



# ITRUVIO

International Journal of  
Architectural Technology and Sustainability



## CIRCULAR ARCHITECTURE

Interview to **BENEDETTA TAGLIABUE**



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# Editorial

The contemporary scenario gives an increasingly higher complexity to the project of the built environment, determined by the quantity of factors involved and by the crisis that afflict them. Architecture has always followed the evolution of contexts and people, but today it is called upon to absorb radical changes that do not only concern formal or functional aspects but the survival of the planet and of men. If *firmitas* remains an invariable factor, even if it acquires complexity for the risks given by natural disasters, *utilitas* and *venustas* are destined to broaden their meanings. In fact, today the usefulness of a building is not only directly proportional to the possibilities of using it immediately but also compared to the possibilities that it can offer in the future (considering the conditions of the economic and health crisis). The concept of beauty of architecture has also overcome formal issues to be realized through the harmony between building systems, natural cycles of ecosystems and the quality of human life. It is no longer enough giving or giving back architectural quality to the building but it is urgent to seek a 360° quality, reconsidering the relationship between nature and buildings. The current reality configures particularly articulated demand frameworks, to whom rather than deciding if to demolish, transform or preserve we have to 'design' sustainable development processes of building systems and contexts as a whole. In the design activity, besides having to consider with particular attention requirements such as adaptability and flexibility because they are fundamental to prolong the life of buildings, it is necessary to bring the concepts of reuse and recycle back to the works to be carried out (both for new and existing buildings). Therefore the project can no longer only respond to the intervention needs of the present but must provide a predisposition to the evolution processes to satisfy future needs. Architecture should not only be built to become a real estate but it must also be built to externalize the character of a "built organism" and combine with natural cycles. The material-constructive choices should also consider among the available resources, those that can give not only excellent technical results but also advantages for people and for the planet. In this direction, the problems resolution can become the trigger for sustainable development processes if it is possible "to put into operation" the resilience capacities of places and individuals.

The writings in this issue of Vitruvio (*Circular construction, technology and architecture*), decline in different directions the need to find new and shared design approaches, dictated by the just described scenario. The issue of circularity is faced, both in material terms (products and technical solutions) and in immaterial terms (performance of the spaces), at different scales and contexts.

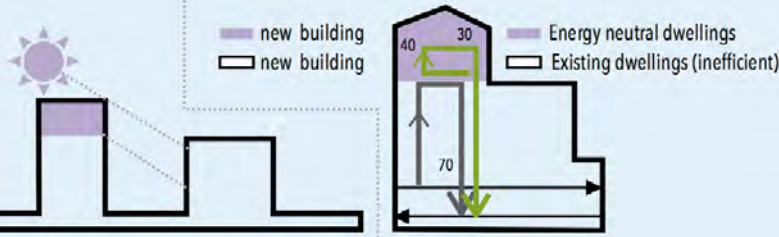
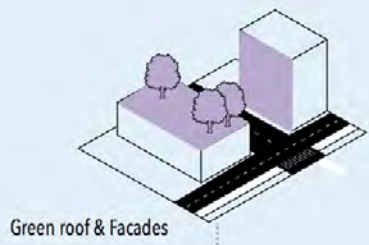
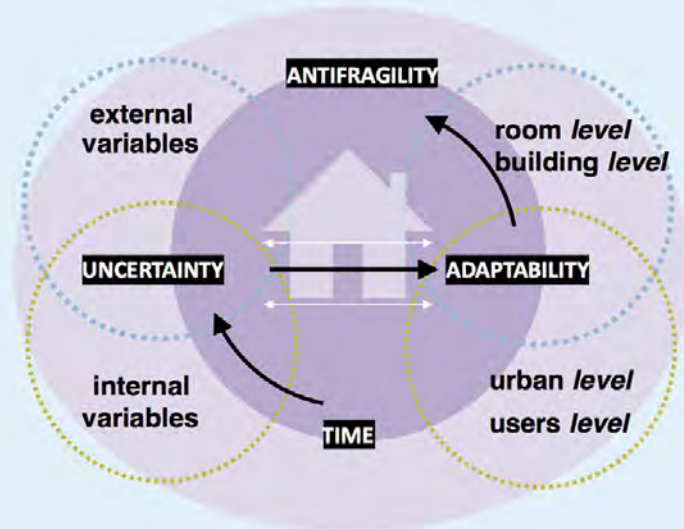


Reflections are proposed on the relationship between the sustainability of the built environment and the ability of building systems to meet evolving needs. The circularity of the building is also addressed, presenting patented technical solutions able to simplify and speed up assembly and disassembly operations, to promote systems that can be reused and change location, with particular reference to emergency situations or the living needs. With this in mind, the project of adaptability becomes the key for defining and implementing resilient solutions. The articles also offer a critical reading of the (linear) architecture built before the development of the circularity concepts, to focus on the actions necessary to achieve a performance adjustment of public housing. Still with reference to this type of building, reflections are developed and studies are presented on the theme of regeneration aimed at achieving adaptive solutions to the scales of individual environmental units, accommodations, buildings and public spaces. Then they present material-construction solutions oriented towards circularity that is to trigger development processes through a project aimed at sustainability, adaptability, disassembly and recycling. Characteristics of sustainability are also found in some examples of traditional Turkish architecture which reveal excellent functioning in terms of comfort (temperature, ventilation, natural lighting) with consequent minimum energy consumption. For these buildings, analyses and developments are presented to re-propose the principles of sustainability in a new circular architecture. Another central issue of circular architecture that is dealt for the abandoned buildings and networks (as a result of processes of deindustrialisation), such as the disused railway heritage. Building reuse therefore becomes an important issue and acquires new roles as it allows “on standby” resources to be put back into operation and to design architectures that hopefully should never go “on standby».

The articles contained in this issue bring out various aspects and lines of research that can be further investigated and expanded to promote a complete development of the circular architecture concept.

Donatella Radogna

# CE design process



# Circular economy strategies for adaptive reuse of residential building

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**Abstract:** The paper deals with the issue of the regeneration of the existing building heritage by framing the problems that characterize the relationships between users-buildings-neighbourhoods in a circular vision. Circular Economy concepts are well suited to the building and construction sector in cities. For example, refurbishing and adaptively reusing underutilized or abandoned buildings can revitalize neighborhoods whilst achieving environmental benefits. A systematic review of the literature and case studies has led to the identification of three areas of action of the CE in the regeneration of the built environment: a Macro-level (the public space), a Micro-level (the single component), a Meso-level (the building). However, the traditional approach of carrying out timely interventions aimed at responding to individual problems, be they of a structural, energetic, functional nature, relating to the building, the context or the single component is not entirely effective in terms of reformulation of the building characteristics. In this perspective, the paper suggests strategies of circular regeneration of residential buildings through adaptive solutions at room level, home level and urban in pursuit of human wellbeing.

**Keywords:** circular economy; circular regeneration; adaptive regeneration; adaptive reuse; built environment; building design.

## 1. Introduction

Circular economy strategies seek to reduce the total resources extracted from the environment and reduce the wastes that human activities generate in pursuit of human wellbeing. Circular Economy (CE) concepts are well suited to the building and construction sector in cities, in particular, to the adaptively reusing underutilized or abandoned buildings (extending their useful lifespan). The CE has multiple benefits that extend beyond the project itself to the surrounding area. It can revitalize neighbourhoods whilst achieving environmental/social and economic benefits.

In the 1990s buildings were responsible for 40% of the material and a third of the energy consumed globally (Rees, 1999). Two decades later, the construction sector is still the world's largest consumer of raw materials and accounts for 25e40% of global carbon dioxide emissions (WEF, 2016). According to the UN-Habitat 2016 World City Report, 70% of urban land is occupied by housing. According to the United Nations' 2018 estimates, fifty-five per cent of humans now live in cities (United Nations, 2018). This is an upward trend in many countries (Habitat, 2016). However, since the mid-1950, the total area of urban areas in the EU has increased by 78%, compared to population growth of only 33%.

Thus we are witnessing an evident acceleration in the enlargement of the dimensions of cities; this modality of expansion, defined by experts as the "occupation of decoupled land"<sup>1</sup> (Bonara, 2013), is attributable to profound changes in lifestyles and to the obsolescence of housing, which is no longer capable of fitting in with new paradigms of contemporary housing rather than to population growth.

The United Nations Sustainable Development Goal 11, "Make cities and human settlements inclusive, safe, resilient and sustainable", includes the target "Strengthen efforts to protect and safeguard the world's cultural and natural heritage" (United Nations, 2018). Likewise, the Urban Agenda for the European Union established in 2016 incorporates cultural heritage as a major aspect of urban development. Although not all cultural heritage buildings are located in urban areas, the majority of buildings that adaptively reused in future are concentrated in cities (Girard, 2017). They are critical to sustainable urban development. The above shows that there must be a shift from the tendency towards the indefinite and relentless expansion of cities (Latouche, 2012) to that of urban renewal, not only, as often happens, of the historical town centres but also of the parts that have grown up in more recent times, of those early suburbs that have been subsumed by the rapid expansion of recent decades (Landolfo et al.,

2013). By framing the problem in a circular vision, it is, therefore, apparent that urgent and critical action must be taken to slow down this phenomenon and reverse the process of urban expansion into a process of urban regeneration to promote sustainable urban development.

## 2. Circular economy for Sustainable urban development

In an age of sustainability it is important that we maintain an understanding of the broader characteristics which make places sustainable over the longevity of time and the CE can be a new and compelling strategy to achieve sustainable habitats and buildings. Time as a design contingency relies on placing architecture in context, making it susceptible to its temporal reality and biggest fear - change. In 1987 the Brundtland report, "Our Common Future", broadened the concept of sustainability to socio-economic aspects and the balanced development of People - Planet - Profit. In this vein, sustainability is seen here as the objective of ensuring a substantial level of environmental, social and economic quality in the future. This objective of balance must be confronted with the change, vulnerability and fragility that characterizes today: People (The population ageing, the crisis of the family structure, the temporary use of the city and living spaces, the socio-cultural mixité and the change in preferences regarding well-being), Planet (urban heat island effect, atmospheric pollution, landslides, drought, water scarcity, violent and short-term precipitation) and Profit (changes in employment relationships, the crisis in the labour market, the advent of new low-cost communication technologies and ever faster mobility on a global scale) (Fig. 1).

Designers tend to ignore these temporal aspects focusing in a static idealized object of perfection. Their work is based on descriptions and design hypotheses concerning the life of the building, considering future situations as certain, invariable, and attributed to a specific moment in time, thus leaving out uncertainty in planning during its elaboration and the uncertainty of future requirements pertaining to its useful life. This design approach is analogous to the linear supply chain that processes natural resources into products that support human wellbeing. Consumers use these products (e.i. objects, buildings etc.) and subsequently dispose of them as waste.

A reaction to this way of operating is the encouragement of a sustainable approach through a more dynamic and long-term understanding of the built environment. How then, does one design for its time?




	Indicators of sustainability			Barriers to CE		Benefits of CE
<b>PEOPLE</b> 	<b>SAFETY</b> traffic potential flood casualties external safety	<b>LIVING ENVIRONMENT</b> demographic diversity satisfactory residential environment insulation / air ratio cultural heritage presence of facilities	<b>HEALTH</b> air quality noise physical activity	<b>LACK OF AWARENESS</b> for consumers, buying new products can be seen as demonstrating higher status than renting, repairing or buying second-hand.  <b>RESISTANCE TO CHANGE</b> powerful stakeholders have vested interests in keeping production processes linear		<b>BENEFITS FOR CITIZENS</b> reduce their ecological footprint benefit economically from the extended lifespan of products improve quality of life
<b>PLANET</b> 	<b>ENERGY</b> % renewable energy performance per residential block	<b>NATURE &amp; GREEN</b> biodiversity degree of connection to ecologic networks green space per capita	<b>CLIMATE &amp; WATER</b> presence of water CO <sub>2</sub> emissions heat islands groundwater economic damage from floods soil sealing	<b>ADVANCES IN TECHNOLOGY</b> digital platforms facility deployment of innovative circular solutions	<b>PRODUCT DESIGN/MATERIAL COMPOSITION</b> opportunity to consider environmental impact in design selection (produced and avoided waste, embodied energy and emission)	<b>SALES MODEL</b> shifting from selling volumes of products to selling services and taking back products at the end of their useful life  <b>HR/INCENTIVES</b> developing incentives and training for culture shift towards adoption of
<b>PROFIT</b> 	<b>VITAL</b> number of stores property values per block purchasing power per household	<b>ACCESSIBILITY</b> pedestrian and cyclist trips congestion accessibility by car accessibility by public transport parking pressure	<b>HIGH TRANSITION COSTS</b> costs to businesses in terms of management, planning, research and development, physical and digital infrastructure.  <b>UPFRONT INVESTMENT</b> investments that yield returns only over a longer time frame	<b>BENEFITS FOR CITIZENS</b> opportunities to expand into new areas such as remarketing, component remanufacturing and refurbishment. reducing use of virgin material reduces exposure to price volatility and supply shocks due to natural disasters or political imbalances.		implementing circular economy concepts promotes wider re-evaluation of supply chains, which can lead to improved resilience.  the circular economy can create jobs in areas such as high- quality recycling and repair practices and logistics

Figure 1 | The indicators of sustainability.

In the best-seller book *Antifragile: Things That Gain From Disorder*, Taleb suggests that a useful way to understand how buildings survive over time is to investigate what makes them fragile or antifragile. Taleb discusses the concept of antifragility: «Some things benefit from shocks; they thrive and grow when exposed to volatility, randomness, disorder, and stressors and love adventure, risk, and uncertainty. Yet, in spite of the ubiquity of the phenomenon, there is no word for the exact opposite of fragile. Let us call it antifragile. Antifragility is beyond resilience or robustness. The resilient resists shocks and stays the same; the antifragile gets better... Antifragility makes us understand fragility better. Just as we cannot improve health without reducing disease, or increase wealth without first decreasing losses, antifragility and fragility are degrees on a spectrum» (Taleb, 2012).

Thus, an antifragile system is one that benefits from perturbations in the outer environment, or from the uncertainty of the Antifragile in this sense, are many things: our body, in some aspects in its life horizon, is antifragile; biological evolution is antifragile: In *Theory Of Evolution*, Darwin says that the process of natural selection operates «every day and now», scrutinizing the minor variations, «rejecting anyone who misbehaves, preserving what is good»: the species better equipped in terms of adaptability to environmental changes tend to be preserved longer

(Darwin, 1979). In this regard, the Economist Terborgh in its *Dynamic Equipment Policy*, states that machinery, or systems in general, are both constantly subjected to mutations and the unpredictability of their contexts, as well as functional by aggressiveness competing products. Systems that thrive longer, or have longer service life, are the ones that are able to cope with the unpredictability and mutation of their environment; therefore if a system has to be designed for an extension of its service life, the ability to cope with the unpredictability and the changes must be incorporated into the system (Terborgh, 1949).

Uncertainty, as “unpredictability” is a fundamental condition in which natural and man-made systems are compared and generally all complex systems. One way to deal with uncertainty is to incorporate the antifragility in the initial design, so as to ensure the possibility of choice in the future and be able to tackle successfully the changes that may occur during the life of these systems.

An “antifragile design” in architecture depends on its adaptability to the change. Adaptability as a design characteristic embodies spatial, structural, and service strategies that allow the physical artefact a level of malleability to fit functional, technological, and aesthetic metamorphoses in society.

This paper puts forth adaptability as a design principle that brings to the forefront this critical dimension: time. As Croxton (2003) points out, “If a building doesn’t support change and reuse, you have only an illusion of sustainability.”

The average lifespan for a dwelling lies somewhere is around 100 years (Tas, 1968). House designers are faced with the task of giving form to the enclosure that, for those 100 or so years, is to provide shelter for dwelling, an activity that is continually subject to change. Many mutations in household make-up and the associated spatial rituals occur in the course of time (external perturbations such as environmental disasters - earthquakes, floods, hurricanes - and internal perturbations due to user variability, change of times of use of the house and ways of living it) (Eijk, 2000).

In *Measuring Building Performance*, Frank Duffy, says: “The unit of analysis for us isn’t the building, It’s the use of the building through time. Time is the essence of the real design problem [...] A building properly conceived is several layers of longevity of built components” (Duffy, 1990). In fact, He divides the building into three layers: shell (is the structure, which lasts the lifetime of the building); services (they have to be replaced every fifteen years or so) and scenery (is the layout of the partitions, which changes every five to seven years).

The American architect Stewart Brand, draws up a similar system of categories. He divides building into (Brand, 1994): Site, Structure, Skin, Service, Space Plan, Stuff. At these levels, we can add another one which is the body (of the user). Its change speediness goes never more than a minute (Fig. 2).

These levels represent a closed hierarchical system where the higher levels govern and affect the shape of the lower levels; therefore, any analysis on any level should not disregard the others. Furniture limits the freedom of movement of the body, the fixed partitions limit the movement of furniture, and eventually, the architectural conformation of the building, intended as spatial organization and technological apparatus, affects the underlying levels, thus limiting the adaptability of space and furniture to the specific needs of the users. If we consider the levels in terms of “change speediness”, they would be classified in the following way:

site<structure<skin< service<space plan <stuff<body

From this comparison is clear that the permanent, meaning the more durable component of the house, constitutes the frame within which change can take place (Habraken, 1998). In terms of time, it emerges that a static construction cannot meet, in terms of time, the changing

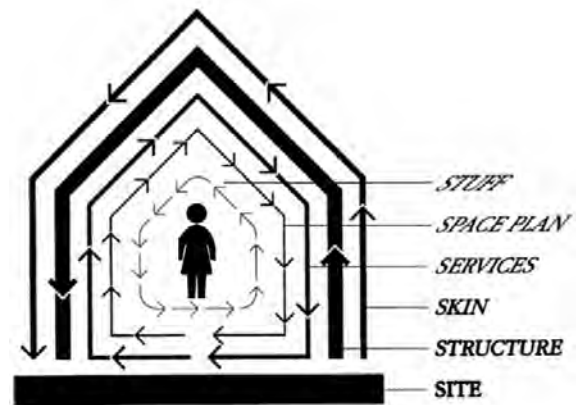


Figure 2 | The body as 7th category.

requirements of the body and this is even clearer in the case of standardized residences, which attempt to accommodate a broad spectrum of users in a small number of typical units (Seo, 2013). It follows that the duration of suitable home (its antifragility) is closely linked to its adaptability, or its ability to adapt to changes in demand.

Therefore, a fragile product (object, space, building, component) is a rigid product that is unable to adapt to change (in demand and in the market). It is, in fact, obtained from a ‘cradle to grave’ design approach, as the product is designed for a linear life cycle, ‘produce, use, dispose’. On the other hand, an ‘antifragile’ - therefore sustainable - product is a product that adapts to change to extend its useful life in a circular vision. It belongs to a ‘cradle to cradle’ thinking, a design framework that includes the Circular Economy. It entails a circular paradigm to achieve total recycling through product design (or redesign). CE must be embedded in the design process through two dimensions. Upstream circularity (before use) concerns managing resources efficiently, improving productivity in production and consumption processes, minimizing waste, and keeping product costs as low as possible. On the other hand, downstream circularity (after use) concerns preserving the value remaining in otherwise “waste” materials, and maximizing the extraction of that value within the system (World Economic Forum, 2018).

### 3.1 Building research and circular economies

To explore this complex issue the research methodology consisted of four steps: 1) conducting a systematic review of national and international best practice and International research experiences, which shows that

## how to apply the circular model?

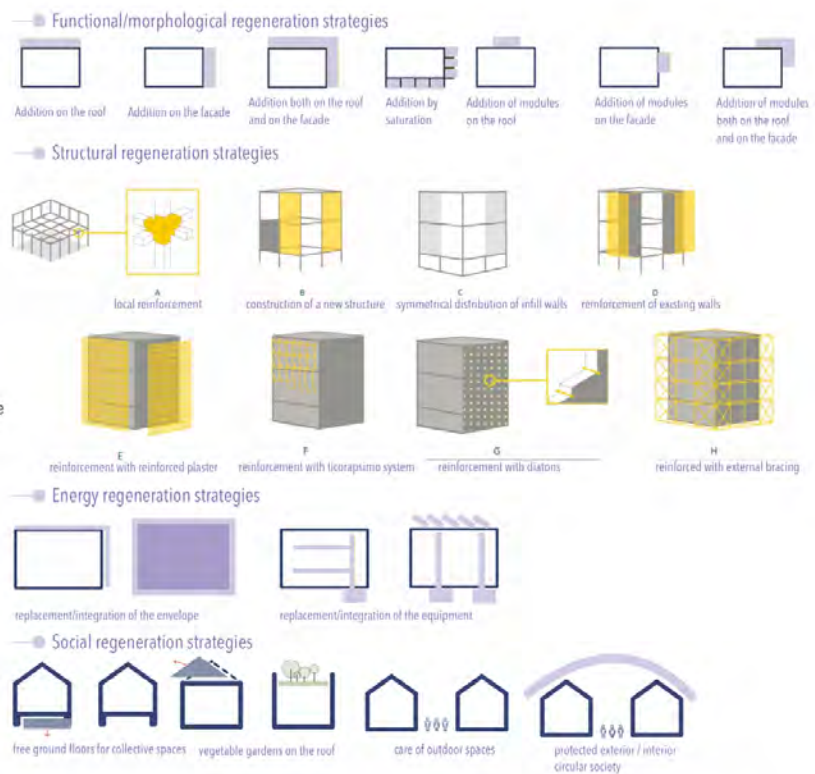
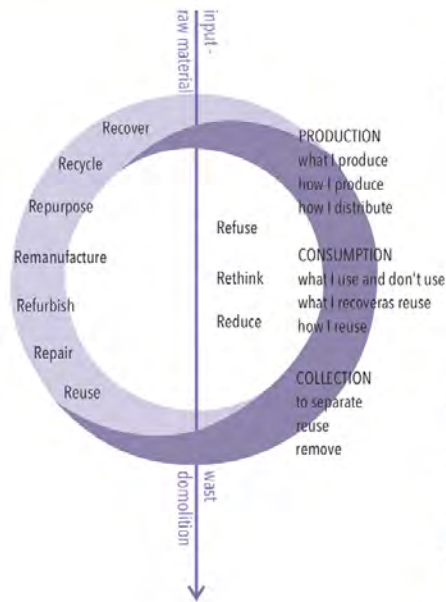


Figure 3 | Social, energetic and structural regeneration strategies.

although the literature on CE in the built environment is still in its infancy, the concept is gaining momentum in the construction sector (Fig. 3); 2) selecting a CE framework of regenerative design actions identified in a ‘circular perspective; 3) defining the level for the application of strategies; 4) synthesizing for each level discreet interventions from the literature according to the new model of circular regeneration. Analyzing the CE in the context of the regeneration of existing buildings, three areas/levels of regenerative design actions were identified in a circular perspective:

- Macro-level. This level concerns the public space and its social dimension and is characterized by actions that reactivate the traditional alliance between human and natural components as co-acting forces in order to obtain a rebalancing between densification and greening. This level includes projects for the integration of water cycle management in the built environment; – examples of Water Sensitive Urban Design (Climate Adaptation Plan Copenhagen, PICBA’06 Barcelona, Greater New Orleans Urban Water Plan, Rotterdam Climate Proof) and Green

Infrastructure (Plant Village, Seoul, by MVRDV; Fiume verde, Milan, by S.Boeri; Huerta -Turia in Valencia, Your City Center, Glasgow, by MVRDV etc.) – research on urban metabolism and the concept of eco-city (Van Berkel et al., 2009). In this level, the innovations that support these actions are found in the ‘social roots’ of the circular economy understood as the ‘sharing economy’ (Cohousing Numero Zero, Turin); in the networks for sharing and reusing resources (Cheshire, 2016, Greenfield, 2016); in the broadest commitment with all the stakeholders involved.

- Micro-level. This level affects the component and its material dimension and is characterized by actions aimed at updating the technical and technological elements to improve energy, structural and living comfort performance. Depending on the objectives to be achieved, the interventions can be punctual or on the entire building and structured according to a Circular Supply Chain Management (SCM) approach (Lacy et al., 2015). To support these actions, the innovations concern the use of online platforms and apps for sharing resources (O’Connor, 2015) and

new technologies such as Design for Manufacture and Assembly (DfMA) (O'Rourke, 2016) or Design for Deconstruction or Disassembly (DfD) (Adams, 2016, Densley Tingley and Davison, 2011).

- Meso-level. This level concerns the building and its functional / architectural dimension and is characterized by actions aimed at increasing the duration of the building product through solutions aimed at: 1) counteracting the seismic vulnerability due to the presence of strong construction irregularities in plan or elevation; 2) improve the building from a functional and morphological point of view through the subtraction of portions of the building aimed at reducing the population density, creating strategic openings or redistributing the various environments (the interventions of Foster Architekten in Leine-felde-Worbis, Germany, 2002-2006); 3) add volumes on the facade and/or on the roof in order to combine the improvement from an energy point of view with the increase in the surface area of the dwellings (G. Reinberg, Wollzeile, Vienna, 2005; Blauroom Architekten, Bogenallee Living, Hamburg, Germany, 2003-2004; Chartier and Corbasson, Social Housing in Rue Saint Antoine, Paris, France, 2009).

An evaluation of these experiences confirmed the need to adopt an integrated approach that takes into account the object as a whole and uses all the elements available to enhance its potential. The traditional approach of carrying out timely interventions aimed at responding to individual problems, be they of a structural, energetic, functional nature, relating to the building, the context or the single component is not entirely effective in terms of reformulation of the building characteristics and architectural. In this perspective, therefore, the regeneration of the built environment requires the ability to measure the processes of economic growth and the efficient (and circular) use of scarce local resources, where the latter include not only economic ones but also environmental ones, through a multiscale/multidisciplinary perspective that provides for the integration of different scientific skills (economic and spatial analysis, urban studies, evaluation studies, design and development of sustainable technological projects) (Cattaneo et al., 2020).

### 3. Strategies of circular regeneration

Based on the above considerations, the circular regeneration of the built environment depends on its adaptability to the following categories of variables:

- Internal variables: the uncertainties concerning the social and economic context, relative to the variability

of users' needs and the satisfaction of psychological and functional needs.

- External variables: the uncertainties regarding the system performance in relation to the vulnerability of the context (environmental disasters).

Residential buildings are subjected more than others to these internal and external variables and a circular regeneration can extend their useful lifespan and generates multiple benefits that extend beyond the project itself to the surrounding area, contributing to economic and social development.

The approach proposed lies in adopting the addition of 'Adaptive Retrofit Envelope' for the rehabilitation of the existing buildings. This flexible approach considers both space and user as 'open systems' in constant evolution and becoming, and the envelope as an 'exoskeleton' that adapts itself to internal and external changes.

G. Alistair, R. Schmidt, T. Eguchi and S. Austin have held that adaptability is the characteristic of design that adopts spatial, structural, and fixture strategies to endow the structure with the malleability needed to respond to the mutability of external parameters over time (Schmidt, 2010). In this case, a building is not considered a finished work, but rather an imperfect object whose shape continuously evolves to adapt to functional, technological, aesthetic and climate evolutions (Schneider, 2005; Fitch, 1980).

The 'Adaptive Retrofit Envelope' is not a simple skin that modifies a building's appearance, but it is a reinforcement structure providing static and seismic adjustment, where necessary, and support to host expansions of dwelling units, eventual loggias, additional floors and system to improve energy efficiency (Kronenburg, 2007) (Fig. 4). The proposed envelope is thus 'adaptive' in the following levels of strategies):

- At the room level, by the increase in interior surface space with the addition of ambient units;
- At the home level, by the adaptability of the envelope to external climatic conditions;
- At the building level, by a reinforcement of structure providing static and seismic adjustment.
- At the urban level, by creative use of collective spaces;
- At the users level, by the improvement of his conditions of livability and psycho-physical well-being.



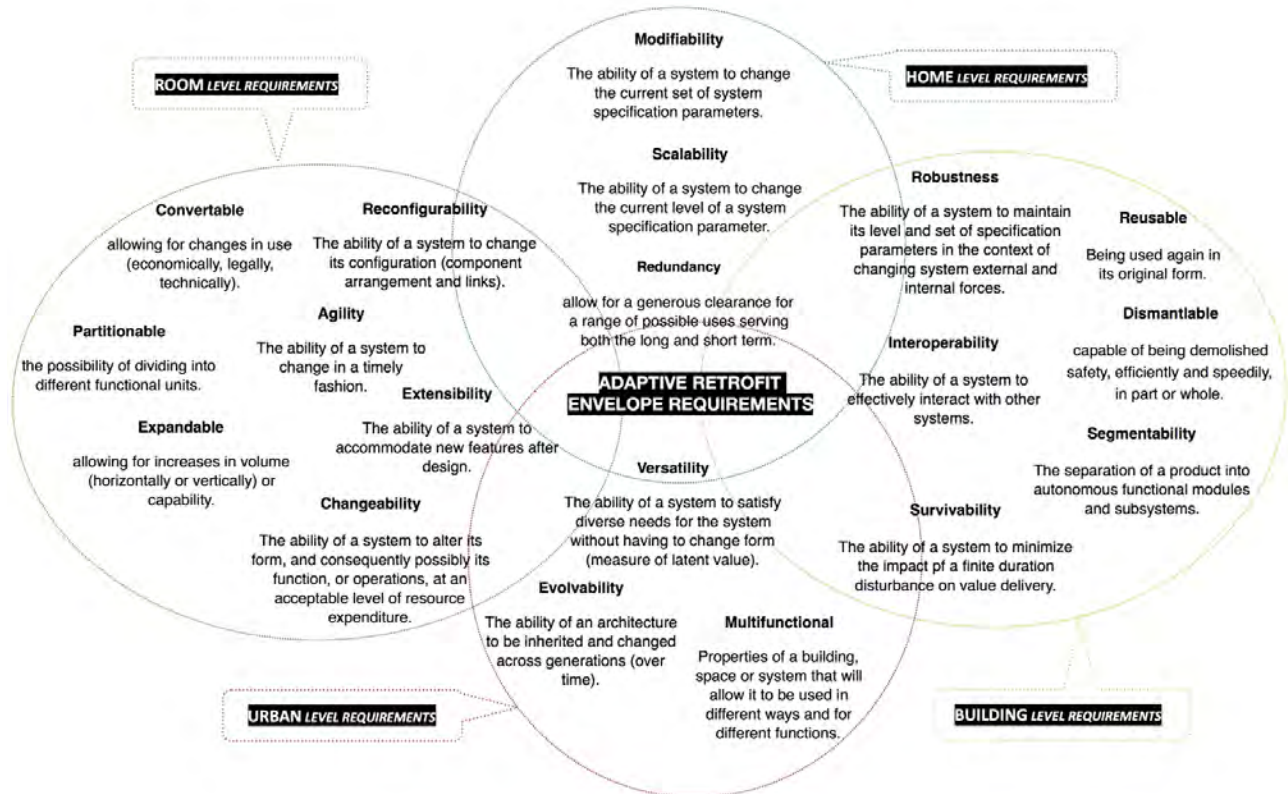


Figure 4 | The Adaptive retrofit envelope requirements).

### 3.1 Room level. Densification by increasing surfaces and volumes on the roof and facade

This strategy offers the ability to expand existing apartments into external loggias, occupants can adapt their home to meet their changing needs, increasing or decreasing enclosed space as required. A design proposal attempts to update and functionally improve no standards-compliant buildings that have lost quality and comfort, and also to revive the ‘spartan luxury’ in housing mentioned by the French architects Locaton and Vassal (2004). Already Habraken, in the 1970s, presupposed the definition of an equipped frame (wall support and engineering structures) opened the possibility to change the organization of indoor space from the active participation of the users (Habraken, 1973). This form of adaptability foresees the planning of the alternation of expansions and contractions within the life cycle of a home. In fact, existing supports – such as balconies or terraces – can be closed with minimal architectural interventions to form a part of the interior living space.

Furthermore, existing buildings with a solid construction are suitable for densification by “topping-up”. Because new dwellings need to adapt to existing substructures, this strategy encompasses a large diversity of building typologies: from roof villages with a communal character (Didden Village, designed by MVRDV) to individual penthouses (some project of Archipelontwerpers). An additional advantage of adding houses on the building is that, from an energy perspective, each new house or space can be an energy storage device. By adding house in the right place, heat and cold can be exchanged between buildings (Till, 2009), resulting in immense reductions in energy use for the existing building stock. Further, existing district energy networks will become more efficient and profitable because they will supply energy to a greater number of buildings. Doubling the number of dwellings will strongly help to decrease the average energy consumption per dwelling of the city area, because new housing will have to meet stricter standards of energy efficiency.

According to carbon data from C40 cities, 29% of city buildings’ emissions are associated with the supply

of electricity (C40 and Arup, s.d.). Circularity in energy systems – which encompasses the entire supply chain, from generation to storage, transmission, distribution and consumption – is vital to meeting the Paris Climate Agreement (COP21) goal of reducing emissions to a level that would limit global temperature rise to 1.5°C. Densification on the existent building has the added benefits of contributing to a more compact urban form (more clustering within the urban morphology leads to more energy efficiency as well) and increasing the use of renewable energy (adding generating solar energy; smart grids to charge and discharge electricity to and from the grid; efficient energy distribution through real-time communication between energy generators, utility companies and consumers). This smart form of energy exchange requires new coalitions and organisational innovations, but it has the potential to help the city radically reduce its eco-footprint. In addition to this, the smart positioning of building volume in relation to prevailing winds, urban green and water bodies can be a valuable instrument in cooling the city, making it more comfortable in what appears to be increasingly hot summers and heat waves.

### 3.2 Home level. Adaptability of the envelope to external climatic conditions

The densification can be combined with urban greening that directly improves the living environment. The Adaptive Retrofit Envelope can be available to creating attractive green surfaces (green roofs and facades).

Green roofs and facades provide extra ecological quality, capture fine particles and CO<sub>2</sub>, and provide green scenery (from high-rise buildings) and green recreational (sitting and playing) environments. Moreover, they have a positive effect on the densified inner-city climate and function as water buffers, thus contributing to urban water management. Green roofs and facades also provide excellent locations for realising urban agriculture. Combinations of functions in buildings (e.g. restaurants and schools) and agricultural activities on roofs and facades also have socio-economic value.

The intention of this strategy is to shape the skin according to specific needs. The steel bracing structure positioned outside the existing building does not weigh on it, but it collaborates with its host instead, adapting to incorporate diverse technologies designed to improve energy efficiency, such as traditional greenhouses, brise soleil, green facades, a double skin as well as more innovative solutions based on intelligent envelopes. This is possible through certain technologies that can be assembled on site. Thus, in complete balance with technique and form, the building can be molded to adapt it to the evolution of the external climatic changes

(compensation of solar radiation; alteration of the surface albedo; attenuation of wind speed on external surfaces and consequent reduction of heat losses and improvement of thermal resistance). Besides the complete reversibility of system-building, this solution provides for the replacement of certain elements with higher-performing ones, as well as their relocation. Moreover, the Adaptive Retrofit Envelope is the support for integrated solutions: 1) of green walls which, in addition to cooling the ambient temperatures through evapotranspiration and shading processes, improving both internal and external comfort and reducing energy consumption and building costs (Demuzere et al., 2014), create natural ecological cycles, favour biodiversity and the formation of ecological corridors by increasing environmental quality, through a reduction of pollutants and a general improvement of people's well-being; 2) of water sensitive urban design, through the integration on the exoskeleton of technical devices (green roofs, vegetated surfaces connected to the urban scale with accumulation and retention basins, rain gardens) which will allow, in the long term, to maintain/restore the natural hydrologies by absorbing rainwater, allowing it to slowly infiltrate the soil, be absorbed by plants or captured and recycled for later use. This system involves a reduction in the amount of water that flows into conventional rainwater systems (reducing investments for the implementation of new grey infrastructures and the costs of electricity and pumping) and reuse of the same at the source (Farrugia et al., 2013). The benefits of resource management are combined with an improvement in people's well-being.

### 3.3 Building Level. Reinforcement structure providing static and seismic adaptability

As far as structural retrofit techniques are concerned, nowadays two leading approaches are addressed: the local approach and the global approach. "Global interventions", which are based on the construction of a new global seismic-resistant structure, are generally more effective and reliable from the structural point of view, than "local approach", which consists in local strengthening of existing frame joints (Riva, 2010). A global intervention can be carried out by integrating existing in RC frames with steel bracing systems, either over-resistant or dissipative (Balducci, 2011), or by adding RC shear walls (Marini, 2009). The adaptive envelope re-elaborates and merges traditional methods and Balducci's one providing an integrated solution: the three-dimensional structural envelope, while improving the seismic behaviour of the structure, offers additional space for services and functions, increasing the economic value of the building and improving its energy performances and its architectural characteristics. The new frame is realized with steel elements, bolted together to allow the greater reversibility

and the possibility to modify the structure over the time. In particular, the engineering-structural-technology double skin innovatively integrates ad-hoc systems and devices to attain the building structural safety with respect to seismic action and it stems as an efficient alternative to the existing building demolition and reconstruction practice. The resulting physical object bolsters the capacity for change to take place through an ease of tension between building components, particularly at the distinctive levels of short-life/ infill and long-life/ base building. This mindful separation supports a conscious effort by the designer to think about the durability of the materials and systems and their relationships to other components.

### 3.4. Urban Level. Planning of indeterminate collective spaces and a green densification

The Adaptive Retrofit Envelope is the support for the addition of universal and indeterminate containers, collective spaces for the residents and the inhabitants of the neighborhood, adaptable to market demands and to the variability of user needs. Indeterminacy consists in arranging a non-defined space, impersonal spaces, that may be used creatively by the users, incubator of entrepreneurial, collective-intelligence, co-planning and co-production activities of value. This indeterminate approach embodies a social process between designer and user over time and demands a greater response from its users due to the greater ambiguity of the space.

To this effect, participation becomes a driving force in the process. Participation here does not mean only debate and deliberation but also direct action in the 'construction' of the space. The space-user relationship is thus translated from a participatory point of view through the fostering of a 'Collective Intelligence', which returns the citizen to the center of the processes of transformation and management of the territory in which he/she lives.

Because the addition of services and housing is not enough to create a quality space, this implies that the construction of new dwellings should be accompanied by the provision of extra urban green (more and better quality urban green).

The design of this public domain is decisive for the atmosphere, tempting people to dwell longer and, finally, to feel more connected with the city.

Consequently, continuing to invest in high quality, green outdoor space the value of real estate, current and future, will grow, encouraging private investment. It is important that private parties and developers can also contribute in this respect and not only the municipality. In fact, private parties can contribute to the development of

outdoor space, for example with the gift of a tree, a bench or through urban agriculture, in which city inhabitants produce food for personal consumption or sale at local markets.

### 3.5 Users Level. Improvement of livability and psycho-physical well-being

Technical feasibility, of the previous levels alone does not accomplish a sustainable solution. If adaptability brings an understanding of time, it brings an emphasis on process and enabling the building to 'learn' and the users to 'teach' or shape the space themselves. Adaptability forces design to become an ongoing social process between designer and user over time. The designer must focus on enabling adaptation to take place; as opposed to attempting to control experiences and anticipate the future. Hertzberger (1991) stresses, "Architecture should offer an incentive to its users to influence it wherever possible, not merely to reinforce its identity but more especially to enhance and affirm the identity of its users." In this context, citizens reassume the role of protagonist in terms of culture and local identity, and through a process of co-creation transform the space in which they live by adapting it to their own needs to internal functions and to different external climatic conditions (Fitch, 1980) according to an idea of self-help construction that allows users to manage the assembly of the housing and the filter screens at their own discretion. The benefits of self-management are combined with an improvement in people's well-being, and favor behavioral and social goals. Through this "project re-appropriation", users become "environmental administrators", themselves "smart", physically and socially active.

## 4. Conclusions

Donald Schön argued that architects represent something that does not exist, "something that must be brought to reality", along a path that takes into account uncertainty, unknown variables, obstacles and other implications that must be uncovered during the project (Schön, 1987; Dewey, 1938). The different strategies proposed are an alternative approach that considers the uncertainties, involved in the discovery of the unknown and unexpected changes during the life of a building, as a part of the design process (Fig. 4). These strategies lie in a reconceptualization of time that goes beyond matters of durability to a circular view of a building as a product constantly in the making, a view that chimes with what Till (2009) describes as 'thick time'. Here architecture can no longer be thought of as a noun, but as a verb - always on the move - responding to a milieu of change.

In this sense, successful adaptability may not always need to come from the capacity of the building itself, but from the user or owner's capacity to adapt and/ or any other numerous variable which supports the dynamic interplay between building and context. Piore defines this design process as an open process and in relentless interpretation, as much as interpretation is "the activity that brings about something new, interpretation is not directed at the solution of well-defined problems and therefore it is not possible to say that interpretation has a final endpoint" but rather continues in time (Lester, 2004).

Talented jazz musicians are able to improvise by moving from reflection to action in an interpretative and creative process that takes place in real-time. This sequence of reflection – interpretation – improvisation – action as the basis for the creative process is consistent with the circular regeneration process through variations, combinations, and rearrangements of a series of solutions and figures in real-time, which are adaptable to contingent needs and requirements.

## Notes

- <sup>1</sup> With this expression, Bonara wants to indicate the occupation of land, for building purposes, not proportional to the real housing demand.

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