Ernesto Antonini, Jacopo Gaspari

Architectures for Next Generation EU Cities

Challenges, Key Drivers, and Research Trends

Ricerche di tecnologia dell'architettura

FrancoAngeli

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diretta da Giovanni Zannoni (Università di Ferrara)

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Table of contents

Section 3 - Adapting systems and components to Next Generation needs

12. A multiscalar approach to renovate the building stock towards a resilient and adaptive built environment

Fabio Conato[1], Valentina Frighi[1] and Laura Sacchetti[1]

[1] Department of Architecture, University of Ferrara, Ferrara, Italy

As most of the built environment consists of low-performing buildings, to achieve the European twin transition, it is essential to improve the *flexibility of existing buildings* towards variabilities of context in order to optimise the performance in terms of sustainability (minimising consumption and maximising efficiency) and resilience (enhancing preparedness against unexpected events). The definition of a comparative approach to assess the adaptability of the existing stock allows to foresee the extent and feasibility of the renovation and to predict its expected impact. Through the integration of multiple scales, ranging from urban characters to construction materials, the proposed *multiscalar approach* can identify strengths and constraints of the existing for the deployment of compensation strategies aimed towards the accomplishment of the overall desirable level of resilience. This conceptual framework, structured as a comparative matrix, is conceived to orient and guide the regeneration of the existing building stock according to innovative and adaptive solutions.

12.1. Introduction

In the urgency to drive cities towards a more sustainable and resilient future, multiple compelling reasons prompt to believe it is essential to take action to improve the performance and efficiency of the existing building stock. Most of the operating buildings are old and need upgrading: over 85% of the EU building stock was built before 2001 (EU, 2020a), whereas in Italy, there are over 1.504.711 buildings which date as far back as prior to 1991, accounting for 78% of the overall stock (SIAPE, 2021).

Such a large number of unqualified buildings has led, in the past few years, to a rising interest towards the renovation of the existing stock, promoted on the one hand by the European and national directives and, at the same time, embraced by the construction sector through increasing investments (CRESME, 2021).

As for now, the communitarian and national issued policies and actions have addressed the primary environmental consequences of the old building provision, as most of it is scarcely efficient and highly demanding, resulting in the 40% of EU energy consumed by the building sector and 36% of energy-related GHG emissions (EU, 2020a). However, the major share of the existing building stock has also shown to be obsolete, inadequate and unsuitable to respond to the specific functional and spatial requirements defined by their intended use (Bellomo and Pone, 2011), especially under the circumstances of the latest pandemic emergency.

The most recent trends show an increasing need for "temporary" spaces, available for short-term functions, accelerating the obsolescence and shortening the lifespan of buildings and technologies (Lavagna et al., 2020). On these grounds, the reversibility level of the existing building stock plays a significant role in ensuring the possibility to adapt and readjust according to unsteady and unpredictable circumstances. In the thus outlined scenario, it becomes essential to consider that the latest investment programs for the renovation of the existing building stock should be taken as a great opportunity to improve and optimize the building performance not only in terms of sustainability, minimising consumption and maximising efficiency, but also to optimise the resilience of the built environment, meaning the possibility to adapt to the variability of context and demands, while enhancing preparedness against unexpected events.

Therefore, this contribution aims at providing a *conceptual framework* for the further development of *a multi-criteria support tool*, suitable to assess the adaptability of the existing building stock to be renovated towards a more flexible and adaptive built environment.

The following sections intend to build a brief state-of-the-art concerning traditional and current approaches towards renovation and to convey the conceptual framework for the decision-making support method through the introduction of a *comparative matrix*, conceived to orient and guide the regeneration of the existing building stock, according to innovative and adaptive solutions. Further discussion concerns the future development of the proposed multiscalar approach.

12.2. European and national renovation trends

12.2.1. European and Italian regulatory context

As already stated, the latest trends driving European policies towards urban regeneration take into great consideration the renovation of existing buildings (Serrano-Jiménez et al., 2020). EU directives on this matter, so as Italian national legislations, follow a common path: they aim at achieving better building energy performance through specific renovation actions (STREPIN, 2020), as energy efficiency is essential to reach the European targets, set for 55% emission reduction by 2030 compared to 1990, thus 60% buildings' GHG emission reduction and 14% final energy consumption decrease (Climate Target Plan 2030) (EU, 2020a).

The so-called Renovation Wave has been introduced to meet this ambition, recently leading to the activation of policies and actions directed towards reducing the environmental impact of the building sector. This generalized approach operates for the upgrade of the regulatory framework, introducing new and more appropriate funding instruments to drive sustainable development at different scales.

Just to mention a few, the EU's Recovery and Resilience Facility, known as the NextGenerationEU, allocates an unprecedented amount of resources to accelerate the renovation process and is complemented by the Cohesion Policy and other support funding sources, while strengthened by the implementation of attractive private financing thanks to the Renewed Sustainable Finance Strategy (EU, 2020).

At the local level, European states are requested to comply with the Community directives by defining the National Recovery and Resilience Plans (NRRPs). Some of these funding instruments are dedicated to the housing stock, while others mainly target public and less energy-efficient buildings, as "the objective is to at least double the annual energy renovation rate of residential and non-residential buildings by 2030 and to foster deep energy renovations" (EU Renovation Wave, 2020b, p. 3).

In general, in Italy, the National Energy Strategy 2017 sets specific goals, that are much closer to achieve for the residential sector: the expected achievement of such objectives in 2020 was 172,5% – in contrast with the

66,6% for the non-residential sector (ENEA, 2021) – hence driving the expected renovation increase for the residential sector in the next decades to get lower than the non-residential.

12.2.2. Current renovation approaches

At the European level, the latest discussion on the building stock involves "deep renovation". Although this topic is soaring in the European research agenda, this term still needs to be fully legally defined (BPIE, 2021), as in the past decades, it has been interpreted in various ways.

Through this definition, the EU generally describes renovations attaining a significant (over 60%) energy efficiency improvement (EU, 2013), thus ascribing deep renovation to substantial climate-mitigating interventions. Nowadays, the average of what is considered the EU deep renovation rate is as low as 0.2% – just a small proportion of the overall occurring retrofits (BPIE, 2021) – as the effort undertaken to its application is remarkable in terms of costs, time and resources (Fawcett and Topouzi, 2019).

What the EU Commission does define is "major renovation", set by the Energy Performance of Buildings Directive as "the renovation of a building where: (a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25% of the value of the building, excluding the value of the land upon which the building is situated; or (b) more than 25% of the surface of the building envelope undergoes renovation" (EU, 2010, Article 2). As highlighted by this definition, the indexes to identify the different types of renovations are set to be the percentage of building envelope and technical systems involved by the intervention, hence exclusively considering energy efficiency parameters. Consequently, other levels of renovation can be defined through the amount of Primary Energy (PE) savings (EU, 2019):

- medium = PE savings from 30% ≤ 60%;
- light = PE savings from 3% ≤ 30%;
- below threshold = PE savings <3%.

In line with these criteria, the Italian legislation articulates the definition of the intervention types according to the energy efficiency of thermal appliances and the percentage of the implicated building surface area: exceeding the 25% of the building envelope involved in the retrofit leads to second level major renovation, while overstepping the 50% results in a first level major renovation action. [*Ministerial Decree 26/06/2015 "Requisiti Minimi", Annex 1. The intervention types are classified as follows: 1) new buildings* *(including demolition and new construction and significant extensions); 2) major renovations: 2a) first level = involves over 50% building surface area and thermal appliances re-placement/improvement; 2b) second level = involves over 25% building sur-face area and might entail thermal appliances replacement/improvement; 3) energy upgrading = involves up to 25% building surface area and might entail thermal appliances replacement/improvement.*]. On these grounds, what comes to light is that the definition of the renovation "level" is always energy-centred and set according to the extent of the environmental impact reduction.

12.3. The conceptual framework for the multi-criteria support tool

Besides this vision, which traces back to the definition of the European goals of the Green Deal, a new awareness has arisen within the pandemic context, bringing into sharper focus the need to dispose of flexible and adaptable spaces for swiftly changing functions. Both the public domain, particularly referring to healthcare facilities and crowded public spaces, and the residential sector have proven to be functionally unprepared to unexpected demands.

To ensure an effective response to such considerations, it appears then necessary to improve the systemic adaptability of the building stock, according to the emerging need for flexible and resilient operational spaces. Considering the great potential given by future renovation pathways, but also the new and challenging tasks, it is of utmost importance to reckon that the improvement of energy efficiency within building performance is just one of the various issues to be tackled with renovation: designers, indeed, are challenged to look upon more holistic approaches, considering functional adaptability and performance indexes alike.

The current financial circumstances offer a unique opportunity to reconsider and rethink the role of design in the renovation, not only as a way to reduce the environmental impact of the building industry, but also to upgrade and modernise the building stock to meet future needs (EU, 2020b). In the past decade, literature on this matter has registered extensive discussion on support methods for decision-makers interested in renovating the existing (Nielsen et al., 2016).

The analysis of those methods highlights that much has been said about sustainable approaches to renovation and that the debate has almost always targeted the environmental impact factors, climate mitigation and carbon neutrality goals of the action. Some research studies have tackled the topic through multi-criteria methods, including investigation parameters on accessibility, behavioural analysis, thermal comfort or structural and fire safety (Serrano-Jiménez et al., 2020). However, the literature review underlines that the so far conceived tools need to be implemented in order to additionally involve more substantial discussion on the multidisciplinary variables that will be the design focus in the next few years, especially because of the great diversity of each project, which demands precise response to how the requirements can be implemented in the design (Konstantinou, 2015).

Thus, current research about renovation should not underestimate other significant elements: to actually fulfil the paradigm shift towards a considerably more resilient built environment, it is necessary to fully leverage the potential of a renovation wave in terms of co-benefits, namely, it is required to endorse an integrated approach (EU, 2020b), capable of merging energy performance, functional, spatial and fruition factors, while exploring social, accessibility and safety aspects, including also digital and smart technologies. In addition, these comprehensive tools should be developed through simplified models, in order to be flexible and meet the potentially changing needs without resulting outdated (Nielsen et al., 2016); these tools should specifically target architects, as the decisions concerning the upgrading of existing buildings are normally set in the pre-design phase; instead, architects are often reluctant in adopting them, assuming that such tools are non-user-friendly (Konstantinou, 2015).

12.4. A multiscalar approach to renovation for a more flexible built environment

To tackle the issue of renovation through the implementation of resilient design strategies, a possible solution could envision a multiscalar and multi-criteria approach to assess the adaptability of the existing building stock, to be refurbished through flexible solutions, thus providing useful information in the decision-making and early-design phases. As a preliminary support tool, such comparative approach could serve the purpose, on the one hand, to evaluate the feasibility of the renovation actions, while predicting desirable design solutions and, on the other hand, to foresee the expected impact of the project in providing high levels of flexibility. Both complementary parameters, when analysed in combination, could offer a perspective on the success of the visualised interventions, informing and guiding decision-makers towards the most effective and appropriate choices.

12.4.1. Proposed methodology

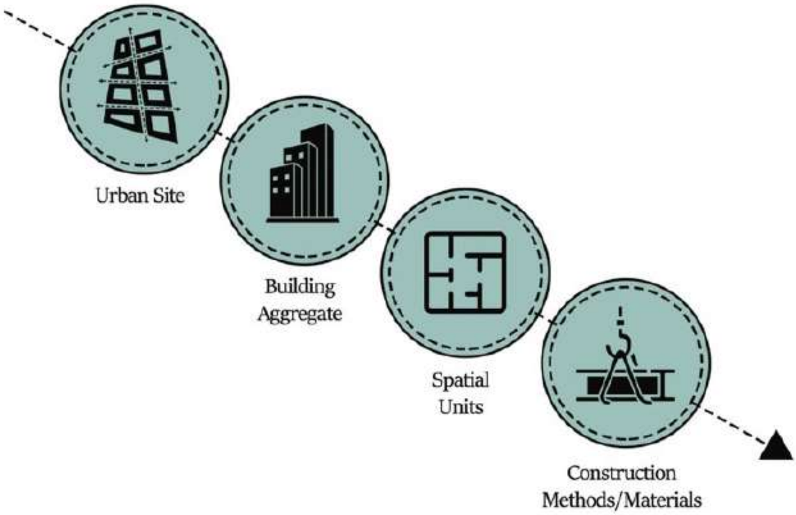
The proposed approach takes into account multiple criteria and scales, in order to convey a complete inspection across the big picture of the renovation actions. Gaining experience from previous research activities [*conducted within the Department of Architecture of the University of Ferrara, focused on the evaluation of the adaptability of the building stock to be converted, especially in relation to territorial healthcare facilities*] the investigation is carried out through the following scales (Fig. 12.1):

- Urban site. The building sustainable and resilient behaviour is deeply affected by the urban context, intended as the geographical and climatic region, along with environmental and urban factors (such as urban presence of greenery, urban fabric, urban density) and social, cultural and historical values;
- Building aggregate. The flexibility outcome of the planned renovation intervention is closely related to the building typology, distribution scheme, structural system, that have to be thoroughly analysed at a global scale;
- Spatial units. At this scale, the environmental (lighting, thermal, hygrometric and acoustic) characters are reviewed, addressing the overall users' comfort; in addition, considering dimensional and spatial factors is essential to evaluate the suitability of the existing distribution to generate internal spatial reconfigurations and correspondingly achieve the flexibility expected rates;
- Construction methods and materials. Deepening the focus, this analysis is aimed at identifying the range of possible interventions allowed at the executive scale, to be operated on the existing.

Given the compelling challenges involved when operating on the existing building stock, the proposed multiscalar approach allows for the accurate identification of strengths, weaknesses and constraints of the existing at different levels.

This building diagnosis is relevant to understand at which scale the assets and the major criticalities are, in order to establish where to direct the renovation actions to maximise their efficiency (avoiding fields with potential limitations) and how to undertake the deployment of compensation strategies aimed towards the achievement of an optimised and balanced outcome, ensuring the accomplishment of the overall desirable level of resilience. In other words, once the drawbacks and advantages of each project-site are exposed, it becomes possible to mitigate the first by leveraging the latter, addressing the most "elastic" scale accordingly, to attain the desired building performance. For instance, if operating on a protected building with extremely restrictive constraints on the façade layout (building scale), actions intended to rearrange the inner layout would be a more viable option (spatial units scale). Once the feasibility and potential of a specific site have been assessed and the most "ductile" scales have been selected, the following steps move towards the definition of a *comparative matrix* – a diagram that can incorporate, combine and manage sets of complex data – providing information about the actions to be operated on the buildings, through specific technical solutions, in order to meet the initial goals.

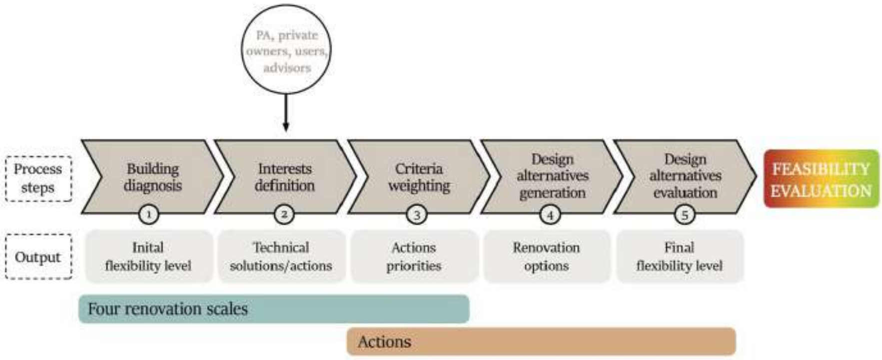
Fig. 12.1 – Four different scales to be investigated through the proposed approach.



Source: Elaborated by the authors.

For each of the predefined working scales, the matrix could propose a specific list of applicable and congruent actions, suggesting the most feasible intervention options. Examples of such actions could comprise windows replacement, roof renovation, electric installations, addition of vertical connections and installation of shading systems. These specific actions could be sourced by categorising the existing building stock on the base of equivalent parameters; for instance, these categories could refer to the geographical location, extent of damage, new intended use, construction method/materials and building typology and, more in general, can be established in relation to the subjective interests of the involved actors, users or decision-makers, should they be architects of professionals within the building industry, public administrations or private owners. Once the main interests have been defined, the respective actions should be analysed at the different scales to understand if any of them, and which of them, should be prioritised. Should this be the case, the criteria weighting process could set preferences according to the more favourable working scale by associating quantitative and objective criteria to measurable values (such as numbers or symbols) (Fig. 12.2).

Fig. 12.2 – The proposed process steps towards the feasibility evaluation of the renovation options.



Source: Elaborated by the authors.

Moreover, the applicable actions should be grouped into different types, ranging from the most extensive (generating the optimal flexible/reversible outcome) to the least extensive (adapting the existing to the current needs/codes without compromising the existing with major interventions), through four different intervention "intensities": minor, moderate, significant, major. As a consequence of this scheme evaluating the intensity of each action, in addition to the preferable working scale and the possible solutions – based on the subjective selected parameters – the proposed tool can offer feedback information about the predictable final level of flexibility: according to predefined weighting criteria, each "action intensity group" could be linked to a specific value that would add up to the final score, informing the decision-maker about the potential outcome of the renovation, referring to pre-set flexibility goal thresholds.

If the overall score does not exceed the minimum predefined standards, the identified actions are not sufficient to achieve a satisfactory reversible intervention, and are eventually to be considered unfeasible or barely feasible. The user should therefore step back to the initial stage and reconsider the selection of more extensive renovation actions.

12.5. Conclusions

The present contribution aims at building a theoretical framework for the development of a multiscalar approach to the renovation of the building stock, towards a resilient and adaptive built environment. Too often, indeed, the poor compatibility between plans and changing context leads to the demolition and replacement of buildings, instead of pursuing the attempt to flexibly rearrange them. On the contrary, it occurs that a building still in use after 50 years, albeit for a different purpose from the original, stands next to one 30 years younger, that has to be demolished because this happens to be cheaper than adapting it to the new demands. Noticeably, something is going wrong in harmonising design with programmatic constraints.

Because of the natural inclination towards efficiency – in the limited sense of doing the minimum to comply with the brief – the match between design and programme may become too perfect, leaving no margin for changing either, so that it is necessary to completely demolish and rebuild the existing (van Hinte et al., 2003). The proposed tool indeed, laying the foundation for its further implementation, provides useful information that could support the decision-making of renovation strategies through the creation of what-if scenarios.

These alternatives would allow, on the one hand, the organization of existing measures according to the state of the object of intervention, and on the other, their comparison and qualification in relation to the final goal.

The systematic compilation of renovation actions, through their organisation within a matrix, can help to acknowledge the available options and support choosing or rejecting them, according to the different application scale and involved parameters. In this way, the beneficiaries of this tool are provided with practical information in the early stages of design, rather than after most decisions have already been made, which is often the case in the current practice. However, it has to be said that the proposed approach is neither to generate ready-made answers nor to suggest complying solutions, especially if considering the uniqueness of each project.

Rather it aims at providing a holistic approach contemplating different application scales, and the related parameters, that can influence the "resilience level" of a building, combining actions and variables to facilitate and support design interventions during the whole decision process.

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Cities are facing unprecedented challenges driven by different forces. On the one hand the ever-increasing effects of climate change are impacting on the urban microclimate and environmental balance, on the other one social, political and economic issues are influencing the living conditions, the accessibility to primary services and resources, as well as growth opportunities for the younger generations.

The rise of a social awareness regarding these topics suggests how relevant scientific-based evidence could be and calls for additional efforts to bridge the gap between science and society, in order to stimulate a collective responsibility and due actions.

The complex interaction among these factors inspired a forward-looking reflection not only on key drivers of change but also on possible future trends for research assuming an interdisciplinary and multiscale perspective. The book collects several experiences from different contributors working in many contexts and countries, but sharing the same projection to the future. Four key priorities are addressed: the resilience to climate-related events and impacts, the energy issue with reference to both the advances at building level and the role of end users, the capacity to adapting components and systems to emerging needs, and the adoption of assessment and simulation tools for improving the design capacity within a circular system perspective.

The book provides therefore insights, experiences, approaches to deal with current and especially with future transition processes which are expected to shape the cities of tomorrow. Thus, its ambition is not to provide definitive answers but to become a starting point for exploring promising research pathways for the next generation cities.

Ernesto Antonini is an Architect, PhD and a Professor of Architectural Technology at the Department of Architecture of University of Bologna. His research interests deal with process and product innovation trends in buildings and related supply sectors, tools and strategies for energy optimization, renewable energy sources in the building sector including barriers to diffusion, dissemination measures, definition of criteria for impact minimization and for the selection of better integrable RES technologies in existing buildings. His findings and outcomes are internationally published.

Jacopo Gaspari is an Architect, PhD and a Professor of Architectural Technology at the Department of Architecture of University of Bologna. His research fields include design strategies for urban regeneration, building renovation and energy efficiency, behavioural implications in energy transition, climate responsive building design, urban transition to low carbon solutions, strategies for climate change mitigation. His work on these topics is widely published at national and international level.

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