focus.

The Boston Harbor Association, City of Boston, and the Boston Redevelopment Authority are looking for design solutions envisioning a more resilient, more sustainable, and more beautiful Boston adapted for end-of-the-century climate conditions and rising sea levels (Source: City of Boston, Living with Water, 2014). They want the students to help the City of Boston and area businesses and residents develop and apply new concepts and strategies, including Living with Water design principles, to increase the City's sustainability and climate change resiliency.

Established behind the protective landforms of today's Winthrop, Hull and the 34 Boston Harbor islands, the natural land configuration affords the city extraordinary protection from ocean wind and waves. Comforted by the historic safety of Boston's inner harbor, our ancestors built much of the city very close to the water. Over the last three centuries, Boston has confidently filled in marshes and tidelands creating new neighborhoods and increasing the city's footprint by over fifty percent. With predictable sea levels, these neighborhoods were safely sited as little as two to eight feet above high tide. In the last century, water levels have risen almost .3 meters (1 foot). Today portions of Boston's waterfront flood monthly during the "wicked", or astronomical, high tide when the sun and moon align. With the Boston Harbor sea level predicted to rise as much as five to six feet by 2100, over thirty percent of Boston faces chronically salt water flooding. Our challenge is to prepare our historic coastal city for sea level rise and climate change while continuing to strengthen its social, environmental, and economic vitality. Our choice is to respond to climate change as a threat or an opportunity; this studio is an opportunity to envision a future Boston that is more resilient, more sustainable, and more beautiful.

Traditionally, managing low-probability, high-impact flood events such as Superstorm Sandy or Hurricane Katrina depended on preventing flooding using "grey" infrastructure such as seawalls, bulkheads, and barriers. Although effective, such fortifications require significant upfront investment and can exacerbate flood damage if they are breached or overtopped. As sea levels rise and chronic flooding becomes the "new normal," even master Dutch dike builders are moving to more flexible, resilient options that decrease vulnerability to catastrophic flood damage while maintaining their connection to waterways. The Dutch coined the phrase "Living with Water" to describe this shift in focus. Living with Water design allows defined areas to flood in order to prevent harm to vulnerable people, places and resources. The concept considers water to be a "design opportunity", calling for managing chronic flooding while providing other benefits such as new recreation areas, marsh habitat, and more livable communities. Both flood prevention and resilience strategies are needed; socio-economic goals and available resources dictate the balance between the two strategies. The Boston Harbor Association and Sasaki Associates recently published Designing with Water: Creative Solutions from Around the Globe (August 2014). This publication describes 12 case studies that successfully use Living with Water design principles; an appendix lists dozens more. In this research five key principles emerged:

1. Design for Resilience: Resilience implies adapting to or bouncing back from a disturbance quickly. Resilient planning and design incorporates redundancy and anticipates change over time.
2. Create Double-Duty Solutions: Double-duty solutions afford protection in times of need and provide for other uses when idle realizing multiple benefits and maximizing economic, ecologic, and cultural gain.
3. Strengthen Community Resilience: Community resilience maintains and enhances the cultural identity that defines a city through resiliency networks and social support systems. Strategies that strengthen social resilience can both cost less and provide meaningful benefits to participants.
4. Incentivize and Institutionalize Preparedness: Citywide and regional adaptation plans are necessary to guide resiliency efforts. Insurance standards, zoning laws, construction codes, and policy are tools that local and state governments should consider to encourage adaptation within their communities.
5. Phase Plans Over Time: Designing with Water requires design and planning for flexibility and adaptability over time. Planning efforts that address sea level rise should be phased and have the ability to change based on external conditions..

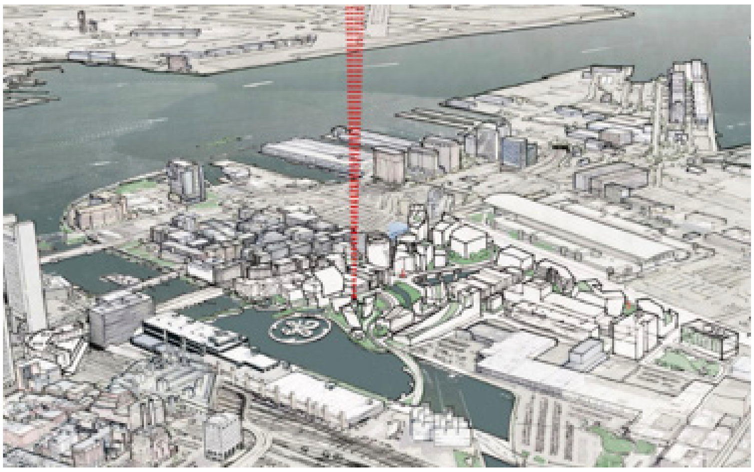
Map of the Fort Point District: Left - Current Sea Level with Site in Red; Right – 7.6 Meter (25 Foot) Rise in Sea Level

Primarily used for surface parking, the "100 Acres" site is located on filled tidal land abutting the Fort Point Channel and poised for redevelopment. The 100 Acres Master Plan, completed in September 2006, provides a framework to transform the area into a vibrant mixed-use neighborhood with new public open space. Situated directly adjacent to the Fort Point District, an iconic collection of historic turn of the century brick warehouse buildings, and a short walk from downtown Boston and South Station, the location is becoming a highly walkable and bikeable neighborhood. Future workers, residents and visitors will enjoy views and access to the Fort Point Channel edge via Harbor walk, a continuous public way extending around the Harbor. The continuing development of the Innovation District, approximately 20 million square feet of new residential, commercial and institutional use buildings along the Harbor, will assure easy access to a wide range of assets, amenities, and cultural institutions including places of employment, entertainment, and services. Public transit service provides direct access to Logan International Airport and local connections throughout the metro area including South Station which provide access to regional and national rail service. The Proctor & Gamble / Gillette company, whose Gillette World Headquarters abuts the site, and the US Postal Service own the major land parcels in the district.

The Fort Point District 100 Acres Master Plan sets a framework and vision for redeveloping the area into "a vibrant 24-hour, mixed-use neighborhood anchored by over 11 acres of new public open space and almost 5.9 million square feet of development." Key elements of the Master Plan include:

• Preserving industrial uses while encouraging an increased mix of uses.
• Ensuring that at least one-third of development is housing, including an expansion of artist housing, and aggregating residential elements around open spaces.
• Extending Harbor-walk along the entire length of Fort Point Channel.
• Providing an open space connection from the South Boston Bypass Road/Haul Road to the Fort Point Channel.

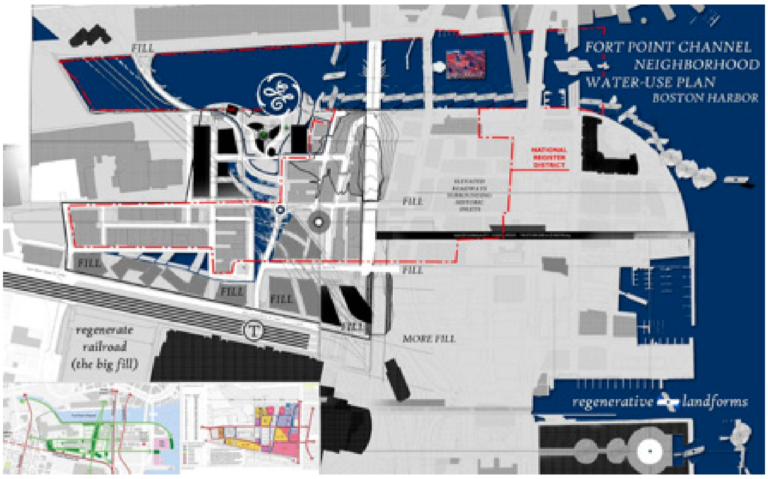
The site's ownership is concentrated among four landholders (Proctor & Gamble / Gillette Company, the United States Postal Service, the Archon Group, and Beacon Capital Partners, Inc.) who own approximately 93% of the site. A key component of the current 100 Acres Master Plan is an agreement among the major private landowners and the City on implementation of recommendations. The area is generally low lying and, during "wicked high tides", the Fort Point Channel floods over its banks along the northern edge of the site. The east terminus of Interstate Highway 90 (the Massachusetts Turnpike) runs under the Fort Point Channel and diagonally below the site in a new tunnel. On and off ramps surface at the north / east corner of the site affording vehicle access to points west and east to Logan International Airport.
Assignment: The students were given the original masterplan for the area, which they can modify, but need to keep existing structures and their uses on the site as they currently are. Their task was to create a unified design that allows for near continues recreational use along the water itself. The term "recreational use" refers to playgrounds and sports fields, but also to jogging, walking, and cycling paths, as well as to areas to sit and relax. The major challenge was to develop resilient and adaptable morphologies that conform to your broader design vision. They were reminded that infrastructure can be sunken or raised to increase pedestrian safety and access to the site. Additionally, some features could also be moved.
They began by considering the positive and negative aspects of the site as it exists currently. What about it is most pleasing? What works there? What are its natural aesthetic draws? What group of people does it best serve? Then they considered the larger picture. Who are the other users of the sites or other potential users? What time of day or night might they occupy? What would each group of users most like to change? How might you weave these competing desires together, or can you find common interests on which to focus?



View of Regenerative Landforms Student Response with Revised Waterfront, Landscape and Building Forms.

Regenerative Landforms: The Student Response
In response to the assigned studio charge, three graduate students, Tim Applebee, Joseph James, and Ben Wisniewski, worked on the analysis of the Fan Pier area of Boston, which realized an urban redevelopment proposal. This research helps to explain the historic situation
related to the construction of this harbor, and the current issues specifically confronting this water-front neighborhood
Much of the land of Boston Harbor was manmade or infilled low lying land, created to facilitate industrially scaled harbor-to-rail goods transport during the late 1800s. While the neighborhood of Fort Point has retained some industrial characteristics, much of industrial activities have relocated outside of the city proper, and the "Fan Pier" rail lines have been all but abandoned. In their place, the state and city have located a sizeable portion of the "Big Dig," an outsized conference/convention center, and converted much of the existing industrial warehouse built fabric to residential and office occupancy (adaptive reuse). In the past ten years (following the completion of the Big Dig), no other neighborhood of Boston has undergone such dramatic commercial development. Almost all surface parking has been sold, giving way to mid and high rise mixed use structures. The neighborhood's existing urban fabric and open space has also undergone an urban renaissance, which mirrors that of Brooklyn: providing more affordable real

estate in immediate proximity to city center, and promoting in-city living for Boston's growing work force.
These early planning efforts, unfortunately, occurred prior to the acknowledged, critical need for coastal resilience strategies to address rising sea levels. Authorities representing the city of Boston, the state of Massachusetts, and the Boston Harbor itself, have since implemented large scale studies and planning efforts to address the imminent impact of rising seas on their coastal populations and industries.



Site analysis incorporating student response to sea level rise.

Regenerative landforms (2017), proposed by Applebee, James, and Wisniewski, is an aggressive, innovative, and adaptive re use planning effort. Their proposal for the Fort Point neighborhood focuses on resiliency planning at both the neighborhood scale and at the regional scale. Before particular resiliency options could be identified, the team performed extensive site, neighborhood, urban, and coastal analyses. Unlike an inland urban planning effort, the coastline of Boston is subject to numerous oversight agencies and programs at all levels of government. Hard barrier, soft barrier, and hybrid barrier strategies (and locations) were individually assessed, including at critical inlet locations of the Big Dig. Open space and access to the water (as well as protection from the tides) was also carefully assessed.
The final proposal prominently incorporated a dynamic extension of Fredric Law Olmsted's "Emerald Necklace" as well as a hybrid, operable levee system. This levee system, the first proposal of its kind, understands the purpose and life expectancy of levees from multiple perspectives. Levees are most often considered immobile and singularly functioning. Their proposal, however, unitizes each levee member (a concrete pontoon structure sized to fit on a rail car) and suggests that these pontoons, when strategically located and dynamically deployed, can serve multiple functions.

1. Sea Wall - An interconnected link of submersible pontoons can, in times of predicted tidal surges, provide the low lying neighborhoods a primary level of protection from flooding.
2. Green Space - These levee pontoons, when linked, also provide new open space opportunities, extending the "Emerald Necklace" into the Fort Point Neighborhood and along its current coast line.
3. Electricity Generation - When deployed as pontoons (rising and falling with the harbor's tides), the levee system can also provide continual, large scale power generation. Similar to the regenerative braking technology used in current elevator cab design (as well as in electric vehicle braking systems), the dynamic levee pontoons would incorporate advanced fly wheel and battery technology. The massive weight of each pontoon, when lifted by the tide, becomes potential energy that can be captured by fly wheel generators as the tide falls.
4. New Industry - The geographically protected harbor (and industrial capacity) has well positioned Boston to mass produce this dynamic levee system for the entire seaboard, effectively promising a resilient strategy that contributes to Boston's economy.
5. New Urban Forms - Dynamic pontoons, technologically speaking, should be considered analogous to the horse and carriage: a first, important step. When clustered at larger scales, for example, they can become the heart of coastal resilience strategy that is centered on entire urban developments that rise (and fall) with the sea level, rather than simply succumb to it.

Regenerative landforms critically suggest that corporations and developers on Boston's waterfront (General Electric for example) have an opportunity and an obligation to partner with governments to pursue resiliency strategies that go beyond a sacrificial first floor. The GE symbol, for example, as seen in the team's design, is proposed as a human made ecological habitat, another exploration of large scale coastal/urban pontoon technology. Without such dynamic and strategic planning proposals as Regenerative landforms, the City of Boston will inevitably confront the need for a monumental infrastructure land filling project which could easily dwarf the scale and cost of the Big Dig. This planning effort as defined by Regenerative landforms, in counterpoint, was undertaken to explore and develop economically viable and civically vibrant alternatives to an otherwise ungainly task: The Big Fill of Boston's coast.

Historically speaking, beyond the unfortunate and gargantuan inlets created by the Big Dig in Fort Point, I'm thinking that there is also an example to be made of DS+R's ICA 2006 landmark. Or even better, Pei Cobb Freed and Partners Moakley Courthouse (1999) which stood alone for years, or Vinoly's Convention Center (2004). Looking at the flood maps and understanding the architectural landmarks' role in establishing development priorities and patterns, it's hard to argue that these projects were responsibly undertaken by either the authorities or the architects. But this is a somewhat incendiary, unfriendly indictment. Another pressing question is: What to do about protecting all of these follies, let alone the neighborhood structures listed on the National Historic Register?

Regenerative landforms (2017), Master Plan proposed by Applebee, James, and Wisniewski

Regenerative landforms (2017), Site Plan with new waterfront, buildings, and infrastructure.

Spring 2018 Assignment Program Brief

During the spring of 2018, ARC 521 Architecture Studio II was conducted by Associate Professor Theodore Sawruk. The studio, consisting of four students developed individual proposals for mixed use commercial/residential buildings, which specifically addressed an evolving waterfront due to rising sea-levels. Building on the urban planning scholarship of the previous year, these students proposed innovative methods of integrating program, structures, and landscape, under an overarching sustainable focus. The South Boston Waterfront Public Realm Plan, issued in 1999 by the Boston Redevelopment Authority, served as a framework for waterfront development in the area. The Plan was developed to ensure that this emerging district will provide not only a place for business expansion and job opportunities, but also an accessible waterfront, an attractive open space network, active civic uses, new places to live, a strong urban design character and convenient system of public transit. The vision for the area is to create a 24-hour neighborhood with a mix of industrial, residential, commercial, civic and retail uses, which will build upon Boston's character and utilize the area's waterfront location.

Students were asked to develop an urban scheme for the development of a site located in the recently developed South Boston Waterfront area. This waterfront site has various amenities, but also some environmental considerations. The site is expected to be impacted by the rising water levels over the next twenty years. The developer would like to see a combination of office and residential condominium towers, with a civic component at the base. The site will have to include on-site parking, as well as a

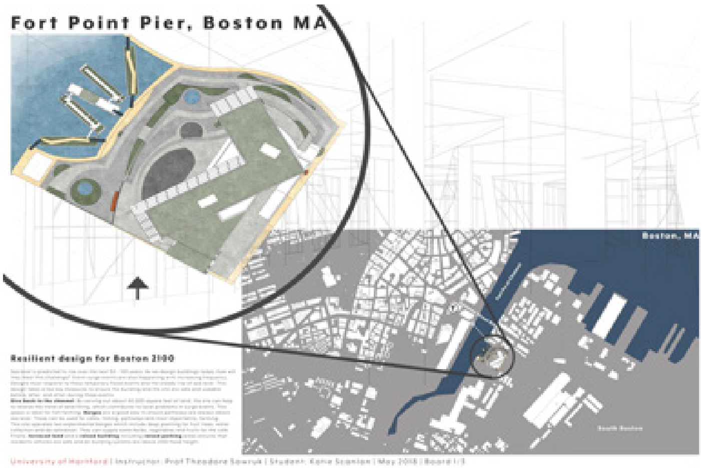
waterfront recreational amenity, such as a public plaza, river walk, restaurants, or entertainment facilities, while connecting to pedestrian and vehicular access/egress.
The proposed site is representative of the opportunities of urban waterfront mixed-use districts with existing, historic, and new buildings and green and blue open spaces. Student designs were required to address the following principals and site specific challenges:
• End-of-century Sea Level Rise: A new vision and plan that increases the sustainability and resiliency of the district for end-of-century sea level rise adapting to a 1.5 meter (5 foot) increase in sea level in Boston Harbor. This means that monthly "wicked" high tides (aka the astronomical high tide or King Tide) and moderate storm surges chronically reach elevation 5.7 meters (18.5 feet) on the Boston City Base (BCB) datum.
• The integration of new development and existing buildings, and the interface of new and existing infrastructure. (The design of GE world headquarters is unique in its address of projected flooding threats. Other newly developed parcels might also have some interesting strategies worth noting)
• The most sustainable and resilient mix of land uses, buildings, both green and blue open spaces, circulation, and infrastructure including transportation, water, stormwater, wastewater, energy, and environment.
• Incremental Adaptation: Adapting to a continuously changing environment and incremental sea level rise. Designs should anticipate the ongoing need to adapt iteratively for rising sea levels and increasing coastal flooding over time.

Student Design Proposals
The following two projects by Mary Katie Scanlon and Yi Jun Ooi present two of the innovative and unique projects proposed by students within the studio context. Their projects Fort Point Pier and the Boston Hive seek to address the dynamic requirements of the assignment, while aggressively addressing the impact of flooding and sea-level rise on the Fort Point Channel waterfront.

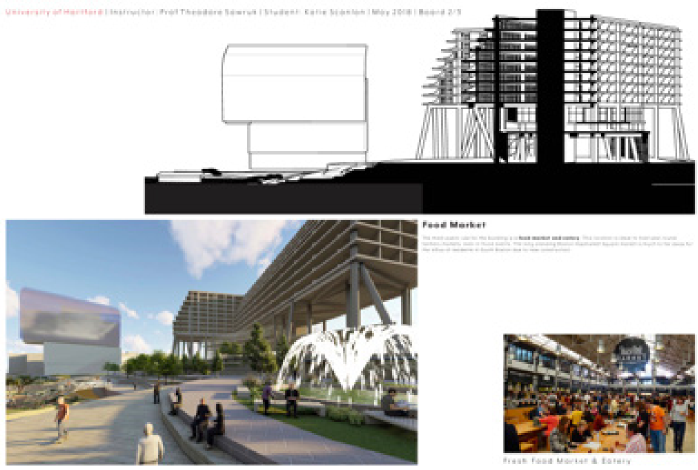
Fort Point Pier, (2018) by Mary Katie Scanlon

Views of Fort Point Pier (2018) proposed by Mary Katie Scanlon

Fort Point Pier (2018), proposed by Mary Katie Scanlon, takes a few key measures to ensure the building and the site are safe and useable before, after, and often during these events. Give back to the channel. By carving out about 60,000 square feet of land, the site can help to reverse the trend of land filling, which contributes to local problems in surge events. This space is ideal for fish farming. Barges are a good way to ensure pathways are always above sea level. These can be used for cafes, fishing, pathways and most importantly, farming. This site operates two experimental barges which include deep planting for fruit trees, water collection and desalination. They can supply some herbs, vegetables and fruits for the cafe. Finally, terraced land and a raised building including raised parking areas ensures that residents vehicles are safe and all building systems are above 2100 flood heig



Site Plan and Location Map of Fort Point Pier (2018) proposed by Mary Katie Scanlon



Site Section and Renderings of Fort Point Pier (2018) proposed by Mary Katie Scanlon

The building is designed for Boston's climate to take advantage of passive solar gain in winter with balcony depths providing optimal sun shading during the summer. The building design also takes advantage of the hot air exhaust from the large kitchen area and refrigeration exhaust with a heat exchanger to temper the semi-open public space at the top of the terrace, which is used as an ice skating rink in the winter months. Deciduous trees provide shading in the summer to make the outdoor cafe area more comfortable along with furniture such as pergolas and umbrellas.

To integrate with the existing streets, which are located at or below flood-level, retail spaces connecting with the street are designed with flood resistant materials to allow commerce to continue after minor flood events and are designed with 20' ceilings, allowing the shops to be modified with raised floors to align with the Fort Point future street level which will need to be lifted between 3 to 6 feet. The overall design still contributes to the neighborhood if sea level rise causes the perimeter shops to be abandoned entirely with the main market, food hall & housing on or above the raised platform.

The terraced public space leading to the reclaimed waterfront with barges is also designed to allow the barges to be accessible even when the water does not retreat. It is important that the waterfront be accessible to the community with signage and programming that provides education about sea level rise. Terrace patterns and levels have sea level rise numbers engraved on them so that people can quickly see how high the water is and also easily say, "meet me on level 8".

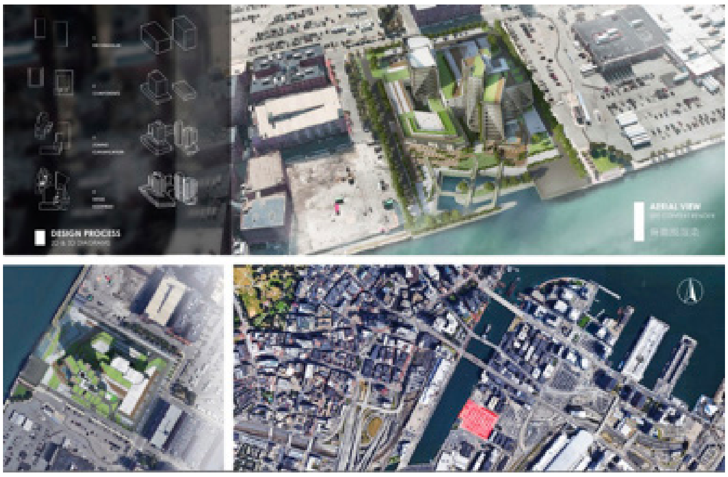
This project ties into the riverwalk, encouraging pedestrian connections from existing and proposed walkways. It also has a strong urban farming component which addresses other critical issues for future cities of food production, storage, transportation and waste collection and reduction. The barges are able to leave the dock to deliver food to the city and to embark on educational journeys as well.

The Boston Hive, (2018) by Yi Jun Ooi

The Boston Hive, a waterfront architecture development, located at South Boston Waterfront, is an architectural design that would be strategically built to combat the issue of annual flooding and sea level rise in Boston. The overarching concept of the architecture design was a 'Floating City', where the entire programmable building was designed above the estimated rising sea levels of around 6 meters (20 feet). As water levels increase, the buildings are offset from the varied water levels.

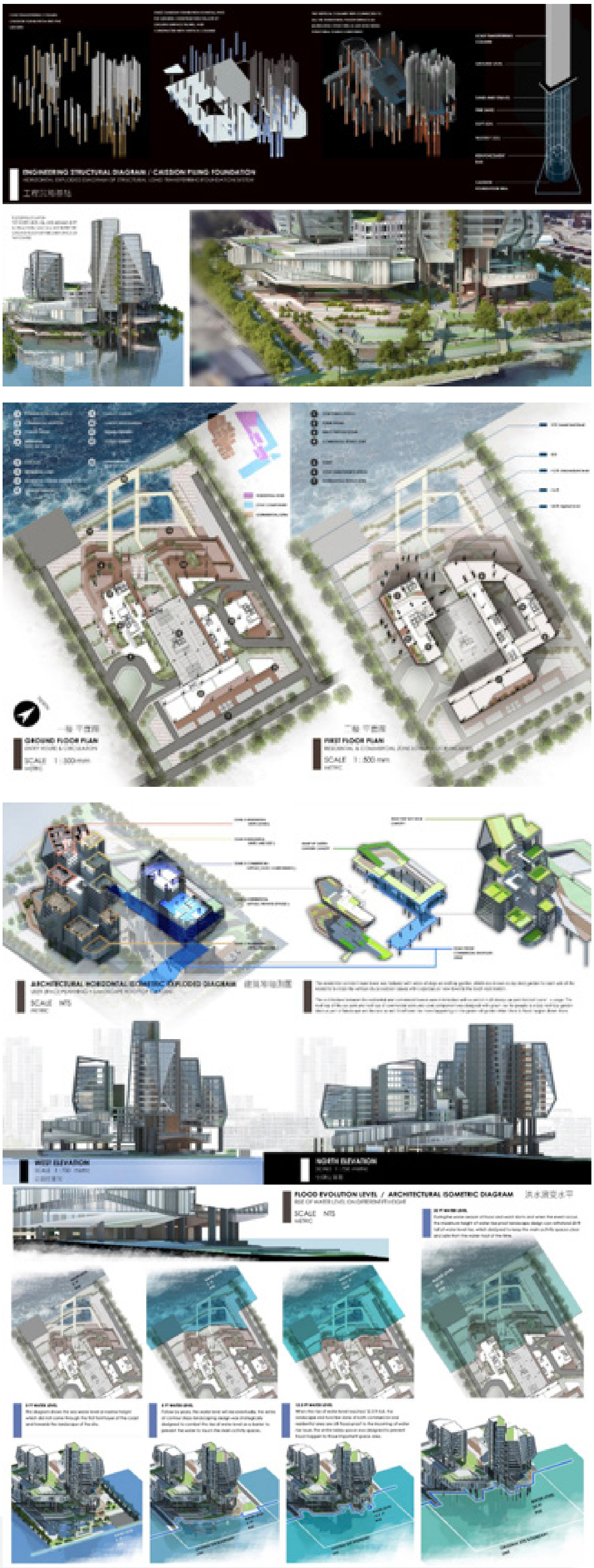
The innovative architectural form was features a combination of office and residential condominium towers, with a civic component at the base. Additionally, a 10 story height car park for both the commercial and residential patrons was included, and was equipped with a row of commercial shop lots along the street side of the site, providing a retail connection to the adjacent city scape.

The entire exterior waterfront or landscape along the river is designed with series of steps, at various contour heights. This allows the site to address, absorb, or resist both the seasonal and permanent flooding as it occurs. As such, rising water levels will not affect the buildings and related commercial amenities. However, the waterfront landscape would naturally be modified over time, as walkways and landscape give way to shore and pools, eventually evolving into docks and a domestic harbor (see progressive imaging below).



To be stably built exact on water front, especially an annual flooding zone region in South Boston area neighborhood, the engineering construction behind the architecture projects

was using caisson piling foundation system. The load transferring column method into deep of the ground. Once the caisson foundation is install into the deep ground, the construction then followed by ground surface filling process, and constructed with vertical column, the vertical column then connected to all the horizontal floor surface as monolithic structures as an architectural structure stability component to hold the entire architecture.


ENGINEERING STRUCTURAL DIAGRAM / CAISSION PILING FOUNDATION
GROUND FLOOR PLAN
SCALE 1 : 500 mm
FIRST FLOOR PLAN
SCALE 1 : 500 mm
ARCHITECTURAL HORIZONTAL ISOMETRIC EXPLODED DIAGRAM
SCALE NTS
WEST ELEVATION
NORTH ELEVATION
FLOOD EVOLUTION LEVEL / ARCHITECTURAL ISOMETRIC DIAGRAM
SCALE NTS

Flood adaptive water front architectural landscape and adapting to the change of Boston sea water level:
• 0 feet water level The first diagram shows the sea water level at normal height which did not come through the first front layer of the coast and towards the landscape of the site.
• 5 feet water Follow by years, the water level will eventually rise, the series of contour steps landscaping design was strategically designed to combat the rise of the water level as a barrier to prevent the water to touch the main activity spaces.
• 12.5 feet water level When the rise of water level reached 12.5 feet tall, the landscape and function zone of both commercial and residential area are still flood adaptive to the incoming of water rise issue. The entire lobby space was designed to prevent flooding to this vital access area.
• 20 feet water level During the worst season of flood and worst storm and when the event occurs, the maximum height of water rise adaptive landscape design can withstand 20 feet tall of water level rise, which designed to keep the main activity spaces clear and safe from the water most of the time.

The residential condominium tower building blocks was featured with series of steps as roof top garden, which also known as sky deck garden for each unit of the residents to enjoy the vertical city as outdoor spaces with a spectacular view towards the South East Boston. The architecture between the residential and commercial towers were interlocked with a central multi story for both zones of usage areas. The roof top of the car park and roof top of commercial zone / civic component was designed with green roof for people to enjoy the roof top garden deck as part of landscape architecture as well. It will even be more happening on the green roof garden when there is flood happen down there.

Conclusion
The successful execution of these student projects speak to the potential of real world simulation within architecture and engineering coursework. It is essential that designers prepare to address critical challenges looming on the horizon. As such, it is possible for academic pedagogy to be the first step in addressing these and similar issues. Sustainability can no longer be an add-on aspect of architectural design. It must be the foundation principles on which all future designs are based. As exemplified by these modest proposals, students are able to comprehend and integrate new and emerging technology into their scholarship.
Successful designs from both studio exercises were able to embrace Living with Water design strategies and solve multiple challenges, including minimizing damage from chronic and episodic coastal flooding. These proposals were able to mitigate adverse building impacts on the environment, enhance climate resiliency, be incremental, and implementable. They serve to propose a feasible future for Boston that could be economically and social sustainable, inclusive and equitable, and physically ecological and beautiful.

Innovative features in training methods for sustainable architecture design

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Keywords: environmentally friendly materials, design, skills, learning models

Abstract

The adoption of environmentally friendly materials and constructive solutions is one of the most effective action to reduce the relevant environmental impacts generated by the building construction and renovation activities. Since architect plays a decisive role in performing these strategies, his training should be oriented to make him aware of this responsibility, by providing them knowledge and skills suitable to include sustainability as an objective that the design must achieve at all scales. This requires a coherent and incisive intervention on both methods and contents of architect training, developing adequate and effective teaching tools right from the initial stages of the learning process, within the schools of architecture.

The paper provides the first results of a comparative study carried out on the architecture degree courses of three Italian universities (Bologna, Reggio Calabria, Iuav Venice). A mapping of structure, contents and organization of the five years of training has been performed, to detect the type and weight of the supplied relevant skills related to building sustainability, as well as to identify the applied learning models.

In particular, two main topics have been deepened: the knowledge provided on designing constructive solutions and selecting eco-friendly materials; the use of sustainable building rating systems (SBRS) and other tools for the environmental impacts assessment.

The collected data are then elaborated through comparison matrices, in order to bring out qualitative and quantitative aspects related to both the learning models used in the three Universities and the methods by which the acquired skills are assessed.

Introduction

Three Italian Master's Degree Programs in Architecture were analysed, those active respectively at University of Bologna, Mediterranea University of Reggio Calabria, and Iuav University of Venice. The analysis was carried out on the available public documents on the Programs and, in particular, by examining the "learning goals of the Degree Program" declared in the Teaching System Order ("Ordinamento didattico") as well as the syllabus for each Learning activity provided within the Program.

We sought in these documents the occurrence of terms which we consider as indicators of attention to issues concerning sustainability, resource use, energy efficiency, relationships with physical and climatic context and related impacts. In order to provide an up-to-date description, the survey was limited to the courses taught during the last two academic years (2017/18 and 2018/19), when none of the three Universities made changes of Teaching regulations for the selected Programs. The indicators were subsequently reworked in a matrix, to quantify and compare the results obtained. Finally, the collected data has been interpreted and commented

1. The Methodology

The Decree n. 270/2004 of the Italian Ministry for Education (article 3, paragraph 7) concerning the compulsory contents of university degrees, establishes that << In defining the teaching regulations of the degree programs, the universities must specify the educational goals in terms of expected learning outcomes, with reference to the descriptor system adopted at European level. >>. It follows that the format in which the teaching regulations are organized refers to the "Dublin Descriptors" as defined in the 5 points below:

- Knowledge and understanding
- Applying knowledge and understanding;
- Making judgments;
- Communication skills;
- Learning skills.

These are applied recursively to each of the "learning areas" that are considered as characterizing the Program, thus they provide the common framework to be adopted for communicating the contents of any Program.

For Architecture Programs, the learning areas typically cover the 11 topics defined by the European Directive 2005/36 / CE[1], and precisely:
a) ability to create architectural designs that meet aesthetic and technical needs;
b) adequate knowledge of the history and theories of architecture as well as of the arts, technologies and related human sciences;
c) knowledge of the fine arts as factors that can influence the quality of the design architecture;
d) adequate knowledge of urban planning, planning and techniques applied in the process planning;
e) ability to understand the relationship between man and architectural works and between architectural works and their environment, as well as the ability to grasp the need to adapt between their works architectural and spaces, according to human needs and measure;
f) ability to understand the importance of the profession and the functions of the architect in society, in particular elaborating projects that take into account social factors;
g) knowledge of the methods of investigation and preparation of the construction design;
h) knowledge of structural design, construction and civil engineering related problems with the design of buildings;
i) adequate knowledge of physical problems and technologies, as well as the function of buildings, in so as to make them internally comfortable and protect them from climatic factors;
l) technical capacity that allows the design of buildings that meet the needs of users, within the limits imposed by the cost factor and by the building regulations;
m) adequate knowledge of the industries, organizations, regulations and procedures necessary to carry out building projects and to integrate plans into general planning.

The analysis of this source focused on the first two "Dublin Descriptors", assuming that, if correctly applied, they should indicate respectively:
- the "avant-garde themes in one's field of study" that the course intends to give to its students and the "original ideas, often in a research context", to which it is aims to prepare them;
- "problems in new or unfamiliar areas, inserted in wider (or interdisciplinary)" contexts that the course wants to teach to solve.

Unlike the objectives of the Degree Programs, whose definition must comply with a unified national framework which is coordinated at European level, the syllabus of the individual classes are more freely articulated, generally based on the directives of each University. They all, however, supply core information declaring the educational targets, the knowledge and skills that the teaching intends to provide (learning outcomes), as well as the description of the main contents of the class (course contents). The analysis of this source has considered the whole texts of the programs, with the only exception of the section on bibliography and suggested readings.
When a course has been found providing outcomes related to sustainability, a further analysis was carried out about the teaching methods, looking for the adopted and possibly innovative learning models or tools.

2. The choose of indicators

Within these official texts the recurrence of the following terms was sought:
- Sustainability
- LCA
- Energy or energy efficiency
- Climate
- Environment or environmental impact

The operation was conducted by searching for the individual terms on all the texts, thus recording the number of occurrences and the position of the terms present with respect to the type of source that contains them.
A second stage of the analysis was carried out on the classes which syllabus included at least one of the selected terms, focusing on the declared "teaching methods" in order to possibly find any topic concerning simulation tools, sustainability rating systems for building or neighbourhood, LCA applications.

3. University of Bologna

For the University of Bologna, the Single Cycle Degree Program in Architecture (Class LM4) was analysed, which is active at the Cesena Campus and aims to train <<professional figures with specific competences in architectural design, urban and landscape planning, structural, technological and environmental design, architectural restoration, conservation and promotion

of architectural assets, interior design. The programme includes single-subject course units and workshops to develop design skills in the different areas of architectural and urban design, restoration, structural design, as well as knowledge of the economic and legislative issues connected to all fields of architectural design. The ultimate objective is to produce designers able to oversee the formal, constructive, productive and regulatory aspects involved in the transformation of the built environment, on different scales and in different contexts>>[2].

For the Degree Course program, with respect to the two Descriptors considered (knowledge and understanding, applied knowledge and understanding), the recurrences of the terms in the texts related to the different learning areas are those indicated in the following Tab 1:

Tab. 1: Relationship between Learning Areas and Terms in Single Cycle Degree Program in Architecture of Cesena Campus (UNIBO)

		LEARNING AREAS											
		a	b	c	d	e	f	g	h	i	l	m	TOT
Terms	Sustainability	0	0	0	0	0	0	0	0	0	0	0	0
	LCA	0	0	0	0	0	0	0	0	0	0	0	0
	Energy/energy efficiency	0	0	0	0	0	0	0	0	1	0	0	1
	Climate	0	0	0	0	0	0	0	0	0	0	0	0
	Environment/Environmental impact	0	0	0	0	0	0	0	0	0	0	0	0

With regard to the programs of the individual courses, the situation found is represented in the Tab.2 below:

The amount of ECTS corresponding to these teachings is shown in Tab. 3:

Tab. 2: Relationship between Learning Areas and keywords within the syllabus of the individual courses of Cesena Campus (UNIBO)

		LEARNING AREAS											
		a	b	c	d	e	f	g	h	i	l	m	TOT
Terms	Sustainability	0	0	0	0	0	0	0	0	3	0	0	3
	LCA	0	0	0	0	0	0	0	0	0	0	0	0
	Energy/energy efficiency	0	0	0	0	0	0	0	0	3	1	0	4
	Climate	0	0	0	0	0	0	0	0	0	0	0	0
	Environment/Environmental impact	0	0	0	0	1	0	0	0	3	0	0	4

Tab 3: Compulsory and Elective (*) courses and corresponding ECTS, by Year of study

		YEAR OF STUDY (UNIBO)					
		1	2	3	4	5	TOT
Terms	Sustainability	0	0	0	0	9 (*)	9
	LCA	0	0	0	0	0	0
	Energy/energy efficiency	8	0	0	0	4 (*) 2 (*)	14
	Climate	0	0	4	0	0	4
	Environment/ Environmental impact	0	8	4	0	6 (*) 4 (*)	22
							49

[1]"European Parliament and Council directive on the recognition of professional qualifications".
Published in E.U.O.J. September 30, 2005, n. L 255. Entered into force on October 20, 2005. Receipted in Italy by Legislative Decree 206 of November 9, 2007 (E.U.O.J. November 9, 2007 S.O. 228)
[2]*https://corsi.unibo.it/singlecycle/architettura*

The 49 ECTS account for 16% of the total ECTS amount of the Degree, but less than half of them (45%) corresponds to compulsory courses, while 55% are related to elective ones, so they are available for only a share of the Program students. Moreover, the involved classes belong to three Scientific Sectors only (ICAR/12: Technology for architecture, ING_IND/11: Environmental Technical Physics; ICAR/20: Urban Planning) and more than 70% of the ECTS belong to the first two of them, while the overall range of classes offered by the Program spans on 15 Sectors.
No mention is made of peculiar teaching methods nor of training in application of specific tools, if not software for simulation of building energy behaviour, within the environmental physics classes.
Among the elective classes taught in last Year of the Program, a multidisciplinary graduation atelier is offered, explicitly focusing on the specific target ("sustainable design lab") but mainly feed by a scientific sector only (ICAR/12). Its syllabus includes several of the keywords selected as indicator for this survey, but only 15% of the students are involved among those of fifth (and last) year of the Program.

4. Mediterranea University of Reggio Calabria
For the Mediterranea University of Reggio Calabria, the Single Cycle Degree Program in Architecture (CLASS LM4), of the Department of Architecture and Territory of Art, was selected, which aims to train *«professionals able of designing at various scales, through the architecture's own tools, including those of large-scale planning with the aim of knowing how to govern project processes, up to the territorial dimension. Graduates must be able to use the skills acquired to verify the feasibility of the project, the construction operations of the works, the transformation of the physical / artificial environment, even in a research context. (..) graduates must be able to direct their implementation, coordinating for this purpose and, where necessary, other specialists in the fields of architecture, building engineering, urban planning, restoration and conservation of architecture and landscape. Issues in which the themes of environmental sustainability, energy efficiency, consumption of material resources and the tools available to control them represent a common thread that determines the awareness and responsibility of a future designer with respect to his / her area of intervention»*[3]. For the Degree Course program, with respect to the two Descriptors considered (knowledge and understanding, applied knowledge and understanding) there are no recurrences of the terms in the texts related to the different learning areas although, different teachings have an approach that, although not explicitly stated, is oriented and based, as a well-established assumption, on the themes related to the different aspects of the theme "sustainability". With regard to the programs of the individual courses, the situation found is represented in the following Tab 4.
The amount of ECTS corresponding to these teachings is shown in Tab 5.

Tab 4: Relationship between Learning Areas and keywords within the syllabus of the individual courses of UNIRC

		LEARNING AREAS											
		a	b	c	d	e	f	g	h	i	l	m	TOT
Terms	Sustainability	1	0	0	0	1	0	0	0	0	0	1	3
	LCA	0	0	0	0	0	0	0	0	0	0	1	1
	Energy/energy efficiency	0	0	0	0	0	0	1	0	1	0	2	4
	Climate	0	0	0	0	0	0	1	0	1	0	0	2
	Environment/ Environmental impact	0	0	0	0	0	0	0	0	0	1	2	3

Tab 5: (*): Compulsory and Elective (*) courses and corresponding ECTS, by Year of study:

		YEAR OF STUDY (UNIRC)					
		1	2	3	4	5	TOT
Terms	Sustainability	0	6	12(*)	0	6(*)	24
	LCA	0	0	0	0	-	0
	Energy/energy efficiency	6(*)	6 6	4	0	-	22
	Climate	-	-	0	0		0
	Environment/ Environmental impact	0	-	0	12 6(*)		18
							64

The 64 corresponding ECTS to the courses identified account for 21% of the total amount of ECTS (300) of the course, but are provided in just four SSD (ICAR/12 Technology for Architecture, ING_IND/11 Environmental Technical Physics; ICAR/14 Architectural Design and ICAR/15 Art of Gardens), compared to the 16 SSD that cover the overall range of courses offered by the Program. The programs of Technology of Architecture Area provide training courses aimed at controlling construction processes and acquiring the concepts of environmental safeguard and principles of eco-efficiency / energy efficiency and thermo-hygrometric well-being since the I year, up to V. The common method is to work on the technological system by developing constructive solutions with characteristics related to energy efficiency, the choice of materials and their end-of-life scenario, in a logic of control of the entire life cycle of the building organization. The innovative features in training method are mainly evident in Courses placed in IV/V year and regard different Scientific Area. Some Curses provide tools for the advanced knowledge of the relationship between Technology and the environment, introducing the concepts of Enabling Technologies (KET) and resilience to the urban scale, with the aim of proposing experiments on prototypes of sustainable architecture and experimentation of technological processes innovative on components of the technological system, also with the support of Companies in the sector. The expected results concern, for these disciplines, the control of the construction process and of the environmental problems (and not only) involved at all levels of the design. The relationship between building and environment is defined in its specialized aspects through the Courses of Environmental Technical Physics Area that mainly deal with two areas: 1) the study of the typical applications of building thermophysics, for the analysis of the thermal behaviour of the building envelope elements, through the acquisition of the laws governing the heat exchange mechanisms in the steady state; 2) learning the techniques of environmental control within the confined space for the control of the thermo-hygrometric comfort conditions. The area of Architectural Design addresses the question of the relationship between form, sustainability, energy saving through the design experimentation of new housing methods. Students acquire the methodological and cultural tools for typological experiments that combine the three aspects, addressing the critical question of the crisis of contemporary architectural language. There is also, through The Art of Gardens Area, orientation towards the acquisition of knowledge of the Mediterranean context through the study of landscape design, the maturing of a critical awareness towards the themes of ecology and environmental and social sustainability.

5. Iuav University of Venice

For the Iuav University of Venice, the Architecture Construction Conservation Bachelor Degree Course and the Master's Degree in Architecture for the New and the Old were examined. The scientific-cultural project underlying the Triennial Degree Course responds to three needs: "The degree course pursues a teaching of the project based on the transmission of the fundamentals relative to the different knowledge that contribute to the architectural project: history, architectural and urban composition, representation (geometry-design-relief), construction (structures and technology), environmental control (technical physics-plants), urban planning, as well as the transmission of operational methodologies related to the different cases of project intervention, from the new construction to conservation and restoration of the existing, to the transformations of the urban environment. In particular, the degree course pursues an integration between technical and scientific knowledge and the culture of form, typical of an architectural project teaching that is also based on a capacity for historical and critical analysis and analysis of the existing, addressing an issue (always present) that crossed the entire history of architecture schools".

Similarly, the scientific-cultural project at the base of the Master's Degree is aimed at "the formation of a professional able to confront the complexity of the design process in all its aspects and to understand, using, coordinating theories and techniques of different disciplinary fields [...] the scientific-cultural project is aimed at training a designer-builder whose knowledge is based and articulated on theoretical and technical-scientific foundations, consistent with the present and future demand for operational knowledge. The proposed designer figure must be able to develop effective syntheses of the historical-humanistic and scientific disciplines, reflecting on the most innovative aspects and contents of the contemporary world".

Through the analysis of the two Degree Courses it emerged how the issues related to environmental sustainability, energy efficiency and climate, including in them also the different declinations, are present particularly in the field of Architecture Technology (ICAR/12), Technical Physics and Systems (ING-IND 11) and in the Integrated Design Laboratories. The latter represent a particular teaching method that brings together different disciplines in a single coordinated planning exercise. The disciplines, from time to time and depending on the type of laboratory and the year of the course, can belong to the area of architectural and urban design, of sciences and techniques, of restoration, of economic evaluation, of representation. The laboratory activity, which ends with a single examination, is aimed at introducing the student to the theme of the integrated project, in a sort of progressive preparation of what should presumably be the prevailing professional activity at the end of studies.

In the specific area of the three-year Degree Course, it emerges how the sustainability aspects are already included in the first year, in the course of Constructive Elements. The topic of sustainability – on the scale of the material, the product / component,

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[3]*http://www.unirc.it/didattica/corsi_laurea.php?uid=61f1651c-bab1-4443-883c-edf757e94c69*

and the building – fall within the contemporary architecture project, depending on both their environmental characteristics and the effects on the "formal" aspects of the project.

At the same time, the courses in Technical and Environmental Physics introduce the strictly performance aspects of technical/design solutions, also with regards to the issue of internal well-being. Although the course is in the second year, it is in continuity with the first-year, mono-disciplinary courses, which provide the student with the "foundations" of the various disciplines and the skills necessary to deal with design laboratories. It is in the latter, in fact, that some environmental issues, such as technological flexibility and maintainability, recycling/reuse of materials, and the evaluation of the various design choices, also with a view to sustainability, are part of the Triennial Degree Course. The location of the Laboratories in the second and third years (both including the teachings of Architectural Design-ICAR/14, and Technology of Architecture-ICAR/12), as mentioned, allows the student to apply the knowledge acquired in the course of the mono-disciplinary courses, and to prepare both for the possible entry into the labour market at the end of the three-year period, and for the continuation of studies in the Master's Degree Course, specifically characterized by the presence of laboratories. It is in fact in the Master's Degree Course that the topic of energy efficiency of buildings is placed more expressly, through the coordinated experience of two laboratories, the Existing Laboratory of Design, Analysis and Evaluation (including the teachings of Architectural Design, Design Structural and Seismic) and the Laboratory of Requalification and Efficiency of the Existing (including the teachings of Technical Physics and Systems and Technology of Architecture).

In summary, from the analysis of the two Degree Courses in their entirety and the specific course programs, it emerges how the environmental issues are mainly dealt with by the Architectural Technology courses, both in the three-year period and in the two-year period, and by the Technical and Environmental Physics courses. In particular, it emerges how environmental issues are present in the Design Laboratories, specifically focused on the sustainability aspects of materials, products and technical solutions oriented both to the respect of the architectural project and to the achievement of adequate performance levels of the element's components of the building organization.

Regarding to the programs of the individual courses, compared to the descriptors considered (knowledge and understanding, applied knowledge and understanding), the recurrences of the terms in the texts related to the different learning areas are those shown in Tab. 6 below.

The amount of ECTS corresponding to these teachings is shown in Tab. 7:

Tab 6: Relationship between Learning Areas and keywords within the syllabus of the individual courses of Iuav:

		LEARNING AREAS											
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**l**	**m**	**TOT**
Terms	**Sustainability**	0	0	0	0	0	0	0	0	1	2	0	3
	LCA	0	0	0	0	0	0	0	0	1	0	0	1
	Energy/energy efficiency	0	0	0	0	0	0	0	0	2	0	0	2
	Climate	0	0	0	0	0	0	0	0	0	0	0	**0**
	Environment/Environmental impact	0	0	0	0	0	0	0	0	0	3	0	3

Tab 7: Courses and corresponding ECTS, by Year of study:

		YEAR OF STUDY (IUAV)						
		Bachelor Degree				Master's Degree		
		1	**2**	**3**	**TOT**	**1**	**2**	**TOT**
Terms	**Sustainability**	6	0	12	18	18	0	18
	LCA	0	0	0	0	12	0	12
	Energy/energy efficiency	0	0	0	0	12	0	12
	Climate	0	0	0	0	0	0	0
	Environment/ Environmental impact	0	8 12	0	20	0	0	0
					38			42

The 38 ECTS of the Bachelor Degree account for about 21% of the total ECTS amount of the Degree, while the 42 ECTS of the Master's Degree account for 35% of ECTS amount of the Degree. The involved classes mainly belong to four Scientific Sectors (ICAR/12: Technology of Architecture, ING_IND/11: Environmental Technical Physics; ICAR/14: Architectural Design), and to Laboratories, which include different courses. Regarding the single programs, no references are reported concerning the use of specific tools or softwares (e.g. simulation tools).

6 Conclusions

a) The methodology adopted for the analysis does not allow to draw general conclusions on the contents and learning outcomes provided by the Programs, but it brings out some highlights about the self-representation that each Program communicate and the priorities in learning strategy that it declares. Due to the topic complexity, a deeper study is needed to measure in detail the effective share and weight of sustainability issues within the Programs, avoiding any hasty conclusion and possibly wrong judgments on the taught knowledge and skills provided. However, the sustainability issues do not appear to be assumed as a relevant topic by no one of the analysed Programs, and even less as an element to be highlighted within the main skills offered by the Program to the students.

b) Despite it has been in force since 1989 (Directive 89/48/CEE and 92/51 CEE) and recently confirmed with only few modifications (Directive 2005/36/CE), the "by skill approach" in defining learning areas for architect is still largely unapplied within the academic milieu. Since it is on this bases that the mutual recognition of architect' qualification within EU is assured, the adoption of a coherent structure in formulating each Program and course outcomes could be suitable and effective, but it has not so far replacing older habits. In addition to the sharing of this traditional approach representation by all the three Universities, a relatively homogeneous reticence also emerges in stressing on sustainability issues when the Program goals are declared. Our survey does not provide evidence to relate this to a really limited relevance reserved for these issues by the Program, but it shows that evidently this does not represent an asset by which the Programs characterize their learning offer. Moreover, it seems that the Architectural courses, both of Bachelor and Master's Degree, still show the persistence of an approach that usually tends to consider all the technical aspects of buildings as something that can be "added" at the very end of the design process, which is significantly opposed to an integrated view inducing the proper consideration of sustainability issues.

c) Within this framework, is not surprising than quite no mentions were found on specific tools nor on teaching methods specially designed to acquire skills on sustainable building design, environmental balance, climate issues, except for only few concerning energy simulations at building scale.

d) With respect to this framework, a disconnection therefore appears between the increasingly pressing needs of a constantly changing professional and the teaching provided by Universities who should answer this demand. While professionals are increasingly involved in multidisciplinary processes, asked to managed them in their entirety and complexity, the university programs, although certainly rich in contents, remains largely traditional in their provision an approach, apart from some specific case, mostly of them related to few disciplines adopting a more responsible attitude on environmental issues of architectural design.

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The Rural Making Lab: Tactic of Social, Cultural and Sustainable Innovation for the Inner Areas of Calabria

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Keywords: Inner Areas, Territorial Laboratories, Social and Sustainable Innovation, Training and education actions

Abstract
In the last two decades, the inner areas in Italy have shown a tendency to experiment new local development practices through projects oriented to the participation and knowledge transfer on the topics of innovation and process technologies. In this context fits the Rural Making Lab1, the tactic promoted by the Pensando Meridiano association, which has become the experimental phase of research within the PhD thesis entitled "Inner Areas, innovative processes for emerging communities. Strategies and tactics of Rural Making in ITI called Presila Catanzarese, Reventino-Savuto and Area Grecanica". The main objective is the adoption of sustainability approaches to activate projects of social, cultural, productive and environmental innovation for the inner areas of Calabria as the field of "transfer of knowledge and practices" for the activation of new emerging communities, sustainable micro-economics chains through the co-production of innovative goods and services, with reference to the local development drivers proposed by the National Inner Areas Strategy. The tactic is activated through four territorial laboratories and collaborative networks, organized in two phases: work-education, for the information and co-planning on the themes of sustainable culture, and work-project for actions of "self-construction" with the use of advanced technologies and digital processes. The capacity of Rural Making Lab to implement "training and education actions" in the case of experimentation on the Calabrian inner areas, produces a multiplier regenerative effect for the landscapes and "temporary" communities that move between urban areas and inner territories, according to the new paradigm based on the theoretical and scientific contribution argued in the research (commuting).

1. The territorial and cultural reference scenario

1.1. The Calabrian inner areas in the National and Regional Inner Areas Strategy

The Calabria region's territory includes over 50% of small municipalities with a population of less than 6,000 inhabitants currently living in the geographic areas of the coast, where there has been in recent years the largest land consumption, and with a large natural availability and settlement in inner areas, over the urban. For the identification and classification of Calabrian inner areas, the methodology developed by the DPS (now Department for Cohesion Policies) has been applied, which returns a geography of the Calabrian territory characterized by a high presence of municipalities classifiable as Inner Areas, in total 323, corresponding to 78.7% of the total (while the national average stands at 52%). In the Calabrian inner areas there are just over half of the population, with a strong incidence of "peripheral" and "ultra-peripheral" municipalities (almost 40% compared to 22.5% national data). The remaining municipalities fall into the category of "Centers" and are classified as Poles, Inter-municipal Poles and Belt. The methodology adopted in the first SRAI document returns a mapping of the Calabrian Municipalities as in figure 1. It is expected that we can intervene with projects that affect demographic weakness of the occupied communities, of the lack of urban processes (metabolism) and of services for citizens (education, health, work and mobility), including the same inner areas of Calabria in a territorial project over existing geographical and administrative boundaries, not only associative structures, but also variables structures on scenarios of different relationships.
The goal is also to enable the protection processes, enhancement of natural and cultural resources, innovation in the fields of agri-food systems, local branches of renewable energy and a new craft sector connected to the enabling technologies and extra-national competitiveness, as reported by the National and Regional strategy for Inner Areas (see National strategy document for Inner Areas, par. 1.7, p. 22).
Referring to the National Strategy for the Inner Areas (SNAI), there are five areas of intervention (drivers) that include development projects:
- active protection of land/environmental sustainability;
- enhancement of the natural/cultural capital and tourism;
- enhancement of agri-food systems;
- activation of chains of renewable energies;
- know-how and craftsmanship.

Referring to the National Strategy for Inner Areas, the region Calabria defines for areas of action in compliance with the drivers for local sustainable development:
- Protection of the territory, essential and local community services;
- Enhancement of natural and cultural resources for the development of sustainable tourism;

- Sustainable mobility
- Manufacture, Crafts, agricultural products.

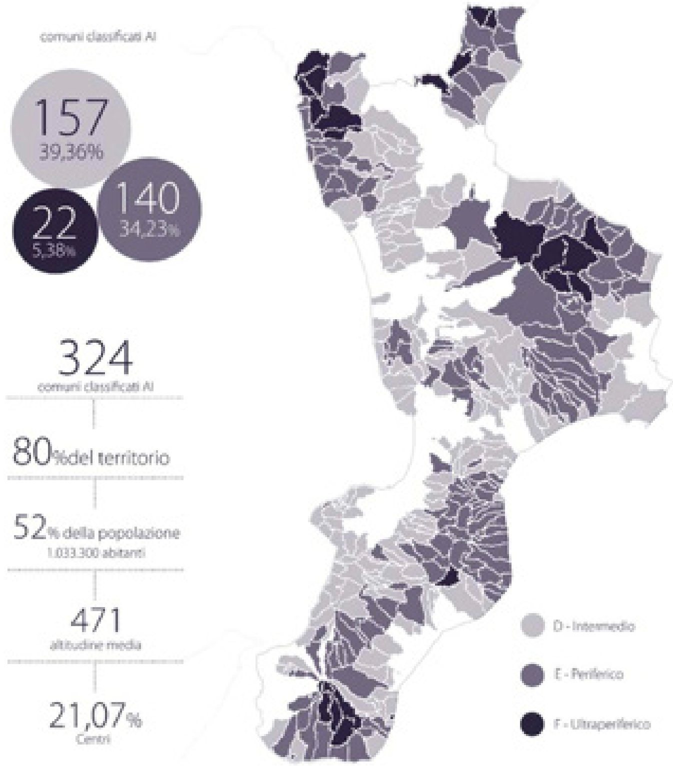


Figure 1 Map of Inner Areas in Calabria. Source: G. Mangano's graphic processing

The attention of national, regional and local government on inner areas, in parallel with the increasing spread of experiences of return to the "rural" as good practices for developing these territories, triggered the testing of a number of innovative models of participatory planning, together with the instruments provided in the measures by European funds POR and PSR 2014-2020 and of probable integration with the National Strategy for the Inner Areas.

1.2 The "emerging" communities and the innovative instrument of Rural Making Lab: territorial laboratories of social, cultural and sustainable innovation for capacity building and regenerative actions in the inner areas of Calabria.

The "emergent communities" of such "co-territories" are identifiable among the new inhabitants that can settle due to the integration of migration processes, to new business commuting and attractiveness, to favourable conditions of residency and to a transfer of sustainability processes from the coast to the inner areas (Fig. 2- 3-4)

Figure 2 The categories of new citizens (populations of non-EU citizens) in virtuous new experiences residency and economies for territories.

Figure 3 The young generations who will be able to engage in activities innovative able to create a new value and a new one consumption economy sustainable.

Figure 4 A new entrepreneurship, also coming from extraterritorial experiences, capable of transferring innovation and good practices in territories particularly favorable to competitive processes.

On the sidelines of the National Forum for internal areas 2017 in Aliano (MT), Fabrizio Barca underlined the value of community participation processes in the construction of local development policies as the only true instrument for the rebirth of the internal territories. A complementary reflection to that of Veronica Lo Presti, Daniela Luisi and Silvia Napoli (2018) according to which, through the adoption of a sustainable approach, it is possible to "constitute an innovative way to tackle the design of development interventions in the local area, enhancing the resources and proposals that emerge directly from the territories and that, if implemented with the accompaniment of experts, they can amplify the capacity building of all the stakeholders involved in the process of relaunching and developing an area, [...] since change and the relaunching of inner areas necessarily pass through the propulsive thrust of young people who must be adequately equipped with citizenship and innovation skills (as indicated in objective 4 of Agenda 2030 for Sustainable Development)".
This is the context within which the Rural Making Lab is inserted, the planning and operational tactic of the association Pensando Meridiano for projects of social, cultural, productive and environmental innovation for the internal areas of Calabria, selected as territorial Laboratories experimentation sites with the aim of triggering inclusion and cohesion processes for "emerging communities" (young innovators, visitors, entrepreneurs promoting local development, returning citizens, migrants) and to activate local micro- economies and knowledge through collaborative networks (with bottom-up approach) to respond to the marginalization phenomena of these same territories. With reference to the drivers proposed by the regional strategy for inner areas, the research intends to experiment strategies and tactics of social innovation through the creation of permanent laboratories for the social and occupational inclusion of "new residents" that will constitute emerging communities (young people, migrants and new entrepreneurs) in the internal areas of the mapped case. The Rural Making Lab is activated through four laboratories of sustainable, social, cultural and technological innovation that possess their own "themes", "objectives", "products" and "inclusion tools / strategies" and are able to find effectiveness within the actions put in place and drivers of local development defined by the National Strategy for Internal Areas and also implemented by the regional one. The four laboratories are structured as follows:
a) The Territorial Laboratory, which aims to trigger and coordinate all the innovative actions envisaged on the topics "internal areas, sustainable local development, innovation and emerging communities". The laboratory defines and coordinates the thematic trajectory of the entire project as a link between the subjects of the collaborative network and the local communities, as a real control room on a place-based approach. Furthermore, the objective of the laboratory is to activate innovative processes and projects on the development drivers of SNAI / SRAI / Area Strategy through the construction of collaborative territorial networks and to use open knowledge seminars as a dissemination and participation strategy (open knowledge) and the launch of co-planning laboratories with local communities (citizens, associations, informal groups, institutions, cooperatives and entrepreneurs). In this regard, the laboratory intends to build an integrated information system (dossiers and smart mapping on the topics of SNAI / SRAI or Area
Strategy) as a work tool for the analysis of sustainable scenarios that can be activated in the territories;

Figure 5 A moment of the Territorial Laboratory of Belmonte C. Ph. courtesy C. Zappalà (PM)

b) The Storytelling Laboratory, which develops multimedia communication strategies with the objective of enhancing and promoting the cultural, environmental, landscape and architectural heritage of the territories affected by the actions of the Rural Making Lab. This workshop creates storytelling in an innovative and creative form for communities, places and cultures but also of ongoing activities. "Storytelling" is a horizontal action foreseen in many Area and SNAI Strategies, as a tool through which it is possible to promote territorial values and contexts through new narrative and multimedia forms;

Figure 6 VideoStorytelling in Gallicianò (Condofuri, RC). C. Ph. Courtesy M. Cannizzaro (PM)

c) The Eco-Design and Enabling Technologies Laboratory, which works on the themes of advanced manufacturing processes and open-source technological innovation to trigger regenerative actions of spaces and places with sustainable self-building-recycle technologies. The objective of this laboratory is to regenerate and "compensate" places located in fragile contexts (marginal or abandoned spaces) or to be reactivated as collectives and identities for the communities through projects carried out with hybridized processes that use recycle technologies, additive manufacturing tools (digital fabrication and 3D printing) and Arduino open source technologies for environmental monitoring with self-built sensors;

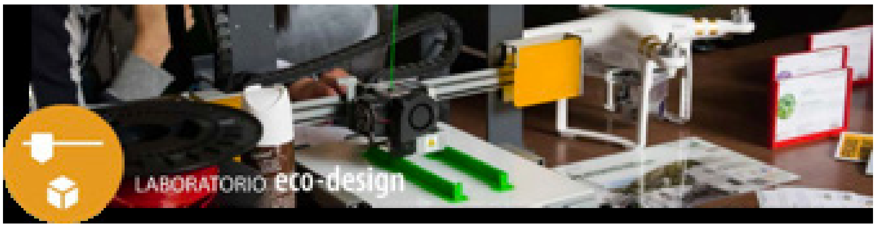


Figure 7 Additive manufacturing laboratory in Belmonte C. Ph. Courtesy M. Cannizzaro (PM)

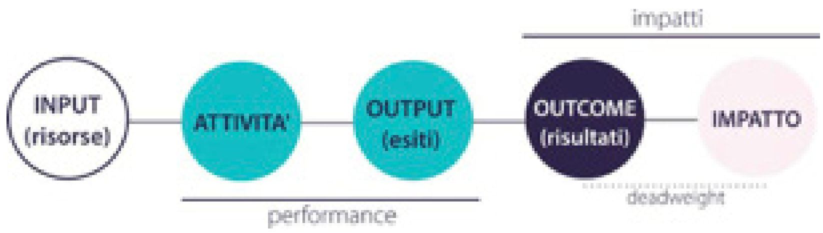
d) The Creative Cultural Projects Laboratory, which aims to promote open knowledge of places and landscapes through integrated innovative communication devices through the use of "analog" (totem mapping) and "digital" devices (mappings on open platforms, eg Google My maps, media, qr-code, etc.). Furthermore, this workshop intends to make information on places, territories, and landscapes accessible and integrated by developing devices with a high content of integrated information. The enabling technologies used also refer to the processes of open knowledge of the context values examined.

Figure 8 Integrative information maps in Belmonte C. Ph. courtesy D. Emo (PM)

The Rural Making Lab is a sustainable strategy that adopts enabling technologies "to control the transformations of the built environment, implementing impact regenerative design models, defining more coherently the nature of the term environmental impact towards its strictly connected meaning to the social impact" (Nava C, 2016).

Figure 9 Informative totem maps in Belmonte C. Source: extract from G. Mangano's PhD Thesis, elaboration by A. Procopio (PMopenlab srls)

And again, on the theme Key enabling technologies and innovation design driven in the regenerative approaches of the aforementioned work, Consuelo Nava relates the measurement of impact and regenerative systems of social and sustainable innovation as factors that "intercept and trigger process aspects (process design) and product aspects (product design), incoming (in) and outgoing (output) with respect to the ecosystems of the resources, the scenarios that can be produced, the operation of the networks. These three reference domains feed and manage values connected to the available data, to the detected performances, to the reactivated resources, to the functioning of the devices, to the configuration of different geographical models, to the variable and flexible arrangements of the territories and contexts (co-territories)".The impact of the projects referring to the activities and the technologies employed can be illustrated in the figure 10.



The actions of the Rural Making Lab find effectiveness in the construction of "co-territorial" collaborative networks that activate public-private partnerships as a new participatory dimension of emerging communities for the local development of inner areas. In particular, for these innovative forms of co-planning and collaboration in projects aimed at social, cultural and productive innovation of the internal areas, it is possible to define different levels of participation and active subjects. The four laboratories are organized in two phases:

- the Work Education phase, a training workshop, the in-training of young "makers" under 35 (who have joined the project on open call of the association) on the themes of innovative processes for internal areas, of the sustainable design and visioning for the transformation of places and the construction of information mappings with the identification of the spaces affected by the projects;
- the Work Project phase, during which the project is carried out on site in "self-construction" by activating the four operational laboratories, using recycle and innovative technologies.

2. Rural Making Lab Experiences on the SNAI experimental inner areas of Calabria

The experiences of Rural Making Lab conducted in the Territorial Integrated Investments (ITI) Presila Catanzarese, Reventino-Savuto and Area Grecanica represent the experimental and application phase of the research within the PhD thesis entitled "Inner Areas, innovative processes for emerging communities. Strategies and tactics of Rural Making in ITI called Presila Catanzarese, Reventino-Savuto and Area Grecanica". From September 2016 to June 2018, five territorial laboratories have been activated (figure 11):

The activities of the Rural Making Lab are promoted by the association Pensando Meridiano and, since november 2017, also in collaboration with the innovative start-up PMopenlab srls.

Figure 11 Rural Making Lab, projects timeline. Source: elaboration by G. Mangano

2.1 Rural Making Lab_Sila Orientale: activation of emerging communities processes through urban and rural regeneration projects in Zagarise (CZ)

The Collective Landscape Opera in Zagarise, a small village of about 1500 inhabitants located in the Catanzaro presila, concerned the regeneration of the landscape path that leads to the remains of the twentieth-century fountain called by the local population “acque e' fohre", or "waters at outside the country", through an installation of information totems about the identity, cultural and productive values of the village and the self- construction of a landscape room, which together with the refurbishment of tanks and realization of seats in eco-design and additive manufacturing, returned the place for collective use of the community. With the Collective Landscape Work at the "Giardini delle Esperidi" Festival in Zagarise, the Rural Making Lab was able to experience a real research / action program on the themes of environmental and landscape regeneration with training activities (capacity building) and the realization of projects on site at two different times (pre- festival at the university classrooms and during the festival at the Fontanile "Acque e 'fohre"), employing the 23 young people selected on the association's open call in over 150 hours of activity (see figure 13).

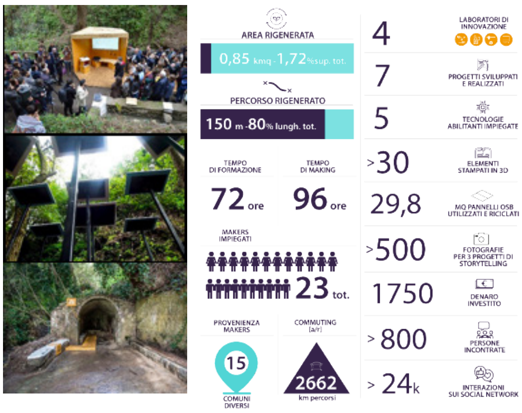


Figure 13 Projects and Impacts for Rural Making Lab in Zagarise. Source: extract from G. Mangano's PhD thesis, elaboration by G. Mangano

2.2 Rural Making Lab_ Reventino-Savuto: transfer of knowledge and innovation for the enhancement and regeneration of the cultural and landscape heritage of Belmonte Calabro (CS)

The opportunity to carry out a project in the field of regeneration and at the same time of training and continuous information on the issues of social and sustainable innovation for the Belmonte Calabro co-territory was presented by ErgoSud, the cultural project for young people from south, conceived by Professor Consuelo Nava in 2013, for the transfer of knowledge on innovation and sustainability of the Southern regions. The third edition of Ergosud provided a time dedicated to training and the transfer of skills within Officine Sostenibili in Reggio Calabria (Work-education), directed by the coordinators of the Pensando Meridiano association for the 40 "makers" enrolled in the school during the first half of May 2017 and then conducting the activities in

Belmonte Calabro on 19-20-21 May for the Rural Making Lab in a "residential" form with a project of environmental regeneration and cultural narration of the landscapes and the Gardens of the Castle "Galeazzo di Tarsia" (Work-project). The objective of the four laboratories was to create innovative projects and products for the reactivation of spaces of strong historical, cultural and landscape value to return them to its community also with a view to possible actions that can be activated in the future (figure 14). In this regard, the path of the gardens has been regenerated with cleaning and reclamation operations and the installation of five information totems with integrated technologies, a temporary event room was built in a cave previously used as a rubbish dump and plantings were carried out in collaborations with primary school students in the area. All the action was narrated on social media through photo and video products and the school ended with an open public seminar involving representatives of regional politics, experts and entrepreneurs.

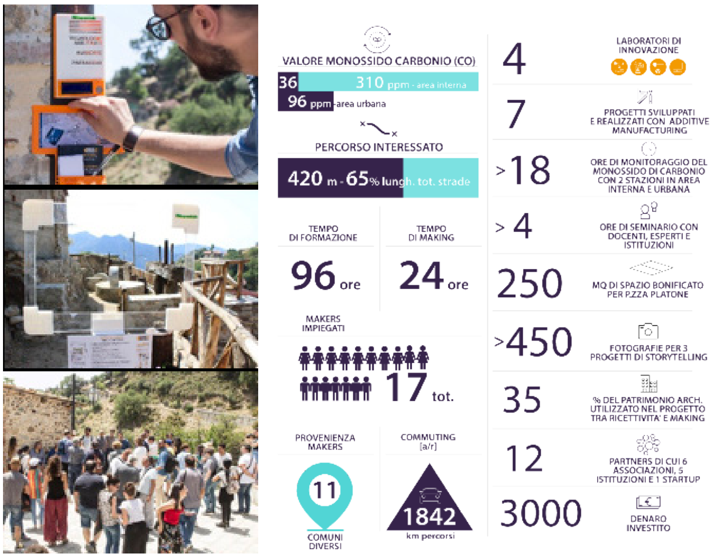


Figure 15 Projects and Impacts for Rural Making Lab in Gallicianò. Source: extract from G. Mangano's PhD thesis, elaboration by G. Mangano

3. Conclusions

Measuring and rereading critically the impacts of the three experiences illustrated above, it is possible to affirm that the Rural Making Lab can be inserted as a contribution to the most innovative instruments of governance of territorial development as a practice of sustainable social innovation, capable of activating virtuous and new networks supply chains of knowledge on local development and sustainability issues through territorial projects and laboratories for the training and information of communities active in the inner areas of Calabria.

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Pensando Meridiano Association, www.pensandomeridiano.com and PMopenlab srls – innovative startup www.pmopenlab.com

Living in the Clouds: Sustainable Pencil Towers for Hartford, Connecticut

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Abstract
This paper examines the pedagogy of sustainable education for architecture students, and presents the varied environmental design strategies as a measure of student learning outcomes. This paper addresses how sustainable modeling can be successfully integrated into the design studio, while this design project addresses these specific site locations, the student proposals could be used as precedents or prototypes for sustainable urban design in other cities.

Introduction

Hartford, like other American cities, saw and exodus of urban dwellers during the 1960/70's. Empty of inhabitants, Hartford's downtown is populated with office workers from 9-5, but a ghost town in the evening. To address this situation, the city has actively sought to encourage people to move back downtown. The city planners have initiated various incentives, including the renovation of historic offices into apartments, the renovation of streetscapes, and the introduction of an "I-Quilt" of urban parks. However, these various initiatives have not been successful, as the availability of residential units remains limited.

Over the last two years, the first semester Masters of Architecture students at the University of Hartford have engaged a design project to explore innovative building solutions. Inspired by our neighbor to the south, New York City, the students devised a proposal to introduce sustainable pencil towers into the urban landscape. Taking advantage of four modestly scaled, empty building sites surrounding Bushnell Park, the students proposed design options for increasing the density of inhabitants, while providing opportunities for daily contact with nature. In their own way, they present models that encourage pedestrian and public transit, address human scale, while contributing to the social life of the city.

Beyond addressing urban issues, the projects were required to explore innovative building skins, as a means of supporting a sustainable urban center. Students considered materials, orientation, natural ventilation, and passive/active solar design. Students analyzed their proposals using performance evaluation software to determine best-case scenarios.

Following the semester, two of the student proposals were submitted to the Connecticut Green Building Council design awards and each were awarded 2017 student design awards.

NAAB Design Pedagogy Criteria

The community based design project was conceived to address critical components of the architecture program curriculum as defined by the National Architecture Accrediting Board (NAAB). NAAB requires that all problem-oriented studio projects are intended to broaden/deepen individual understanding of the process, theories, and systems that influence the design of building and the built environment. As such, the objective of this course was to encourage holistic thinking by developing the individual's ability to effectively and efficiently address design issues. Conceptual, critical and imaginative thinking skills were necessary to this end. There was a strong emphasis on the development of analytical skills through tools of communication and a basic introduction of design theory.

As the first design course in the design studio sequence, this course (ARC511) and the related projects had to test previous design experience, introduce new coursework, and promote transformative learning. 'Design Thinking Skills' are identified by NAAB as the ability to raise clear and precise questions, use abstract ideas to interpret information, consider diverse points of view, reach well-reasoned conclusions, and test alternative outcomes against relevant criteria and standards. Projects proposed by faculty are expected to explore a student's investigative skills, or their ability to gather, assess, record, and comparatively evaluate relevant information and performance in order to support conclusions related to a specific project or assignment. These conclusions are then integrated with the student's architectural design skills and used to effectively consider basic formal, organizational, and environmental principles and the capacity of each to inform an architectural design.

Prior to design, students develop a site analysis, a comprehensive program, and examine relative precedents. The insights gained from these various forms of evidence serve as the basis of design assessment criteria and bare on each individual design conception. The ability to prepare a comprehensive program for an architectural project includes an assessment of client needs; an inventory of spaces and their requirements; an analysis of site conditions (including demographics, existing buildings, weather conditions, access /egress, and sight lines); a review of the relevant building codes and life-safety standards, including relevant sustainability requirements, and an assessment of their implications for the project constraints; site selection, and

design criteria.
In many cases, it is necessary to consider local history, as well as the impact of contemporary and global culture: When intervening in an established urban center, architects and planners need to be aware of the parallel and divergent histories of architecture and the cultural norms of a variety of indigenous, vernacular, local, and regional settings in terms of their political, economic, social, ecological, and technological factors. As such, the new residential towers needed to maintain a level of contextual continuity, while incorporating the most current technological innovations.
To that end, building envelopes consisting of systems and assemblies were explored. Students were asked to show an understanding of the basic principles involved in the appropriate selection and application of building envelope systems relative to fundamental performance, aesthetics, moisture transfer, durability, and energy and material resources. The selection of building materials and their specific assemblies required an understanding of the basic principles used in the appropriate selection of interior and exterior construction materials, finishes, products, components, and assemblies based on their inherent performance, including environmental impact and reuse.
And finally, 'Integrative Design' or the ability to make design decisions within a complex architectural project while demonstrating broad integration and consideration of environmental stewardship, technical documentation, accessibility, site conditions, life safety, environmental systems, structural systems, and building envelope systems and assemblies was required. All of these architectural aspects had to be technically documented via clear orthographic and rendered perspective drawings, and complemented with construct models illustrating and identifying the assembly of materials, systems, and components appropriate for a building design.

Urban Pedagogy Criteria
Creating an innovative and sustainable urban intervention requires the consideration of more than just real estate values, commercial trends, and construction techniques. The contemporary city requires sincere consideration of issues related to community, health, sustainability, and equity. Social, physical, environmental and just design considerations are essential to creating a livable urban neighborhood. Contemporary urban design is now more than just 'place making,' it requires the integration of all aspects of society in built form. Planers and urban designers are dealing with one of the most important challenges of our time – how to overcome growing inequality to make our cities healthy for ALL. Can we create high density, urban centers that facilitate walkability, bikeability, public transit, community, nature and provide healthy food accessible to poor neighborhoods that suffer the greatest health problems? Educators, consultants, and planners like Dr. Suzanne H. Crowhurst Lennard, director of the International Making Cities Livable (IMCL) conference are working to address these issues and see them instituted in inner cities around the world. Working directly with politicians, city administrators, urban planners and policy makers, the IMCL promotes the 'Healthy, 10-Minute Neighborhood.'
In a healthy 10-minute neighborhood most trips – to school, shops, services, work, recreation, and public transit - can be made by foot or bike within 10 minutes. The IMCL contends that "it must nurture the spirit, and be functional; it must assure quality of life for all ages, be affordable for all residents; it must reduce energy consumption in its construction and daily functioning, and be financially viable for developers; and to ensure development responds to community needs, citizens must be involved in the planning, design, and improvement process."[1]
Internationally renowned pediatrician and public health expert, Dr. Richard Jackson emphasizes that a neighborhood must be designed to support healthy child development, encouraging a healthy way of life for all. In Designing Healthy Communities (2011), Jackson relays that our dependence on the car, have created suburban neighborhoods that indirectly encourage isolation, lethargy, and aspects of obesity within families. Humans are essentially social beings, and require regular interaction to remain vital. A recent report[2] on the relationship between social relationships and mortality risks observed that loneliness and social isolation may be even more damaging to health and well-being than lack of exercise, poor diet, or smoking. Our neighborhoods must, therefore, be designed to promote pedestrian interface, thereby fostering social life and community. Regular access to exercise, healthy foods, and social interaction reinforce health benefits for all members of society, including the young and the old, and the poor as well as the rich. When people walk they are more likely to begin to "recognize neighbors, talk, and build social networks; this is invaluable for strengthening individuals' social immune system, reinforcing social bonds, and developing kids' social skills."[3] The built environment directly impacts social well-being, by either enhancing or discouraging social life and personal relationships[4].
It is not enough for urban planners to create a playground for children or a place for elders to gather. Philip Stafford, Director of the Center on Aging and Community, believes that urban places and events need to foster engagement across generations. Open green spaces must be both child and elderly friendly, while creating social and recreational places where all people can thrive. As such, 'intergenerational contact zones' are only one urban design strategy collaborating agencies and organizations can use to bring together different generations, when creating a more vibrant and compassionate city.
To this end, the IMCL often invites elected officials, practitioners and scholars to address issues that make cities more livable.

The Healthy, 10-Minute Neighborhood is just such an initiative. In his new book, Within Walking Distance (2017), New Urban News Editor Philip Langdon describes six walkable neighborhoods in US cities – Philadelphia, PA, New Haven, CT, Brattleboro, VT, Chicago, IL, Portland, OR, and Starkville, MS. Langdon is convinced that "places organized at the pedestrian scale are, on balance, the healthiest and most rewarding places to live and work."[5] Based on this text, and other related scholarship, the IMCL has published a list of design criteria essential to realizing a healthy, equitable, and ecologically sustainable 10-minute neighborhood, which is available on their web site, www.livablecities.org.
Recognizing the value in this urban design scholarship, the studio encouraged students to engage the principles of the Healthy, 10-Minute neighborhood in their designs and emphasize community, health, sustainability, and equity. Projects had to focus on one element that is needed to bring about a healthy neighborhood, such as walkable, streets, with a neighborhood park; or they may focus on a project that provides a new community amenity. However, every project had to enhance livability by creating a more humane, multi-functional, stimulating, useful, beautiful, sustainable environment. Outstanding projects contributed to creating a city that is integrated with its region and landscape, that were good for children and the elderly, that engaged human scale and the pedestrian, while promoting health and healthy behavior … A livable city.

Eco-Towers: Sustainable Cities in the Sky
In 2015, Dr. Kheir Al-Kodmany, an Associate Professor in the Department of Urban Planning and Policy at the University of Illinois at Chicago, published research related to innovative ways of thinking about a new generation of green skyscrapers that could provide solutions to crises the world faces today including climate change, depleting resources, deteriorating ecology, population increase, decreasing food supply, urban heat island effect, pollution, deforestation, and more[6]. His book, Eco-Towers: Sustainable Cities in the Sky, introduces readers to groundbreaking architectural designs, highlighting recent progressive projects. This scholarship suggests that the eco-tower culminates the cultural and technological evolutions of the 21st century by building and improving on the experiences of earlier designs of skyscrapers, while merging contemporary green, sustainable, and ecological philosophies. It argues that the true green skyscraper is the one that engages successfully with its larger urban context by establishing symbiotic relationships with the social, economic, and environmental aspects. Urban conditions require high-rise structures that serve a greater number of people, and exerting higher demand on the environment and existing infrastructure. Any improvements in their design and construction will significantly enhance the form and function of our cities
As urban centers evolve and respond to advancing climate changes, it will be necessary to employ green features in constructing new skyscrapers and retrofitting existing ones. Designing eco-towers will better serve tenants, mitigate environmental impacts, and can simultaneously improve integration with the city infrastructure. Al-Kodmany explains how a skyscrapers' long life cycle offers the greatest justifications for recycling precious resources, and makes renovation of urban structures both justified and recommended. Subsequently, he presents recent designs that employ cutting-edge green technologies at a grand scale, including water-saving technologies, solar panels, helical wind turbines, sunlight-sensing LED shading, rainwater catchment systems, graywater recycling systems, and the like. Finally, Al-Kodmany contends that, new building materials and smart technologies will continue to offer innovative design approaches to sustainable tall buildings with new aesthetics, referred to as "eco-iconic" skyscrapers[7].
Therefore, if sound design and planning aim to promote sustainable buildings, it is important that people adopt "sustainable" lifestyle that reduces consumption of resources, carbon emission, and waste, and reuses and recycles materials. The architecture design project proposed by the graduate faculty at the University of Hartford adopted and promoted these values or lifestyle, and introduced them as design constraints for the students.

The Program Brief
This assignment was developed as a part of the first-semester, graduate M. Arch design studio. The five-week project was to design an urban residential high-rise building in Hartford, Connecticut. Urbanity promotes a composite of diverse and unique cultures, values and lifestyles[8]. In the most successful urban centers, the variety of human expressions provides for a dynamic, energetic and adventurous day-to-day experiences and interaction between artifacts and inhabitants.
In recent years many cities, including Hartford, have made efforts to reinvent their city center by reestablishing residential buildings and amenities (urban components lost with the increased use of the automobile). A number of former office and hotel buildings have been redesigned to accommodate apartments and condominiums within the city's downtown district; these buildings are scheduled to open within the next year and have received much attention from home owners looking to live downtown. Many residents seeking housing in downtown areas include both professionals as well as young urbanites looking to live a more "car-free" or "car-less" lifestyle. The addition of a downtown supermarket along with an increase in retail, entertainment, and restaurant amenities are planned to service the new downtown residential district
The sites along Bushnell Park were strategically selected by the faculty to accommodate this emerging building type. The project was designed to physically and aesthetically connect to its immediate surroundings. Bushnell Park is a primary component of

Hartford's urban core. Central parks of this nature are intended to provide open space as a place of recreation, contemplation, and communal gathering to residents who live or visit the city. Designed by Swiss born landscape architect Jacob Weidenmann and built in 1868, the park has served this purpose well and has acted as the front lawn to the state capital building. The park is considered the core aspect of the recent I-Quilt downtown master plan, which intends to connect the numerous downtown districts with outdoor spaces and programs to also attract residents to downtown. Each high-rise tower design will be located on one of 4 sites directly adjacent to Bushnell Park; the park will be a source of view, light, and recreation for your building's residents.

Tall building developments have been rapidly increasing worldwide[9]. Recent high-rise residential design has included a new form of skyscraper: The Pencil Tower. These skyscrapers are typically constructed on narrow infill sites and rise dramatically above the surrounding buildings to provide breathtaking views to the building occupants. New York City has seen numerous buildings constructed or underway including 432 Park, 111 West 57th, One57 among others. Given the views and complex constructability on small sites, these towers often provide high cost condos that occupy an entire floor. Though urban centers should provide a healthy mix of residential offerings for all income levels, Hartford lacks high end residential spaces of such caliber.

Contingent to this design exercise, a structural system and building skin will be developed for the exterior fenestration. A building skin not only provides protection from the elements, but it allows access to sun, wind, and temperature. Recent advances have been made in smart façade and green façade technologies. These façade types allow greater access to exterior environmental conditions allowing for more sustainable control of interiors spaces through daylighting, shading, natural ventilation, passive heating and cooling, water collection, and air purification. Furthermore, building massing and orientation plays a crucial role in the effectiveness of a smart façade and sustainable environmental control system strategy. Each façade of a building, particularly a narrow tall building, will provide a different environmental condition between inside and outside. Each proposal should provide a form and façade analysis to establish proper passive environmental control and smart façade strategies. Built components can include, but are not limited to: operable windows and vents, daylight control, shading devices (static or dynamic), integrated mechanical systems, vegetated facades, water collectors, etc. Conceptual structural consideration should be indicated for all façade design components.

The project is to be designed to physically and aesthetically connect to its immediate surroundings. The building's entrance(s) needs to be a part of the pedestrian street; whose scale, materials, and landscaping seamlessly extends the pedestrian quality of the street promenade. The building's façade needs to continue the streetscape, while creating an individual identity, reflecting the building's unique complexity.

Whenever possible, the project should consider the Leadership in Energy and Environmental Design (LEED) standards as well as alternative energy sources and sustainable design. Buildings have a substantial impact on the health and wellbeing of people and the planet. "They use resources, generate waste and are costly to maintain and operate. Green building is the practice of designing, constructing and operating buildings to maximize occupant health and productivity, use fewer resources, reduce waste and negative environmental impacts, and decrease life cycle costs.[10]"

Teams formed of three to four students will complete a detailed site analysis and masterplan for the Bushnell Park district in relation to increasing residential living in downtown Hartford. The project program should be evaluated, configured and proposed as a redevelopment and residential revitalization plan for the district. The master plan summary should be presented via one 24x36 (vertical) board. Additionally, each team will construct a portion of the Bushnell Park District site model (1" = 40'-0" scale); model construction coordination will be conducted in-class regarding material selection, specific tasks, site boundaries, etc.

Each faculty instructor developed a system to evaluate the students' work using the criteria set forth in this program. The evaluation process was an integral part of the design process, encouraging students to scrutinize their work in a manner similar to that of the review jury. In addressing the specific issues of the design challenge, submissions were expected to clearly demonstrate the design solution's response to the following requirements:

- An articulate mastery of formal concepts and aesthetic values
- A mature awareness and innovative approach to environmental issues
- A thorough appreciation of human needs and social responsibilities
- An expressive understanding of the building skin construction and operational techniques
- A capability to integrate functional aspects of the problem in an architectural manner
- A capacity to coordinate and articulate environmental building systems and building services.

Critical Thinking Issues

Throughout the five-week design process, students were asked to consider various critical issues related to their response to the project program. Listed below are some of the issues they addressed:

- How does the new building relate to the existing facades and adjacent structures?

o Should it be less integrated or more integrated?
• Who is the building for - public or private clients or both?
o Is the concept development appropriate for these clients?
o Is the site relationship the best for that client?
o How much should the various clients interact?
• What physical activities happen in and around the building?
o And, are the spaces appropriate for those activities?
o How does the new facade affect the streetscape?
• Were liberties taken with the site approach?
o Program and project size to strengthen the project?
• How should the building be best represented on the exterior?
o Does it respond to its context?
o Does it exemplify the design concept?
o Does it represent the activity of the program?
o How is steel used in the building structure and fenestration?

Connecticut Green Building Council Design Awards

Following the 2016 fall studio course, two projects were submitted to the Connecticut Green Building Council (CTGBC) for consideration in their 2017 design awards. The CTGBC is the Connecticut chapter of the US Green Building Council (USGBC), a professional organization that is committed to transforming the way our buildings are designed, constructed and operated. Utilizing the LEED verification system for sustainable structures around the world, the counsel evaluates the success of various design and construction projects throughout the nation. The USGBC seeks to advance spaces that are better for the environment and within which it is healthier for us to live, work and play.

Each year, CTGBC recognizes outstanding green building projects and design efforts in Connecticut in different categories, including residential, commercial, and public/institutional buildings. The "CTGBC's Awards program is a celebration of the great work that's being done in our communities advancing us towards a more sustainable future," said Brian Dwyer, chairman of the CTGBC Board of Directors. "With a near-record number of project submissions, it's a positive sign that building owners, designers, contractors and suppliers are embracing smarter, lower impact, more sustainable and resilient buildings."[11]

With the support of the studio instructors, Sawruk and Holmes, two students, Fahed Baker and Timothy Applebee submitted their design proposals to the student design competition. After being reviewed by the CTGBC design award committee, Baker was awarded the Student Award of Honor for his proposal Trumbull Rise, and Applebee was awarded the Student Award of Merit for his proposal Carpenter's Tower, recognizing the outstanding quality of their work.

Conclusion

In conclusion, this paper recognizes the success of the faculty curriculum and the perseverance and creativity of the student participants. The competitive awards serve to reinforce the merit that a pedagogy of sustainable education for architecture students can achieve, and presents the varied environmental design strategies as a measure of student learning outcomes. This paper verifies that sustainable modeling can be efficiently integrated into the design studio. While this design project addresses very specific site locations in Hartford, Connecticut, the student proposals could be used as precedents or prototypes for sustainable urban design in cities throughout the country.

Student Design Proposals

For the purpose of this paper, five outstanding student design proposals were selected to serve as examples of the scholarship resulting from this academic exercise. Each presentation and the related summary were developed by the individual students and reflects their interpretation of the project needs, constraints, and opportunities. Each student considered various issues in combination, applied their own creative vision, and provided the supporting documentation. While all five proposals have merit, they are not complete building projects. It is important to consider that these are student proposals, and should be evaluated as such. Yet, each presents a precedent for future building considerations, with insights that can be applied to high-rise urban interventions in other city centers.

Trumbull Rise, Fahed Baker

'Trumbull Rise' is a luxurious residential tower proposed for a site adjacent to Bushnell Park. The goal was to create a unique vertical neighborhood, that distinctively stands among the skyline of the City of Hartford. A key design feature is the twisted form, which was a challenging structure for a site of this small size. One advantage of this form is that it allows the residents of each apartment a different perspective view of the city. A thin profile, amongst the giant Hartford high-rise buildings, Trumbull Rise has emerged like new seed from a tiny planter.

Based on an extensive site investigation and program analysis, the building was aligned with the street layout, engaging the pedestrian streetscape. The mass of the building was divided up into segments, allowing the form to related to the height of the adjacent buildings, while transitioning to a dramatic height. The core was developed in a way that enabled the building orientation to address the sun. Additional programmatic spaces were introduced to enhance the lifestyle of the building's residents.

This high-rise tower design was located directly adjacent to Bushnell Park; with the park serving as a source of view, light, and recreation for the building's residents. The building's entrance(s) were conceived as a part of the pedestrian street; where scale, materials, and landscaping seamlessly extends the pedestrian quality of the street promenade. The building's façade continues the streetscape, while creating an individual identity, reflecting the building's unique complexity

In order to realize the design, it was necessary to do extensive studies of the building structure. Thus, a structural model was proposed, based on a precedent study of the Mary Axe Building in London by Foster and Partners, and the Cayan Tower in Dubai by SOM.

Building Systems - The building adopts several active and passive climate control systems. Chillers for cooling are positioned on the roof, boilers for heating are located in the basement. Within the residential unit, Fan Coil Units are used for cooling, and perimeter hydronic heating for heating. Both heating and cooling branches are connected into larger convection units, that are located in one service floor for each eight condo floors.

Due to the compact size of the building core, most of the electrical, mechanical, and pluming shafts are reduced as well. Therefore, most of the proposed systems shall consider the smallest possible connection for risers, for example the VRF system is proposed for the HVAC.

Sustainability - Several passive design techniques are used in the design to increase building environmental systems efficiency and to reduce energy consumption. First is the double-skin facade, which creates a thermal air-buffer on the perimeter of the building to increase winter insulation and allow pre-heated air to enter the building. Conversely, in the summer, the double-skin reduces heat gain through shading and perimeter stack ventilation of the façade. The second passive technique, the garden spaces, separate each group of eight floors to prevent the air handlers from overheating in summer by minimizing distribution networks and shading chilling equipment. The shade areas created by these spatial openings in the building form also allows for a pleasant air current as well for the associate public spaces provided. Additionally, the green spaces reduce the buildings overall carbon footprint by increasing vegetated cover in the urban environment.

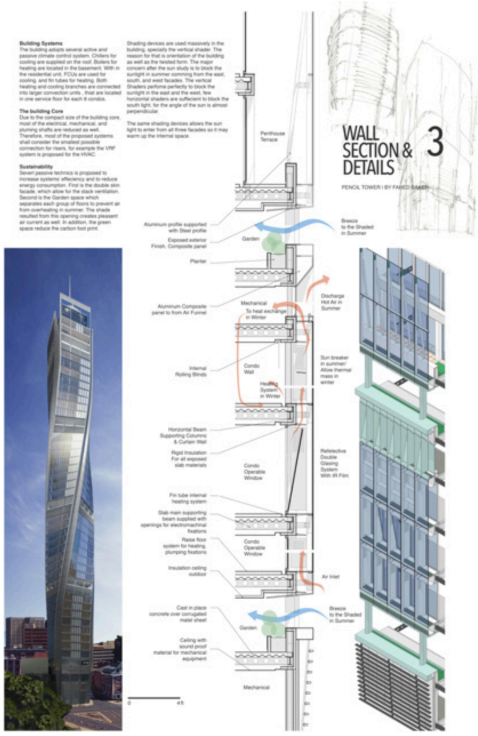
Shading devices are used extensively throughout the design of the building, especially as vertical shade elements. This feature addresses the orientation of the building as well as its twisted form. After completing a solar geometry study, a primary concern was limiting the amount of direct sunlight in summer, especially light coming from the east, south, and west. The vertical shade elements block the sunlight from the east and west, while a few horizontal shade elements are sufficient to block the southern light, as the angle of the sun is almost perpendicular. These same shading devices allow for direct solar gain on all three facades during the winter, so natural sunlight warms the internal living spaces.

The project included extensive building performance modelling to calculate, analyze, and optimize energy usage as it relates to envelope heat/flow, solar heat gain, heating and cooling equipment efficiency, and lighting.

Energy Modeling - A "THERM" model was constructed for a portion of opaque facade exposed to external climate and weather at the structural corners of the building. The analysis indicates consistent resistance to heat flow and minimizes condensation potential internal to the moisture and vapor barriers behind the exterior aluminum composite panels.

An energy model of the building was constructed using Sketch-up and Sefaira and iterative design process used to optimize energy efficiency. The baseline model included primary building functions, geometry, and envelope materials; but simply used code requirements for insulation, window-to-wall ratio (WWR), and had no shading. Various sustainable solutions strategies (shading, increased insulation, various WWR) were applied to the baseline model to individually assess their effect on energy consumption. Then, the most efficient strategies were gathered in a bundle and applied to the model to determine the best combination of strategies for improving energy efficiency. Overall, the optimized strategy combination of shading, WWR, and building insulation helped reduce energy consumption by 18% compared to the baseline design.

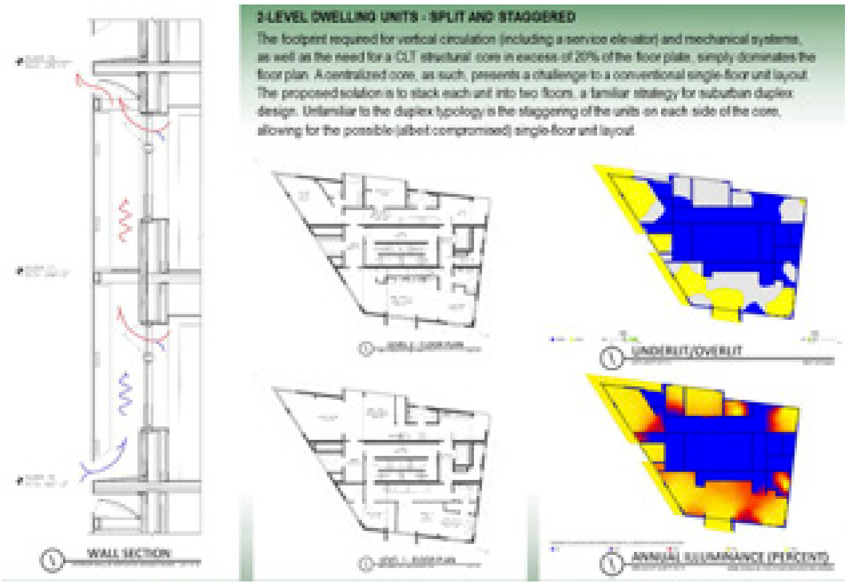
A daylighting analysis was conducted using the Sefaira model. The orientation of the floor plan changes slightly at each floor due to the building form "twist"; therefore, lighting levels change at each level even if the plans are similar. To account for this, the design includes dynamic environmental treatments such as operable shades and plantings to allow for lighting customization throughout the day and seasons. These solutions were chosen following an interactive daylighting analysis examining various geometry and shading typologies; the final design provides an acceptable 16% Annual Sun Exposure and 55% Spatial Daylight Autonomy for a typical residential floor unit.



Carpenter's Tower, Tim Applebee

We can take these smaller trees and take the smaller cuts of them, and laminate panels that weigh 10,000 pounds—massive panels bonded together to be stronger than concrete and one fifth the weight. Chad Oliver, Director of Yale's Global Institute of Sustainable Forestry[12]

In the previous statement, Chad Oliver discusses the benefits of cross-laminated timber construction. This studio project, Carpenter's Tower, proposes a new mass timber structure for downtown Hartford, Connecticut, specifically.
The footprint required for vertical circulation (including a service elevator) and mechanical systems, as well as the need for a CLT structural core in excess of 20% of the floor plate, simply dominates the floor plan. A centralized core presents a challenge to a conventional single-floor unit layout. The proposed solution is to stack each unit into two floors, a familiar strategy for suburban duplex design. Unfamiliar to the duplex typology is the staggering of the units on each side of the core, allowing for the possible (albeit compromised) single-floor unit layout.
Building Systems - This 35-story high-rise design, predicated on Skidmore Owings & Merrill's "Timber Tower Research Project" (2013), explores the interrelationships between the structural principles of Cross-laminated timber (CLT) in high-rise design, urban residential programming, natural ventilation, among other efforts at sustainable best practices. CLT is distinct to glued laminated timber, consisting of a wood panel product made from gluing layers of solid-sawn lumber together.
Similar to SOM's proposal, this structure system is beyond the limits of current building code. Its structure, façade, and building systems stand, nonetheless, as an example of a design proposal that is inherently more sustainable than conventional concrete and steel high-rise structures. However, CLT was incorporated into the US National Design Specification for wood construction in 2015. This allowed CLT to be recognized as a US code compliant construction material. These code changes permit CLT to be used in the assembly of exterior walls, floors, partition walls and roofs.
Sustainability - Ventilated double facades in New England, in particular those with vertical bays less than 4-stories in height, increase natural ventilation in the summer and mitigate heat transfer (loss) in the winter. The concept sketches in the proposal explore such façade organizations while expressing the formal bifurcation imposed by a centralized core and elevator shaft (which rises on Bushnell Park with views of the Connecticut state capitol). A ventilated double façade, for example figures prominently on the southern and western exposures and augments the natural ventilation of each residential unit. Upon analysis of annual illuminance, fenestration and solar-gain walls were strategically placed to maximize daylight and solar-gain (one passive hot water system per dwelling unit).
Energy Modeling - The proposed tower was modelled and submitted to Sefaira for energy analysis. While this web-based software is user-friendly and quite comprehensive, the real benefits of a CLT structure and ventilated double façade could not actually be analyzed. Since these are the two primary sustainability strategies proposed by this structure, the current energy analysis should not be taken at face value. It should be understood that the effort to accurately model and analyze sustainable design strategies of a high-rise tower or ventilated double façade require deeper modelling and analysis than Sefaira can currently provide. Note the presence for passive solar hot water system on the southeast wall and the naturally ventilated mechanical services on the east wall. A solid white fin, rising past the roof line on the east façade, physically separates the mechanical intakes/exhausts from the ventilated double façade.



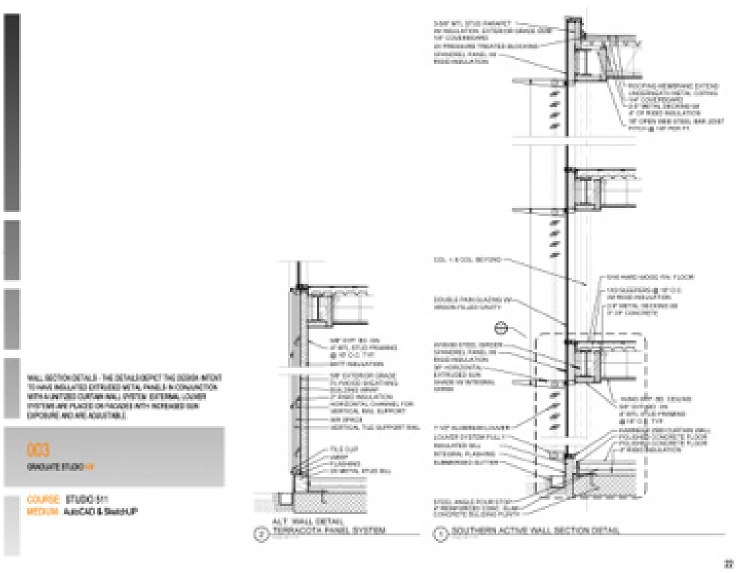
The Monolith, Evan Switzer
The Monolith, a proposal for a luxury residential tower was developed using a combination of AutoCAD & Sketch-up. The design challenge was to maximize real estate through verticality. The "pencil tower" was the selected typology. Situated to the east of Bushnell park, the Monolith captures a multitude of views with a luxurious layout for each condominium flat. Atop the tower is a 3 story penthouse. The floor plans were developed to provide luxury, while attempting to achieve a layout that countered the

external elements to which each individual facade is exposed. Through the operable windows and external active systems, each residential floor can maintain an optimal comfort level efficiency.

Additionally, each floor is equipped with its own heating & cooling system. The heating system is fueled by natural gas. Water pumps provide supply and return lines for fan coil unit system (FCU)'s in each room for zoning. A FCU is a simple device consisting of a heating and/or cooling heat exchanger and fan. Each FCU is provides a supply of outside air to ensure adequate natural ventilation in each unit. Aside from operable windows, an energy recovery ventilation system is installed within the plenum to draw air from each bathroom, while bringing in fresh air into the unit during operation.

Sustainability - The southeast elevation of the Monolith is shown in the design rendering. The mechanical and service program is concentrated on this portion of façade, as it does not require large amounts of natural light. This aspect of the design can be seen by the reduced or absent glazing. This reduces solar heat gain as a result of placing activity programing that requires natural light on elevations that access indirect light, or absent from southern exposure. Wall section details depict the design intent to have insulated extruded metal panels in conjunction with a unitized curtain wall system. External louver systems are placed on facades with increased sun exposure and are either manually adjustable or automatically programed to respond to modifications in solar exposure.

Energy Modeling - Included in this presentation is a chart generated by Sefaira energy modeling software for building efficiency. Each element added to the building was analyzed and the program provided a percentage of energy cost/consumption reductions. Numeri values are presented documenting the percentage of energy reductions per facade element. The results of the energy modeling were superior - however there is always consideration of human error in experimentation, for example the simplicity of the model, the assumptions made for u-factors, insulation factors, etc., and all add up to potential discrepancies.



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POLICIES AND PROGRAMS

Induced impacts from the building and transportation sectors as a means to achieve environmental goals

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Keywords: Built environment, induced impacts, buildings, transportation, policy recommendations

Abstract
Realizing a sustainable built environment is not possible at present due to the fractured nature of stakeholders, policies, and assessment tools. In order to achieve environmental goals, induced impacts (i.e., impacts resulting from the interplay between sectors), must be accounted for. Research findings show that induced impacts resulting from the building, transportation, and energy sectors are critical for sustainability of the built environment. This paper presents specific policy recommendations at the building and transportation level based on induced impact research. While "innovative" and "new" solutions are often favored, the recommendations illustrate that well-known, yet politically difficult, steps are required to achieve a sustainable built environment.
In order to account for induced impacts in the built environment, this paper provides policy recommendations at the building and transportation level. For the building level, assessment tools must be expanded to include the building's transportation footprint and the building's neighborhood context. Concrete recommendations include a moratorium on parking, prioritization of mixed-used neighborhoods, and conservation of existing buildings (older buildings and neighborhoods are more environmentally sound). These policies can be implemented through construction permits and environmental certification. For the transportation level, policies must focus on new technologies, existing public transportation, and urban planning. Specific recommendations are to restrict autonomous vehicles to multi-passenger use, require sector coupling for electric vehicles, provide high-quality public transportation (divert subsidies from single-occupancy vehicles to public transportation), and give transportation providers agency in real-estate and neighborhood development.

1. Introduction
The overriding challenge facing stakeholders in the built environment is climate change. In accordance with the Paris Agreement nations legally committed themselves to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels" (UN 2015, p. 3). According to the subsequent IPCC report curbing global warming at 1.5°C above pre-industrial levels necessitates "rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems" (IPCC 2018, p. 17). Thus the role of the built environment, specifically transportation and buildings, is readily apparent. This paper outlines the challenges of meeting climate goals in the built environment, critically examines proposed solutions, and offers recommendations to achieve necessary reductions.
In this paper I focus on two sectors, transportation and buildings, with a particular focus on transportation. The central role of the built environment, particularly transportation and buildings, in achieving climate objects is well established (Anderson 2015-1, Anderson 2015-2). However, it is critical to review recent developments. I will focus on the case studies of Germany and California as both represent developed economies with ambitious climate goals.

1.1. Transportation emissions
Germany, a signatory to the Paris Agreement, developed a Climate Protection Plan 2050 to meet its climate obligations. The plan defines emissions reductions per sector (BMU 2016). For the building sector, greenhouse gas (GHG) emissions will have to decrease by 66-67% compared 1990 levels in 2030 (i.e., 70-72 million metric ton CO2-Eq.) (BMU 2016). For the same timeframe, the transportation sector will have to decrease emissions by 40-42% (i.e., 95-98 million metric tons CO2-Eq.) (BMU 2016). Similarly, the California Global Warming Solutions Act of 2016 set the goal of 40% reduction in GHG emissions by 2030 compared to 1990 levels (AB 2016, CARB 2014). While the plan directly addresses the transportation sector, sector specific goals are not defined. The transportation sector is responsible for 22% and 39% of GHG emissions in Germany and California, respectively (CARB 2018 , UBA 2016, UBA 2019).
Of critical concern is the fact that transportation related emissions are not decreasing. In Germany the most recent data shows that emissions were higher in 2016 compared to 1990 (168 versus 164 million tons CO2-Eq.) (UBA 2016, UBA 2019). Similarly, the latest data show that California transportation GHG emissions actually increased 2% from 2015 to 2016 and have only slightly decreased since 2000 (CARB 2018). Based on this data, one must honestly ask if it possible to achieve climate goals in the transportation sector, and if so how?

2. Transportation revolution
Although transportation sector emissions have not decreased, numerous new technologies and mobility concepts may dramatically alter this sector. These changes can be grouped into vehicle technologies, mobility concepts, alternative fuel

vehicles, and renewable fuels. New vehicle technology is dominated by autonomous personal vehicles. New mobility concepts include sharing (e.g., carsharing, bike sharing), mobility-as-a-service (e.g. Uber, Lyft), and digitalization (e.g., connected mobility via smartphone applications). Alternative fuel vehicles include electric vehicles, hybrid electric vehicles, and fuel cell vehicles among many others. Finally, new renewable fuels include biofuels, synthetic fuels, and numerous other fuels from renewable energy sources. While these technologies and concepts are interesting and have the potential to radically transform the transportation sector, they are often promoted as the solutions to achieve climate goals in the sector.

2.1. Actual impacts

Next I will examine the anticipated impacts from these new technologies and concepts in regard to climate goals. First, the main new vehicle technology is autonomous personal vehicles (AVs). Aside from increased safety and improved accessibility for certain user-groups, AVs are anticipated to increase the number of trips and vehicle miles traveled (VMT) and therefor increase emissions (Bierstedt 2014, Clements 2017, Gruel 2016, Ross 2017, Wadud 2016). While AVs can minimally reduce emissions (10%) by optimizing traffic performance, these saving would be offset by increased VMT (Aria 2016, Bierstedt 2014). As more trips and VMT are expected from AVs, the argument then becomes that shared-autonomous vehicles (SAVs) will solve the emissions problem (Clements 2017, Fagnant 2014, Ross 2017, Wadud 2016). The argument that shared-autonomous vehicles will reduce emissions is found to be also unrealistic. A review of shared ride services in the United States shows that these services, counter to their claims, increase VMT (Schaller 2018). Further, single-user ride services also increase VMT and drew customers away from public transportation and non-motorized modes (i.e., biking, walking) (Schaller 2018).

In comparison alternative fuel vehicles and new renewable fuels may provide GHG emission reductions for the transportation sector, but face other challenges. First, these developments rely on the continued use of personal vehicles, which may be appropriate for rural areas, but not for urban settings. Second, long vehicle turn-over rates limit the impact these changes will have on emissions goals by 2030. Third, the necessity to import sufficient alternative fuels results in an exporting of emissions to other countries.

Consequently, these new technologies and concepts within the transportation sector are seen to be questionable in order to meet the climate goals. This fact combined with the absence of reductions to date, highlights the necessity of finding alternative means of achieving emission reductions. In order to do this it is necessary to move beyond sector confined analysis via induced impacts.

2.2. Induced impacts to meet climate goals

In order to achieve climate goals, induced impacts (i.e., impacts resulting from the interplay between sectors), must be accounted for. Research findings show that induced impacts resulting from the building, transportation, and energy sectors are critical for sustainability of the built environment (Anderson 2015-1, Anderson 2015-2). For the building level, assessment tools must be expanded to include the building's transportation footprint and the building's neighborhood context. On the other hand, the transportation sector must account for how the built environment influences travel demand, travel behavior, and mode selection. Using induced impacts as a methodology, specific policy recommendations at the building and transportation level based on induced impact research is presented in the next section.

3. Policy recommendations

In order to account for induced impacts in the built environment, this section provides specific policy recommendations at the building and transportation sectors and across sectors. At the building level policy recommendations include a moratorium on city-center parking, prioritization of mixed-used neighborhoods, and conservation of existing buildings as older buildings and neighborhoods are more environmentally sound. Parking in new residential urban buildings dramatically influences mode choice for residents and thus should be prohibited. Such policies can be implemented through construction permits and environmental certification (e.g., LEED, DGNB). Thus through the building side, the focus on personal vehicle transportation is addressed.

At the transportation level, policies must focus on new technologies, existing public transportation, and urban planning. Specific recommendations are to restrict autonomous vehicles to multi-passenger use, provide high-quality public transportation (divert subsidies from single-occupancy vehicles to public transportation), and give transportation providers agency in real-estate and neighborhood development.

Another area of critical attention is between the transportation and the energy sectors. Sector coupling, the joining of the two sectors, is critical to ensure that electric vehicles and alternative fuels produce emission reductions. Policy recommendations include the requirement that electric vehicles have controlled and vehicle-to-grid charging capacities based on the needs of the energy system. Furthermore, excess renewable electricity should be utilized to create synthetic transportation fuels.

4. Discussion and conclusion

It is clear that the outlined policies to achieve climate goals in the built environment are not new. The more important issue to recognize is that they are politically difficult. Urban planning and especial parking are emotional topics drawing lots of attention from residents. This in part explains the reason for focus on new technology fixes and new mobility concepts to date. While these are insufficient to reduce emissions, they offer low risk to decision-makers under the guise of innovation within the existing paradigm.

To emphasize the importance of shifting to an induced impacts assessment methodology two oft forgotten factors must also be discussed. First, national transportation sector emissions do not account for international travel. This large emissions source must be included somewhere in the accounting scheme. Second, travel patterns (i.e., VMT) and car ownership rates in developed countries serve as a target for the desires of developing countries. These factors underscore the extent of the challenge in meeting climate goals worldwide.

While "innovative" and "new" solutions are often favored, the recommendations illustrate that well-known, yet politically difficult, steps are required to achieve a sustainable built environment. Utilizing induced impacts extends the stakeholders involved, provides new policy and assessment tools, and offers the possibility for achieving climate goals across sectors.

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Working on value chains for sustainable buildings in Calabria: the approach of the regional Pole of Innovation Green HoMe

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Keywords: Smart specialisation strategies, regional Innovation policies, poles of innovation, technology transfer services, value chains

Abstract
This contribution discusses how the pole of innovation Green HoMe is going to fulfil the objectives of the Smart Specialisation Strategy in Calabria (S3) in the sustainable building area.
The mission is particularly relevant as the construction sector is one of the main drivers of the regional economy, with about 20% of the turnover of regional companies, a very large share of the total employment and, conversely, the need for a radical change of business models due to the long period of economic crisis. High performance infrastructures and security, low energy consumption, high comfort, sustainable life cycle are at the centre of emerging models and opportunities. Competitive companies are forced to look for external markets, and innovation is needed in all value chains.
In such a context, the Calabria Region has revised the policy for the regional poles of innovations to be more demand driven.
Green HoMe includes about 70 undertakings, including 4 large and 13 extra-regional companies. University of Calabria and University Mediterranea of Reggio Calabria are part of the managing body and they connect 24 major R&D and technical laboratories including large infrastructures.
Starting from the trajectories identified by the S3, Green HoMe intends to exploit innovative market opportunities and available entrepreneurial and R&D resources around a "bottom up" development of five value chains: Production of components with natural fibers (hemp), Multifunctional and modular innovative facade, Waste recovery from demolition and restructuring, Calabrian wood certified for structural purposes, Smart building solutions for comfort and energy saving.

1. Introduction
Recently, the need for innovation and eco-innovation has become very important not only at a technical-scientific level, but also at a political level. The territorial impacts concern the entire planet, with an increasing focus on some of the most defined territorial contexts such as Europe. A confirmation of this trend is guaranteed by the Sustainable Development Agenda 2030. Infact, the 17 Sustainable Development Goals (SDGs) of this Agenda, adopted in September 2015, recognize the need to select integrated strategies that promote the economic and social growth of all Countries. It is clear, therefore, that innovation is reorienting scientific research and policies on the great challenges for our society (climate change, human health, energy efficiency, resources depletion, etc.) (Lenzi et al., 2015).
The latest trends in scientific research confirm the need to identify instrumental and non-instrumental solutions to directly intervene on these shared global issues, linked to smart, sustainable and competitive needs. In literature there are many studies carried out in this direction, capable of dealing with different aspects such as the management of water resources (Maiolo et al., 2019), structural building heritage (Zagari et al., 2016; Zinno et al., 2019) or non-structural (Cassano et al., 2007; Bruno et al., 2017; Bevacqua et al., 2018; Bruno et al., 2018) and for increasing resilience in urban contexts (Carbone et al., 2014; Maiolo et al., 2017; Brunetti et al., 2016).
These trends justify the increasingly emerging global interest in the construction sector. Indeed, about 910 billion euros was invested in construction in 2003, representing 10% of the gross domestic product (GDP) and 51.2% of the Gross Fixed Capital Formation of the EU-15 (Ortiz et al., 2009).
The interconnection and interdisciplinarity that defines these global emergencies, requires a strategy characterized by an integrated and innovative approach, which can be guaranteed only by a programming sensitive to the single territorial realities. For this reason, in fact, the European Commission asked the European regions to develop a Smart Specialization Strategy (S3) (Foray et al., 2009; Foray, 2014), to guide the regional development strategy in the 2014-2020 programming period, with the aim of satisfying the demand for innovation in a sustainable perspective (Bevilacqua and Pizzimenti, 2016). To this aim, the Calabria Region has based its innovation strategy (S3 Calabria, 2016[1]) on eight innovation areas, that explicitely include Sustainable Building as a key priority, in line with the needs expressed by 26 European regions or countries (EYE@RIS[2]). Furthermore, the S3 Calabria

has configured four main development trajectories for the Sustainable Building area: Sustainable building in new constructions; Requalification of existing constructions and building waste recovery; New constructions techniques and materials (structural and components); Smart Systems.
It is evident that, the construction sector, which dominates activities in developed countries, is a valid indicator to appreciate the causes and effects of these critical issues in time. The CRESME[3] estimates have revealed a building stock of over 250,000 buildings in very poor maintenance conditions and more than 2.3 million in poor conditions. In this direction, clusters play a key role due to the approach based on cooperation between companies in the regions and between value chains, to increase their competitiveness in larger territorial contexts. Clusters bring together different stakeholders along value chains and can foster job creation in the regions, making regional businesses fit for rigid global competition (Borghi et al., 2010). Clusters are non-random geographical agglomerations of companies with similar or complementary capacities (Maskell and Kebir 2006). The interrelation between innovation policies, regional development, entrepreneurship, industrial and internationalization are the foundations of the cluster policy modernization, which can be associated with dynamic processes, sensitive to the influence of many parameters. For these reasons it is growing the importance of innovative clusters, which are present in various sectors, with the aim of structuring in an advanced and competitive manner scientific, technical, political and entrepreneurial activities with respect to those sustainability criteria useful for the mentioned social, economic and environmental challenges.
The mission of Green HoMe, pole for sustainable building in Calabria, is to interpret these needs for innovation, cooperation, internationalization and development. The vision of Green Home is based on the affirmation of a way of designing, building and enjoying an eco-sustainable house adapted to the Mediterranean climate. This aspect opens up the opportunity to exploit the natural, entrepreneurial and research resources available in the region, pursuing extra-regional projections. The specific mission of the Pole is oriented to networking for the development of supply chain innovation projects and specialized services for sustainable construction, aiming at the creation of a Mediterranean home brand.
The concept of innovative "supply chain" represents the core of Green Home, with the aim of leveraging the potential of the Calabrian territory to develop globally competitive solutions, in line with the priorities identified by the regional innovation strategy.

2. The regional context

The construction sector is traditionally one of the main drivers of the entire regional economy. It accounts for 20% of the total turnover of regional companies and for a very large share of the total employment. However, the long period of economical crisis is radically changing the business models of the sector. The new models are centered on high performance infrastructures and security, low energy consumption, high comfort, sustainable life cycle. Competitive companies are forced to look for external markets, and innovation is needed in all value chains. As it will be discussed in the next section, one of the key characteristics of Green HoMe is the approach based on value chains. In fact, the Pole will work to design and build new products and services in five regional value chains. Thus, a brief outline of their context is useful to understand their potential.
1. Production of components with natural fibers (hemp)
The spread of hemp cultivation is a fairly recent phenomenon: almost all crops (92.7%) started in the last five years and more than half in the last two (29.3% in 2014 and 24.4% in 2015)[4]. In Italy in particular, production is constantly increasing with good prospects for future development, especially in the construction sector where its use is spreading for the production of waxes, paints, coating materials, insulating and permeable to water vapor. In the building sector, and especially in the world market, hemp is already widely used for the manufacture of insulating brick and cement, for the replacement of glass fiber in reinforced plastics, for the production of biofuels, for the production of ecological paper, for phytodepuration, for biofuels.
2. Prefabricated systems, flexible and energy efficient
The requalification of the existing building stock represents the most important building development market with 20% growth in the last two years: 28 billion in 2013 and 33 billion in 2014[5]. In Calabria there is a real estate patrimony largely of an energy category below C, built for 60% before the 70s[6].
The potential for redevelopment of these structures is linked to the recovery of the components and materials of the building envelope, reconstruction of all the internal plants and the associated distribution systems. Such interventions, however, are not always easy to achieve due to high costs and long lead times. Furthermore, the invasiveness of some interventions requires the suspension of the habitability and/or interior activities, until the work completion. It has to also be added that the interventions on the building envelope with technological solutions, that permanently overlap the existing building, does not make it possible to inspect the components cracking state of the enclosure and the materials compactness after the presence of seismic phenomena, compromising the verification of the building security status.
3. Waste recovery from demolition and restructuring
Proper waste management has always distinguished the national reality compared to other highly competitive European countries. In Calabria, in particular, the "waste problem" has always been considered sensitive, even in the face of the stringent

regulations that require a renewed management. The results, even if at a slow pace, highlight the maturation of an ecological conscience: the data show an 18% share of recycled waste in 2014, which grew in 2015 up to 25%, 35% in 2016 and 40% in 2017[7]. The culture of "re-use", as is known, has significant impacts on the economy, particularly if it is a special waste, whose management has always been problematic. In a regional context where the building activity dominates, the need to rationalize the production and treatment of waste deriving from the construction and restructuring activity appears to be a priority.

4. Calabrian wood certified for structural purposes

For all Italian regions there is an increase in the surface area of wooded areas, but in the regions of central and southern Italy (Lazio, Molise, Campania, Basilicata, Calabria, Sicily) the increase is significantly higher than the national average. In the Calabria Region, according to what reported in the last National Inventory of Forests and Carbon published by the State Forestry Corps, (INFC 2005), against a territorial extension of 1.508.055 hectares, the forest surface is estimated in 612.934 hectares, for a woody index (forest sup. / territorial sup.) equal to 40.6%, the highest in the south and fifth place nationally: this highlights the particular silvana vocation of the region[8]. The construction sector in Calabria represents 20% of the total turnover of regional companies and has a strong employment momentum even if today it is in crisis. The actors of the wood supply chain are the companies: of forest utilization, of first and second processing. In Calabria there are about 2,500 woodland and primary processing companies spread across the region in a heterogeneous way: 37% of the companies fall in the province of Cosenza, 26% in the province of Reggio Calabria and the remaining 37% is divided between the provinces of Catanzaro, Vibo Valentia and Crotone[9].

5. Smart building solutions for comfort and energy saving

For the introduction of automation technologies in a building, the definition of new regulatory constraints is envisaged. The importance of smart management on a building scale is linked to important and well-known energy and economic benefits. From a legislative point of view, the UNI 11337, concerns the general aspects of the digital management in the information process regarding to the construction sector. The standard takes in account the entire construction world, at any type of product (building or infrastructure), at each stage of the process and each type of intervention, both on the new and builted. The needed of this smart specialization in the construction sector is necessary based on some EU surveys: the construction sector has a crucial impact on environmental and energy policies, considering that it absorbs 40% of the total European energy consumption and generates 36% of the greenhouse effect[10].

3. Green HoMe: entrepreneurial discovery and value chains

In September 2018, the Calabria Region selected Green HoMe as the managing body of the Pole of Innovation for Sustainable Building. Green HoMe has been founded by five SMEs (Italbacolor, Iavarone Wood Technology, Italcanapa Development, Solaretika and Vega Energia), already active on relevant regional and nationa markets with an innovative offer, together with the University of Calabria and University Mediterranea of Reggio Calabria. About 70 undertakings, of which 4 large and 13 extra-regional, have already joined Green Home, to take advantage of its services and networking opportunities, by paying a small annual fee. The Pole connects 24 major R&D and technical laboratories including large infrastructures, with a portfolio of about 70 technology and consultancy services. Green HoMe became operational at the beginning of January 2019.

With reference to the territorial, environmental, social and political context, previously presented, the Pole of Innovation Green Home implements a policy instrument to innovate and renew the regional building sector, in order to increase its competitiveness and adapt it to national and European sustainability standards.

As such, Green HoMe has to activate effective actions to increase the awareness of the entrepreneurial fabric on the usefulness (if not on necessity) of adopting innovative behaviors, progressively introducing technological and organizational innovations.

To be effective, the Green HoMe proposal follows two guiding principles: i) to work for "value chains", activating the full range of competencies and components needed to create a product or service; ii) to select a limited set of key issues with extra-regional potential, for an effective use of available resources. Thus, in line with the principle of "entrepreneurial discovery" that guides the S3 development, Green HoMe decided to decline the technological trajectories of the regional S3 in five more specific value chains. Each value chain exploits strengths and opportunities in terms of (i) regional context, (ii) entrepreneurial resources, (iii) global trends and access to extra-regional markets. Clearly, a group of companies and R&D groups associated to Green HoMe supports each value chain.

In this way, the Pole concentrates the available resources on concrete issues and it will be able, over time, to assess the progress made. In particular, Green HoMe will have to achieve a few demanding Key Performance Indicators in terms of number, quality and intensity of services (i.e. a minimum of 30 innovation services per year, with market revenues covering at least 25% of the overall costs).

Thus, the choice will not be crystallized but subject to evaluation and review, taking into account the ability to activate innovation processes and, possibly, on the identification of new emerging issues.

The selected value chains are:

1. Production of components with hemp and natural fibers

2. Multifunctional innovative facade systems for building requalification
3. Waste recovery from demolition and restructuring for beach nourishment
4. Calabrian wood certified for structural purposes
5. Smart building solutions for comfort and energy saving

In addition, the Pole of Innovation will not neglect some "transversal" activities, such as dissemination, training and certification of entrepreneurial and technical resources related to quality and sustainability of the buildings life cycle. Indeed, there is an important demand, often generated by recent regional and national regulations (e.g. about energy efficiency, BIM), that is not adequately supported by other public or private actors at regional level although it is important to allow regional companies to access wider markets.

The five value chains, representing the best interpretative key of the Green Home approach, are detailed below.

Production of components with hemp and natural fibers

The use of natural fibres in construction is one of the current trends for sustainable, high-performancee and echo-friendly solutions in construction. Among the various proposals present in the European markets, the hemp use in construction appears to be of increasing interest.

This material can contribute significantly to the development of housing models suited to the Mediterranean climate, typical of the Southern Italy regions, where the energy demand for cooling is often higher than the heating demand. Hemp panels, in fact, are characterized by high thermal inertia and good thermal wave phase shift capability. These are essential elements to prevent overheating of the interior spaces in the summer and to minimize the use of plant systems. Furthermore, the use of hemp promotes adequate indoor comfort thanks to its ability to absorb moisture and thus prevent the formation of mold. The physical properties of some hemp extracts make this material suitable to be used also for constructions in areas with high seismicity. The development of a hemp supply chain can therefore favor the production of panels to be used as closing elements of the building envelope and as partitions of the interior space, expanding the current catalog of components used in today market. The Pole is able exploit strong R&D competencies on similar materials (e.g. brooms) and processing with the entrepreneurial know-how of a network of SMEs.

Multifunctional innovative facade systems for building requalification

Various national and international summits have highlighted the urgent need to find easily actionable solutions that can convert old energy-intensive buildings into buildings with innovative features and low energy consumption. Only the industrialization of the redevelopment process of the building envelope that makes use of a sustainable and innovative construction technology, will allow to reach significant objectives in terms of redeveloped buildings.

This chain intends to support companies in the sector to meet the growing demand coming from the recladding segment, that is the request for interventions to replace with the new aesthetically modern, functional and performance systems. Therefore, it is evident the needed to support the development and diffusion of innovative technological systems, capable of implementing an integrated energy efficiency solutions solving the typical problems of today building market in order to:

• confer new aesthetic quality to buildings and to the surrounding urban context, solving the problems of aesthetic disfigurement caused by the insertion of modern air conditioning systems,
• improve environmental sustainability and reduce urban heat islands,
• solve the inevitable problems of materials degradation linked to the building envelope,
• implement non-invasive interventions for the building occupants, who will be able to continue to use the internal spaces even during the redevelopment works.

Waste recovery from demolition and restructuring for beach nourishment

For construction, demolition and excavation waste, the recovery of material from the inert fraction requires the availability of an adequate collection network and storage facilities. Traditionally, demolition activities in Italy do not always provide for a particular commitment in the selection activities at the source of the different types of waste. On larger building sites, there is a tendency to separate the dangerous fraction of waste, the ferrous fraction and sometimes even the wood fraction, while nothing is done on the remaining waste. The practice of selective demolition is therefore non-existent, which involves the design of the demolition with an important initial phase of dismantling and separation of the main building components, which can be addressed mainly to reuse. For this reason, the waste leaving the construction sites is particularly heterogeneous. Therefore, it is necessary to spread good management practices, to promote technological developments to improve the materials characteristics to be recycled, so that their use becomes a real alternative to the use of new raw materials. In detail, an alternative form of recovery and recycling of demolition waste relates to the beach nourishment, which is widespread in recent years. Because of the current situation of the Italian coasts, in fact, such use would be considered a priority compared to other possibilities of recovery. These sediments can constitute a primary resource within the framework of coastal sedimentary balance. In some Italian regions such as Sicily the reuse of the sediments in question has already been envisaged in erosion beach nourishment projects.

Calabrian wood certified for structural purposes

The integration of this supply chain structure in the Calabrian context brings with it considerable advantages from different points of view. Among these, the local wood valorisation has a strategic role for the production of the building materials as lamellar wood or mixed structures. Currently, in fact, the use of local wood for these purposes is limited and the technological improvement can determine new market outlets, cost reduction and better sustainability. The supply chain also intends to encourage the construction of wooden structures by virtue of the fact that construction times are reduced (the processing and treatment of the elements is already completed in the plant) and that, for renovations, the structure once installed it is immediately able to support the operating load, without maturation times. The products derived from wood are those best suited to the green building criteria, for the ability to reduce the energy consumption and non-renewable resources, limiting the pollution in the internal space and the possible damage to the human health. Another fundamental theme, which intends to develop this supply chain, is the forest certification of Calabrian wood resources (for example Pino Laricio). Valuing these resources, in addition to the increase in the workforce of production personnel, would also have a huge impact in terms of employment on the labor required for operations in the forest for collecting transport and assortment of timber.

Smart building solutions for comfort and energy saving

Building performance can be controlled and monitored in a way that makes the owner or occupier responsible for making the right decisions about the long-term operation and performance of the building. By making use of the information available from the sensors used on a wide range about the functioning of the building and its internal space, it is possible to offer the occupants an unprecedented view of the building performance: systems optimization during the hours of occupation using data in real-time, also paying attention to the privacy rights of building owners and occupants. Therefore, it is essential to introduce a building automation and control system in order to increase awareness of their use and potential. For this reason, the combination of equipment and control systems is fundamental to standardize the planned energy performance and that actually achieved.

4. Conclusions

The paper has illustrated the approach adopted by Green HoMe, the managing body of the regional pole of innovation for Sustainable Building, to fulfil the mission assigned by the Smart Specialisation Strategy Calabria.

In particular, the paper presents the five value chains that Green HoMe selected as its main working ground to exploits entrepreneurial strengths and opportunities in a sort of "entrepreneurial discovery" process.

The choice will be monitored and possibly refined starting from the evaluation of a few Key Performance Indicator in terms of number, quality and intensity of services.

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Sustainable Building Program of the Calabria Region. First results

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Abstract
The Calabria Region's Sustainable Building Program, developed and perfected over the last three years by the Department of Infrastructures, Public Works and Mobility, provides for an organic system of procedures aimed at pursuing the environmental sustainability of the environment built through a quality construction.
The Region has started a virtuous path towards sustainable development of the territory through the approval of the technical regulation for the implementation of Law. n. 41/2011 "Regulations for sustainable living" and technical documents that allow the assessment of the level of environmental sustainability of the interventions.
The Disciplinary makes the certification of environmental sustainability mandatory for interventions that want to obtain public funding, incentives or facilitations and identifies the roles, requirements and responsibilities of the subjects involved in the certification process by defining the various stages of the process and the mandatory documents. The numerous training courses carried out have enabled hundreds of technicians now registered in a regional list.
Calabria is the first region on the national territory to have created an organic and structured Sustainable Building Program and to have put it into practice in such a short time.
Creating a well-structured, effective and efficient system guarantees the achievement of the established goals and offers the possibility to collect and measure in a concrete way the results achieved to correct and plan the actions necessary to achieve the future objectives.

1. Targets

Italy is among the 193 UN member countries that signed the 2030 Agenda, on 25 September 2015, pledging to reach, by 2030, the 17 Sustainable Development Goals (SDGs)) and approved in 2017 the National Strategy for Sustainable Development as the main coordination tool for Agenda 2030.
Once the idea that sustainability is only an environmental requirement has been overcome, an integrated vision of the existing problems and criticalities is required with an effort at national and regional level to share objectives and working methods and define local strategies for sustainable development. The Calabria Region, starting in 2015, has embarked on a virtuous path that has resulted in a program oriented towards the creation of an organic system of procedures aimed at sustainable development of the territory starting from the construction sector which is the emblem of unsustainability of modern society. The implementation of the provisions contained in the Regional Law n. 41 of 2011 "Standards for sustainable living", was the obligatory step to start the sustainability path required by the European Community and the 2030 Agenda.
This article aims to describe the positive experience of the Calabria Region in pursuing the principles of environmental sustainability: Calabria is in fact one of the few Regions in Italy to have implemented a Sustainable Building Program and a certification system for building interventions that includes : technical and regulatory documents, an accreditation system for the figures involved in the certification process and the procedures for issuing environmental sustainability certifications. In line with the main objectives of the National Strategy for Sustainable Development, the Region intends to pursue the sustainability of the built environment through a process that is planned and managed right from the design phase, going through the implementation and analyzing aspects that also concern the phase of disposal of the building.
The goal of the Sustainable Building Program of the Calabria Region is to disseminate the potential and opportunities that Regional Law n. 41/2011 and its implementation guidelines offer for the construction of quality buildings and low environmental impact. It aims to guide the choices of private operators and the policies of public institutions towards environmentally sustainable solutions and processes.

2. Actions

The Calabria Region has chosen to use the ITACA Protocol for assessing the environmental sustainability of building interventions. It is a rating system that expresses the level of sustainability through a quantitative judgment varying between -1 and 5. The main features of this tool, which derives from the SB Method and SBTool international evaluation method, are the versatility and the possibility to modify the calculation methods of the indicators and scores by choosing the aspects to which to give greater weight and relevance to respond to the peculiarities of the territory. In fact the regional territory is characterized by a strong orographic and climatic variability. Calabria has a predominantly hilly surface and has large mountainous areas, a percentage of the territory less than 10% is flat. The climate is generally defined as Mediterranean, more arid on the Ionian side and milder on the Tyrrhenian Sea. From the building point of view, the urbanized area is characterized mainly by small villages, about 75% of 404 municipalities have a population between 800 and 7000 inhabitants. The coastal areas have a more recent construction and present a greater density of population while there is a progressive depopulation of the historical centers, especially those located in mountain areas. With a careful analysis, the massive construction of coastal areas and new expansion areas reveals and highlights the critical issues and problems inherent in a design that is detached from the principles of economic, environmental and social sustainability, that today are so focal in the programs and strategies of development. Some of the aspects on which it is necessary to focus and focus and which take on greater weight in assessing the environmental sustainability of interventions in the regional territory are: the choice of the site of intervention, taking into consideration the presence of services and equipment for associative life avoiding also the consumption of new soil, the production of energy from renewable sources and the use of materials and techniques to mitigate the effects of unfavorable weather conditions, the use of technologies for water saving and the reuse of rainwater. The ITACA protocol is a system that provides for the subdivision of the aspects to be evaluated into reference macro-themes, defined as Areas: site quality, resource consumption, environmental loads, indoor environmental quality and service quality. The aspects taken into consideration to establish the performance of the building have been translated into Criteria with which an indicator and a score are associated through a linear link. The overall sustainability score is obtained from a linear combination of the weighted scores attributed to the Criteria and to the Areas. The Criteria, the method of calculating the indicators, the Areas and their weights have been chosen with reference to the Calabrian territory, its characteristics and the aspects that most affect the environmental sustainability of the built environment.

3. Sustainable Building Program

The Department 6 - Infrastructures, Public Works and Mobility of the Region, through a Project realized in agreement with the two Calabrian Universities: University of Calabria (Department of Civil Engineering) and Mediterranean University (Department of Architecture and Territory) and with the support of the Association iiSBE Italia, has drafted the technical documents necessary to launch the Sustainable Building Program:
- the Technical Regulations implementing the L.R. n. 41/2011;
- the Synthetic ITACA Protocol for Residential Buildings;
- the ITACA Protocol for School Buildings
- the Regional Regulation of the L.R. n. 41/2011.

In the last months of 2016, the Regional Council therefore approved the technical and regulatory documents necessary to implement the Sustainable Building Program and, in November 2017, the ITACA Protocol for Public Buildings is also implemented. In order to promote a design inspired by the criteria of environmental sustainability and to encourage the use of technical solutions and sustainable technologies, the Law requires the assessment of the environmental sustainability of the intervention and the obtaining of the sustainability certificate at the end of the work, as a mandatory requirement for the granting of state grants, volumetric incentives and tax breaks. The Technical Regulations establish a minimum score of zero for the release of the certification, and a minimum score of 1 for access to contributions and incentives. The Disciplinary also describes the phases in which the certification process is articulated, the procedures and documents necessary for the request and the issue of the certificate, the requirements of the subjects who, for various reasons, play fundamental roles in the process and the accreditation system for technicians working within the process.

The certification process is divided into 3 distinct phases: a Pre-evaluation phase, which is activated only for participation in regional public tenders that envisage the possibility of submitting projects to a lower level than the executive. In this case the score can be confirmed by the Certifying Body, through a Pre-evaluation Certificate, or it can be attested by the technician who prepares the report. In the technical-economic feasibility projects and in the final projects, some aspects are not defined in detail, the pre-evaluation can refer to numerical data hypothesized by the designer and can contain a declaration of intent. The Project Phase foresees the assessment of the sustainability of the intervention based on the executive project and ends with the release, by the Certifying Body, of the Project Certificate which confirms the sustainability performance achievable with the intervention. Once the Project Certificate has been obtained and at the beginning of the work, the third phase can be started: the Construction Phase. In the Construction Phase, the checks are aimed at verifying that what is reported in the evaluation report, validated in the previous phase, is carried out for the achievement of the certified environmental sustainability level. At the end of this phase, the Environmental Sustainability Certificate is issued, only after successful inspection visits, by the Certifying Body. Project Certificates and Sustainability Certificates are issued by regional offices following the checks that are now carried out by an external entity.

The Technical Regulations of the Calabria Region provide that the assessment of the environmental sustainability of the intervention can only be carried out by the technicians, defined Evaluators, registered in a specific regional list: "Expert List of the ITACA Protocol" which is accessed by passing the final exam of a course of at least 30 hours. The Construction Phase must also be followed by a technician registered in the list and who is called the Compliance Officer. The Accreditation System establishes the requirements of the training courses: of the teachers, of the training program and the contents of the final test. The president of the Examination Committee is the Manager of the competent sector or his delegate. The regional offices, following the communication of the activation of a training course, carry out checks for consistency with the regulatory provisions and issue the authorization at the beginning of the lessons. The quality of the course is tested through the monitoring of the test results and the administration of a questionnaire that the students fill in anonymously and whose results are sent to the course organizers as feedback on the activities. The regional program also makes use of a dedicated website with public access (http://itaca.calabria.iisbeitalia.org/) which, through a regional register, guarantees maximum transparency to the certification processes activated, in progress and concluded. On the site it is possible to consult the relevant legislation and documentation (evaluation protocols, regional laws ...), news on related topics, FAQs on application and interpretation and the list of accredited technicians.

4. Applications and First results

After the approval of the Technical Regulations, in all the notices published for the granting of loans and contributions, it is now required, as a participation requirement, the drafting of an evaluation report on the level of environmental sustainability of the intervention that is proposed for the selection. In November 2016, in fact, the first Call for Applications was published which envisages the assessment of the environmental sustainability of the proposed application as an admission requirement. Starting from 2016, the following Regional Calls have introduced the Environmental Sustainability - "Expression of interest for the granting of contributions for the execution of seismic adjustment or, possibly, demolition and reconstruction of school buildings" (D.G.R. n. 427 of 10 November 2016) ("Safe Schools" Announcement);

- "Public notice aimed at drawing up the 2018-2020 three-year plan for school building interventions, in execution of the Interministerial Decree (MEF, MIUR and MIT) 3/01/2018, n. 47 and of the Regional Council Resolution n. 616 of 11/12/2017 "(Three-Year Plan 18-20);
- "Public Notice for the granting of regional contributions aimed at the realization and redevelopment of sports facilities "(Deliberation of the Regional Council n. 413 of 08/09/2017) (Call for Sport facilities);
- Public notice for the granting of contributions aimed at strengthening the existing public assets used for social housing "(Executive Decree n. 592 of 23/01/2019) (Social housing call).

Summarizing the available data it is possible to obtain a general picture of the state of environmental certification processes in Calabria. It should be borne in mind that the Program has only been fully operational in the last 2 years and the procedures are slowed down by the bureaucratic requirements linked to the granting and provision of financing to public bodies.

The Call for Sport facilities is aimed at redevelopment, compliance and implementation of sports facilities; the Social Housing Call provides for the financing of projects for the seismic adjustment and the strengthening of structures owned by the Municipalities to increase the availability of social housing and housing services for fragile categories. These two Calls are now in the preliminary investigation phase and therefore the data and information reported refer only to the school buildings covered by the loans made available with the first 2 Announcement cited.

The Safe Schools Announcement, aimed at the seismic and plant adaptation of school buildings, was the first to foresee the certification of the environmental sustainability of the intervention with a score at least equal to 1 as a requirement for access during the application phase, for this reason, and due to the lack of subscribers in the newly established List, in the transitional phase, non-trained and non-trained technicians were allowed to carry out sustainability assessments. The level of design required to participate was a definitive one and 58 interventions received the pre-assessment Certificate. The executive projects are now in the drafting stage and they must obtain the Project Certificate. In this case, the scores validated in the pre-assessment are not very representative of the performance of the building since, in order to draw up the merit rankings within the established terms, an office procedure was implemented which led to the modification of the scores. In general, the score to be taken into consideration to get an idea of the sustainability level of the intervention is reported in the Project Certificate, calculated with the data and information related to an executive level design. Score that must be confirmed in the construction phase and in the final Sustainability Certificate.

Similarly, with the Three-Year Plan 18 - 20, the Calabria Region has established the programming, for the three-year period 2018 - 2020, of seismic adjustment and plant adaptation interventions as well as bringing it into line with the fire regulations of school buildings. The definitive ranking, approved in November 2018, provides for the financing of around 112 seismic adaptation or demolition and reconstruction projects which, at the end of the works, will obtain the environmental Sustainability Certificate. In this case, only technicians enrolled in the Calabria Region Expert List could draft the environmental sustainability assessment of the interventions. The scores declared by the technicians in the application phase must be confirmed by the Project Certificate and the Environmental Sustainability Certificate. Decreases in the intervention's sustainability score will result in a proportional reduction of the loan granted since this value was used for the purpose of positioning the intervention in the ranking. With reference to the planning of school building interventions, it was estimated that by 2023, at the end of the funding program, when the interventions will be completed, 10% of the schools located in the Calabrian territory (out of a total of about 2,400) will be certified with the ITACA Protocol with an environmental sustainability level of at least 1. This result, focusing attention

only on the design phase of the interventions, was achieved in 2 years, in a context, that of construction, in which the term "sustainability" had no placement.
In order to promote the principles related to sustainability and to boost construction activity, in the provision of modification and extension of the Regional Law n. 21 of 2010 "Extraordinary measures to support the building activity aimed at improving the quality of the residential building stock" called the Housing Plan, the Regional Council introduced sustainability assessment as a mandatory requirement to obtain volumetric incentives in the case of interventions carried out on public buildings and in all cases of demolition and reconstruction of the building. The Law now provides, for any implementing party, the possibility of combining the volumetric incentive provided by the Regional Law n. 41/2011 according to the level of sustainability achieved by the intervention. In the case of interventions carried out by private subjects, the certification is, in any case, voluntary.
During 2017, more than 10 technical training courses were approved and carried out, and to date, more than 600 technicians have been enrolled in the ITACA Protocol Expert List, qualified to perform the role of Evaluators and who can follow the certification process also in Construction Phase, covering the role of Compliance Officers. During 2019 inspectors will also be trained who, on behalf of the Certifying Body, will carry out the verification, control and validation of the evaluation reports and carry out the inspection visits during the Construction Phase.

5. Conclusions and Future Prospect

The results obtained with the Sustainable Building Program of the Calabria Region are, to date, detectable only by referring to school building interventions financed through the regional Calls for Proposals. Through all the regional published notices, structures with different destinations of use (sports facilities, social assistance structures), will be certified according to the standards of the ITACA Protocol. The protocols adopted today as technical documents allow the assessment of the environmental performance of buildings with the following destinations of use:
- residential buildings,
- school buildings;
- public buildings: office buildings, for recreational activities (cinemas / theaters / halls, meetings for congresses, exhibitions / museums, libraries) and buildings for sports activities (gyms / swimming pools).

The future perspective is to create, approve and adopt evaluation protocols also for hospitals and tourist / accommodation facilities that present innumerable critical issues due to their environmental, economic and social impact. Starting from the territory and the built environment, it will be possible to make citizens aware by highlighting and demonstrating the advantages inherent in the pursuit of sustainable development. Benefits that materialize in:
- better quality of the building: the third party certification is developed throughout the building process, from the preliminary project to the testing / completion of the works;
- containment of energy consumption, resulting in the efficiency of the envelope and of the plants and the use of renewable energy sources;
- reduction of CO2-NOx-SOx emissions;
- reduction of drinking water consumption;
- better indoor environmental quality for occupants (thermo-hygrometric, acoustic, luminous comfort);
- greater attention to the design of outdoor areas with positive effects also on outdoor environmental quality (heat island, soil permeability);
- lower management and maintenance costs.

Sustainability will thus become the modus operandi, a characteristic and inherent property of society and not a peculiarity that can be pursued only in some fields.
The implementation of the Sustainable Building Program of the Calabria Region has encountered many difficulties, involving and requiring a methodological but above all cultural change in the design phase. An assessment of the building's environmental performance, in order to increase its sustainability, requires an organic approach to the project, taking into consideration the various aspects that affect the performance of the building. It also requires a broader perspective of action that contemplates and governs the various phases of the realization of the work: from the choice of the site to the selection and procurement of the materials and up to their disposal. Furthermore, the introduction of new assessment methods in a regional and national system, penalized by the slowness of administrative procedures, has met the initial resistance of local technicians and administrators who, over time, have recognized the long-term advantages and the perspective of action of the Program. The implementation of the provisions of the Law and of the Disciplinary has required the effort and commitment of all those involved: the regional offices that implement the procedures, the technicians working in the process, the institutions that deal with issues considered up to today marginal and promote the implementation of the regional law and the reference documents.
The described System has the undoubted advantage of being easily replicable in other Regions that intend to undertake the same path and pursue the same objectives. The Calabria Region proposes itself as a test laboratory and a pilot project on a path of sustainability which, in order to produce concrete results, should also be undertaken at national level.

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SUSTAINABLE NEIGHBOORHOODS AND CITIES

Rebuilding a community for sustainability and resilience

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Abstract
'Rebuild Green' is a theme echoing throughout California communities devastated by recent natural disasters. It is a call to create neighbourhoods and districts that are more sustainable and resilient in the face of these increasingly frequent climate-driven catastrophes. This paper covers a broad range of sustainability and resiliency initiatives that have sprung up in response to this call, including the Rebuild Green Expo (first held in February 2018 and again in February 2019), 'advanced energy' utility incentives, a community microgrid project to demonstrate grid modernization strategies, a grassroots decarbonization campaign, participatory public planning workshops, and workforce green building training programs.
These initiatives have engaged stakeholders ranging from public agencies, non-profits, and utilities, to thousands of private citizens, and represent models ripe for adoption in communities worldwide. The paper covers several of the different initiatives and includes lessons that have been learned from interactions with the stakeholders and the implications regarding future community-scale rebuilding efforts. The paper offers not just a backwards look, but insight into future design priorities and opportunities after forthcoming disasters – as well as forward planning to facilitate more rapid recovery from those disasters.

1. Introduction
In the wake of last fall's tragic fires in California, a compelling drive emerged in the North Bay region (Sonoma, Napa, and Mendocino Counties, north of San Francisco) to "build back right" — to create more robust and resilient communities with environmentally responsive housing and transportation along with clean, reliable local energy and water infrastructure systems. The Northern California green building community, along with the local utilities and environmental and civic organizations, responded with a variety of recovery initiatives, described in the remainder of this section.

1.1. Rebuild Green Coalition
Shortly after the catastrophic Northern California fires of October 2017, in which 44 people died and thousands of homes and other structures were destroyed, several informal email and phone discussions among different individuals, focused on 'how can we help?' resulted in a meeting attended by about 20 Bay Area green building professionals. This rapidly coalesced into an informal group called the Rebuild Green Coalition, which since has evolved into an online Google Group of about 100, with a leadership group of ten people – both individual practitioners such as myself, and representatives of organizations including the local chapters of the U.S. Green Building Council and the American Institute of Architects and the non-profit organizations Ecological Building Network and Sustainable North Bay. The group's mission: to help in whatever way we could to foster more sustainable and resilient outcomes in the rebuilding efforts. How we would do that was not initially clear, but we were determined to contribute in some meaningful way.
Our first on-the-ground effort was a workshop on December 1, 2017, to which we invited 60 members of the Bay Area green building community, environmental and housing groups, and local officials. In the meantime, various other sustainable/resilient rebuilding initiatives had sprung up in parallel to ours. The goal of our workshop, therefore, was not to duplicate those efforts but instead to identify green rebuilding needs, priorities, and resources in support of the other groups because, while sharing similar aims, they lacked the technical expertise to clearly and specifically define their objectives for 'sustainable and resilient' construction.
Soon after the December workshop, inspired by one of our leadership team members, we launched into planning the Rebuild Green Expo. Two months later, on February 23, 2018, an estimated 2,000+ local residents turned out to the Santa Rosa Veterans' Memorial Building to learn about topics ranging from healthy materials to electric vehicles, 100% electric homes to fire-safe landscapes. We offered more than 30 educational sessions taught (pro bono) by more than 60 subject matter experts, and had more than 60 exhibitors on the Expo floor. The event was free to the public, funded by sponsorships from a wide variety of public, private, and non-profit donors. The community's response was overwhelmingly positive.
A couple of months post-Expo, we regrouped to discuss what further work the Rebuild Green Coalition might do in support of the ongoing rebuilding. While we considered several options, ultimately we decided to reprise the Expo the following year, and in fact did so this past February 22, 2019. Many participants had encouraged us to do this, and we reasoned that the rebuilding work would be continuing far into the future (in fact, 18 months later, it has barely begun) and that the Expo was an effective way of both inspiring and informing a large number of people about greener rebuilding options. Fundraising for the second Expo, despite having more planning lead time, was nevertheless more challenging. Even so, it was equally popular and successful with the

public as well as the participating exhibitors and education presenters.
The future of the Expo is uncertain. Members of the leadership team are considering transforming it an annual, ongoing event, possibly co-presented by the local chapters of the U.S. Green Building Council and the American Institute of Architects. Even before the fires, there was a housing shortage in Sonoma County, which lost the greatest number of housing units (5,283), and further population growth is expected in the area in years to come. The anticipated housing demand is 30,000 units between now and 2023. (County of Sonoma 2018)

1.2. Clean Coalition North Bay Community Resilience Initiative

The Clean Coalition is a non-profit organization whose mission is to accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise. In the winter after the 2017 fires, the Clean Coalition launched the North Bay Community Resilience Initiative, working with the local community choice aggregators (CCAs), Sonoma Clean Power (SCP) and MCE; and Pacific Gas and Electric Company (PG&E), the local investor-owned power utility, to develop a community microgrid approach in the area as a model to demonstrate a modern, resilient, carbon-free energy system. (EPA 2019) The Clean Coalition's goal is to establish a blueprint for rebuilding disaster-affected areas – and ultimately the entire grid – in a way that is cost-effective, uses local distributed energy resources (both renewable energy production and storage), and provides reliable, clean electricity to critical sites in the event of area-wide power outages.
Current efforts are focused on identifying optimal areas for demonstration projects to take place – locations that include a mix of building types and uses, meet the needs of the community to rebuild energy infrastructure, and can accommodate renewable electricity production and storage in ways that fully demonstrate the multiple benefits that these local energy solutions deliver to communities. While PG&E's participation has been sporadic, Clean Coalition has made great progress in developing a set of microgrid-ready development specifications and in assembling a "Tiger Team" comprising representatives from numerous stakeholder groups and individuals with subject matter expertise who have contributed to the specifications development and concept for the demonstration project. This effort is ongoing.

1.3. Advanced Energy Rebuild Incentive Program

Soon after the 2017 fires, a new utility incentive program, dubbed Advanced Energy Rebuild (AER), was developed collaboratively by PG&E; SCP, and the Bay Area Air Quality Management District (BAAQMD). The program is funded via public goods fees assessed on services provided by California investor-owned utilities and budget allocations by Sonoma Clean Power and BAAQMD. The program required approval from the California Public Utilities Commission (CPUC), and included doubling the amount of incentives normally offered by PG&E's for new construction unrelated to fire losses; the contributions from Sonoma Clean Power and BAAQMD did not require CPUC approval.
AER (https://sonomacleanpower.org/programs/advanced-energy-rebuild) offers three incentives to area residents whose homes were destroyed in the fires and are rebuilding. In all three cases, the new home must be 20 percent more efficient than required by California's energy code (California Code of Regulations Title 24, Part 6) and must include an electric vehicle charging station (provided free by Sonoma Clean Power). The three incentive levels are:

1. $7,500 for a home that is designed for future full electrification, including electric outlets at stove, water heater, and clothes dryer locations; and has conduit and structural support for a rooftop photovoltaic array (Tier 1)
2. $12,500 for a home that is all-electric (has no fossil fuel-powered end uses) from the start (Tier 2)
3. $5,000 in addition to either of the above incentives for including a solar array sized to offset annual electric usage and a 7.5kWh battery storage system, or a 20-year pre-purchase contract for the CCA's 100% local renewable power upgrade option (renewable energy bonus)

As the nature of these incentives suggest, the participating entities are encouraging rebuilding that is consistent with the California's climate and energy goals, as embodied in State legislation designed to reduce greenhouse gas emissions via more efficient and cleaner-fueled new construction, e.g., Senate Bill 32, California Global Warming Solutions Act. (CARB 2018)
To date, SCP has received 30 Tier 2 applications out of a total of 82 (37%), and 14 applications (17%) for the renewable energy bonus. This compares with 2,868 building permit applications from October 2017 to date in the City of Santa Rosa, which comprises 35 percent of Sonoma County's population.

1.2. Electric-ready Campaign

There is a strong environmental community in Sonoma County, including 350 Sonoma, an affiliate of 350.org, a non-profit named in reference to 350 parts per million – the safe concentration of carbon dioxide in the atmosphere; the group has a very strong current emphasis on "decarbonization" via elimination of fossil fuels (see Figure 1).

Figure 1. 350.org home page, as of 25 March 2019

After the 2017 fires, 350.org members and other local activists banded together to develop a proposal to the Santa Rosa City Council to promote all-electric new construction. The group named itself Friends of the Climate Action Plan (FoCAP), alluding to and gaining political leverage from the City's Climate Action Plan goals related to reducing greenhouse gas emissions. While their ultimate goal is to have all new construction be 100 percent electric, they chose a more pragmatic initial goal – to have the City Council adopt an ordinance that would require simply that all new homes be all-electric-ready. This would entail meeting a relatively simple and inexpensive set of construction specifications, shown below in Table 1.

Table 1. Proposed All-electric Ready Specifications for New Residential Construction in Santa Rosa

Dedicated circuits for: • Water heater • Clothes dryer • Kitchen range (induction) • Heater/air conditioner • Electric vehicle (EV) charger	 30A 30A 50A 30A 40A
Code-required solar conduit	Enforced
Code-required wire for EV charger	Enforced
Wire for battery & emergency circuit	Encouraged

FoCAP approached this project very strategically, recognizing that they needed to be prepared to address potential financial, technical, and political challenges. Accordingly, they conducted analyses and determined as follows:
• Financial impact: cost would be between $100 and $1,000 per home
• Technical impact: negligible – routine wiring for additional electric outlets
• Political impact: there are no State regulatory obstacles; the primary need is to educate local officials
The current status of the effort is approval by the City Council on February 21, 2019, to establish a Council subcommittee to manage the implementation of the Climate Action Plan and pass the electric-ready ordinance for new residential construction. However, a timetable for passage of the ordinance has not yet been established. (Gang 2019)

1.3. Workforce Green Building Education

PG&E, in collaboration with SCP and the County of Sonoma, recruited a team of five residential green building practitioners (including myself) to develop and teach a series of classes titled, "Integrated Design and Construction: Rebuilding for Comfort, Efficiency, and Affordability." The series was prompted by the realization that a rapid mobilization of the construction workforce would take place to address the sudden housing deficit, and that there was a concomitant imperative to introduce high-performance building practices to promote a more sustainable built environment in the disaster's aftermath. The five topics, covering high- performance/zero-energy fundamentals, were:
• Design Thinking for Zero Net Energy

- Advanced Framing Saves Energy, Materials, and Labour
- High Performance Enclosures: Air Tight, Well-insulated, Properly Ventilated
- Residential Heating, Ventilation, and Air Conditioning
- Water, Energy, and Time-efficient Hot Water Systems for New Homes

We taught the series once in the spring and again in the fall of 2018. The classes were relatively short (3 hours) and held on Friday afternoons, in response to the heavy workload that developers, architects, construction workers, and other building professionals were experiencing due to the extraordinary volume of post-fire contracts. The classes were well-attended and reviews were overwhelmingly positive and enthusiastic. Nevertheless, attendees represented a relatively small fraction of the building workforce, and much more education on these topics is needed.

California's energy code is updated every three years, increasing in stringency with each iteration. The last two code cycles have seen relatively greater changes than in past decades, with the result that building professionals are more challenged than in the past to incorporate the changes into their design and construction practices. The ramp up to higher levels of efficiency will inevitably exacerbate that phenomenon, and thus more education opportunities, resources, and formats are needed to address the changes, particularly in areas like the North Bay where the workforce is under above-normal time pressures.

2. Lessons Learned

2.1. Imperative, NOT Opportunity

At one early meeting after the fire, convened by the Center for Climate Protection, Sonoma County Supervisor Lynda Hopkins admonished attendees that – notwithstanding the strong sentiments throughout the county in favour of rebuilding to higher environmental standards, the situation should not be referred to as an "opportunity;" that framing of the situation was viewed as extremely insensitive to the traumatic losses sustained by not only those who sustained direct losses of life and property, but to the community as a whole, and its losses. The framing thereafter adopted by the Rebuild Green Coalition was the imperative of rebuilding to achieve a more sustainable, resilient community.

2.2. The Power of Positive Options

Attendees at the Rebuild Green Expos were interested in and grateful for the information presented there. However, what became apparent by the end of the first Expo was that the most valuable outcome was that we had offered a positive, uplifting, and hopeful event for the traumatized fire survivors.

2.3. Tabula Rasa? Not So Much

While entire neighbourhoods were incinerated, and there were early conversations (e.g., at the December 1 green building workshop) about sustainability and resiliency benefits that might accrue from changes to zoning and land use development patterns – such as densification in proximity to transit corridors – those possibilities have not materialized. The vacant land belied the power of the so-called "real property" boundaries overlain on the land historically through subdivision maps and ownership transactions. These legal structures form enduring constraints on development that aren't readily unravelled by the forces of disaster. In fact, the fear, panic, and grieving that ensued from the disaster posed an impediment to such changes even being proposed; they were perceived as burdensome and even threatening.

2.4. Haste Makes Waste

The rush to rebuild also has represented an impediment to introduction of greener practices. The residents who lost their homes have been forced to move, without prior plans, anywhere they could, and they are understandably in a hurry to have their homes rebuilt. As mentioned earlier, this has put unprecedented pressures on members of the area's design and construction workforce. Further, some of them also lost their homes; some have had to move away; and even for workers willing to move to the area to supply their labour, housing is difficult to come by, further exacerbating the region's labour shortage.

At the best of times, it is difficult to introduce changes in practice within the U.S. home building industry, which is traditionally change-averse (the reasons for which are numerous and worthy of a paper unto themselves). When that workforce is overloaded, the difficulty of introducing change increases dramatically. PG&E offered free technical assistance to builders willing to pilot zero net energy practices in their new homes in the area. Even those who expressed interest in this offer, however, failed to respond to attempts to further the discussion. They simply did not have time.

2.5. Exodus

Not all those who lost their homes have remained in the area. Forced to leave to find temporary housing, or simply disheartened by having lost so much, many former residents have opted to relocate rather than start over with a vacant piece of land. The vast majority of homeowners have never been involved in building a project from the ground up; faced with this daunting prospect – compounded by bureaucratic hurdles with insurance companies, toxic clean-up requirements, and other obstacles – many have left in frustration, putting their land up for sale.

As this exodus takes place, it is changing the situation from one of homeowners rebuilding to that of developers purchasing abandoned lots and redeveloping for profit. With demand high and labour resources thin, this is inflating prices for this hard-hit community – countering aims of economic sustainability.

2.6. Temporary Doesn't Mean Fast

8th Wave is a B-corp (B Lab 2019) formed with the goal of rapidly creating green, affordable, temporary-to- permanent housing for North Bay fire survivors, leveraging recent policy changes that encourage creation of infill accessory dwelling units (ADUs) and utilizing modular and panelised systems. The pilot project, completed in late 2018 for Homes for Sonoma, provided housing for five displaced families, at the relatively (for the Bay Area) affordable price of $100,000 per one-bedroom unit.

However, principal Robin Stephani, at the U.S. Green Building Council's Pacific Region GreenerBuilder conference in August 2018, shared two painful lessons she and her fellow 8th Wave founders learned in the process: it's not quicker to build temporary rather than permanent housing; and the cause is regulatory constraints that simply can't be removed quickly or effectively enough under crisis conditions.

3.Advance Planning For Disasters

3.1. Perception Carries a Price Tag

Although thousands of zero-energy and Passive House projects have been completed worldwide, at market- acceptable prices, there remains a widespread perception that green projects carry a price premium. Eventually, perhaps, the reality that sustainable performance criteria can be accommodated successfully within a project's budget will be more widely understood, but in the meantime incentives may be necessary to win hearts and minds. The Advanced Energy Rebuild program was built on that premise and actively promotes this understanding among participants. It also acknowledges the reality of learning curve costs – until green/sustainable/resilient design practices are mainstream, an investment of education, labour, and sometimes materials will be needed to surmount that learning curve.

3.2. Anticipate Post-disaster Needs

Robin Stephani's takeaway from 8th Wave's experience is perhaps the most important message for all of us. All communities potentially in harm's way – irrespective of the nature of the disaster risk – should begin planning now for how they will provide housing and other needs for displaced and traumatized residents when the need arises, as it surely will.

3.3. Institutional Changes Take Time

Regulatory changes are labour-intensive long plays. For example, if changes in land use, or revamped building regulations, will reap sustainability or resiliency benefits for your community, start the planning process to introduce them immediately. These changes can be very difficult to institute and in many instances are

politically very challenging. A concerted long-term campaign may be needed to overcome political obstacles as well as to address administrative and bureaucratic processes that govern institutional and regulatory changes.

4. Conclusions

Communities in California are ill-prepared for disasters. My participation in post-fire rebuilding initiatives in the North Bay since the fall of 2017 has made me painfully aware of the consequences of this ill-preparedness. The State since then has experienced further fire disasters. The November 2018 Camp Fire in Paradise, California, resulted in evacuation of 27,000 people, loss of 6,700 structures, and 86 deaths. Disasters in other parts of the world are occurring at increasing rates and at increasingly high human and economic costs. Of course attacking root causes – including anthropogenic climate change, inadequate investment in infrastructure, inappropriate management of forests and other natural resources – must be a paramount priority for us all. But even with our best efforts, there will be other disasters and they will affect communities near us. It is equally imperative that we begin to mobilize our professions and our decision makers to become better- prepared to address the disasters heading our way – everywhere.

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Effects of urban morphology on outdoor thermal comfort. A microclimate parameterization of housing blocks in the Euro-Mediterranean context

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Keywords: urban morphology, housing blocks, urban parameterization, microclimate, outdoor thermal comfort

Abstract
A methodology to analyse the influence of urban morphology on air temperature (T_A) is presented to investigate the behavior of some typical housing blocks of euro-Mediterranean cities. A parametric study is carried out by modelling with the ENVI-met tool seven housing blocks with three different configurations of surface cover. Then, a numerical experiment is carried out considering three wind directions for each configuration. The resulting TA is compared with some urban design descriptors (land-use, density and built-form descriptors) in order to highlight the performances of different urban forms and the mutual interactions between microclimate conditions and physical characteristics of urban settlements

1. Introduction
At present, urban environments are experiencing variations in climate patterns compared to their surroundings, posing serious challenges (cities warming, poor air quality and increased impacts of extreme weather and climate events such as heat waves, flood, droughts and storms) to the population. Such an alteration is related to the different design and building materials highly influencing mass and energy flux budgets at the surface. Land use change, high-built density, multi-faceted buildings and high concentration of people and activities in urban environments can indeed affect the outdoor microclimate by modifying physical properties of urban surfaces (thermal and radiative properties) and local airflow, resulting in a worsening of pedestrian thermal comfort conditions and building environmental performances.
On this topic, the scientific community is deeply involved in activity aimed at investigating the complex interactions between urban form and local microclimate to counter the negative effects of heat-related weather and climate events supporting design and planning processes. Most researches investigate the effects of different streets layouts (Andreou, 2013; Achour-Younsi & Kharrat, 2016) and vegetation types (Shashua-Bar & Hoffmann, 2000; Georgi & Zafiriadis, 2006; Gonçalves et al., 2019) or the impact of urban morphology on building energy performances (Vartholomaios, 2016). The contribution of geometrical characteristics of urban blocks in determining suitable microclimate conditions in open spaces is however often neglected. In this regard, Oke (1988) states that there are almost infinite combinations of different climatic contexts, urban geometries, climate variables and design objectives. These combinations require then an in-depth study of building typologies to characterize their behaviour under specific climate conditions.
Under these premises, this study aims at assessing the microclimate performances of built environment at the scale of urban blocks. The main research question is: "How does urban form and density, as expressed in different building typologies, affect microclimate conditions?". This study addresses this question by analysing the outdoor thermal comfort conditions induced by different urban block layouts in euro-Mediterranean area. The main goal is to quantify the contribution of morphological parameters and vegetation in exacerbating or mitigating heat stress conditions at local scale.
This objective is addressed through a parametric investigation adopting a typological approach. Seven housing blocks (detached, attached, slab, U-shaped, block with courtyard, block with multiple courtyards, tower) are selected among the most common types of single and multi-family housing in euro-Mediterranean cities (Shashua-Bar et al., 2006, Perini & Magliocco, 2014; Salvati et al., 2019). They are modelled with the ENVI- met v4.4 Computational Fluid Dynamic (CFD) code (Bruse, 1999) considering a plot area of 1 hectare (100m x 100m), three different configurations of surface covers (0%, 20% and 60% pervious) and three wind directions (W = 270°, SW = 225°, S = 180°). By combining on a case-by-case basis housing blocks, surface covers and wind directions, the influence of built environment and vegetation on the microclimate conditions within urban blocks are investigated assuming the air temperature (TA) as output related to the human thermal comfort. Such an output is then analysed trying to establish a relationship with some urban design descriptors that are commonly used in urban and architectural planning to define land-cover, density and geometrical characteristics in order to highlight the performances of different urban forms and the mutual interactions
between microclimate variables and physical characteristics.
The paper firstly introduces the methodology developed to investigate the climatic performances of urban blocks and their

effects on outdoor thermal comfort (§2); then it presents and discusses the main results highlighting the thermal effects associated to the built form and vegetation (§3); finally, it draws conclusions (§4).

2. Methodology

The methodology developed in the study consists of three steps (Figure 1):
1) selection and parametric modelling of the most common housing blocks in euro-Mediterranean cities;
2) numerical simulation of microclimate conditions through the ENVI-met code;
3) comparative analysis of a microclimate parameter with some urban design descriptors.

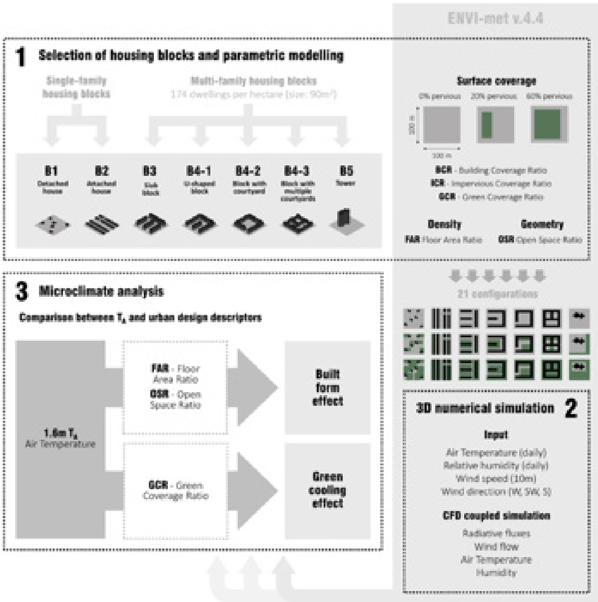

Figure 1 Methodology flow chart.

1. Selection and parametric modelling of the housing blocks

The housing blocks are selected considering the most representative types of euro-Mediterranean cities. These "typical blocks" have to be regarded as hypothetical districts or simplified urban forms including peri- urban and urban typologies. Seven blocks are modelled with different density values and building arrangements according to single-family (attached, detached) and multi-family housing types (slab block, U- shaped block, block with courtyard, block with multiple courtyards, tower block).

The single-family detached housing block (B1) consists of six houses (mean height: 5.4 m), while in the attached (B2) 76 apartments on two levels are placed in 4 parallel rows (height: 6 m). The five multi-family housing blocks were developed by adopting the same number of dwellings for each block (174 dwellings) and placing them differently in order to evaluate the best use of land in order to improve local microclimate conditions. To model open, semi-open and closed block types with multi-storey housing units, three common massing forms were considered: the slab, the perimeter and the tower. The slab block (B3) consists of four rectangular buildings that are longer than tall, three of which arranged in parallel rows and the fourth placed orthogonally to them (height: 18 m). The perimeter type includes a courtyard at the centre created by housing slabs around all or part of the perimeter. It is articulated in three different configurations: 1) U-shaped block (B4-1), which is semi-open and delimited on three sides by buildings and with a slab placed orthogonally to the open side (mean height: 16.3 m); 2) closed block with one courtyard (B4-2 - mean height: 16.3 m); 3) closed block with multiple courtyards (B4-3 - mean height: 11.6 m). Finally, one tall building with stacking housing units forms the tower block (B5 - mean height: 51.7 m). The size of the apartment considered in the modelling is the same for all the seven typologies (=90 m^2).

All blocks are modelled considering some morphological parameters related to surface coverage (Building Coverage Ratio – BCR, Impervious Coverage Ratio – ICR, Green Coverage Ratio – GCR[1]), built density (FAR- Floor Area Ratio[2]) and geometry (Open Space Ratio – OSR[3]). Table 1 summarizes the morphological characteristics of the housing blocks reporting for each case the related urban design descriptors. In this way, twenty-one configurations are implemented according to the three different green surface covers (GCR=0; 0.2; 0.6).

Table 1 Morphological characteristics of housing blocks

Housing blocks		Main characteristics		Urban design descriptors				
				Surface coverage			Density	Geometry
		N° of dwellings	Height (mean) [m]	BCR [m²/m²]	ICR [m²/m²]	GCR [m²/m²]	FAR [m²/m²]	OSR [m²/m²]
B1	0% p.	6	5.4	0.08	0.92	0	0.12	0.93
	20% p.				0.72	0.2		
	60% p.				0.32	0.6		
B2	0% p.	76	6.0	0.36	0.64	0	0.68	0.66
	20% p.				0.44	0.2		
	60% p.				0.04	0.6		
B3	0% p.	174	18	0.27	0.73	0	1.57	0.74
	20% p.				0.53	0.2		
	60% p.				0.13	0.6		
B4-1	0% p.	174	16.3	0.32	0.68	0	1.57	0.71
	20% p.				0.48	0.2		
	60% p.				0.08	0.6		
B4-2	0% p.	174	16.3	0.31	0.69	0	1.57	0.71
	20% p.				0.49	0.2		
	60% p.				0.09	0.6		
B4-3	0% p.	174	11.6	0.40	0.60	0	1.57	0.59
	20% p.				0.40	0.2		
	60% p.				0.00	0.6		
B5	0% p.	174	51.7	0.09	0.91	0	1.57	0.91
	20% p.				0.71	0.2		
	60% p.				0.31	0.6		

2. 3D numerical simulation

The microclimatic conditions for each configuration are simulated using the ENVI-met v4.4 CFD code. ENVI- met is a prognostic three-dimensional high-resolution microclimate model that simulates surface-plant-air interactions, allowing analysing the small-scale interactions between urban form and microclimate (Bruse, 1999). It consists of the following sub-models: 1) the 1D boundary model, adopted for the initialization and the definitions of the boundary conditions of the 3D atmospheric model; 2) the 3D atmospheric model, in which air temperature and humidity, wind flow, turbulence, radiation fluxes and pollutants dispersion and deposition are simulated; 3) the soil model, in which the water balance and heat transfer from the surfaces into the ground and vice versa are calculated; 4) the vegetation model, including the simulation of the exchange of heat and moisture between plants and atmosphere (Simon, 2016; Tsoka, 2018). The ENVI-met model is chosen as it allows the simulate microclimate and human thermal comfort through many variables (as radiation, air flow, turbulence, humidity, reflection of buildings and vegetation) and indices (e.g. PMV, PET, PPD). Furthermore, despite some limitations, it was widely used by researchers not only for the investigation of current microclimatic conditions but also for comparing the performances of adaptation and mitigation strategies (Tsoka et al., 2018).

The simulations are carried out according to the following basic assumptions: 1) flat terrain and simplified box shaped buildings; 2) cubic grid with max resolution of 1 m in the horizontal axis and higher grid resolution enabled only for vertical axis; 3) constant wind profile during all simulations times; 4) building with constant indoor temperature and no heat storage; 5) 1D soil model based on the initial temperature and humidity profile of the soil and the various surfaces; 6) vegetation model considering the photosynthesis rate, the CO2 demand, and the state of the stomata, the interaction of humidity and radiation in soil and air (Makropoulou, 2017; Nasrollahi et al., 2017).

A 3D model of the housing blocks is developed with a horizontal and vertical spatial resolution of 2m within a domain size of 55x55x30 cells. The diurnal cycle (01-24) of major climatic variables is simulated for each housing block in July 15th by adopting the following input data for the simple forcing of the meteorological boundary conditions: 1) typical air temperature and relative humidity (RH) values of euro-Mediterranean areas (TA-min: 16°C; TA-max: 28°C; RHmin: 50%; RHmax: 70%); 2) wind speed (10 m): 3.00 m/s; 3) wind direction: 270°,
225°, 180°; 4) cloud coverage: 0%; 5) indoor temperature: 20° C; 6) grass 50 cm average dense as vegetation;
7) loamy soil and asphalt road as soil types. With these input data, 63 simulations are carried out.

3. Microclimate analysis

The thermal performances of 63 housing block configurations are investigating considering as output the TA at the height of 1.6m during the time range of 01-24 on July 15th. Results are synthetized by extracting the output over the computational domain

at 06.00 (representative of nighttime condition) and 16.00 (representative of daytime condition). These time step corresponds precisely to the minimum and maximum input air temperatures, respectively.
Operatively, the median TA for each housing block are compared considering the FAR and OSR indices, in order to highlight their typical performances, or the propensity of some morphological characteristics to negatively affect local microclimate. Such comparison between microclimate variables and urban design descriptors has allowed focusing attention on two specific thermal effects:
1) "Built form effect" investigated considering the impervious housing blocks (GCR=0), neglecting the effects related to the presence of green areas;
2) "Green cooling effect" investigated comparing the housing blocks with the same green surface cover (GCR=0.2 and GCR=0.6) to the housing blocks with impervious cover (GCR=0).

3. Results and Discussion
1. Built form effect: impervious housing block configurations with wind direction W = 270°
The built form effect is firstly investigated considering the impervious housing block configurations (GCR=0), neglecting then the effects related to the possible presence of green areas and considering only the wind coming from West. Figure 2 shows the median value and 5-95 percentile spread of TA carried out for the different housing block configurations at nighttime (Fig. 2a) and daytime (Fig. 2b). These values are displayed reporting for each housing block configuration also the corresponding FAR and OSR.
The single-family housing blocks (B1 and B2) reveal during the nighttime (Fig. 2a) the lowest median values; these values (about 15.3°C) are about 1.5°C lower than those obtained with the other impervious configurations and about 0.7°C lower than the air temperature input (16°C). Conversely, during the daytime (Fig. 2b), B1 and B2 experience an antipodal behaviour: B1 returns the highest median value of TA (30°C) while B2 exhibits the lowest one (28°C), despite the unfavourable orientation (long façades perpendicular to the wind direction). This is probably due to the reduced buildings height characterizing this latter configuration with respect to the other ones. On the other side, the multi-family housing blocks (B3, B4-1, B4-2, B4-3 and B5) yield with respect to the air input temperature a systematic increase in TA during both the nighttime (Fig. 2a) and the daytime (Fig. 2b). Such an increase is in both cases of about 0.5-1°C.
Referring to the 5-95 percentile spread, it varies as for the single-family housing blocks against the multi-family housing blocks as for nighttime against daytime. During the nighttime, the single-family housing blocks yield a TA spread of 0.4°C for B1 and of 0.8°C for B2 that, in any case, result to be lower than the spread returned for the multi-family housing blocks (on average about 1.3°C). During the daytime, the spread increases; specifically, the B1 presents the lower spread (about 1.3°C) while the B2 seems to behave as the multi-family
housing blocks. The spread is about 2°C except for B5 where it is about 2.6°C.

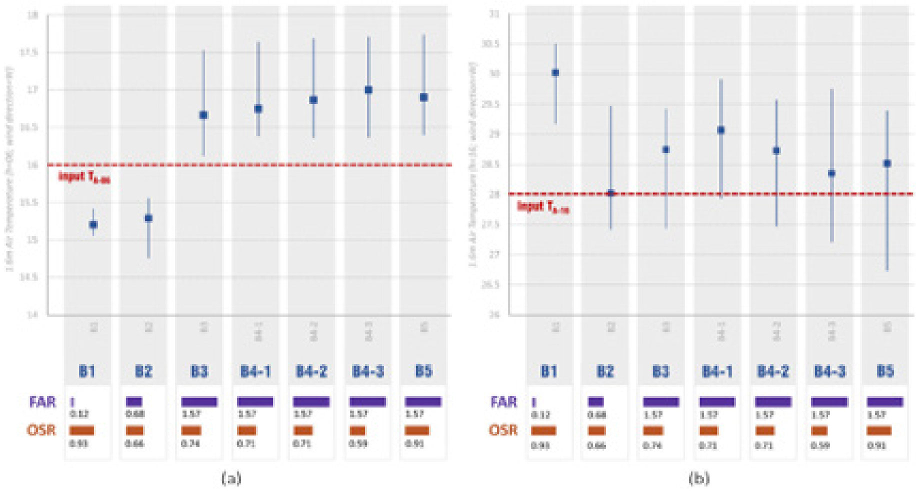

Figure 2 Nighttime and daytime Air Temperature - TA (median and 5-95 percentile range) of impervious housing block configurations with wind direction W = 270°.

2. Built form effect: impervious housing block configurations with wind direction W = 270° - SW = 225° - S = 180°
Figure 3 shows the outcomes of the numerical experiments when the impervious housing block configurations are forced considering all the wind directions (W = 270°, SW = 225° and S = 180°). The data are reported also in this case as median value and 5-95 percentile spread of TA at nighttime (Fig. 3a) and daytime (Fig. 3b).

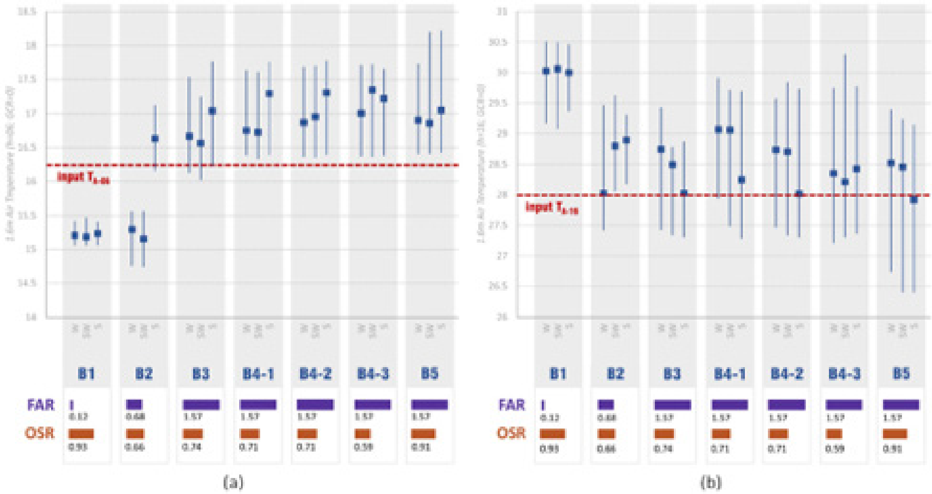

Figure 3 Nighttime and daytime Air Temperature - TA (median and 5-95 percentile range) of impervious housing block configurations with wind direction W = 270°, SW = 225° and S = 180°.

By comparing T_A as median value and 5-95 percentile spread for the three wind directions, a different behaviour emerges depending on density and geometry features of each block.
As regards the single-family housing blocks, the wind direction does not seem to affect the B1 configuration while the opposite occurs for B2. In this latter case, the wind coming from south (S) returns during the nighttime a median TA value higher than those obtained with the wind from SW and W (+1.3°C), while during the daytime it is slightly higher (+0.1°C) than SW (+0.1°C) but much greater than S (+0.9°C). As regards the multi-family housing blocks, the cases B3, B4-1 and B4-2 yield the most significant variations as S determines the highest values at nighttime and the lowest ones during the daytime. The wind direction does not seem to influence the other two cases (B4-3 and B5) excepting for the wind coming from S during the daytime for the B5 configuration.
3. Green cooling effect: impervious against pervious housing block configurations with wind direction W = 270°
The green cooling effect is analysed as intra-/inter-variability in/between housing blocks considering the impervious cover condition (GCR=0) and those obtained introducing different percentage of urban vegetation (GCR=0.2 and GCR=0.6). Such an application allows identifying parametrically the effective percentage of green cover that should be considered in these urban schemes to reduce the temperature and then the heat- related stress. The results are reported in Figure 4 as median value and 5-95 percentile spread of TA at nighttime (Fig. 4a) and daytime (Fig. 4b).

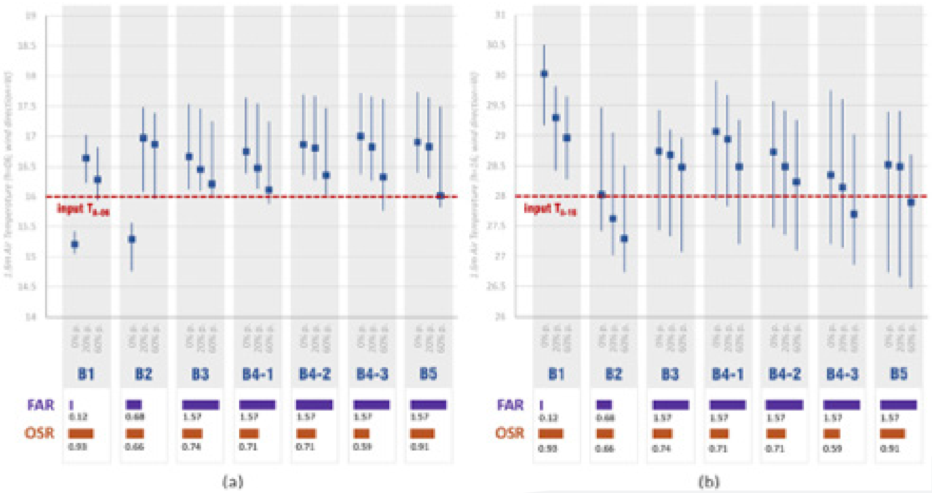

Figure 4 Nighttime and daytime Air Temperature - TA (median and 5-95 percentile range) of all housing block configurations with wind direction W = 270°.

The introduction of green areas within the single-family housing block schemes return a particular condition; the green areas tend to reduce TA during the daytime but they tend to increase TA during the nighttime. B1 shows the higher TA reduction, both with 20% of green areas (-0.7°C) and 60% (-1.1°C). The urban vegetation indeed has the advantage of shielding the underlying surfaces from incident solar radiation temperature during the day, reducing the heating and then the temperature; however, in the night hours, it could prevent the radiative cooling of the surface increasing the air temperature.

As regards the multi-family housing blocks, the green areas reduce the TA during both daylight and night hours. Slab (B3) and tower (B5) blocks highlight the most peculiar behaviours. The former is scarcely affected by the greenness (reduction of 0.3°C) especially during daytime; the latter returns a temperature reduction negligible moving from 0 to 20% and appreciable (about 0.5-1°C) moving toward 60% of open space area occupied with urban vegetation. The block with courtyard (B4-2) is finally very interesting as TA decreases during the daytime much more with GCR=0.2 with respect to the reduction occurring from 0.2 to 0.6.

4. Correlation between FAR-OSR and built form effect and green cooling effect

The results are also interpreted in terms of FAR and OSR during nighttime and daytime (Figure 5).

When green areas are missing, TA increases with the FAR during the nighttime (Fig. 5c) and decreases with the FAR during the daytime (Fig. 5a). In this perspective, the single-family housing blocks (low-rise buildings with a small area and low FAR) seem to act as a typical peri-urban area, characterized by lower T_A values during nighttime and higher T_A values during the daytime, while the multi-family housing blocks behave precisely as an urbanized space. Introducing green areas, the T_A variations with FAR are attenuated. Moreover, the trends during the nighttime (Fig. 5c) are opposite than that obtained without vegetation, especially for low FAR values (see §3.3).

The OSR against T_A (Fig. 5b and Fig. 5d) returns an antipodal behaviour with respect to the FAR against T_A both with and without green areas. Such a descriptor allows explaining the differences arising between B1 and B2 (single-family housing block configurations): despite the B2 is a peri-urban configuration with low FAR, it presents a high number of buildings that reduce the open space area at values comparable to those ascribable to the multi-family housing block configurations.

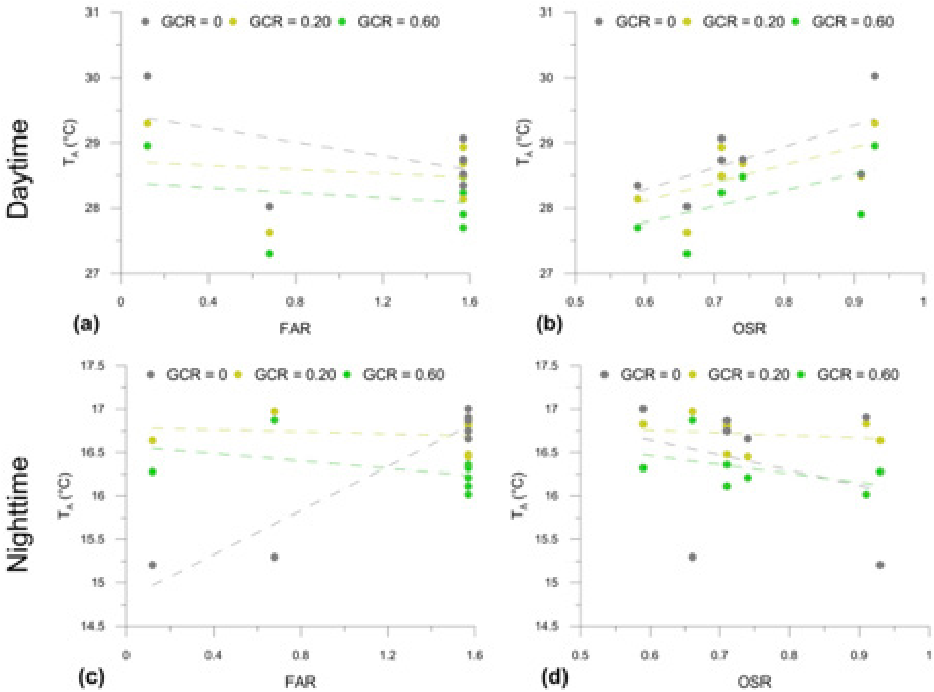

Figure 5 Correlation between FAR-OSR and TA (nighttime-daytime)

4. Conclusions

This study investigated parametrically the influence of layouts of seven housing blocks on urban microclimate and thermal comfort conditions. The main findings are:

• without green area, TA increases with FAR during night hours and decreases with FAR during the daylight hours;

• without green area, the OSR points out the role attributable to the house density and location as TA increase with OSR during daylight hours (detached and tower configuration) while it decreases with OSR during night hours (others configurations);

• the wind direction affects the thermal behaviour of the housing blocks; this point will be investigated considering other geometry parameters accounting for aspect ratio of buildings (e.g., Façade-to-Site Ratio, Frontal Aspect Ratio, Complete Aspect

Ratio, Envelope Ratio);

• not all housing blocks require more vegetation cover to achieve significant temperature reductions; the design of green solutions must take into consideration the contextual characteristics: combining knowledge on microclimate processes and site-specific design is essential to optimize their implementation and management in urban areas;

• the key morphological factors affecting the urban thermal environment could provide theoretical basis for the improvement of design and planning measures: the future aim is to extend these findings to urban and environmental design in order to support local authorities and professionals by providing them with a decision-making tool that can steer both future policies and design processes.

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[1] The Floor Area Ratio is the ratio between the building's total floor area (gross floor area) and the size of the lot upon which it is built (plot area).

[2] The Floor Area Ratio is the ratio between the building's total floor area (gross floor area) and the size of the lot upon which it is built (plot area).

[3] The Open Space Ratio is calculated as the opposite of the BCR (open ground area/plot area).

Sustainability and resilience in the southern outskirts of Reggio Calabria. Strategies and projects for soil recycle and management.

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Keywords: Soil Management and Design, Learning Policies, Urban Sustainable Strategies

Abstract
In the soil treatment scenario that, from COP21 in Paris to the issues related to the urban metabolism of resilient cities, can an annotated atlas of strategies and design solutions for the neighborhoods be enabling and represent a useful tool towards environmental sustainability and social objectives?
In this context in the southern neighborhoods of Reggio Calabria, as a suburb, the soil, fundamental factor for the perception of the quality of life, is the first environmental system on which a sustainable urban development strategy should intervene to respond to the urban problems of the heat island effect and flooding. In this sense, the policy of HQMI (High Quality Multiplier Investments) is proposed for the design of the public space-ground followed by the economic learning based model, which can incentivize private design solutions deriving from learning the enabling technologies of the HQMI type and realizing processes towards "transition cities".
This experience starts with the first definition of the atlas corpus, applied to urban areas of the southern suburbs of Reggio Calabria and it is experimented in the academic-didactic fields and the research for the degree thesis.

Strategies that enable the circular rather than linear and dissipative development model for water and soil are proposed, recycling and soil management tactics in the short, medium and long term 2020/2030/2050 are defined, information for design solutions for the soils of the suburbs are built, planning the impacts for urban and social aspects and for the perception of the quality of life by citizens.

1. The anthropocene consequences as starting point.

The impacts of climate change are already highly perceptible, they will increase in a short time and the anthropocene phenomenon as the consequences on the planet of the industrial revolution through the acceleration of man-made territorial (Maurizio Carta, Re-cyclical Urbanism) is definitely exacerbating the process. The Paris pact offers a long-term vision to encourage sustainable resilient climate development and, from the analysis carried out, in Europe, climatic risks include an increase in economic losses and an ever-increasing number of people suffering from problems related to flooding, heat waves, drought or forest fires. With regard to soil treatment, according to the measures and guidelines provided by the European Union, adaptation actions can aim to solve many of these risks. For example, it has been estimated that every euro spent on flood protection could be 6 euros in damage costs.
Adaptation also means taking advantage of the opportunities that arise and could increase, noting that such opportunities may present themselves in the form of problems to be faced: in this sense, adaptation is expressed through the transformation of problems into resources. This new field offers areas of development and experimentation for creativity and for the development of innovative approaches and technologies, which often lead to co-benefits.
Action is necessary at all levels - from local to international. For this reason, trials, developments, studies, and best practices found abroad and on the Italian territory will be taken into consideration in this forum to understand the current state of technological and management research in this regard and apply some suitable cases to the southern suburbs of Reggio Calabria.

2. European Union Adaptation Strategy, SMS and the Mediterranean Area

The laying of impermeable surfaces in the context of urbanization and land-use change, with consequent loss of soil resources, represents one of the great environmental challenges for today's Europe.
We need to use the soil more intelligently if we want to safeguard and transmit to future generations its multiple vital functions. (Janez Potočnik, European Commissioner for the Environment, concerning the soil treatment)

The European Union Adaptation Strategy, adopted in 2013, promotes adaptation actions in all Member States to contribute to a more climate-resilient Europe.
The strategy focuses on three key objectives:
• Promotion of actions by Member States;
• Climate-proof actions at European level;

• More informed and informed decision-making processes. (Commission staff working document)

Europe is one of the most urbanized continents in the world. Cities are not just economic engines, but also have an unparalleled role in providing the constituent elements of quality of life from every point of view: environmental, cultural and social.
In a review of United Nations in 2014, it was estimated that 54% of the world's population resided in urban areas in 2014. In 1950, 30% of the world's population was urban, and by 2050, 66% of the world's population is projected to be urban [Nations, 2014]. In particular, the percentage of urban population in Italy is currently of 69% [data.worldbank.org]. This means that the urban environment has become the most common ecosystem for humankind, and this phenomena keeps growing.
Moreover, urbanization is one of the main anthropogeny processes responsible for big changes in atmospheric and land surface heat exchange process.

The Mediterranean area is becoming drier, making it even more vulnerable to drought and wildfires.
Urban areas, where 4 out of 5 Europeans now live, are exposed to heat waves, flooding or rising sea levels, but are often ill-equipped for adapting to climate change.
Climate change is already having an impact on human health:
• There has been an increase in the number of heat-related deaths in some regions and a decrease in cold- related deaths in others.
• We are already seeing changes in the distribution of some water-borne illnesses and disease vectors. Damage to property and infrastructure and to human health imposes heavy costs on society and the economy.

3. Risks associated with soil sealing
The soil is a fundamental factor for the perception of the quality of life within a city and paradoxically it is the first element on which the city works and on which urban development presses unevenly.

As an integral part of urban metabolism, the inhibition of this natural factor can negatively influence more urban areas, including artificial networks on the surface and subsoil, air quality, mobility, perception of urban temperatures, presence and transport of pollutants to the surface, evapotranspiration and alteration of groundwater in the subsoil, and indirectly - through the incorrect design of the urban surface - also energy efficiency to the building scale.
The risks associated with soil sealing and incorrect urban planning are manifold and relate to two main phenomena that require sudden corrective actions and that, as natural phenomena, are destined to be strengthened due to climate change: flooding and urban heat.
3.1. The flooding
The flooding is a phenomenon of uncontrolled flowing and depositing of surface waters to the point of inevitably threatening the properties and the infrastructures, destined to become more frequent and more important in the future also in conjunction with the growth of the civil and industrial settlements that have determined, as the main consequence, the increase in the degree of sealing of basins and soil and, therefore, the increase in outflows generated in times of rain. In particular, for the entire urban drainage system, attention must be paid to quantitative aspects (increase in the frequency and intensity of extreme meteorological events), and to qualitative aspects and the impact of pollutants transported on the receiving water bodies.
The causes of flooding have been individuated as natural (intense and / or prolonged precipitation...) and / or anthropogenic (changes in land use, waterproofing...) (Chapman, 1999) and particularly from the four main ways in which urbanization influences the formation of floods (Smith, 2001) and the different types of flooding depending on the origin.

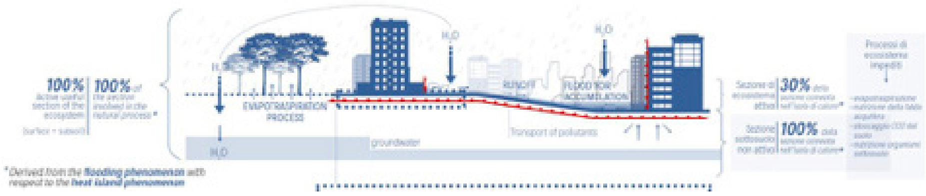


Figure 1 Section of an urban area during a flooding event. Active and non-active part of section and ecosystem processes involved

3.2. Urban Heat Island
The urban heat island (also referred to as UHI, from the English acronym Urban Heat Island) is the micro- climatic phenomenon that occurs in metropolitan areas and determines a warmer microclimate within urban city areas, compared to the surrounding areas peripheral and rural. It is a phenomenon known and studied for some decades and is mainly caused by the thermal and radiative characteristics of the materials that make up urban surfaces (first of all asphalt and cement) in which the absorption of solar radiation prevails over reflection. The surfaces of urban areas interested by the highest levels of risk of heat are on coastal cities more than internal cities.

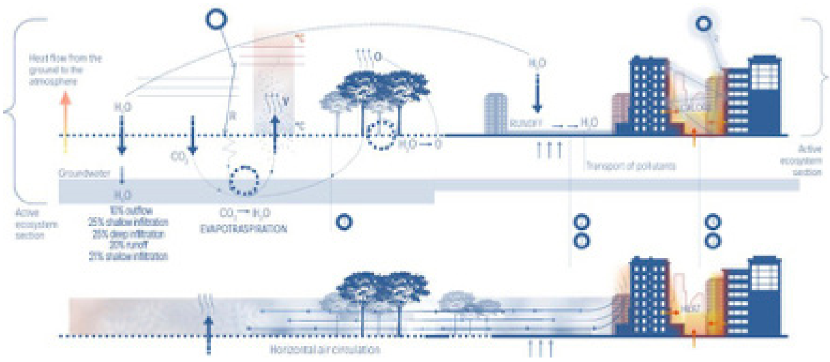


Figure 2 Urban Heat Island Effect. Ecosystem processes involved depending on quality of urban context.

For the resolution of urban flooding and heat island problems, it is necessary to proceed with integrated projects in terms of design and process development, that is to say the network functioning of point systems distributed over the urban territory, over time. The projects must therefore measure the technological level to the measures of reduction of atmospheric latent heat, providing where possible extensive interventions of de-waterproofing and implementation of shade vegetation, therefore of the wide foliage type.

5. Designing resilience is ...

5.1. Tactics as change over time

Every successful strategy needs tactics to transform themself in actions over time.

The experimentation in the southern suburbs of Reggio Calabria as a laboratory starts from a reflection derived from the observation of flooding phenomena following water bombs during the winter period and the activity already started in the suburbs as a laboratory city. But the real idea stems from the consideration of the strong drought and scarcity of water resources that characterize the outskirts, the most populous and densest of Reggio Calabria, and which consequently causes serious administrative and livability problems due to the strong perception low quality of life. Hence the observation of the paradox: flooding in winter and severe water shortages in summer; destiny correlated to the instance of climate change and the increase of the population residing in the cities from now until 2030.

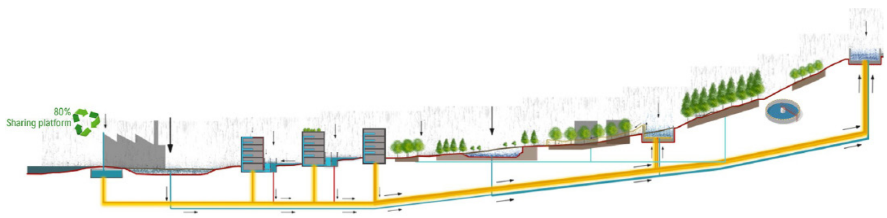


Figure 3 Type section on the periphery. Representation at 2018.

The anthropic causes identified are: a tendency to soil sealing, even stronger on the coast, abandonment of agricultural and non-agricultural land, a linear and dissipative economic model of water and soil resources, leading to social consequences such as the perception of low quality of life especially during important precipitation events.

The principal problem on handling this kind of urban fragile situations is that lot of adaptation plans for cities actually never find a practical definition, lacking of the translation in their related necessary actions. This is because several cases in the global vision of the final date-strategies forget to refer every intention to the local vision in the middle time, that's the factor that can define the successfulness of a strategy. Every strategic project or plan needs the application of tactics as a transformation of strategy in practical actions, in order to control and verify for each time-goal the urban and social aspects involved. To do this the method is fundamental, so 3 soil recycling and management tactics have been developed:

-To 2020: storage tactics: Urban aspects: the trend towards sealing new soil in the periphery, the occupation of the coast and the abandonment of some agricultural land will remain in two years; it will begin with the activity of designing the soil and public spaces. Social aspects: Study and beginning of the development of a public circular economic model even though the private is still far from this, adopting a linear dissipative model; meanwhile public attention to the water resource will increase, from which an average quality of life will be obtained during important precipitation events. These actions will be the instrument of starting a process of knowledge for the community.

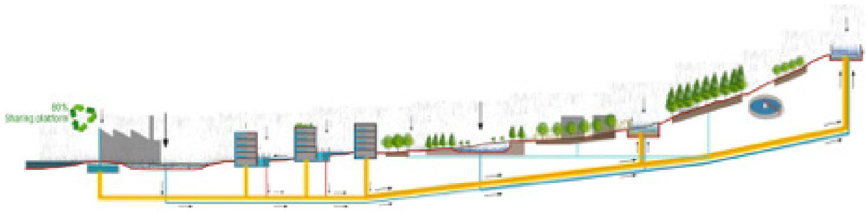


Figure 5 Type section on the periphery. Tactic to 2030.

-To 2050: product tactics: urban aspects: continuous optimization of the approach to soil design for storage and return of permeable soils, consequent elimination of the old network system that led to dissipative development, double sharing network and reception of water resources for private members of the new incentive system for the treatment of the soil element and water resource. Social aspects: start of an upcycle process of water resource and attention to soil treatment by all actors, creation of companies linked to water purification and / or disposal activities and increase in specialized employment, a completely regenerative economic model for the area in question, reactivation and activation of specialized human resources related to maintenance, network design, water disposal and purification, adaptation and construction of new drainage and collection systems and covers.

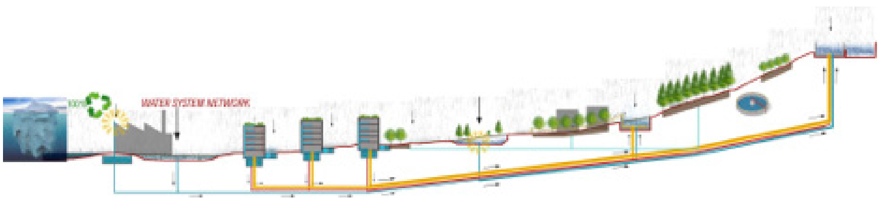


Figure 6 Type section on the periphery. Tactic to 2050.

The periphery could be recognized in the new eco-creative city, that is, attentive to the environmental and urban development aspects, identifying what today represents the problem, an indigenous resource and approach, being able to set an example and, in the case of important amounts of resources in stock, an economic factor of product as a service to the rest of the city.

The challenge for the periphery is twofold:
- make the problem a resource, that is to fight and reduce the effects of flooding and the island of urban heat through the redesign of some spaces in order to obtain benefits such as the storage of water for periods of drought, the return of permeable and livable spaces, the awareness of the community with respect to problems, the recovery of disused infrastructures, through incentive and training actions and at the same time obtaining as direct consequences reduction of costs of damage related to flooding;
- make the solution approach not a mere emergency response system, but an efficient and renewed approach to urban development, educating the community, and daily adaptation, effective to determine strong positive effects on the quality of life in the periphery.
The method here proposed returns a line of reasoning of circular economy and sustainability applied to the urban and architectural scale in a deeply integrated way.

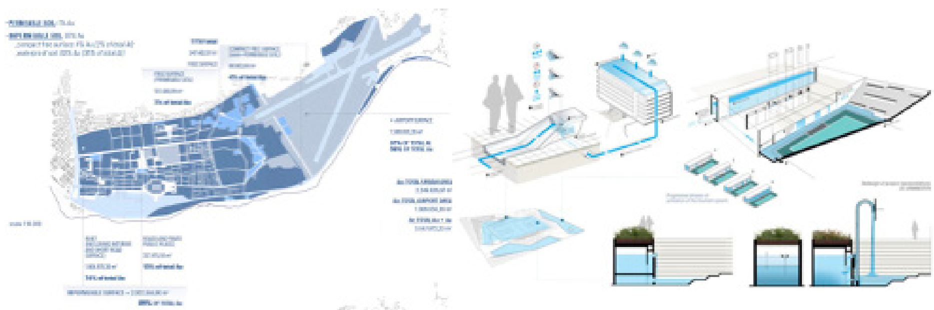


Figure 7 Two scales of application of strategy and tactics: urban (calculation of percentages of permeable and impermeable surfaces to determine mitigation, compensation and adaptation approaches) and architectural (built system of storage of water during heavy precipitation events. Redesign of Benthemplein square, De Urbanisten).

5.2. Integrated approaches and agile everyday solutions

Soil recycling and management are carried out by rethinking and redesigning spaces and networks (surface and subsoil). In literature there are still no design manuals related to the recycling of soils and the management of the networks they employ, but only guides to good practices and some best practices, many of which published by the European Union. A system of approaches to the process design and soil design is proposed, following a study in literature and in direct experience of successful experiments.

Based on the research and studies carried out, we are able to classify the types of scenarios and elements obtained by designing variations in design and in the process in order to take advantage of a design base of addressing technologies and point solutions. These can be combined with relevant design adjustments of the case according to the place, the use made of it, the availability, and urban, economic, social and environmental characteristics. It should be noted that the primary objective remains the integrated design in terms of the functioning of the networks and of the spaces that are part of urban metabolism processes.
First of all, it is useful to distinguish 3 cases of presentation of the work scenario based on the type of distribution of the primary spaces identified in the building, public space and storage area, as shown in the following diagrams.
Taking into account the project quality theory (needs, requirements, performance), we proceeded with the identification of the project requirements for the development of each alternative, taking them into account as elements of differentiation from the other variations. 16 performance levels (qualities, attributes) have been identified which can be summarized as follows:

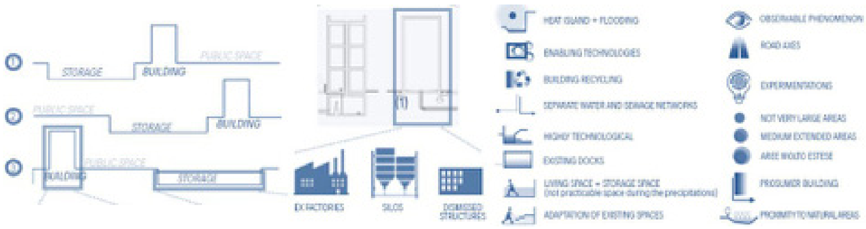


Figure 8 The 3 cases of work scenarios and the 16 performance levels

On the basis of the previous analysis, we come to the definition of some design models of application to the urban case, bearing in mind that these are not models to be adapted indifferently once the urban specifications corresponding to the case in question are identified, but models in terms of example of technological-environmental approach based on different cases that could arise and which must be examined by a judgment of effective applicability and in detail, being able to apply more than one example, thus giving rise to new and infinite variations.
Taking as a basis of analysis the exit dataset of the SID Course (population density, urban metabolism, public lighting, electricity grid, water network, natural gas network, coverage of telephone networks, public and private spaces, types of urban spaces, ...), deepening and implementing the available mappings with more depending on the data to be investigated (land morphology, more tarred areas, areas subject to flooding and of what degree, vegetated and non-vegetated public spaces, type of materials and areas by districts, quantitative parametric calculation of heat island through BCR, BD, BH, P, AOU, A, H/H, BO, MOS, reflected radiance and incident radiance for different kind of superficial material, ...), crossing these with the first ones, and following considerations deriving from further data provided at the European level (the percentages of occupied soil and those of soil with a strong environmental impact in the main European countries), it was possible to identify the most critical areas for the Southern Suburbs of Reggio Calabria, those that are usually more affected by the phenomena of flooding and/or urban heat island. It was subsequently possible:
- the identification of the causes of agents,
- the classification of adaptation solutions through mitigation and compensation actions
- the drafting of a series of possible punctual and sustainable interventions on the urban scale, deriving from the study and redesign of the experiences observed and taken as a reference
- the experimental design of variants to some alternatives already investigated.

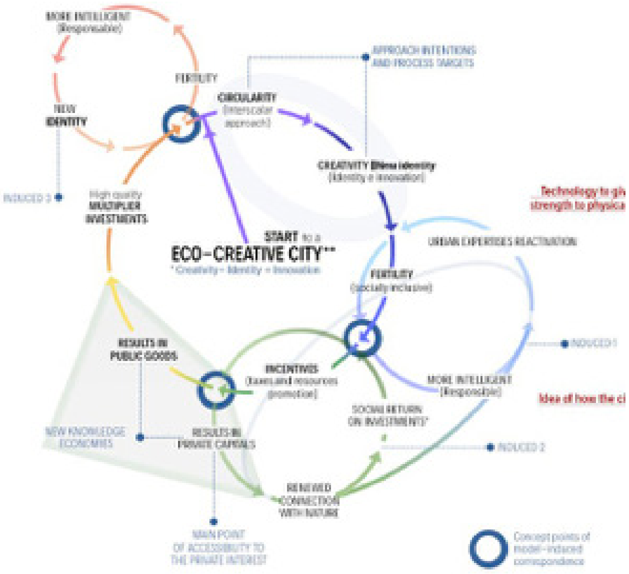
The sensitive areas identified were chosen as pilot areas, that is, more representative of the main types of distribution in the periphery, based on the different proportions and combinations of factors: asphalt, population density, building height, presence or absence of vegetation and of what type, public space or private. They have been the subjects of an integrated project of climate adaptation actions for compensation and mitigation.

5.3. The Oiko-creativity and the Knowledge-based development

The development model designed and proposed for cities that, like the southern suburbs of Reggio Calabria, must face an environmental problem is based on the Knowledge-based economy as a declination of the Green economy for the eco-creative (or oiko-creative) city. It defines itself as knowledge-based because it starts from the awareness that the main topic on which to discuss talking about sustainability, resilience and recycling of resources in the city, is the need to admit that the community does not recognize.

The citizen, who works in the city, does not know how it really functions, how it works and how it lives, and above all how it risks succumbing to the use made of it. The whole issue of lack of awareness, born of non- knowledge, becomes stronger and more risky if considered at the level of the effects on the entire urban metabolism and if discussed with reference to the existing relationships with respect to phenomena linked to climate change, relationships that alter the quality of life.

It's possible to demonstrate that there is a development model for the eco-creative city, which allows, through the manipulation of the problem, to obtain a resource; output product of the application of a circular development process through which the community is formed, which is carried out starting from HQMI (High Quality Multiplier Interventions), which returns a renewed relationship with nature with respect to climate change and the daily quality of life, with advantages in terms of public goods and private capital. An intrinsic objective stems from this reflection: the possibility for the peripheral community to recognize itself in a new identity derived from renewed characters of sustainability and resilience



6. Conclusions

Permeability is concerned as a recycle factor through the recovery of the soil, because from interventions of this type it can change its function or the already existing function can be manipulated in a percentage. In this regard it would perhaps be more correct, in support of the thesis, to define this mitigation activity as soil restitution, as recovering the soil does not exclusively return the natural element that allows the natural process of evapotranspiration, but frees itself and returns automatically, as a deterministic effect, the community space that previously "knew" to use it exclusively in one way (fast mobility) increasing the slow relations and reactivating hidden factors of the identity of a community. It is in this context that the instrument for implementing the proposed development model is configured: the design of the soil as an enabling technology, or the use of technology to give more strength to physical communities.

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Mapping trees in European cities with Urban Atlas under consideration of natural vegetation formations

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Keywords: urban trees, Urban Atlas, natural vegetation, city comparison, Europe

Abstract

A good urban greening is often equated with a high environmental quality and quality of life in cities. In the European context, however, this has to be differentiated and city comparisons ought to recognize differences due to spacious location, climate, relief, soil composition and history. The presented study critically reflects Urban Atlas geodata against the background of the natural vegetation potentials.

The Copernicus Land Monitoring Service offers new geodata on the greening of urban areas as an information in the European Union's Urban Audit. The street tree layer (from Urban Atlas) contains patches of tree covering over artificial surfaces. The Natural Vegetation Map of Europe presents potential vegetation types on a uniform concept for the entire continent. These data sources were used for this investigation.

For this explorative study cities with a clear assignment to a vegetation zone were selected. The analysis results show considerable differences in green tree areas in cities of different vegetation zones. The high dependence on the natural vegetation formations can be demonstrated by the results. Cities within the zone "Mediterranean sclerophyllous forest and scrub" have relatively few green area and tend to have small and isolated green patches. Of course, anthropogenic influences on land use play an important role. Nevertheless the degree of urban greening is a valuable information, but it should take the potential natural vegetation into consideration. A simple green indicator based on Urban Atlas data without specification along vegetation zones is not very helpful for city comparison in Europe.

1. Introduction

The importance of green spaces in cities for our wellbeing is subject of numerous publications and EU research projects (e. g. Greenkeys, URGE, SALUTE4CE). Sandström identifies six important functions of green for a liveable city: recreation and health, conservation of biodiversity, cultural identity, nature experience, improved environmental quality, alleviated technical problems (like stormwater retention, floods) (Sandström et al. 2006). For each of those functions one can find publications of research projects with empirical evidence for the benefits of green areas (URGE-Team 2004, Lee and Maheswaran 2011, Kazmierczak 2013, Hartig et al. 2014, Kabisch and Haase 2014, Kabisch et al. 2016, Mathey et al. 2018). Within the topic of urban green areas their quality depends largely on the green-volume differentiated in medium (bushes) and high (trees) (Smaniotto Costa et al. 2008). Trees more that bushes define the quality of stay in these green areas (shaded space, rest and walkability).

The presented study focuses on tree coverage and presumes, that tree coverage in cities is influenced by the natural vegetation formations of Europe. Against this background, this study addresses the following questions: Is there a European data source on green volume respectively tree coverage? What is the value range of tree coverage in large cities? Could the natural vegetation formations help to understand the differences of tree coverage (according to the Urban Atlas)? Does tree coverage and natural vegetation zone show interrelations and allow the creation of spatial city clusters?

Of course cities are unique due to their development over centuries, changing planning paradigm, attitudes to green, the management and financial budgets. Each city has its strength and weaknesses along the planning paradigms of making them compact and green at once (Deilmann et al. 2017). In this context the anthropogenic transformation of natural environments over history is of great influence with regard to the topic. Artificial parks or lawns – which survive climatic conditions only by high efforts of maintenance – are highly valuable areas for the wellbeing in the city. But looking at the entire city area like the associated natural vegetation formation sets a frame and helps as an overarching important factor to understand the different green characteristics of cities.

More and more cities in Europe tend to develop threshold values for urban green per capita or for the accessibility of green (distance, public /private, free of charge, etc.). The intensity of the debate varies between countries, also with regard to the possible effects of climate change. Citizens and planners are increasingly worried and climate change debate confronts them with the future of the green areas (size, distribution, climate resilient types of trees, costs, etc.). On the other hand European policy developments as the Green Infrastructure Strategy (European Commission 2013), the Nature-Based Research and Innovation Policy Agenda (European Commission 2015) and the Biodiversity strategy (European Commission 2011) initiate discussions and ask for strategy implementation. In this context – before making comparisons – it is necessary to look closer not only at the potentials, but also to the limitations for urban greening under consideration of natural vegetation formations in Europe (rather than classifications along nations).

To the best of our knowledge, no study so far has looked at the relation of urban trees and the natural vegetation preconditions from a European perspective. We want to contribute to the current debate on urban green in a European context. The differences of cities in their regional climatic context need to be considered when looking from a perspective of the whole continent. In the search for a simple approach for a first differentiation of cities, we believe the potential natural vegetation could be used as a suitable proxy or indicator. The main formations of natural vegetation implicitly reflect the complexity of geographical location (latitude, continentality, altitude) and the associated climate zone on the basis of typical geological and soil formations.

2. Data and Methods

2.1. Urban Atlas

The Urban Atlas as part of the Copernicus Land Monitoring Service provides detailed vector data on land cover and land use for numerous city-regions in Europe. Such data is available with a largely standard nomenclature of 28 classes at scale 1:10,000 for the reference years 2006 and 2012. For the latter year, the Urban Atlas has been available for almost 700 European city-regions ("Functional urban areas" or FUA) as Open Geodata (Copernicus Land Monitoring Service 2018). These include all EU cities of more than 100,000 inhabitants as well as their commuting zones. This data is used for spatial analysis within the framework of the European Union's Urban Audit (Montero et al. 2014). With the help of the Urban Atlas data, generalized patterns of urbanization can be identified by deriving various metrics on settlement structure, as shown in a methodological study that compared Greek cities (Prastacos et al. 2017).

The Street tree layer (STL) is a new separate layer from the Urban Atlas 2012 within selected Functional urban areas. The layer does not only contain street trees, but it includes contiguous rows or patches of trees covering 500 m^2 or more and with a minimum width of 10 m over artificial surfaces. Gaps between tree patches or within a larger patch that are less than 10 m wide are included in the STL. Rows of trees along the road network outside urban areas or forest adjacent to urban areas are not be included (EU 2016, 27). (Note: This layer describing the tree-lined urban green contains preliminary, not yet validated data.)

2.2. Natural Vegetation of Europe

The purpose of mapping the potential natural vegetation of Europe is to reproduce the current natural site potential based on vegetation types. The map displays the potential distribution of the dominant natural plant communities consistent with the current climatic and edaphic conditions in the small scale of 1: 2,500,000. The effects of direct human intervention and utilisation, as well as changes in the environmental conditions caused by air and water pollution and recent climatic changes, are not taken into consideration (BfN 2004, 59).

The fundamental units of the vegetation map are linked into a hierarchically structured classification system within the framework of the overall legend. The main groups form 19 physiognomic-structurally and ecologically characterised formations and formation complexes for the entire continent. Of these, 14 zonal vegetation formations (A to O) are primarily climatically conditioned (BfN 2004, 61). Among them, the following six zones are of particular interest for the consideration of large cities:

C: Subarctic, boreal and nemoral-montane open woodlands / subalpine and oro-Mediterranean vegetation, D: Mesophytic and hygromesophytic coniferous and mixed broadleaved-coniferous forests,

F: Mesophytic deciduous broadleaved forests and mixed coniferous-broadleaved forests, G: Thermophilous mixed deciduous broadleaved forests,

J: Mediterranean sclerophyllous forest and scrub, M: Steppes.

In addition, there are azonal vegetation types that are characterized by predominantly edaphic site factors, and are only modified secondarily by macroclimatic factors (coastal and inland halophytic vegetation, tall reed vegetation, tall sedge swamps, aquatic vegetation, mires, swamp and fen forests, vegetation of floodplains, estuaries, polders, other moist or wet sites).

2.3. City selection and geodata processing

The selection of the reference cities was based on the clearest possible assignment to a main formation of zonal vegetation. Since this study deals with the climatic influence on urban green, cities with a significant proportion of azonal vegetation were excluded from the outset. It is clear that this condition greatly restricts the choice of reference cities because man has always preferred to settle near to rivers. For the study, 14 cities in Europe were selected in order to ensure the broadest possible geographical distribution, with half of each city located north and south of the Alps. The decisions to select the reference cities were made GIS-based visually, but not via GIS intersection, because the map scales of the Urban Atlas (including STL) and the Natural Vegetation of Europe diverge widely. During the selection process, care was taken to ensure that the respective administrative area and, above all, the urban area can be assigned as clearly as possible to a specific natural vegetation zone (main formation A to O). Cities in the transition area of two main formations were not considered. The locations of the reference cities are shown in Figure 1. Before the analysis can proceed, it is necessary to define what we mean by an "urban area". Here this term is used in analogy with the term "Ortslage" from official German spatial surveys. The following definition is given in the documentation of the ATKIS Basic Landscape Model: "An 'Ortslage' is a contiguous built-up area. It encompasses 'residential areas', 'industrial and commercial areas', 'mixed-use areas' and 'areas of special functional character' as well as areas which have a close spatial and functional relationship to these dedicated to transportation, watercourses, areas occupied by 'buildings and other facilities', for recreation, sport and leisure, as well as 'vegetation areas' "(AdV 2015, 215). However, the Urban Atlas geodata contains no specific layer of "urban area" which could be used for our analysis with focus of the urban green. That's why we have proposed a method to construct the urban area with the help of Copernicus data. This methodology consists of six GIS work steps, the first five of which are automated, but the last step requires interactive editing (Schumacher and Deilmann 2019). During the geodata processing the street tree layer was clipped with the urban area. Subsequently, the area percentage of the tree population (STL) in the urban area as well as other parameters such as the mean patch size of the tree population were calculated.

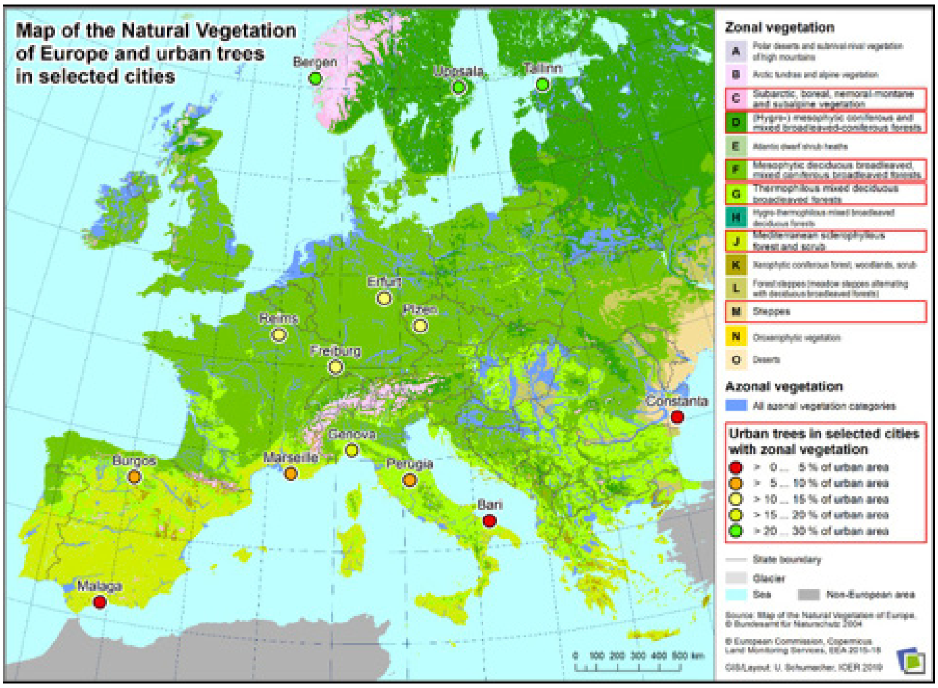


Figure 1 Main natural vegetation formations of Europe and urban trees in selected cities with zonal vegetation

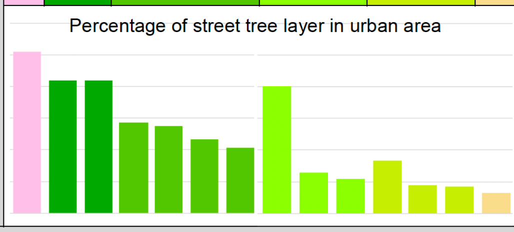
3. Results and Discussion

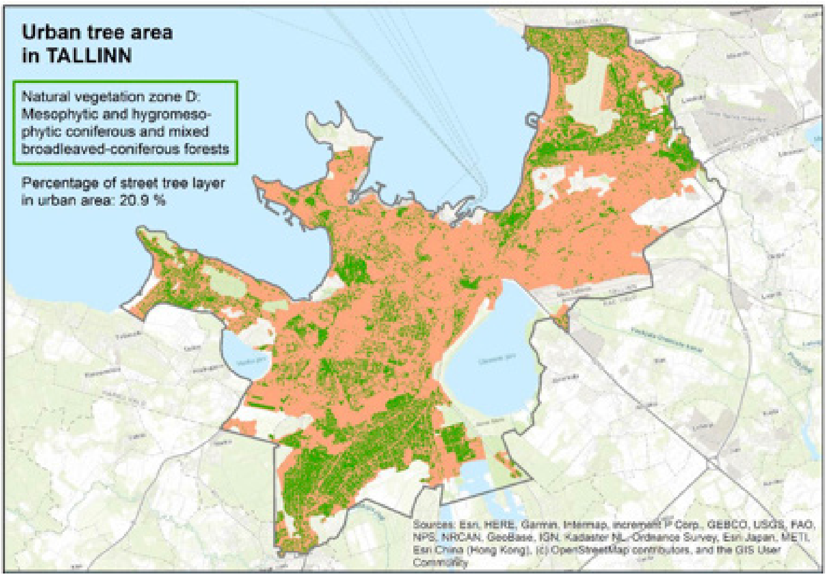
3.1. City comparison

The main results of the study for all reference cities are presented in Table 1. The total area of trees within the urban area of each city is characterised by the percentage of street tree layer in urban area and its mean patch size. There is a correlation between the two measures. A diagram shows the STL percentage in urban area, whereby the respective bar of a city is coloured according to its main formation of zonal vegetation. From this presentation a correlation between the potential natural vegetation and the tree population of cities becomes clear. Northern and Central European cities have much larger areas with trees than southern European Mediterranean cities, although there are exceptions (e. g. Genova). The map of Europe in Figure 1 shows the reference cities classified according to this criterion. Of course it is desirable to extend the empirical basis to more cases per vegetation zone in future research. For a start, this explorative study presents first indications for clear interrelations between natural vegetation formations and urban tree coverage.

Table 1 Natural vegetation formations and urban tree areas in selected European cities (Data sources: Map of the Natural Vegetation of Europe, BfN 2004; Urban Atlas 2012, © European Commission, Copernicus Land Monitoring Services, EEA 2015-2018; Data processing: U. Schumacher, IOER 2019)

City		Natural Vegetation of Europe (main formation of zonal vegetation)						Urban tree area (street tree layer)	
		C	D	F	G	J	M	Percentage in urban area [%]	Mean patch size [m²]
North of the Alps									
Bergen	NO	X						25.5	6,570
Uppsala	SE		X					20.9	5,986
Tallinn	EE		X					20.9	6,819
Erfurt	DE			X				14.3	3,758
Freiburg	DE			X				13.7	4,066
Plzen	CZ			X				11.6	2,741
Reims	FR			X				10.3	3,234
South of the Alps									
Genua	IT				X			20.0	5,628
Perugia	IT				X			6.4	2,297
Burgos	ES				X			5.4	3,481
Marseille	FR					X		8.3	3,644
Malaga	ES					X		4.4	2,600
Bari	IT					X		4.2	1,515
Constanta	RO						X	3.2	1,861





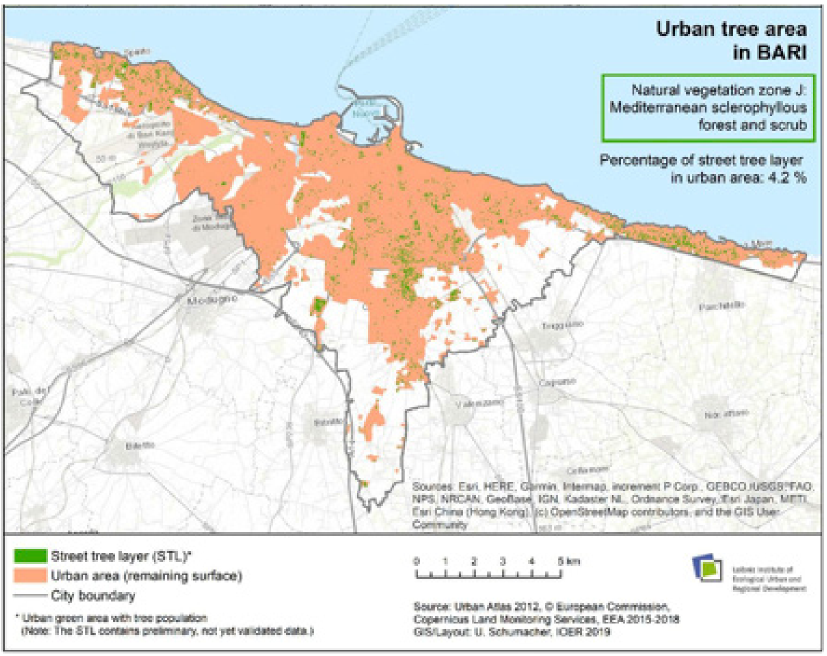


Figure 2 Urban area in Tallinn and Bari with urban green (tree population) in comparison

3.2. Discussion

Basically, the results show a dependence of the tree-covered areas in the urban area on the potential natural vegetation zone in which the respective city is located. Southern European Cities within the zone J "Mediterranean sclerophyllous forest and scrub" have relatively few urban green area and tend to have small and isolated tree patches. Cities in zone G "Thermophilous mixed deciduous broadleaved forests" have a slightly larger tree-covered area in the urban area. Central European Cities in zone F "Mesophytic deciduous broadleaved forests and mixed coniferous-broadleaved forests" have usually higher values. Northern European cities in Zone D "Mesophytic and hygromesophytic coniferous and mixed broadleaved-coniferous forests" have even higher proportions of tree-covered areas. The two (each only) large cities in the vegetation zones C and M span the value range between minimum and maximum.

The two cities of Tallinn and Bari shall serve as contrasting examples for the street tree layer within the urban area. The natural vegetation in the Tallinn region at the Baltic Sea coast consists of mesophytic and hygromesophytic coniferous and mixed broadleaved-coniferous forests (vegetation formation D). On the other hand, the natural vegetation in the Bari region at the Adriatic coast consists of Mediterranean sclerophyllous forest and scrub (vegetation formation J). Both cities are exemplarily well comparable: They are coastal cities on the plain (relief of no significance) and of roughly the same size (urban area or population). The maps in Figure 2 shows spatial concentrations of urban tree areas in both cities, independent of the tree species. On a city-wide scale there are big differences in the tree cover of the cities, especially in the peripheral residential areas.

As own test calculations have shown, cities in azonal vegetation zones (mostly large flowing and still waters with elevated groundwater levels in the surrounding area) would have considerably more and larger tree- covered areas, which would probably be due to the tendency towards better water supply.

Further points must be taken into account during the discussion:

- anthropogenic influences on land use,
- underestimation of urban tree area by minimum size of a mapping unit (500 m^2),
- geometric design of urban area (generalizing and editing).

After a validation of the STL data, somewhat modified analysis results of the urban tree population can be expected. Natural and anthropogenic peculiarities of individual cities would have to be discussed separately (e.g. Genova on the Ligurian coast).

It is questionable, whether the tree layer included in the European Urban Atlas does justice to the cause of Mediterranean cities. The size of tree patches might be a specific of Mediterranean cities. With these observations the authors also intend to stimulate discussion with the Copernicus consortium and help to qualify the Urban Atlas.

4. Conclusions and Outlook

The results of this explorative study give first indications, that there is an interrelation between natural vegetation formations and urban tree coverage in continent wide comparison. The findings deliver both arguments and an approach to acknowledge different climatic and edaphic preconditions for the monitoring of urban green in cities. It shows the possibility of understanding the differences in urban green coverage in EU cities using macrogeographical regions of vegetation formations. According to the results of this study, it seems difficult to define minimum requirements for urban green areas with trees in a European city in general.

The case study provides insights into difference of urban tree coverage in European cities, with two contrasting examples being examined in more detail. The Street tree layer is a geodatabase which is still in development. The Copernicus consortium points out, that the data are yet not fully approved. Up to our best knowledge so far hardly studies were carried out using the STL. Application tests – like this explorative study – can stimulate discussion with the consortium and help to qualify the STL and thus the Urban Atlas in the future.

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Cost-effective structural planning of the apartment for flexibility and durability

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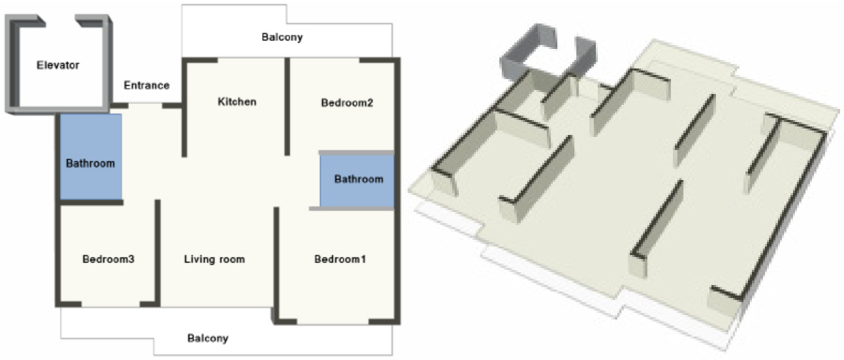
Keywords: Long-term housing, Long-life housing certification, Flexibility, Durability, Structure

Abstract
It becomes increasingly important to develop the sustainable housing to protect environment. The long term housing should be able to meet new demands by change of the population structure; low birth rate, aging and increase of single households. Therefore, spatial flexibility of apartments becomes more important and structural system should be developed to meet requirements of spatial flexibility. In addition, structure should have durability for constant maintenance. Long-span columns type structure with advanced spatial flexibility and durability is developed for long-term apartments. In addition, structures are demanded to have thicker cover thickness of reinforcing steel and stronger concrete compressive strength than general structures. These are factors of increase of construction cost. However, the cost of construction depends on the column span, which is determined by underground parking lot layout considering underground space utilization, which is effective to reduce the cost of construction. The results of this research can be used in testbed of the long term apartment with the unit 59 m2 and 15 stories.

1. Introduction
Apartment is a typical type of house in Korea and have similar unit plan with no consideration for inhabitant's lifestyle. The area of apartment units is legally set at 60, 85, 102, 103, 165 m2, etc. And, the spatial composition within the unit plan is also generalized as a mathematical formula, as shown in Fig. 1(a): a living room, a kitchen, two-bathrooms, and three-bedrooms. Moreover, reinforced concrete wall structures are widely used in apartment, which is effective in reducing construction costs, but it is hard to change the composition of space. Specially, it is not easy to retrofit or repair building service systems in concrete. For these reasons, apartments in Korea are being rebuilt before 30 years although they are used for a minimum of 50 years. The government announced to make a law “Long-life housing certification system” in 2014 as part of its efforts to use apartments longer.



(a) Unit plan

(b) Wall type structurestructure plan

Figure 1 Unit 59m2 in apartment

2. Long-life Housing Certification System
The certification system for long-life housing was made to use houses for more than one hundred years in 2014. This should be applied to the construction supplying more than 1,000 housing unit. The concept of “Long-life house” is an outstanding house with excellent durability, flexibility, and easy maintenance; it is durable for a support to stay structural for a long time, it is flexible to change Interior space of a plan according to the residents, it is easy to repair or retrofit the building service systems which lives are shorter than a support. The detailed items of each evaluation criteria are listed Table 1. In short, long-life housing is planned for easy maintenance by separating short lived building service systems from a long-lived structure to use for long

periods of physical life. In addition, it can be planned the floor plan of the house as the needs of residents by application of a column types structure, not a bearing wall structure. Accordingly, the building service systems are planned to respond to changes in floor plan. And it with a fifteen-year old should be not included into a structure and be separated common from exclusive facilities for easy maintenance.
Therefore, the housing is evaluated to three criteria: durability, flexibility, and easy maintenance in Long-life housing certification system. Housing is divided into four classes according to the evaluation score: Pass (score 50 or more points), Good (score 60 or more points), Excellent (score 80 or more points), Outstanding (score 90 or more points).

Table 1 The Evaluation Item in Long-life Housing Certification System

Evaluation Criteria	Required/Selected	Detailed Evaluation Items
Durability	Required	Cover thickness of reinforcing steel, Concrete compressive strength and quality
Flexibility	Required ①	Ratio of length of bearing walls and columns to a total of walls and columns inside
	Required ②	Ratio of dry walls to a total of walls
	Required ③	Installation methods of dry walls
	Selected ①	Position of bathroom piping in/out my house
	Selected ②	Story height (over 3,000 mm)
	Selected ③	Double floors
	Selected ④	Movable a bathroom or bathrooms
	Selected ⑤	Movable a kitchen
	Selected ⑥	Replaceable cladding
Easy Maintenance (Exclusive facilities)	Required ①	Separation of common facilities from exclusive facilities
	Required ②	Design for maintenance of pipes and wires
	Selected ①	Prohibition of pipes and wires in concrete
	Selected ②	Dry floor heating system
	Selected ③	Space plan for 2 households in one house
	Selected ④	Equipment plan for 2 households in one house
Easy Maintenance (Common facilities)	Required ①	Layout plan for common facilities in common space
	Required ②	Installation of an access shaft in common facilities
	Selected ①	Elimination interfaces between pipes in a shaft
	Selected ②	Constructible piping structures
	Selected ③	Additional 20 % shaft in common space for energy demand increase
	Selected ④	Additional installation of a shaft or shafts

3 Structural Plan for flexibility and durability
3.1 Flexibility
The structure of the long-life housing should be long-span columns type system without columns inside housing unit for flexibility. Thereby, residents can plan the unit plan of the housing according to the number of families or patterns of living, as shown in Fig. 2a to e. Figure 2a is a typical apartment floor plan with the unit 59 m2; it consists of a living room, a kitchen, two-bathrooms, and three-bedrooms. This flexible plan in accordance with the needs of residents is shown in Fig. 2b to e.

(a) Default type (b) Combination of two living rooms

(c) Enlargement a living room

(d) Rearrangement of a kitchen

(e) Division of housing for rent

Figure 2 Flexible unit plan

However, the construction cost of a structure increases as the span of the column increases. Accordingly, it is important to reduce costs by increasing the utilization of the underground space because underground space of apartment buildings in Korea is generally used as parking lots. Therefore, the span of the column in transverse direction is determined by considering two or three parking spots for economical Design: the size of a park spot is 2.5 m by 5.1 m. And an eight-meter span of the column in longitudinal direction can be considered for two parking spots and a passageway. The concept of structural plan considering the underground parking lot is shown in Fig. 3.

Figure 4 is the structural plan with this concept and the testbed of the long term apartment with the unit 59 m2 and 15 stories; this testbed in Sejong city will be completed in June 2019

Figure 5 is the structural unit plan of apartments by long-span columns type structure. Both unit 59 m2 and 84 m2 are planned as a long-span columns type system without columns inside housing unit and the spans of column are 8 m, 8.3m, and 8.39m. In other words, the underground space can be used efficiently by aligning the columns of ground and underground.

In addition, partition walls between housing units and exterior walls of a housing unit, which are unlikely to move in the future, can be planned then as bearing walls to reduce the construction cost. Except for these walls, the rest inner partition walls are planned as dry walls for flexible plan.

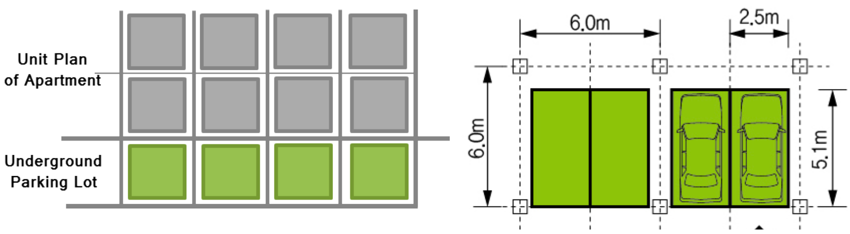
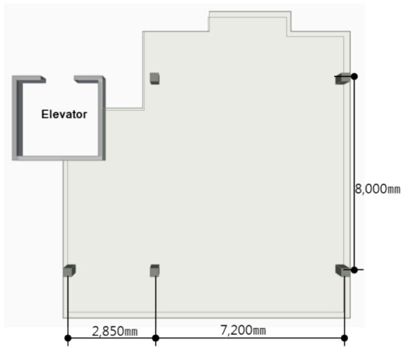


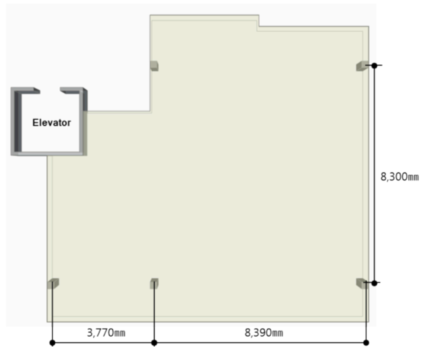
Figure 3 Structural plan considering efficient use of the underground space

(a) Floor plan

(b) Underground parking plan



(a) Unit plan 59 m2



(b) Unit plan 84 m2

Figure 5 Floor plans of long-span columns type structure

3.2 Durability

The Long-life housing certification system in comparison with the international building code and guideline on the durability of concrete structures values similar items for durability: cover thickness of reinforcing steel, concrete compressive strength, slump value, water-cement ratio, air content, weight of aggregate, and weight of chloride ion per unit volume of concrete. Except for water-cement ratio, air content, and weight of aggregate per unit volume of concrete, the remaining items affect the cost of construction. Especially, cover thickness of reinforcing steel has the greatest effect on the increase in construction costs while concrete compressive strength and slump value somewhat reduces the cost of construction. Except for cost of partition dry walls, an increase of 10mm in cover thickness of reinforcing steel of structural members increases construction cost per m^2 by 0.7%. This value is based on an analysis of computer analysis results and actual construction cost of the the long-life validation complex.

4 Conclusions

To plan long-life housings for flexibility and durability, the structural plan as important as anything else. The structure of the long-life housing should be long-span columns type system for flexibility and have thicker cover thickness of reinforcing steel of structural members. It results in increase of construction cost.

Therefore, the structure should be planned considering the utilization of the underground space to reduce costs. The span of the column is determined by considering two or three parking spots for economical Design. The cost of long-lived housing cannot help increasing compared to general one. Therefore, further studies are needed to investigate the cost reduction of long-term housing for flexibility and durability.

5 Acknowledgements

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ASSESSMENT METHODS AND TOOLS – BUILDING SCALES

BuildDOP: one single tool to evaluate energy, environmental impact and costs

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Keywords: BuildDOP, Life Cycle Assessment, Sustainable building, ProCasaClima software

Abstract
The paper discusses the assessment of a tool which analyses the impact of buildings from several points of view. The tool has been developed within the ERDF European project BuildDOP and represents a new generation of the ProCasaClima energy certification software, updating the functionalities of the current version. The innovative aspects concern the energy performance evaluation of buildings through a dynamic simulator, the implementation of a well-equipped material database where environmental impact and resource consumption indicators referred to the different life cycle stages are used to assess the sustainability. Moreover, for a simple financial computation an integrated system examines investments and periodic replacement costs so that in conclusion a complete tool for design and certification phase which can compare different design solutions evaluated under several aspects is obtained.

1. introduction

During the last years the European and Italian real estate is alternating between periods of new-residential growth and predominant renovation of existing buildings (EUROCONSTRUCT Conference, 2018). What these two trends have in common is the research of sustainable solutions in terms of:

- energy efficiency
- environmental impact
- costs

To achieve this goal, a central processing of energy certification with an integrated uniform calculation is required, in addition to uniform legislation in order to produce a set of statistically comparable data. The final objective of such an analysis should be the definition of upgraded benchmarks or targets for new generation buildings in the field of energy, but above all in the environmental one.

Considering this scenario, CasaClima Agency has developed three standards starting from 2002 with the aim to adopt the European "Energy Performance of Building Directive" (EPBD 91/2002/EC and 31/2010/EU) in South Tyrol (Autonomous Province of Bolzano-Bozen). The result is that buildings designed in accordance to these standards can save up to 90% of energy compared to the traditional ones thereby resulting in both CO2 and financial savings. The design and executive quality are assessed by the evaluation of the project, on-side audit as well as by calculus elaborated by the tool ProCasaClima (Santa et al. 2019).

Concurrently, several tools have been developed on national scale and are currently on the market focusing on different aspects related to buildings:

- Software designated to the energy performance calculation and consequent energy certification on local and national scale
- Dynamic simulation tools for an accurate computation of thermal loads
- Life Cycle Assessment tools to evaluate environmental impact and more generally sustainability of buildings
- Cost-benefit analysis methodologies

The aspects that the above-mentioned software typologies assay should be considered and evaluated simultaneously to obtain buildings with a low energy demand (rather from renewable sources), reduced-impact on environment and an optimal cost proportional to the service.

Such an approach has been partly experimented examining energy, environmental impact and cost perspectives on a single building material and specifically insulators (Anastaselos et al. 2009). The next step that BuildDOP project is intended to achieve is the development of a specific and user-friendly tool able to assess the interdependency of these three aspects for a whole building based on an existing software. The advantage of having an integrated system greatly facilitates the user who will no longer have to enter repetitive input data in different tools but instead only in one.

2. BuildDOP: the concept

The main idea underneath the ERDF European project BuildDOP is the creation of a means that produces results aimed at increasing technological efficiency on residential and non-residential buildings establishing new and more actual targets. This goal is achieved through the implementation of some additional functionalities on the existing software ProCasaClima obtaining in this way an evaluation one-stop shop tool able to ensure optimal performance of the building from design to operation phase (Agenzia per l'Energia Alto Adige – CasaClima 2018). The new application will perform a simplified calculation in "certification" mode, and detailed calculation in "design" mode. Basically, the new features involve a dynamic energy simulator, a larger database of materials for which physical and thermal properties as well as an increased number of environmental impact and resource consumption indicators are specified, and a more in-deep investment analyser, all this while keeping the system free of charge.

2.1. Starting point: ProCasaClima energy certification software

The implementation of additional procedures starts on the already existing ProCasaClima energy certification software which is a Microsoft Excel® and VBA-based tool employed on Italian scale but more widely in South Tyrol and having the primary aim to assess an energy classification of buildings based on the energy performance. In addition to the primary energy demand, it evaluates the CO2 emissions, the percentage of renewable energy used and the calculation of the environmental assessment for a sustainability certification (Nature). The software is not the only one instrument to support the planning phase and certification process, but instead technical directives and guidelines are provided by CasaClima Agency as well as a collection of construction nodes verified through a FEM (finite element method) analysis as illustrated in Figure 1 (Santa et al. 2019). Through this set of practices CasaClima Agency acts as supporter of the client in the design, requalification, verification and monitoring phases.

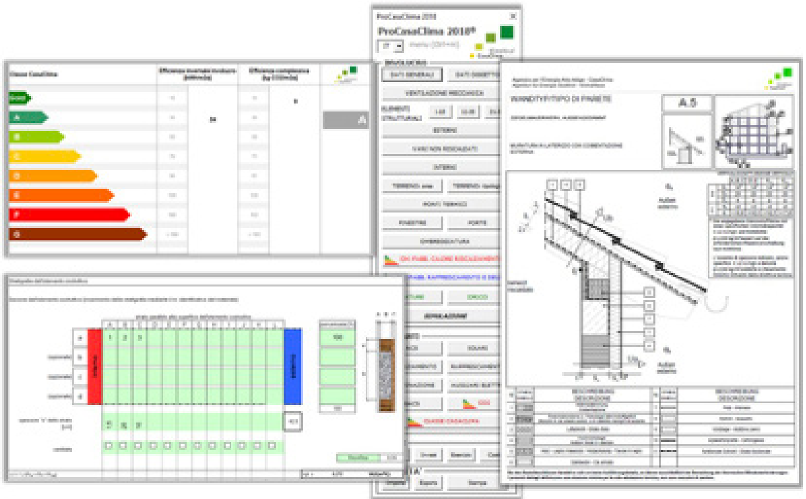

Figure 1 ProCasaClima Software features and CasaClima catalogue of preverified construction nodes

The basic structure of the current program is sketched by the flowchart in Figure 2. After the monthly average climatic data are set for the chosen municipality (UNI 10349) the user can define the envelope opaque and transparent components using a database of materials for each of those thermophysical properties are reported as well as four environmental indicators referred for instance to the global warming and acidification potential.

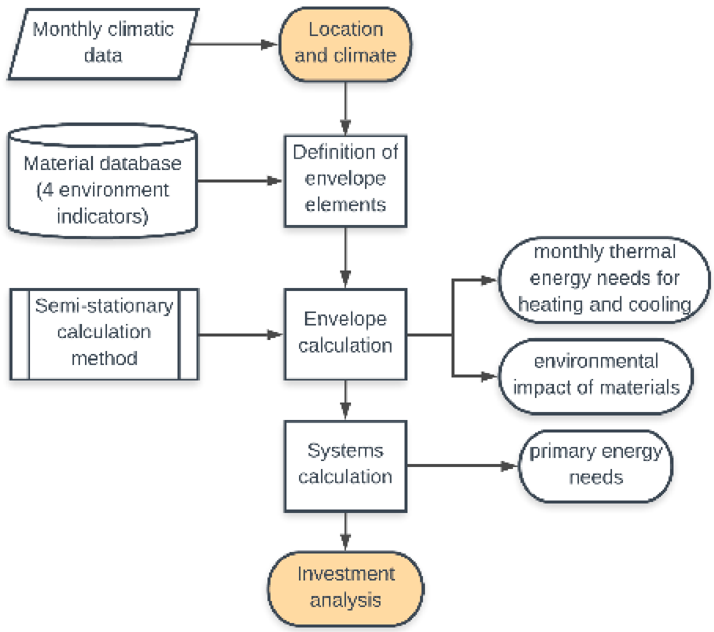

Figure 2 Flowchart representing the structure of the current version of ProCasaClima software

The calculation concerning the envelope gives as results the thermal energy needs for heating and cooling using the semi-stationary calculation method (UNI/TS 11300-1) and the environmental impact of employed materials. Regarding this second aspect, this software rates it by means of an eco-index calculated using the previously described indicators referred in this case to the total amount of materials employed for the envelope (and their eventual replacement).

$$I_{eco} = \frac{1}{3} \cdot \left(\frac{1}{20} \cdot \left(\frac{PEI}{NFA} - 1000 \right) + \left(\frac{GWP}{NFA} + 50 \right) + 200 \cdot \left(\frac{AP}{NFA} - 0.3 \right) \right)$$

where NFA stands for the net floor area.

The actual ProCasaClima software is also equipped with a session regarding the various systems to obtain the final primary energy requirements of the building and the CO2 emissions produced. For a simple financial computation, this software owns an integrated system where the user can enter the initial investment as well as maintenance costs that are forecasted for each year including also periodic replacement costs. The economic evaluation procedure for the energy systems of a building is directly derived from the European standard EN 15459 and it is based on the identification of the payback period considering proper service lives for each material and system element. This assessment method states the simplest approach for both the technician and the costumer who finances the investment.

The final outputs that the tool produces are basically of three types: energetic values, environmental impact indicators and a cost planning. The most relevant are summarized in Table 2.

Table 2 ProCasaClima final outputs

Table 2 ProCasaClima final outputs

Output type	Index	Unit of measurement
Thermal energy needs for heating	HWB_{NGF}	kWh/(m^2 year)
Sensible cooling needs	$Q_{C,SENS}$	kWh/(m^2 year)
Environmental impact of materials	$PI3_{CC}$	points
Primary energy needs	EP_x	kWh/year
CO_2 emissions	-	kg CO_2/(m^2 yea)r
CasaClima class	-	Gold-G
Global costs	-	€

As can be seen from the previous description of the current version of the software ProCasaClima, it already represents a quite integrated tool which analyses different aspects concerning buildings. Despite this, it still presents intrinsic limitations contributing to the production of insufficient output parameters for a comprehensive evaluation of the building from a qualitative and quantitative point of view.
First of all, the current program is strongly aimed at the certification, it would be instead useful to develop a tool that offers the user the possibility to simulate different configurations and compare them to find the most suitable solution. It is in fact of great advantage integrating design with performance simulation feedbacks in the early design stage so that it is possible to make changes in a faster way (Negendahl 2015).
Due to the general external temperature increase in the last years even in the alpine region, the possible overheating of internal environment has become a more and more relevant aspect that affects significantly the estimation of energy needs of the whole year. It is therefore necessary a precise evaluation of cooling requirements through a calculation method involving shorter timesteps and taking into account the effect of the previous step to the next one. Such an approach is well represented by the dynamic calculation method which will be illustrated in the next subchapters.
In addition, concerning the environmental impact of materials, this evaluation is currently performed examining not the whole life cycle of the primary sources but instead only the first part. This is of course an aspect that can be deeply investigated and can be subject of further improvements.

2. New assessment of ProCasaClima software through BuildDOP project
In light of the previous considerations, the BuildDOP project has been developed with the aim to further improve the ProCasaClima software focusing on its weaknesses and on the interdependency of a broad spectrum of building-related aspects.
The evolution of the program must always comprise a certain ease of use. The final users of such product are mainly designers (architects, surveyors, engineers) or thermo-technicians, for this reason, the new assessment of ProCasaClima should be as intuitive and practical as possible in order to facilitate the job of experts. Another significant point is to interpret the necessities of the territory which in this specific case is first of all South Tyrol. The population of this territory has a long tradition linked to its own environmental heritage for whose safeguard it has developed care and dedication. Particular attention is therefore paid to the environmental issues related to the impact of materials during their lifecycle and building procedures.
A schematic representation of the new ProCasaClima assessment structure is provided by the flowchart in Figure 3 where the green shapes stand for the additional or modified parts (compared with Figure 2) through the processes carried out within the BuildDOP project. It is therefore possible to appreciate the introduction of hourly climate data as input as well as hourly thermal energy needs as output.

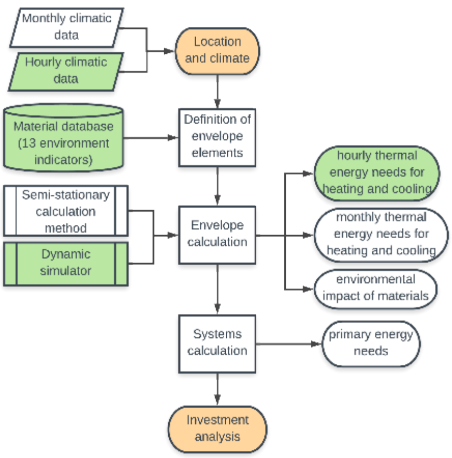

Figure 3 Flowchart representing the structure of the renovated assessment of ProCasaClima software

2.1. Energy performance: the dynamic simulator
Even if the semi-stationary calculation method for the evaluation of the energy performance of buildings will be maintained in the software to assess the energy classification, another tool will be available for the user which ensures more accurate results and can therefore support the design phase. The dynamic simulator is a new module completely integrated in the ProCasaClima software that requires only a few simple tricks from the user. This peculiarity makes the dynamic component a user-friendly and very helpful tool that can be lightly managed by the users.
Regarding the execution of the module, it has been based on a series of Excel® sheets freely downloadable from the official

website of the EBP (Energy Performance Building) Center. They represent the digital transcription of the international standard ISO 52016-1 which clarifies both the monthly and hourly calculation procedures designated to the energy needs for heating and cooling, internal temperatures, sensible and latent heat loads. The next step for the implementation concerns the integration of these sheets with the actual ProCasaClima program so that the user does not need to fill the input part twice. In case the user decides to carry out a detailed calculation through a dynamic simulation, a few additional input data must be specified concerning especially the ground and some setpoint temperatures whereas the remaining data are automatically obtained from other sheets of the program. A particularly relevant aspect is represented by the climate data files which have been created for all the Italian provinces starting from the reference years elaborated by the CTI (Comitato Termitecnico Italiano). Since not all the climate data required for the dynamic calculation are reported in the CTI files, it has been necessary to re-elaborate them using a widely used software environment that simulates the behavior of transient systems TRNSYS (Transient System Simulation Software). In such a way it is possible to obtain the solar vertical irradiance on building components in eight different orientations leading to an accurate estimation of the solar gains for each timestep.
After the implementation phase, the engine for the dynamic calculation will be validated by means of BESTEST verification cases (according to ANSI/ASHRAE Standard 140-2017) as reported in the international standard ISO 52016-1.
The final results of the simulation are visible to the user through tables and graphs. Having this tool been developed on the basis of an international technical standard, it represents the guarantee of a uniquely recognized calculation methodology.

Table 3 Dynamic simulator outputs

Table 3 Dynamic simulator outputs

Output type	Index	Unit of measurement
Sensible energy needs for heating and cooling	$Q_{H/C,nd}$	kWh/an
Latent energy needs for humidification and dehumidification	$Q_{HUM/DHM,nd}$	kWh/an
Thermal load for heating and cooling	$P_{H/C}$	kW
Recorded indoor and outdoor temperatures (min, max, number of hours above or below a certain threshold)	-	°C or number
Recorded indoor and outdoor relative humidity (min, max, number of hours above or below a certain threshold)	-	% or number
Additional monthly parameters	-	-

2.2. Environmental impact: Life Cycle Assessment

The building environmental impact evaluation plays a fundamental role in the renovated assessment of the software. This step is mainly carried out by implementing a simplified calculation based on the "Life Cycle Assessment". The purpose of the BuildDOP project with respect to this theme concerns in fact a further development of the computation procedure compared to the one of the previous version of ProCasaClima which specifically involve:

• An update of the database of standard products used in the ProCasaClima calculation with datasets derived from the ÖKOBAUDAT-database and complying with EN 15804. The environmental impact indicators available for each product entered in the database become more in number (it goes from 4 to 13) and are represented by GWP (Global Warming Potential), ODP (Ozone Depletion Potential), POCP (Photochemical Ozone Creation Potential), AP (Acidification Potential), EP (Eutrophication Potential), ADP elem. (Abiotic depletion potential for non-fossil resources), ADP fossil (Abiotic depletion potential for fossil resources), PENRT (Total use of non-renewable primary energy resources), PENRM (Use of non-renewable primary energy resources used as raw materials), PENRE (Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials), PERT (Total use of renewable primary energy resources), PERM (Use of renewable primary energy resources used as raw materials), PERE (Use of renewable primary energy excluding renewable primary energy resources used as raw materials). (EN 15804)
Furthermore, the estimated service life is also needed for calculating environmental and financial impacts related to replacement.

• A revision of the calculation algorithm used to assess the environmental impact of the building. The assessment is extended to several phases of the life cycle of the building: in addition to the potential environmental impact for the construction of the building (phases A1-A3) and the potential environmental impact for the replacement of components within the expected life of the building already considered in the current software, the tool will also calculate the potential impact related to the end of life of the building (phases C1-C4 and D) and the potential impact for the operational use of the building related to the annual final energy needs of the building.

• The definition of benchmarks to be used as minimum requirements in the CasaClima`s sustainability certification schemes for residential buildings (CasaClima Nature) and non-residential buildings (CasaClima School, ClimaHotel etc.).

3. Application

At the end of the whole implementation process, the new version of ProCasaClima software will result in an integrated tool constituted by several Excel® sheets, each one designated to differentiated purposes. All these parts contribute to provide a unified evaluation scheme for building design and classification. Since BuildDOP project is still ongoing it is not yet possible to state final results based on the application of real and complex case studies. Nevertheless, the objective is to create a tool able to support (and in some extend simplify) the work of technicians who represent the target audience of the software. The employment of this integrated tool is suggested not only for residential buildings but in addition for commercial, educational and healthcare, industrial and craft ones getting the calculus along all these cases. As already discussed in detail above, on the one hand the new ProCasaClima will perform a simplified energy performance calculus based on the semi- stationary calculation method during certification mode. On the other hand, it is additionally equipped with more detailed computation procedures that the user can exploit in the design phase to verify some design choices that will not interfere with the final class allocation of the building. The classification is based on energy consumption and environmental impact of the building, whereas further final results can be obtained from the program concerning for instance the cost assessment. In order to provide the user with outputs that can be easily de-coded and offer an overview on the overall performance of the building, several graphs are included in the analysis. They are related not only to the energy needs but in addition to the typology of energy sources involved in the case study, the level of CO2 emissions and several others. Some of them are reported in Figure 4 as clarifying example.

Figure 4 Pie chart illustrating the shares of energy produced by different sources and differentiating that produced on site or off

4. Conclusions

The updated ProCasaClima assessment has been and it is currently developed within the ERDF European project BuildDOP with the major objective to produce an evaluation tool which ensures optimal performance of the building from design to operation stages. Both the software design and implementation phases are aimed at the final user who represents the stakeholder of the product and to whom the tool is offered free of charge. This latter feature, together with the user-friendly configuration makes the ProCasaClima software a highly competitive product on the market. Furthermore, it offers an innovative integrated structure which is able to evaluate different building-related aspects at the same time and produces outputs according to calculation procedures stated by technical standards and directives. The holistic concept underneath the CasaClima Agency task is sustainability, which in BuildDOP project is achieved in the energy performance, environmental impact and costs assessment.

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Analysis of the discrepancy between estimated energy demand and real energy consumption of buildings

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Abstract
In Germany, heating and cooling of buildings account for nearly one third of the total energy consumption. It is a declared objective of all European member states to achieve a notable reduction in this sector. The thermal protection of buildings has been regulated for more than 50 years by German laws. The currently valid energy savings regulation EnEV ensures a minimum standard of energy efficiency for new and existing buildings. The supposed energetic performance of a building is calculated within this regulation as the estimated energy demand of the building. This calculated energy demand has been shown to differ significantly from the real energy consumption for a large number of buildings. Therefore, expected operational costs for new or refurbished buildings cannot be estimated with sufficient precision, leading to imprecise predictions of the economic viability of measures of energetic optimisation and potentially to lower user acceptance for these measures.
In this paper we address the question of whether this discrepancy between demand and consumption is systematic. Different existing buildings are investigated with regard to their energy demand, which is then compared it to their real energy consumption. The calculation method is examined for the influence of the various input parameters, in order to identify the most important influencing variables. Furthermore, the energy demand of the buildings is calculated using the building simulation program TRNSYS, which allows for a detailed examination of user influence. The overall aim is to adjust the calculation method so that demand and consumption do not differ systematically.

1. introduction

The energy savings regulation EnEV [Deutscher Bundestag 2014] is an important tool of the German energy and climate policies. On the one hand, it defines standard technical specifications for an efficient energy demand of buildings. On the other hand, it allows for a comparison of the energy standard of different buildings, assuming certain boundary conditions. Various studies have shown that there exist discrepancies between energy demands, calculated according to EnEV, and actual energy consumptions of buildings. This leads to lower acceptance of the EnEV with building owners or tenants. Furthermore, precise statements about the economic viability of measures of energetic optimisation are difficult to make.
Here we present first results of an ongoing research project in which differences between calculated energy demand and measured energy consumption for a selection of buildings are analysed. Influencing factors on the calculation can be both user-dependent influences, such as differences in room temperature and ventilation with regard to the standard user, and user-independent influences, such as wrong assumptions of the heat transfer coefficients of the external walls.
In a first step, for each building the calculated energy demand is compared to the energy consumption. To determine the user influence, each building is simulated in the thermal building simulation TRNSYS [TRNSYS 2019], applying three different user types. To investigate the user-independent parameters those are varied in the calculation of the energy demand. The results are presented, demonstrating the summation, superposition or cancellation of different parameters.

2. Influencing factors on energy demand calculation

Numerous input parameters can have a significant influence on the result of the calculation of the energy demand of a building. After an extensive literature research a list of parameters has been compiled, see table 1. These parameters can be divided in user-dependent parameters and user-independent parameters.

Table 1 Influencing parameters on energy demand calculation

User-dependent parameters	User-independent parameters
Room air temperature	Deviations caused by the person performing the calculation
Presence / residential density	Chosen standard
Ventilation rate	Energy reference area
Hot water consumption	Coefficient of heat transmission
	Thermal bridges
	Building services equipment
	Solar yields

2.1. User-dependent parameters

Studies have shown that users choose lower room air temperatures in non-energetically optimised buildings in comparison to users in energetically optimised buildings [Hoffmann 2017, Hofmann 2017, Hofmann 2017, Loga 2003, Sunnika-Blank 2012]. One reason can be a limited budget for utilities, another reason an increased requirement for comfort (e.g. higher room temperatures) that goes hand in hand with the energetic standard of a building. Additionally, higher ventilation rates via opened windows can be found in air-tight buildings [Loga 2003]. Furthermore, the hot water consumption as well as the internal heat loads depend strongly on the user preferences and habits, alongside with the residential density. The flat-rate value for hot water consumption used in the EnEV calculation can differ fundamentally from the actual values [Knissel 2006, Stolte 2013].

The influence of the user on energy consumption is highly individual and cannot be quantified categorically as a systematic discrepancy.

To investigate the impact of different user behaviour three different user types were introduced: the standard user, the economical user and the extravagant user. Table 2 gives an overview over the differences in parameters for these users.

Table 2 User profiles

User profile	Nominal room temperature [°C]	Ventilation rate [1/h]	Internal heat loads [Wh/m²d]
Economical	18	0,45	50
Standard	20	0,50	45
Extravagant	22	0,55	40

These user profiles were used in a thermal building simulation model of each of the considered buildings using the software TRNSYS. Multi-zone models of the respective buildings were produced to take the thermal mass within the buildings into consideration.

2.2. User-independent parameters

The calculated energy demand can vary depending on the person performing the calculation [Erhorn 2007]. There exists room for interpretation in various parts of the calculation process. To avoid these deviations all calculations should be performed by the same person.

The energy demand calculation can be performed using different German standards: either using DIN V 18599 [DIN V 18599 2011] or DIN 4108 [DIN 4108 2011] in conjunction with DIN V 4701 [DIN V 4701 2003]. These standards use different user parameters (e.g. room temperature of 19°C in DIN 4108 and 20°C in DIN V 18599) as well as different incorporations of building geometry and services. Not referring to the same energy reference area when comparing calculated and measured energy data is another cause for deviations.

Building envelope: For older buildings the exact build-up of the external construction is often not known in detail. The standard values to be used for the coefficient of heat transmission (according to EnEV) can often be too high [Hoffmann 2017, Knissel 2006, Merzkirch 2014, Stolte, 2013]. Furthermore, the standard values for losses through thermal bridges are often overestimated [Großklos 2016].

Building services: If the heat generator is not known in detail it is often assumed to be less energy efficient than it is in reality [Knissel 2006]. After façade refurbishment the building services are often oversized, which can lead to a change in generator efficiency [Diefenbach 2002]. The heating control can be mistuned and the beginning and end of the heating period can be wrongly estimated [Bischof 2009, Großklos 2016]. Finally, the losses through storage and distribution can be under- or overestimated.

Solar gains can be smaller than the assumed values, as in practice external shutters are often used. If the energy transmittance of windows is unknown the assumed values can be wrong and lead to deviations [Hoffmann 2016, Hoffmann 2017].

3. Results

In this chapter results from 3 buildings are presented, one single-family house (EFH Ferchland) and two apartment buildings (MFH Halstenbeker / MFH Kroogblöcke).

3.1. Primary energy demand vs. primary energy consumption

The primary energy demands were calculated using the software ZUB Helena Ultra [ZUB Helena Ultra 2019], following the standard DIN V 18599. These calculations result in the reference values for variations performed hereafter. The primary energy consumptions were each averaged from three years' worth of heating bills, correcting for the local climate, using the same software. The comparison of the calculated demands (i.e. the reference values) to the measured (averaged and climate-corrected) consumptions is shown in table 3.

Table 3 Primary energy demand and consumption of selected buildings

Building	Primary energy demand [kWh/m²a]	Primary energy consumption [kWh/m²a]	Deviation from consumption [%]
EFH Ferchland	453,4	194,5	233,1
MFH Halstenbeker	238,1	171,9	138,5
MFH Kroogblöcke	86,9	113,2	-23,2

The deviations of the primary energy demand from the consumption range from -23% to 233%. Figure 1 shows a graphical representation of these results. In the following the potential reasons for these deviations are examined.

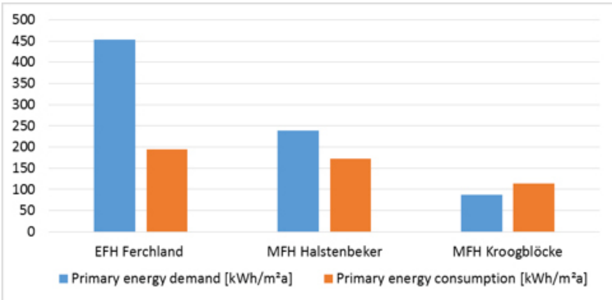

Figure 1 Primary energy demand and consumption of selected buildings

3.2. Impact of influence parameters

3.2.1. User influence

Using the thermal building simulation software TRNSYS, the 3 buildings were examined regarding the influence of three different users (see table 1). The resulting useful energy demands for heating are summarised in table 4.

Table 4 Useful energy demand for heating in kWh/a

Building	Economical user	Standard user	Extravagant user
EFH Ferchland	41.405,1	48.962,7	57.016,4
MFH Halstenbeker	168.347,8	215.172,6	269.575,2
MFH Kroogblöcke	32.262,4	40.586,3	50.398,9

As can be seen, the energetic condition of a building has a strong influence on the useful energy demand for heating. This is even more apparent when considering the useful energy demand for heating related to the energy reference area, as shown in table 5. The single-family house "EFH Ferchland" was built in 1890 and the only modernisation undertaken was the replacement of some of the windows, while in some parts of the building single-paned windows are still found. The apartment building "MFH Halstenbeker" was built in 1973 (no modernisation) and the other apartment building "MFH Kroogblöcke" was built in 2014.

Table 5 Useful energy demand for heating related to the energy reference area, in kWh/m²a

Building	Economical user	Standard user	Extravagant user
EFH Ferchland	240,0	283,8	330,5
MFH Halstenbeker	117,0	149,5	187,3
MFH Kroogblöcke	22,1	27,8	34,5

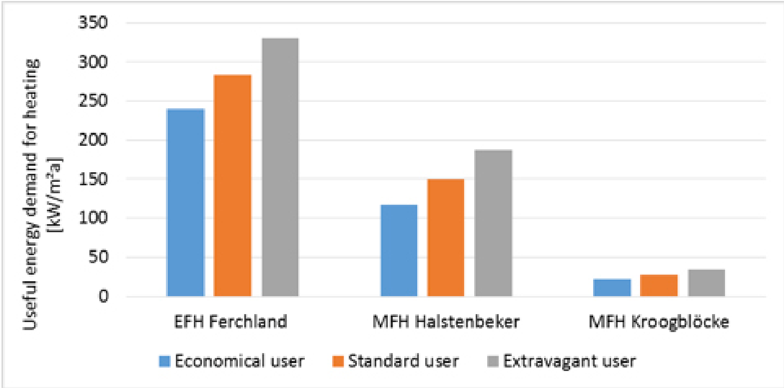

Figure 2 Useful heat demand related to the energy reference area, for different user types (TRNSYS simulation)

In figure 2 a graphical representation of these results is shown. The maximum deviations between the economical and extravagant user are about 37% for "EFH Ferchland", 60% for "MFH Halstenbeker" and 56% for "MFH Kroogblöcke". It can be seen that the user influence cannot be set at the same level for all buildings. Furthermore, these deviations cannot account for the total deviation between energy demand and consumption of up to 233% (as seen in table 3). Therefore, other influencing factors have to be taken into account.

3.2.2. User-independent influence parameters

The following user-independent influence parameters, which are deemed to be the ones with the strongest influence, were investigated:

Building envelope:

- coefficient of heat transmission: given or standard value vs. a coefficient improved (i.e. less heat transmission) or degraded (i.e. more heat transmission) by 20%
- thermal bridges: standard losses (DIN V 18599) vs. values improved (i.e. less losses) or degraded (i.e. more losses) by 10%

Building services:

- heat generator losses as specified or about 10% lower / higher
- storage losses as specified or about 10% lower / higher
- distribution losses as specified or about 10% lower / higher

As a first step the reference calculation of each building (see table 3) was altered by improving or degrading the building envelope. In a second step the building services components were improved or degraded. To identify whether the changes in building envelope and building services influence each other, both were then applied at the same time. In addition to the aforementioned variations the user influence itself (economical vs. extravagant user) and in combination with the alterations in building envelope and building services was taken into account. Figures 3 and 4 display the results from these parameter variations for two buildings. The actual energy consumption is marked with an orange line. The reference energy demand calculation value is marked in black, and the improvement is marked in green while the degradation is marked in red. All energy values are primary energy related to the same energy reference area.

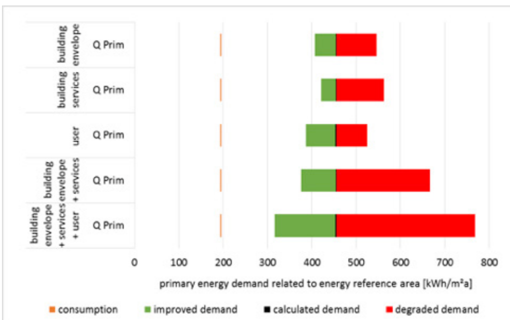

Figure 3 Primary energy demand and consumption, related to the energy reference area, EFH Ferchland

In Figure 3 the results for the single-family house "EFH Ferchland" are shown. It can be seen that the calculated energy demand never matches the actual measured consumption, even when applying improving assumptions on building envelope and building services and assuming the economical user (bottom row). On the one hand this seems to indicate that the assumed improvements on building envelope and services are not sufficient. On the other hand the users in this building seem to act even more economical than assumed, e.g. by only heating single rooms. A case like this should be investigated by performing user surveys.

Figure 4 depicts the same results for the apartment building "MFH Halstenbeker". Here the actual consumption can be matched when assuming an improved building envelope and improved building services alongside with an economical user. However, one would assume that an average of all users in a building with 18 apartments would rather result in the behaviour of the standard user. In this case the assumptions of improvement for the building envelope and building services do not appear to be sufficient.

For both buildings it can be seen that improvement or degradation of building envelope and building services are not simply adding up. These two components interfere with each other and therefore effects can cancel out to a certain degree, e.g. if components of building services are located within the thermal envelope (and thus the area which is considered for the heating demand). In this case some of the losses of the heat generator / storage / distribution are internal heat loads and thus reduce the heat energy demand.

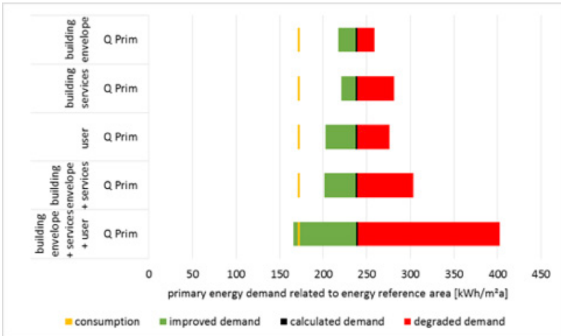

Figure 4 Primary energy demand and consumption, related to the energy reference area, MFH Halstenbeker

4. Summary & Outlook

In this paper we investigated the deviation of the calculated energy demand according to EnEV from the actual energy consumption of 3 buildings. To determine the causes for these deviations, which were found to be up to 233%, the influence of various user-dependent and user-independent parameters was examined. The user influence was investigated by introducing different user types in a thermal building simulation of the buildings. The user-independent influence parameters were examined by changing the assumptions (for better or for worse) on various components of the building envelope and the building services in the energy demand calculation.

It was found that for a single-family house built in 1890 even the most positive assumptions of the building performance and of the frugality of the user could not match the much lower energy consumption in this building, resulting in the realisation, that in these cases a user survey might be most helpful. For the apartment building the match between actual consumption and an improved building was made, assuming an economical user on average. However, an average economical user for a building with 18 apartments seems unlikely, therefore this result indicates that the assumptions on improvement of the building envelope and building services are not sufficient. It can be assumed that the combination of user influence, building envelope and building services depending on the age or the level of refurbishment could lead to systematic discrepancies. More data is needed to confirm this assumption.

While these first results are very promising, more buildings need to be investigated in order to find the most important influence parameters. The overall aim is to adjust the calculation parameters or method in such way as to diminish the discrepancies between calculated energy demand and measured energy consumption and thus to achieve more reliable predictions of the performance of buildings after energetic optimisation.

5. Acknowledgements

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Remarks on Application of Building Physics in changing climatic conditions

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Keywords: climate change, building physics, overheating, roof window, shading

Abstract
Building physics knowledge should be used in overall assessments of building performance focusing on minimized energy use from non-renewable sources by keeping the requirements on indoor comfort. At the same time the building physics should be understood as a substantial element in development of building components. The first part of the paper deals with the analysis of climatic data for Prague in the future. The second part illustrates the possibilities of using the knowledge of building physics and modern technologies to ensure comfort in under-roof spaces illuminated by roof windows and a new way of shading of office buildings. These concepts include the use of photovoltaic cells and advanced control. It confirms the possibility and necessity of cooperation of experts of different orientation in the design of new elements.

1. Introduction

In recent decades, the attention of Central European experts has focused on reducing the energy demand for space heating [1]. Both, the building design strategy and the assessments led in this direction and very good results were reached, like passive house standard [2]. In the Czech environment for example, it was not expected that buildings, especially residential, would have to be actively cooled. With regard to climate change, it appears that this approach is unlikely to be sufficient if the criteria for indoor comfort are to be maintained. In view of this, new solutions have to be found, especially in the area of building measures, advanced shading and controlled ventilation.

We should have in mind that the design of a particular building should correspond not only to current but also future boundary conditions, at least for the first period of the building's life cycle. This concerns both, designing technical systems and predicting energy performance and controlling the provision of required values in terms of comfort.

With reference to the gradual warming, the argument that there is no need to improve the thermal insulation quality of the building envelope might appear. This is not correct, as detailed studies have shown for Czech climatic conditions [3]. It is true that the proper design of building will be more complex issue than in the past. Appropriate building physics knowledge should be applied actively.

2. Problems of future climatic data

Climate in the future can be predicted by computer climate models. Since it is uncertain how fast climate change is, calculations are often carried out by different calculation models and for various global scenarios [4]. Changes in climatic variables are then compared with recent past (usually time period 1960 - 1990). The computer prediction of future climate data is the subject of very high uncertainty.

The measured and calculated monthly mean and monthly maximum and minimum ambient air temperatures in Prague for January and July, as well as winter design ambient temperature according to [5], are depicted in Figure 1. Data in time period 1971 - 2018 were recorded at Prague Libuš weather station. Data in time periods 2020 - 2050, resp. 2070 - 2100 were calculated in the framework of EU project Climate for Culture [6] by calculation model REMO [7], with assumption of A1B scenario defined by IPCC. It is worth noting that the calculated climatic data do not include the heat island effect created by a large urbanized area. It is interesting, the evaluated mean values for July from the period 1990-2018 are already slightly above the predicted mean value for 2020-2050.

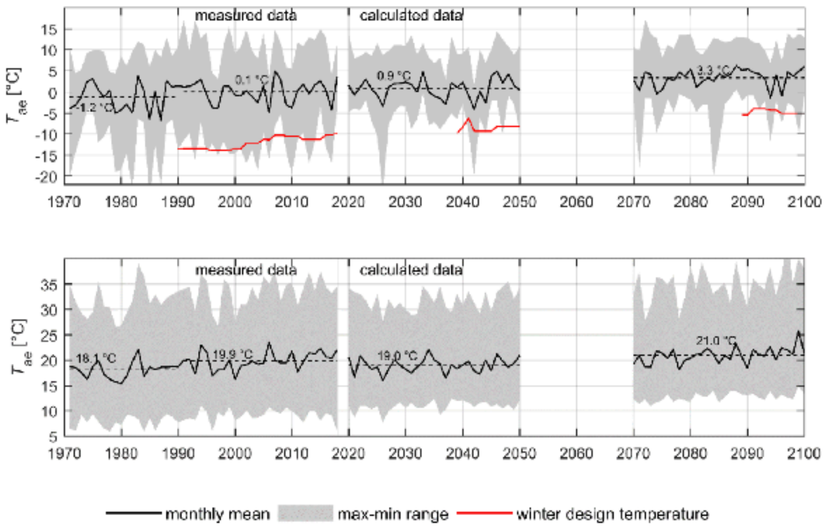

Figure 1 Ambient air temperature in January (top) and July (bottom) for Prague.

It can be expected in the near future, there will be a shorter winter season with a significant decrease of freezing days (days when ambient air temperature drops below 0 °C). Consequently, the time period with a continuous snow cover will be shortened. On the contrary, summer periods may be prolonged and warmer with the substantial increase of tropical days (days when daily maximum exceeds 30 °C) and tropical nights (night when minimal night temperature exceeds 20 °C). Due to simultaneous occurrence of tropical days and tropical nights hot periods will be more difficult to survive without effective cooling, especially for elderly people. Population in working age could suffer from a lower working productivity, higher error rates and the increased number of traffic accidents if the comfort indoor temperatures are not guaranteed.

3. Preliminary strategies for future building design

From previous studies performed for family houses [3] following preliminary conclusions can be formulated: The heat demand for the space heating of residential buildings is likely to fall to about two thirds in the future compared to 1960-1990. For the very low energy demand for space heating, the high insulation quality of the building envelope will continue to be necessary.

Periods of risk of overheating (above 27 °C interior temperature according Czech requirements) [1] will be more frequent and longer. Higher maximum values will be achieved. It is likely that even the exterior shading of the windows will not always guarantee that the temperature does not exceed 27 °C. It could be possible to eliminate such overheating using active cooling, where the cooling demand does not exceed 5 kWh/(m2a). Without high performing shading, the need for cooling would be much greater.

4. Under-roof spaces

A specific problem was selected here to document future challenges and need for better understanding during building design: the under-roof spaces. These rooms are usually made up of structures with lower thermal inertia than other parts of the building, so they are more prone to overheating. In addition, if it is necessary to illuminate the spaces through roof windows, the problem may become even more obvious.

The problem of heat loss in winter is solved by very low heat transmission (expressed as thermal transmittance). The project SONG [8] has found an acceptable solution for passive building windows reaching the thermal transmittance in the range of 0.7 to 0.5 W/(m2K). Now there is also a need to address the limitations of penetrating heat gains over time contributing to overheating.

Roof windows used in residential buildings may be partially or completely shaded for a considerable part of the time when exposed to sun rays, because the rooms (typically bedrooms) are not used during the day or a part of it. However, if rooms are used, sufficient daylighting must be provided, which may be difficult to ensure at the same time as the shading has to be applied.

4.1 Shading of roof windows

4.1.1 State of art

When exposed to sunlight outside the heating season, roof windows facing the sunlit side typically introduce such amount of heat into the interior of the building that, in addition to optical discomfort due to direct sunlight penetration, the air temperature in the interior of the building may be increased to such an extent, that hygienic conditions are exceeded, unless intensive ventilation and/or cooling is provided. Shading elements located within the glazing unit or on the interior side of the glazing affect only the visual comfort in the room and have almost no effect on reducing the penetration of undesired solar thermal gains into the room.

However, available (simple) solutions of exterior shading devices preventing access of sun rays onto the glazing area result in a virtually closed air space created under the shading louvers or a roller blind system, which is further warmed up by heat conducted by the louvers or blinds exposed to solar energy (Fig.2). As a result, there is an increased air temperature in the cavity or gap in front of the exterior side of the glazing, which leads to the transmission of heat through the glazing into the interior, albeit to a lesser extent than without the use of a shading system.

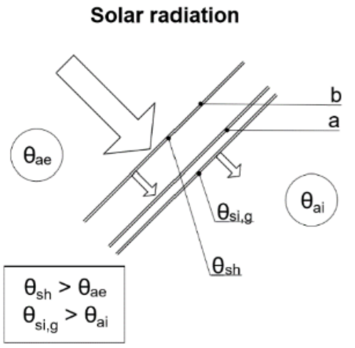

Figure 2 Roof window equipped with simple protective screen at the exterior side. (a glazing, b shading screen, θ_{ae} external air temperature, θai room air temperature, θ_{sh} temperature of shading device, $\theta_{si,g}$ temperature at interior surface of glazing).

4.1.2. Proposed solution

The above-mentioned drawbacks are eliminated by a solution [9] which proposes installing an exterior shading system on the roof window exterior side made of set of positionable lamellae (Fig.3). In addition, the system significantly increases air flow movement in the air gap between the shading set of lamellae and the exterior side of the roof window glazing unit by means of electrical elements, thus decreasing the expected temperature on the glazing unit surface. The movement of air in the continuous air gap is ensured by a suitable geometric arrangement and can be significantly enhanced in a controlled manner by means of electric fans. To power them, it is particularly advantageous to use the solar energy incident on the shading system elements, and because part of the incident solar energy is converted to electric energy by means of the photovoltaic cells placed thereon, and thus further reduces the thermal load into the air cavity by approximately 10%.
Additionally, there is a high degree of time correlation between the photovoltaic electricity generation and its use for the operation of electric fans. Another additional element supporting the air movement and air temperature reduction can be Peltier cells powered by electric energy from the photovoltaic cells. The proposed solution can thus operate with a considerable degree of autonomy and/or be advantageously multi-level controlled by an electronic control system responding to information from installed sensors, to user requirements and to evaluation by a superordinate intelligent control system.

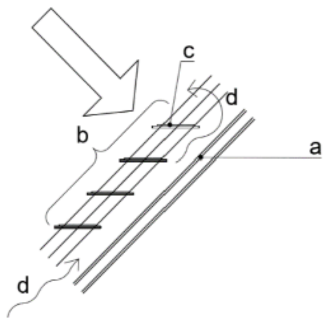

Figure 3 Roof window equipped with a set of positionable lamellae at the exterior side. (a glazing, b set of lamellae, possibly covered by PV cells (c), d air movement in a partly opened cavity).

The electronic controlled advanced shading described here (Fig.4,5) can be classified as a smart energy harvesting: Energy produced by PV is used directly at the site to control the system. In addition, the excess photovoltaic electricity can be used for artificial lighting using illuminating fixture with LED technology, conveniently located on the window lintel or lining or directly on the window frame.

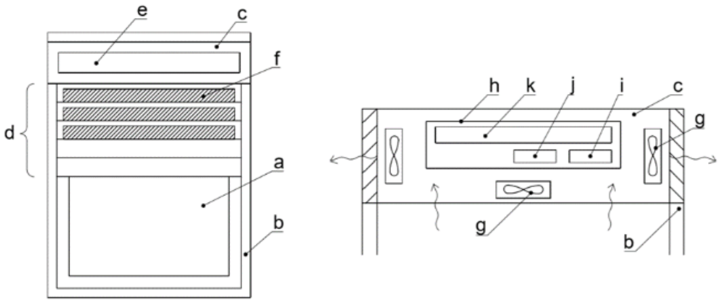

Figure 4 Overall scheme of an advanced shading system for roof windows. Left: overall view (a window, b metallic frame installed above the window, c box for lamellae in parking position containing the electric and electronic part, d set of positionable lamellae, e, f PV cells. Right: Electric and electronic part placed in the box c (g fans, h central unit, i power supply with an accumulator, j electronic control unit, k driving system for movement of lamellae).

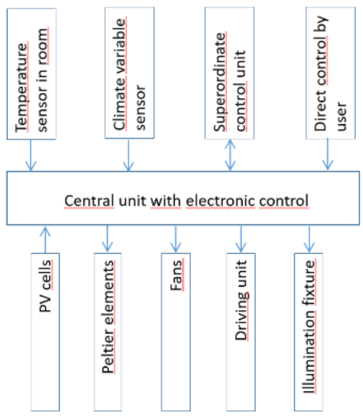

Figure 5 General diagram of the power and data interconnection of the elements of the entire system.

5. Shading for non-residential buildings

Office buildings represent another specific case. They are usually characterized by large glazed surfaces and considerable internal heat gains. Obviously, the exterior shading of glazed parts is preferred here. This is the most effective protection against overheating and glare. Movable shading systems are preferred, in order to meet the requirements for daylighting in rooms behind windows. While such shading is not always sufficient to eliminate the risk of overheating fully, it can effectively contribute to significant reduction the required cooling demand. Depending on local conditions and daylight requirements, a system can also be used where the upper group of shading blades is controlled differently than the lower one.

The problem arises when it is not possible to use exterior shading. In the case of tall buildings, wind exposure can be a problem. Another reason can be possibly higher demands for cleaning and maintenance, especially in dusty areas or just non-acceptance by the architect. It seems to be necessary to offer solutions for such situations as well.

It may be an acceptable compromise to use controlled shading elements in the interspace if certain specific conditions are met. To verify a particular solution, it is advisable to perform a dynamic simulation combining the question of daylight and heat transmission. Emphasis must also be placed on the very low thermal transmittance of the glazing in the interior.

The situation in school buildings seems to be critical and very complex. High-quality daylighting and not exceeding classroom air temperature requirements along with adequate ventilation are the key requirements. Metabolic heat forms an essential component of the heat load, which cannot always be dissipated by ventilation with uncooled air. If large passive solar gains are added, we need to install a large cooling capacity according to the routine design. At the same time, it is necessary to consider the frequency with which peak loads occur, inter alia, with regard to summer holidays. It turns out that for a building designed on a passive house level, with high-quality shading, equipped with mechanical ventilation, it is possible to meet the comfort requirements without installing a cooling system, based on the reference year data. If we use recent climate data, active cooling will be needed, but still only to the extent that the cooling module can be placed in the ventilation unit.

6. Concluding remarks

In the context of built environment, the climatic situation will necessarily mean a change in the approach to design of buildings, even those still perceived as simple. It necessarily involves both the overall design strategy and the individual components. The challenge is to use new technologies such as the renewable energy system integration at different scale and advanced control systems. Obviously, the calculations will be more complex.

Electricity necessary for operation of cooling as well as increased power of mechanical ventilation during summer can be advantageously obtained from photovoltaic systems, which substantially reduce the environmental load caused by building operation. All that confirms the highest importance of a better collaboration of experts of different backgrounds during entire design process, operation start and monitoring. It is understandable that crossing the boundaries between traditional disciplines is a great challenge but also a chance to find sustainable solutions.

Acknowledgement

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Ontology-based cost estimation for construction projects

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Keywords: Ontology, Cost Management, Building Construction, Data Structure, Data Sharing

Abstract
Building construction projects involve complex work processes and each process requires managing various levels of information throughout project execution process. Among those project execution process, cost management is the key process because cost management process is inter-related to most other processes. The researchers investigated existing cost management processes and systems in an effort of enhancing efficiency of the process. Two core elements for the efficient cost management system is to meet the need for accumulating relevant data in a structured way and enhancing reusability of the accumulated information. Most projects have project-specific features and data should have flexibility while maintaining its features and properties. Enhancing interoperability to manage the huge volume of construction information can be an effective way for the cost management purpose. This research is to develop an ontology-based knowledge framework by defining the relevant classes of cost management process for building construction projects. The ultimate goal of using the ontology concept for the cost management process is to enhance cost and possibly project management process by improving data structure, sharing, and interoperability among project participants

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1. Research Background

Data-driven methodologies for managing construction projects especially are not well established when it comes to cost and schedule controls. Practitioners in construction industry tend to solve problems based on personal experience on a daily work process rather than utilizing relevantly accumulated data. The cost and
scheduling process are distinctly different but profoundly interrelated. Integrating cost and schedule creates a baseline or sets of performance metrics critical to project control (Del Pico 2013). Because the complexity of construction projects has increased, mostly by construction project size and the industry's needs, estimating project cost, which is the core element of cost control, becomes more complicated. Estimating cost for various projects requires a certain level of semantic information expression method (Kim et al 2004). Therefore, compatibility of estimating information is very important for properly address variations of project environment in the construction industry.
Most cost database systems are structured by unit price of standardized breakdown structure, and due to the variable terms and processes among various projects, using the standardized forms of database is not always easy task. Also, estimation highly relies on individual capacity due to the estimators' various knowledge level. Moreover, project participants has a different aspect and level of details for estimation. Improving interoperability among various cost database can serve as a vehicle to integrate various estimating works performed by various project participants.
Ontology is the philosophical study for the nature of being, becoming, existence or reality as well as the basic categories of being and their relations. According to Gruber (1993), the widely-accepted "ontology is an explicit specification of a conceptualization". Ontologies' components commonly include individuals, classes, attributes, relations, function terms, restrictions, rules, axioms, and events. An ontology models information and knowledge in the form of a hierarchical structure of concepts, taxonomies, mutual relations among concepts, and axioms (Noy and Hafner 1997). In general, concepts represented by all ontologies are things, processes and events, relations, and properties.
Regarding construction projects by individual contractors, the estimator must create a cost breakdown structure (CBS) and work breakdown structure (WBS) for every project because these structures are not reusable when they work with various owners and under various project requirements. This leads to inconsistency of the breakdown structure for cost management. Ontology can be a means of support to reduce the work time for estimation, to reuse previous estimation information, and to extract certain information regarding the estimated level. Thus, concerning reusing existing knowledge, an ontology can be an active tool. Therefore, as a higher concept, a construction information knowledge structure should be established to enhance the efficiency of cost reusability.

1.1. Research Objectives

Each construction project has different requirements and environment for project management. This research is to develop an ontology knowledge framework by defining the relevant classes of cost estimation for industrial construction projects. The ultimate goal of using the ontology concept in cost estimation is to develop an integrated project management tool. The significance of this research is in the possibility of using ontology for integrated project management to enhance efficiency of cost estimation by reducing the estimating time and minimizing redundant work. Converting the same or similar concepts into a standard form of pricing structure is an essential idea of the research. The purpose of the research is to develop and implement ontology concepts for the construction project estimation task and increase work efficiency.

1.2. Research Scope and Procedure

Project Management Institute (1987) identified nine knowledge areas on which project managers should concentrate while managing projects: integration management, time management, cost management, quality
management, human resource management, communications management, risk management, procurement management, and scope management. Among them, this research cost, time, and risk management are closely related. The research scope involves developing an ontology model for the cost, time, and risk management purpose. Research procedures are shown in Figure 1.

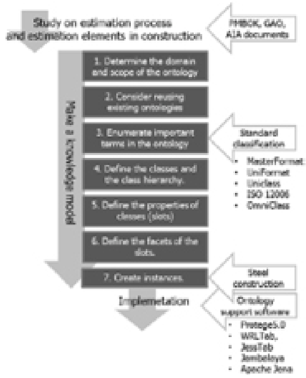

Figure 1 Research process

2. Literature Review

There are few completed research projects on interoperability or construction ontologies, and several others are underway. Most of these ontological modelling efforts were focused on the building product and its subcomponent, thus topics on construction project management using ontologies is still lacking. In construction management academia, ontology has been tested for knowledge representation, decision making, risk management, cost estimation, and information integration.

The infrastructure field in ontology has focused on specific areas of knowledge, which includes: highways, telecommunications, and bridges. First, El-Diraby and Kashif (2005) proposed an ontology for managing highway construction knowledge in a semantic way by encompassing six major concepts. That concept
included projects, processes, products, actors, resources, and boundary conditions and was used to classify construction knowledge. El-Diraby and Briceno (2005) created a "scenario for the use of the taxonomy for building a knowledge base" and presented the taxonomy of outside plant construction in telecommunication infrastructures to support "knowledge-based virtual teaming." El-Diraby and Osman (2011) researched an ontology related to the construction aspects of infrastructure products. The product was the result of construction work processes and included physical products, decisions, abstract knowledge, and knowledge items. The ontology provided a conceptualization for knowledge in civil infrastructure.

Lastly, Costin (2016) proposed a methodology that would enable the interoperability of multidisciplinary information models for bridges. That method was used and validated by an industry domain case study. A software tool to automate the capture of domain knowledge and development of a taxonomy was presented. In general, ontology is a way of formally specifying a mutually agreed upon understanding of a certain domain of interest regarding axioms, relationships, and concepts (Gruber 1993). The ontology presented in that research attempted to bridge this interoperability gap among asset management, infrastructure deterioration modelling, and sustainable infrastructure.

3. Application to Construction Estimation

Ontology as a concept has gradually migrated over time from the field of philosophy to the domain of computer science and information systems. Because of this migration of ontology, more research has emerged recently. Studies of ontology assess the way in which entities are organized, related within a hierarchy, and further divided by similarities and differences. The top-down method, the algorithmic method, and expert judgment/Delphi method were chosen to foster a cost estimation ontology model. It led to a parametric approach to cost estimation in ontology development and critically analysed many cost factors included in the process of ontology engineering. Those characteristics of ontology that work with entities regarding properties

can potentially have significant roles in the field of construction management.
According to a study by Lee et al (2014), BIM-based information management has become more frequently used in the practice of construction; for example, "the construction industry has augmented its use of IFC or Industry Foundation Classes XML File (IFCXML) during construction projects." However, one of the downfalls of BIM-based information management is that it cannot provide any information on the actual work items. BIM information was introduced into IFCXML and remodelled into RDF information in a machine-understandable format. In order to support the Resource Description Framework (RDF) query language, that research proposed a "Simple Protocol and RDF Query Language (SPARQL) endpoint" and a Web-based user interface for a semantic query language for databases. The ways in which classes and instances were described in that research can be a highly relevant reference because all current ontologies share a common higher-level model that enables all systems to work together by following the same general framework (El-Diraby and Osman 2011).
There were two types of research on ontology in construction estimation. One type focuses on conceptualization and application, and the other type was ontology coding and information processing, which included computational language. In 2004, the World Wide Web Consortium (W3C) recommended using Ontology Web Language (OWL) and Protégé as the representative ontology tools; most ontology studies in construction cost estimation work with the object property and data type property. According to Ma et al (2013) and Sabol (2008), in practice, estimates can be obtained by manually extracting useful information from printed design drawings or CAD drawings or rebuilding three-dimensional models of cost estimation. So, there were academic effort to make construction estimation automatic to reduce estimating time. Lee et al (2014) developed an ontology-based approach for building cost estimation.

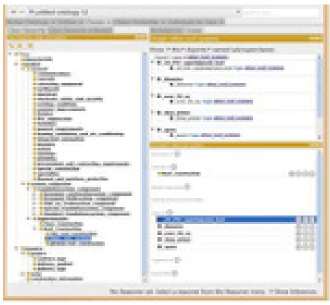

Figure 2 Ontology development

The researchers defined construction project management process with a WBS (Work Breakdown Structure) by using "class" structures. Each class defines knowledge concepts, and the property defines knowledge application. Therefore, concepts (knowledge) are define as a tree structure as if they are related with hierarchy. Each concept then is applied to "practice" to be operated. Then the options of operations are defined as properties. Implementation was conducted via Protégé-OWL 3.5 by inputting the designed superstructure. The study created an ontology-based representation based on the models and real world practice to create a prototype tool for cost estimation. The prototype tool worked by using a computerized automatic classification system of building components, which would then classify the building components into bills of quantities and quota items. The proposed cost estimation ontology consisted of domain, range, and object properties, which defined the relationships among domains. The major domains were actors, work items, and building products as seen in Figure 2. The model enables faster and more efficient cost estimates as it is expanded to embrace the whole estimating process. The expansion of building proposed model is underway.

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Smoothing out the interaction among BIM, sustainability rating systems and minimum environmental criteria

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Keywords: bim, sustainability, workflow, rating system, cam, itaca, visual scripting

Abstract

The introduction in the construction industry of the building information modelling (BIM), sustainability rating systems and the minimum environmental criteria (CAM) is deeply changing the design approach.

BIM, a process based on codification that allow for interoperability among different disciplines, along with the rating systems that are a tool to promote sustainability, and CAM for Construction, that are mandatory provisions to support green public procurement, are all based on a methodology that relies on coordinated processes and aim to achieve a better quality level in building design and construction. Nevertheless, using those resources integratedly may appear complex to the BIM user, ending up discouraging him and leading him to the loss of the many potential benefits.

The research shows a possible way to this integration, considering, with reference to an Italian case study, how the criteria of the non-residential ITACA Protocol, chosen as a sample rating system, and the CAM for Construction can be included in the BIM workflow with the intent of achieving an optimization of the process and enabling the evaluation of consequences of every design choice at every step of the way.

It was carried out the identification of the criteria typology in order to find those BIM functions that can better support verification. A BIM workflow was formulated in connection with other softwares that could complement the BIM software for the specific task.

The method developed was tested as a sample on the BIM project of the addition to the Palazzo dei Diamanti in Ferrara.

1. Introduction

The project for the addition building to the Gallery of Modern and Contemporary Art of Palazzo dei Diamanti in Ferrara, developed entirely in BIM, to be certified with the non-residential ITACA protocol, under the obligation to comply with the minimum environmental criteria (CAM in Italian) as a public building, was the starting point to address the issue of the relationship between these three topics. In particular, the workflow that was adopted, which could be defined as traditional, highlighted how the development of the three processes in a non-integrated manner led to a series of repetitive and difficult to manageprocesses.

Below it will be described problems and critical aspects that were found out and it will be presented a proposal regarding the work method aimed at a more fluid workflow.

2. BIM and sustainability

2.1. Building Information Modeling (BIM)

The Building Information Modeling (BIM) is a tool that supports and allows for an integrated type of design which, through a (single) model created with an appropriate software, permits a digital flow and an exchange of information with horizontal and no longer vertical or sectorial actions. A BIM model is therefore a multidisciplinary parametric model that can be imagined as a container of information continuously updated and shared. Each BIM element carries within quantitative and qualitative informations related to the use for which the model is prepared and to the type of definition pursued (i.e: the level of detail required by the design phase). At the European level, the Directive 2014/24 /CE aims at a modernization of the public contracts sector with the aim of pursuing smart, sustainable and inclusive growth. The Italian Government implemented this Directive with Legislative Decree no. 50/2016 "Code of public contracts", published on G.U.

n. 91 issued on 19/04/1016. In addition, the Decree n. 560 issued on 01/12/2017 defines methods and timing for a progressive introduction, by the contracting stations, the granting administrators and economic operators, of the mandatory methods and specific electronic tools, such as those for building construction and infrastructures, during planning, construction and management phases of the works and relative verifications. Regarding the digital management in construction and civil engineering works, the UNI 11337: 2017 standard is the main reference.

2.2. Sustainability

Sustainability in construction includes multiple thematic areas. Under the famous triple bottom line people- planet-profit, the existing environmental sustainability rating systems have taken up this complexity defining sets of actions that lead to buildings that are designed (or refurbished) environmentally consciously. This requires different professionals with different field of expertise to work in a coordinated way.

2.2.1. Minimum Environmental Criteria (Criteri Ambientali Minimi CAM)

The Minimum Environmental Criteria for Construction, often quoted under the acronym CAM (Criteri Ambientali Minimi), introduced with the Ministerial Decree issued on 24/12/2015, are requirements aimed at identifying, in the various possibilities offered by the market, the design solution, the product or the best service under the environmental profile.

At the moment CAMs are adopted for 17 categories of supplies and assignments. Among these, the one related to construction, "Entrusting of design services and works for the new construction, renovation and maintenance of public buildings", provides general indications for new construction, renovation, maintenance and energy requalification of buildings and for the management of construction sites.

The latest version of CAMs is the one contained in the Ministerial Decree issued on 11/10/2017, published in the Official Gazette of the Italian Republic General Series n. 259 dated 6/11/2017. Pursuant to art. 34 and 71 of Legislative Decree n. 50/2016 "Procurement Code" (amended by Legislative Decree 56/2017), the application of CAM is mandatory by all contracting stations.

2.2.2. ITACA non-residential rating system

The ITACA non-residential rating systemis the Italian protocol to assess the sustainability of all types of non residential buildings that was set up by ITACA, Istituto per l'Innovazione e Trasparenza degli Appalti e Compatibilità Ambientale.

It is a multicriteria analysis system for assessing the environmental sustainability of buildings, based on SBTools, structured hierarchically according to criteria, categories, areas of evaluation.

The criterion is the elementary unit of the protocol and the set of criteria describes the entire production process of the building. The criteria refer to the categories, which are grouped into evaluation areas.

The performance of the building according to each criterion is described through a set of numerical values, each with its unit of measure and its order of magnitude. The normalization phase renders the indicators dimensionless and normalizes them according to the interval (-1, 5). The score sets are "weighted" according to the importance of the topic in the rating system, established on the estimated impact on the environment. The final aggregation phase produces, starting from the normalized values, a final score indicative of the overall performance of the building.

-1	Performance below current construction practice standard
0	Minimum acceptable performance as defined by applicable laws or regulations. It represents the current construction practice (neutral threshold)
1	Improvement in performance compared to current regulations and current construction practice
2	Substantial improvement in performance compared to current regulations and current construction practice
3	Best current practice
4	Increase in the best current practice
5	Considerably advanced practice

2.2.3. Overlapping of ITACA non residential rating system and CAMs

The compliance with the CAMs requirements is mandatory for public procurement, whereas undergoing a certification process with a rating system is a building with an environmental sustainability protocol is left at the discretion of the client. The conformity of a project to the CAMs is demonstrated abiding by the verifications required by each criterion or alternatively, if the project pursues a certification with one of the energy- environmental sustainability rating systems, by meeting the requirements of the criteria of which the rating system is made. Compliance is achieved if the verification required by the rating system criterion overlaps with what is required by the CAM criterion verification.

The newly updated version of the ITACA non-residential rating system, currently under evaluation to become a UNI practice, has been adapted to the CAMs. In most cases the neutral threshold for the rating system criteria correspond to that required by the CAMs criteria, thus leading to their complete overlap.

As an example of this circumstance the comparison between the ITACA B.4.10 "Disassemblable Materials" criterion and the CAM 2.4.1.1 "Disassembly" is described. The CAM requires that at least 50% weight / weight of the building components and of the prefabricated elements must be reclaimable at the building end-of-life with selective demolition. The 50% threshold is considered in the rating system as sufficient for the achievement of a score of zero. Meeting the CAMs requirements therefore represents a basic level of achievement for the rating system. An increase in the performance leads to a better score.

However, in some cases the requirement of the rating system is lower than that of the CAM. This is the case of CAM 2.6.5 "Supply distance" and 2.3.5.6 "Acoustic comfort" compared to the related ITACA criteria B.4.8 "Local materials" and D.5.6 "Building acoustic quality".

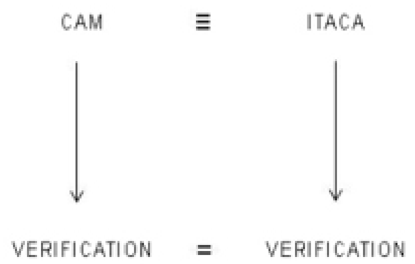

Figure 1 - Overlapping of ITACA and CAM

3. The traditional workflow

In a traditional workflow, intended as the usual design development, the three processes are developed separately: the BIM project is carried out, the necessary documentation is prepared a) for the evaluation report required by the ITACA rating system b) for the CAMs verification. ITACA criteria are checked on the data provided by the different design team professionals and are processed to quantify the performance indicators that express the level of sustainability achieved. To do this, a calculation sheet is prepared which returns the value of the various performance indicators. In a subsequent step these values are weighed and aggregated

to form the score first in the category, then in the area and eventually in the final one. For the verification of the CAMs, the evidence of the correspondence to what is required by each criterion contained in the Decree must be produced in a documentary way.

The expansion project of the Modern and Contemporary Art Gallery of Palazzo dei Diamanti in Ferrara was developed entirely in BIM using Autodesk Revit software. The model we worked on is a federated model, that is shared between 3TI Progetti and Labics (the design team) and represents a good example of disciplinary interoperability.

Since this is a project at the final design stage, the assessment with the non-residential ITACA rating system was carried out in the form of a pre-assessment, which was calculated using the traditional methodology. Therefore, although a continuously updated BIM model of the project is available, we worked independently from that, with the consequent need to manually update the data, causing time-consuming, data management difficulties and the risk of incurring in error.

By the analysis of criteria and verifications required by the ITACA rating system and those required by the CAMs and by putting them in connection with the BIM project, two levels of integration maturity can be identified. We therefore speak of "integrated" and "integrable" criteria, where "integrated" refers to that type of criteria for which, with more or less complex passages, it is possible to extrapolate the data that need to be processed: from appropriate inputs the outputs are obtained. For "integrable" we mean those criteria for which it has not yet been reached such a level of maturity that they can easily fit into the BIM workflow. A good example for that are the ITACA criteria belonging to category A.1 "Site selection" for which assessments concerning the area that must necessarily be conducted by making assessments that take into account variable and non-intrinsic parameters of the template. Of course, there may be external extensions of BIM software that may support designers in the assessments required.

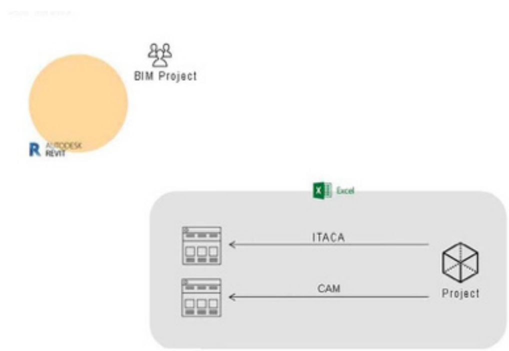

Figure 2 - Traditional workflow

4. The enhanced workflow

From the analysis of the critical issues that emerged with the traditional working method, a new workflow was developed with an integrated approach whose objective is to smooth out and to optimize the ITACA criteria calculation process and verification of the CAMs within the BIM flow.

Autodesk Revit was used as a BIM software and through the use of external programs and / or plug-ins, a possible working method is outlined.

Given the layout of the ITACA criteria calculation sheets and the requested output which calls for the creation of tables and the crossing of data for the attribution of weights to the various criteria and the calculation of the final score, Office Excel, a software for the production and management of spreadsheets was used. In this way the same tables are exported in .txt format and then transferred to a new Excel file where the values obtained are used to calculate the performance indicators.
Due to the nature of some criteria, the export of data in a spreadsheet cannot always be direct. An automated BIM process was therefore used, through the creation of a script within the Dynamo application.

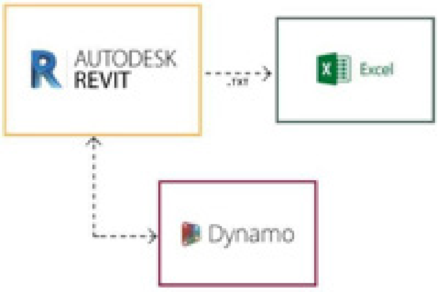

Figure 3 - The enhanced workflow

4.1.1. Automation
It's often the case that starting from an idea one gets to the final results following precise rules, with a workflow made up of actions that follow a logic made up of input, processing and output. As for the creation of an origami, for which it is necessary to follow precise instructions for the attainment of the expected result, the same happens for the automation in the management of the processes, in which the problem is solved through a procedure made of a finite number of clear and elementary actions that are called algorithms. Their formalization according to a coded language is called Computer Programming.
The same goes for the Visual Programming Process which, however, carries within the idea of programming, traditionally made, of text, in a graphic language, visual in fact. We are talking about Visual Programming Language (VPL), which is a language that allows the management of elements in a graphic context, rather than with written syntax. VPLs are generally organized into schemes made of nodes and wires, or "nodes" and "cables". Each node can perform simple or complex actions and are generally composed of inputs and outputs. The relationships between the nodes and the definition of the flow occurs through connections called wires, which can be imagined as electrical cables that carry data pulses from one object to another. The use of a graphic language and no more text, for this type of programming, greatly facilitates operations especially with regard to debugging, or the identification and amendment of software bugs.
Currently the main (more popular or widespread) BIM authoring softwares integrate the Visual Programming Process in the data design and management system, such as Autodesk Revit which, through Dynamo, allows information control and the construction of complex and parametric geometries. Dynamo is an open source application that allows the creation of scripts that are logical sequences elaborated to achieve a given objective. Once created, scripts can be repeated in other projects for similar purposes with the modification of certain nodes to adapt it to the specific case.
4.2. Application of the proposed enhanced workflow to the case study
For the sake of this presentation, due to conciseness reason, we show how the ITACA material criteria were integrated in the process.
The preparation of the model, intended as working according to specific criteria according to the requested output, is a step of fundamental importance. Therefore, first of all we proceed with the creation of the "project parameters", or containers of defined information associated with one or more categories of elements in a project. Each parameter was created with reference to an ITACA criterion and associated with the "materials" category, therefore they will be parameters "instance" and will be specific to the project.
The ITACA B.4.6 criteria; B.4.7; B.4.8; B4.10 share the same method that consists in calculating a performance indicator given by the ratio between the total weight of the materials and the total weight of the recycled materials (for B.4.6) or from a renewable source (for B. 4.7) or locally sourced for (B.4.8) or disassembled (for B4.10). Therefore, for these cases the type of parameter is of the "number" type. In this way the model is equipped with as many project parameters as there are ITACA criteria to be verified. Thus, the values required by the parameters have been associated with each material.
In an ideal workflow, this operation is performed by each actor participating in the design process that creates a new material, based on parameters previously created by a coordinator. In this way, with a targeted predisposition of the BIM model, the researched output can be obtained in a direct and ordered way.
We then proceeded with the creation of the "material schedules", in order to organize tables containing the type of material and the related project parameters. Furthermore, within the same schedules it is possible to create "combined parameters", i.e.

a type of parameter not associated with any category that allows simple operations to be performed between the parameters themselves. In this way, with the "combined parameters", the values of "A" and "B" were calculated for each criterion.
At this point all you have to do is to relate "A" and "B" to obtain the performance indicator and consequently the score of the specific criterion. This step is done outside of Revit, with Office Excel. Eventually the criteria scores were calculated in Excel, which in a second phase will be combined together and organized into tables as required by the rating system. The criteria scores, just calculated, can then be subsequently transcribed in the Revit model, through the "global parameters" so as to keep them associated with the project.

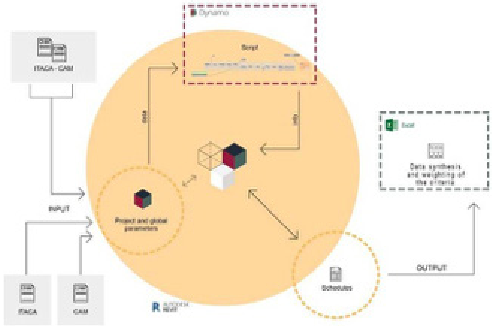

Figure 4 - The enhanced workflow

Regarding criterion B.4.11, it has a different calculation setting. This implies the counting of materials having specific types of certification, so the sum of the numbers of the certified materials multiplied by the coefficients depending on the type of certification, allows to obtain the value of the indicator.
Therefore, the type of "project parameter" parameter identified for the previous criteria cannot be used in this case. Instead, a "yes / no" type parameter must be chosen, in order to indicate the presence or absence of a specific certificate for a given material.

Once the parameters are created, in Dynamo a script consisting of twenty nodes has been elaborated, which allows to reach, starting from an input, constituted by the parameters, to an output, that is the indicator. Specifically, the algorithm counts the materials with the required certificates and inserts these values in a "bock code" that shows the formula for calculating the indicator. In this case, the automation obtained through visual scripting was of fundamental importance, as it allowed to overcome a limitation given by Revit of the counting of the parameters and to avoid having to perform the operations manually. Moreover, through the use of specific nodes, it was made so that the indicator could be readable directly in Revit and associated with the "global parameter" of that specific criterion. Below is the overall script created with Dynamo.


Figure 5 - Dynamo script

The value of the indicator calculated with Dynamo in the already prepared Excel table was then reported. The score of the criterion was calculated, which in a subsequent calculation will be weighed to calculate the overall score of the building.

5. Conclusions
The workflow described represents one of the possible alternatives in response to the critical issues highlighted in the use of the traditional workflow. The use of automation may appear to be a complicated step, but in practice it gives the possibility to carry out even very complex operations that could hardly be carried out in any other way. In the specific case, the use of Visual Scripting allows for a smoother workflow. Having a model equipped with information that can be continuously updated not only allows a more precise and quick verification of the criteria, but also allows, in a broader view, to bring sustainability ever more into the design process. The possibility of monitoring the way in which the developments and changes to the project affect the criteria of the certification rating system allows to better and more consciously test targeted sustainable design choices.

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Itaca-food a model for the sustainability assessment of food process buildings

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Keywords: Sustainability, Buildings, Food process, Assessment models, worker safety

Abstract
The models for the sustainability assessment of the construction sector, have assumed a fundamental importance with a view to determining the impact that these have mainly on the environment and on the health of users. These have mainly affected the residential buildings, offices and commercial buildings, but not considering the food process buildings because the latter, in addition to the indoor well-being of the operators, must also ensure the "well-being" of the product, as a suitable level of hygiene-safety health and conservation, reduces the risk of contamination and / or deterioration of the product itself that could have effects, even serious, on the health of consumers. The aim of this paper is to propose a model of assessment of building sustainability for industrial agro-food buildings based on the ITACA Protocol (SBMethod). In fact, in addition to the environment, energy consumption and health of the operators, the assessment of the level sustainability was also considered, taking into account all the physical, structural and hygienic safety factors suitable for maintaining the product in healthy conditions. The developed model maintains the characteristics typical of the ITACA protocol but integrated with indicators specifically developed to analyze the typical conditions of the production buildings while respecting their peculiarities. In fact, each type of production has well defined characteristics and needs that must be analysed, addressed and evaluated differently. The evaluation process of this model has been automated through the creation of a software that determines its level.

1. Introduction

Buildings are responsible for more than 40% of global CO2 emissions (UN-Habitat, 2016) and building structures for consumption of 35% of the world-wide energy and 40% of CO2 polluting emissions (UNEP, 2017). In recent decades, the international community has become aware of the serious consequences generated by the excessive consumption of environmental resources and the effects produced by this exploitation, and to counteract this phenomenon, it has encouraged environmental policies based mainly on the promotion of sustainable development, especially in construction sector, through assessment methods supporting decision-making that take into account multidisciplinary aspects such as environmental, social and economic (Sala et al., 2015). These policies aim to direct the construction sector towards the use of new environmentally friendly materials with high energy efficiency, construction techniques and plants such as to passively reduce the energy needs of the building structure, maintaining, within it, adequate comfort conditions to users. Therefore, different tools have been created for assessing the level of sustainability, used as an engine to undertake sustainable paths through rating systems, encouraging the use of eco-compatible products and processes (Ameen et al., 2015).
Other methodologies for assessing building sustainability levels have been, and still are, at the center of important research topics. These models aims bring back all those useful information to help the decision-making process, the design and use of buildings, taking into account the aspirations of sustainable building, rather that simply assess sustainability levels (Kaatz et al., 2006), these tools should also embrace all the main aspects of sustainability but often prefer exclusively the assessment of the environmental aspect only in terms of satisfying performance conditions such as usability, duration, safety and comfort (Blok et al., 2011).
For these models, specific tools have been developed that allow their practical application in buildings with different destination as houses, offices, schools, commercial and industrial buildings (Barreca et al., 2014) and also in urban development planning, taking into account the specificity of territorial context in which these buildings are located.
In this paper, a model for the assessment of building specific sustainability for buildings for food production is proposed and illustrated, based on the Italian ITACA protocol, which derives from SBTool, model applied internationally.
The proposed protocol is applicable not only nationally but also internationally, as it also includes the regulatory, legislative limits and good practice at community level. This protocol can also be characterized according to the national and regional context in which it is inserted and therefore of the different importance to be assigned to the different services, as it is possible to set specific levels of benchmarks proceeded from the normative, legislative framework and construction practice at local level.

2. Materials and methods

The main models for the evaluation of building sustainability developed nationally and internationally have focused attention mainly on residential structures and, only in the last decade, have been adapted for evaluations in scholastic, commercial, industrial areas without however, still consider food production buildings, which present very different problems from those of the structures so far analyzed, since in addition to considering human well-being and health, it is essential to consider the food product which, if not adequately preserved, can cause negative impacts not only in the environmental, social and economic fields, but also in the health field since the proliferation of microorganisms within the production structures, for to unsuitable environmental and hygienic conditions, can produce contamination of the product both by air and by contact with work surfaces (Barreca et al., 2017), not adequately sanitized, generating zoonoses in consumers. Furthermore, construction techniques are still connected to standards that are often out of step with respect to new research in terms of environmentally friendly materials and environmentally sustainable plants.

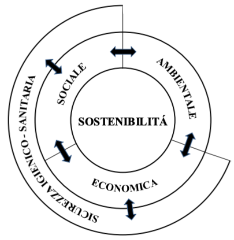

Figure 1 – The sustainability pillars

The ITACA protocol is a multicriteria method, adopted by the Italian regions to assess the level of environmental sustainability and the energy performance of buildings, which aims to encourage the use of building and installation practices to improve environmental performance compared to building standards established by law not only in new buildings but also in those subject to restructuring (Principi et al., 2015).
The proposed model, deriving precisely from the ITACA protocol, appears to be of strategic interest as it was developed to assess the level of building sustainability in food buildings, a construction type that presents aspects of sustainability of greater impact than those typical of the residential building sector.
For the application of the model in the agri-food sector, in addition to the 33 criteria set by the model adopted by the Calabria Region for the residential sector, a further 15 specific criteria have been added for the productive sector of the food industry.
In particular, in the "Site selection" category, three additional criteria have been included regarding the "Distance from contaminating production sites" (Fig.2), the "Proximity to major roads" and the "Settlement dispersion".
In the area "Environmental loads" criteria were considered such as "Reuse of water for production" for drinking purposes, "Production waste reused / recycled".
In the area "Indoor air quality" instead of "Indoor air quality (IAQ)", "VOC", "Microbiological air quality" and "Radon" which are those concerning health (hygienic-sanitary safety) and comfort of the air that can have repercussions not only on operators but also on food products. Other specific criteria are: "Visual Comfort", "Acoustic Comfort" and "Industrial Frequency Magnetic Fields (50 Hz) (Measurements)".
In the "Service Quality" evaluation area the criterion "Functionality of spaces" was added and others were redefined for the food industry.
The model proposed here is divided into four levels: the criterion (CR), which constitute the initial assessment element, the categories (CA), the evaluation areas (EA), and the final evaluation index (FI) to be attributed to the industrial building structure being evaluated. For the evaluation of each criterion a performance scale is used consisting of 4 levels of judgment (NEGATIVE, SUFFICIENT, GOOD, EXCELLENT) with a score ranging from -1 to 5, each of which is associated with a value belonging to the characteristic range of the evaluation element subject of analysis.

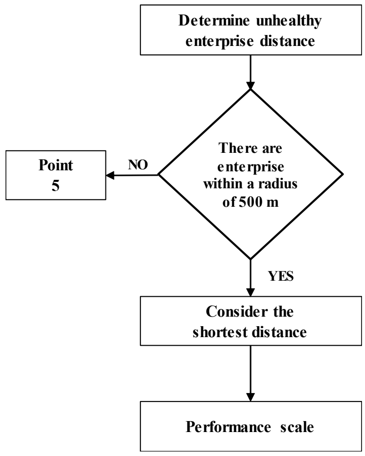

Figure 2 – Example of criterion scheme A.1.4 Distance from contaminant production sites

The score of each CR is weighed according to a value (p) that depends on the impact this has on sustainability within the CA of belonging and dependent on local policies that often suffer from different needs depending on the territorial area in which it is adopted.
To simplify the calculation and evaluation procedure, the proposed model has been automated with a software specifically developed in visual basic. This consists of an initial userform in which there are buttons both for entering the data necessary for the evaluation and for viewing the final results both global and related to the 4 levels of evaluation through the definition of explanatory graphs making the consultation of the results easier.

3. Results and conclusion

In the following section we will proceed to the analysis of the results of all the evaluation levels characteristic of the proposed model, applied to a "bakery products" industry in southern Italy belonging. First, the level of sustainability of the criterion was assessed, and then the scores of the categories were examined and then those of the evaluation areas, up to the global index characteristic of the productive building structure.
In the Quality of sites area, of the 10 criteria provided, six were judged negative, three were judged excellent and one sufficient. From the weighing of the criteria it emerged that the two categories A.1 Site selection and A.2 Design area were assigned a score equal to 0.45 and -0.42 respectively, obtaining an overall score for the entire area equal to 0.03 corresponding to a judgment of sufficiency. The score corresponds to a sufficient judgment because they mainly weighed the position of the building structure, built in an area of industrial expansion without services, as well as the presence of unhealthy companies, the absence of areas of common use end green areas planted with native species as a service to workers.
In the Resource consumption area at 38% of the 13 criteria, a score was assigned equal to 0 (sufficient), to 23% a negative judgment and only one criterion was evaluated excellent, the remaining 30% are included in a range of scores between 1 and 2. All the categories have reached a sufficient score to except "B.1 Primary energy required during the life cycle" which has reached a level of evaluation slightly lower than the sufficiency (-0.25). By weighing the scores of the categories, it was possible to determine that of the entire evaluation area equal to 0.51.
The Environmental loads area was evaluated with a score of around 2.7 and a rating corresponding to good. In fact, 70% of the criteria were given a score of 5 (excellent), the remaining 30% was evenly divided between 0 and 3 (Fig. 3).

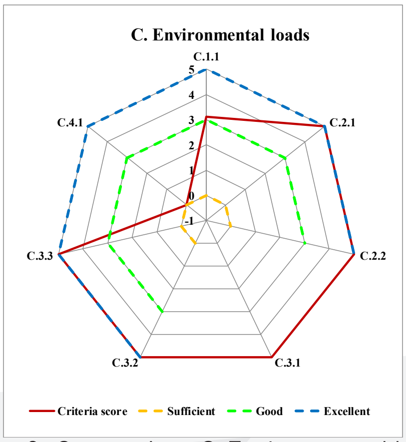

Figure 3 Score – Area C: Environmental loads

Of the 13 criteria in the Indoor environmental quality area, 30% of these were assessed as good, 30% were sufficient, 25% excellent and the remaining 15% were negative. All the categories have positive scores between 0 and 4, which determined a score of 1.86 for the entire evaluation area. Also for the Service quality area, an overall score of around 1.70 was achieved, between sufficient and good. This derives from the scores attributed to the criteria, all between 0 and 3. A total of 80% of the criteria was given a score lower or equal to 3 of which 16% with a negative rating (-1). Approximately 18% of the criteria were given excellent rating (5) and only 2% of the criteria were given a score between 3 and 5. The global index of evaluation score equal of 1.14 well above the sufficient judgment. The proposed model is of fundamental importance for assessing the level of sustainability in the building structures of the food industry, since the criteria present in the original protocol, have been supplemented by other specific criteria for the production activity analyzed. From the results obtained its application, it emerged that it can be easily used to assess the level of sustainability during all the life phases of the building structure, starting from the design stage up to that of utilization, as well as disposal. Furthermore, the software developed facilitates the application of the same through the automation of the analysis process, making the model more flexible according to the needs, both of public administrations and, through the modification of the weights to be attributed to the different evaluation elements, they can use it as a form of control and / or rewarding, but also by the companies themselves to verify the functional level of the building structure in relation to both the current production activity and as a forecast element.

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Dry construction systems for sustainable design: issues and perspectives for the use of dry construction systems in the Mediterranean context

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Keyword: architectural engineering, architectural design, technological flexibility, building industrialization, dry construction systems

Abstract
The proposed study is part of the researches on sustainable building construction approaches and technologies for the Mediterranean area and presents the partial results of an ongoing research on the use of dry construction systems. This technology is based on the combination of specialized technological layers organized according to different sequences that can be modified over time, to guarantee the required performance of components. Their adaptability makes these systems able to reduce both energy consumption and emissions related to adaptation and demolition works, representing an effective response to the mutability of the contemporary building demand. Key references for the proposed study are, therefore, the concepts of technological flexibility and construction reversibility and the renewed interest in building industrialization, of which dry-construction systems are an expression. This study aims to analyze the main issues that the use of dry construction systems presents in the Mediterranean context and concerning, for example, the relationship between design, construction and industry - in the Italian context which is sometimes related to an artisanal organization of the building process - and the difficult adaptability of this lightweight construction system at climatic conditions that prefer heavy systems (masonry and reinforced concrete). The analysis is supported by the partial results of the "Ac.Ca. Building. Progettare e Costruire in Sicurezza con l'Acciaio e la Canapa. Tecnologie Innovative per Edifici Ecosostenibili" R&D project, funded within POR Calabria FESR- 2014-2020, which currently involves a research group of the Department of Civil Engineering of University of Calabria to which the author belongs.

1. Introduction

The interest in dry construction systems is representative of the transformation process of methodological paradigms that have guided the selection, organization and use of resources within the building process. The recent evolution of building cycle control methods refers to a design and construction approach aimed at prefiguring methods and techniques for the transformation and/or demolition of buildings or parts of them, limiting the consumption of resources, the production of waste and of polluting emissions.

Dry construction systems are defined as techniques based on the use of prefabricated industrial components assembled on site using dry connections, without the use of wet binders (concrete or mortars). A more recent articulation of the theme has introduced the dry-sandwich construction systems (Zambelli et al. 1998; Imperadori 2010, 3-40), characterized by the ordered succession of parts, functionally and technologically related to forming a solution with a performance that can be graduated and modified in each of its components in relation to the specific needs of the project and, above all, considering the transformations of the building over time, until its complete demolition (Greco 2017b, 27-38). There is therefore a peculiar character of this construction system, which affects the necessary relationship between the project and the production of prefabricated components. This relationship is not original, but is now distinguished by the past seasons of building industrialization for the development of open technological packages, designed ad hoc thanks to the multiple integration options suggested by the specialization of the performance of materials and products (Greco 2017a, 15-26). The original aspect that distinguishes the new dry construction expression is precisely the concept of layering, related to the open and changeable composition of the walls, floors and roofs (Zambelli et al. 1998). The number and specialization of the component parts of the technical element, in fact, allow today the management of thermo-hygrometric control, acoustics, fire safety, structural strength, plant installation, maintainability, organizing the specificities of parts thanks to the mechanisms of connection and separation. Dry sandwich construction systems are therefore characterized by their ability to influence the environmental quality of buildings and of building processes (reduction of resource consumption and production of waste and polluting emissions, recovery and recycling of materials and components).

However, the spread of dry construction systems needs to relate to the reference context, in terms of the technological-productive framework and environment-climate aspects, so as to temper the general principles with specific solutions suggested by the context. This is the background of the research in progress within the Laboratory of Design and Survey of Architecture (Section of Architectural and Technological Design) of the Department of Civil Engineering of the University of Calabria concerning the use of sandwich construction systems in a warm-temperate climate, and in the Italian context in particular.

2. The industrialization for sustainable construction: relationships between phases and operators of the building process

The use of dry sandwich construction systems involves several subjects (designer, builder, manufacturer) and many phases of the building process (project, construction, management), revising traditional tasks and operating boundaries. The effects concern the necessary collaboration between designer and industry to improve the technological devices used in dry systems (which can be more or less complex and preassembled layers, connection systems, finishing profiles) (Greco 2017b, 29). Combinatorial rules and modularity of the sandwich solutions are new conditions of the industrialized approach that allow the safeguarding of the decisional autonomy of the designer, responsible for the appropriateness of the performance selected for the different components and technological elements. In this perspective, dry-sandwich construction systems are a useful tool for the development of sustainable industrialization in environmental, economic and social terms (Pizzi 2012). The correct design of the solutions defines the conditions to take into account the environmental climate conditions, to prefigure methods of transformation and demolition of the components, to reduce construction time and costs, to support a customization of the series production that considers the complexity of the contemporary building demand.

In the construction phase of the building process the implications related to the use of dry systems concern construction companies, engaged to manage resources and time, independently of climatic conditions and anthropic context. On the other hand, the reduction of the work on site does not correspond to an automatic simplification of the building site but requires the ability of workers to understand the systems and the relationships between their parts and the precision of the connections.

With reference to the management phase, an important aspect concerns the maintenance cycle of buildings. Dry sandwich construction systems ensure a greater degree of disassembly, separability, combinability and re-use of the parts. The disassembly of a technical element is conditioned by the assembly technique of its parts and, in particular, by certain conditions such as the reversibility of connections, the accessibility (the possibility of reaching the element to be dismantled without difficulty), physical and chemical separability (the possibility of separating the two connected elements by carrying out operations that do not compromise the chemical integrity and physical characteristics of the parts), the demountability (the condition that guarantees to operate the decomposition manually and with commonly used tools), the energy economy and times (Longo 2007).

The theoretical-methodological framework outlined relates to specific contexts in different ways, due to technological and production peculiarities. This essay concerns the Italian context, distinguished in the last 70 years by a debate on the evolution and industrialization of construction techniques, which began after World War II (Talanti 1978) and whose results have slowed down the industrialized systems (Poretti 1997). The causes of this situation are due to the technological backwardness of the Italian building industry, to the resistance offered by the masonry tradition in construction practice, to the hegemony granted to the reinforced concrete system as an expression of modern techniques. Dry-sandwich construction systems have suffered under these circumstances for decades, despite the lively experimentation carried out in Italy in the 1930s on dry construction techniques and materials (Greco L. and Spada F. in press). The slow evolution and transformation of the building process today still constitutes a circumstance that influences the diffusion of sandwich construction systems in Italy. This awareness of the specific Italian condition, evident above all in the less advanced areas of the country, such as the regions of Southern Italy, demands the participation of manufacturing and building construction companies in the experimentation of methods and processes aimed at the integration of dry systems in the construction practice of these areas. This, obviously, requires the specialization of production towards this sector of building evolution and it also necessitates the updating of skills in terms of architectural and engineering design and of construction-site management.

3. Dry construction systems in Mediterranean climate areas. Studies for the Italian case

As previously stated, the use of dry-sandwich construction systems presupposes the consideration of the climate and economic context of reference, in order to optimize technological performance in relation to the environmental framework and to maximize the correspondence between supply and demand in economic and technological terms. It is within this framework that research activity has been conducted in recent years in the

Laboratory of Architectural and Technological Design of the Department of Civil Engineering of the University of Calabria. The interaction of light construction systems, such as sandwich systems, with the environmental characteristics of Mediterranean areas with a warm-temperate climate, is a primary issue. It is worth remembering that a building with a correct energy behaviour is generally distinguished to favour the penetration of solar radiation in winter and limit its effects in the summer, to use the benefits of natural ventilation for the purposes of thermo-hygrometric control, to reduce thermal exchanges with the outside through the insulation of the building envelope, for the use of thermal accumulation masses (walls, floors) able to reduce internal thermal fluctuations during the day.

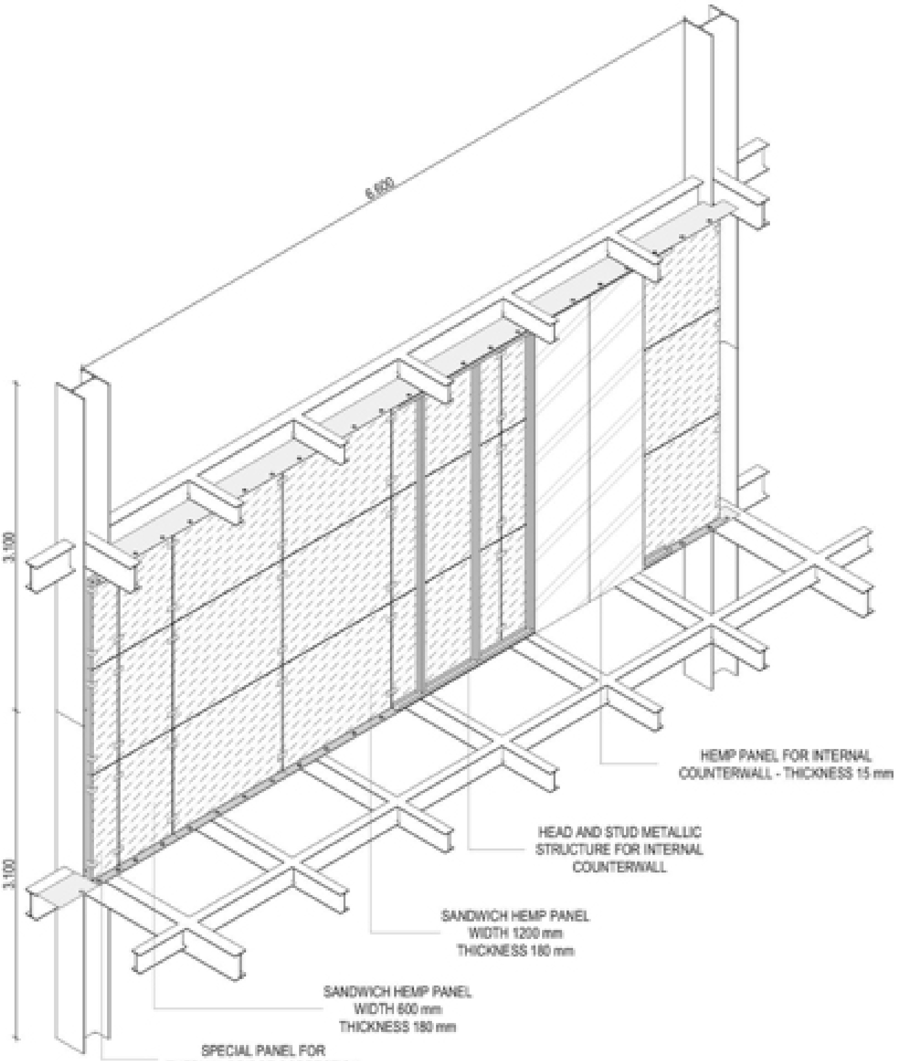

Figure 1 Scheme of the typical external wall of the Ac.Ca. Building construction system.

These attitudes of the building become more complex in temperate Mediterranean contexts, where the climate variability demands different environmental control solutions (defence from cold, protection from heat) and, therefore, complex design solutions (Rogora 2012, 6-8). These considerations, referring to dry construction systems, on the one hand, show the predisposition of sandwich solutions to support a selective and variable operation, with technological performances that can be modified and adapted to different energy needs during the year and/or day; on the other hand, instead, the lightness of these construction systems highlights critical issues related to the reduced thermal inertia of the solutions, and therefore the difficulty in regulating the

internal temperature of the rooms by the insulation of the building. The reduced thickness of walls, roofs and floors of the building, together with the thermo-physical characteristics of the materials typically used in dry construction systems, do not allow the control of internal thermal fluctuations in the hot season. In Mediterranean areas with a temperate climate, a relevant design aspect for the control of oscillations concerns the integration of thermal storage elements in the building envelope, in the floors and in the internal walls. In order to contrast the thermal inertia deficit of dry systems, it is possible to introduce "heavy" layers within the composition of the walls and/or floors. The reduced thermal inertia and the consequent need to correct the indoor conditions with plants marked the beginning in Italy of this type of solution from the 1930s, despite the experimentation of new insulating materials suitable for sandwich dry systems (Bertolazzi 2017; Greco and Spada in press).
Starting from this premise a working group constituted by Laura Greco and Roberta Lucente of the Civil Engineering Department and Natale Arcuri of the Mechanical, Energy and Management Engineering Department of the University of Calabria has studied an external wall associated with a steel structure for the construction of single-family residences with high environmental

performance in the Mediterranean area. Various highly insulated multilayer wall solutions have been studied, formed by an OSB sandwich panel with an insulating layer of wood fiber (120 mm) interposed and completed by another external wood fiber layer (75 mm). This system is combined with an internal gypsum wall that closes an interspace in which aluminum cylinders (d = 80 mm) filled with dry sand are placed. The sandwich panel ensures the requirements of thermal insulation and impact resistance, while the sand inserted in the cavity provides thermal inertia to the wall. A problematic issue concerns the integration of sand into the stratification of the wall (the insertion of sand in plastic bags was also considered). In any case, the effects caused by the mass of sand on the static behaviour of the wall and the mounting costs of the wall must be evaluated. Lastly, the solution is not effective for large multi-storey buildings, given the difficulty of assembly and construction times. As a result, in the study its use was limited to single-family storey houses.

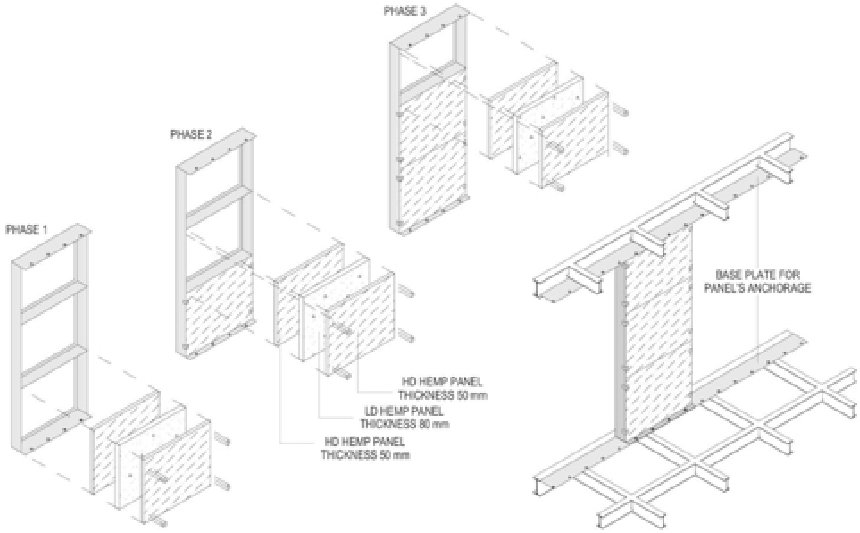

Figure 2 Assembly sequence of the external wall of the Ac.Ca. Building construction system.

The application of sandwich dry construction systems in a temperate area for the realization of multi-storey buildings is considered in the R&D project "Ac.Ca. Building. Progettare e Costruire in Sicurezza con l'Acciaio e la Canapa. Tecnologie Innovative per Edifici Ecosostenibili", concerning the development of an integrated system of typological and technological solutions with high flexibility for residences (collective, co-housing, mixed systems) and for advanced working spaces (co-working offices, fab-lab), destined to temporary users (for the typological aspects of the project see the paper of Roberta Lucente in this volume). The project seeks
to contribute to the formation of useful tools for the policies of public and private promoters for the construction and management of new buildings. The project, funded within the POR Calabria FESR- 2014-2020, is based on a partnership that commits a working group of the Department of Civil Engineering of the University of Calabria and the following companies: Metal Carpenteria, entrusted with the steel carpentry and components, Edil Canapa, which takes care of the components for walls, floors and thermal-acoustic insulation based on hemp and lime fiber, and Irenova involved in plant design. The partnership aims to involve the companies in the production of industrialized dry systems in a context marked by the hegemonic presence of concrete building technique. From a technological point of view, the project is characterized by the improvement of the use of steel in the residence sector and by the definition of an open construction system (with recyclable industrialized components that can be customized according to a mass customization process) that unites the steel framed structures with building envelope and partition components made mainly of hemp fiber products, that, so far, have been almost exclusively associated with reinforced concrete structures (Figs 1-2).
The methodological approach pursued combines an industrial research activity and an experimental development phase. The first step concerns the formulation of the typological repertoire (customizable by the client/user in its aesthetic-formal and functional qualities) and of the technological one (sub-systems and components of reduced number and organized in sandwich combinations). The second step refers to the construction of a housing unit prototype. The results achieved so far concern the definition of modular typological solutions and technological components compatible with all the design schemes and related to the combination of three sub-systems, of which two - structure and staircases - permanent, and the third - the building envelope - modifiable over time in its performance. The internal partitions are movable. The entire system is designed to be disassembled and largely recycled.

Table 1 External wall layers

Layers from the inside out	Thickness s (mm)	Conductivity λ (W/mK)	Resistance R (m^2K/W)	Density ρ (Kg/m^3)
Thermal conductance	-	-	0.130	-
Hemp putty	5.00	0.130	0.038	600.00
Hemp panel	20.00	0.063	0.317	275.00
Not ventilated cavity	75.00	0.440	0.170	1.00
Hemp panel	50.00	0.063	0.794	275.00
Hemp panel	80.00	0.039	2.051	40.00
Hemp panel	50.00	0.063	0.794	275.00
Hemp plaster	20.00	0.089	0.225	497.00
Hemp putty	3.00	0.130	0.023	600.00
Thermal conductance	-	-	0.040	-
Total	303.00	-	4.583	-
Transmittance of the structure U (W/m^2K)				0.218

In this paper are presented the partial results related to the solutions developed by the technological design team, coordinated by the author of this paper and consisting of the engineers Carmela Aversa, Barbara M. Laurato and Francesco Spada. The structural system consists of a square-modular steel frame combined with steel floors with double frame. The solution developed is based on the standardization of profiles and connections, on the optimization of transport, handling and assembly methods. The use of bolted solutions, combined with welded joints only in some cases, ensures the dismantling and reuse/recycling of the components. The system adapts to the typological schemes defined within the project, concerning single- family-story houses, multi-level residential complex and production buildings. In fact, the structural scheme constitutes an invariant geometric and technological grid on which different and changeable functional and dimensional configurations can be inserted, thanks to the system of building envelope and partitions arranged.

The major items of technological interest of the Ac.Ca. Building system in fact, concern the design of the building envelope and of the partitions. As anticipated, it is a matter of sandwich dry solutions, with a performance adaptable to specific climatic conditions and use, gradable and modifiable over time. In fact, the combination of the component parts of the building envelope and partitions allows its performance to be modulated by means of a limited number of elements.

The technological flexibility that characterizes the walls and floors of the Ac.Ca. Building system are qualities that are consistent with the variability of climatic conditions in warm-temperate contexts that stimulate different environmental control solutions (defence against cold, defence from heat) and which are compatible with different uses and changeable spaces (variability of demand, flexibility and adaptability of spaces).

From the point of view of the production and assembly cycle of the parts, and therefore of the interaction between project and production, the research objectives favour the combination of the specialized contributions of the companies involved, aiming at production process optimization. The production cycle in the factory concerns primary components (walls panels and thermal/ acoustic insulation panels based on hemp fiber and steel accessory elements) with a medium level of prefabrication, which can be assembled on site to create the necessary stratifications for the building envelope and partitions.

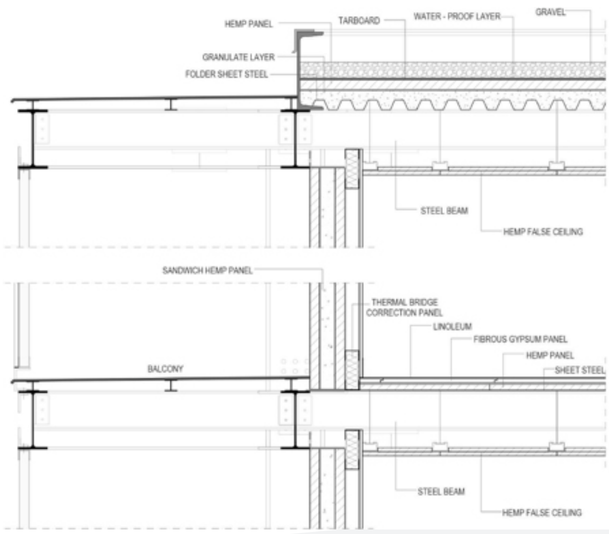

Figure 3 Ac.Ca. Building system. Typical section of a multi storey housing building.

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determining a negative balance of the emissions related to the production of the conglomerate used in building construction (compensating the behaviour of lime). The products used in building construction sector have low weight (about 300 kg/mc), high thermal-acoustic insulation and transpiration, and the good elasticity allows its use in combination with structural steel frames, as in the case of Ac.Ca. Building.

The wall of the Ac.Ca. Building solution consists of a sandwich panel made of hemp fiber and lime binder with an external finish of lime and hemp plaster and internal counter wall. The sandwich consists of two panels (50 mm) with intermediate thermal insulation layer (80 mm) formed by compressed hemp fiber mixed with natural binder (density 35 Kg/mc, U=0,040 W/m2K). The panel has a steel frame (4 mm) that allows its transport, movement and connection to the building structure. The internal wall, spaced from the outer panel by a gap (55 mm), is formed from fiber hemp components of the same type as the external ones, but of reduced thickness (20 mm), which is easily workable in order to integrate, where necessary, the installations. The external finish is a layer of plaster based on hemp wood and lime applied in several layers (25 mm). The studies conducted on a single-storey-family house (70 square meters) showed a thermal transmittance of the external wall U = 0.218 W / m2K and a phase shift of the thermal wave of 9 hours and 25 minutes (Tab.1).

The results achieved to date are of interest for the rationalization of the construction process and for the thermal performance. In particular, the Ac.Ca. Building wall contributes to expanding the solutions of highly insulated multi-layer walls typically used in dry sandwich systems, using materials with a good environmental profile, thanks to the presence of products based on hemp, with transpiration and thermal insulation requirements and a fair control of the thermal inertia value of the building envelope.

The partial prefabrication of the wall panel makes it possible to use different external finishes and to graduate the thermal performance of the building envelope and, at the same time, favouring a decisive reduction of work on site (limited to external finishing), and combining effectively with the steel structure (elasticity and lightness of the component).

Table 2 Roof layers

Layers from the inside out	Thickness s (mm)	Conductivity λ (W/mK)	Resistance R (m^2K/W)	Density ρ (Kg/m^3)
Thermal conductance	-	-	0.100	-
Hemp panel	40.00	0.063	0.635	275.00
Not ventilated cavity	284.500	1.880	0.151	1.00
Folded sheet steel	4.00	80.00	-	7870.00
Granulate layer	95.00	0.103	0.922	300.00
Water-proof layer	5.00	10.00	0.001	900.00
Hemp panel	50.00	0.063	0.794	275.00
Tarboard	5.00	0.500	0.010	1600.00
Water-proof layer	5.00	10.00	0.001	900.00
Gravel	125.00	0.700	0.179	1500.00
Thermal conductance	-	-	0.040	-
Total	613.500	-	2.832	-
Transmittance of the structure U (W/m^2K)				0.353

The external wall is set back with respect to the steel structure of the Ac.Ca. Building. This solution makes it possible to modify the stratification of the wall over time, varying the size or type of products used (i.e. adjustments for new technical standards, replacing products with new, more efficient components), without interfering with the steel structure of the building.
The continuity of the thermal insulation layer, inserted into the external wall and at the intrados of the floors, allows thermal insulation, greatly reducing the effect of thermal bridges and thus creating more stable indoor comfort conditions (Fig.3). This solution was preferred to the external thermal insulation composite systems to make the structure and the building envelope autonomous in terms of construction and management. Moreover, it also allows the aesthetical characterization of the two key elements of the Ac.Ca. Building system, the structure and the building envelope, highlighting them in the façade, thanks to the use of different materials. The multi-layer building envelope made with hemp panels of the Ac.Ca. Building system is completed by the roof (Fig.3). It is thermally insulated and is formed by the steel structure and folded roofing sheets on which a granular dry screed is placed, and then completed by the hemp and lime thermal insulation panel, the waterproofing membrane and a layer of gravel (Tab. 2).

4. Conclusions

The study on the use of dry construction systems in warm temperate areas, whose partial results have been presented in this paper, has so far been concerned with the analysis of general issues and aspects related to the organization of the building process and the compatibility of the technique with complex weather conditions. The design experimentation of the Ac.Ca. Building, referring to the Italian context, allowed us to define a flexible technological repertoire, to select components, materials and to define connection systems. The construction of the prototype of a housing unit (scheduled between May and June 2019) will allow the project choices to be verified. In particular, the aim is to verify the production and assembly sequence, the effectiveness of the connection techniques in terms of simplicity, safety and rapid construction and to verify the real conditions of internal comfort. These items concern, in particular, the process of production and assembly of the panels for the external walls, also in relation to the interaction between the phases linked to the construction of the metal frame and those relating to the production of hemp-based components, as well as to the execution of the external finish of the wall.

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Maintenance and assessment of environmental sustainability in buildings: a possible synergy between present and future

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Keywords: Maintenance, Environmental sustainability, Assessment tool

Abstract
"Shaping the Future of Construction" (WEF, 2016) is the title of a group of reports produced for 2016 World Economic Forum, concerning the new directions and orientations towards which the construction sector must place its attention. Seizing both the opportunities deriving from the digital revolution and the need no longer to postpone guaranteeing design and constructive quality over time, as well as the eco-efficiency of buildings and the saving of resources. An integrated approach in line with the contents of the EU Communication "Towards a thematic strategy on the urban environment" (COM, 2004-60) which oriented towards the adoption of tools for assessing the integrated energy performance of buildings to be applied from the design phase. Issue that, the experience in the joint working group of the Mediterranean University of Reggio Calabria and the University of Calabria for the drafting of the ITACA Region Calabria Protocol, has tried to transfer, in current practice; introducing them among the contents of the Area Evaluation E_Quality of the service. These aspects, with specific reference to Area E, differentiate and characterize the version of the ITACA Regione Calabria Protocol as a peculiar and distinctive factor. The principle underlying the choices related to Area E, is the awareness that it is important to design, build or renovate buildings in order to be sustainable, efficient and environmentally friendly. Likewise because these are able to guarantee and maintain over time the performance offered thanks to the opportunities offered by home automation and Building Automation Systems and Information Technologies.

1. Introduction and background
Sustainable development has long been recognized as a principle to be the foundation of human action. The attention of our society towards this binomial has slowly become a central issue since the 1970s (Report, 1972) and today it is a recognized priority. (Agenda 2030, 2015)
The guiding that now links sustainability and construction sector, leaves, therefore, both from the respect of natural resources and their conscious use, as well as from the protection of environment in its most extended meaning. According to this meaning some questions like hydrogeological and /or seismic safety, etc., are associated with problems of infrastructure and new and existing building heritage management. In this way, our urban centers represent a synergistic whole of opportunities and contradictions, common, albeit with different characters, both to small and medium-sized centers and to large cities; both in neighborhoods of new expansion and in highly historicized contexts. Widespread and recognized issues that are key issues in the context of sustainable development strategies. Aspects, which in turn need to come in with effective tools from which to derive good practices of intervention as well as of management.
"Shaping the Future of Construction" (WEF, 2016) is the title given to a group of reports, produced for the World Economic Forum in 2016, relating to the new directions and guidelines towards which, in a perspective of sustainable approach, the construction sector must pay attention. By seizing both the opportunities arising from the digital revolution and the no longer delayed need to guarantee savings in resources over the time, design and construction quality but also eco-efficiency of buildings.
Designing in an eco-efficient way, therefore, stands for optimizing the cost/benefit ratio of each project, suggesting for optimizing costs, the ability to find the right balance between human well-being, economy and ecology.
An integrated approach in line with the contents of the Communication "Towards a thematic strategy on the urban environment" (COM, 2004-60) of the EU Commission that, with reference to eco-efficiency, already in the early 2000s, oriented towards the adoption of assessment tools for integrated energy performance of buildings as from the design phase.
Essential in this direction the environmental assessment tools that allow certifying the energy performance of a building and its environmental impact. Developed for several decades, these tools combine appropriately chosen indicators with merit scores, thus obtaining a multi-criteria evaluation, through which it is possible draw up information document concerning the energy-environmental quality of building.
Among these: the LEED and BREEAM and the Italian ITACA and CASACLIMA systems.
There are many aspects related to the energy issues that have oriented and direct today a series of important provisions at both European and national legislative level, and European Planning in terms of sustainable development. They all sanction the direct connection between the design and execution aspects and the various issues related to building management and the maintaining of their thermo-physical qualities over the time. Moreover crucial, from this point of view, is the changeover from the evaluation of the only construction cost to the assessment of the overall costs that, with reference to the life cycle, also consider the costs of management, maintenance, demolition, as well as, in some cases, social and environmental costs.

In the scenarios briefly outlined, maintenance turns, if properly planned, from unavoidable burden into a factor of competitiveness, as potential "avoided cost". All this, also thanks to approaches directed towards the reversibility of construction; the use of innovative plant engineering technologies aimed at saving energy; the prevision of integrated IT systems for supervision and control.
In fact, the trend today is to create increasingly innovative buildings, with zero energy, reduced water consumption and maintainability. Maintenance have the task of guaranteeing building performance, functioning, full use of technological systems, safety and reliability requirements of building as a whole.
Maintenance, furthermore, gets in a more general context that introduces two further crucial aspects.
The guarantee of optimal management of the real estate assets also in terms of customer care, that is for positive use by users.
The need that the management strategies applied during the operation phase of building, meet criteria of greater dynamism than in the past, through the ever more conscious use of domotics and Building Automation Systems. This last aspect confirms the strong attention turned to the application of Information Technologies also to the planning and maintenance management.
Aspects, that expressed in scientific disciplinary field (Cattaneo, 2012), are confirmed both at standardization (CEN TC319 Maintenance and for Italy the UNI-Italian National Unification Body), and normative level (Legislative Decree 163/2006 implementing directives 2004/17 / CE and 2004/18 / CE, Legislative Decree 50/2016 implementing directives 2014/23 / EU, 2014/24 / EU and 2014/25 / EU).

2. ITACA Protocol_Calabria Region: Area E. Maintenance and evaluation of the environmental sustainability in the constructions
Assumptions, cultural, regulatory and legislative guidelines, those briefly outlined, that the working group, for the drafting of ITACA Protocol_Calabria Region, composed by researchers of Mediterranean University of Reggio Calabria and of University of Calabria, tried to transfer, in current practice, introducing them, in particular, in the contents of Evaluation Area E_Quality of service.
The whole form of ITACA Protocol_Calabria Region represents an important result in the field of Sustainable Building. The editing activities took into account both the general structure of the National document and the updates of the UNI PdR 13.1.
The work accepted the IISBE guidelines to promote the adoption of policies, methods and tools to facilitate the dissemination of sustainable building principles. At the same time, also, the objective of constantly developing and updating a methodology capable of combining the advantage of the use of a common international standard, the SBTool standards, with the possibility of its complete contextualization with respect to the single national and regional areas.
The fundamental principle of the SBTool and the ITACA Protocol is, in fact, the quantification, through a performance score, of the sustainability level of a construction compared to the typical construction practice of the referred geographical region, defined as a benchmark. This through the structuring of a frame-work at hierarchical levels - evaluation areas, categories and evaluation criteria - based on a calculation system that allows to express a "vote" - a weighted index - for each project or intervention examined, verifying their environmental sustainability.
The introduced method addresses the complexity of building design by describing the quality of some fundamental components such as the absence of polluting substances, natural lighting, sound insulation, reuse of rainwater, type of materials used for construction, energy consumption of buildings with the consequent reduction of gas emissions into the atmosphere, etc. Issues related to the environmental quality of living spaces that in this way take on increasing importance even in the absence of specific regulations on the matter.
With reference to Area E_Quality of service, the working group, of which the undersigned is a member, coordinated by Professor Grimaldi of University of Calabria and by Professor Lauria of Mediterranean University of Reggio Calabria, has dealt with the definition and structuring of the relative contents. Categories and Criteria have been borrowed from UNI PdR13.1, operating through appropriate critical assessments integrations and modifications of existing criteria and the introduction of new ones.
The Evaluation Area E_Quality of service, in the synthetic version of the ITACA Protocol_Calabria Region, is therefore currently divided into 5 (five) Criteria, organized in 3 (three) Categories.
The full version is instead composed of 8 (eight) Criteria, organized in 4 (four) Categories.

National Protocol	Calabria Region Protocol
	E.2 Functionality and efficiency
	E.2.1 Endowment of services
	E.2.4 Quality of the data transmission system
E.3 Controllability of the installations	E.3 Controllability of the installations
	E.3.5 B.A.C.S
E.3.6 Domotic systems	E.3.6 Domotic systems
	E.3.7 Integration of building automation systems in the building
E.6 Performance maintenance in the operational phase	E.6 Performance maintenance in the operational phase
	E.6.1 Maintenance of building envelope performance
E.6.5 Availability of technical documentation of buildings	E.6.5 Availability of technical documentation of buildings
	E.7 Social Aspects
	E.7.1 Design for all

Table 1. Area E. Comparison between National Protocol-UNI / PdR 13.1: 2015 and Protocol Calabria Region.
In red the criteria inserted in the synthetic version, in green those referred to the extended version proposal.

The aspects introduced by the research group differentiate and characterize as a distinctive factor ITACA Protocol_Calabria Region in confront of the National and the other regional versions.
Two are the main aspects that explain the relationship between maintenance and environmental sustainability assessment introducing important innovative features.
To focus and reaffirm the centrality of maintenance aspects related to building life cycle, through the adoption of a series of categories and criteria already present in the SBTool, the primal document of ITACA Protocol.
To direct towards the widespread use of Information Technologies and in particular of interoperability systems as innovative tools for information management throughout the completely building life cycle.
The basic principle at the proposal phase dealing with the new definition of Area E_Quality of service is the awareness that it is important to design, build and renovate buildings in order to be sustainable, efficient and environmentally friendly. Likewise, it is also fundamental guarantee and maintain performance over the time thanks today also to the opportunities offered by domotics, Building Automation Systems and Information Technologies
According to these premises, with reference to the synthetic and currently adopted version of ITACA Protocol_Calabria Region, Area E results structured into three categories. Divided in turn into criteria that, integrate each other, identifying as many useful questions to guide the design choices to the purposes of "quality of service" in the life cycle of building and of its parts, and to optimize the management procedures in terms of Facility Management.
Premises that have also orientated the proposal to integrate in the full version of the Regional Protocol, as well as in the Synthetic version, an additional Category (E.7 Social aspects) and a series of Criterion Sheets supporting and enhancing those already adopted.
All new criterions are strongly in line with the policies and strategies related to social-housing and co-housing (E.2.1 Endowment of services), turning attention to the weaker segments (E.7.1 Design for all) and in general to the need to increase the automated control relative to both energy saving in terms of safety and user comfort (E.3.5 BACS).
The proposed additions, in particular, respond to the needs related to the raising of life quality. Moreover, they identify, in an even more precise manner, the specificities of Area E_Quality of service and the possible effects that the application of the relative criteria can trigger in terms of congruity of the project with respect to the sustainability principles as introduced by the ITACA Protocol.
Three, therefore the issues focused by the whole categories and criteria of Area E and the relative contents.
The first question is the checking of building and components (structures, casing, home automation systems, etc.) performance, through the provision/efficiency of integrated Building Automation systems and home automation systems.
The second concerns the choice of maintenance strategies to be implemented.
The third concerns the availability of technical documentation as a tool for structuring and transmitting information functional to the management of the building asset.
In addition, with only reference to the complete regional version of Protocol, there is a fourth aspect aimed at ensuring the availability of additional services and external and internal accessory spaces for common use for improving life quality.
With reference to the various Categories, some of the contents that identify their specific characteristics are reported belong.
Within the category, E.2. Functionality and Efficiency, the work group made the choice to maintain Criterion E. 2.4. Quality of the data transmission system. It evaluates the appropriateness of the wiring system of the housing units for the purpose of data transmission for different uses, operating a series of changes relating to performance scale and scores.

The objective is to guide towards choices that, starting from minimum thresholds established by law, refer to quantitatively and qualitatively higher conditions and equipment directly connected to the diffusion of digital technologies.
Similarly, the category, E.3. System controllability, evaluates the possibility of adopting automatic control, regulation and management systems to optimize performance, also considering, through criterion E.3.7 Integration of building automation systems in the building, the possibility of activating structural monitoring systems for the purposes of seismic safety. By introducing in this way the possibility of being able to perform, at any time, and in real time, reliability checks of the structure during its operating life, evaluating anomalies and deviations of the safety coefficients and/or damage levels as a result of extraordinary events.
The category E.6. Maintaining performance in the operational phase, re-proposes the centrality of maintenance issues, with the goal of directing the designer towards the control and maintenance over the time of the expected performance levels of building and its components through the optimization of the management maintenance phase.
According to this, the choice to insert criterion E 6.1. Maintaining performance of Building envelop, modifying appropriately indicators and performance scales initially referring to the formation of surface condensation. The new indicators deal with the pre-established objectives for monitoring and maintenance over the time of expected performance levels and optimization of the management of the building and its parts in terms of Facility Management.
Furthermore, with reference to the same category, criterion E.6.5 Availability of technical documentation of buildings, assesses the presence, reliability and filing of technical-descriptive documentation, and also guides, in line with the most recent legislative provisions (Legislative Decree 50/2016 recepimento) towards using of interoperability systems (IFC ISO / 16739/2013). These systems set up as potential tools for the management and transfer of information between the various operators in the construction sector, also producing significant advantages and repercussions both in economic terms and in terms of process transparency according to the principles and purposes introduced by the Code of Digital Administration (Legislative Decree 82/2005 updated Legislative Decree 179/2016). Recepimento
The last integration refers to the category E.7. Social aspects. In a sustainable point of view, and according to an overall improvement of the life quality of end users, it responds by orienting towards integration in building of solutions that can guarantee everyone the accessibility and usability of building in all its individual units. Objective that generally directs towards a holistic approach that considers together both the aspects connected to the usability of the internal (private) and external (common) spaces, and the availability of services and equipment and not least security.

3. Conclusion

With regard to the basic contents and aims of Area E as just described, there is an important consideration related to the coming out of some critical issues and opportunities that certainly represent a future field for experimentation.
It is clear, from the scenarios introduced, that the definition of strategies to improve the energy performance of buildings must today necessarily meet with the tools that the digital revolution makes available.
With reference to the provision of a widespread presence of integrated Building Automation systems, the goal for the future is to optimize the efficiency of home automation systems and, in particular, where possible the monitoring of the behavior of the building over the time, with particular reference to the control of energy requirement and seismic behavior.
Moreover, the presence of innumerable devices (Television, Internet, Video CC, etc) connected to each other, makes strategic the sharing and protection of information, making it fundamental no longer just the transmission speed compared to traditional systems but above all the efficient and secure data transmission. It is important to be able to guarantee, within the building, an adequate data transmission system, a correct management and connection of the various devices, a structured cabling system capable of restoring reliability, flexibility, ease of management and convenience.
The opportunities given by the possible choices connected to the strengthening of the building automation systems also open up, in perspective, towards the hypothesis of a maintenance planning no longer based on the logic of the "failure occurred" intervention but oriented to its prevention.
While in the past, in fact, the concept of maintenance has generally been associated with modalities of "a posteriori" or corrective intervention, today we tend to privilege the preventive character and the economic benefits (avoided costs) connected to it.
Strategy that involves new methodological approaches and new organizational and operational forms; that requires precise knowledge on the phenomena of durability of the construction elements and on the various factors (physiological and/or pathological) that can determine or favor conditions of physical, functional or technological obsolescence of the building. The diagnostic tools and techniques for detecting the degradation or failure state and/or the monitoring and control of the operating status constitute the first resource for maintenance planning. Condition that reintroduces the necessity and the importance of the opportunities deriving from the use of Information Technologies and in particular of interoperable information systems such as BIM methodologies. Among the objectives connected with the definition of BIM model for Facility Management there is the management of the information gathered from the design and construction phases or detected as built-in data for being available for maintenance operations. In fact, the effectiveness of Facility Management activities depends on the accuracy and accessibility of the data provided.

Another fundamental aspect is the integration between the sustainability assessment protocols and the BIM model. They all are based on an integrated collaborative approach that allows an automatic and continuous updating of the data.
The future perspective is therefore in the possibility of applying modern information technology both to the drafting of environmental sustainability assessment protocols and to maintenance, to be able to monitor year-by-year the service life of building, refining through computer systems, the operation of equipment, components and systems and the knowledge of their behavior in use. Availability of constantly updated, transmissible and sharable data allows the introduction of the predictive aspect of maintenance, connected to the time variable. An aspect that in turn allows the improvement of the efficiency of systems and components through the long-term forecasting and control capacity.

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